Advances in Deer Biology

Luděk Bartoš, Adam Dušek, Radim Kotrba,
Jitka Bartošová-Víchová (Editors)

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Deer in a Changing World

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Proceedings of the
6th International Deer Biology Congress

Prague, Czech Republic
7-11 August 2006

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Editors:

Luděk Bartoš, Adam Dušek, Radim Kotrba,
Jitka Bartošová-Víchová

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Preface

This year's congress is a continuation in the tradition of previous congresses. The "ancestor" to the International Deer Biology Congress series was the conference on "Antler Development in Cervidae", organized in 1982 in Kingsville, Texas by Robert Brown. This initial conference subsequently gave rise to the First International Deer Biology Congress (1983, "Biology of Deer Production), organized by Ken Drew and Peter Fennessy in Dunedin, New Zealand. Subsequent congresses were organized by Bob Brown at Mississippi State, U.S.A. (1990), John Milne in Edinburgh, U.K. (1994), László Sugár and Zoltán Zomborszky in Kaposvár, Hungary (1998), and Michele Crête in Québec City, Canada (2002).

In the earlier congresses, complete papers were published in the Proceedings. However, during later years the proportion of full papers declined reflecting an increasing tendency in the academic world to present papers at conferences, but to publish the full paper in an impacted journal afterwards. As a result, in the Fifth International Deer Biology Congress, only a Scientific Program and Abstracts were released. In the current Congress, we stepped back and present a compromise. While this Proceedings consists predominantly of abstracts presented at the Congress, it also contains longer contributions.

This Congress brought together a diverse group of deer scientists and deer management professionals from Europe, North and South America, Asia, Australia and New Zealand. Topics covered include deer management, diseases of deer, genetics and evolution, management of endangered deer, reproduction, behaviour and welfare, censusing and modelling populations, antler biology, responses of deer to global environmental change, problems of deer overabundance, conservation of free ranging populations, feeding ecology, seasonal and non-seasonal deer: (Arctic to Tropic), venison and its potential contribution to human diet, and deer zooarcheology and history. Thus the Advances in Deer Biology: Deer in a Changing World is a comprehensive and up-to-date source of information on all current areas of deer research.

Welcome to Prague, whether you are coming for the 6th International Deer Biology Congress or just for a visit!

Luděk Bartoš

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Priorities in Cervid conservation: Why science, zoogeography and history do matter.

V. Geist

Professor Emeritus of Environmental Science, The University of Calgary, Calgary, Alberta, Canada

A review of the long history of successes and failures in cervid conservation, suggest that there are no universal and global solutions to conservation. The review suggests that the first priority in conservation must be a detailed understanding of the autecology of each species. The better the science, the richer the opportunities for effective intervention, especially where limited means are at hand. In practice this means that regardless of ongoing conservation efforts, there is a need for continuity of in basic research, with due regard for geographic species differences in ecology. Some troublesome foci that need scientific attention are taxonomy, as such has crept into legislation and can now be subject not to scientific but judicial interpretation. Predation and cervid security adaptations need attention, as current examples of predator reintroductions have highlighted deep errors in formerly accepted assumptions. How to manage cervids is thus not unrelated to how to mange predators. Here, as in other lines of inquiry the local Pleistocene history of faunas may be surprisingly relevant. In North America habituation of wildlife is vexing concern. However, while science is a necessary, it is not a sufficient condition for conservation. It is necessary to research models of conservation for relevant policies and practices. Here the nearly century old North American model of Wildlife Conservation offers important insights. It not only returned wildlife and thus basic bio-diversity to North America, points to policies essential to conservation as well as the creation of wealth from wildlife, but also is the only large-scale system of sustainable natural resource use to date. Using this model as a guide indicates that, globally, the de facto ownership and use of wildlife by politically potent group of people is the best long-term protection for wildlife.
(Plenary lecture)

2
Deer responses to global environmental changes.

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"In one sense the conditions of life may be said, not only to cause variability, either directly or indirectly, but likewise to include natural selection, for the conditions

determine whether this or that variety shall survive." Charles Darwin (On the Origin of Species, 1859).

Ever since Darwin's foreseen reflections, we have become increasingly aware of the importance of abiotic or climatic conditions in forming the evolution of organisms, their life histories, distributions and population dynamics. Indeed, our awareness peaked in 1995, when the Intergovernmental Panel for Climate Change summarised that "the balance of evidence suggests a discernable human influence on global climate", realising that in addition to direct interactions, we may indirectly, through our apparent increasing influence on global climate, incur even more severe damage to the Earth's ecosystems. Clearly, understanding how climate affects the lives of organisms is seminal for predicting the effects climate change on ecosystem structure and functioning. Effects of local weather conditions and their seasonal influence have been studied intensively in the past. Recently, however, focus has turned to the potential ecological repercussions following changes in global climate and, during the last few years, the use of integrative, large-scale climate indices has become somewhat of an "industry". There are at least two important reasons for this. First, whereas local weather vary in response to global climate change, large-scale systems, like the North Atlantic Oscillation, *is* a major component of global change, which, indeed, may be an advantage to use when ecological responses have to be interpreted on a large-scale and, in particular, in a global change context. Secondly, due to its integrative nature, implicating large-scale climate indices rather than local weather may provide us with definitive cues of across-species as well as across-taxa responses to global change, which is central to climate-related issues of biodiversity and conservation. Here, I selectively review recent studies of deer biology in relation to interannual variations in the North Atlantic Oscillation (NAO) / Arctic Oscillation. The NAO is a large-scale seesaw oscillation in atmospheric mass along a meriodinal gradient in the North Atlantic. By influencing the speed and direction of westerly surface winds across the Atlantic Ocean, the NAO induces variation in temperature and precipitation in North America as well as Northern Europe and may, hence, potentially affect the deer species living in these regions. In particular, I focus on explaining and contrasting the potential direct and indirect effects of variations in the NAO on phenotypic variation in life history traits, dynamics of populations and, ultimately, the intertrophic interactions characteristic of deer species and the environment in which their embedded.

(Plenary lecture)

3
Emerging disease in wild and captive Cervids.

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Abstract

Global warming and a resurgence of nuclear energy issues are evidence of the geographical and political pressures that are influencing and altering our world. One of the consequences of the accelerated changes to the 21st century world is the emergence and re-emergence of infectious disease in animal and human populations. Changes to agricultural and wildlife management activities and policies are important determinants of emerging disease. Furthermore, human activity, or anthropogenic change, is the single most potent force driving the emergence of these diseases. Perhaps in response to a global increase in meat consumption, there has been an increase in the farming of unconventional or non-traditional livestock, including cervids. Deer farming has created changes in the ecology of deer diseases and has altered previous concepts of the wildlife/livestock interface. We know very little about the interactions of wild and farmed cervids or wild cervids and domestic livestock such as cattle. Likewise we have not examined the importance of cervid product movements, wild or farmed, in the transmission of disease. We do know that translocation of wildlife for management purposes and commercial trade in farmed cervids are human activities that have resulted in pathogen pollution and the spread of new and old diseases such as chronic wasting disease of cervids and *Mycobacterium avium* subspecies *paratuberculosi*s infection, also known as Johne's disease. Environmental change and modifications in agricultural methods of food storage and the artificial feeding of wildlife for hunting and non consumptive purposes have resulted in the re-emergence in North America of *Mycobacterium bovis* infections also known as bovine tuberculosis. This paper examines the emergence of bovine tuberculosis in elk from Riding Mountain National Park, Canada and in White-tailed deer in Michigan, USA. The history and epidemiology of chronic wasting disease in North America is briefly examined as an example of a newly emerging disease. *M. paratuberculosis* infections in elk from Point Reyes National Park in California and Key deer in the National Key Deer Refuge in Florida are discussed as examples of the importance of understanding disease ecology. One of the answers to disease emergence is to recognize that there is an ecology of disease in farmed and wild populations of cervids and for us to carefully consider the consequences of anthropogenic change to ecosystem health.

Introduction

Global climate changes and a resurgence of nuclear energy issues are evidence of the geographical and political pressures that are influencing and altering our world. The consequences of change on such a large scale are more than most of us can

comprehend but we can understand the manifestations of changes affecting us more directly such as what we eat and how we produce it. For instance, the world is eating more meat than ever before. Increased incomes and standards of living in developing countries are allowing people to eat diets that are higher in protein. World consumption of livestock products has more than doubled in the past 30 years, driven mainly by increases in consumption of meat and dairy products in nations such as China and Brazil, which have accounted for more than half the increase in per capita meat consumption in developing nations since the 1970's (Holmes, 2001). This shift in dietary habits has affected the use of agricultural land and changed the way food animals are produced. There has been an expansion and intensification of livestock production that has favoured industrial farming systems because they offer an inexpensive way to produce many animals on a single site, using small amounts of land close to markets or ports (Holmes, 2001). Even in countries with lots of available land there has been an increase in "landless" systems using stalls, pens, and feedlots to intensively raise livestock. The Food and Agriculture Organization of the United Nations (FAO) has predicted that the proportion of cattle and sheep produced in this manner in Latin America, sub Saharan Africa, the near East, and North Africa will more than double by 2030 (FAO, 2000).

The demand for protein and perhaps more importantly the need for a broader economic base in agriculture in some countries has led to the farming of nontraditional species of animals such as ostrich, emu, wild boar, crocodiles, guinea pigs and capybara. Although deer have been farmed in one form or another for millennia, deer farming is a relatively new agricultural activity to Western countries like Canada, the United States, New Zealand and Australia. The rise in non-traditional animal agriculture parallels the burgeoning global trade in bush meat, which is rapidly becoming a concern to conservationists because of the alarming increase in the number of threatened species and to world health officials from the equally alarming risks from zoonotic disease posed by the consumption of bush meat. It has been estimated that tens of millions of wild animals are shipped each year regionally and from around the world for food or use in traditional folk medicine (Karesh, 2005). For instance, live wildlife markets in Guangzhou, China trade in masked palm civets, ferret badgers, barking deer, wild boars, hedgehogs, foxes, squirrels, bamboo rats, gerbils, and various snakes and other reptiles as well as domestic dogs, cats and rabbits (Asia Animals Foundation, 2006).

Intensification of animal agriculture, addition of newly farmed species, and the trade in wildlife to satisfy the need for protein in human diets are examples of forces that drive local, and sometimes global, ecosystem changes. One of the consequences of changes of this nature is the emergence or re-emergence of infectious disease. The general determinants of emerging infectious disease are described as increased international travel and trade in animals, changes in human demographics and behavior, advances in agricultural technology and intensification of the livestock industry, increased economic development and land use, breakdown of public health measures and microbial adaptation and change (Daszak et al., 2002). Most of these determinants are directed by human activities and behaviors and their influence on ecosystems and the ecology of diseases. Ecology is the study of how organisms interact with each other and their physical environment. The relationships of wild cervids with other animals including farmed species and their environment is, to a

large extent, influenced by humans and therefore the largest part of emerging disease in cervid populations is driven by anthropogenic changes and activities.

Emerging disease problems can be created or made worse by poor decision making and planning by wildlife managers and agriculturalists. Robert Hepworth, executive secretary to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) said "The proximity of migratory birds to poultry is the outcome of incorrect planning and faulty development, which have caused the sharing of important habitats for migratory birds - like wetlands - between wildlife and farms, with the obvious consequences that we are now experiencing." The sharing of habitats and the decision to farm new species or to traffic in animals and animal products are examples of human activities creating new interfaces for disease occurrence. The wildlife/livestock interface is complicated by the fact that some of the livestock populations are now also cervids and the emergence of infectious disease in wild cervids has been made possible, perhaps inevitable, by changes made to the wildlife/human interface by human activities such as supplemental feeding of wild deer or deliberate changes to habitat favoring artificially high population densities. The translocation of cervids and cervid products, either for commercial or wildlife management purposes, has created enormous opportunities for the spread of disease between cervid populations. North American examples of emerging cervid disease are bovine tuberculosis (*Mycobacterium bovis*) and Johne's disease (*Mycobacterium paratuberculosis* infection) in elk (*Cervus elaphus*) and white-tailed deer (*Odocoileus virginianus*), and the transmissible spongiform encephalopathy of cervids, chronic wasting disease.

Bovine tuberculosis

Bovine tuberculosis can be found in wild white-tailed deer in a localized area of the state of Michigan, USA. In 1994, a hunter-killed deer in Michigan was found to have lesions of tuberculosis, prompting a 1995 survey that isolated *M. bovis* from 5.1% of the deer sampled (Palmer et al., 2000). Subsequent multi-species sampling since 1996 has found *M. bovis* in 19 coyotes, 8 raccoons, 7 black bear, 4 bobcat, 3 red fox, 2 opossum and 1 domestic cat. Since 2000 there have been 30 positive beef, and 7 positive dairy herds. Also since 2000, there have been 4 positive wild elk found (Michigan Government, 2006). In 1997, a captive herd of white-tailed deer was found to be infected and when depopulated, it had a herd prevalence of 12% (Palmer et al., 2000). Interestingly, the captive herd appears not to have contracted tuberculosis from interacting with wild deer outside the farm fences, but when the farm was created, wild deer were purposely trapped inside the perimeter fences as they were erected and these were used to populate the farm with animals. This was confirmed by DNA typing of the *M bovis* organisms found in the farmed deer (Palmer et al., 2000). Continued surveillance in the local deer population indicate that since intervention strategies have been employed prevalence rates have fallen to approximately 0.2% (Michigan Government, 2006).

Presumably the origin of the tuberculosis infection was an interaction between wild deer and infected cattle. The conventional wisdom of 20 years ago thought that tuberculosis could not sustain itself in a wild deer population. Prior to 1994 *M. bovis* infection had been diagnosed only sporadically in wild North American deer (Rhyan et al., 1995, Friend et al., 1963, Levine, 1934, Belli, 1962). What happened? Human

activity in the ecosystem caused the contact rate of infected and uninfected deer to favor the transmission of disease. It had become common practice in Michigan for private citizens to supplement the winter food supply of deer on their property with sugar beets, carrots, corn, apples, and pelleted feed in order to discourage migration and decrease winter death losses, thereby increasing deer numbers for hunting and non consumptive tourism. The practice of supplemental feeding increased the population of deer to focal concentrations of 19 to 23 deer per km^2 (Palmer et al., 2004b). Winter-feeding not only increased the contact rate among susceptible animals but provided fomites through which transfer of infective organisms to uninfected deer could occur (Palmer et al., 2004a). The epidemiological principle at work here involves the basic reproductive number (R_0) of disease, which refers to the number of secondary cases expected from the introduction of one primary case into a completely susceptible population. R_0 =pcD where p = the probability of infection on contact, c = contact rate (number of contacts per unit of time), and D = duration of infectiousness (Wobeser, 2006). In order for disease to remain in a population R_0 must be 1. Since the contact rate is determined primarily by behavior, transmission routes of the pathogen, animal density, environment etc. in a specific population, it is obvious that anthropogenic changes in the local ecosystem are responsible for an increased R_0 and the subsequent maintenance and increase of tuberculosis in wild Michigan white-tailed deer.

Similar circumstances exist in the Greater Riding Mountain Ecosystem of Manitoba, Canada where wild elk (*Cervus elaphus manitobensis*) have become infected with and are maintaining bovine tuberculosis. The difference is that human activities have not only altered population density and contact rates but have greatly influenced animal behavior and movement as well. Riding Mountain National Park (RMNP) is a relatively small reserve (approx. 3000 km^2) located in a forest-agricultural transition zone and is almost surrounded by agricultural land. There are currently about 50,000 cattle in the area around the park with an estimated 2500 elk, 2500 moose (*Alces alces*), and 5000 white-tailed deer in the greater ecosystem. In the 1950's and 60's bovine tuberculosis was routinely found in cattle that were allowed to graze inside the park. Even subsequent to a very effective national tuberculosis eradication program in the 1970's, tuberculosis was occasionally (1981, 1991) found in cattle herds bordering the park and since 1991 there have been 11 cattle herds diagnosed with tuberculosis in 4 separate outbreaks (1991, 1997, 2001, 2003) in the vicinity of RMNP. In 1992 the first naturally tuberculosis infected elk reported in North America was shot by a hunter in the vicinity of a diseased cattle herd. Between 1998 and 2000, four more infected elk were found in or near the park through a multi-jurisdictional wildlife surveillance effort that included deer, moose, bear, beaver, coyote, and raccoon samples. The only non cervid species ever to have been demonstrated to have Tuberculosis were 2 wolves in the 1960's, discovered retrospectively in park records of wildlife necropsies. Farmed cervids have not been affected by tuberculosis in Manitoba. Since 2000, a total of 20 tuberculosis positive elk and 7 positive white-tailed deer have been discovered within the Greater Riding Mountain Ecosystem (Copeland 2006, Copeland pers com.). Prevalence is not high but the existence of the disease is significant because of the impact this tuberculosis reservoir is having on local cattle production and export trade.

Despite the obvious relationship between cattle, elk, and white-tailed deer disease near RMNP, researchers know very little about the wildlife/livestock interface in this

ecosystem and little is known about the ability of elk to transmit *M. bovis* among themselves or to other susceptible hosts. In 2002 telemetry collars were placed on elk from RMNP to examine animal movements and to gather information on the temporal and spatial aspects of elk interactions with agriculture at the periphery of the park. Data were also collected to examine environmental and farm management factors that influence these interactions (Brook et al., 2006). It was widely believed that due to park management policies elk habitat inside the park has changed and that less favorable conditions now exist, forcing elk to use agricultural land to feed. Fires, once commonplace on the prairies and allowed to burn, are now suppressed. Haying, forestry and cattle grazing activities within the park were stopped years ago. This has caused areas of the park to be overgrown with forest and shrub cover. Beavers, no longer trapped in the park, have flooded large areas of elk habitat. It is perceived that poor quality habitat inside RMNP forces elk out of the park to feed on agricultural land (Brook et al., 2006). Standing hay and grain crops, and stored hay bales are regularly consumed and destroyed and fences are damaged. Similar to Michigan, hunters and outfitters have used food to bait the elk out of the park so that they could be more easily hunted. Elk accumulate at hay bales left exposed in the fields, at feeding sites for local cattle, and at bait piles placed by hunters providing opportunity for transmission of tuberculosis between elk and between elk and cattle through direct contact as well as feed contamination (Palmer et al., 2004a, 2004b, Brook et al., 2006).

In both Michigan and in Manitoba the approach to resolving an emerging tuberculosis problem in cervids has been to modify the conditions that permitted R_0 to increase to disease maintenance levels. This strategy should cause a decrease in the incidence of new disease and a move towards extinction. In Michigan, the provision of winter feed supplements has been banned and the number of hunting permits for deer of both sexes has been increased (Schmitt 2006). In Manitoba, a large public relations and information campaign aimed at farmers to change livestock feeding and feed storage practices was undertaken. The result has been that forage harvested in the area around RMNP is now mostly stored in fenced elk-proof hay yards and there have been changes to the wildlife baiting and feeding regulations and the level of enforcement of these. An extension of the cervid hunting season has been made and there was an increase in the number of hunting permits issued in an effort to reduce the population of susceptible animals (Brook et al., 2006). In Michigan apparent prevalence in the core area of the outbreak was 1.2% in 2005, a decrease of 76% since 1995 (Schmitt et al., 2006). Similar results are expected for the RMNP area (Copeland pers com).

Chronic Wasting Disease

Chronic wasting disease (CWD) was first recognized in 1967 among captive mule deer (*Odocoileus hemionus*) that had been assembled at wildlife research facilities in Colorado from several sources including free ranging populations and a wildlife research facility in Wyoming (Williams 1980). It wasn't until 1978 that chronic wasting disease was identified as a spongiform encephalopathy and at about the same time the disease was identified in captive mule deer and elk in the Wyoming facility (Williams et al., 1980, 1982). In the years between 1980 and 1990 CWD was diagnosed in free ranging elk, mule deer, and white-tailed deer in Colorado and

Wyoming. Surveillance data and modelling have suggested that CWD may have been present in free ranging populations for decades before being discovered (Miller et al., 2000).

The origins and nature of the causal agent of CWD remain contentious issues but the cause is presumed to be an abnormal prion that perhaps resulted from a spontaneous change in the configuration of normal prion protein to a resistant form occurring in a Wyoming mule deer, with subsequent transmission to other deer and elk in the area. Alternatively, mule deer in the research facility could have been infected with a cervidadapted strain of scrapie derived from research sheep also housed at the facility, or even a genetic form of TSE arising in deer, with subsequent natural transmission (Williams et al., 2002).

In 1996, CWD was discovered on an elk farm in Saskatchewan, Canada and subsequent disease investigations and tracing of animal movements resulted in finding several more infected farms. CWD has been found on 40 farms in Saskatchewan and 3 deer farms in Alberta. Approximately 8,000 cervids from infected and trace-out herds have been killed with 227 testing positive however, there have been no new cases in Canadian farmed elk in approximately 4 years. Canadian Food Inspection Agency traceback investigations indicate that CWD was imported into Canada in 1989 through commercial trade in farmed elk from South Dakota (Kahn 2004). CWD was first diagnosed in the US elk industry in 1997 and since then the disease has been found in commercial cervid farms in Colorado (1herd), Nebraska (4), Minnesota (2), South Dakota (8), Montana (1), Kansas (1), Wisconsin (7), Oklahoma (1), and New York (2) (Chronic Wasting Disease Alliance, 2006). CWD has been found in free ranging cervids in all of the above states as well as Utah, New Mexico, and Illinois (Chronic Wasting Disease Alliance, 2006).

Prior to 2000, CWD in free-ranging deer was believed to be limited in the wild to a relatively small endemic area in northeastern Colorado, southeastern Wyoming and southwestern Nebraska. However, since 2002, CWD has been found in new areas of these states as well as those listed above, and including states where there are no cervid farms. Researchers suggest that the emergence of CWD in farmed and free ranging cervids are essentially independent events with minimal geographic overlap and if the epidemics share a common origin, it dates back several decades (Williams et al., 2002). This is quite possible since, in the early days of elk farming, foundation stock were often derived from wild populations in what are now known as endemic areas for CWD.

What sets CWD apart from other TSEs is the fact that it is apparently contagious and can be spread horizontally from animal to animal or from prion contaminated environments to cervids in the environment. The incubation period can exceed 36 months, and the clinical course of disease can be protracted (days to months), making unapparent carriers and prion shedders important to the dissemination of infectious material in the environment. The determinants of emerging infectious disease operative in the example of CWD are: increased trade in animals, advances in agricultural technology, intensification of the livestock industry, increased economic development and land use, and disease agent adaptation and change. Because of the Canadian system of individual animal identification, the CFIA were able to trace the movement of infected animals, and leave no doubt that commercial trade and translocation of farmed cervids was responsible for the geographic spread of CWD in

the western Canadian farmed cervid industry. Similar assumptions can be made about the spread of CWD in the United States cervid industry. What is less clear is the relationships between disease in farmed cervids and free ranging cervids. There is an assumption that CWD in the wild has resulted from spillover infection from escaped animals or interactions between farmed and wild cervids. As far as I know there is only circumstantial spatial or geographic evidence for this. In fact, very little is known about the ecology of this disease (on farm or in the wild), the livestock/wildlife interface, and the interactions between hosts, ecologic and climatic influences, and societal/transport/commercial factors. We do know that the most common factor driving the emergence of wildlife infectious disease is the anthropogenic movement of pathogens into new geographic locations, a phenomenon called pathogen pollution (Daszak et al., 2001). The translocation of infected hosts either through commercial trade or wildlife management activities constitutes pathogen pollution. In a broad sense, so does artificial increases in uninfected host populations through human activities such that emergence of disease in a new geographic location is supported (Daszak et al., 2001).

As with bovine tuberculosis in cervids, increased population density resulting from farming or artificial feeding of wildlife increases the likelihood of direct and indirect transmission between individuals. In a heavily infected Wyoming research facility, more than 90% of resident mule deer either died or were euthanatized due to clinical CWD over a 2year period (Kahn et al., 2004). In the US, CWD was shown to be the primary cause of adult mortality in at least 2 captive elk herds (71 and 23%) and prevalences of 59% have been detected at slaughter in elk from CWD affected farms (Williams et al., 2002).

There is a strong environmental component to CWD ecology in that environmental contamination is a factor in transmission. Miller et al. (2004) demonstrated that CWD can be transmitted to susceptible animals indirectly from environments contaminated by excreta or decomposed carcasses. Mule deer became infected when placed in paddocks where infected deer carcasses had decomposed in situ almost 2 years earlier and also in a paddock where infected deer had resided just over 2 years earlier (Miller et al., 2004). The role of scavengers in the spread of prions in the environment remains unknown and is an example of the complex possibilities for the role of other ecosystem factors in emerging diseases like CWD. Similarly, disposal of prion-infected carcasses resulting from disease eradication efforts on commercial cervid farms creates environmental concerns. The current Canadian practice has been pit incineration followed by deep burial but the long-term consequences of this are unknown.

Johne's disease

Johne's disease or paratuberculosis is a chronic intestinal tract disease of ruminants resulting from *Mycobacterium avium* subsp. *paratuberculosis* (MAP) infection. It has been reported in elk and red deer (*Cervus elaphus*) as well as white-tailed and mule deer (genus *Odocoileus*), axis deer (*Axis axis*), and fallow deer (*Dama dama*). Paratuberculosis organisms have been found in numerous other ungulates, rabbits (*Oryctolagus cuniculus*), foxes (*Vulpes vulpes*), stoats (*Mustela erminea*), and ravens (*Corvus corax*)(Manning et al., 2003). The organism persists in the environment and has been recovered from standing water and feces almost a year after contamination

by infected animals. Disease transmission is easily accomplished via fecal-oral or transplacental routes and through ingestion of milk or colostrum from infected females.

In the late 1980's, MAP organisms were isolated from 2 of 5 asymptomatic adult white-tailed deer killed on a Connecticut cattle farm that had a 6-year history of bovine paratuberculosis. The authors of the documenting report observed that wildlife populations had become infected and could therefore serve as continuous sources of infection to domestic livestock. Their concern was that infected deer migrating to paratuberculosis-free pastures might seed the soil with organisms that would then persist in the environment and subsequently infect cattle placed there (Chiodini et al., 1983).

In 1978, 14 tule elk (*Cervus elaphus nannodes*) were released at the Point Reyes National Seashore, California into a fenced area that had been livestock range for more than a century. In 1979, fecal testing of local dairy herds and previously introduced axis and fallow deer in the park found that 50% of the dairy herds, as well as 9.6 % of axis deer and 5.4 % of fallow deer killed in a depopulation effort were infected with MAP organisms (Riemann et al., 1979). Predictably, 3 tule elk born in the fenced translocation area showed clinical signs of Johne's disease in 1981 and after culling were diagnosed on post mortem with paratuberculosis infection (Jessup et al., 1981). Since the initial release, the Point Reyes tule elk population has grown to more than 400 animals and is in excess of environmental carrying capacity. A more recent report of infection rates in elk from the Park found that MAP organisms were cultured from 10 of 45 (22%) elk intended for translocation from the infected area to unfenced areas of the park (Manning et al., 2003). Twenty-two of the 45 elk tested positive by ELISA or fecal test and were killed leading to isolation of the organism in 10 animals. Eventually, 18 animals were translocated in spite of the fact that serology testing for Johne's is known to be relatively insensitive.

Interestingly, the author cited above reported that the elk tested were all asymptomatic. Despite the presence of paratuberculosis, the elk population grew rapidly initially and stabilized over 2 decades with apparently low morbidity and the infection appears to have had minimal impact on the population. This is confusing since it is understood that Johne's disease often profoundly affects captive cervid herds of many species, often with a much shorter clinical course and in age groups not usually affected with cattle or sheep herds (Manning et al., 1998).

Clearly, the ecology of Johne's disease in tule elk at Point Reyes National Seashore differs from that in other wild populations and commercial cervid farms. However, we know nothing about the interactions between the high environmental bacterial burden, a stable host population, possible spillover hosts, and the many other determinants of Johne's disease in this ecosystem. It is entirely possible that equilibrium between Johne's disease and the tule elk population has been achieved in this ecosystem such that the host and its immune system have adapted to the presence of *M. paratuberculosis*. If a stable Johne's disease ecology exists it is possibly because we have allowed it to occur through not interfering. At Point Reyes there is no threat to the agricultural economy or humans. To date, a causal association between paratuberculosis and human disease has not been demonstrated. This cannot be said for tuberculosis caused by *M. bovis*, and CWD will be always be viewed as a zoonotic threat because of the association between variant Creutzsfeldt Jakob disease of

humans and another prion disease of ruminants, bovine spongiform encephalopathy or mad cow disease.

Another, more enigmatic occurrence of Johne's disease in Key deer, an endangered subspecies of white-tailed deer (*Odocoileus virginianus clavium*) found only on several islands known as "keys" off the southern tip of Florida. Hunting pressure in the early 1900's reduced the herd to less than 100 deer before legal protection of the species and the establishment of the National Key Deer Refuge in the Florida keys increased their numbers to approximately 400 animals by the 1970's (Quist et al., 2002). However, a 1986 population study suggested that the Key deer numbers were declining (Humphrey et al., 1986). In 1996 and 1998 single cases of clinical Johne's disease were found in deer observed and captured in a residential area on Big Pine key. A subsequent fecal culture survey for MAP of 96 live-captured deer yielded one positive deer which was not showing clinical signs at the time of sampling (Quist et al., 2002). The most intensive culture sampling was done on the small herd associated with the 2 clinical cases with no positive results. Elsewhere on the key, only one positive sample was obtained and two subsequent samples from this animal that remained apparently healthy were negative. These data suggest that large-scale environmental contamination with MAP is not occurring in the keys. However, a more or less simultaneous serologic survey of Key deer showed approximately 7% of tested deer to be possibly infected with MAP, lending support to the hypothesis that MAP is established, and is perhaps endemic, in Florida Key deer and the ecosystem where they live.

The origin of the infection in Key deer is unknown. There have been no commercial livestock operations in the islands since the mid 1900's, but in 1950 a goat herd existed about 5 km from the location of the index case and local horse owners sometimes maintain goats as stable companions (Quist et al., 2002). Quist (2002) suggests that high deer population density, low nutritional quality of native habitat, and high concentrations of deer at artificial feeding sites might have been contributing factors to the establishment of MAP infection in this population. What has influenced the determinants of R_0 such that R_0 1 in this instance is unknown and remains unstudied using modern epidemiological tools, as does the examination of the role of anthropogenic change to the ecosystem in the Keys.

Summary

There is little doubt that diseases will continue to emerge in animal populations including both farmed and wild cervids. In many cases, these emerging diseases are not necessarily caused by genuinely new pathogens. From the examples described in this paper, it would seem that many of the emerging diseases in cervid populations are a direct result of changes in human activities associated with these species. The intensification of farming of these species, the translocation of species and or their products resulting in pathogen pollution and human activities which change the contact rate between both farmed, wild cervids, and other animal populations can create changes in the ecology of these systems that allow diseases to emerge and proliferate. Understanding and responding to disease emergence in cervid species requires a more detailed understanding of the interrelationships between wild and farmed cervids and other species. There is remarkably little research that helps to define the contact rates between cervids and farmed animals of a variety of species.

The study of how cervid species are utilized by humans and their movements of both animals and products is an important part of understanding this new disease ecology. Tools such as network analysis and geographical information systems may be important in examining the role of these factors in disease emergence.

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(Plenary lecture)

4

Seasonal versus non-seasonal reproduction in deer: From the arctic to the tropics.

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Deer are found in all geographical zones, from the tropic climate to the high arctic. The richest variety of cervid species are found in Southeast Asia and South America. The most adaptable deer are white-tailed deer, which are distributed from Northern Canada to Southern Peru. Smaller species with shorter gestation periods, inhabit mostly tropical and subtropical regions. Bigger cervids, exhibiting longer gestation periods, generally live in the temperate and boreal regions. Deer ancestors, which developed in the relatively warm Miocene period in both Europe and Asia, were most probably aseasonal breeders. The changing climate in the Pliocene and Pleistocene and the migration of cervids to temperate and boreal regions forced them to become a short-day seasonal breeders. However some relics of that ancestral reproductive pattern still persist. Whereas most tropical and subtropical species exhibit asynchronous reproductive cycles independent of the photoperiod, most temperate and boreal cervids exhibit annual rutting season, synchronized by light. Most temperate species exhibit seasonal breeding characterized by a concise rut and parturition periods. The activation of seasonal reproduction begins as a response to changes of environmental photoperiod and continues as a cascade of hormones which include melatonin, prolactin, luteinizing hormone (LH), follicle stimulating hormone (FSH) and testosterone. Cervids are capable to respond to photoperiodic clues if the difference between summer and winter solstice is at least one to one and half hours. That global transition zone (separating tropical from temperate cervids) corresponds to latitudes of 14-18^{o}N or S. A substantial evidence indicates that ancestors of temperate cervids might have had two rutting periods per year. Two peaks of testosterone in blood (smaller in the spring, larger in the fall) were found in plasma of several boreal cervids species. In addition Southern pudu (*Pudu puda),* living in central Chile, exhibits only one rut but two equally high peaks of testosterone and LH, whereas his Northern cousin (*Pudu mephistophiles),* living in the tropical regions of Peru, have two rutting seasons per year. Similarly, two peaks of reproductive hormones (one corresponding to antler mineralization, the other to the rut) are present in the male European roe deer. Many deer males (irregardless of their geographical distribution) are fertile for a better part of the year and are capable of mating, if the females are in the heat. Some tropical and subtropical cervids are year round breeders, others are seasonal but non-photoperiod breeders. Their rutting and parturition periods are determined by environmental factors other than light, such as the onset of the rainy season. Temperate deer species, translocated to the Southern hemisphere, synchronize quickly with the local photoperiod. However, in some translocated tropical and subtropical species their reproductive and antler cycles became either asynchronous

(exhibiting year round breeding) or they maintain their original seasonal pattern which is unsuitable for the survival of their offspring.
(Plenary lecture)

5
Fallow deer, lekking and alternative mating strategies in San Rossore, Italy: insights from a long term study.

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Throughout the analysis of long-time series census data (1984-2003) and by means of radiotelemetry (1997-2001; 23 females and 25 bucks), we assessed fallow deer spatial and habitat sexual segregation on different spatial and temporal scales in the San Rossore Estate (Italy). The combination of different studies performed in the same area allows us to show that a detailed analysis can outline a situation in which more than one theory is valid for explaining sexual segregation in the same species, as probably several factors act on different temporal and spatial scales. From 1984 to 2003 females gradually abandoned the eastern disturbed sector of the Estate, the only area affected by human presence (increased year by year from 1984), to the detriment of the western undisturbed sector. Males remained in the eastern sector, in spite of the increasing disturbance, supporting the predation risk hypothesis (large spatial and large temporal scale). From 1989, males gradually increased their presence in the disturbed sector, as they benefited from lower female density, avoiding areas with higher female density, supporting therefore the indirect competition hypothesis (large spatial and large temporal scale). Intersexual competition was pronounced in a small area inside the undisturbed sector affected by habitat modification during the 1980s, when a scrub area was converted to an open pasture, and this phenomenon further incited males to leave this area and reach the disturbed sector, supporting again the indirect competition hypothesis (small spatial and large temporal scale). As a final result of this long term process, during the last five years we showed that males used consistently disturbed areas, both during the day and the night; instead, females frequented eastern disturbed areas only during the night, when human presence was absent. Therefore, large scale segregation recorded during the day disappeared during the night, when females usually reached the eastern sector, supporting again the predation risk hypothesis (large spatial and small temporal scale). Nevertheless, sexes segregated on a small scale inside this area, as they showed different habitat choices, supporting the forage selection hypothesis (small spatial and small temporal scale).
(Plenary lecture)

6
Recent progress in antler regeneration and stem cell research.

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Epimorphic regeneration is the "Holy Grail" of regenerative medicine. Research which aims to investigate different models of epimorphic regeneration is essential if a fundamental understanding of the factors underpinning this process are to be established. Deer antlers are the only mammalian appendages that are subject to annual epimorphic regeneration. Therefore, antlers offer a unique opportunity to explore how nature has solved the problem of mammalian organ regeneration. However, establishment of an antler model for epimorphic regeneration study in the past has been painfully slow. With the advancement of the modern technologies, antler biologists in recent years have made significant progress in this field. Through detailed morphological and histological examinations, we advanced a hypothesis that antler regeneration may not be a blastema-based process as previously thought, but rather a stem-cell based process. Subsequently, we set up experiments to test this hypothesis. Using IHC and in situ hybridisation techniques, we provided evidence that the mode of antler regeneration is not compatible with blastema-based epimorphic regeneration. Through tissue deletion and membrane insertion, we precisely located the tissue type from which antler regeneration takes place, i.e. pedicle periosteum. Pedicle periosteal cells express crucial embryonic stem cell markers, for example CD9, Nanog, telomerase and a low level of Oct4. In addition they have the potential to differentiate into multiple cell types, such as chondrocytes, adipocytes and possible neural cells, convincingly demonstrated that they meet the criteria for adult stem cells. Therefore, we conclude that antler regeneration is not a blastema-based, but rather a stem cell-based epimorphic process. Antler stem cells exclusively reside in pedicle periosteum. In order to study the regulation of antler regeneration, we constructed a subtracted cDNA library using tissues from the antler growth centre. From this library, we identified 331 ESTs similar to those with no known function and 17 novel genes. Whether antler regeneration is realised through recapitulation of developmental processes, unique antler-specific factors or novel regulation system remain to be determined in the future research.

(Plenary lecture)

7
Conservation of tropical deer: what does the future hold?

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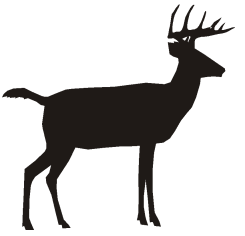
There are 4 stages of conservation: exploration, science, policy/education, and management. Whereas, temperate deer populations are often in a management mode, we still lack basic scientific information for most tropical deer species. A recent volume of deer biology contained 487 references for temperate species and 69 references for tropical species, 36 of which concerned captive populations. Whereas, deer management in developed countries has generated significant funds to maintain and enhance most deer populations, the stark needs for tropical species are unmet by international organizations. To be sustainable, deer conservation in the tropics must move to the management level, yet we still lack basic knowledge to make the transition. Tropical deer conservation currently focuses on 2 factors; suitable habitat and adequate protection. Suitable habitat is assumed for most deer species, as they are generalist browsers or grazers. Within Southeast Asia, however, increased pressure for agricultural production (i.e. rice, sugar cane, and palm oil) has removed significant amounts of lowland forests. Habitat is not the sole limiting factor, as a recent analysis for Cervus eldi reveals most suitable habitat is unoccupied. Few governments provide sufficient protection of low density deer populations. At this time, international aid would best be focused on supplementing patrolling staff salaries. Training of reserve staff should emphasize that effective conservation is proactive management of all resources available. Use of fire and water as habitat management tools should follow the successful models for bovid management in Southern Africa. Scientists and managers must be willing to engage in the third stage of conservation (i.e. policy and education) or there is little hope for moving to a sustainable, management stage for tropical deer species.

(Plenary lecture)

Deer management



8

Three years of roe deer (*Capreolus capreolus*) radio-tracking in a Mediterranean environment.

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During three years, several roe deer were equipped with radio collars and followed in summer and winter periods. On those tracking periods several fixes were obtained (about 30 fixes/animal/season) and the home ranges calculated using MCP and Kernel models. This study was made in a mountain area (Serra da Gardunha), localized in the centre of Portugal, in a Mediterranean environment with hot and dry summers and mild winters. Annual. seasonal home-ranges and it evolution were compared with results obtained in other populations in different habitats condition. When consider the distribution of the resources in the study area we can demonstrate that the roe deer present a spatial behaviour, different from the central and north populations and adapted to the Mediterranean climate constrains.
(Oral presentation.)

9

Seasonal home range shift of red deer in a forest-agriculture area, Hungary.

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A long-term radiotelemetry study on red deer (*Cervus elaphus* Linné, 1758) has been carried out in a lowland forest-agriculture area in Hungary between 1993-2006. Previous observations suggested seasonal changes in population distribution between forested and agricultural habitat. Red deer concentrated in the forest during winter, but they appeared in the agricultural field during the vegetational period. We investigated the ranging behaviour behind this phenomenon. To do so two alternative hypotheses were made: home range expansion and home range shift. Weekly radiotelemetry localisations revealed that nine of 28 hinds showed a clear home range shift from the forest to the agricultural area for a prolonged time during the vegetational period. The remaining portion of the animals used a home range within the forest throughout the entire year. Diet composition analysis using indicator plant species showed that neither daily passages between habitats, nor home range expansion exists. These

ranging behaviours were stable year on end, hence, if an animal shifted one year it shifted again in consecutive years and vice versa. We suggest, that there is no feeding reason for seasonal home range shift. In another study area, where radiotelemetry study on red deer was carried out between 2000 and 2006, we revealed daily passages between forested and neighbouring agricultural areas. Use of agricultural fields by red deer is influenced by the scale of the patchiness of landscape including forested and agricultural areas. Our results could be useful for the successful management of red deer populations in such complex habitats and to decrease agricultural damage.
(Oral presentation.)

10
Space use patterns of Persian fallow deer following reintroduction.

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The ability to disperse and populate new areas is an essential condition for long-term survival of reintroduced populations. Consequently, understanding the spatial dynamics of reintroduced populations is crucial. We studied the movement patterns of 70 radio-collared Persian fallow deer (*Dama mesopotamica*) (53 f, 17 m), of 120 deer reintroduced to Israel. Deer were released from the same habituation enclosure, in bi-annual releases, on 10 occasions, starting 1996. We obtained 2-3 radio locations/ /individual/week for up to five years and characterized annual home ranges using GIS. The spatial dynamics were characterized by: (1) Short distance movements (up to 1.5 km from the release site) until home range establishment, mainly of deer from early releases; (2) long distance movements, up to 15 km until home range establishment, mainly of deer from latter releases; and (3) spatial shifts in annual home ranges away from the release site, which occurred usually within the first three years post release. The radial expansion of the population during the first 5 years of the project was 0.5-1.5 km/year, slower than that of other deer species. While population growth over time was linear (mostly due to repeated releases), the area occupied by deer increased exponentially, from 6 km during the first year to 47 km during the fifth. This spatial expansion was largely due to long distance movements from the release site to new unpopulated areas, which were frequent during the last years. Radiation of reintroduced Persian fallow deer is driven mostly by animals from later releases. One possible benefit of multiple releases is increased rates of population expansion.
(Oral presentation.)

11

Population size and demographic variables of red deer in Bydgoszcz National Forest, central Poland.

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During February 2006, population size of red deer (*Cervus elaphus* L.) inhabiting Bydgoszcz National Forest (76.8 thousand ha) was estimated. In 5 Forest Districts (Bydgoszcz, Cierpiszewo, Gniewkowo, Solec Kujawski and Szubin) including 25 hunting districts, 120 line transects (420 km total length) were established. During 5 consecutive days, the number of daily snow tracks were recorded. Using relationship between daily snow track density index (T/km) and absolute population density (N/1000 ha), population density and numbers for every hunting district were calculated. The everage number of red deer estimated from the 5 days tracking period was equal to 3850 animals i.e., 50.1 individuals/1000 ha of forest. In September 2005, data on population sex ratio and the autumn recruitment rate were collected by direct observation of 959 animals. Sex ratio i.e. females per one male was equal 1: 1.50. The autumn recruitment rate amounted to 48.2 calves per 100 females. It was concluded that the official hunting statistic data based upon so called round year observation, underestimated 3 times number of red deer calculated in presented work.
(Oral presentation.)

12

Management of red deer in Poland: field data versus official hunting statistic.

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Management of red deer in Poland is based upon population census including estimating number of the animals in hunting districts, sex ratio of adults, age structure of stags and annual recruitment rate. We have compared population numbers and

structure based upon official hunting statistic data with data collected during 1998-2006 by line/strip transect technique and by standard observations. Analysis of 155 Forest Districts (FD) of the total area of 2.48 mln ha, showed that only in 14 FD hunters data were ±15% different than data collected by line/strip transect method. In 98 FD number of red deer was higher than official hunting statistic data and this error ranged between 15-50%. Much higher errors i.e., 50-100% and over 100% were found in 31 FD and in 12 FD respectively. Data from direct observation cards showed that sex ratio of adults (females/males) was calculated as 1:1.68, while according to hunters this parameter was equal to 1:1.33. Hunters report there are 9.7% stags over 10 years old, but field data indicated only 4.6% such age class in the population of males. The described situation is result of the present Hunting Low that allows hunters to use quess-estimate data for red deer management in Poland. Such non-professional management resulted in overabundance of deer in many regions of the country and drastic decline of high trophy stags in the population of red deer. The management of red deer has to be based upon data collected by hunters in field using objective and reliable methods. This basic data should be processing in Forest Districts by professional service and the hunting clubs would obtain back population census and harvest plan. However the presented here feed-back mechanisms of data flow can be introduced if the present Polish Hunting Low will be changed.
(Oral presentation.)

13
Over-abundance of deer: Is shooting the answer?

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Shooting is an important population control measure. However, in many regions demand for hunting is declining and it is not clear if shooting can control expanding deer populations. The issue is particularly acute in the Highlands of Scotland, where over 2 million hectares of land are owned as sporting estates for shooting deer but where the population of red deer has more than doubled over the last 30 years, threatening native woodlands and other protected nature conservation sites. The Deer Commission for Scotland has identified voluntary shooting effort as the preferred approach to the problem but in 2003-2004 less than one-third of all local cull targets were met and culling effort on private land has declined. The aim of this paper are to: i) investigate the constraints on deer shooting from a landowners perspective and ii) suggest future strategies for encouraging landowners to shoot more deer. A statistical analysis of data derived from interviews and a mail survey of landowners is used to understand the role of motivation and objectives, attitudes to nature conservation and the regulatory system, as well as resource constraints such as labour on culling activities. Key findings are: 1) traditional deer management objectives seek to satisfy demand for trophy stags by maintaining high population densities and this over-rides

other objectives; 2) financial rewards from increasing culling rates are meagre; 3) shooting efficiency of some estate employees is low and may reflect poor motivation and 4) there is no direct public funding to assist private estates with culling or with the costs associated with developing markets for venison or commercial shooting. It is suggested that a possible future strategy based upon better support for marketing of venison and shooting opportunities, together with better incentives and training for estate employees might be partially effective. However. resistance to greater culling is likely to among estates where traditional values persist and where employees lack incentives to intensify culling operations.
(Oral presentation.)

14

Slaughter records as a body condition indicator or reindeer - How can records be improved?

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Reindeer and caribou (*Rangifer tarandus ssp*) population densities are known to fluctuate in cyclic patterns. Pasture quality is one important factor that determines these fluctuations (Klein, 1968, Reimers, 1997). In semi-domesticated reindeer herds, the fluctuations are usually not as dramatic as in many wild populations, but they still are large enough and cause problems and an unstable economic situation for the reindeer herder. Knowledge of changes in pasture quality is essential in order to not, because of management inabilities, make management decisions that drive large fluctuations. Indicators of pasture quality that can be monitored continuously are therefore important.

During the snow-free season reindeer herding is usually extensive, using wide ranges. Direct monitoring of pasture quality on these ranges would be expensive and time consuming, if possible at all. Since the body condition of reindeer in early winter is affected mainly by pasture quality during the preceding summer (Adamczewski et al., 1987, Skjennerberg and Slagsvold, 1968), long-term changes of the general body condition in the herd should reflect the long-term changes of the pasture. The condition of the reindeer in the early winter could therefore be a good indirect indicator of the condition of the ranges used during the snow-free season. The main slaughter period for reindeer is usually in the early and midwinter (November to January) and information on carcass size and quality might thus be used to assess the condition of the reindeer at this time.

The objective of this study was to investigate the possibilities to of using and improve information from carcass records as an indicator of animal condition.

Records from 696 reindeer slaughtered in the winter 2002/2003 were included in the study. The records received from the slaughterhouses included herding district,

carcass weight, fatness and conformation (classified according to the EUROP system) and animal category (calf, female and male adult). In addition three body size measurements (back-, radius- and jaw length), sex of calves and age class of adults (yearlings or older adults) were recorded.

The fatness and conformation classification was transformed into normal distribution using normal score transformation. Principal component analyses (PCA) where used for assessing the relationships among weight, the body size measurements, fatness score and conformation score without needing to define dependent and independent variables. General linear models (GLM) were used to investigate the possibilities to use improve precision of body weight, by adjusting for body size, as a body condition indicator and to investigate the gain in precision of differing between sex and age categories.

The PCA showed that the relationships among the variables differed between age and sex categories. The linear models showed similar results since the size and significance of the fixed effects on weight differed between categories. Male and female calves were most alike and differed from the older animals. There was a clear difference between male and female yearlings, where male yearlings showed more similarities to calves than female yearlings, which more resembled female adults. Yet, discriminating between female yearlings and older females improved precision of adult carcass weight records by reducing standard deviation (SD) with 15,5 %. The results also showed that discriminating between sexes for calves reduced SD of calf carcass weight records with 36,2 %. It is hence essential to differ between females and males when calf records are used as body condition indicators, since varying proportions of the sexes will easily cause a bias.

All body size measurements were strongly correlated within animal age and sex category ($r = 0.78 – 0.88$) and all measurements gave almost similar results when adjusting weight for body size. Adjusting weight for the different body size measurements reduced SD of weight records with 8 – 30 % (exemplified with adjustment for back length in Tab. 1).

Table 1. Reduction of standard deviation for weight by adjustment for back length

	N	Mean carcass weight (kg)	SD before adjustment (kg)	Remaining proportion of SD after adjustment
Female Calf	103	20,5	2,7	72 %
Male Calf	312	22,7	2,8	71 %
Female Yearling	44	28,1	3,5	91 %
Male Yearling	77	30,7	3,0	79 %

	N	Mean carcass weight (kg)	SD before adjustment (kg)	Remaining proportion of SD after adjustment
Female Adult	159	33,6	3,7	89 %

High correlations between the body size measurements and weights of calves suggest that weight gain and skeleton development could be considered as parallel indicators of animal body condition affected by range conditions during the last season. Therefore, adjusting calf carcass weight for body size would likely diminish its power as indicator of range conditions. Adult body size, in contrast, is affected by growth conditions during several previous seasons. Hence adjusting carcass weight of adults for body size can prevent confusion of range conditions during several seasons. Instead skeleton size per se may reflect range conditions over a longer time period.

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(Oral presentation.)

15
The management of reindeer in the Mongolian Tsaatan culture.

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The Tsaatan (or Dukha) peoples of north-western Mongolia are one of the few remaining reindeer herding cultural groups in the world. They are a migratory people who live and move with their reindeer in the Eastern Sayan mountains that span the Siberian and Mongolian border. The use of reindeer as transport animals is a dominating feature of the Tsaatan's tradition of reindeer husbandry, as is milking deer for the purpose of making various dairy products consumed by Tsaatan individuals. The spiritual significance of reindeer in the Tsaatan's shamanistic traditions plays an important role in pastoral activities and trends. The close association between the people and their stock has led to a marked degree of domestication, and the animals seldom stray far from camp. It is common for animals to be released from their tethers at dawn, move off to feed for a few hours, and then return to camp without coercion by about mid-day. Others are herded back in late afternoon in the company of community members who ride out on saddled reindeer to round them up. During field trips throughout three years (2002, 2004, 2005), we conducted interviews with herders in the two distinct areas where families of this community reside. Like most of the traditional reindeer-herding peoples of the world, the Tsaatan face many challenges as they struggle to maintain their ancestral lifestyle. One example is the erosion of the hunting rights that the Tsaatan have enjoyed for centuries, possibly millennia. Traditionally the Tsaatan have not used reindeer as a primary source of meat, relying instead on several wild game species such as moose, red deer, wapiti, roe deer, bear, lynx, wild boar and others. But recent shifts in socio-economic systems stimulated by Mongolia's transition from socialism to democracy in 1991 has led to an increase in hunting pressure from non-subsistence hunters outside the community, contributing to the reduction of wildlife populations, and tightened government control over hunting. On top of this, wolf predation on the herds, especially of the young calves, has contributed to a decline in reindeer numbers.
(Oral presentation.)

16
Can supplementary feeding improve productivity in reindeer husbandry?

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Reindeer (*Rangifer tarandus tarandus*) in Sweden are semi-domesticated and managed by their owners. They normally graze on natural pastures in forest and mountain areas all year. Artificial or supplementary feeding is only used occasionally, mainly during gathering and migration or when hard snow or ice crust makes the ground vegetation unavailable. In some areas, feeding is used as a measure to reduce radioactivity prior to slaughter. Reindeer are only rarely fed with the main purpose to improve their body weights before slaughter.

Artificial feeds for reindeer are mainly grain-based pellets, hay or grass silage or a combination of these. Hay or silage has proven to be unsuitable as the only feed to reindeer for longer periods (Nilsson et al., 2000). The costs for feeding reindeer are high, and the weight gain of the animals is usually low. Reindeer calves fed pellets during winter will normally not gain more than 100-150 gram live weight (corresponding to 50-75 gram carcass weight) per day, if fed ad libitum, while eating about 1,5 kg dry feed (15 MJ) per day (Jacobsen et al., 1977; Åhman, 1996; Nilsson et al., 2000 and own recent results). The cost for feed to reindeer calves fed ad libitum will be about 0.3 euro per animal and day. With the current Swedish prices on reindeer meat (about 5 euro per kg carcass weight), the animals need to gain at least 120 g live weight per day, on average, to compensate for the costs for feed. Costs for labour, transport, equipment etc. will not compensated for if the weight gain (or the meat price) is not considerably higher.

During harsh conditions, feeding could be the only way to prevent reindeer from starving and eventually dying. Feeding during critical periods, when grazing conditions are unfavourable, may also improve the general condition of the reindeer herd. The benefit on production depend on the general condition of the herd as well as the severity of the grazing conditions, and is thus difficult to assess. However, if there is a risk of animals starving and dying the animal welfare aspect has also to be taken into consideration.

The average condition of adult females has proven to be fundamental for calf production and survival (Rönnegård et al., 2002). Finnish studies have shown that the conditions of lichen pastures in winter increases the number of calves per adult female the following winter (Kojola et al., 1995) and that supplementary feeding with hay improves the body weights of both calves and females the following autumn (Helle & Kojola, 1994). Supplementary feeding during winter has also been shown to improve milk production and calf body mass (Jacobsen et al., 1981). Improving the condition of females by feeding during winter may thus be an effective way to improve the production of the herd.

We have simulated the effect of feeding on reindeer body weight during varying

grazing conditions and at different times of the year to assess the possible long-term effect on production. In herds with initially low production, the productivity could be significantly improved by feeding females during late winter and spring. There is little economic reason to feed reindeer prior to slaughter in order to improve their body weight and carcass quality. In addition, it has been shown that feeding changes the chemical composition (Wiklund et al., 2001) and taste (Wiklund et al., 2003) of reindeer meat, which could be negative. There is also a risk that extensive use of feeding in reindeer management will change the image of reindeer meat as natural product and thus be negative for marketing. We therefore believe that artificial feeding of reindeer should be made only in special situations where it has a proven positive effect for the production.

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(Oral presentation.)

17
Twenty years of impact of the Chernobyl accident on reindeer management and meat production in Sweden and Norway.

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The accident in 1986 at the Chernobyl nuclear power plant caused serious impact not only locally but also far away from the reactor. Large parts of the reindeer herding area in Sweden and Norway were severely affected by radioactive fallout. Radioactive caesium (^{134}Cs and ^{137}Cs) proved to cause a main problem. As an effect of the reindeer diet, normally containing a large proportion of ground lichen during wintertime, levels of radiocaesium in reindeer meat from many areas raised to far above what was accepted for human consumption. This initiated extensive monitoring and control, as well as a number of different measures to reduce the radiocaesium levels in reindeer before slaughter.

The levels of radiocaesium in reindeer vary typically with season as an effect of the seasonal changes in the reindeer diet (Fig. 1). Lichens absorb radionuclides directly from air and precipitation and get more contaminated than e.g. grass, which absorbs radiocaesium from the ground. Lichens are eaten predominantly in winter, whilst the summer diet of reindeer consists mainly of grass, leaves and annual herbs.

The first year after the Chernobyl accident, 78 per cent of the reindeer meat produced in Sweden was destroyed because of too high levels of radiocaesium. The highest allowed activity concentration of ^{137}Cs in most food products at that time was 300 Bq per kg fresh weight. This was later changed to 1500 Bq per kg for reindeer, game and some other "wild" products. Consequently, considerably less reindeer meat (29 per cent) had to be destroyed the following year. In Norway, the intervention level was first set to 600 Bq per kg (the combined activity of ^{134}Cs and ^{137}Cs), but in late November 1986, this was changed for reindeer meat and game to 6000 Bq per kg. If the lower level had been kept, 85 per cent of the reindeer meat in Norway would have been destroyed, while increasing the level reduced condemnation to 27 per cent of the total production. Since 1994, the intervention level in Norway has been 3000 Bq per kg.

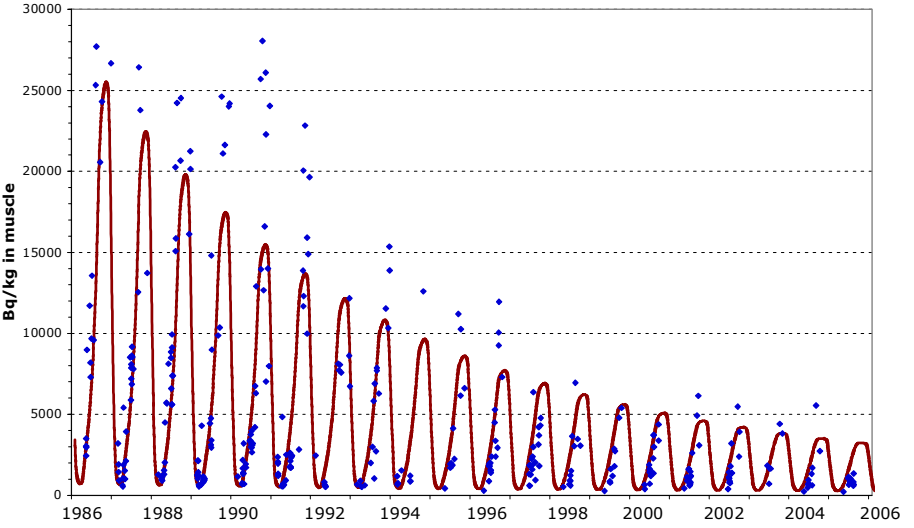

Figure 1. ^{137}Cs in freely grazing reindeer from one herding district, Vilhelmina norra, in northern Sweden. Each point is the average of data from at least 10 reindeer measured at the same sampling occasion (meat sampling at slaughter, or live reindeer monitoring). The reindeer received no feed or caesium binder.

The need for counter measures was obvious in both Norway and Sweden at an early stage. Already during the first winter after the accident, some reindeer herders fed their animals uncontaminated feed prior to slaughter. Caesium is relatively mobile in the body of animals and it is excreted via urine and faeces. If the reindeer has no intake of radiocaesium, the levels in their bodies is reduced to half the original level in about two to three weeks (Åhman, 1996; Skuterud et al., 2004). Feeding has been a common counter measure to reduce radiocaesium in reindeer before slaughter in many areas. Compounds that bind caesium in the gut and prevent its absorption into the body were commonly used during the first years, to enhance the effect of feeding or to reduce the contamination of freely grazing animals (e.g. Hove & Hansen, 1993; Åhman, 1996), and salt licks containing ammonium-iron-hexacyanoferrate (AFCF) are still used in some reindeer grazing areas in Norway.

Another common counter measure has been the adaptation of slaughter time to the seasonal variation of radiocaesium. The large part of the reindeer slaughter usually takes place from November until January, with some additional slaughter later in winter. By slaughtering earlier in the autumn, contamination of reindeer from the lichen pasture can be avoided. It was not possible to use this measure in areas with the highest ground depositions, where reindeer were too contaminated already in early autumn. As the levels in reindeer declined, early slaughter however gradually replaced feeding as the most effective and convenient counter measure. However, during the last years, seasonal variation in radiocaesium in reindeer have been less significant, and in a number of Norwegian reindeer herding districts there is no difference in

contamination levels in early autumn compared to winter (Skuterud et al., 2005). Furthermore, in years when fungal fruit bodies are abundant, radiocaesium levels in reindeer may be higher in autumn than winter.

There was a clear decline the levels of radiocaesium in reindeer from year to year, independently of counter measures, shown already a few years after the accident (Hove et al., 1992; Åhman & Åhman, 1994). In Sweden, the rate of decline from 1986 until 2006 corresponds to an effective half-life of 6.2 years at average (recent estimations using data from 20 out of 52 Swedish reindeer herding districts). The decline was considerably faster during the first years after the accident than during later years (corresponding to and effective half-life of 3.6 years for the first ten years, and 9.6 years for the following ten-year period). In some reindeer herding districts in Norway (Skuterud et al. 2005), as well as in some of the Swedish herding districts, no observable decline can be observed during the later ten years.

When the Chernobyl accident happened, there was some radiocaesium contamination left originating from nuclear bomb tests 20-40 years earlier. It seems that this "old" radiocaesium decline at a considerably slower rate in reindeer than does caesium originating from the Chernobyl accident (Åhman et al. 2001). An explanation to a slower decline with time could be that radiocaesium is gradually removed from the lichen carpet, but that it still remains in the ecosystem and is available for root uptake by other parts of the vegetation.

In 2006, 20 years after the accident, the activity concentrations of ^{137}Cs in reindeer are below 10 per cent of the initial values. Nevertheless in some regions they are still above the national intervention levels. Very little reindeer meat is however destroyed because of too much radiocaesium (less than one per cent during the last ten-year period). Instead, counter measures like altering the time of slaughter and clean feeding are used. In Sweden 10–15 per cent of all slaughtered reindeer are fed to reduce the contamination. Due to the higher national intervention limit, early slaughter is now the most common counter measure in Norwegian reindeer herding, affecting about 3–8 per cent of the reindeer that are slaughtered. Herders are compensated for costs related to counter measures aimed at reducing radiocaesium levels of reindeer. Presently, the yearly cost for control and counter measures reaches about one million euro in Sweden and 300,000 to 400,000 euro in Norway. Although the reindeer herders are economically compensated, management practises have had to be changed, which affects reindeer management and the traditional life of the Saami reindeer herders at large. With the current national intervention levels, we predict that it will take at least another 10 o 20 years before the impact of the Chernobyl accident on reindeer husbandry is no longer a problem.

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(Oral presentation.)

18
Economic sustainability of farmed venison production in the UK.

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Deer farming in the UK has maintained a steady state during the last five years. Recent changes in agricultural support following the Mid-Term Review (MTR) could have significant implications for deer farming. A desk study was undertaken in 2005 to better understand the economics of farmed venison production compared with other red meats. Three systems of production were considered; (i) lowland deer units producing finished animals; (ii) upland deer units producing weaned progeny for others to finish, and (iii) specialist deer finishing units.
Gross margins achievable from lowland deer farming (£368 per hectare) now look more attractive, particularly compared to suckler beef enterprises where subsidy has historically made up 70-75% of gross margins. However sheep farming, which has received only 30% of its gross margins from subsidies, still fares better. Gross margins from upland deer farming are unattractive because of the weak market demand for this class of stock. In comparison, upland suckler beef systems are facing a difficult future, but sheep still remain the most attractive option for the uplands. Returns from

finishing deer units look particularly attractive at £740 per hectare.
Farmed deer, show a slight negative net margin (after deducting fixed costs) of £6 per hind on lowland units, similar to average sheep flocks, but significantly better than suckler beef. By boosting output through more efficient feeding and pasture management, net margins approaching those being achieved by the top sheep flocks should be achievable. However, upland deer units with net margins of-£42 per hind are clearly unsustainable. For finishing deer calf enterprises, a positive net margin of £30 per stag is achievable and presents a potential opportunity for those lowland livestock producers considering diversification.
Net margin per kilogram of product is the most important measure of economic sustainability. Receipts per kg of live weight sold from the three livestock enterprises show contrasting figures, with finished deer at £1.75 per kg about 50% higher than beef at £1.00-1.15 per kg and lamb at £1.15 per kg. The high variable costs incurred in deer farming, together with the very high fixed costs per kg of live weight, lead to negative margins in both lowland and upland herds (-8p and -113p per kg live weight respectively). Upland deer production seems completely unsustainable unless calf selling prices rise substantially, but the significantly higher net margins being achieved by specialist deer finishing units (30p per kg live weight) are attractive.
(Oral presentation.)

19
Public perception of deer management and control strategies.

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Countryside management policy in the UK now favours wider public access to the countryside, supported by forestry policy, woodland grant schemes and legislation promoting access to open country which may bring about potential conflicts with deer management practice.

UK silvicultural policy has successfully brought about an expansion of forest and woodland cover, rising from 5.8 % in 1947 to 11.6 % in 2005. This land use change has favoured the expansion of the wild deer population (Fuller & Gill, 2001) with apparent impacts on farm crops and trees (Mayle, 1999) wildlife habitats (Cooke, 1995) and disruption to food webs (Kirby, 2001).

In addition to environmental impacts of deer, there are additional public health concerns regarding bovine tuberculosis, the spread of Lyme disease and an increase in deer-related road traffic accidents; which has prompted the calls for increased culling of deer, including the wider use of amateur hunters.

A view of the public perception of deer management was obtained through a UK wide survey undertaken in 2004/5 targeted at recreational users of the countryside. Responses were received from a cross-section of socio-economic groups who provided information on the type, frequency and location of their activities undertaken

in the countryside.

Public agreement with the principle of deer management, preferred strategies for reducing road accidents; favoured deer control methods, the sale of venison and the role of state agencies are reported. Additional evaluation of the respondents' awareness of deer management, perceived compatibility of public access and shooting, risk reduction strategies and preference for UK or EU training standards are also provided.

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(Oral presentation.)

20

Preferences of red deer for subtropical pasture species.

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The subtropical Australian deer industry is pasture-based but there is very little information on the preferences of deer for the pasture species present in this region and which form the industrys main food resource. An investigation into the diet selected by red deer (*Cervus elaphus*) grazing tropical pastures was conducted at the University of Queenslands Gatton Deer Research Unit in the summer of 2003. Twenty mature hinds (5 and 6 years old, 102.9 ± 10.10 kg) were allocated to one of two paddocks containing 22 plant species. Predominant species were the forb *Cyperus rotundus*, the native grasses *Eleusine indica* and *Sporobolus elongatus*, and the naturalised grasses *Chloris guyana*, *Cynodon dactylon*, *Cynodon nlemfuensis* and *Pennisetum clandestinum*. Faecal alkanes were used to investigate the diet composition in five consecutive weeks. The main species in the selected diets were *C. dactylon* (overall mean ± se, 38.5 ± 9.22%), *C. nlemfuensis* (6.5 ± 0.81%) and *C. rotundus* (53.9 ± 1.15%). The other species were largely avoided. There were small differences in the diets selected by the deer in the two paddocks: for *C. nlemfuensis* those in Paddock 1 ate 5.3% v. 7.7% for Paddock 2 (P=0.0368), and for *C. rotundus* the Paddock 1 diet contained 57.4% v. 50.2% in Paddock 2 (P=0.0074). The

differences for *C. nlemfuensis* and *C. rotundus* reflected the abundances of those species in the paddocks. Diet preferences evolved throughout the experiment: selection for *C. dactylon* and *C. rotundus* increased after Week 1, while that of *C. nlemfuensis* was reduced. This behaviour suggests that the deer avoided *C. nlemfuensis* as it matured. *C. dactylon* may have been consumed because it was the predominant species in both paddocks. The results show that *C. dactylon*, which is a common component of southeast Queensland pastures, is a suitable species for deer farms, and that *C. rotundus*, which is often considered a weed, may be more valuable than generally thought.
(Oral presentation.)

21

Evaluation of forage herbs for farmed red deer: feeding value and trace elements.

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This paper summarises three studies aiming to: compare the copper, vitamin B12 and selenium status of young farmed red deer grazing perennial ryegrass-based pasture (*Lolium perenne*), chicory (*Cichorium intybus*) or plantain (*Plantago lanceolata*) in spring; contrast the feeding value of perennial ryegrass-based pasture with chicory and plantain in spring and plantain in autumn; and determine the effect of grazing perennial ryegrass-based pasture alone, or with intermittent grazing of plantain from one month pre-partum to one month post-partum on copper and vitamin B12 status of calves. Feeding value, determined by live weight gain, of deer grazing chicory was greater than for deer grazing plantain and pasture in spring and feeding value of plantain was greater than pasture in autumn. Grazing chicory significantly enhanced the copper status of weaner deer in spring compared with both pasture and plantain. Grazing plantain significantly enhanced the copper status of weaners in autumn but not weaners or younger calves in spring and early summer, enhanced the vitamin B12 status of weaners in autumn and spring and calves in early summer, and boosted the selenium status of weaners during both spring and autumn. This study has highlighted the complementary role of forage herbs in achieving higher growth rates and maintaining trace element status of young farmed deer.
(Oral presentation.)

22

Habitat Utilization by Himalayan Musk Deer (*Moschus chrysogaster*), Sambar (*Cervus unicolor*) and Barking Deer (*Munitacus muntjac*) at Kedarnath Wildlife Sanctuary, Western Himalaya.

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We investigated the habitat utilization by Himalayan Musk Deer (*Moschus chrysogaster*), Sambar (*Cervus unicolor*) and Barking Deer (*Munitacus muntjac*) from 1989 to 1991 in a 20 Km2 intensive study area that had 10 habitats and altitude ranging from 1700m to 3680m, with diverse aspect and slope categories at the Kedarnath Wildlife Sanctuary, Uttaranchal, India. For Musk deer and Sambar in the subalpine zone, we estimated density using the silent drive count method and collected habitat use data by systematic searches. We estimated encounter rates, density estimates and habitat use by Barking deer and Sambar in the Temperate zone using line transects (N=5; L=1 to 4.8 km). In the subalpine forests, Musk deer and Sambar density estimates were 3.7/km^2 and 0.9/km^2 respectively. The encounter rates and density estimates for Barking deer and Sambar in the temperate forests were 0.37 and 0.54/km walk; and 2.9 groups/km^2 (mgs=1.6) and 2.5 groups/km^2 (mgs = 1.9), respectively. Musk deer (n=52) mostly used the 3,000-3,300m altitude range, southern and south western aspects and 41o- 60o slope categories. It mostly occurred in sites that had 26-50% tree cover; 1-50% shrub cover, and 1-25% ground cover. Sambar (n=75) mostly used the 2,100-2,400m altitude range, north eastern aspect and 31o-40o slope categories. It mostly occurred in sites that had 1-50% tree, shrub, and ground cover categories. Barking deer (n=117) mostly used the 1,700-2,000m altitude range, north eastern aspect and 31o- 40o slope categories. It mostly occurred in sites that had 26-75% tree cover; 1-50% shrub cover, and 1-50% ground cover. Musk deer used the alpine scrub habitat more than its availability, Sambar used the Temperate oak-fir-maple habitat more than its availability, and Barking deer used the Temperate oak-alder habitat more than its availability and all other habitats were used by these three species in proportion to their availability. The differential use of altitude by these three species was the major reason for their ecological separation. Although the musk deer and barking deer are similar in body size and being small solitary forest ruminants, they are considered allopatric whereas Sambar with its large body size was more sympatric to barking deer.

(Oral presentation.)

23

Feeding habits of red deer in Hungarian forested and agricultural areas.

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The red deer (*Cervus elaphus* L. 1758) is a very important large herbivore in the Hungarian fauna. This species has high ecological and economical impact on its environment. Department of Wildlife Biology and Management of St. István University has carried out long-term studies on the diet composition and feeding characteristics of red deer in Hungary. The results, however, are often contradictory with earlier knowledge and beliefs about feeding ecology of red deer. Our investigations conducted in several forested and agricultural habitats of Hungary revealed the following important facts: 1.In forested habitats red deer dominantly consumed the different browse species of the understory vegetation.
2.In agricultural habitats red deer preferred available browse species (along canals, or in forested patches). Cultivated plant species (mainly maize) were not preferred, their proportion in the diet was very low. 3.The proportion of grasses in the forest diet was also very low, its consumption was much higher in agricultural areas, but red deer did not show preference to grasses. 4.Red deer diet was highly variable and well-adapted to the actual food supply of different habitats. Some species were highly preferred in all areas (*Robinia pseudoacacia, Rubus spp., Sambucus spp., Cornus sanguinea, Salix spp.*), but many other browse species also appeared in the diet. 5.Quality (crude protein/crude fiber ratio) of the preferred diet components was higher, than the other species. 6.Plant species available in hunting grounds or provided as winter supplemental food were found in very low proportion in the diet of red deer. One exception was *Medicago sativa* - with high protein content - , which was regularly consumed. Our results can be supported with ecophysiological constraints of red deer. The species is an intermediate feeder, which is able to consume a higher proportion of grasses, but it has to eat a high proportion of good quality food. Problems of game damages in forested and agricultural areas can be decreased by considering our results on the feeding biology and behaviour of red deer.
(Oral presentation.)

24

Detection of needles: tool for evaluation of diet quality in wild ruminants.

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Norway spruce needles are a wide-spread food resource and their utilisable biomass exceeds the needs of herbivores. Needles seem to be a generally ignored food source that is consumed at the last place especially during severe winters with deep snow cover. Aim of our study was to examine the possibility of evaluation of needles in the diet as an indicator of quality of diet of free living large herbivores. We verified low quality and dietary preference of spruce needles in comparison to other ungulate diet resources in winter. Consummation of spruce needles can be used as a good indicator of quality of the environment and suitability of herbivore density in most localities in the central Europe. We developed easy applied technique using near infrared spectrophotometer to determine the content of spruce needles in the faeces.
(Oral presentation.)

25

Environmental factors affecting Scots pine debarking by red deer in south-western Poland.

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Scots pine debarking by red deer was studied in sixth (1999) and seventh (2000) years after the large (10,000 ha) forest fire in south western Poland. The main aims of the study were to: i) compare debarking in artificially regenerated prethickets with that in stands regenerated naturally; ii) check if security cover conditions (dependent on the height of prethickets) influence debarking intensity and iii) check if debarking of the prethickets depends on the tree density.
There was no significant difference in the debarking intensity (% of debarked trees) between artificially and naturally regenerated stands neither in 1999 nor in 2000. When similar comparisons were made controlling the age (and at the same time the height) of artificially regenerated stands (majority of naturally regenerated thickets were of the same age), in 1999 naturally regenerated thickets were debarked with similar intensity as the plantations of the same age. However, younger pine plantations were debarked less and older plantations more than the stands coming from natural

regeneration. In 2000 (when all the thickets got high enough to provide deer with favorable cover) all the plantations were damaged with the same intensity as naturally regenerated stands. In general, debarking in pine plantations was positively correlated with their age but only up to eight years old and further increase in age did not influence debarking intensity. The relation between percent of debarked trees and the height of artificially regenerated pine stands depended on their age. In younger prethickets debarking intensity was correlated with their height, while in older ones the relation disappeared. It can be concluded that security cover is important determinant of debarking intensity of Scots pine prethickets. Tree density had no significant influence on debarking intensity in the plantations nor in the naturally regenerated stands.
(Oral presentation.)

26
New technique for estimation Cervidea hiding cover.

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Hiding cover is a key factor for habitat selection by Cervidae, and its knowledge is a matter of great concern to wildlife management. Usually evaluating of the animal hiding cover is performed by measure the vegetation horizontal capacity of cover one target. These techniques present some difficulties due to observation bias and field resources. A new horizontal cover measurement method was tested and compared to most commonly used techniques for cover valuation. It is based on digital analysis and edition of images of wide sampling areas. It proved to be an effective technique with no different results from other methods, as well as easier and faster to manage in the field, allowing higher number of samples with similar effort. Besides, it proved to be more sensitive to extreme cover situations, resulting into more real estimations. Keeping a digital record of the samples is another advantage of our method, because posterior analysis becomes independent of field sampling.
(Oral presentation.)

27
Calving sites fidelity in free-ranging moose.

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Northern ungulates are generally considered to exhibit fidelity to their previous calving sites conditionally to the spatial scale considered. Much of our knowledge about the tendency of these animals to return to the same area to give birth is drawn from open-dwelling species as caribou (*Rangifer tarandus*). Estimation of calving sites fidelity is however notoriously difficult to achieve for inconspicuous forest ungulates as moose (*Alces alces*) and deer. Our objective was to quantify fidelity of moose to their calving sites and if so to determine how individual life history influence patterns of site fidelity. We used long-term monitoring (1992-2005) from an isolated island population of moose in northern Norway (Vega, Nordland county) consisting of a dataset of 31 moose cows with at least two, and up to nine known calving site locations. Locations were determined based on intensive radio-locations of marked females and direct observations of calves in the first few days following birth. We generated null expectations of fidelity from the distribution of distances between locations of calving sites from all females in the population comprised within the home range of each specific female (home range scale) and from all known calving sites on the 119 km island (landscape scale). We contrasted distances between consecutive-year locations of calving sites to these expectations using log-linear regression analysis on the ratio of observed: expected distances. Site fidelity has been shown to exhibit individual variation based on previous age and previous reproductive success. Female experience (age, number of offsprings produced and recruited) and other fitness correlates (body mass) were used to explain the variability in site fidelity within the population. The effect of the mother fitness on calving site fidelity of her daughters was also investigate using 26 female-daughter pairs with known calving locations (from 14 adult females). Results from this study contribute to our understanding of the effect of this ecological pattern of habitat use on the demographic stochasticity in moose population.
(Oral presentation.)

28

Spatio-temporal distribution of white-tailed deer relative to prescribed burns on rangeland in south Texas, USA.

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This study is being done to determine the spatial and temporal distribution of white-tailed deer (*Odocoileus virginianus*) on prescribed burned areas in a rangeland restoration project. Overgrazing and fire suppression has left much rangeland in the United States in poor habitat condition. Prescribed fire is one method used to increase the range health. Browsing by deer may have a major impact on the regrowth of vegetation. Three areas of rangeland, each of 40 ha will be burned each year. To determine habitat use and distribution of deer relative to these burns 3 bucks and 3 does will be netted from a helicopter and fitted with Global Positioning System (G.P.S.) telemetry collars (Lotek GPS 3300s) for a period of 45 days during each season. These collars are programmed to take a position fix every hour which limits problems due to spatial autocorrelation. Six deer were collared in August 2005, prior to implementing the prescribed burns. This preliminary data showed that the future treatment areas were under-utilized by deer. The next three collaring seasons will follow response of deer to the burns as the vegetation matures. At this point, the first, second, and third trials have been completed. The second trial was approximately one month after burning and the third was at spring green up. Thus far, the data indicates that bucks use both burned and untreated areas but does tend to avoid the newly burned areas. Whether this is due to reduced browse, loss of escape cover, or natural weariness are unknown at this point. The second trial was done during the breeding season which could affect movement patterns, especially for bucks. Analysis of the spring trial is ongoing. Geostatistical analysis will be applied to spatial and temporal data collected by the G.P.S. collars to determine spatial dependence of deer distributions, on vegetation and burned areas. The Animal Movement extension in ArcView 3.2 and Hawths Tools extension in ArcGIS 9.1 will be used with ANOVA to relate habitat use with vegetative characteristics.
(Poster presentation.)

29

Sexual segregation and differences in quality of diet in white-tailed deer (Odocoileus viginianus mexicanus) in a tropical dry forest in Mexico.

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Sexual segregation in deer can be seen at food level, as dietary composition reflects diverse biological aspects, demonstrating intersexual differences. Some authors suggest that females select higher quality diets, which is attributed to differences in body size and reproductive strategies. The present study evaluated the diet quality, as well as temporary and intersexual variations in the white-tailed deer through non-invasive fecal indexes such as the nitrogen fecal content (NF). The objective was to test the following predictions: a) NF concentrations will be higher in females, and b) differences will exist between reproductive and non-reproductive periods. The study was conducted in a tropical dry forest in the state of Morelos, Mexico. Five sample collections were obtained from January through May, 2004. A total of 113 groups of fecal samples were analyzed individually and in duplicate, of which 63 belonged to females and 50 belonged to males (the pellet morphometry was used to distinguish sex by the fuzzy set method) at two reproductive periods: one corresponding to mating season, (when both sexes are together) and the second, the non-reproductive period (when the sexes are separated). The period between sampling did not exceed 30 days, to avoid loss of fecal nitrogen. The percentages of NF between both sexes showed significant differences ($F = 5.88$; g.l. = 1; $P = 0.017$). NF concentrations in fecal groups belonging to females was evidently greater; however, no significant difference was found between reproductive and non-reproductive periods ($F = 2.48$, g.l. = 1,111, $P = 0.1181$). These results show that both sexes during mating season are occupying better habitats with high quality food, while in dry season females increase their quality of diet despite adverse conditions. This confirms that sexual segregation can be reflected at the level of diet.
(Poster presentation.)

30

Sex comparison of linear body measures of growing red deer calves (*Cervus elaphus hippelaphus*).

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The aim of the present study was to investigate whether the sex differences affects the body shape of red deer calves below the age of 16 months. The study was performed on 186 female and 166 male calves born between 1998 and 2005 in Kosewo Research Station (53°42' N, 21°38' E). About 90 % of animals originated from natural population in Poland and less then 10% were 12.5 % Wapiti or Maral hybrids. All calves were kept from birth until late autumn together with hinds on natural pasture. Prior the winter they were separated from hinds and fed the diet consisted from mixture of oats or barley and ground soy bean with free access to hay or haylage in amounts calculated for daily intake of 1.5 g total protein and 0.16 MJ metabolic energy per kilogram of body weight. After wintering all calves were put to pasture again. Since there was no significant effect of the year on analysed parameters the data were calculated together with respect to sex and age. The life weight (LW; 1372 records) increased with age in the sex specific manner, and were fitted to quadric equations ($p<0.001$) $Y= -0.0343x^4+1.183x^3-13.73x^2+65.77x-38.64$ for males and $Y= 0.0252x^4+0.904x^3-11.00x^2+55.14x-30.67$ for females, where Y is LW (kg) and X is month of life (3 to 15). The linear body measures analysed (496 records/parameter) included body length (BL), head length (HL), lower jaw length (LJ), length of front pastern (FP) and back pastern (BP), and chest depth (CD). The changes of all measures were found to be strictly related to LW and were not dependent on sex. They were fitted to following quadratic equations ($p<0.001$) $Y=aX+b$, were Y is respective parameter (cm) and X is LW (50-150 kg): BL = 0.461X+123.8; HL = 0.140X+25.2; CD = 0.131X+26.6; BP = 0.106X+31.2; LJ = 0.097X+18.4; FP = 0.065X+21.5. Based on linear body measures analyzed we conclude that no sexual differentiation of body shape occur in red deer calves during the first 16 months of life and parametric description of accumulated data may serve as reference for comparative studies.
(Poster presentation.)

31

The influence of management system of farmed fallow Deer (*Dama dama*) on selected production traits during winter season.

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The aim of this study was to determine optimum method of winter management system of farmed fallow deer (*Dama dama*). The investigation was conducted on group of 73 calves both sexes. In December 2004 animals were drenched (injection of 1% ivermectin), weighted and divided into two groups. The first group was held in half-open shed during winter season. The second group of calves was wintering along with hinds on winter pen. In May 2005 calves became weighted again. From animals (before and after wintering), chosen at random, was taken samples of faeces, to make parasitological explorations. Analysis of weight exhibited, that calves, which were hold in the shed, had bigger increase of body weight. The parasitological explorations proved that drenching was more effective in group of calves held in the shed, without contact with hinds.
(Poster presentation.)

32

Deer home range overlap and habitat heterogeneity in Northeastern Mexico.

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The knowledge about the use of habitat by animals and how it change with environmental conditions is important for management programs. We analyzed deer home range overlap between sexes (13 females and 10 males), seasons and years, and the relationship with habitat heterogeneity using radiotracking during 1994 to 1998. The data were grouped in three physiological seasons: 1) Reproductive or breeding

(November to February), 2) Posreproductive or gestation (March to June) and 3) fawning (July to October). This research was carried out at the San Francisco Ranch located in Northeastern Mexico. The area is an 1000 ha enclosure for deer . An intensive water management program operate in the area (3 dams and 32 water troughs). The climate is semiarid, with a mean annual temperature of 21C. Annual rainfall averages less than 400 mm, with notable variation. The vegetation is a xerophyllous brushland. The habitat heterogeneity was obtained within cells (1000 m^2), taking into account the total borders and number of habitat types. Home range was estimated with the Minimum Polygon Convex model. Overlap was obtained between females, males and males-females, for each season and year. ANCOVA was used to know significant differences between sexes, seasons and years. More than 70% of overlap was obtained during post-reproductive season (dry season) for the three sex interactions. The less overlap occurred between females during fawning season, mainly in dry years, so this demonstrate that females prefer isolation during fawning, maybe to secure resources for their fawns. There was a significant positive correlation between habitat heterogeneity considering borders and number of deer locations. The number of habitat types by cell varied from one to five, with the highest number of deer locations in cells with three and four habitat types and the least with one habitat type. Deer prefer habitat heterogeneity because these areas had higher resources diversity for cover their requirements.
(Poster presentation.)

33

Influence of ranging strategy on home range size: red deer hinds in a forest-agriculture habitat.

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Radiotelemetry studies of 27 red deer (*Cervus elaphus* Linné, 1758) hinds in a forest-agriculture habitat between 1993 and 2000 revealed two stable alternative ranging strategies. Shifters relocated their home range from the forest to the agricultural area during summer. Residents stayed in the forest throughout the entire year. Because of these clear differences between ranging behaviours and the two habitats substantial differences were expected in the home range size between the two groups. Three theories were taken into consideration: body-size, habitat-productivity and habitat-heterogeneity hypotheses, all of which predict larger seasonal home ranges in the case of a suboptimal ranging strategy. Consequently, summer and winter home range sizes were compared between strategies and seasons. Both entire home ranges and core areas were significantly larger for both strategies in winter than in summer. There was no difference between strategies during the summer period. Contrarily, both entire winter home ranges and core areas of shifters were significantly larger than that of

residents. Our findings suggest that shifters suffer disadvantages in the forest in winter. These results could not be clearly explained by any of our hypotheses. We suggest social factors to be considered for a better understanding.
(Poster presentation.)

34
New project on red deer *Cervus elaphus* in Sweden.

A. Jarnemo

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A new research project on red deer *Cervus elaphus* was started in Sweden in 2005. The aim is to produce data that can be used to improve management of red deer in Sweden. The project will study home range, movement patterns, habitat choice, reproduction, monitoring methods and management practices. The project uses two study areas: one in southernmost Sweden (Skåne) and one in central Sweden (Kolmården).
(Poster presentation.)

35
Mapping of male red deer *Cervus elaphus* movements in southern Sweden.

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Summer and winter sites used by individually identified male red deer in southernmost Sweden (Skåne) were linked to areas where the stags appeared during the rut. Individuals were identified on antler characteristics and photo-documented during rut. Trophies from harvested deer and carcasses were documented as were found cast antlers. Stags were also photo-documented during summer. From 1970 to 2005 a link between summer/winter site and rutting ground could be established for 58 individuals. The mean distance between rut documentation and summer/winter documentation was 15 km, ranging from 2.5 to 47 km. Mapping of male red deer movements can help to establish the minimum area needed for an effective joint management and to coordinate harvest and management between rutting grounds and winter-summer areas of males. The identification of the summer-winter areas should

also serve as a first step in an attempt to study the causes of sexual segregation of red deer in the area.
(Poster presentation.)

36
Importance of floodplain forest for deer management.

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Floodplain forests represent despite their small size very important forest habitat in the Czech Republic from point of view of natural conservation. They are characterized by high biodiversity, which could be decreased by human activity (regulation of rivers, transformation to agricultural area) as well as by high abundance of big herbivores (browsing, trampling, bark stripping). Most of the floodplain forests are commercially managed for timber harvesting so for forestry the presence of deer is because of its browsing impact on planted seedlings undesirable.
The aim of our study was to estimate the density of red and roe deer and to assess their impact on biodiversity of floodplain forest ecosystem from point of view of carrying capacity of this habitat, using mainly the height of browsing impact. Based on these results we tried to make required conclusions for deer management.
During the research in 2002 – 2004 we found that the densities of both deer species are above-averaged (9.6 ind./km^2 and 7 ind./km^2, red and roe deer respectively) in comparison with other forests in Czech Republic. In spite of high proportion of broadleaved trees in their diet (red deer 71%, roe deer 56%), the browsing impact did not exceed 30% and is relatively low in comparison with other forested areas. The shrub layer is very well developed and regenerates naturally. On the other hand browsing is an important threat to artificially planted oak. They have to be fenced.
High carrying-capacity of floodplain forest makes it possible to keep high abundant populations of red and roe deer. In spite of high density and high proportion of trees in deer diet, the natural regeneration of the forest and its biodiversity are not threatened. But high deer density causes problems to forestry and the artificial plantations of economic tree species have to be protected against browsing. Their protection by fencing is quite effective and for the present the reduction of deer abundance is not necessary.
The study was supported by GA AS CR S6093003 and by grant No. LC06073 of the Czech Ministry of Education.
(Poster presentation.)

37

Gross composition and protein fractions of milk from fallow deer (*Dama dama*).

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Thirty milk samples were collected from 18 lactating does lambed on June and July. The lactating herd comprised 12 adult animals older than 3 years (mean age: 42 months) and 6 young animals in their third year of live (mean age: 23 months). Sampling was carried out in late August 2004 (13 milk samples) and in the same period of the year 2005 (17 milk samples). Does were reared at the deer research facility Antonio Servadei (University of Udine), located in Pagnacco, north-east of Italy. The lactating herd was allowed to graze a pasture dominated by Festuca arundinacea and daily supplemented on 7 kg of a concentrate feed based on cereal grain and soybean meal (CP 20.3 % on dry matter basis). During milking, deliveries were maintained in the does herd. Does were immobilised by means of a crush and 10 I.U. of oxytocin were injected by intramuscular administration to facilitate milk ejection. After 1-2 minutes, does were handly milked as deep as possible in 10-20 minutes. About 70 mL of milk was collected from each does. On milk samples, the following parameters were determined: total nitrogen (TN), soluble nitrogen (SN) and non protein nitrogen (NPN), from which total protein (TN x 6.38), casein ((TN - SN) x 6.38), true whey protein ((SN-NPN) x 6.38); fat and lactose and ash contents. Dry matter, total protein, fat, lactose and ash contents (meansd) of fallow deer milk resulted, respectively, 29.27±3.13, 8.04±1.16, 14.92±2.42, 3.25±0.27 and 1.08±0.12 g/100g. Concerning protein fractions, the contents of casein, true whey protein and NPN x 6.38 resulted, respectively, 6.89±1.11, 0.79±0.12 and 0.30±0.08 g/100g. Csapo et al. (1987) in a study carried out on milk samples collected in two occasions (15-20 days after dropping and in the second-third month of lactation) from 3 hinds of fallow deer reared in captivity, reported values clearly lower of dry matter (-33%), total protein (-14%) and fat (-44%) than those observed here. As far as protein fractions, compared to our results, the value of casein content resulted lower (-20%), while true whey protein and NPN x 6.38 contents were similar.
(Poster presentation.)

38

Estimating in vitro digestibility of wild sika deer (*Cervus nippon yesoensis*) in Hokkaido, Japan.

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In Hokkaido, a northern-most island of Japan, the damage to agriculture and forestry by sika deer has recently increased. The nutritional information such as intake and digestibility of wild sika deer is one of the most important information for the population management and accurate estimation of the carrying capacity, while determination of digestibility for wild sika deer have been fairy difficult. In this study, in vitro method was applied, 1) to determine the digestibility of wild sika deer, 2) to compare them with those of cattle (*Bos taurus*). In Experimental Farm of Hokkaido University, four and five wild female sika deer were harvested in November (fall; FA) and February (winter; WI), respectively. The rumen fluid was collected from these deer and used to measure in vitro digestibility and gas production immediately. Additionally, in vitro digestibility using the rumen fluid collected from three cattle with rumen cannula was measured. To compare in vitro digestibility and gas production of deer and cattle, dried Lolium perenne (L), leaves of Sasa nipponica (S), leaves of Carpinus cordata (C) and barks of Acer mono (A), were used. In vitro digestibility of dry matter (DM), crude protein (CP) and neutral detergent fiber (NDF) were determined after 48-hour incubation. In vitro gas production was measured at regular intervals thoughtout 96-hour incubation and calculated the parameters by curve fitting. Content of CP was 27.3, 16.7, 14.1 and 7.6% of DM, and the NDF content was 39.5, 65.3, 55.8 and 74.1% of DM in L, S, C and A, respectively. The digestibility was the highest in L and the lowest in A in both deer and cattle. Digestibilities of CP and NDF for all plants in deer decreased in WI, especially in C and A. The asymptotic gas production (ml/gOM) was the highest in L in both deer and cattle. The fractional degradation rate (/h) in deer was faster in FA than in WI. In vitro digestibility and gas production parameters were significantly correlated between deer and cattle. These results suggested that in vitro digestibility and gas production in wild sika deer could be estimated by those in cattle.

(Poster presentation.)

39
Comparison of physical condition of two Red deer (*Cervus elaphus*) populations.

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The body condition of Cervidae is usually an important source of information about the population performance. In the present study we evaluated the physical condition of two red deer sub-populations localized in the same climate area (Mediterranean climate) that are apart of which other by about 30 km. However with the same climate conditions, the two areas have a distinct management history, manly in the land use. One population is localized in a characteristic mediterranean habitat, composed mainly by Quercus spp. and the other in a highly managed conifers forest. Using a combination of the kidney fat index (KFI) and the bone marrow fat (BMF) we could compare the performance of both sub-population that have the same genetic origins and similar management practices. Some considerations about the combined use of these two indexes and the land management option are address in this work.
(Poster presentation.)

40
Distribution, abundance and management of the two native deer in Italy.

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In the last decades the distribution and abundance of roe deer and red deer, as well as several other Italian ungulates, constantly increased, but this expansion phase occurred unevenly throughout the peninsula. Aim of this poster is to present the distribution and abundance of the two Italian native deer and to illustrate the development in their population dynamics and management strategies starting from 1999-2000 (Pedrotti et al., 2001). The data were provided by the National Ungulates Database, implemented by the National Wildlife Institute (INFS), in which all the available information regarding wildlife censuses carried on by local administrations and protected areas, as well as harvest plans and annual hunting bags starting from 1996 are recorded. At present, roe deer (most widely distrib among Italian deer) and red deer occur in the most of the alpine range, while the distribution in the northern-central Apennines range is wide for the roe deer and scattered for red deer. In the south, red deer is present only in two national parks in which re-introduction programs have been

recently carried out and roe deer in four national parks: in three of them is present the sub-species Capreolus capreolus italicus, also present in a fenced protected area near Rome (Castel Porziano) and in a part of central Italy. The Sardinia Island is inhabited by the red deer sub-species C.e.corsicanus (6,000 animals estimated in 2005), and a relict population of the ancient Italian species is still present in Ferrara Province with about 100 animals (Mesola red deer). In 2000, about 336,000 roe deer and 44,000 red deer were estimated and about 30,000 roe deer and 4,000 red deer have been harvested in Italy. In a few years, roe deer population have increased of about 25% (420,000 animals estimated in 2005), even if the pattern is not homogeneous in the entire country, and the red deer population of about 30% (56,000 animals estimated in 2005). Following the population trends, harvest quotas increased and about 48,000 roe deer (+37% compared to 2000) and 7,779 red deer (+54%) have been harvested in 2004-2005.
(Poster presentation.)

41
Interspecific competition between large herbivores: the fallow deer - roe deer case.

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Integrated management of our Swedish four boreonemoral deer species, moose (*Alces alces*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and roe deer (*Capreolus capreolus*), when occurring in the same area is highly requested but still missing. This is unfortunate but most probably due to an almost complete lack of empirical studies in Scandinavia on how guilds of ecologically similar species may coexist within the same community. However, a prerequisite to create realistic management models would be information not only on the relative influence of all the herbivores on its resource but also measures of the interaction between the species themselves. This just initiated project aim to investigate the type and strength of interactions (interference and exploitive) which may occur among large herbivores in Sweden. This is not only of high scientific value, but also of high importance in our ambition to learn more about the possible effect of multispecies communities on forest production. Since the strongest effects of competition among all the four sympatric Swedish deer species is expected between the exotic fallow deer and naturally occuring roe deer, we will focus our effort, in the short term, on that relationship. As an equally important by-product of this project we will also be able for the first time to describe the general biology of wild fallow deer (i.e. diet, seasonal habitat choice, home range size and seasonal movements), the third economically most important hunted deer species in Sweden, providing a basis for a sound future management of this species. This will be the first time in Fennoscandia that the general biology of fallow deer will be studied in the

wild.
(Poster presentation.)

42

Current knowledge of the Central American red brocket deer (*Mazama temama* Kerr, 1792) in Mexico.

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One of the deer species of which we have the least knowledge is the Central American brocket deer (*Mazama temama*). The objective of this study is to review the information produced regarding their biology and ecology. This deer is considered a subspecies of M. americana, but is currently recognized as M. temama, having been granted species status based on old karyotype data; segregating M. temama from M. americana and including two subspecies; M. temama cerasina, present from Mexico to Costa Rica, and M. temama reperticia, from Panama to Northern Colombia. Information regarding population density is only available locally, varying from 0.09 deer/km^2 (including M. pandora) to 0.25 deer/km^2 in tropical forests, and 0.32 deer/km^2 in cloud forests. The abundance index has been estimated using track counts, ranging from 0.1 to > 1.8 track/km, in areas of sympatric with M. Pandora is higher (> 1.8 track/km). In the Calakmul and Lacandona reserves, Red brocket is the second most important source of food. Control hunting is practiced to reduce damage in beans and corn fields. There have been seven births in the Chapultepec Zoo, with a 71.43% survival rate, weight varied from 0.5 kg to 1.4 kg a few days after birth. A diet was created for captive animals which represented 2 to 4 % of its body weight, and included 16% crude protein, 2% lipids, 26% crude fiber and a Calcium-Phosphorus relationship of 2.5:1. This deer is considered a representative of well-preserved forest sites, however, it can be found in transformed sites. Further research is needed to determine the degree of disturbance and isolation of the fragments that they inhabit since habitat fragmentation, tourism, natural disasters and degradation by agricultural activities are the main factors affecting potential habitats and distribution. This species currently is not considered as threatened in the NOM-059-SEMARNAT-2000. It is necessary to obtain more information on their habitat status, distribution, harvest levels and abundance, as well as their importance to human communities in the areas of subsistence and control hunting.
(Poster presentation.)

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Energy requirement of captive grey brocket deer (*Mazama gouazoubira*) determined by weight equilibrium and double-labeled water.

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There are limited data on energy requirements of brazilian cervids. Thus, it is difficult to succeed in their management and reproduction in captivity. The objective of this experiment was to study the nutritional requirements of the grey-brocket deer (Mazama gouazoubira) in captivity. The determination of energy requirements for maintenance used 8 gray-brocket deer of both sexes in captivity and was carried through two methods: a)weight equilibrium and b)double-labeled water (2H218O). The animals were dosed with double-labeled water (111.8 mg/kgBW for 2H2O and 163.1 mg/kgBW for H218O) and blood samples were collected with 3 days interval, until 3 or 4 half lives of isotopes had occurred (reached limit of detection at approximately 30 days after the dosage). The curves of isotopes disappearance as a function of time were used to calculate the turnover of CO_2 and H_2O. The results obtained from the two methods were similar (111.4 and 112.0 kcal/kg.75.d) proving the double-labeled water technique may be used in nutritional studies of cervids. Information on doses (mg/kgBW) and maximum interval between injection and blood collection (30days), allow the use of this methodology in future studies with free ranging deer. This work determined the requirements of energy of grey-brocket deer in captivity and validated the use of one indirect technique for use in free ranging animals.
(Poster presentation.)

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Modelling the influence of resources on the distribution and aggregation of red deer hinds during the rut: implications for mating system and management.

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Resource distribution is empirically known to affect the spatial distribution of female red deer during the rut. We used geographical information systems and multivariate

analyses to quantify this relationship and assess which resources have the greatest influence on red deer hind distribution in 35 populations in Mediterranean ecosystems. We measured eight resource-related variables in each 50x50 m square, that included distance to ponds, to dry streams, to green meadows, to food supplementation sites, and to pasture areas, percentage of pasture cover, percentage of leguminous plants (in pasture areas), and distance to croplands. For each population we built a stepwise multiple regression model that resulted in a prediction of hind distribution based on a selected significant subset of resources. Our results show that artificial food supplementation and the presence of green meadows are the most important determinants of hind distribution in these populations, although each resource may have different importance in different populations. In addition, the spatial aggregation of the most important resources for hind distribution was significantly related to the spatial aggregation of hinds. This aggregation, apart from population traits such as sex ratio and population size, is known to increase the degree of polygyny , therefore reducing effective population size and tending to decrease genetic variability in subsequent generations. Hence, the models relating female distribution to the distribution of resources might be useful to predict how the management decisions over particular resources are likely to affect relevant behavioural and evolutionary parameters.
(Poster presentation.)

45
Red deer as a newcomer in Estonian fauna.

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Cervus elaphus is a new species in Estonian fauna. The introduction of species started in 1970-s when specimens from Voronez nature reserve, Latvia and Lithuania were released on the islands of Saaremaa and Hiiumaa. Later the red deer reached South Estonia moving there from Latvian territory. Appr. 1700. red deer was counted in 2006 in Estonia.
Forming the strategy how to treat towards the new species we must to find answers to following questions:
1) How has the species adapted to our natural condition?
2) How is the sharing of habitats carried out with indigenous cervidae the roe deer and moose and whether there are any signs of competition?
3) What is the influence of red deer on habitats, primarily upon forest renewal?
In the year 2000 a research project financed by the Centre of Environmental Investments was started. The aim was the detailed study of the new species. In course of it the following has been done:

The red deer was included in the list of monitored species, what means the analysis of hunting statistics and examining of shot animals.
In two regions In Laasi (island Hiiumaa) and in Tündre (South Estonia) the spreading of roe deer, moose and red deer in their winter habitats was estimated using the method of counting the winter pellet groups. Additionally, during winters of 2000/2001 and 2001/2002 all it all 48 specimens of red deer were tracked and their movings and all signs of vital activities were fixed and mapped by using the GPS. For testing a hypothesis if the red deer`s moving are not random because of looking for certain kinds of forage so we studied the distribution and density of tree species in deer tracts and on randomly selected transects.
Our data show:
According to the data got by snow tracking and also by preliminary data got by rumen content analysis the red deer consume economically important tree species in very small amount. Most important food is grasses, forbs and dwarf-shrubs.
There is no evidence of existing acute competition for habitats between red deer and other cervidae.
The condition of our red deer population is very good.
Resulting from the above and from the statement that the red deer is a very valuable game species we can conclude that there is no reason to hinder the spreading of the new species. In a wider perspective we consider desirable that red deer might become the main game species in islands, which means also that the moose number must be cut down by hunting. In Southern Estonia red deer probably remains species of marginal importance.
(Poster presentation.)

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Comparison of different weaning times of farmed Hungarian red deer (C*ervus elaphus hippelaphus*) calves.

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Research on the adaptation of deer farming technologies to Hungarian conditions started in the 1980's. Current practice in Hungary is to wean after the breeding season mainly due to animal welfare concerns. However, due to economical reasons, there is a growing interest in the application of earlier weaning techniques. To investigate the effects of different weaning times under Hungarian conditions, we compared the live weights of red deer (Cervus elaphus hippelaphus) calves weaned in August, September or October in April in the following year. Data were collected in six breeding centers (A-F) of the same company in Southwest-Hungary. Weaning times

were 08 August (AUG), 03 September (SEPT) and 29 October (OCT), 2004. Live weight measurements were taken at weaning and in 21 April, 2005 (yearlings). A total of 75 male and 77 female calves were measured. Data were analyzed with Statistica for Windows 6.0. The effects of different weaning times as well as the different breeding centers were analyzed with Kruskal-Wallis ANOVA followed by a post-hoc Mann-Whitney U-test with Bonferroni corrections. Because sex had a significant effect on April weights (median values for males and females were 74 and 64 kg, resp., $p<0.01$), males and females were analyzed separately. There were no significant differences between the April weights of different weaning times (AUG vs SEPT vs OCT) in case of either sex (median values were 71 vs 75 vs 74 kgs, $p=0.21$ and 61 vs 64,5 vs 63 kgs, $p=0.1$ in males and females, resp.). ANOVA revealed a significant difference among breeding centers in case of females ($p=0.045$) but not in males ($p=0.28$). Post-hoc analysis revealed that the above mentioned difference was significant only between centers B and D ($p=0.002$); all other differences were not significant. The lack of significant differences between the live weights of calves with early and late weaning dates in the following spring suggests that an early weaning can be safely adapted.
(Poster presentation.)

47
A photographic guide for aging fallow deer *Dama dama*.

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A photographic reference system for aging fallow deer *Dama dama* based on permanent teeth eruption pattern and presence-absence of wear characters in jaws is presented. Eruption pattern has been established by examining the jaws of 38 animals (18 females and 20 males) of known age. The relationship between tooth wear and age was studied counting cementum annuli in the root tips of I1 extracted from 35 jaws of known age (22 females and 14 males). Incisors were demineralised, sectioned with the use of a cryostat and stained with Ehrlich's haematoxylin. As the age assigned reading cementum annuli was consistent with the known one of each jaw, we extended the study to 94 animals (37 females and 57 males) of unknown age. Fallow deer were shot (from November to May) in the Preserve of Castelporziano near Rome (Italy) as part of the normal culling programme, between 2003 and 2005. As shown by the ongoing researches in the Preserve all the fawns are born within a short 4-week period between the end of May and the beginning of June. During this period some fawns were ear-tagged with plastic tags; the tags were numbered and colour coded for the year. The permanent teeth eruption sequence is as follows: I1, M1, M2, other incisors and canines, P3 and other premolars, and M3. Full eruption is completed at 24-25 months of age. Studying permanent teeth eruption pattern we distinguished 4 age

classes: 5-6 months, 7-9 months, 10-12 months and 17-24 months, while studying presence-absence of wear characters we used classes of 12 months. Males have higher wear than females supporting the recent data on sex-specific life history tactics in ungulates. The accuracy of the system was assessed through a blind test carried out by three trained observers. The photographic reference system proposed can be easily and quickly applied in the field and in routine data collections, keeping the time required for aging each jaw to a minimum, but yielding reliable age determination. However since times and sequences of eruption and tooth wear may differ between areas, a calibration for each area is clearly recommended.
(Poster presentation.)

Diseases of deer

48

Recent advances in health and welfare of farmed deer in New Zealand.

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Health and welfare of farmed deer in New Zealand are of internationally high repute, but continuous improvement is essential to minimise clinical and sub-clinical losses and to maintain market access for products. This paper summarises recent progress with identifying, understanding and controlling diseases and initiatives underpinning deer welfare. The national tuberculosis control programme reduced infected herds to fewer than 50 in June 2005 a 32% reduction since June 2004, and has adopted new rules and ancillary tests. Quality systems are employed to ensure optimum testing standards. Johne's disease has emerged as the most significant current deer health threat with implications for lesion differentiation from tuberculosis at slaughterhouses. A substantial industry and government supported research and development project is underway. Significant progress has been made in awareness and understanding of this disease, and possible management strategies to reduce its impact. Leptospirosis was recognised as a deer and human health concern resulting in significant research to characterise the disease in deer and its epidemiology, and to investigate control strategies. Vaccination reduces leptospiral shedding and kidney lesion and culture rates. Preliminary observations have shown growth and reproductive responses in some situations. Brucella ovis can cause high prevalence of disease in deer but a research project characterised the disease and its epidemiology, identifying that self-cure is common, and that an industry-wide control strategy was unwarranted since there have been few recurrences. Recently, Cervid Herpesvirus-1 has been isolated from deer eyes with keratoconjunctivitis, and from lesions in the vagina of deer. These findings require further investigation. Recent evidence describes sub-optimum efficacy of anthelmintics, and research shows the potential of forages for internal parasite control. A national surveillance programme has confirmed no evidence of Chronic Wasting Disease in New Zealand farmed deer. A number of veterinary and laboratory reports of existing and novel clinical disease occurrences demonstrate effective passive surveillance systems within the industry. Deer producers have collaborated with industry stakeholders to develop a Deer Welfare Code that defines minimum and preferred standards for the care of farmed deer, including health. This code is currently undergoing regulatory approval, and thereafter will have legal standing.

(Oral presentation.)

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Health and production challenges facing intensive deer farming industries.

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Deer farming industries in each country have specific consumer, economic, management and health issues but many are common most. This paper briefly addresses the key challenges likely to be faced by successful deer industries in the future.

Consumer awareness of nutritional properties, production, welfare, product safety and health will be a significant driving force for developments on-farm, but should be regarded positively since solutions are generally compatible with improved production and economics. Food safety concerns are universal, and will prompt a greater requirement for assurance. Chemical usage and genetically modified substances, organisms and possibly animals will be increasingly questioned. Natural alternatives for disease, pest and parasite control, such as forages with health-promoting properties and genetic selection for disease resistance as demonstrated for tuberculosis and yersiniosis will increasingly be adopted. Farm management practices will be increasingly scrutinised for animal welfare and environmental impact significance. Failure to comply with community and consumer expectations for animal welfare risks increased support for animal rights and liberation factions. Disease of real or perceived significance possibly presents the greatest threat as demonstrated by consumer and regulatory authority reaction to Chronic Wasting Disease. New diseases or cross-species disease transmission, possibly with altered manifestation will continue to be identified, and these must be researched to provide solutions to reduce risk to animals and people. International trade will continue to be governed by phytosanitory regulations but status may increasingly be at regional and possibly individual farm level, requiring independent assurance. Economic trends dictate that continuous production efficiency improvement will be necessary, often by increasing the scale of operation, with its incumbent problems. Initial gains will be by conventional or novel application of current technology such as forages and genetic selection for production efficiency, and animal health plans including vaccine use to reduce wastage caused by clinical and sub-clinical disease. Research will identify and refine systems, but on-farm improvements will ultimately require more detailed multi-facet recording and efficient information management systems. There will be an increased requirement for professional advice and education to enhance the skill level of managers.

(Oral presentation.)

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Chronic wasting disease in North America - A deer farmer's perspective.

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First observed in 1967 at a research facility in Fort Collins, Colorado; Chronic Wasting Disease (CWD) did not affect deer farmers until discovered in herds of free ranging and captive elk (wapiti) late in the 1990s. After almost a decade of extensive sampling and testing, CWD has been identified in wild deer and elk herds in 13 states and Canadian provinces and in captive deer and elk herds in 12 states and provinces. Over 20 years of exhaustive study show no evidence that CWD poses any risk to humans or domestic livestock. Despite this fact the necessary programs to monitor and control the disease have placed an onerous burden on deer and elk farmers.

The regulatory burden combined with the misconceptions generated by the media with their salacious appetite for the "killer disease of the month" has dried up the pool of potential deer farmers and driven many established farms out of business. An example of this irresponsible journalism has been the implication in many articles and broadcasts that humans could contract CWD or the related Creutzfeldt-Jakob by the eating of venison.

Commercial herds numbering one thousand or more farmed deer and elk have all but disappeared from the North American landscape. Over 10,000 small hobby farms survive with the great majority consisting of less than 30 animals. Those of us who remain with herd populations once considered potentially economically viable are continuing with the hope that some of our allies in the research institutions of our state and federal governments or private enterprise will discover an accurate and efficient live animal test.

This test, along with the much needed epidemiological information that only expensive research can provide, may remove much of the burden under which we now must operate. Valuable research has already confirmed the mode of transmission of the disease. In addition, two separate research projects, one conducted by our United States Department of Agriculture Veterinary Services division and another by our USDA Agricultural Research Service have indicated that it is possible that the Fallow species of deer may possess a resistance to chronic wasting disease. Many other projects are ongoing and promising.

(Oral presentation.)

51
Chronic wasting disease in Canadian wildlife: An expert opinion on the epidemiology and risks to wild deer .

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Introduction

The Canadian Wildlife Federation is one of Canada's oldest and largest wildlife conservation organizations. For more than 40 years we have been promoting the sustainable use of Canada's natural resources and the conservation of wildlife and its habitat.

Along with Environment Canada, a department of Canada's federal government, CWF co-sponsored the 2004 report entitled "*Chronic Wasting Disease in Canadian Wildlife: An Expert Opinion on the Epidemiology and Risks to Wild Deer*", more commonly referred to as the Expert Panel on CWD. My presentation will focus on the outcomes of this Expert Panel.

The Report:

"The overall objective of the Panel is to provide an expert opinion on the best way to research and manage CWD in wild deer populations in Canada. We hope that our report will offer guidance to federal and provincial regulatory agencies in drafting policies to contain or eradicate CWD in free ranging deer populations. A second but equally important objective of the Panel is to provide a package of information to the general public about risks associated with CWD based on data and experience gained internationally in the last decade or so."

Specifically, the mandate of the Panel was to:

1) Improve the collective understanding of CWD in Canadian wildlife

2) Review risk factors and implications of CWD to wild cervid populations, including future development of the disease throughout Canada

3) Provide an expert opinion on the potential risks of CWD to humans

4) Propose recommendations to manage impacts of CWD, focusing on surveillance and monitoring programs, prevention, eradication, containment and human health

5) Encourage a national and international cooperative framework to assess risks and manage CWD in wild deer populations

Panel Conclusions and Recommendations:

Recommendations, unanimous among members of the Panel, were divided into 4 parts, namely management of game farms, management of free-living cervids, research needs and communications. Overall the Panel felt a sense of urgency in taking actions to eradicate or at least contain CWD in Canadian wild deer populations.

CWF Concerns

CWF's concerns stem from the unknown aspects of CWD. Of primary interest is the range of susceptible species. We now know that moose are indeed naturally susceptible to CWD, despite government assurances and best scientific guesses that they are protected by the species barrier. We couldn't agree more with the Panel that research is needed into the susceptibility of caribou populations.

Environmental contamination, only confirmed as a reality within the last few years, has us deeply concerned for the impacts of CWD on Canada's environment and species.

The Panel states that a financial investment into CWD in the wild equal to that on game farms is necessary to control or eradicate CWD. In an age of budget cutbacks, we are worried that this will not occur.

The Future

CWF is encouraged by the Panel's recommendations. We are hopeful that adequate funds will be directed to all aspects of CWD containment, eradication and research. CWF's policy is clear that research on CWD should continue until the disease is successfully eradicated from Canada.

The report *Chronic Wasting Disease in Canadian Wildlife: An Expert Opinion on the Epidemiology and Risks to Wild Deer* can be downloaded or viewed at the following website:
http://wildlife1.usask.ca/Publications/CWD%20Expert%20Report%20Final%20-%2020040804.pdf .
(Oral presentation)

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Epidemiological investigations of Johne's disease in deer.

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Johne's Disease (JD) has become an important disease in farmed deer herds in New Zealand, causing losses of up to 20% of young growing deer on some farms, and significant losses in older deer. A substantial research project is under way to quantify the disease, and to identify, formulate, test and monitor practical and effective farm management policies and practices to reduce its welfare impact upon animals and economic impact upon farmers. Case control, crosssectional and cohort/longitudinal study methodologies have been considered for this investigation. A nationwide descriptive analysis and casecontrol study of 176 deer farms throughout New Zealand, comparing farming practices between JD infected and clear herds was chosen as the

initial methodology, and preliminary results will be presented. Culture of six pooled faecal samples from 10 mature deer each, estimated to have a herdbased sensitivity of 68%, was chosen to define herd status, along with clinical and other evidence. Further analysis of the sensitivity of this screening method is under way. All herds with, and some without clinical evidence of JD were culture positive suggesting herd, environmental, management and/or other factors may predispose to clinical disease. Potential factors have been surveyed in detail for all participating farms and will be subjected to multivariable statistical analysis to identify likely risk factors for expression of disease. Key risk factors identified will be investigated using intervention studies. Concurrently, wildlife on three properties with severe expression of disease in deer have been hunted and necropsied, and tissues cultured for Mycobacterium avium subsp paratuberculosis. The organism has been identified in mesenteric lymph nodes or gut of 22% of wildlife animals sampled including rabbits, hedgehogs, hares, possums, feral cats and ducks. The significance of these infections will be investigated further. A national database to record lesion status from deer slaughterhouses is being established to help define the present situation, to assist slaughterhouse carcass inspection procedures, to monitor the effect of interventions and adoption of new technology on infected farms in the future, and to monitor progress toward control. A brief description will be presented.
(Oral presentation.)

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Johne's disease in farmed deer in New Zealand.

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Johne's disease, caused by *M. avium* subsp. *paratuberculosis,* has emerged as an important problem in farmed red deer (*Cervus elaphus*) in New Zealand and other countries. It causes financial losses due to poor growth rates and death in young deer, it increases the rate of non-specific reactions to the skin test for tuberculosis (Tb) and interferes with normal meat inspection procedures in deer slaughter premises by causing Tb-like lesions in mesenteric lymph nodes. Infection has been confirmed by culture on ~10% of New Zealand deer farms. Unlike the disease in sheep and cattle, Johne's disease in farmed red deer commonly occurs in young animals, 8-15 months old. Affected animals lose weight and condition over a relatively short period and develop diarrhoea terminally. Typical gross signs at necropsy include enlarged mesenteric lymph nodes, which may contain caseous lesions, thickened intestinal mesenteries, often with cord-like lymphatic ducts and mild to moderate thickening of the small intestine. Histopathological examination reveals varying degrees of

granulomatous enteritis, which may be multi- or paucibacillary. Clinical disease is most likely to result from heavy oral challenge in young animals. Although the ovine strain of *M. paratuberculosis* has been isolated from deer, it appears that most disease problems are associated with the bovine strain. Diagnosis depends on combinations of gross signs, serological tests, histopathology, culture and PCR. A commercial IgG1 ELISA has been shown to be relatively sensitive and has been useful for screening affected herds and reducing clinical disease in seriously affected herds. Pooled faecal culture offers a cost-effective means of detecting infected herds. Tissue culture remains the gold standard for differentiating between bovine tuberculosis, avian tuberculosis and paratuberculosis. Improved, cost-effective methods are required for the control of Johne's disease in farmed deer. Control of Johne's disease currently relies on reducing the exposure of young animals to heavy challenge by culling clinically affected animals, optimising nutrition and minimising stress. Screening hinds with the IgG1 ELISA is useful for culling subclinically infected deer, because pregnant hinds infected with *M. paratuberculosis* are very likely to pass infection onto the unborn foetus. In future, vaccination may assist in reducing losses if problems of sensitisation to tuberculin testing can be overcome.
(Oral presentation.)

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Insights into the pathogenesis of Johne's disease in red deer (*Cervus elaphus*).

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Research over the last 5 years has resulted in a clearer understanding of the pathogenesis and epidemiology of *M. avium* subsp. *paratuberculosis* infections in farmed red deer (*Cervus elaphus*) in New Zealand. Using an experimental challenge model, we showed that oral challenge of young red deer with a high dose (10^9 cfu) of bovine strain *M. avium* subsp. *paratuberculosis* resulted in clinical disease in approximately a third of animals, whereas medium (10^7 cfu) and low doses (10^3 cfu) did not cause clinical Johne's disease but resulted in dose-related degrees of subclinical disease. The ovine strain appears to be less virulent for red deer than the bovine strain of *M. paratuberculosis*. Pregnant red hinds are very likely to pass infection onto their offspring either *in utero* or via infected milk. Necropsy and culture of 9 clinically affected hinds in the last trimester of pregnancy showed that the foetuses of 8/9 hinds were infected. Similarly, 14/18 subclinically infected hinds in the second half of pregnancy had infected foetuses and *M. paratuberculosis* was isolated from the mammary tissue or lymph node of 13/16 of these subclinically infected

hinds. A challenge trial showed that vaccination with a killed *M. paratuberculosis* mineral oil adjuvanted vaccine significantly reduced the severity of paratuberculosis lesions. However, the vaccine significantly interfered with *ante mortem* skin testing for bovine tuberculosis. Over 90% of vaccinated and challenged animals gave a false-positive reaction to the single intradermal skin test with bovine tuberculin, but all the animals gave avian responses to a comparative skin test conducted 13 months after vaccination.
(Oral presentation.)

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The efficacy of oral and pour-on ivermectin and pour-on moxidectin in farmed red deer.

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The efficacies of ivermectin (IVM); oral (IVMo) and pour-on (IVMp), and pour-on moxidectin (MOX) were determined using forty 4-month-old weaner red and wapiti, red deer naturally infected with both lungworm and gastrointestinal (GI) parasites. Deer were maintained on ryegrass pasture in mid-autumn and randomly allocated based on liveweight, sex, genotype, faecal egg and larval count, to 4 treatment groups (n=10) which were control (no anthelmintic), oral IVM (200µg/kg), pour-on IVM (500µg/kg) or pour-on MOX (500µg/kg). Faecal egg (FEC) and larval (FLC) counts were taken at -3, 0, +7 and +10 days post treatment. At Day +10 post-treatment deer were necropsied for total worm counts. In the control group the geometric mean (GM) burdens of *Dicytocaulus* spp., *Teladorsagia*-type spp., *Oesophagostomum* spp. were 4552, 244 and 196 respectively. No *Haemonchus*, few *Trichostrongylus axei* and no small intestinal nematodes were found. Arithmetic mean worm burdens were generally similar to GM burdens and reductions in AM burdens are summarised here. Anthelmintic efficacy against lungworm ranged from 99.98-100% despite high numbers of larval lungworm in control deer. Reduction in FLC at +10d was 100% for all anthelmintics. At Day +10 small numbers of lungworm were recovered from lungs of 50% of animals treated with IVMo and 20% of animals treated with MOX. Efficacy against *Oesophagostomum* was 100% for all anthelmintics. Efficacy against total *Teladorsagia*-type spp. from the abomasum were: pour-on MOX 94.1%; IVMo 31.1%; IVMp 68.5%. Nematodes were recovered from the abomasums of all deer treated with both IVM formulations and 60% of deer treated with MOX. Efficacies against *Teladorsagia leptospicularis*, *S. kolchida*, *Spiculopteragia spiculoptera* and *S. assymmetrica* varied between anthelmintics with MOX totally effective against *Spiculopteragia* spp. FEC reductions (corrected for change in control FEC) were MOX and IVM pour-on 100% and IVMo 56.3%. The sub-optimum efficacy against

Teladorsagia-type nematodes with IVMp, the formulation licensed for use in deer, requires further investigation.
(Oral presentation.)

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An internatinal review of Leptospirosis in wild and farmed deer.

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Leptospira infections in wild and farmed deer occur worldwide. This paper reviews technical literature on leptospiorisis in deer first available from 1957 to 2005 including 66 reports from 16 countries. Forty-five reports (68%) were from wild deer including four that were leptospira negative, sixteen were from farmed deer including nine from New Zealand, three describing experimental infection, and two from zoos. Most (29.5%) were from red (*Cervus elaphus*), with 18% from fallow (*Dama dama*), 17% from white-tailed (*Odocoileus virginianus*) and 10% from roe deer (*Capreolus capreolus*). Most reports (73%) described serology only, with evidence for 19 serovars including Pomona (26%), Hardjobovis (15%), Copenhageni (15%), Grippotyphosa (11%) Ballum (6%). Culture was reported only for serovars Hardjobovis, Pomona, Copenhageni and Roumanica. Disease, culture and gross and/or histopathological lesions were described in 18 (27%) reports associated with serovars Pomona, Hardjobovis, Copenhageni, Roumanica and Ballum. Proof of disease causation requiring culture, is described only for Pomona, Copenhageni and Roumanica. Most reports of disease were from farmed deer in New Zealand, describing haemolysis, jaundice, renal lesions, haemoglobinuria and sudden death in individuals or outbreaks attributed to Pomona. Mixing of young stock from several sources appears a significant risk factor. Subclinical kidney lesions are associated with Pomona and Hardjobovis. Slaughterhouse workers are at greatest risk of contracting disease from deer. Vaccination produces serological responses, but effectiveness in protecting from disease, and reduction of shedding in urine, remains unreported. Evidence suggests that various deer species can act as a reservoir (maintenance) host for Hardjobovis, an accidental individual and alternative maintenance population host for Pomona and possibly accidental hosts for serovars Roumanica and Copenhageni. Insufficient evidence exists for establishment of the host:organism relationship for other serovars. More robust knowledge of leptospiral occurrence in many countries, epidemiology of infections, and the effectiveness of vaccines and vaccination regimes is needed to assist farmed deer industries to develop leptospirosis management strategies.
(Oral presentation.)

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Epidemiology of Leptospiral infections with Serovars Hardjobovis, Pomona and Copenhageni in farmed red deer (*Cervus elaphus*) in New Zealand.

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This paper reports two longitudinal studies of the epidemiology of leptospirosis in farmed deer herds in New Zealand and a national prevalence survey. A serum bank of 3-monthly samples from each of 10 rising 1-year-old, 12-24-month-old and adult deer on 16 farms during 1992-3 was used for a retrospective sero-epidemiological analysis. All 16 farms and 51.8% of individuals were seropositive for Hardjobovis with seroprevalence lowest in 4-month-old deer and highest in deer >1-year-of-age. Four farms (25%) and 24.6% of individuals were seropositive to Pomona with the pattern within and between farms resembling epidemic infection. Two farms (13%) and 10.5% of individuals were seropositive for Copenhageni but evidence suggested cross-reactivity to serovar Pomona. In 2003-4 a second study involved approximately 6-weekly sampling over one or two production cycles for serology, urine culture and urine dark field microscopy (DFM) from predominantly young deer from one farm infected with serovar Hardjobovis, and two with dual Hardjobovis and Pomona infections. Kidneys were collected from deer at slaughter. Hardjobovis seroprevalence ranged from 7.5-57.5% and titres ranged from 0-3072. Pomona seroprevalence ranged 15-97.5% with titres up to 12,228. There were mild kidney lesions but no disease associated with Hardjobovis, but evidence of disease and severe kidney lesions in 68% of deer with Pomona. Up to 60% of urine samples were DFM positive with shedding persistence exceeding nine months. Infection patterns suggest that deer are maintenance hosts for Hardjobovis and accidental individual and possibly maintenance population hosts for Pomona. Twelve to 20 blood samples/herd from 9- to 30-month-old unvaccinated red and red x wapiti deer farms throughout NZ (n=110; 80 sampled on-farm, 30 sampled at slaughterhouses) were collected March 2003 to February 2005 for leptospira serology. Overall, 82% of herds were infected. At the herd and individual animal levels, respectively, seroprevalence for Hardjobovis was 77.7% and 60.8%, and for Pomona 20% and 8.4%. Within-herd seroprevalence for both serovars ranged from 0 to 100%. Concurrent Hardjobovis and Pomona infections were observed in 16.4% of herds and 6.6% of individuals. There were no regional differences in seroprevalence.

(Oral presentation.)

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Anthelmintic use and internal parasite control in farmed deer in New Zealand.

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A questionnaire was posted to 500 deer farmers in New Zealand in November 2004 to gather information about parasite control yielding 227 replies (45.4%) with 198 suitable for analysis. Ninety four percent of respondents used anthelmintics at least once in the 12-month period defined with 53% treating all deer classes and 22% treating young deer only. Seventy four percent based anthelmintic dose on weight of the heaviest animal, with 36% using a weigh scale. Deer up to 1-year-of-age (n=175 farms) were treated 1-13 times (mean 3.2) starting from January to November. Mean treatment interval ranged from 41- 46 days. Yearling and adult hinds and stags were treated at least once (range 1-7) on 55-64% of farms, depending on animal class. Moxidectin was the most commonly used anthelmintic (46-58%, depending on animal class), followed by abamectin, eprinomectin, oxfendazole, ivermectin, albendazole, levamisole and doramectin with selection based mainly on perceived efficacy. Weight gain and body condition were the most common means for monitoring parasitism in young and older deer, respectively. Few respondents used faecal egg and/or larvae counts. Coughing and/or scouring were diagnosed as parasitism in young deer on 13-14% of farms, and deaths associated with lung and gastro-intestinal worms were recorded on 5% and 3% of farms, respectively. Veterinary diagnosis occurred in 23% of events. Production losses and/or death of yearling and/or adult deer due to parasitism were reported by 27% of respondents. When planning anthelmintic treatment programmes, 63% of respondents followed advice from veterinarians. Thirty four percent always placed deer on clean or spelled pastures after treatment, while 32% did that often. Fifteen percent had incorporated forages and/or herbs with presumed anthelmintic properties into their parasite control programme. Forty four percent were very confident of a return on investment when using anthelmintic on their deer. Respondents stated that their knowledge of the life cycle of the major parasites of deer was very good (8%), reasonably good (61%), poor (28%) and nil (3%). Results demonstrate variability of parasite control practices for farmed deer in New Zealand and suggest that improvements could enhance productivity and profitability.

(Oral presentation.)

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Subdural occurrence of *Elaphostrongylus cervi* and *Setaria cervi* in red deer of West Hungary.

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Prior final settlement, young specimens of *Elaphostrongylus cervi* and *Setaria cervi* nematodes visit the subdural space of the cranial cavity in red deer (*Cervus elaphus* L). To evaluate the frequency, intensity, seasonality and possible pathological consequences of this subdural activity 196 red deer from six West Hungarian populations were examined in the period of March 1998 and March 2006. Deer heads were bisected sagittally and the surfaces of brain and dura mater observed for worms and disorders. *E.cervi* worms were found in all deer populations examined with values of prevalence from 18.2 to 46.7%. The highest prevalence was observed in the population living inthe area of Danube flood-plain called Gemenc. The mean intensity (worm burden) varied between 1.4-2.3 worm in all populations, with an individual maximum of 6 in two calves. In regard of the host age, calves were the most affected: 36.3% prevalence and 1.79 mean intensity. Then the decreasing values indicate the evolvement of the solid immunity. The presence of *S servi* was usually infrequent 3.16% overall prev, with a surprisingly high value, 40.7% in a sample (n = 24) in January 2000 in Zala county. Both worm species occurred between October and February only, except one calf in June 2001, with three *E. cervi* specimens. The gross pathological alterations were restricted to the inner surface of dura mater; yellow infiltration, colorless translucent, pearl-like application. Because clinical symptoms were never observed, our opinion is that *E. cervi* seems to be a harmless parasite of red deer.
(Oral presentation.)

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Disease problems in Mongolian reindeer.

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During two (2004, 2005) one-month summer field trips into the taiga regions of north-western Mongolia where the Tsaatan people herd their reindeer we took whole blood samples from 147 and 97 animals respectively. The samples were either preserved in EDTA or allowed to clot. Serum was harvested from the clotted samples after they had been allowed to stand for 30 min at ambient temperature. As the region is at least a

weeks travel from laboratory facilities we carried out initial screening for Brucellosis using Brewer card test kits on site within 24 hours of sample collection. Serum and blood was stored in sterile vials and maintained in coolers using river water or packed snow. In 2005 parallel Rose Bengal tests were carried out on sera using a Mongolian antigen at the State Central Veterinary Laboratory in Ulaanbaatar. There was a reactor rate in excess of 23% in both years. A limited number of whole blood samples were subjected to DNA extraction and primers for *Brucella* spp. were used to detect the presence of this organism. Because a *Brucella* Strain 19 live vaccine vaccination program was carried out under government mandate in the mid-1980s we are endeavoring to distinguish between this organism, which can cause a self-sustaining infection in reindeer, and other possible strains, including *B. suis* Biovar 4. Blood smears were made and stained in the field using Diff-Quik stain and stored for transportation to the laboratory. There they were examined under oil immersion at 100X. An unidentified hemoparasite was seen in approximately 10% of slides. We collected milk samples from 27 reindeer and one sample of a sero-sanguineous material aspirated under sterile conditions from a swollen carpal joint. DNA and bacterial culture was conducted on these samples. Udder lesions with the appearance of cow pox were seen on 17 reindeer at two camps in 2004. We carried out further clinical examinations on 14 and 12 individual reindeer in the two years. Of these, 10 were for lameness and /or swollen joints. Six cases of saddle sores were seen at three camps.
(Oral presentation.)

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Histopathology of fluorotic coronal dentine of roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*) teeth.

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Intake of excessive amounts of fluoride during dental development causes pathological dental changes, known as dental fluorosis. Dental fluorosis is used as a biomarker of elevated fluoride exposure of wild deer. The present contribution summarises pathological changes of dentine structure and mineralization in fluorotic teeth of roe and red deer from fluoride polluted regions in Central Europe. Mandibles were selected based on their dental lesion index of fluorosis and compared to non-fluorotic specimens. From each specimen ground sections of P4, M1 and M3 were analysed using light microscopy and microradiography.
In fluorotic dentine, long period incremental markings were accentuated in the form of hypomineralised bands. In severely affected specimens, single or multiple broad bands of interglobular dentine were present, occurring preferentially in the dentine

below the infundibulum and near the enamel-cementum junction. In some cases, bands of interglobular dentine could be followed through the entire coronal dentine. In places it could be demonstrated that hypomineralized long period incremental markings were continuous with bands of interglobular dentine. Both phenomena are regarded as denoting different degrees of impairment of the process of matrix mineralization, occurring along the dentine mineralization front. It was possible to match pathologically enhanced striae of Retzius in the enamel with accentuated long period incremental markings in the dentine. So-called Owens contour lines were found to be associated with interglobular dentine. It is hypothesized that in the affected specimens, fluoride exposure constitutes an additional stress factor responsible for an increased susceptibility of the odontoblasts, leading to a deviation from their normal course. Different degrees of pathological dentinal changes occurred among different teeth of one individual, with the M1 showing the least severe alterations. This situation can hypothetically be related to the developmental sequence of the permanent dentition. Since dentine formation continues throughout the life of an individual, the analysis of fluorotic changes in dentine allows an assessment of the fluoride exposure of an animal throughout life.
(Oral presentation.)

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Mineral composition and requirements for growth of farmed red deer in New Zealand.

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This paper presents the first substantial data on the concentrations, quantities and requirements for growth of Ca, P, Mg, Na, K, Cu, Mn, Fe and Zn in farmed red deer in New Zealand. Six normal neonatal, four 12-month and four 20-month-old deer averaging 9.6, 68.25 and 94.7 kg, respectively, were dissected, and organs (brain, lungs, heart, spleen, liver, kidney, pancreas), offal, digestive tract (stomach, small and large intestines), muscle, bone, skin and blood weighed and sub-sampled for mineral determinations carried out by inductively coupled emission spectrometry. Data are presented on the concentrations and amounts of each mineral in each organ and tissue, and estimates of total content and concentration against empty body weight. Expressed as a percent of total mineral in the empty body weight bone contained 99% of Ca, 88% of P, 59% of Na and 59% of Mg, muscle contained 82% of K, 38 % of Fe and 62% of Zn. The organs contained less than 6% of the minerals with the exception of Fe, Mn and Cu. The lungs, spleen and liver had a high concentration of Fe and the digestive tract a high concentration of Mn. Each kilogram live weight gain was associated with 14.5 g Ca, 10.7 g P, 0.54 g Mg, 1.1 g Na, 2.4 g K, 1.56 mg Cu, 0.63 mg Mn, 42.7 mg

Fe and 26.6 mg Zn. The distribution of Cu between the liver, muscle and bone was 77, 8 and 3% for the newborn and 24, 59 and 2% for older deer. Data can be used to estimate mineral requirements, using a factorial model, adopting assumptions from other species for absorption and endogenous losses pending deer-specific data. Thus the Cu requirement of a deer growing at 180g/d can be estimated as 0.18 kg x 1.56 mg (mg/kg live weight gain) = 0.28 mg, plus endogenous loss (7g (estimated loss/kg) x 68 kg) = 0.48 mg, divided by the estimated absorption coefficient (0.05) and daily DM intake (2.2 kg/day). The requirement is therefore estimated to be at least 7 mg/kg DM. Confirmation requires controlled feeding studies.
(Oral presentation.)

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Recent advances in understanding therapy with Copper Oxide Wire Particles in New Zealand Farmed deer.

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This paper summarises investigations into the distribution of Copper Oxide Wire Particles (COWP) and effect of molybdenum on their efficacy in red deer. In study 1, 10g COWP were given to 10 of 20 deer grazing pastures containing low, medium or high Mo concentrations for 92 days from late October. Treatment maintained adequate mean serum Cu concentration in deer grazing low and medium Mo pastures (< 5 mg/kg DM) for >92 days but <50 days in deer on high Mo pastures (8-12 Mo/kg DM) ($p=0.003$). Peak and overall mean liver Cu concentrations in deer on high Mo pasture were lower than in those grazing low and medium Mo pastures ($p<0.001$). Thus elevated dietary Mo reduces absorption and therefore storage of dietary Cu, requiring higher supplementation frequency. Study 2 investigated gastro-intestinal distribution and faecal excretion of particles of a novel copper oxide wire particle (COWP) product (CUE Bullet). Twenty 18-month-old red deer hinds were treated orally with a bolus of 10g COWP and four slaughtered on days 1, 5, 15, 30 and 60 after treatment. The gastro-intestinal tract was secured between compartments and contents rinsed until sedimentation of particles occurred. Sediment was oven dried and copper particles were separated and weighed. Faeces were collected continuously from four additional animals in metabolism cages for four days after treatment, and sub-sampled for daily particle recovery estimates. Copper oxide wire particles were found in all compartments of the gastro-intestinal tract caudal to the oesophagus for at least 15 days and in the rumen/reticulum and abomasum for at least 60 days. After 24 hours, a mean of 6.21g of COWP were recovered, declining to 2.6, 0.46, 0.52 and 0.15 after 5, 15, 30 and 60 days, respectively. The highest recovery rate at every sampling day was from the rumen/reticulum (55-97%). A mean of 0.09g of COWP (range 0 0.24g)

was recovered from faeces during the first 24 hours. Over four days, a mean of 0.94 g (range 0.03 2.61g) was recovered from faeces. These studies have added to knowledge of factors affecting the efficacy of COWP, and their dynamics in the gastrointestinal tract.
(Oral presentation.)

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Nasopharyngeal bot fly, Oestridae larvae in red deer in Hungary.

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Bot fly larvae (*Oestridae, Diptera*) develop for about six month period in the nasal cavity and later in the pharynx of the host. In red deer (*Cervus elaphus* L.) two species occur in general *Cephenemyia auribarbis* Meigen 1824 and *Pharyngomyia picta* Meigen, 1824. The joint occurrence of the two species was examined in a total of 138 red deer of West Hungary between March 1998 and March 2006. Larvae were detected and collected after the midsagittal cutting of the head. The species identification, prevalence and number of larvae (intensity), and the variation due to host age and season were analyzed by statistical methods. The overall prevalence was 92,7%, with 22 median intensity if the two bot fly occurrence data were combined. However the prevalence of C. auribarbis was only 46.9 % in contrast to 90.6% for *P. picta* due to the elongated development of the later species. The highest values were found in the calves and yearlings: 97,3% and 100% prevalence 17,0 and 6,0 median intensity respectively (what are in conflict with the results experienced in Spain previously). The evaluation of the seasonal occurrence of larvae shows clearly the differences in the seasonal development characteristics of the two bot fly species. C. auribarbis larvae reach their maturation tightly together (February-March), therefore seemingly earlier, than the great mass of the *P. picta larvae* (March-June). It was often difficult if not impossible to count the total number of larvae in the host, especially in regard of *P. picta*, because most of the first stage larvae staged in the lower airways (trachea and bronchi). In regard to the bot fly larvae we did not see signs of obvious acquired immunity in contrast of the situation experienced with the warble fly larvae (*Hypoderma spp.*). The general pathogenic or weakening effect of the bot fly larvae could not be proved too.
(Oral presentation.)

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ITS2 sequences of Dictyocaulus lungworms from red and fallow deer in Hungary: molecular evidence for a new genotype.

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Infection caused by lungworms (*Dictyocaulus spp.*) in deer is a well known problem for wildlife managers and deer farmers. Lungworms are considered to be the most important parasites in deer (*Cervidae*). There are evidences for exist a few *Dictyocaulus* species in deer in Europe (*D. eckerti*, *D. viviparus*, *D. capreolus*, *D. sp.* from fallow deer), but it is hard to distinguish them accurately on the basis of their morphological features. In our study, sequencing of the second internal transcribed spacer (ITS2) of nuclear ribosomal DNA (rDNA) was applied to the genetic characterisation of *Dictyocaulus* collected in different Hungarian red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) populations. The ITS2 of *Dictyocaulus* from fallow deer and part of red deer congeners with previously published sequences of *D. eckerti*. However, lungworms from red deer derived from central Transdanubia differed in sequence from *D. eckerti* and *D. viviparus* by 38% and 30% respectively. The ITS2 sequence data indicates that it is as genetically different as are the mentioned species of *Dictyocaulus*. It was thought until that date, the specific *Dictyocaulus* parasite of red deer is *D. eckerti*, although *D. viviparus* occured in some cases as well. These data show evidence for existing of a significantly differed lungworm genotype living in red deer. It is indicated there is real need for a large-scale molecular systematic study of *Dictyocaulus* specimens from red deer (and other cervids) for epidemiological studies.
(Poster presentation.)

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Fascioloidosis of red deer and its therapy in "Szigetköz" region in the North-West of Hungary (1998-2005).

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The giant liver fluke (*Fascioloides magna* Bassi, 1875)was detected for the first time in Hungarian red deer shot in 1994 and became extensive up to date.The parasite can be found in the region extending from the Czech Republic, through Slovakia and from 2000 into Austria. The mean prevalence of fascioloidosis among red deer in Hungary

between 1997-1998 was 72.0-60.7%. In the period of 1998-2005, at necropsy of 459 deer livers (using Egri's method), the number of flukes per host ranged from 1 to 138. The first attempts for game treating was performed until 2000, using the Rafendazole-premix(with rafoxanide)
-medicated feed in feeding places and feeding boxes. The efficiency was low (mean prevalence:51%). The efficacy of later used other preparations (SBH-Exwormer(SBH)(with triclabendazole + levamizole) or Tribex (Chanelle) (with triclabendazole)) - feeding method was the same - were evaluated in the treatment of naturally acquired fluke-infections in red deer. The efficiency of preparations in different years was different. Using the QP 2.0 method of the quantitative parasitology, the typical extreme values of eight years were the following: Confidence limits of prevalence:9.55-78.5%,mean prevalence values:44.19%, and the confidence limits of median intensity were:1-77. Index of Discrepancy was:0.641-0.896. Differences between the data on prevalence-level of the eight years were statistically significant, because "P"(chi square test for comparing prevalence) was 0.016.
(Poster presentation.)

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Coprological monitoring of Trematodes in free-ranging red deer population at eastern Croatia.

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During the four year period (2001-2004) a coprological monitoring was applied on free-ranging red deer population at eastern Croatia, with purpose to detect presence of trematodes developmental stages in faeces. Dropping samples of deer were collected monthly according to different areas (hunting grounds). All samples were analyzed in laboratory by standard flotation and sedimentation method and at the same time eggs per gram (EPG) determination were done. Over four years in nine hunting grounds total number of 2017 samples was collected. Eggs of three trematode species were detected, i.e. large American liver fluke (*Fascioloides magna*), liver fluke (*Fasciola hepatica*) and ruminal trematode (*Paramphistomum cervi*). In one hunting ground ("Podunavlje-Podravlje" - referral number XIV/9) maximum percentage of positive samples was detected for *P. cervi* (78,3 %) with high EPG value (max. = 556, $\bar{x}$ = 48,5), *F. magna* have lower positive percentage (52,5 %) with lower EPG value (max. = 300, $\bar{x}$ = 41,5) and *F. hepatica* have just 9,3 % of positive samples with max. of 55 EPG ($\bar{x}$ = 17,2). In five hunting grounds ("Radinje", "Koha-Kozarac", "Haljevo", "Munjoroš", "Podravlje") we determined no presence of *F. magna* eggs, while *P. cervi* eggs were detected in 45 % (mean value) of samples from all five hunting grounds with EPG = 31. Presence of *F. hepatica* eggs were detected in 11,9 % of samples and mean value of EPG for all five hunting ground was low (<5). In three hunting grounds ("Šarkanj-Vrblje", "Spačva-South", "Spačva-North") we found low ratio of *F. magna*

eggs (12,3 %) with EPG = 12,5, while *P. cervi* eggs were found in 53 % of samples with EPG = 33,5 and *F. hepatica* eggs were detected in 7,9 % of samples with EPG = 5. Correlation between antitrematod treatment and EPG values for all found trematodes is also given in this paper.
(Poster presentation.)

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Sub-clinical parasitism, weaning date, growth of deer fawns and reproductive performance of hinds .

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A recent survey indicated March was the most common month for pre-rut weaning of farmed deer in New Zealand (31%), with 5% weaned in February (n=119 farms). Both weaning date (March vs. June) and date of first anthelmintic treatment potentially influence liveweight gain of young deer. This study investigated the impact of pre-rut weaning date on parasitism and liveweight gain (LWG) of red deer fawns and hinds, and conception date and rate of hinds by untrasound scanning. Seventy-six deer fawns were randomly allocated in a 2x2 factorial design, involving weaning date (February 17 or March 17) and two treatments with moxidectin anthelmintic at a six-week interval (Jan 14 and Feb 25) or no anthelmintic treatment. LWG of fawns was monitored at 2-4 week intervals from Jan 12 to Mar 31. Sixty-four mixed-age hinds were used to investigate the effect of pre-rut weaning date on internal parasitism and conception date. Deer grazed permanent perennial ryegrass-based pasture together until weaning. Fawns weaned in March had a higher LWG to March 31 than those weaned in February ($P<0.0001$). A significant weaning by anthelmintic treatment interaction was found ($P<0.02$), with LWG being higher in treated fawns weaned in March ($P<0.017$) but not February ($P>0.10$). Faecal larval counts (FLC) in treated fawns were zero, but faecal egg counts (FLC) in treated fawns averaged 136 epg (range 0-600). In hinds, FLC averaged 5 lpg (range 0 – 122) and FEC averaged 26 (range 0- 200) with no significant relationship between weaning date and either FLC or FEC. No effect of weaning date was shown on conception rate or date. This study has shown that pre-rut weaning date and sub-clinical parasitism during summer and early autumn can influence LWG in young farmed deer.
(Poster presentation.)

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Investigation of the sanitary status of red deer (*Cervus elaphus*) culled in the Italian Alps between 2001 and 2005.

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The sanitary monitoring of wild populations is desirable to improve knowledge about the epidemiology of those diseases present, to provide guidelines for a preventive medicine programme, to protect the health of people who work with those animals and to preserve the health balance between the different species present in the study area, especially in alpine environments, where spatial overlap may occur between wild and domestic ruminants in summer ranges. The health status of wild red deer of Fontana Valley (where red deer and domestic ungulates coexist during the summer grazing period), in the province of Sondrio (Italy), has been monitored since 2001. Gross examination was carried out on 143 animals culled from 2001 to 2005, during the hunting season (September-November), and body conditions were scored from 1 (poor) to 3 (good). Blood sera were obtained from blood collected from the heart and were submitted to serological analysis, while tissue samples from organs including heart, lungs, kidney and diaphragm were submitted to histopathological analysis. Arcview 3.2 was used to provide topographic maps to monitor the spread of the two most common diseases in the study area, namely parasitic bronchopneumonia and Sarcosporidiosis, to evaluate the incidental influence of the presence of the domestic ruminants and to highlight the areas of greatest risk of transmission. Epidemiological index of prevalence was calculated for each disease. The most important diseases found in the study population are Leptospirosis (*Leptospira* serovars *Australis/Bratislava, Grippotyphosa, Pomona, Seyroe/Hardjo, Icterohemorragiae/Copenhageni*), Bovine Respiratory Syncytial Virus, parasitic bronchopneumonia and Sarcosporidiosis. The prevalence is generally low, except for bronchopneumonia (74.1%) and Sarcosporidiosis (63.3%). *Brucella abortus/melitensis* was recorded by the rose bengal plate agglutination test. However, complement fixation test could not confirm these results, because of an anticomplement activity of these sera. The general conditions of the study population were good, in spite of the relatively high prevalence of some diseases. This suggests that red deer in the Fontana Valley are coping well with the present situation, but topographic maps show that they may represent a risk for the transmission of diseases to domestic livestock, and highlights the importance of the sanitary monitoring of wild populations.
(Poster presentation.)

70

General comparison of taxonomic characters distinguishing two closely related species of deer lice - *Solenopotes burmeisteri* and *S. capreoli* (Phthiraptera, Linognathidae).

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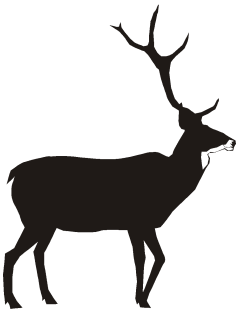
The history of description of two deer lice is discussed. Adults of *Solenopotes burmeisteri* (Fahrenholz, 1919) and *S. capreoli* Freund, 1935 are redescribed and the male of S. capreoli described and illustrated for the first time. The species are compared on the basis of major taxonomic characters: morphology of head, thoracic sternal plate, male and female genital area, abdominal chaetotaxy and body measurements. Both the lice have been noted as very rare species, S. capreoli have been observed only in three European countries; this may be due to inadequate collecting technique. Dissolving deer hides in 5% potassium hydroxide solution seems to be the only accurate method of assessment of prevalence and infestation intensity.Both species of lice are localized predominantly on the hosts head, around the eyes and on the cheeks.
(Poster presentation.)

Genetics and Evolution



71

Landscape features affect gene flow of Scottish Highland red deer (*Cervus elaphus*).

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Despite Scotland holding the largest population of red deer (*Cervus elaphus*) in Europe, population genetics studies have been mainly undertaken in the Island of Rum. For red deer inhabiting mainland Scotland, in particular the Highlands where a more semi/natural population exists, studies assessing effective dispersal (gene flow) and population genetic structure are lacking. In this study we assessed the population genetic structure of Scottish Highland red deer by analysing 695 individuals for 21 microsatellite markers. Additionally, we also assessed the influence of several natural and man-made landscape features on red deer gene flow in the Scottish Highlands by following a landscape genetics approach and using GIS techniques. Despite the relatively small scale of the study area, significant population structure was found using F-statistics (FST = 0.019) and the Bayesian clustering analysis implemented in the program STRUCTURE (K = 4). Population genetic structure analyses, isolation by distance analyses and the Monmonier's algorithm implemented in the program BARRIER indicated the Great Glen valley as the major gene flow barrier in the study area. Landscape features were shown to significantly affect red deer gene flow as they explained a greater proportion of the genetic variation than geographical distance between populations. Sea lochs were found to be the strongest red deer gene flow barriers in our study area, followed by roads, mountain slopes and forests. Inland lochs and rivers were identified as red deer gene flow corridors.
(Oral presentation.)

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Sex biased dispersal in an expanding red deer population.

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The demography and distribution of species vary through time and space and greatly affect levels of genetic variation and population structure. We have investigated the genetic variation and differentiation of 14 microsatellites in the Norwegian red deer subspecies (*Cervus elaphus atlanticus*), which has expanded demographically and

spatially the last hundred years after a major population decline from 300 to 200 years ago. Significant F_{st}-values from 0.021 to 0.197 between localities sampled across the present distribution indicated moderate to strong genetic structure and a Mantel test showed highly significant isolation by distance. Similar levels of genetic variation and recent bottlenecks indicated that genetic drift during the population decline formed the present genetic structure. Natural barriers to gene flow consituted by steep fiords and high mountains has maintained isolation by distance during population expansion. This was supported by Bayesian assignment tests that showed a 99.9% probability of five Norwegian subpopulations, four of which were concurrent with the distribution of four of main locations during the population decline. The assignment tests further revealed that first-generation dispersal was heavily sex-biased with twice to six times as many males as females. Division of the data-set into five clusters according to the assignments test, F_{st} values among males were significantly lower than among females, suggesting that female matrilinear groups have kept together during the spatial expansion. Female matrilineal grouping in red deer thus even seems common during a spatial population expansion.
(Oral presentation.)

74

A molecular phylogeny of the evolutionary radiation of New World deer (*Odocoileinae*, *Cervidae*): Implications for biogeography and the evolution of antlers.

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Molecular phylogenetic relationships among 11 genera of telemetacarpalian "New World" Cervidae were investigated with the mitochondrial cytochrome *b* gene and the more slowly evolving 12S rRNA gene. Telemetacarpalian deer, which comprise "New World" Odocoileinae and antlerless Old World *Hydropotes*, can be divided into three monophyletic tribes: Capreolini (*Capreolus* and *Hydropotes*), Alceini (*Alces* only), and Odocoileini (holarctic *Rangifer* and endemic nearctic and neotropical deer). Antlers evolved only once: *Hydropotes* shows a secondary loss of antlers, and does not represent the plesiomorphic state for cervids. The data challenge conventional hypotheses about the evolution of New World cervids. *Odocoileus*, the typical nearctic deer genus, extends into Central America, and the occurrence of *O. virginianus* in South America north of the Amazon basin has been taken to suggest that all South American deer evolved recently from *O. virginianus*. Molecular analysis shows instead that the endemic large-bodied South American genera, comprising Marsh Deer (*Blastocerus*), Pampas Deer (*Ozotoceros*), and Huemul & Taruca (*Hippocamelus* spp.), are part of a monophyletic clade that diverged from the North American clade at the time of the reconnection of the Panamanian Isthmus 3.5 MYBP. Small-bodied

Pudus (*Pudu*) are the sister group to this clade. In contrast, the small-bodied Central and South American Brocket Deer (*Mazama* spp.) are more closely related to *Odocoileus*, and represent a secondary invasion of the neotropics. Relationships within *Mazama* are complex. Reduced "spike" antlers in Brocket Deer and Pudus appear to be parallel consequences of allometry for reduced size, rather than an indication of close relationship.
(Oral presentation.)

75

Genetic distinctiveness of isolated and threaten Tsaatan reindeer herds in Mongolia.

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The Tsaatan and their reindeer have historically nomads throughout the Sayan border region, covering a taiga home range that stretched far north of todays Siberian-Mongolian border. The community historically interacted with neighbouring ethnic groups, swapping deer as needed. In the 1930-50s, the Tsaatan group fled south to Mongolia after which the border was firmly closed and all contact with other herds and ethnic groups stopped. The herd on the Mongolian side was probably around 2-3000 reindeer according to a 1977 estimate. In the following decades the size of the herd was further reduced to probably only a few hundred individuals for thereafter to increased and during the last 15 years the herd size has been around 6-700 animals. The population is split between the two taiga settled areas called east and west taiga, between which virtually no interaction occurs, and these are further split into different family herds. Here we present data on the genetic variation of the east and west Tsaatan reindeer herds by analyses of allelic variation of 14 microsatellite DNA markers together with sequence variation of the control region of mitochondrial DNA. The Tsaatan reindeer herds are genetically very distinct compared to other reindeer across Eurasia. The herds are characterized by significantly reduced amount of genetic variation probably attributable to bottleneck processes with subsequent effects of inbreeding and genetic drift.
(Oral presentation.)

76
Conservation genetics of Argentinean pampas deer populations.

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Populations of the endangered Pampas deer have been dramatically reduced particularly in the southern part of its range where only four small and highly isolated populations remain in Buenos Aires (Bahía Samborombón), Corrientes, Santa Fe and San Luis provinces of Argentina. In order to deduce genetic units for conservation and to better understand the effect of habitat fragmentation on gene flow and genetic variation, we performed a molecular genetic study of three populations of Pampas deer from Argentina and compared them to samples obtained from other South American localities. In total, we examined 100 individuals using two mitochondrial DNA markers, the control region and the cytochrome b gene. Analysis of the control region revealed that pampas deer had high levels of polymorphism reflecting large historic population sizes of millions of individuals in contrast with the low numbers observed today. The three Argentinean populations analyzed showed high levels of polymorphism and did not share haplotypes. In spite of having unique haplotypes, the populations from San Luis and Bahía Samborombóm did not show significant levels of genetic differentiation suggesting that they belong to the same genetic unit. The cytochrome b marker revealed a star like phylogenetic network with a central common haplotype present in all the populations from Brazil, Argentina and Uruguay. The direct ancestor of the Pampas deer probably first appeared in the Ensenadan stages/ages during the Pliocene about 2 million years ago. The phylogenetic pattern suggests a range expansion in the pampas deer in the Pleistocene. The current demographic decline is so recent that genetic variation has not yet been depleted. The molecular genetic results provide a strong mandate for habitat restoration and to plan alternative management strategies to preserve the levels of genetic variation and recover the historic patterns of abundance.
(Oral presentation.)

77

Genetic characterisation of roe deer (*Capreolus capreolus*) population of Parma Apennines.

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According to historical reports, the roe deer (*Capreolus capreolus*) population of Parma Apennines should be constituted of allochthonous subjects (coming from Central Europe and from Slovenia) introduced for hunting purposes during the first half of 1800. As a result of the improvement of conservative hunting management and the decrease of intesive agricolture activities the consistency of roe deer stock dimension markedly increased from 1950s in Parma. For the same reasons a continuos habitat arose between allochthonous population of Parma and authochtonous population of Southern Tuscany, with possible repecussion on expected genetic structure of roe deer populations. The aim of this research was to study the genetic structure of roe deer population of Parma Apennines by mitochondrial DNA variability. In this concern, 40 mtDNA D-Loop (about 600 bp) taken from roe deer tissue samples collected during the hunting season 2005-2006, were sequenced. We have observed two main mitochondrial aplotypes that clusterised, respectively, with central Italy mtDNA aplotypes (>70%) and Central Europe/East Alps (<30%). Nuclear characterisation based on microsayellites variability to confirm these genetic distribution is in progress.
(Poster presentation.)

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Aplotypic characterization of roe deer by asymmetric PCR and SSCP analysis.

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Mitochondrial D-Loop sequences of 40 roe deer (*Capreolus capreolus*), representative of population of Parma Apennines (I), exhibit two main aplotypes that shows high similarity respectively with sequences of Central-Italy (subspecies *C. capreolus italicus*) and of East-Alps and Central-Europe (subspecies *C. c. capreolus*). The alignment of D-Loop sequences have revealed four conserved nucleotidic mutations which discriminate the two aplotypes, localized in a 200 bp length region. A pair of

primers were designed to amplify this variable region with whom we have performed asymmetric PCR. The PCR samples, mainly single strand DNA synthesized by forward primer, were mixed with two volumes of loading buffer (95% formamide, 20 mM EDTA, bromophenol blue and xylene cyanol) and loaded on an 8% nondenaturing polyacrylamide gel, containing 5% glicerol and 1xTBE buffer. Electrophoresis was carried out at 20C, at 10 V/cm for 6 hr, and then the gel was stained with ethidium bromide. Clear different electrophoretic patterns with SSCP (Single Strand Conformation Polymorphism) analysis were detected for different aplotypes. The method is fairly rapid and inexpensive, and could be used to screening large samples before carry out more expensive analysis.
(Poster presentation.)

79

Phylogeography of Iberian red deer populations and their relationships with main European red deer lineages.

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The Iberian subspecies *Cervus elaphus hispanicus* is morphologically distinct (lighter and smaller) from the other western subspecies of red deer, but few samples have been so far used to study its variability at mtDNA level and its relationships with other western red deer populations. Here we use the first hipervariable segment of mitochondrial D-loop (control region), which has proved to be a very informative marker for defining subspecies boundaries. We screened 229 samples in total, of which 195 were from four main Iberian areas (Extremadura in the west, Castilla-La Mancha in central Spain, Andalusia in the south and Pirineans in the north), together with 34 samples from other European areas (Britain, Norway, Germany and Balkans). Additionally, some GenBank sequences were incorporated for haplotype matching and phylogenetic analyses. A total of 53 different haplotypes were obtained, which revealed two distant genetic lineages within Spain: one in the west and another in central Spain. Some of our samples were obtained from trophies hunted during the first half of XX century, presumably before most recent translocations took place. Haplotypes from these samples provided support to the geographic distribution of current native populations, and allowed us to detect some cases of exceptionally rare haplotypes sampled in current populations that matched with foreing, distant populations, hence presumably resulting after recent reintroductions. We suggest that large areas in Iberia where the two genetic linages still persist should be preserved from genetic admixture by preventing translocations.

(Poster presentation.)

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The artificial occurrence of the fallow deer, *Dama dama dama* (L., 1758), on the island of Rhodes (Dodecanese, Greece): insight from mtDNA analysis.

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The aim of the present work is to investigate the origin of the fallow deer of the island of Rhodes Dama dama dama (L., 1758) (Dodecanese, Greece), by molecular means, and survey this population for phenotypic variability. Our results show that these deer have homogeneous phenotypic patterns. All specimens fell within the common colour coat variety typical of the wild form. The Rhodian deer appear to be rather small, especially if compared with specimens from central and northern Europe. We then sequenced the HVR-I of 13 deer from Rhodes and compared these sequences with other 31 samples obtained from different European and Anatolian populations of fallow deer. Out of 44 sequences, 23 haploypes were found. When compared to the Turkish and Italian population, the population of Rhodes revealed lower values of within population genetic diversity. The fallow deer from Rhodes are characterized by an 80bp mtDNA insertion not found elsewhere. As a consequence all the deer from Rhodes form a tight cluster, distinct from all other fallow deer populations. This uniqueness makes the conservation and management of the Rhodian population particularly urgent.
(Poster presentation.)

81
Comparative anatomy of three Asian ruminant animals.

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The suborder Ruminantia can be divided into two infraorders, Tragulina and Pecora. Tragulidae occupies a basal position with respect to all other ruminant families. The considerable phylogenetical differences between Tragulidae and the other, more recently evolved, ruminants have been established by means of DNA sequence analysis. In this study, the comparison of the anatomical characteristics of the salivary glands and the placenta of three ruminants in Asia were attempted.
Lesser mouse deer (*Tragulus javanicus*) were obtained from a breeding farm in East Malaysia. Reeve's Muntjac (*Muntiacus reevesi*) which had been introduced from Taiwan were hunted in Chiba prefecture, Japan. Sika deer (*Cervus nippon*) were hunted in Kanagawa prefecture, Japan. Their salivary glands and placentas were dissected out and their histological structure was observed. The weight of the parotid glands relative to the body weight was calculated. Among the three species, the lesser mouse deer has the heaviest parotid glands (2.5g/kg). Reeve's Muntjac was 2.0g/kg, while the Sika deer was 0.8g/kg. There is a significant difference between mouse deer and sika deer and also between muntjac and sika deer. The data on the lesser mouse deer is the largest compared with other ruminants investigated by Kay (1987). The function of the salivary glands in the lesser mouse deer must be most significant as it is a concentrated selector in the ruminant animals. It has been speculated that the significance of the salivary function changed through adaptation and evolution with the selection of food intake. The gross structure of the placenta in the mouse deer was diffuse and thus noticeably different from that of the muntjac and sika deer which are polycotyledonary. Histologically, however, the placenta of Tragulidae appears to be epitheliochorial and therefore similar to other ruminants. Numerous trophoblastic binucleated cells, characteristically present in all other ruminants, were observed. These results suggest that the placenta of Tragulidae is a transitional type between diffuse epitheliochorial and polycotyledonary synepitheliochorial categories.
(Poster presentation.)

82

Characterization of the growth curve of red deer (*Cervus elaphus scoticus*) in a herd in Central Mexico.

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Introduction

Red deer (*Cervus elaphus*) has changed from being considered as a cynegetic species to an alternative species for meat production (Van den Berg y Garrick, 1997), therefore description of the growth pattern in a defined environment and production system, allows assessment of the importance of some factors that affect the productive efficiency. These curves and their estimation from different functions (Behr *et al*., 2001; Huisman *et al*., 2002), have been widely discussed in the literature on domestic animals (Behr *et al*., 2001; Kaps *et al*., 2000; in cattle; Bathaei and Pascal, 1998 in sheep; Huisman *et al*., 2002 in pigs; Mignon-Grasteau *et al*., 2000 in poultry; López *et al*., 2000 in fish; and Landete-Castillejos *et al*., 2001 in Iberian red deer). The objective of this study was to compare four different models in order to characterize growth curve in red deer within a herd in the state of Queretaro, Mexico.

Material and methods

The information corresponded to the weight records of 240 deer born between 2000 and 2002 taken every two months from birth to two years of age. Four models were used with unadjusted weights within each sex in order to obtain the growth curves, which were then compared using the determination coefficient (R^2), square mean of the error (SME) and Mallows' Cp statistic (Cp).

Results and discussion

Least square means of weights at birth, 95, 240, 380 and 660 days are shown in Table 1, where it can be seen that males exceeded females by 8%, 14%, 14%, 17% and 39% respectively ($P < 0.05$). Table 2 shows the equations and comparison criteria taking into consideration R^2, SME and Cp. We observed that the equations obtained from the non-linear model. Within the non-linear models that estimate the parameters with a biological perspective, the one that best fit the data was Brody's model. The parameter of weight at maturity varied from 63 to 69 Kg in females and 105 to 130 Kg in males in the different models with biological interpretation.

Table 1. Least square means grouped by sex for weight at birth (WB), weight at 95 days (WW), weight at 240 days (W8M), weight at 380 days (WY) and weight at 660 days (W2Y)

Trait (kg)	N	FEMALES	N	mALES
WB	112	$8.82 + 0.13^{a}$	126	$9.56 + 0.12^{b}$
WW (95 days)	66	33.71 ± 0.65^{a}	81	38.47 ± 0.59^{b}
W8M (240 days)	260	44.91 ± 0.46^{a}	301	51.01 ± 0.43^{b}
WY (380 days)	136	55.41 ± 0.86^{a}	182	65.10 ± 0.78^{b}
W2Y (660 days)	32	65.56 ± 2.54^{a}	177	91.40 ± 1.08^{b}

a,b, means with different superscript in each row are statistically different, $p<0.05$
n= number of records

Table 2. Growth curves Characterization in red deer

	SME	R^2	Cp
Brody (exponential)			
F y= 69.0075(1-0.8552 exp (-0.00392 x))	42.45	0.978	76.15
M y= 130.5(1-0.8959 exp (-0.00158 x))	95.69	0.974	281
Von Bertalanffy (sigmoid)			
F y= 64.7309 (1 - 0.4414 exp (-0.00589 x))^{3}	45.9	0.976	130.78
M y= 110.2 (1 - 0.4727 exp (-0.00296 x))^{3}	104	0.972	379.24
Richards (sigmoid)			
F y= 63.6237 (1 + 0.0660 exp (-0.00676 x))$^{24.6297}$	47.47	0.975	157.83
M y= 106.0 (1 + 0.0602 exp (-0.00357 x))$^{29.3409}$	107.5	0.971	423.64
Gompertz (sigmoid)			
F y= 63.5100 exp (-1.6732 exp (-0.00687 x))	47.69	0.975	159.27
M y= 105.6 exp (-1.8116 exp (-0.00364 x))	107.9	0.971	426.36

Females(F), Males (M); means square error (SME), coefficients determination (R^2) and Mallows' Cp statistic; x= age in days

The weight at maturity varied from 63 to 69 Kg in females and from 105 to 130

Kg in males. A model by Brody standardized by the number of observations indicates that the weight at maturity in females is 60 Kg and males is 132 Kg. been daily gain if 855 and 899 g.The results suggest that Brody's model is the one most adequate for characterization of the growth curve of red deer in this study, with the comparison criteria that are being used.

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(Poster presentation.)

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Mitochondrial DNA variability and polymorphism of ISSR-PCR markers in the reindeer population of Eastern Siberia.

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Mitochondrial DNA variability was analyzed in one of the southernmost isolated populations of domestic reindeers (*Rangifer tarandus* L.) in the Republic of Tuva (in south Eastern Siberia, Russia). DNA isolated from 29 skins of reindeers from Tuva was used to analyze mitochondrial DNA polymorphism. A 470 bp fragment of the control region of the D-loop of mitochondrial DNA was amplified and sequenced. After alignment, a 418 bp sequence was taken for subsequent computer analysis. Conservative regions were revealed in the sequence under study: at the beginning B between base pairs 1 and 150 and at the end B between base pairs 355 and 418. In variable regions transitions were mainly revealed B 23 T-C substitutions, 34 C-T substitutions and 4 A-G substitutions. When comparing all nucleotide sequences under study the number of variable sites was found to constitute 3,5% of the total number of nucleotides. Eight haplotypes were found among 29 studied tuvinian samples. Intrapopulational nucleotide diversity in the studied population was determined, p=0,00859 ± 0,00234. For comparison with our material sequences from GeneBank belonging to 3 known mtDNA haplogroups. Suppose that haplogroup III has the east-Siberian origin. Our data agree with their inference. The evolutionary relations between the sequences D-loop of mtDNA were analyzed using the package of computer programs. The results of statistical analysis of suggest the existence of at least eight nucleotide positions characterized by a high level of homoplasia B from six to three parallel mutations per position. The estimates evolutionary age of individual groupings of mtDNA types in the tuvinian reindeers. The age of these three evolutionary lines exceeds a presumable time of domestication of reindeers. Moreover, 62 animals of the tuvinian reindeers were investigated with the help of ISSR-PCR method. It has been revealed 71 fragments of various lengths. Also indexes of average paired similarity and value of average heterozygosity are counted. Values of average heterozygosity for first marker is 0,7307, and for another - 0,7488. This values of the studied population comprised with the results of the microsatellite DNA investigations of the reindeer populations. Thus, reindeers of the south of Eastern Siberia keep high enough value of heterozygosity than island populations of reindeers of Spitsbergen and Greenland, and also caribou Canada. The tuvinian population was reduced significantly last years, so it is necessary to watch the genetic variety preservation providing steady maintenance of a population.

(Poster presentation.)

84

A new conservation genetic union from Pampas deer (*Ozotoceros bezoarticus*) in Southern Brazil.

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The pampas deer is an endangered species in the state of Paraná, southern Brazil. In the past, this species was widespread in this state and inhabited the open grasslands and the Brazilian cerrado. However, in recent times, destruction of their habitat has caused populations to decline in numbers and the few populations that remain are fragmented and isolated. We performed a genetic study to analyze the genetic variability of a population from Piraí do Sul District, which is the largest known population of pampas deer in southern Brazil with an estimated population size of 71 individuals. Samples from tissues were extracted from dead animals found in the field and from skulls kept by ranchers and poachers in this area. Tissue samples (50 mg or 100 l) were transferred to 1.7 ml eppendorf tubes containing 95% ethanol. Procedures for DNA extraction was done and no-template polymerase chain reaction (PCR) controls were used in each amplification. Universal primers Thr-L15910 and DL-H16498 were used in PCR reactions to amplify a 601 bp fragment. In addition, a 486 bp fragment of cytochrome b gene was amplified for using primers L14724 and H15149. Purified PCR products were sequenced using the ABI Big Dye ready reaction kit and ran on an automated sequencer ABI 377. Sequences were aligned using Clustal X. Of the 51 samples that were extracted, 11 samples were successfully amplified and sequenced for the D-loop region and 8 for the cytochrome b gene region. The 11 D-loop sequences resulted in 4 different haplotypes and the 8 cytochrome b sequences resulted in 2 different haplotypes. We compared these haplotypes with previously published D-loop sequences and from unpublished cytochrome b sequences from Brazil, Argentina, Paraguay and Uruguay. The results of our analysis revealed that all 4 D-loop and the 2 cytochrome b haplotypes were different from all the mitochondrial haplotypes reported. Furthermore, our results suggest that this small remnant population of pampas deer may be genetically differentiated from other pampas deer populations and should be carefully managed as a separate conservation genetic unit.
(Poster presentation.)

85

DNA microsatellite analysis for parentage control of red deer in Czech Republic.

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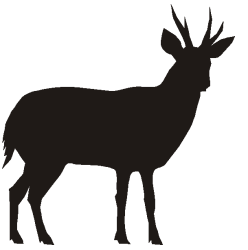
This preliminary study describe the utilization of DNA microsatellite panel for parentage verification of red deer in Czech Republic. The efficient high-throughput microsatellite genotyping protocol was designed by optimising microsatellite markers already isolated for red deer (*Cervus elaphus*), wapiti (*Cervus elaphus canadensis*), reindeer (*Rangifer tarandus f. domestica*), sheep (*Ovis ammon f. aries*) and cattle (*Bos primigenius f. taurus*). The panel is based on our assembled and present for genotyping used set of 10 microsatellites. Randomly selected, unrelated animals of red deer were genotyped. Genotyping was done on ABI 310 Genetic Analyser. The results from testing of larger set of tested animals will be available in time of poster presentation.

(Poster presentation.)

Management of endangered deer



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Status, ecology and conservation of barasingha (*Cervus duvauceli duvauceli*) in Terai grasslands of Northern India.

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The barasingha (*Cervus duvuaceli*) is an endangered deer species in India. Three subspecies of barasingha are known to occur in Indian limits. The subspecies Cervus duvuaceli duvuaceli is found in Terai grasslands in northern India. A project was initiated in 2003 to investigate the current population status, ecology and conservation problems of C. d. duvuaceli. An examination of literature on past distribution of C.d. duvuaceli coupled with extensive field surveys of extant patches of Terai grassland showed a drastic decline in population size, distribution and abundance of this subspecies. The C. d. duvuaceli has become locally extinct from many areas and it currently survives at 5-6 locations where the populations are isolated and face major conservation problems. The largest population of C. d. duvuaceli survives in Dudhwa Tiger Reserve-Kishanpur Wildlife Sanctuary Conservation Unit (DKCU) which approximately covers 829 km^2. Intensive studies on abundance, habitat use, food habits and social organization have been carried out in DKCU using a combination of direct and indirect methods since March 2005. A total of 125 barasingha groups have been recorded so far. The largest group comprising of 293 individuals was recorded from Jadi Tal area in DKCU. The mean group size was found to be 35.3±5.2 (mean±S.E). 82% of groups had 1-20 individuals. The population in DKCU comprised of 12.3% adult males, 14.8% sub adult and yearling males, 35.3% adult females, 9.5% sub adult and yearling females, 16.9% fawns and 10.9% individuals could not be classified. The mean male to female and fawn to female ratio was 50 males:100 females and 47.2 fawns:100 females. The barasingha preferred areas which had significantly higher grass richness ($t=2.4$, $P<0.01$) and grass density ($t=4.2$, $P<0.001$). It also utilized short grasslands more than the tall grasslands ($t=16.9$, $P<0.001$). A total of 13 grass species were utilized by barasingha in DKCU. An analysis of various major activities revealed that animals rested during the day time in summer. The major threat to barasingha conservation throughout northern India is the destruction of its habitat and illegal poaching whereas in DKCU, the illegal poaching, which takes place when barasingha groups move out of the DKCU boundaries into agricultural fields, emerged as major cause of its decline.

(Oral presentation.)

87
Swamp deer in Uttaranchal state, India.

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Swamp deer (*Cervus duvauceli duvauceli*) is listed as an endangered by IUCNs Cervid Specialist Group. The species has dwindled in number from historical levels in last century to populations that are fragmented. One of the main reasons is the degradation of the habitat and loss of connectivity. Dudhwa Tiger Reserve is the strong hold of Swamp deer with population of 1250+ (2004), which also include the population in Kishanpur Sanctuary. One small population of swamp deer is also reported in Hastinapur in Uttar Pradesh which is under threat due to poaching, degradation of loss of habitat due to grazing pressure and removal of grasses. All the populations are below historical numbers and presumed carrying capacity.

Uttaranchal State which was created in 1999 is also facing problems in managing the grassland areas along the flood plains of Ganges. Due to number of anthropogenic pressures and developmental activities in the past and in recent years most of the grassland areas are vanishing and in some places do not exist any more.

On 1st February 2005 Jhilmil Jheel was visited by me and Mr. Chandola, Adl PCCF Wildlife, Uttaranchal Forest Department to find out the possibilities of reintroducing rhinos in this area. While surveying the entire area with on foot and on the elephant back we found traces of hoof marks of swamp deer. Also heard a call of a stag from inside the tall grasses. Finally from a newly built watch tower saw 34 Swamp deer inside an open patch of grassland along a water channel. Nine fully grown stag along with doe and first year fawn were seen. Swamp deer antlers were also collected from the area as evidence and for record. Jhilmil Jheel is a saucer shaped wetland situated on the right bank of River Ganges in Chidiyapur forest range in Haridwar district in Uttaranchal. Around Jhilmil Jheel, nine huts of Gujjars (a pastoralist community) are situated along the forest belt and a village on the southern side. People are settled here since 50's. Most of them are from Punjab, Himachal Pradesh and Garhwal. In the past there were no authentic data or information on the sighting of swamp deer in this area. The area is rich in faunal and floral diversity considering the presence of all the five species of deer, elephant, nilgai and tiger seen here with large number of resident and winter migratory birds. Due to grazing pressure and presence of Gujjar community organic matter flows directly into the Jhilmil Jheel. It has been observed that nearly half of the Jhilmil Tall is infested by Typha and other unpalatable species. Fortunately *Pharagmities karka* is flowering in the half area of the Jheel. Fortunately the local villagers around Jhilmil Jheel are vegetarian and do not take any hard drinks because they are followers of Sanatan dharma. After declaration of this area as Swamp deer conservation reserve it is going to be a strong hold of swamp deer in Uttaranchal. This

area is now one of the India's first Conservation Reserve declared by Hon President of India on 14 August, 2005. The presentation and paper is based on how this remnant Swamp deer population is existing in this area with conservation altitude of the local villagers and is discussed.
(Oral presentation.)

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Distribution and abundance of wild ungulates in Royal Suklaphanta Wildlife Reserve, Nepal.

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"Distribution and Abundance of Wild Ungulates in Royal Suklaphanta Wildlife Reserve, Nepal" was aimed to to determine distribution, abundance and habitat preferences of wild ungulates. The pellet groups counting along line-transect was carried out in the western part of RSWR. A total of 7,342 pellet groups were recorded from 2500 plots of 25 different samples. Spotted deer, hog deer, swamp deer, barking deer, wild boar and blue bull were recorded as main ungulate species occupying the western part of RSWR. Spotted deer was more abundantly distributed (2.28±2.23) among all ungulate species where as blue bull was least abundant (0.002±0.05). Ungulates were highly abundant (3.37±2.58) in grassland habitat. In four different types of habitat, spotted deer was highly abundant (2.67±2.08) in Sal forest, hog deer in grassland (0.53±0.74), swamp deer in grassland (1.03±1.52), barking deer in Sal forest (0.02±0.14), blue bull in Sal forest (0.002±0.06) and wild boar in grassland (0.13±0.034). The distribution pattern of wild ungulates was clumped type with significant difference ($P^2 = 969.28$, $P = 0.05$ and $df = 24$). Habitat preference was found high in Sal forest for spotted deer (29.20%), barking deer (44.16%) and blue bull (64.51%), and grassland for hog deer (74.81%), swamp deer (92.18%), and wild boar (55.52%). Present study found relatively high distribution of ungulate species in core area suggests to ungulate monitoring in extension areas.
(Oral presentation.)

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Swamp deer (*Cervus duvaceli*) habitat evaluation using remote sensing and GIS in Suklaphanta Wildlife Reserve, Nepal.

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Application of the remote sensing technology for wildlife habitat evaluation and management is relatively new but, studies using remotely sensed data on physical attributes of the habitat as well as analysis of spatial data through geospatial modelling have been found the technology to be accurate, cost and time-effective.
I evaluated satellite derived landscape parameters to predict suitable habitat for endangered Swamp deer (*Cervus duvaceli*) using GIS modelling of known wildlife habitat relationship in the Suklaphanta Wildlife Reserve (SWR) of far western lowland Terai, Nepal. Spatial and temporal dimension of land use/land cover was determined by analysis of multi-temporal satellite imagery using supervised classification techniques available in ERDAS IMAGINE 8.6 software. The pellet groups counting along line-transect method was carried out to determine relative abundance, habitat use and preference of the Swamp deer in the SWR. Arc GIS has been used to integrate and analyse spatial data, in order to determine suitable habitat for Swamp deer. Six major habitat/land-cover classes including dry sand, water body, grass land, riverain forest, Sal forest and mixed hardwood forest were identified and delineated by analysing Landsat ETM digital data of 2002. Habitat suitability map was prepared for Swamp deer on the basis of linking of species with specific land cover types, water resources and sensitivity to prevailing human activities. The swamp deer preferred habitat mosaics consisting of grasslands, water body and small patches of forest because such mosaic provides food, water and cover for the species. Land cover types and their dynamics, water availability; topography, altitude, prevailing major human activities and their impact on habitat are important landscape and anthropogenic variables predicting suitable habitat for Swamp deer. SWR provides an excellent habitat for a viable breeding population of Swamp deer, but the future conservation efforts should be directed to grassland habitat management and reduction of human intervention in the reserve.
(Oral presentation.)

90

Population Ecology of Hangul (*Cervus elaphus hanglu*) in Dachigam National Park, Kashmir, India.

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The Hangul or Kashmir Stag (*Cervus elaphus hanglu*), a highly threatened species listed in the IUCN's Red data list, is one of the four eastern most species of Red deer (*Cervus elaphus*). However, unlike Red deer, which has a wide global distribution, Hangul distribution is limited to Kashmir Himalayas in India. Today a genetically and demographically viable population of Hangul is confined to only Dachigam National Park (340 (34^0 05' and 34^0 10' to 74^0 53' and 75^0 09') in the North Western Himalayas. The present population of Hangul is estimated between 209 and 243 individuals. In this paper we made an attempt to present current information on Hangul distribution, status and abundance along with Population Viability Analysis (PVA). Data collection was carried out using seven line transects of varying length (each 1- 2 km long), monitoring of trails in five fixed blocks (of 41.20 Km^2). During the study period (February 2001 to December 2004) a total of 693 monitoring of trails and transects were carried out and total time and distance effort involved were 1839 hours and 5668 km respectively. A total of 326 Hangul sightings were recorded during the trail and transect monitoring. The maximum Hangul sightings (101) were recorded in winter and minimum (55) in summer. The overall Hangul encounter rates was 2.02 Hangul/hour effort and 0.67 Hangul/km walk and it varied significantly between different seasons ($F = 42.22$; $P = 0.001$) and between the study blocks ($F = 173.71$; $P = 0.001$). The overall (weighted for block areas) Hangul density recorded was 5.60 Hangul/Km^2 (S.E. = 1.13) and it varied between different seasons. There was a significant difference mean group size of Hangul during different seasons and it ranged between 1.10 ± 0.33 in summer to 5.36 ± 1.28 in spring. A typical Hangul group size was of 14 individuals and it showed seasonal variations from 5 individuals in summer to 17 individuals in spring. The overall Hangul sex ration was 23.23 males/100 females (S.E. = 2.60) and Hangul fawn to female ratio was 29.95 fawns/100 female (S.E. = 1.90). During four years study period the Hangul population showed an increase at an estimated rate of 9.9% ($r = 0.099$). It is predicted that the Hangul population in Dachigam National Park would show a gradual increase at an estimated rate of 7.9% ($r = 0.079$ S.D. (r) = 0.129) during the next 20 years and would reach to a maximum of 292 ± 1.51 (S.E.) and after that it would remain static. Therefore it is predicted that the Hangul population in Dachigam NP apparently is not under any threat of extinction at least for the next 100 years. However, under the influence of demographic stochasticity (Stoch. r.), some fluctuations in the population growth rate are predicted in Dachigam National Park.

(Oral presentation.)

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Microsatellite variation of Hainan Eld-s deer (*Cervus eldi hainanus*) in China: Implications for conservation.

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Hainan Eld‘s deer (*Cervus eldi hainanus*) experienced rapid population declined in the end of 1960's and early 1970's. Recovery programs include in-site and of-site conservation. in-site conservation was carried out since 1976. Effort in off-site conservation was launched in China since 1986. The current population size is over 1300 and the demographic data may be able to sustain the population development. However, the effect of in-site and off-site conservation on the current population genetic structure remains to be investigated. We used 10 microsatellite DNA loci to assess genetic differentiation and diversity for 213 Hainan Eld's deer from 6 off-site populations. The mean number of alleles per locus was 4.1. There was significant genetic differentiation among populations and the majority of genetic variation (>94.65%) within populations. There was no correlation between genetic distance and geographic distance ($r = -0.1998$, $p < 0.8013$) and there was no correlation between genetic distance and the introduced interval time ($r = -0.1093$, $p < 0.6010$). The result showed that population genetic variation was not completely depleted as a result of either genetic bottlenecks or founder events due to the deer population had a certain extent genetic variation and past management and conservation actions are successful for populations maintaining fine-scale genetic structuring. Based on significant genetic differentiation among Hainan Eld's deer populations, where possible, it may be advisable to translocate individuals between isolated populations to maintain levels of genetic variation in remaining Hainnan Eld's deer populations.
(Oral presentation.)

92

Social structure of the reintroduced Persian fallow deer (*Dama mesopotamica*) population: integrating three observation methods.

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In order to increase the probability of success of reintroductions, it is essential to estimate the social-structure of the reintroduced species. Collection of this information is especially difficult in hard-to-observe species (e.g., hidden in the thicket). Additionally, previous knowledge about many reintroduced species is unavailable due to their rarity in their original environment. We studied the social-structure of the

Persian fallow deer population, one of the rarest deer in the world, now being gradually reintroduced to the Western Galilee, Israel, since 1996. The deer were bred in captivity under artificial conditions for many generations, and we feared that they will not be able to adjust their social-structure as expected from a wild population. We used three observation methods: 1) radio-telemetry collars mounted mostly on females (due to the technical difficulties of tagging males); 2) direct-observations, conducted from pre-defined observation points and occasional sightings along roads; and 3) portable IR video-camera, installed in deer activity areas. We found that in the winter, groups were larger and associations were stronger than in other seasons. Groups were also larger at night. Adult males were in smaller groups than young males and females. Additionally, negative correlations were found between group-size to both time form release and distance from release site. Group size stabilized in ca. 6 months after release on 1.670.9 (meanSD), with a tendency of adult males to be solitary. Overall, the deer apparently do not keep fixed social-structure over time, even when home-ranges highly overlap. Integrating the three methods provided us with a more accurate picture of the deer social-structure: telemetry provided continuous recordings of home-ranges overlap and assessment of association levels, whereas the other methods were more sporadic. However, because most reintroduced males and wild-born fawns were not collared, a complete assessment of the social-structure was impossible without the implementation of these additional methods. Video-recordings added important information about the social-structure at night and in the thicket, that could not be otherwise obtained. Together with already reported parameters, it seems that the deer established a viable wild population, and that the chances for a successful reintroduction are high.
(Oral presentation.)

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Ecology and conservation of the huemul in southern Chile.

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The huemul *Hippocamelus bisulcus* is an endangered deer occupying temperate woodland habitats in the Andes of southern Chile and Argentina. The distribution and numbers have declined substantially since settlement by Europeans, due mainly to a combination of hunting and habitat loss. However, current information on ranging behaviour and population ecology in general is very limited. We selected three sites selected in Aysén, Chilean Patagonia, to study the movements, survival and habitat

associations of huemul using radio telemetry. Although substantial seasonal migrations are commonly reported amongst other deer species in mountainous regions, we found that huemul undertook either no or only modest movement between summer and winter. Long distance movements (>5km) were very infrequent. Habitats selected by huemul included lenga Nothfagus pumilio forest, rocky places and open shrubs; those avoided included grassland and steppe. Amongst the sample of marked animals and their offspring, we found that recruitment rates were barely sufficient to balance mortality. The principle sources of mortality included poaching and predation by puma, dogs and foxes (on fawns). Although huemul are protected in a number of reserves in both Chile and Argentina, populations are thinly distributed in suitable habitat along valley sides and there is little scope for increasing the number of protected areas. Conservation efforts are currently focussed on raising awareness of the plight of the huemul amongst farmers and the general public, and encouraging sympathetic land use practices, such as ecotourism.
(Oral presentation.)

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Status, genetic structure and Conservation suggestion of Chinese water deer.

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Chinese water deer *(Hydropotes inermis inermis)* is an endangered species, ranked as LR/nt in IUCN red data book, which is native to China. The distribution of the water deer in China used to extend to Liaodong Peninsula£¬North China plain and the shores of the lower reaches of Yangtze River and adjacent lake areas, with a region from the latitude 28º to 42º N and the east limit, the longitude 110º E. However, due to habitat loss and hunting, the population of the water deer has declined rapidly and its distribution is now limited and fragmented only to the coastal areas of Jiangsu Province, Zhoushan Archipelago of Zhejiang Province, and Poyang Lake areas in Jiangxi Province. In order to decide conservation strategy, we analysis the reason of the deer's population shrink sharply and do test to understand the genetic structure of the distributions. In view of climate variations in the past 10,000 years and human population growth, We consider that the deer's population changes in North China was mostly due to climate change, agriculture development, human population increase and vegetation degradation. The populations of Chinese water deer shrunk sharply in China recently, especially the lower reaches of Yangtze River and its adjacent lake areas and south of Yangtze River. The reasons were no others but habitats lost and poaching.
The cytb, D-loop and 12SrRNA of mtDNA were sequenced from the samples collected noninvasively from Zhejiang, Jiangsu and Jiangxi province. The results show that Chinese water deer have high genetic diversity and the population in

Jiangsu is the highest. The population from Jiangxi should be ESU and worthy of conservation consideration. There are no clear diverging between the populations from Zhejiang and Jiangsu province. Another conservation suggestion is reintroducing this animal to the area where Chinese water deer existed before to enlarge and restore the population area where Chinese water deer existed before to enlarge and restore the populations.
(Oral presentation.)

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Spatial pattern characteristics of wapiti habitat fragmentation factors based on spatial autocorrelation and semi-variance analysis in Northeastern China.

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Both spatial autocorrelation analysis and semi-variance analysis by Geo-Statistics were used to study the spatial pattern characteristics of wapiti *Cervus elaphus xanthopygus* Milne-Edwards' habitat fragmentation factors during three winters from 2003 to 2005, which revealed the relationship between patch scale structure and wapiti population distribution. Our data suggested that: 1) Under fourteen distance classes (2303220 m), nine habitat fragmentation factors had spatial autocorrelation significantly ($P < 0.05$) and Moran-s I reached at 73%; Six habitat factors appeared different spatial correlation characteristics significantly under different distance classes, which indicated that there were different microhabitat scale structure characteristics of these habitat factors. Three habitat factors (Settlements, abandoned logging roads and farmlands) appeared correlated significantly under all fourteen distance classes, which indicated not only higher consistency in influencing on the spatial pattern of habitat fragmentation, but also their important role in the process of habitat fragmentation of wapiti during winter; 2) Semi-variance analysis and fractals analysis showed that nest structure characteristics of the changes of semi-variance of population distribution responding to the changes of spatial distance classes, which revealed that there was a multiple scale variations in spatial pattern of wapiti distribution; however, fractal number-D of wapiti distribution approached 2, which indicated the variation of spatial pattern of wapiti distribution mainly occurred not only at smaller scale but larger scale for larger standard deviation, which showed that differences of track numbers of wapiti occurred in sample sites were very large, and small numbers came after a period time of larger numbers of wapiti tracks. The above data showed that multiple scale of wapiti distribution, class patches of spatial distribution and vulnerability of wapiti microhabitats, indicating that spatial pattern of wapiti distribution would change greatly once microhabitat changed. In addition, it was of importance for validity, independence and representative of applying survey

scale during wapiti habitat research through revealing spatial autocorrelation and distribution patterns of habitat fragmentation factors under different spatial scales in the future.
(Oral presentation.)

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Assisted reproductive technologies for endangered deer species.

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Within two hundred cervid sub-species over the world, almost 40 subspecies are considered to be threatened with extinction by the IUCN (International Union for Conservation of Nature and Natural Resources). In most of the cases, preservation of this biodiversity relies on conservatory programs performed in and ex situ. In parallel with ex situ conservatory programs based on classical farming in zoo, assisted reproductive technologies may represent an efficient way to produce and disseminate offspring and to prevent genetic loss from rare remaining individuals. In this aim, association of techniques such as recovery of semen/oocyte and in vitro production of embryos appears especially suitable for deer species. Achievability of in vitro embryo production methods was investigated for *Cervus nippon* and *elaphus* after processing of oocytes recovered respectively by aspiration of follicles from live donors using laparoscopic ovum pick-up (LOPU) after gonadotrophin stimulation (0,5 IU oFSH) during the breeding and non breeding season or from abattoir-derived ovaries during the breeding season. LOPU collection from live sika deer hinds were performed with minimal stress to the donor and were repeated without complication. An average of 8 to 10 cumulus-oocyte complexes (COC) were collected per hind per LOPU session during the breeding season vs. 4 to 5 COC during the non breeding season. After in vitro maturation and fertilization, about 60 to 80 % of sika or red deer cumulus-oocyte complexes were fertilized. Developmental competence was assessed for both red deer and sika deer embryos in two different culture systems. Embryos were cultured in synthetic oviduct fluid (SOF) medium in the presence or absence of ovine oviduct epithelial cells (oOEC). In contrast with classical SOF culture, high proportion of embryos reached the blastocyst stage in presence of oOEC (20-40 % with oOEC vs. 0-5 % in culture medium alone). Viability of frozen red deer embryo produced in vitro on oOEC was assessed by transfer of ten blastocysts to five synchronised recipients. Three male calves (one from vitrification and two from slow freezing) were born unassisted after 237 to 238 days of gestation (Locatelli et al., 2005). These results illustrate achievability of IVP procedures in two deer species and may offer new possibilities for conservation of rare deer species in future.

(Oral presentation.)

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Diet composition and habitat selection of red deer during winter in Helan Mountains, China.

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Diet composition of red deer in Helan Mountains of China was determined by fecal and rumen content analysis from November 2003 to February 2004. Habitat characteristics were measured by locating from fresh sign or dung on line transects. Red deer consumed 50 plant species, including 9 woody species, 14 shrubs, 5 graminoids, 2 sedges, 19 forbs and other plants unidentified. Woody species, such as Populus davidiana and Salix spp. were utilized significantly more than in proportion to availability. Of the shrubs, Ribes spp., Dasiphora spp., Caragana spp., Syringa oblata, and Lespedeza spp. were selected in greater proportion than its availability. Graminoid species used significantly more than expected included Tragus mongolorum, Calamagrostis spp., and Echinops spp.. Forb species, including Urtica spp. and Thymus spp. were used significantly more than available. Deer preferred montane grassland and montane conifer forests, and used montane savanna in proportion to its availability. Red deer avoided subalpine shrublands and meadows. Red deer preferred mixture habitats, and avoided habitats dominated by Juniperus rigida and Pinus tabulaeformis. Deer showed a strong preference for slope exposed to the sun, and avoided shady slope. Red deer preferred lower slope, and avoided upper and middle slope. Compared with random plots, usage sites were characterized by more shrubs, higher food abundance, lower slope, shallower snow cover and approach to water. Most sites were located farther away from bare rock and human disturbance. Results of principal component analysis showed that the first 6 principal components explained 84.89% of the total variance among all habitat factors. PCA indicated that vegetation type, tree density, shrub density, slope degree, slope direction, snow depth and distance to water were important factors in habitat selection.

(Poster presentation.)

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Conservation status quo and study progress of Siberian musk deer (*Moschus moschiferus*) in China.

J. Wu and Y. Zhang

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In China, Musk deer mainly distribute in Heilongjiang, Jilin, Mongolia provinces etc. It is national degree T conservation animal, listed in CITES appendix U. Recently, no more than 4000 musk deer are reserved in China, and the number is still reducing that caused by illegal capture for economic benefits and lost of suitable habitats. Mountain close for plantation, natural forest protection project and plenty of wildlife nature reserve establishment protect the habitat of musk deer effectively. In addition, a series of legislation were established to protect wildlife and reinforce the conservation of musk deer. The habitat selection and food composition of musk deer was investigated in Huzhong and Tonghe of Heilongjiang province since 2004 following some results: musk deer prefer to the coniferous broadleaved forests, frequently inhabit in the plots that full of cliff bid stone. The habitats are characterized by high altitude, small canopy, abundant food and steep slope. The diet consist of 84 plant species of 56 families, including 33 wood plants (39.28%), 23 herbages (27.38%), 16 mosses (19.05%), 6 ferns (7.14%), 6 lichens (7.14%). The musk deer mainly graze the tip of the plants, such as twig, wand and tender. The mostly food is the twig of wood plants for the whole year especially the low shrub. The wood plants consist of *Rhododendron dauricum*, *Acer mono*, *Deutzia glabata*, *Populus ussuriensis* and *Tilia amurenssis* etc. and the herbage consist of *Carex callitrichos* and *Caulophyllum robustum* etc.
(Poster presentation.)

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Agonistic and non-agonistic behaviour interactions in Indian blackbuck (*Antelope cervicapra* L.) during dominance hierarchy formation.

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The limited availability of necessary resources, such as food, shelter, space and mating opportunities (i.e. selection of female for mate), provokes an agonistic and non-agonistic interaction that lead to the establishment of dominant hierarchies. These interactions may leads to fighting, chasing and the formation of dominance hierarchy

that determines the order of access to both present and future resources. The present investigation was carried out at Arignar Anna Zoological Park, Vandalure, Chennai, to assess the frequency and duration of agonistic (i.e. fighting, chasing and scent marking) and non-agonistic behaviours (i.e. resting and feeding), before, during and after the formation of dominance hierarchy (i.e. determine the territorial ownership) in blackbuck herd. We selected two types of blackbuck groups i.e. dominant and subordinate males. Behaviour was recorded by focal sampling method at intervals through the study period. During field observation, before hierarchy formation the dominant buck spent more time in offensive display, while subordinate buck spent more time in defensive locomotion, although offensive display was strongly affected by subordinate buck for formation of higher social status. Moreover, during hierarchy formation the dominant buck showed higher frequency of scent marking, reproductive and feeding behaviours as compared to subordinate buck followed by before and after hierarchy formation. After the hierarchy was formed, if dominant buck becomes subordinate, then it showed very little aggressive behaviour and spent much more time on resting and submissive behaviour. The occurrence of agonistic and non-agonistic behaviours in blackbuck herd clearly indicates that before and during dominance hierarchy formation, the fighting and chasing behaviours are inflicted injuries in subordinates. The results suggest that dominant male scentmarking odours (pheromonal cues) may rely on strategies to suppress the aggression, mating, scent-marking, scent production, territorial patrolling activities in subordinate bucks, through which the dominant male exhibits its hierarchy and success in reproduction. *(Poster presentation.)*

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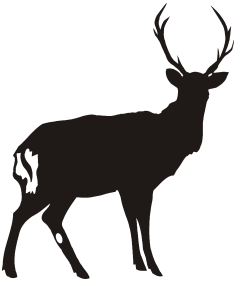

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Gossypol-based contraception in male deer (*Cervus elaphus*).

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Semen samples from 4 adult red deer (*Cervus elaphus*) fed cottonseed (350g for 109 days) as a source of gossypol (15mg/kg body weight/day) were analysed quantitatively and qualitatively by classical methods used in domestic animals. The data from 182 ejaculates were compared with those obtained from 571 ejaculates of stags (n = 5) during three previous natural reproductive seasons. Spermatozoa of mature male deer fed cottonseed exhibited an increase in morphological abnormalities (strongly folded tails) and a decrease in motility, and concentration, leading to decreased semen quality but no detectable side effects in the animals. Follow-up during the next reproductive season when gossypol ingestion was discontinued revealed a return to baseline values for average sperm concentration and motility. These findings point to the influence and safety of gossypol fed to deer in the form of cottonseed as an efficient male contraceptive.
(Oral presentation.)

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The hoarse vocalization and the inflatable laryngeal air sac of reindeer (*Rangifer tarandus*).

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The vocal tract of reindeer has evolved an inflatable ventrorostral laryngeal air sac. This air sac is not present at birth but emerges during ontogenetic development. It protrudes from the laryngeal vestibulum via a short pneumatic duct. In the female the growth of the air sac stops at an age of 2-3 years whereas in males it continues to grow up to an age of about 6 years leading to a pronounced sexual dimorphism of the air sac. In both adult females and males the ventral air sac walls touch the integument. In the adult male the air sac is laterally covered by the mandibular portion of the sternocephalic muscle and the skin. Both sexes of reindeer have a double stylohyoid

muscle and a thyroepiglottic muscle. These muscles may assist in inflation of the air sac. Head and neck specimens were subjected to macroscopic anatomical dissection, computer tomographic analysis, and skeletonization. Acoustic recordings were made during a fall round-up of semi-domestic reindeer in Finland and in a small zoo herd. Male reindeer adopt a specific posture when emitting their serial hoarse rutting calls. Head and neck are kept low and the throat region is extended. In the ventral neck region, roughly corresponding to the position of the large air sac, there is a mane of longer hairs. Neck swelling and mane spreading during vocalization may act as an optical signal to other males and females. The air sac, as a side branch of the vocal tract, can be considered as an additional acoustic filter. Individual acoustic recognition may have been the primary function in the evolution of a size-variable air sac and this function is retained in mother-young communication. In males sexual selection seems to have favoured a considerable size increase of the air sac and vocalization became restricted to the rutting period serving the attraction of females. We propose two possibilities for the acoustic function of the air sac in vocalization that do not exclude each other.
(Oral presentation.)

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Patterns of long-term reproductive success in male and female white-tailed deer.

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Female white-tailed deer (*Odocoileus virginianus*) occur in small groups dispersed throughout brushy habitats. Male mating tactics such as harem holding, resource defense, etc., are not profitable in these environments, so males use a wandering strategy to locate individual estrous females. Although ecological and behavioral factors are known to affect the reproductive success of males, there are few long-term studies of reproductive success in ungulate species. We used genetic parentage assignments over 11 annual fawn cohorts to investigate the variance in long-term reproductive success (LRS) of male and female white-tailed deer on a 1,200-ha management area in Oklahoma, USA. Estimates of LRS during the study period indicate that for successful breeders, male LRS was higher and more variable than that of females (male mean = 2.5, var = 6.2, maximum = 12; female mean = 1.7, var = 1.1, maximum = 7). Reproductive success was strongly age-dependent for both sexes, with

86% and 67% of offspring assigned to females and males Ý3.5 years old, respectively. Breeding lifespan (L) was an important determinant of female LRS, but variance components of L and annual fecundity (F) covaried negatively, indicating that the advantages of living longer could be offset through variable fecundity among years. Circumstantial evidence indicates that fawn survival also is an important factor in female LRS, since few females successfully recruited twin fawns within years or single fawns in successive years. These observations may reflect the importance of adequate nutritional reserves or maternal experience in fawn recruitment. Variance components for male L and F were similar, suggesting that males could achieve high LRS either by living longer or through increased F. A positive covariance between male L and F is consistent with greater F for older males. This study, the first to document LRS in white-tailed deer, emphasizes the differential effects of behavioral, ecological and life history variables on fitness between the sexes. The reproductive success of individual males is limited and breeding is distributed among a greater number of males in this mating system. As a result, the difference in LRS between the sexes in white-tailed deer is much less than in other ungulate species, which are highly polygynous.
(Oral presentation.)

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Observations on the reproductive behaviour of sambar deer (*Cervus unicolor unicolor*) in a bush enclosure in Victoria, Australia.

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The reproductive behaviour of sambar deer (*Cervus unicolor unicolor*) was monitored in a 13ha forested enclosure in Victoria over a twenty-year period during which time sixty-one calves were born.
Antler casting was relatively synchronised in stags, but variable in timing from year to year and was recorded from November through February, peaking during January. Antlers were normally hard and cleaned of velvet in May-June. Signposting by stags comprised antler rubbing, wallowing, scraping and preaching and commenced from the time antlers were cleaned of velvet through until just prior to casting. These activities were recorded from May through December, peaking in September. The activity most frequently recorded was wallowing, with stags as young as five-months-of-age taking part. Wallowing, particularly in the dominant stag, was clearly sexually related. Changes in antler status (antler casting) influenced a temporary change in dominance rank. A dominance ranking in both males and females was evident. An oestrus cycle of about twenty days appears likely and the data was suggestive of a gestation period of about 260 days. The mean age at which seven hinds first conceived was 16.3 months (Range 14.3-20.1), and parturition of first calves occurred at a mean age of 24.9 months (Range 22.8-28.6). One eighteen-year-old hind born in the enclosure reared fourteen calves, another, a yearling when introduced, was known to

have borne twelve calves when, at the age of fifteen years, she escaped from the enclosure. The length and timing of breeding and calving seasons of sambar in the wild has been the subject of conjecture in the literature. Based on a 260-day gestation period, we found conceptions to have occurred in all months excepting February, March, and December, with peak breeding activity taking place from June through November. One conception occurred during January, in a year in which stags did not cast antlers until February. Two hinds conceived when stags were in late stages of antler growth. Births peaked from March through July with none occurring from October to December, nor during February.
(Oral presentation.)

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Sexual choice in lekking fallow deer (*Dama dama*): variable female strategies.

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Here we report one of the first analysis of female mating strategies in lekking fallow deer. The present work try to answer two basic questions. Do females use different strategies of mate selection at lek? If so, do such strategies depend on costs and/or experience of females?
We studied the behaviour of 10 radio-collared and 92 ear-tagged fallow deer females during 4 rutting periods (2000 to 2003) in the Preserve of Castelporziano, Rome. Each female was assigned to a distance class (distance between home range and lek) and this was assumed to be a proxy for the cost of moving to the arena. Since most of females use to visit the lek every year, their age covaries with experience. Younger females spend more time at lek and mate significantly later than adult ones. We interpret the observed increase in the variance in male reproductive success observed after the peak of the rut, as determined by an increase in the unanimity of female choice because young fallow does copy the mate choice of adults. Females living close to the lek, begin to visit the arena early in the rutting period where they spend much time (up to 208 hours), maybe to have the opportunity to assess the quality of the largest number possible of bucks. On the contrary, females living farther from the arena visit males at lek only the time strictly necessary for mating. To increase the precision of choice, these females make use forms of indirect assessment of male quality, such as association to other females and selecting territories which were characterised by high male success in the precedent year, but they do not seem to copy the choice of other females.
Females living at more than 8 km from lek usually do not to visit the arena, since costs for moving are probably too high. Besides, we demonstrate that non-independent strategies of male quality assessment do not results in the same benefits of direct assessment.

(Oral presentation.)

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Variation in fawn production in a semi arid environment: An energetics approach.

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Fawn recruitment is a critical demographic parameter in management of deer populations. In semi-arid southern Texas, USA, fawns are born in June and July when forage production are influenced heavily by heat and precipitation. Thus, fawn recruitment is positively correlated with spring-summer rainfall. Whether low fawn recruitment during drought is the result of increased predation from poor hiding cover, poor forage quality for the doe, or a combination of both, is unknown. Understanding the relative effects of predation and nutrition on recruitment is important in designing management programs to increase fawn recruitment. For example, some management programs seek to increase grass cover, which provides additional hiding cover at the expense of high quality forage. To test the idea that forage quality could limit reproduction in a dry year, we modeled energy intake and energy expenditure of a doe from breeding in December through fawn weaning in September. The model tracked the does fat reserves and when her body fat dropped below 5%, we assumed she was in too poor condition to finish raising her fawns. Diet quality and initial doe fat reserves were varied to understand their interactions. A doe consuming a poor quality diet, such as that expected when consuming browse, could not produce fawns, even if the doe had large fat reserves in December. A deer consuming a high quality diet was able to raise fawns even if she was in poor condition when she was bred. On an annual diet consumed by deer in South Texas (high quality in late winter, moderate through the spring, and poor in July and August), deer needed to enter the reproductive season in good body condition to successfully produce fawns, otherwise they mobilized all their fat reserves before their fawns were weaned. Our model suggests that poor fawn production during dry summers is caused in part by nutritive failure. Management projects that seek to increase fawn cover at the expense of high quality forage plants could be detrimental.

(Oral presentation.)

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Movements of female white-tailed deer during parturition and the rut in a high-quality, balanced sex ratio herd in Maryland, USA.

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White-tailed deer (*Odocoileus virginianus*) movements are affected by life history, density, and demographics. Many white-tailed deer herds have low numbers of males because of past harvest strategies. We examined deer movements during peak life-history events in high-quality deer habitat with balanced sex ratios (approximately 1:1.5) and overall deer density of 25-30 deer/km^2. This study was conducted on Chesapeake Farms (Kent County, Maryland, USA). We attached 16 GPS-telemetry collars to does during the spring of 2001 (n = 10) and 2002 (n = 6). Seven does were also fitted with vaginal-implant transmitters to monitor fawning (n = 6 and 1 for 2001 and 2002, respectively). Twelve collars collected useable location data pre- to post-parturition. Two collars collected data during autumn. Mean adaptive kernel summer home-range size was 32.3 ha. Mean parturition date was 28 May (27 May 3 June). Mean 4-hr distances (straight-line distances between 4-hr locations) for mature does 10 days prior to parturition, 10 days surrounding parturition, 1-10 days after parturition and 11-20 days after parturition were 202.4 m (SD = 238.8), 131.2 m (SD = 159.3), 104.5 m (SD = 94.7), and 154.5 m (SD = 141.9), respectively. Does restricted movements during parturition and shortly afterwards; however, they resumed normal movements after 10 days post-birthing. Female white-tailed deer have been shown to exhibit 2 different behaviors during breeding depending on male density. Females reduced movements to ensure predictable locations with high male density. With low male density, does increased movements to actively search for mates. The 2 collared does exhibited movements indicative of an active search strategy even though males were not limiting. The 5.5 year-old doe in 2001 increased her daily mean 4-hr movements from 320.0 m (SD = 260.4) on 11 November to 966.1 m (SD = 844.7) on 12 November and returned back to lower activity on 13 November (200.3 m, SD = 222.3). These movements were across a tidal creek and outside of her normal home range. The 3.5 year-old in 2002 exhibited a similar pattern. On 8 November, her daily mean 4-hr movements were 166.6 m (SD = 166.5). She increased these movements on 9 November (368.0 m, SD = 408.0) and returned to lower movement (130.5 m, SD = 183.1) on 10 November. We were able to observe these movements with the GPS technology and they corresponded to peak rut dates based on fawning data. Potential active search strategy by does in an area with high male density may indicate female mate choice, provide a mechanism for inbreeding avoidance, and enhance reproductive success.
(Oral presentation.)

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Refrigerated storage impairs chromatin of Iberian red deer (*Cervus elaphus hispanicus*) epididymal spermatozoa kept inside the epididymis.

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Postmortem time negatively affects seminal samples from the cauda epididymis, a potential source of spermatozoa for germplasm banks, and little is known about its effect on sperm DNA. We have studied the effect of chilled storage of genitalia on the chromatin of epididymal spermatozoa, obtained from the cynegetic species Iberian red deer (Cervus elaphus hispanicus). Testicles were collected from 29 stags harvested during the hunting season. The testicles (5 h postmortem) were put into tightly closed plastic bags, placed in a beaker with water and then stored at 5ºC. At 0, 24, 96 and 192 h, sperm was extracted from the cauda epididymis by means of cuts. Chromatin was assessed by flow cytometry after detergent-acid (pH 1.4) treatment and acridine orange staining. We obtained the parameters SDat (sperm heterogeneity regarding chromatin status), DFIm (% spermatozoa with moderate DNA Fragmentation Index) and DFIh (% spermatozoa with high DNA Fragmentation Index). The effect of storage time was analyzed by linear mixed-effects models, including male as random effect, and time as fixed effects (covariate). The models showed and increase in all the parameters, indicating that storage time negatively affected chromatin status ($P<0.01$ for SDat and mDFI, and $P<0.1$ for hDFI). Thus, results at 0 h were (mean¹SD): SDat: 2.1¹1.4: DFIm: 0.4¹0.6%; DFIh: 0.1¹0.2%; whereas at 192 h, results were: SDat: 3.3¹1.6: DFIm: 1.6¹1.5%; DFIh: 0.2¹0.3%. In conclusion, red deer epididymal spermatozoa underwent chromatin damage during chilled storage inside the epididymes. Nevertheless, the impairment were not very important, therefore epididymal samples may be stored inside the epididymes for a long time if necessary, being still usable for IVF or ICSI techniques. However, this situation should be avoided whenever possible.

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(Poster presentation.)

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Immunohistochemical expression of steroidogenic enzymes in the corpus luteum and placenta of sika deer (*Cervus nippon*) during pregnancy.

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Multiple (usually two) corpora lutea (CLs) are often found in the ovaries of sika deer, although they basically deliver a single fawn. Since the corpus luteum (CL) is the major structure that secretes progesterone, we presume that the existence of multiple CLs affects the achievement and maintenance of pregnancy. In this study, we investigated the expression of steriodogenic enzymes, i.e., cholesterol side-chain cleavage cytochrome P450 (P450scc), 3â-hydroxysteroid dehydrogenase (3âHSD), aromatase cytochrome P450 (P450arom) and 17á-hydroxylase cytochrome P450 (P450c17), to compare the process of steroids production and the localization of immunostaining cells between two CLs found in individual animals during pregnancy. The placenta also synthesizes progesterone; however, the synthesis pattern differs depending on the species. Then, we also applied the same analysis to placenta in sika deer. Ovaries, placentae and fetuses were collected from pregnant female sika deer which had been killed for research during pregnancy periods (i.e., from December to May). Fetuses were used to estimate the gestation ages. Almost all luteal cells of both CLs expressed P450scc, 3âHSD, P450arom and P450c17 throughout pregnancy. During mating season, only luteal cells located in the periphery of the CL showed positive immunostaining in latter formed CL. However, both CLs were similar in terms of their immunostaining pattern during pregnancy. There were small luteal cells (thecal cells) and large luteal cells (granulosal cells), and both reacted similarly at least until middle stage of gestation, when small luteal cells could be rarely observed. Regarding the placenta, immunoreactions of P450scc, 3âHSD, P450arom and P450c17 were observed mainly in the chorionic villi at all gestational stages studied and tended to be strong in trophoblast giant cell. These results suggest that throughout pregnancy, both CLs have similar capabilities for synthesizing steroid hormones. And also, the placenta as well as the CL has probably the ability to synthesize progesterone, estrogen, and androgen throughout pregnancy, and both organs may play an important role in the maintenance of pregnancy in sika deer.
(Poster presentation.)

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Objective quality control of frozen-thawed red deer spermatozoa by Computer-Assisted Semen Analysis - instrument settings.

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Cryopreservation of spermatozoa as a tool for genome resource banking of wild animals is well known. Moreover, artificial insemination with frozen-thawed sperm is already used in breeding of some farmed wild species like deer. Computer-Assisted Semen Analyzers (CASA-s) are useful for the quality control of frozen-thawed sperm as they are able to measure several parameters at cellular level and on a high number of cells; however, they require different instrument settings for the different species. The aim of the present study was to establish a red deer-specific CASA setting. During the rutting season of 2004, epididymal sperm samples of five red deer (*Cervus elaphus hippelaphus*) stags were collected post mortem in South-west Hungary. Samples were processed in a commercial bovine semen extender (BioXcell, IMV, LAigle, France), filled into 0.25 ml straws then they were frozen by holding in liquid N_2 vapor. Final cell concentration was adjusted to 100 x 10^6/ml. Initial motility was assessed visually under a phase contrast microscope at 200x magnification. For the post-thaw quality control by CASA (Medealab, MTG, Altdorf, Germany), sperm samples were thawed by holding the straws in a 38° C water bath for 10 sec, diluted to approximately 50 x 10^6/ml with BioXcell, then measurements were taken on 12 fields per sample, using a 20x Negative High Contrast objective and a 20 μm deep counting chamber and a heated microscopic stage. Species specific Average Path Velocity (VAP, μm/s) threshold values of the different categories (nonmotile, slow progressive, fast progressive spermatozoa) were calculated by k-cluster analysis (Statistica for Windows 6.0).The VAP threshold values revealed by k-cluster analysis were the following: Nonmotile: <10 μm/s; Slow progressive: >20 μm/s; Fast progressive: >80 μm/s. With the help of this objective quality control method, our laboratory is ready to build a red deer sperm bank by collecting and freezing spermatozoa of the stags hunted in Hungary.
(Poster presentation.)

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Immunohistochemical expression of androgen receptor (AR), estrogen receptor alpha (ER) and estrogen receptor beta (ER) in the caudal and metatarsal glands of sika deer (*Cervus nippon*).

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The presence of hormone receptors has been reported in the skin appendages of cervid species such as red and sika deer. According to previous studies, it has been indicated that the mane follicles and skin glands of deer are under endocrinological regulations. In this study, we investigated the immunohistochemical expression patterns of androgen receptor (AR), estrogen receptor alpha (ERα) and estrogen receptor beta (ERβ) in the caudal and metatarsal glands of sika deer to determine whether these large skin glands are regulated by sex steroid hormones. All samples were collected from adult females and males shot for research purposes during the non-breeding season (from March to May) on the island of Hokkaido, Japan. Immunoreactivities to the three kinds of receptors were detected uniformly in the nuclei of secretory epithelial cells of the caudal gland. These immunoreactivities were also observed in cell nuclei of sebaceous glands and root sheaths of hair follicles in the metatarsal gland. Expression patterns of these three receptors basically resembled each other in both the caudal and metatarsal glands. In sebaceous glands of the metatarsal gland, however, immunoreactivities of ERs tended to be weak and limited to cells near the marginal area of the glands, as compared with those of AR. These results suggest that secretions of the caudal and metatarsal glands and development of specific white hair at the metatarsal gland area are influenced by sex steroid hormones in sika deer. However, the difference in the steroid receptor immunoreactivities between females and males was not clear in the present work. This may be due to the fact that all samples were collected in the non-breeding season. Therefore, in order to fully discuss sex differences in skin gland regulation systems, the same analysis should be conducted by using samples obtained during the breeding season.
(Poster presentation.)

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Comparison of estrogen receptor and progesterone receptor expression during the estrus and pregnancy in uteri of sika deer (*Cervus nippon*).

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Recently, the wild sika deer population has been increasing in Hokkaido, Japan, and they cause serious problems such as agricultural damage and forest destruction. The pregnancy rate of sika deer is very high, usually over 90% in a high quality population. For the maintenance of pregnancy, it is necessary to inhibit luteolysis that induced by PGF2á secreted from the uterus. The PGF2á secretion from uterus is regulated by sex hormones; therefore, the expression pattern of receptors in the uterus during pregnancy must be altered from that during the estrus. However, the localization of hormone receptor in the uterus has not been reported in sika deer. In this study, immunohistochemical expression of estrogen receptor (ER) and progesterone receptor (PR) in the sika deer uterus during the estrus and pregnancy period (early, middle, and late) were detected. Uteri were collected from wild sika deer that were killed for damage control or research purpose. Localization and immunoreactivities were detected visually in the luminal epithelium, gland, stroma, and myometrium of uteri. During the estrus, both ER and PR were expressed in the uterine cells such as shallower gland and stroma. As pregnancy progressed, the expressions of ER and PR in the uterus become decreased and weaker than those of estrus. In the late pregnancy period, both ER and PR could scarcely be detected, and even when detected the immunoreactivities were very low. These results are corresponded with previous reports on ewes wherein it was found that both the ER and PR expressions were enhanced by estrogen and inhibited by progesterone. In the early pregnant uterus of hinds, ER expressions were similar to estrus whereas those were very weak even in very early pregnancy in cows and ewes.
(Poster presentation.)

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Roaring trends in red deer: a preliminary analysis.

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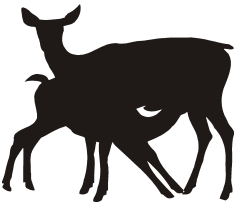
Red deer call loudly and repeatedly during the breeding season to assess dominance between males (Clutton-Brock & Albon 1979). McKomb (1987) showed how roaring can also induce/accelerate ovulation and that harem-holding males can improve their mating success by calling repeatedly. Roaring rates change throughout the course of the rut, with a slow increase of the number of roars/minute, a peak and a sharp decline (Clutton-Brock & Albon 1979). We tried to study the roaring trend of a mature population of red deer and its variability in relation to climatic variables. Within a wider research project (red deer spatial behaviour, Eastern Italian Alps, Natural Park of Paneveggio-Pale di San Martino), we studied some features of roaring behaviour in 2004 and 2005. We noted down the number of roars/hour (roaring rate) during a period of 24 hours (daily trend only for 2004) or 6 hours (trend during the whole rutting period) to estimate the roaring trend. We started our observations 1 hour before sunset, for the 6h period.
The 24h trend showed a peak 5-7 hours after sunset, with a significantly greater roaring activity at night than in daylight (Mann-Whitney U test: n1=65, n2=55, U=432, p=0.000). On the contrary, in Rhum Island, Clutton-Brock & Albon (1979) found a diurnal consistent pattern, although with some variation across individuals. As to the 6h period, there was a higher roaring intensity in 2004 (mean value for the whole rutting period=143.9) than in 2005 (mean = 89.8); moreover, in 2004, the roaring peak lasted longer (12 days) than in 2005 (9 days).
We estimated the influence of climatic variables on roaring (mean daily temperature, precipitations and humidity). A significant negative correlation was found between roaring rate and mean daily precipitation, in 2004, for the whole period (Spearman rank correlation coefficient: N=15, R=-0.609, p=0.03) as well as during the peak (Spearman rank correlation coefficient: N=9, R=-0.842, p=0.004). In both years, a significant negative correlation was found between roaring rate and mean humidity (Spearman rank correlation coefficient: 2004, N= 15, R=-0.736, p=0.02; 2005, N=13, R=-0.582, p=0.04).
Acknowledgement: Parco Paneveggio-Pale di S. Martino, I. Angelini, E. Brunello, D. Gabaglio, M. Ruggiero.
(Poster presentation.)

Behaviour and welfare



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Assessing the performance of a Persian fallow deer population 10 years after reintroduction.

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We evaluated the size and range of a Persian fallow deer (*Dama mesopotamica*) population in Israel, 10 year after its reintroduction began. We compared our results with projections of a spatial-demographic model developed in 2002 based on data from the first 3 years of the reintroduction. A total of 80 adult (>1 year old) females were released between 1996-2005, of which 75 were radio-collared. We estimated female population size using a modified Lincoln-Petersen index based on the proportion of collared females amongst adult females sighted during 2005. We did this in several stages. First, we estimated the number of collared females in the population by simulating the survival for those females that were alive at the time their radio failed and adding to it the number of females with transmitting radios at the end of 2005. Based on 5000 simulations, the mean number of collared females in the population was estimated at 21.3 (95% CI =17-25). Second, based on direct sightings during 2005 we estimated the proportion of collared females in the population as 0.29 with a S.E. 0.09 (N=24). Third, by multiplying each simulation output by a random normal value generated from the estimated proportion and S.E. of collared females, we constructed a distribution of population size estimates. The median of this distribution was 73.3 and the low-end 95% CI was 46. The 2002 model predicted 67 females by the end of 10 years with a lower 95% CI of 54. Based on 66 direct observations between 2003-2005 the population ranges over ~70 km^2, which is also in agreement with the 2002 model projections. The slow growth during the first 10 years was predicted by the model and is attributed to the low first-year post-release survival (<85%) and reproductive success. The effect of these factors is expected to subside as the ratio of captive- to wild-born animals declines. Thereafter, the population is expected to grow exponentially and reach 400-600 females within 50 years. Observed growth of the wild Persian fallow deer population in Israel is consistent with projections, and we conclude that it is performing well.
(Oral presentation.)

114
Social competence in Chinese muntjac deer.

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Subdominant animals in groups of mammals live under continuous strain due to the presence of dominant individuals of the same sex. They are suppressed in different ways and have to develop an ability to cope with this, using the space remaining in their specific situations to generate well-being and to develop their species` specific behavior. This situation of a subdominant animal is investigated in a morphologically conservative deer species, the Chinese muntjac (*Muntiacus reevesi micrurus*), which is mostly described as solitary living animal. Which spatial and social mechanisms does it use and which abilities are required and developed while growing up and remaining in a group ? Which internal states are involved and how are performances individually shaped? In nearly 500 hours of observation breeding groups of three to eight muntjacs of different ages, kept in enclosures of 1,800 - 2,500 m^2, were studied, recording about 250 behavioural units. The data concerning the use of the spatial areas, different forms of activities, resting behaviour and social contacts, combined with the accompanying postures indicating the internal states. With the arrangement of a cartesian coordinate system it was possible to include the distance between two animals at any time to estimate social relations influences. Discussed are individual skills in coping with changing situations, the implications of social relationships and the amount of experiences. First approaches to access the animals` knowlege about their situation are tried. To describe and to analyse the different influences of the various factors a model distinguishing three levels has been designed. This type of study provides complementary insights into what constitutes a fully developed healthy animal including its adequate motivational and affective states. Such knowledge is important in different fields of research and application, for example it allows to improve the animals' living conditions and to access in captive and free-living individuals the extend of their actual well-being.
(Oral presentation.)

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The analysis of sexual segregation in fallow deer (*Dama dama*) on different time and space scales.

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Throughout the analysis of long-time series census data (1984-2003) and by means of radio-telemetry (1997-2001; 23 females and 25 bucks), we assessed fallow deer spatial and habitat sexual segregation on different spatial and temporal scales in the San Rossore Estate (Italy). The combination of different studies performed in the same area allows us to show that a detailed analysis can outline a situation in which more than one theory is valid for explaining sexual segregation in the same species, as probably several factors act on different temporal and spatial scales. From 1984 to 2003 females gradually abandoned the eastern disturbed sector of the Estate, the only area affected by human presence (increased year by year from 1984), to the detriment of the western undisturbed sector. Males remained in the eastern sector, in spite of the increasing disturbance, supporting the predation risk hypothesis (large spatial and large temporal scale). From 1989, males gradually increased their presence in the disturbed sector, as they benefited from lower female density, avoiding areas with higher female density, supporting therefore the indirect competition hypothesis (large spatial and large temporal scale). Inter-sexual competition was pronounced in a small area inside the undisturbed sector affected by habitat modification during the 1980s, when a scrub area was converted to an open pasture, and this phenomenon further incited males to leave this area and reach the disturbed sector, supporting again the indirect competition hypothesis (small spatial and large temporal scale). As a final result of this long term process, during the last five years we showed that males used consistently disturbed areas, both during the day and the night; instead, females frequented eastern disturbed areas only during the night, when human presence was absent. Therefore, large scale segregation recorded during the day disappeared during the night, when females usually reached the eastern sector, supporting again the predation risk hypothesis (large spatial and small temporal scale). Nevertheless, sexes segregated on a small scale inside this area, as they showed different habitat choices, supporting the forage selection hypothesis (small spatial and small temporal scale).
(Oral presentation.)

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Behavioural modifications of female ungulates during late pregnancy and early lactation: the case of fallow deer *Dama dama*.

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Mammalian females exhibit complex behaviour patterns during weaning as a response to energetic requirements and as antipredator behaviour, but this aspect is still widely unknown for female ungulates. We analysed how pregnancy and lactation could influence space use, habitat selection and time budget in female fallow deer. The study was performed in two study areas (n = 23 and n = 15 adult females) of Tuscany (Italy) using radio-tracking techniques and direct observation, respectively. Home range analyses showed marked differential spatial behaviour between calving and non-calving females only when fawns were present. Lactating does occupied smaller home ranges than non-lactating ones only after the birth period. Habitat choices were significantly different since late pregnancy, when mothers reached parturition site. During parturition and lactation, calving females showed a higher use of marshes, which provides good concealment for fawns. Calving females avoided rich areas with short-grass meadows, since these are without any kind of concealment for fawns, while they were selected by non-calving females because of their productivity. During lactation mothers increased time spent foraging. Aimed to generalize behaviour patterns of female ungulates during parturition season, we compared fallow deer behaviour to those recorded in other ungulate researches. Furthermore, we made a comparison with a study performed by our research group on Alpine ibex (*Capra ibex*), a species phylogenetically distant (alpine ibex bovid vs. fallow deer cervid), living on a different environment (Alpine habitat vs. Mediterranean habitat) and characterized by a different young behaviour (*follower* strategy vs. *hider* strategy). Even though these differences, ibex females (n = 28) showed a similar behaviour during parturition season. Lactating ibex females showed smaller home range than non-lactating ones after the birth period. Mothers preferred rocky slope areas and likely they moved to sub-optimal but safer habitats during lactation in order to reduce the predation risk for their offspring, and at the same time they increased food intake. This study show that ungulate mothers may move to sub-optimal habitats, compromising their energy intake, to reduce the predation risk to their neonates, but compensating by spending more time foraging and having a higher bite rate.
(Oral presentation.)

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Pre-orbital gland opening in red deer (*Cervus elaphus*) calves: Signal of excitement?

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The opening of the pre-orbital gland of red deer (*Cervus elaphus*) calves has been previously associated with feeding and achieving satiety. However, it has been suggested to be most likely affected by some other factor or factors, possibly by excitement of the calf. If so, a calf should open its pre-orbital gland while being exposed to any stressful procedure. The hypothesis was tested that the pre-orbital gland is closed in a relaxed calf while it is opened in a stressed calf. Pre-orbital opening was observed in 41 newborn farm red deer calves during a regular daily routine consisting of a search for new born calves, their inspection, weighing and painful marking with an ear tag. The openness of the pre-orbital gland (pre-orbital gland closed or opened) was recorded just prior to manipulation of a lying calf (i.e. in a calm calf), and then during the manipulation (i.e. in a distressed calf). Prior to manipulation, in all but three calves (7.32 %, all of which were males) the pre-orbital gland was closed. All of the observed calves (100 %) opened their pre-orbital gland during their manipulation, at least by the time when the ear was punctured by the ear tag. Thirty eight calves (92.68 %) behaved along with the advanced hypothesis ($_{(1)}$ = 29.88, $P < 0.0001$). That is, the gland was closed prior to manipulation, and was open after the calf was exposed to the stressful event. The openness of the pre-orbital gland in newborn red deer calves was invariably associated with a stressful manipulation by the humans. This suggests that it is likely a signal of calf excitement.
(Oral presentation.)

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The effect of the birth weight on the calf's allosucking success in the red deer (*Cervus elaphus*) supports the compensation hypothesis.

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The allosucking behaviour was studied in a number of ungulate species including the red deer (*Cervus elaphus*). The allosucking calves are expected to be favoured over

the non-allosucking ones because of a surplus milk intake from non-maternal hinds. In general, there are two reasons why the calves may be motivated to suck the non-maternal hinds. The calves may try allosucking either (1) to gain competitive advantage over their peers or (2) to minimize inter-individual differences in the body size. The aim of this study was to test the second "compensation hypothesis" (Bartoš et al. 2001, Anim. Sci. 72: 493-500) presuming an increase in allosucking motivation with the calf's lower birth weight. Two groups of animals differing in the number of hinds and calves (hinds/calves: n = 18/7 and 28/14) were observed. The (allo)sucking success of the calf was expressed as a probability of its sucking by the hind. The probability of successful sucking was modelled using logistic regression (proc GENMOD for repeated measures, SAS V9) with predictors being the calf's birth weight, age, sex, fighting success and aggression of the allonursing hind tested. Out of 1131 sucking events and 303 sucking attempts, we recorded 177 allosucking events and 87 allosucking attempts, respectively. In agreement with the advanced hypothesis, probability of the successful sucking decreased with the calf's birth weight ($\chi^2_{(4)}$ = 10.38, p = 0.0345). This was affected by the calf's sex and by the nursing status of the hind. In terms of sucking, male calves were more successful than female calves sucked by their mothers, while in non-maternal hinds it was the opposite. Probability to suck decreased with the calf's age ($\chi^2_{(1)}$ = 6.42, p = 0.0113). Relatively greater allosucking success of the female calves might result from the inter-sexual difference in the birth weight, with the female calves being significantly (t = 2.86, $N_{(M)}$ = 11, $N_{(F)}$ =10, p = 0.009) lighter than the male calves. Thus, our results support our compensation hypothesis.
(Oral presentation.)

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Do red deer (*Cervus elaphus*) grandmothers nurse their grandchildren?

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Besides maternal investment to their progeny red deer hinds often nurse non-filial offspring. However, causes of such behaviour are not yet fully understood. Across studies, large individual variability in the incidence of allonursing has been reported. It is presumed that the incidence of allonursing is influenced by kinship. Therefore, we tested whether the hinds which nurse the non-filial calves are their grandmothers or their matrilineal relatives. In three successive seasons, suckling behaviour was observed in a herd of farmed red deer hinds having calves between parturition and weaning. From 3952 sucking solicitations recorded in 57 calves mothered by 27 hinds

falling into 15 families, 1047 were immediately terminated by the female ("prevented sucking attempts") and 2905 were accepted ("nursing"), 24.74 % of prevented sucking attempts and 9.43 % of nursing being non-filial. Within non-filial sucking solicitations when a lactating grandmother was present in the herd (13 calves, 240 solicitations), all of the calves except one solicited its grandmother considerably less frequently (10.00 % in total) than other non-maternal hinds ($\chi^2_{(1)}$=16.76, P<0.0001; Fisher exact probability test). The chance that a soliciting calf will be nursed (i.e. proportion of nursing from all sucking solicitations for the calf) was 3.8-times higher in its grandmother than in other non-maternal hinds. Nevertheless, this result disappeared when adjusted for repeated measures within a calf, because the one calf predominantly sucking its grandmother performed 83.33 % of all grandmothers solicitations ($\chi^2_{(1)}$=0.93, n.s.; logistic regression model, PROC GENMOD, SAS). In that grandmother, the probability she will nurse her grandson did not differ from that of her filial calf (0.90 vs. 0.86, respectively), which contrasted to significantly greater probability of being nursed in filial (0.77) than non-filial (0.51) calves in general ($\chi^2_{(1)}$=11.21, P<0.001). We got similar results when we tested the effect of matrilineal relatedness between a calf and allonursing hinds: few solicitations led to a relative hind (12.77 % of 321), similar probability of being nursed in relative and non-relative non-filial calves (0.46 vs. 0.47, n.s.), except of the reciprocal allonursing in grandmother-daughter pair described above. Conclusion: The calves neither predominantly solicit relative hinds nor the kinship between the hind and the soliciting, non-filial calf would influence the hind decision to nurse it.
(Oral presentation.)

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When prey fight back: higher levels of aggressive defence by mule deer than whitetail females lowers vulnerability of mule deer fawns to coyotes early in life.

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Female defence of young is widespread in ungulates, yet little work has been done to investigate how this response affects predation on young. We observed naturally occurring predatory encounters between coyotes *(Canis latrans)* and deer fawns to test the hypothesis that a difference in aggressive defence leads to the differential vulnerability of mule deer *(Odocoileus hemionus)* and white-tailed deer *(O. virginianus)* fawns in summer, when fawns are 0 to 14 wks in age. Coyotes were less likely to attack mule deer than whitetail fawns they encountered, and were less likely to kill mule deer than whitetail fawns they attacked. The simple presence of a mule deer female near a fawn deterred coyotes from attacking, and this was not the case for

whitetails. Once attacked, fawns of both species were less likely to be killed when females defended them. However, mule deer females were far more likely to defend fawns and banded together to defend fawns, resulting in fewer captures of mule deer than whitetail fawns. These results indicate that higher levels of defence by mule deer females contribute to the lower predation rates reported for mule deer than whitetail fawns of this age group. It also raises the possibility that mule deer fawns, and even whitetail fawns, may have improved survival during summer when occupying areas with high numbers of mule deer females.
(Oral presentation.)

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Why Help? The evolution of altruistic antipredator defence in mule deer.

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Both white-tailed deer *(Odocoileus virginianus)* and mule deer *(O. hemionus)* females defend fawns against coyotes *(Canis latrans),* but only mule deer defend non-offspring conspecific and heterospecific fawns. At such times, females may have to decide whether to defend a fawn having imperfect information on its identity obtained from hearing a few distress calls. Playback experiments with fawn distress calls were designed to consider the role of imperfect recognition while testing functional hypotheses for fawn defence. Whitetail females only approached the speaker when whitetail calls were played and when their offspring was hidden, suggesting fawn defence was strictly a matter of parental care in this species. In contrast, mule deer females responded similarly and strongly regardless of the caller's identity (whitetail versus mule deer; own offspring versus unfamiliar conspecific fawn), the female's reproductive state (mother or non-mother), even when accompanied by their own offspring. This lack of behavioural discrimination revealed mule deer females did not defend non-offspring because they have imperfect information on their own offspring. Our results also suggest three traditional explanations for altruistic behaviour maternal defence of the offspring's area, kin selection and reciprocal altruism are unlikely to account for the mule deer's defence of non-offspring.
(Oral presentation.)

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Cooperative anti-predatory behaviour in sympatric white-tailed, fallow, roe and red deer: Experimental confirmation using a dummy.

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Our previous research has shown that grazing time in sympatric cervid species increased if the focal deer was joined by another animal regardless of the species or sex. We hypothesized that this served as an anti-predatory strategy based on interspecific cooperative behaviour among the species (Bartoš at al. 2002. J. Wildlife Manage. 66, 522-527). To experimentally test our hypothesis, we used a plastic dummy ("grazing deer") with a remote control that could prone the dummy into grazing position or lay the dummy down. From 2000 to 2005, we performed 52 observations (135 to 310 minutes each) in the Dobříš Forest, Czech Republic on six locations to get additional data for white-tailed deer (*Odocoileus virginianus*)- OV and fallow deer (*Dama dama*)- DD, and to complete observations for additional two species, red deer (*Cervus elaphus*)- CE and roe deer (*Capreolus capreolus*)- CC. We used the dummy at one location, and simultaneously used one or two other locations as controls. We switched between locations regularly and recorded the time spent on the pasture for any deer present. On the location with the dummy, when any deer entered the pasture and stayed there for 5 min, and was $\geq$ 130 m from the dummy, we erected the dummy and started the measurement. The analysis was performed by the GLM model (SAS) with factors "Dummy" (with or without), "Presence or absence of a dam with a fawn", "Observer", "Location", "Size of a group entering the pasture" and continuous variables "Time until another deer entered the pasture" and "Number of deer joining the focal animal". All species, OV, DD, CE and CC respectively, spent more time with a dummy (LSMEANs ± S.E.; OV 33.55 ± 2.69 min, n= 49; DD 30.56 ± 2.14 min, n= 50; CE 27.13 ± 1.64 min, n= 45; CC 33.64 ± 5.20, n= 13) than without it (OV 21.22 ±1.61, n=369, $P<0.001$; DD 24.01 ± 1.00, n= 361, $P<0.003$; CE 16.80 ± 1.42 min, n= 97; CC 23.41 ± 2.81, n= 28). Thus, our experimental results supported the hypothesis that all deer species, OV, DD, CE and CC, spent longer time on the pasture if a dummy was erected than when it was not.
(Oral presentation.)

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Rutting encounter between males and female choice in fallow deer (*Dama dama*).

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In male fallow deer (*Dama dama*) conflicts and fights during the rut are a frequent occurrence. It was postulated that a choice of the mate by a female is affected by the results of these encounters. The hypothesis was tested that a female will stay in a harem of the winner of an encounter, whereas she will abandon the loser. We observed interactions between adult fallow bucks and the responses of fallow does in the enclosure Březka (Czech Republic) during the rut in 1998-2000. For each encounter between two opponents we recorded: a) which male initiated and which won the encounter, b) did the encounter escalate into a physical fight, c) how many females were present up to 20m from each of the males and d) where the females moved during and after the encounter. A logistic regression model (PROC GENMOD, SAS) was fitted to estimate the probability that a female will desert the male she had accompanied before the encounter. Tested factors were: a) results of an encounter (winner/loser/tie) for the male the female came with, b) whether the male was an initiator of the encounter (yes/no), c) if the encounters escalated into a physical fight (yes/no), d) the presence of females accompanying the opponent (yes/no). The probability of a female's desertion was affected by the outcome of an encounter ($\chi^2_{(2)} = 7.44$, $p < 0.03$) and presence of females by an opponent ($\chi^2_{(1)} = 10.15$, $p < 0.01$). Female desertion was more frequent in losers (0.26) than winners (0.07) or in encounters without a clear outcome (0.16). When both opponents kept some females, the probability of a female desertion was significantly lower (0.04) as compared to the case when the male kept some females while his opponent had none (0.41). Neither initiation of the encounter, nor escalation to physical fight affected the probability of female desertion. Our data support the impact of an encounter outcome on a decision of fallow does to stay with or leave a male she accompanied before the encounter. The probability of a female to desert the male was generally low. That the presence of females accompanying the opponent decreased the probability of female desertion counteracts the mate-copy theory.

(Oral presentation.)

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Habitat selection and home range size of red deer (*Cervus elaphus*) in montane areas of Šumava National Park, Czech republic - preliminary results.

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Home ranges of 10 male red deer *Cervus elaphus* (age 3-6 years) were studied in 2005 in National Park Šumava, Czech Republic using GPS telemetry. Each animal was located 24 times a day. Winter enclosures are used for management of red deer in the national park (NP) to prevent harms in surroundings of NP, thus only summer data are available (May to November). Home range size ranged from 7,63 to 114,89 km^2, mean 40,78 km^2 (MCP 95%). Two different behaviours may be distinguished - sedentary (mean home range size 18,28 km^2 ± 10,49) and migrant (68,90 km^2 ± 32,57). Home range size did not differ significantly during rut season in comparison to summer. NP Šumava is covered mainly by spruce forest (more than 80%). Forest habitat was used by red deer in 58,99 ± 20,24% of locations, non-forested areas (meadows) was selected preferably. There is a significant difference in habitat use during night and day, non-forested areas are preferably selected by red deer during nighttime (high level of anthropic disturbance). There is no significant difference in habitat use between sedentary and migrant animals.
(Oral presentation.)

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Sex-specific strategies of dentine depletion in red deer.

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Worn teeth in herbivore ungulates may be related to lower efficiency in mastication and hence lower performance. However, selection should favour maximal performance in terms of body mass and reproductive capacity during reproductive lifespan, when permanent teeth are already partially worn. We hypothesize that wear rate may respond to a strategy of dentine expenditure, which balances instantaneous wear rate and performance against dentine preservation for future performance and reproduction. Here we study 4,208 carcasses of Iberian red deer *Cervus elaphus hispanicus* to show not only that tooth wear rates were smaller in females than in males but that they also showed different patterns of variation throughout lifetime: while females showed a decelerated wear, males maintained a rather constant rate of

tooth wear. Most importantly, the relationship between tooth wear and body performance also differed between the sexes: females with more worn teeth were lighter but, in contrast, males with more worn teeth were heavier and had larger antlers until senile age when more depleted teeth related to lower performance. These results reveal for the first time sex-specific lifetime strategies of dentine expenditure: maintenance of performance ability throughout a longer reproductive lifespan in females, compared with maximizing performance by depleting dentine reserves within a shorter lifespan in males.
(Oral presentation.)

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Does a hind's rank affect duration of filial and non-filial calf's nursing in red deer (*Cervus elaphus*)?

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The relationship between rank and suckling behaviour in red deer is controversial as it has not been fully explained yet. . We presumed that the dominant position of the hind yields profit associated with suckling behaviour for both the hind and her calf (undisturbed longer suckling, no investment to non-filial calves etc.). We tested three hypotheses: H1) The dominant hind should spend a longer time nursing than the submissive one, H2) The dominant hind should not allonurse and H3) the dominant hind should terminate nursing of her calf less frequently than the submissive one. Ad libitum observation of suckling behaviour were made on a deer farm in a socially stable group of 23 hinds and their 38 calves from birth to one month of the calf's age in two seasons. We used the Clutton-Brock's fighting success index ("FS", Clutton-Brock et al., Anim. Behav. 27:211-225) to determine a hind's rank. Age of hinds positively correlated with their rank. No change in the rank position occurred in the two consecutive seasons (14 hinds were presented in both seasons). The impact of the hind rank on suckling bout duration (H1) was tested using a generalized linear mixed model approach (PROC MIXED, SAS, corrected for repeated measurements of hind*calf pairs) with dependent variable "suckling bout duration" and fixed effects "sex" and "age" of the calf, "FS" nested within "season" and interaction between "FS" and "sex". Suckling bout duration decreased with age of the calf ($F_{(1, 1592)} = 86.63$ $p < 0.0001$). Neither of the remaining tested factors reached statistical significance. The hind's rank had no impact on suckling bout duration. The rank of the hind was not correlated to her allonursing rate (H2; "FS"*"number of allonursing/ all nursings in one hind": $r_s = - 0.11$, n.s.). The rank position had not explained the allonursing rate. A logistic regression model (PROC GENMOD, SAS, corrected for repeated measurements of hind*calf pairs) fitted to test H3 revealed that a probability of the

termination of the suckling bout by the hind increased with age of the calf ($\chi^2_{(1)}$ = 20.31, $p < 0.001$; odds ratio = 1.057), presumably due to weaning process. No effect of hind's rank was found either. Our data suggest that a hind's rank does not affect suckling behaviour in captive red deer.
(Poster presentation.)

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ISAMUD: an integrated software environment for analysis and management of GPS telemetry data.

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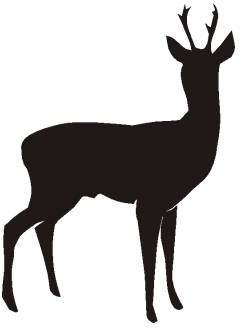
GPS technology has certainly represented a revolution for telemetry. Geographic locations (XY coordinates) of collared animals can be obtained from satellites (via VHF/GSM download or directly via ARGOS system), along with other data, such as activity, outside temperature and precision of the localisation. However, the potentially huge data sets collected by GPS collars may represent a challenge, both in terms of data management and spatial analysis. 25 roe deer (16 females and 9 males) have been captured and marked with GSM-GPS collars (Vectronic GPS-Pro 1D) from January 2005 to date in Eastern Italian Alps (Trentino Province, Monte Bondone area). Data are sent by the collars via GSM net, processed and downloaded as e-mail messages and finally converted to dbf files. We developed an integrated software environment to automatically store, associate geographic variables to and spatially analyse the data. ISAMUD (Information System for Analysis and Management of Ungulates Data) is mostly based on Open Source, Windows (Microsoft) and Linux operating softwares. The Geo-database PostgreSQL (http://www.postgresql.org/) and its spatial geographic extension PostGIS (http://postgis.refractions.net) are the core of the information system. Thanks to the latter, some geographic functions can be applied directly in the database, without invoking an external GIS, e.g. some categorical geographic variables (landuse, hunting districts) can be associated to the localisations. Other more complex geographic features can be uploaded by the Open Source GIS GRASS (Geographic Resources Analysis Support System, http://grass.itc.it/), now available also in Windows version, via the interface Quantum GIS (QGIS) (www.qgis.org). Statistical and geostatistical analyses, including Home Range calculations, are carried out in R (http://www.r-project.org/), thanks to the numerous available packages, Adehabitat among all (http://cran.r-project.org/src/contrib/Descriptions/adehabitat.html), or to ad hoc developed functions. Results are then stored in the main geodatabase, to be available for further analyses. The database can be accessed by either PostgreSQL graphic interface,

including PGADMIN III (http://www.pgadmin.org/) and ACCESS (www.microsoft.com/access/). The user-friendly data input/output format has been developed within the latter. The flexibility of the system allows the development of other modules and the applicability to different data sets from different species.
(Poster presentation.)

Censusing and modelling populations



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Censusing and modelling of red deer (*Cervus elaphus* L.) populations in Poland by using "Invent" and "Antler-2000" software.

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Computer program "Invent" was applied to estimate number of red deer inhabiting 155 Forest Districts (FD) covering 2.48 million ha of forest. In case of snow conditions the input data include snow track density index (tracks/km) calculated on basis of 5 days of tracking on line transects of 50 km per 10000 ha of forest area of hunting district in each FD. It is also necessary to know relationship between tracks/km and population density (N/1000 ha) which is established on basis of 500 ha sampling plots. In case of lack of snow the input data include relative density index i.e. number of animals seen per 1 km of strip transect (N/km) which were calculated on basis of 3 days driving period and strip transects of 30 km per 10000 ha of forest. Additionally relationship between N/km and N/1000 ha were calibrated on basis of 500 ha sampling plots and forest area of hunting district in each FD is required. The obtained results indicated that population density between FD varied from 8.2-55.3 animals/1000 ha of forest.
The data on red deer number may be transported to "Antler-2000" software that allows to simulate number and structure of hunting bags under various hunting regimes. Result of the simulations showed clearly that percent of calves in the total hunting bag and percent of young males (2-5 years old) in the total harvested quotas of stags are the most important variables influencing number of high trophy animals in the population of red deer. Therefore percent of calves in the total hunting bag should not be higher than 5%, while the percent of young males in the harvested quotas of stags have to be maintained at the level of 30%. Practical application of "Antler-2000" program is presented and harvest strategy of the Polish red deer population is discussed.
(Oral presentation.)

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Estimating Red deer populations abundance in the Alps: successful experiments on night surveys.

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The population size of red deer (*Cervus elaphus*) in the Alps has increased at a large extent in the last decades, largely due to the presence of wide protected areas. The Paneveggio-Pale di S. Martino Regional Park (PRP) and the Stelvio National Park (SNP) (Trento province) show very high densities and red deer is becoming a relevant problem. In order to undertake an effective management strategy, Parks require an accurate assessment of actual population size and supported tests on both conventional and innovative survey techniques. We present the results of a long-term project carried out in the PRP and SNP devoted to compare distance sampling & thermal imaging (DS & IR) with more conventional mark-resight (MR) surveys. Since 2003, in both Parks, spotlight counts (SL) were undertaken in April-May (5-6 replicates/year) and more then 20 radio-collared deer were available in each area to adjust survey results for incomplete detectability using MR methods. DS & IR surveys were carried out in parallel with SL & MR counts. A total of 20 and 45 kilometres of forest roads and mountain tracks were walked at PRP and SNP, respectively. Each survey involved 2 observers and lasted 3-6 nights/area. Transects were surveyed between 10 p.m. and 5 a.m. The infrared camera was equipped with a laser range finder and an electronic compass to measure observer-deer distance and angle without substantial error. Mean population size ranges from 700 deer in the PRP to 1600 deer in the SNP. SL & MR and DS & IR surveys provide coherent estimates (< 10% of relative mean difference), both characterised by reasonably low CVs (< 30%). The results are very encouraging and the proposed methodology may be potentially useful in many situations where an accurate population estimate has to be collected. Survey design and costs are described and discuss.
(Oral presentation.)

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Whitetailed Deer Density Estimation Using Thermal Infrared Imaging.

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The thermal infrared portion of the electromagnetic spectrum was discovered in the latter part of the 17th century, with little research conducted on the uses of thermal infrared imaging (TIR) until the 1920s. Croon et al. (1968) were the first to describe the application of TIR for counting white-tailed deer (*Odocoileus virginianus*) using a thermal imager mounted to a fixed-wing aircraft. Since that time, TIR technology has continued to advance. Over the past decade, interest has increased in applying TIR to estimate white-tailed deer densities, primarily because of questions and concerns surrounding the precision and accuracy of other estimation methods. However, inconsistency in sampling design and analysis has produced mixed results. Thus, we initiated studies to investigate the use of ground-based and aerial TIR for estimating white-tailed deer density in eastern Arkansas. Specifically, we compared density estimates between ground-based TIR and spotlight counts (SLC) using 2 estimators, and evaluated detection rates and compared 3 density estimators using aerial TIR.

Studies took place on 5 sites in eastern Arkansas within the Mississippi alluvial plain: White River National Wildlife Refuge (WRNWR), Choctaw Island Wildlife Management Area (CIWMA), Cut-Off Creek Wildlife Management Area (CCWMA), Wingmead Farms (WMF), and Lakeside Hunting Club (LHC). The WRNWR encompassed 87 km of the lower White River and was composed primarily of bottomland hardwood forests (85%) with the remainder (15%) being sloughs, oxbow lakes, and agriculture lands. Topography was flat and flooding occurred annually. All other sites were composed of varying proportions of bottomland hardwoods and agricultural fields. Topography was flat and the areas were subject to seasonal (winter-spring) flooding.

A Mitsubishi IR – M700 thermal infrared imager was used for all studies. The imager had a sensor array of 801 x 512 pixels, a sensitivity of < 0.08°C, and used a 50 mm, f1.2 silicon lens (14° [h] x 11° [v] field of view). It detected electromagnetic wavelengths from 1.2 to 5.9 µm, which consisted of reflective infrared (1.2 to 2.9 µm) and short wave thermal infrared (3 to 5.9 µm). Output was conducted through an RS170, 75 Ω connection to a GV-D1000 MiniDV Video Walkman digital video recorder (Sony, New York City, NY).

For aerial surveys, we used a Cessna 182 fixed-winged aircraft with the imager mounted in the belly of the plane. Surveys were flown at 457 m above ground level with transects 110 m wide and at a speed of 130 kph. A global positioning system (GPS) signal was routed through a video encoder-decoder (VED), and locations of the plane obtained from the GPS unit were recorded on the audio portion of the video tape. The VED labeled the video with a continuous stream of positions as well as time, date, speed, and altitude information. GPS locations, obtained once each second, were

used to geo-reference frames on the digital tape. Double counting was prevented by use of GPS locations integrated with videography. For ground-based surveys, we mounted the imager on a tripod placed in the back of a pickup truck and recorded digital video as described above. All video was reviewed using a high resolution, 1000 line, black and white Sony PVM-137 33-cm monitor.

In 2002 – 2003 on WRNWR, we compared densities derived using 2 methods, SLC and ground-based TIR, using both fixed area (FA) and distance sampling (DS) estimators. Three survey routes (portions of existing roads), North Unit (10.0 km), Jack's Bay (12.7 km), and Ethel (24.6 km), were sampled in winter (December – March). For each survey route, SLC and ground-based TIR were conducted 6 – 7 times each. A hand-held, 700,000 candle-power spotlight was used for SLC. All surveys commenced 1 hr after sunset. The area visible from the transect was measured perpendicularly on each route using a laser rangefinder at 0.16 km intervals in order to compute area for the FA density estimate (number of deer sighted / unit area). Program DISTANCE was used to estimate deer densities using DS (Buckland et al., 1993) for each route. Data from repeated surveys were combined for each route to increase sample sizes for both TIR and SLC. Appropriate models were chosen using χ^2 goodness-of-fit ($\alpha = 0.05$) and lowest Akaike information criteria values. TIR detected 3.4 times more deer and 2.4 times more groups of deer than SLC (Table 1).

Table 1. Mean numbers (SE) of individuals and groups of white-tailed deer detected using a spotlight and ground-based thermal infrared imaging.

Variable	**Route**	**Method**	
		Spotlight	**Thermal**
No. of Deer	North Unit	1.4 (0.97)	9.9 (2.96)
	Jack's Bay	9.8 (2.33)	22.2 (4.36)
	Ethel	6.0 (1.55)	6.8 (2.04)
No. of Groups	North Unit	1.0 (0.58)	4.1 (1.12)
	Jack's Bay	4.8 (1.01)	9.5 (2.11)
	Ethel	3.2 (0.87)	3.8 (0.87)

Densities derived from each combination of method and estimator could be ranked in decreasing order as $TIR_{FA} = TIR_{DS} >= SLC_{FA} = SLC_{DS}$ (Table 2). However, the coefficient of variation (CV) was high for all estimators (>= 25%). Though we did not know the true densities, we suggest TIR combined with FA or DS produced the least biased density estimates because deer/ha computed using FA represents a minimum density.

Table 2. Mean densities (deer/ha) and SE of white-tailed deer obtained from spotlight counts and thermal infrared imaging using fixed area and distance sampling estimators.

Route	Method	Density	SE
North Unit	TIR_{FA}	0.16	0.05
	TIR_{DS}	0.14	0.03
	SLC_{FA}	0.02	0.02
	SLC_{DS}	0.03	0.02
Jack's Bay	TIR_{FA}	0.46	0.09
	TIR_{DS}	0.25	0.06
	SLC_{FA}	0.20	0.05
	SLC_{DS}	0.13	0.04
Ethel	TIR_{FA}	0.06	0.02
	TIR_{DS}	0.03	0.08
	SLC_{FA}	0.05	0.01
	SLC_{DS}	0.03	0.01

In March 2003, we assessed the aerial detection rate of white-tailed deer on CIWMA using human surrogates. Body temperatures of deer range from approximately 37.2 °C to 39.4 °C (DelGuidice et al., 2001), whereas the average human body temperature is 37°C. Preliminary work indicated humans have slightly lower thermal signatures than deer (Kissell, unpub. data); therefore, slightly lower detection rates were expected. We substituted humans for deer to provide surrogate minimum detection rates. Given humans have lower thermal signatures than deer, we assumed that if we could detect humans we would be able to detect deer. Individual persons (n = 20) were sent to random, known locations within the study site. Individuals assumed a reclined or horizontal position on the ground to simulate the dorsal surface area of a deer. Four of the 20 people were located in water and 16 on dry land. Slightly overlapping, parallel transects were flown between 2000 hrs and 2200 hrs. The maximum temperature during the day preceding the flight was 18.3 °C, and the temperature declined from 12.2 °C to 10.6 °C during the flight. Thermal signatures were recorded as people, deer, possible deer, possible people, or unknown. Known locations were compared to locations identified from the video and the percentage of people correctly identified was calculated. We detected 75.0% of the people across the area and 93.8% of the people when the effect of water was taken

into consideration (Table 3). Thermal signatures of people and deer occupying flooded areas were masked by the surrounding thermal signature of water. We found the detection rate was very high in bottomland hardwood forests under dry conditions.

Table 3. Number of thermal signatures classified as people or deer using aerial thermal infrared imaging.

	Detected	Identified As	
		People	Deer
People	15	10	5
Deer	55	0	55

Following our investigation of detection rates, we used aerial TIR to compare deer densities based on FA, mark-resight (MR), and DS estimates. Each of 4 study sites (CIWMA, CCWMA, WMF, and LHC) was surveyed 4 nights each in February 2004. Non-overlapping, parallel transects were flown 400 m apart between 2300 and 0600 hrs. FA densities for each night were calculated, using transects as replicates, as the number of deer/unit area, and then averaged over 4 nights to derive a mean density for each study site. MR densities were determined by using 2 independent observers to review video for each night and record the time and location of each thermal signature. Deer detected by the first observer represented the marked population, and deer identified by the second observer represented the resighted population. Program NOREMARK (White, 1996) was used to derive a density using the joint hypergeometric maximum likelihood estimator, with transects as replicates, for each study site. DS densities were calculated by delineating transects on video images, measuring the perpendicular distance to each deer detected, and entering the information into program DISTANCE. Appropriate models were chosen using χ^2 goodness-of-fit ($\alpha = 0.05$) and lowest Akaike information criteria values. Densities derived from each estimator could be ranked in decreasing order as MR >= FA = DS (Table 4).

Table 4. Mean densities (deer/ha) and SE of white-tailed deer obtained from aerial thermal infrared imaging using fixed area, distance sampling, and mark-resight estimators.

Location	Method	Density	SE
CIWMA	FA	0.26	0.01
	DS	0.26	0.02
	MR	0.32	0.00
CCWMA	FA	0.11	0.06

Location	Method	Density	SE
	DS	0.10	0.02
	MR	0.18	0.00
LHC	FA	0.06	0.16
	DS	0.06	0.01
	MR	0.09	0.00
WMF	FA	0.20	0.02
	DS	0.23	0.05
	MR	0.37	0.00

Though we did not know the true densities, we suggest MR produced the least biased estimates. The lower bounds of the MR estimates were based on the actually numbers of deer observed, and the numbers of deer observed using MR were greater than those observed using either FA or DS. This difference was likely due to 2 observers independently reviewing each tape for MR estimates, as opposed to 1 observer for FA and DS estimates. Regardless, MR density estimates were more precise (CV = 0.0%) than FA (CV = 18.6 – 46.1%) or DS (CV = 8.8 – 26.9%) estimators because of the large number of marked and resighted animals.

Though interest in the use of TIR has increased in the last decade, there are few studies that have addressed its potential for estimating density of white-tailed deer. We have found that ground-based and aerial TIR have great potential for increasing the detection of deer and enhancing our ability to estimate deer densities. However, research using a known population to investigate accuracy of estimators using TIR data is needed. Additionally, all of our investigations have been concentrated in bottomland hardwood ecosystems of the southern United States. Further investigations are warranted to assess the performance of TIR in other geographic and environmental conditions.

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(Oral presentation.)

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Estimating red deer *Cervus elaphus* populations: an analysis of variation and cost effectiveness of counting methods.

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Different counting methods are currently used to estimate red deer populations in the open range in Scotland but there are few data available to compare variation in estimates, or relative cost-effectiveness. While it is impossible to determine the accuracy of counts (as real numbers are unknown), variation within and between different methods can be measured by repeat counts of the same area within a short period as possible. This study aimed to quantify the variation observed from repeat counts by each of four methods (ground, helicopter, infra-red helicopter and dung counting methods) at one of three study sites in late winters 2003, 2004 and 2005. Additional data from digital camera images of groups from counts in other areas of Scotland were also used to assess the accuracy of visual counts. Coefficients of variation within any method of between 5% and 16% were recorded, consistent with previous comparisons for red deer open range counts in Scotland. Coefficients of variation were lowest for ground and helicopter counts. The infrequency of optimal conditions was likely to limit the applicability of infra-red counts in Scotland. In terms of cost-effectiveness, helicopter counting was the least labour-intensive, with costs of other techniques depending on the availability of existing manpower as an overhead cost. It is concluded that helicopter counts are most likely to minimise errors while maximising cost-efficiency. Accuracy can be improved by the use of digital photography for counting larger deer groups. Estimates are likely to be improved further by increasing the frequency of counts and using the same methods, counters and routes for repeat counts.

(Oral presentation.)

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Simple Movement Models for Complex Animals in Heterogeneous Landscapes.

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Most animals have important cognitive capacities which are evident in their movement trajectories. In particular, being able to remember locations and to return to them contrast with simple movement models such as Fickian Diffusion or correlated random walks. I present movement model formulations based on the premises that the complexities of animal movement can be dissected into a few general movement strategies, and that individuals modulate the switch among these strategies as they are affected by changes in the internal and external environment. The models are parameterized with North American elk GPS-tracking data using Markov Chain Monte Carlo methods.
(Oral presentation.)

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Reconstruction of the male population of red deer in Hungary.

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The reliability of spring population reports and the size of red deer (*Cervus elaphus*) population had been debated recurrently during the last decades. Age data collected on the antlers of stags presented for trophy evaluation provides an opportunity for retrospective analysis of population size and trends. For this purpose I collected the data published by the National Trophy Evaluation Committee from 1973 to 2005. Based on these data I developed a simple population reconstruction model to calculate the male cohort sizes and the population sizes for the period of 1973 and 1995. I compared the reconstructed male population sizes with the reported male numbers in the annual game management statistics. Marked differences have been found between reported and reconstructed numbers, e.g., the reports seriously understated the stag population. In this case population reconstruction gives a unique opportunity to reveal the bias of reported numbers, and to study the survival pattern of males in harvested populations. Although, the model is a deterministic one and it can only be used to calculate population sizes in the past, its results contribute to the understanding of

population dynamics and the effects of harvest.
(Oral presentation.)

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The second mass-mortality of an introduced sika deer population.

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Mass-mortality of ungulate populations sometimes occurred due to starvation after they degraded vegetation. To clarify how an ungulate population behaves under food limitation after the mass-mortality, we monitored population size, resource use and mortality of a sika deer (Cervus nippon) population for 13 years from 1992 to 2004. On Nakanoshima Island inside in Lake Toya, Hokkaido, northern Japan, the sika deer population originated in three introduced individuals between 1956 and 1965. The population irrupted up to 299 deer in 1983. The first mass-mortality occurred in 1984 following disappearance of food plants including dwarf bamboos, Sasa spp. At least 67 deer died, and 95 deer were translocated outside the island. Then the population size was approximately halved. Thereafter the deer shifted their main food into fallen leaves of deciduous broad-leaved trees throughout years. In addition, the deer gradually increased use of unpalatable plants such as plum-yew, Cephalotaxus harringtonia var. nana, which had expanded to vacant spaces after disappearance of dwarf bamboos. The sika population re-increased over 400 deer in 2001, and availability of plum-yew decreased to nearly zero until 2003. Then, the second mass-mortality occurred (at least 113 deer died) in 2004 irrespective of milder winter than usual. Annual and winter mortality rates were lower than females particularly during the mass-mortality. Higher tolerance to habitat degradation may cause lower mortality in females than in males. This could allow the population to increase after the first mass-mortality where the vegetation has not recovered.
(Oral presentation.)

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Fecal-pellet group count as index of sika-deer (*Cervus nippon*) population density on subalpine plateau in Japan.

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To assess the validity of fecal-pellet group counts as an index of sika-deer (*Cervus nippon*) population density, we examined the relationship between deer density estimated by a block-count method and fecal-pellet group counts on the Ohdaigahara Subalpine Plateau in central Japan in spring (April 2006), summer (July 2005) and autumn (October 2005). The study area (567 ha) was divided into six blocks according to vegetation and topography. Each block was further divided into several sub-blocks bounded by streams and ridges. As we walked the sub-blocks, we observed and recorded details of sika deer, such as sex and age class, including the time of observation and direction of movement. Furthermore, we set up a transect (1 m - 100 m) in each sub-block, counting fecal-pellet groups (>10 fecal pellets) within it. As a result, the overall estimated deer population density in spring was 12.3/km^2, ranging from 6.0 to 54.0/km^2. In summer, it was 17.3/km^2, ranging from 0 to 43.5/km^2 and in autumn, it was 12.3/km^2, ranging from 9.6 to 33.1/km^2. Fecal-pellet group counts showed a significant positive correlation with deer density in spring ($r = 0.81$) and autumn ($r = 0.88$). No significant correlation was found in summer, probably because sika deer concentrate in the grasslands of Sasa nipponica, which is their main summer forage and is high in nutrients. Therefore, we conclude that fecal-pellet groups should be counted in spring or autumn to give a valid index of population density.
(Poster presentation.)

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Comparison of four techniques to estimate roe deer abundance in Alpine areas.

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This research was carried out in 2005 in Chisone, Pellice and Germanasca Valleys, Western Italian Alps (Piedmont, Italy). The aim of the study was to compare roe deer density estimates obtained by different survey methods: pellet count (clearance plot

sampling and standing crop strip transect counts), distance sampling and block census techniques were applied in sample areas, while data for the whole study area were obtained both through distance sampling and block census methods. Simulations were designed to study the performance of the methods under a wide variety of conditions. Locations of animals were generated (1) according to a pseudorandom uniform distribution and (2) according to presence probabilities derived from habitat evaluation procedures. In simulations, roe deer density was set to 1, 3, 6, 9 or 12 animals/km^2; survey area ranged from 0.01% to 11% (5x5 m or 10x10 m plots). Our results indicated that in sample areas density estimates obtained by pellet counts with faecal accumulation rates were quite similar to those obtained by block census, while standing crop strip transect counts underestimated the number of animals, maybe because estimates were strongly dependent on accumulation rates, which we derived from literature data. Anyway, plot sampling simulations indicated that a great effort was needed to reduce coefficient of variation and to obtain narrow confidence intervals of estimates.
Analysis of distance sampling data was complicated by the limited number of sighted groups during the surveys at both scales of analysis. This technique slightly underestimated roe deer population even in the whole study area, but a limited increase in sampling effort may strongly improve the performance of the method.
We then suggest the use of distance sampling to estimate roe deer abundance in Alpine areas, as pellet counts require a bigger sampling effort and may be unsuitable for assessing roe deer abundance in large study areas; moreover, in our study pellet counts were seriously affected by uncorrect estimation of accumulation rates.
(Poster presentation.)

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Distance sampling and pellet group count to assess deer populations: an application to conservation and management in the Alps.

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In Italian Eastern Alps, deer (i.e. red deer and roe deer) have undergone contrasting changes in density and geographic distribution in the last 10 years. This context may require management/conservation actions for aiming at a balanced deer population structure. Censusing methods commonly applied in game management (e.g. drives, block censuses) may not prove robust and precise enough to allow for short term validation. Pellet group count with distance sampling seems to encompass randomness, replicability, comparability of results and possibility to aim at a certain

level of precision controlling the effort. In this paper, we assessed the feasibility and efficacy of this method in two areas of the Alpine range: red deer density was estimated in Stelvio National Park - Trentino sector (P.N.S.), whilst roe deer density was estimated in Monte Bondone area - Trento Province (M.B.). In both areas, ongoing telemetry studies allowed mark-resight estimates, considered as reference density values. Systematic grids of line transects were randomly over imposed to the study areas and sampled both in spring (winter density) and autumn (summer density), for a total survey length of 24 km (n=240 transects, 100 m each) in P.N.S. and 23 km (n= 115 transects, 200 m each) in M.B. Meanwhile, a retrospective decay rate experiment was carried out in both areas: fresh pellet groups were placed monthly in different habitat conditions and later checked for their persistence. A total of 9792 red deer pellet groups were counted in PNS, corresponding to a highly precise pellet groups density value (winter: d= 1779.2/ha, c.v.= 7.1%; summer: d= 1740.9/ha, c.v.= 11.6%). A total of 481 roe deer pellet groups were counted in M.B., leading to a less precise, but close to the target, density value (winter: d= 123.2/ha, c.v.= 19.6%; summer: d= 107.9/ha, c.v.= 18.3%). Density estimates proved to be robust to environmental factors such as habitat type, exposition, slope. However, precision decreased when the variability due to the estimated decay rate was taken into account to calculate deer density from pellet groups density. The range of density values was comparable with mark-resight results. Pellet group count with distance sampling proved a robust method for deer population assessment in wooded areas and difficult Alpine terrain, both with high and low densities, either concentrated or even distribution of the populations. However, if pellet group count with distance sampling were routinely used for deer population density estimate, a continuous monitoring of decay rate would be strongly suggested. Management efficacy in terms of costs and effort required is also discussed in comparison with other methods.
(Poster presentation.)

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Red deer (*Cervus elaphus*) space use and population dynamics in two Alpine National Parks.

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Having faced almost complete extinction in the Central Alps, red deer (*Cervus elaphus*) experienced a real come back at the beginning of the 20th century. Since then, their populations have been strongly increasing both in the Swiss National Park (SNP) and the Stilfser Joch National Park (SJNP). Their typical migrations between summer and winter ranges and their great adaptability pose difficult tasks for the hunting authorities as well as the people responsible for the protected areas.
Population trend was investigated through different abundance estimates from 1996

to 2006 in the management unit including Trentino sector of SJNP and surrounding hunting preserves of Val di Sole (720 km^2) and cohort analysis allowed the reconstruction of population dynamic from 1973. Red deer reached its carrying capacity in 1999 when natural mortality started to significantly contribute to population regulation. Contrary to Swiss experience, hunting activities could not regulate population growth, as population progressively gathered in wintering areas inside the park. 21 female red deer were equipped with transmitters in the SNP and 35 female red deer in the SJNP within the framework of a co-ordinated project. Their home ranges were determined using one of the classical kernel method. In the SJNP their summer home range amounts to 443.3 ha in the South Tyrol sector and to 960.1 ha in the Trentino sector and their winter home ranges to 384 ha and 501 ha, respectively. In the SNP their summer home range amounts to 486.9 ha in the Il Fuorn area and to 324.4 ha in the Val Trupchun area and their winter home ranges to 586.7 ha and 1391.8 ha, respectively. To migrate between winter and summer ranges the animals cover distances of up to 16 km in the SNP area compared to 4.5 km in the SJNP. We assume that the quality of the home ranges determines the home range sizes, the lack of disturbances being the most essential resource both in the SNP and SJNP. Despite similar population density in the different study areas, condition (body mass) and constitution (jaw and hind foot length) index showed differences, according to habitat quality and climate.
(Poster presentation.)

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A population-dynamic study of red deer in Baranya, Somogy, Tolna and Zala counties from 1970 to 2006.

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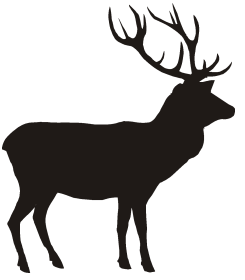
The quality of the Southern Trans Danubian regions red deer stock is well above the world average. This is verified by the fact that from the 17 Hungarian red deer trophies listed among the worlds Top 50, 13 comes from the region studied.
With the aid of the created population dynamic age group model, based on the cover data available form 1970, we have calculated the red deer populations in Baranya, Somogy, Tolna and Zala Counties. Based on this model there were 13.678 red deer in the four counties altogether. That is more than double of the amount estimated by game managers. By 1990 the population raised to 49.298. After reducing the population in 1993 it fell to 47.122. Then by 2000 it climbed to the maximum of 62.278. Because the numbers have been being strongly reduced since then, today there are as few as 25.277 animals. Calculations based on the model show that the original 1:1.5 sex ratio has changed radically as a result of the forced killing of females. Today there are more stags than females. This fact is supported by the field observation

results too. There are about 30.484 trophy data accessible since 1974 in the Somogy County Trophy Evaluation Database. By analyzing these data a study was conducted on the changing quality of the population. In age group 4 to 11 years the average mass of antlers increased in 2004 and reached a 32 years period maximum in 2005. This means that the previously saved stronger stags are killed now even at a young age. Because of this the ratio of the older stags and so the medal awarding trophies are reduced. The red deer population is becoming too young. In 2005 the penalties and monetary sanctions were revoked. The amount of the so called negative mark trophies is 8 times (142:17) higher than the 2004 value.

(Poster presentation.)

Antler biology



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Visualization and characterization of stem cells from the regenerating deer antler.

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It has recently been suggested by different authors that antler regeneration is a stem cell based process; however, the presence of stem cells in the regenerating antler has thus far not been demonstrated. The aim of the present study was therefore to investigate whether cells positive for known stem cell markers are present in the regenerating antlers of fallow deer (*Dama dama*). Using immunostaining, cells positive for the mesenchymal stem cell markers STRO-1 and CD133 were, for the first time, detected in biopsies taken from the cartilaginous tip of the regenerating antler. Here, Stro-1+ cells were found mainly as small groups around vessels and capillaries, thus representing perivascular cells. By cell sorting (FACS and MACS® up to 4% STRO-1+ cells and up to 11% CD133+ cells could be obtained from primary mixed cell cultures derived from the biopsies. To examine their developmental plasticity *in vitro*, we tested the cells displaying the stem cell markers under different culture conditions. Over 90% of the purified STRO-1+ cells remained positive after four weeks of cultivation; subsequently progressive differentiation caused a decline in number of STRO-1+ cells in the culture to only 0.4% after 12 weeks. In contrast to mixed primary antler cell cultures, which contain different cell populations and are able to form complex, three-dimensional structures *in vitro*, structure forming capacity of antler stem cells seems to be restricted. Depending on the culture medium, Stro-1+ cells formed small nodules and stem cell typical "cobblestone areas", while CD133+ cells mainly formed nodule-like colonies. When the cells were cultured in a specific neuroblast medium containing NGF, completely different structures were formed. Our results suggest that the cartilaginous tip of a regenerating antler contains a vascular-associated pool of adult stem cells with a high degree of phenotypic plasticity. This makes the deer antler a useful model for the study of the role of stem cells in organ regeneration in mammals.
This study was supported by the DFG (grant no RO 2520/1-1).
(Oral presentation.)

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Antlers may regenerate from persistent neural crestlike stem cells.

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Complete regeneration of mammalian organs is currently confined to the natural annual re-growth of deer antlers. These are shed each spring then re-grow by endochondral ossification from an undifferentiated antler bud, which forms on the pedicle (a permanent extension of the frontal bone), into large branched bones. There is histological evidence that the pedicle periosteum is potentially a source of stem cells that contribute to formation of the regenerating antler. In this study we explore the hypothesis that these cells are a population of persistent neural crest-derived stem cells. Neural crest cells (NCCs) were traditionally thought to be a transient cell type, present only in embryos. However, multi-potent cells showing NCC characteristics have recently been identified in adult rodent peripheral tissues. Here we show that during the antlers regenerative phase, cells in the pedicle periosteum and in the antler bud display a number of characteristics of NCCs and are multipotential. Using RT-PCR we detected the expression of a number of NCC markers including slug. Quantitative RT-PCR showed that slug expression was significantly higher in periosteum during the regenerative phase compared to the non-regenerative phase. Immunocytochemistry confirmed that slug localised in progenitors in the antler bud and in the periosteum of regenerating antlers. Slug also localised in skin during antler bud re-epithelialisation. However, slug protein was barely detectable in pedicle tissues during the non-regenerative phase. Multipotentially was demonstrated by culturing pedicle periosteal cells under appropriate conditions and could be induced to differentiate into osteoblasts, chondrocytes and adipocytes. These observations suggest that the regenerating antler is supplied with cells that show characteristics of embryonic NCCs. These cells appear to persist in a niche in the pedicle periosteum left by shedding the previous antler. That these cells should be implicated in the only example of organ regeneration in mammals suggests that, if provided with appropriate environmental cues, such cells in species other than deer could similarly be induced to regenerate other organs.

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Stem cells isolated from the regenerating antler express key markers of the osteogenic lineage.

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For years, an increasing number of in vitro - studies have dealt with the influence of hormones and growth factors on the growth of cells derived from the proliferation zone of regenerating antlers. Presently the role of androgens in the in vitro proliferation of antlerogenic cells is still controversial. We investigated cell cultures containing a mixed cell population derived from selected layers of red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) antler tissue. Cultures were treated with testosterone (T) and dihydrotestosterone (DHT) to investigate, whether different doses of steroids can influence antler cells that were incubated in serum-containing medium. We used different cell passages derived from fresh and short-term frozened antler tissue. In addition, long-term cultures of fallow deer antler cells were also tested. Our experiments revealed that in both species "physiological" doses of testosterone and DHT (0.5 to 10 ng/ml) exert mitogenic effects on mixed populations of antler cells in the presence of 10% FCS. For example, in long-term cultivated fallow deer cultures we observed significant differences between untreated controls and cultures containing testosterone concentrations of 0.5 ng/ml and 1 ng/ml. With regard to DHT concentrations we detected the minimum threshold concentration leading to DHT effects on fallow deer antlerogenic cells in vitro is between 0.5 and 1 ng/ml. Our data indicate that the observed mitogenic effects of T and DHT might be altered by one or even more as yet unknown serum factor(s). From our point of view, the observed mitogenic effect of androgen treatment seems to depend on the stage of differentiation and organisation of the antler cells, and might be dependent on serum-containing culture medium.

This study was supported in part by the DFG (grant no RO 2520/1-1).

(Oral presentation.)

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Mitogenic effects of androgens on mixed antler cell cultures.

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For years, an increasing number of in vitro - studies have dealt with the influence of hormones and growth factors on the growth of cells derived from the proliferation zone of regenerating antlers. Presently the role of androgens in the in vitro proliferation of antlerogenic cells is still controversial. We investigated cell cultures containing a mixed cell population derived from selected layers of red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) antler tissue. Cultures were treated with testosterone (T) and dihydrotestosterone (DHT) to investigate, whether different doses of steroids can influence antler cells that were incubated in serum-containing medium. We used different cell passages derived from fresh and short-term frozened antler tissue. In addition, long-term cultures of fallow deer antler cells were also tested. Our experiments revealed that in both species "physiological" doses of testosterone and DHT (0.5 to 10 ng/ml) exert mitogenic effects on mixed populations of antler cells in the presence of 10% FCS. For example, in long-term cultivated fallow deer cultures we observed significant differences between untreated controls and cultures containing testosterone concentrations of 0.5 ng/ml and 1 ng/ml. With regard to DHT concentrations we detected the minimum threshold concentration leading to DHT effects on fallow deer antlerogenic cells in vitro is between 0.5 and 1 ng/ml. Our data indicate that the observed mitogenic effects of T and DHT might be altered by one or even more as yet unknown serum factor(s). From our point of view, the observed mitogenic effect of androgen treatment seems to depend on the stage of differentiation and organisation of the antler cells, and might be dependent on serum-containing culture medium.
This study was supported in part by the DFG (grant no RO 2520/1-1).

(Oral presentation.)

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Antler growth in red deer stags (*Cervus elaphus*) depends on testosterone, but not IGF-1, LH, prolactin or cortisol.

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The role of androgens and IGF-1 in antler growth has been a matter of controversy. Therefore we tested which hormone is associated with antler growth. Twelve red deer stags (*Cervus elaphus*) aged 4 to 9 years were blood sampled and the length of their velvet antlers was measured in one week intervals ranging from the time prior the antler casting to the end of antler growth and velvet shedding. Concentrations of testosterone (T), IGF-1, LH, prolactin and cortisol were determined by RIA The increase in antler length and hormone concentrations were determined for each sampling period. The statistical analysis, using a generalized linear mixed model (GLMM) procedure in SAS, was performed only for samples showing detectable antler growth. We found that antler growth (an increase of antler length per day) was dependent on changes in T concentration per day (GLMM, $F_{(1,42)}$=15.94, P=0.0003), the month when samples were taken (GLMM, $F_{(4,42)}$=11.06, P<0.0001) and the interaction between age of the stag and changes in T concentration per day (GLMM, $F_{(3,42)}$=9.56, P<0.0001). The increase in T concentrations and the intensity of antler growth tended to be higher with age. No significant dependency was established between the rate of antler growth and the changes in concentrations of any other hormone investigated. This finding further supports the concept that the range of low (permissive) concentrations of androgens stimulate antler growth. This does not challenge the fact that higher levels stop the growth and induce antler mineralization. *(Oral presentation.)*

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Fetal differentiation of the antler developing area in red deer (*C. elaphus*).

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At the site of prospective antler development, differentiation of the skin and subcuteneous tissues was observed both macroscopically and histologically in unborn

red deer calves. Important characteristics of this area include an increased pigmentation and epidermal folding in fetuses of both sexes, and local swelling caused by an accumulation of oedematous mesenchymal subcutaneous tissue which was obvious in most male fetuses. The different cell types involved in these features were studied histologically. The localisation of apoptosis was evaluated by means of *in situ* end labelling (TUNEL) and androgen receptor distribution was demonstrated by means of immunohistochemical methods.
(Oral presentation.)

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Central vessels in roe deer antlers (*Capreolus capreolus*) - a histomorphological study.

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For decades, the polished deer antlers have been considered "dead bone". However, recently it has been demonstrated that the spongy core and the compact bone of hard fallow deer (*Cervus dama*) antlers exhibit a well-developed system of capillaries and blood vessels connected to the body vascular system via the pedicle. Furthermore, histological analysis and physiological experiments with fluorescent markers revealed that main parts of the fallow deer antler bone are still alive at least three weeks prior to antler casting (Rolf and Enderle, 1999). In order to test our hypothesis that a vascular blood supply of polished antlers is a general principle in deer we examined 10 roebucks at the age of 1 to 8 years. Eight skulls had polished antlers and two were complete heads with velvet antlers. We investigated the manner in which the antlers could be internally supplied with blood vessels. Our specimens revealed definitive evidence that roe deer antlers also have a similar developed system of capillaries and vessels as observed in fallow deer. In addition, in roe deer we detected canals passing internally from the frontal bone pedicle to the antler base and up to the upper parts of the antler. Besides we have hints that roe deer also possess vessels penetrating the pedicle bone below the coronet and then passing intramedullary to supply the polished antler. There were no differences in the presence of blood vessels varying with age. Thus, we suggest that the detected central vascular canals are main part of a vascular system that enables blood supply of the antler bone in roe deer even after velvet shedding. Based on our results it might be possible that the morphology of these vascular systems supplying polished deer antlers could reflect an interspecies difference in deer. Whether the central vascular canals in roe deer contain either arteries or veins remains to be elucidated. Further studies to clarify these questions are in progress. However, these observations do not seem to be age-dependent in roebucks.

References: Rolf, H. J. and Enderle, A. (1999) Hard fallow deer antler: A living bone till antler casting? Anatomical Record 255:69-77.
(Oral presentation.)

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Antler characteristics of the Sardinian red deer (*Cervus elaphus corsicanus*): a preliminary analysis.

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Since the first descriptions were published in the XVIIIth century, Sardinian red deer has been known for its small body size and simple antler design. Here for the first time the main morphometric traits of antlers from the three subpopulation surviving in southern Sardinia were analysed. We have examined a total of 216 antler beams belonging to stags 2 years and older: 49 antler pairs are from animals found dead and 118 are cast antler beams. Considering adult stags (5 years old), the most frequent structure is the four-tined beam (brow tine, trez tine and terminal fork), with an incidence of 52.2 % (n= 157). Simple spikes, i.e. unbranched antler beams, account for 0.6% of total beams. The maximum number of tines per beam is invariably 6. Twelve-tined antler pairs represent only 2.1%. Bez tine is rare, with a frequency of just 7.3%. Crown is uncommon, occurring in 14 % of beams and far from the typical cup-like shape. A palmation of the upper parts of the antler is a relatively frequent trait, occurring in 18.7 % of adults. The longest antler beam is 85 cm, the heaviest 1.2 kg, the averages being about 63 cm and 0.6 kg.
In subadults (2-4 years old) antler beams with three tines prevail, with an incidence of 36.2% (n= 58). Spikes account for 29.3% of total beams. Palmation occurs in 5.2 %, while bez tine and crown are always absent. The antler conformation and size of Sardinian red deer documented by our survey fit well within the maintenance phenotype model described by Geist, substantially comparable to those of red deer from North Africa, southern Spain, Scottish Highlands living in scarcely productive habitats.
(Oral presentation.)

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What we can learn from antler composition and structure: from nutrition to management.

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Researchers have devoted little attention to bone chemical composition and this has been considered basically constant under normal nutrition conditions. However, if antler bone composition proved to show variation associated to antler characteristics, body size or physiological state, and recent diet, assessing composition and structure might be a useful tool for population diagnosis and management. This talk will discuss a recent line of studies showing factors affecting antler bone composition and internal structure. In Iberian red deer spikes, content of 25 antlers was assessed for ash, Ca, P, K, Na, Mg, Fe and Zn in base and tine to explain variability in antler length, weight, and perimeter. In turn, mean composition and difference in concentration of each mineral was related to body measures at one year of age, weight at birth, that at one year of age and gains during lactation, or between weaning and year of age. Chemical composition differed between base and tine in ash, Ca, P, K, Zn and Fe, but not in Na or Mg. Composition explained a range of variability from 76 to 99% in antler characteristics. Body weight and size, in turn, influenced mineral composition. The greatest body effect was that of gains during lactation on most macro-minerals, which explained a mean variability of 50%. Another study showed that antler bone composition in a captive population with high plane of nutrition and parasite/pathogen treatments differed from those from a free-ranging population with lower quality food and no parasite/pathogen treatments. In addition, cortical layer of antler in antlers of deer living in controlled conditions was thicker than in those of free-ranging deer. Finally, mineral content and opacity to X-rays was also greater in the former than in antlers of free-ranging deer. In conclusion, antler bone composition is variable in normal conditions, variability appears to depend on region of the antler and maintenance conditions, and this together with structural differences suggest that both might play a role in biomechanical properties of the antler. It might also show the nutritional status or physiological effort to grow antlers.
(Oral presentation.)

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Post-velvet shedding antler histology of red deer (*Cervus elaphus*) living in the wild.

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When red deer stags fight, parts of their antler beams may break off. Two right beams, broken off beneath the tray tine, were found in late September, just after stag fights terminated. One of the beams terminated with crown tines, the other being forked. Both beams bled at the site of breaking and exuded a strong, specific smell, perceivable for a few days. Most probably, the smell was related to the heat period and the resultant high content of sex hormones in stag blood. This is evidence that blood circulation in the antler cortical part is maintained, even after the velvet has been shed. The beam histological structure was analysed. The aim of the study was to provide observations on the structure and blood vessel system of the antlers, after the velvet has been shed, in the red deer living in the wild, a few months prior to physiological antler casting. Histological slides were made in the form of tranverse sections of the beams to provide materials for observations on antler structure in the cortical and core part. The beams were cut at various heights to yield 20 transverse sections each. When viewed under the microscope, the antler cross sections were observed to contain bone lamellae, concentrically arranged around Haversian canals, which formed osteons of various diameters; there were also interstitial lamellae, located inbetween the neighbouring osteons. The osteal and interstitial lamellae were interspersed by bone cavities containing osteocytes. The cortical part of the antlers was formed by densely packed, fairly regular, circular and oval osteons; their diameters weresmaller than those in the core part, their Haversian canals being smaller as well. On the other hand, the antler core was formed by osteons consisting of a lower number of osteal lamellae and large, frequently irregular Haversian canals which showed fragments of blood vessel with blood remains (some canals were entirely filled with blood). The Haversian canals, both in the cortical part and in the core, gave rise to numerous Volkmann's canals. Some Haversian canals, particularly in the antler core, showed a clear polarity. The pole of such Haversian canals was found to contain active osteoblasts. The remodelling of bone tissue was particularly well visible in the core, the remodelling continuing after velvet shedding and involving the formation of new, small osteons at the ends of Volkmann's canals, at the junction of at least three osteons, between the interstital lamellae.

(Poster presentation.)

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Lengths of pedicles and antlers in Reeves' muntjac.

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Most species of deer have long antlers on short pedicles which arise from the frontal bones. The pedicles do not reach full size until 14-16 months of age. In contrast, muntjac have long pedicles, arising from a ridge at the supraorbital margins, and short antlers. This is the major reason for placing muntjac in a separate family, Muntiacidae. In all deer the dimensions of the pedicles can change over the years as remodelling of bone takes place. Using a large sample of skulls of Reeves' muntjac(Muntiacus reevesi), some of exactly known age, the lengths of the pedicles and antlers of first and subsequent heads will be compared.
(Poster presentation.)

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Consistent interindividual variability in proliferation potential of antler cells cultivated *in vitro* under various treatments.

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Deer antlers and their growth are under the control of many external and internal factors. These mechanisms are still not sufficiently clarified neither at physiological, cellular, nor molecular level. Antlers periodically regenerate and their growth is one of the fastest in the animal kingdom. The antler cells have a great proliferation potential. It has been postulated over the last two decades that the antler growth and the proliferation of antler cells is influenced by steroid hormones and/or growth factors such as the insulin-like growth factor I (IGF-I).
In this study, antler cells were derived from the tips of regenerating antlers of three-year old red deer stags (A, B, C). Primary cultures and first passages were exposed to various experimental procedures with 1% and 10% foetal bovine serum (FBS) and a mixture of 1% FBS supplemented with oestradiol, testosterone or IGF-I. The proliferation potential of these cells was determined by incorporation of tritium-labelled thymidine. Consistent significant differences have been reported among individual animals across all experimental procedures using the GLMM model (PROC MIXED in SAS). Stag A exhibited the highest while stag B the lowest values in all experiments. Values of the stag C were between those of stags A and B, usually closer

to B rather than to A. The average values of A were 2.1 to 20.1 times higher than those of individual B ($P<0.01$ to $P<0.0001$). The results suggest that the individual potential of each animal may significantly affect the cultivation of antler cells and hence should be reported in all *in vitro* experiments.
(Poster presentation.)

Responses of deer to global environmental change

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Biogeography of Cervidae in Peru.

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Peru is one of the most biological diverse countries in the world thanks to its geography and its variety of climates. When considering deer species, Peru contains both tropical and temperate forms, including five of the six genera native to South America. Of the 13 recognized native species from South America, seven were known to occur in Peru (*Blastocerus dichotomus*, *Hippocamelus antisensis*, *Mazama americana*, *M. chunyi*, *M. gouazoubira*, *Odocoileus virginianus* and *Pudu mephistophiles*). However, new data and collected material confirmed the presence of *Mazama rufina*, beforehand mistakenly included as present due to confusion with a very small subspecies of *M. americana*. Also, an undescribed species has been photographed in the Amazon lowlands, and probably the small *M. americana* subspecies may warrant specific status given large morphological differences. Here, data on distribution and habitats used are presented for all species occurring in Peru. The knowledge on the distributional ranges of *Mazama rufina* and *Pudu mephistophile* are here improved, in the first species increasing its range southwards, and in Pudu closing the gap between the northern population, formerly known only from Colombia and Ecuador, and the southern Peruvian population. Also, habitat use differences between *Hippocamelus antisensis* and *Odocoileus virginianus peruvianus*, and between *Mazama americana* and *Mazama gouazoubira nemorivaga* are described. *Hippocamelus* and *Odocoileus* seemed to separate themselves by altitude and habitat type, whether Mazama species presented a complex division where areas dominated by specific habitat types showed notorious higher densities of either species over the other. *M. gouazoubira nemorivaga* , were more abundant in areas with the canopy dominated by Brazil nut (Bertholetia excelsa), and areas where the undergrowth was dominated by the short palm Irapai sp. *M. americana* was the only species found in seasonally inundated lowland forest. South American deer species present complex niche divisions between species and distributional overlap among several species. The overlap among species in Peru is most notorious throughout the montane and cloud forests. Therefore, there are several macro habitat and biogeography concerns still unexplored that are starting to be understood, that need studies before being encroached by and lost to the growing agricultural frontier.
(Oral presentation.)

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The influence of season, food intake, and social rank on cortisol secretion in red deer (*Cervus elaphus*).

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Deer developed as an adaptation to the nutritional bottle-neck of winter pronounced cycles of voluntary food intake, body mass, and metabolic rate. We investigated in red deer how this seasonal adaptation is reflected in the secretion of glucocorticosteroids measured as the concentration of glucocorticoid metabolites (GCM) in faeces, and how food availability influences the annual rhythm. We sampled faeces throughout the year from a captive population living under close to natural conditions in a large study enclosure, and from free-living deer. The captive deer had during one study year during winter access to a limited amount of hay and beets in addition to natural forage, during two other study years to pellets ad lib. throughout the year. In addition, we studied the effect of social interactions on GCM secretion. GCM secretion varied periodically with a peak during winter and a nadir during summer. The amplitude of this seasonal cycle was on average about 10% of the annual mean both in the captive population receiving only limited supplemental food during winter and in the natural population. Under ad lib. feeding the amplitude of mean GMB secretion was attenuated to 5% of the annual mean. GMB secretion was further influenced by social rank with highest values found in individuals of intermediate rank. We conclude that the amount of glucocorticosteroids secreted is an important endocrine signal in the regulation of the annual change from an anabolic growth phase timed to summer when food is abundant with an accumulation of body energy reserves, to a winter physiology characterized by a catabolic metabolism and anorexia. This cycle is controlled by an endogenous rhythm entrained to the natural photoperiod that enables anticipation of the seasonal environmental changes and timely adaptation. However, the magnitude of the reaction and presumably to some degree also its phase is modulated by food availability. Our results further demonstrate an important influence of social rank on GMB secretion. However, glucocorticoid and GMB secretion can be used as reliable indicators of stress only when controlling for the confounding effect of season and food availability. For assessing the latter, variation of climate, habitat quality, and population density needs to be considered.
(Oral presentation.)

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Defense of territories by rutting red deer stags, *Cervus elaphus*, in Patagonia, Argentina.

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Introduction

Mating behavior of both Old and New World *Cervus elaphus* males has generally been characterized as harem defense (Struhsaker 1967, Clutton-Brock et al., 1982), basically referring to mobile harems where females are followed and defended across their foraging range by rutting males. An alternative strategy whereby males establish mating territories has been previously described for red deer populations in the savannah-like Pampas of Argentina (Dietrich 1987) and in southern Iberia (Carranza et al., 1990). Defense of mobile harem and mating territories by prime males, evidencing intraspecific variation in red deer mating systems, are only known to coexist in southern Iberia (Carranza et al., 1990, 1995). Our study, a first to empirically describe mating behaviors of territorial red deer in Argentina, was conducted to determine if the mating strategies employed by prime stags of the Andean-Patagonian cordillera were comparable to that of the southern Iberian population, as both populations enter the rut at the end of the dry season, when forage availability is at its lowest and more patchily distributed across the landscape. If resource distribution indirectly influences choice of mating systems (Carranza 1995), one might also expect to find rutting stags holding territories in the lower elevations of the ecotone habitat of the Andean cordillera, where high numbers of females concentrate in open areas to forage during the rut. This study tested if dominant rutting males in areas with high female concentrations were defending territories. The various mating strategies employed by rutting males of this Andean cordillera population are described, providing a new example of between-population variation of mating systems.

Study Area

The study population inhabits the mountainous ecotone and steppe habitats of the eastern Andean cordillera in Patagonia where the dominant climate is temperate with main precipitation occurring between April and September. The breeding season, occurring sometime between early March and late April, lasts 3 to 6 weeks, and peaks around the last 2 weeks of March. The study area was located on private land within the Nahuel Huapi national reserve, (40158"S; 71º12"W), Argentina. The area over which the rut takes place is characterized by a mosaic of habitats:

1) forest patches represented by a variety of pure and mixed stands of *Nothofagus antarctica*, *Austrocedrus chilensis*, *Lomatia hirsuta*, *Maytenus boaria* and *Schinus patagonicus*;
2) brush patches represented predominately by *Berberis spp*., and *Colletia spinosissima*.

3) mallins - a type of wet grassland - common throughout the eastern cordillera of the Andes, which are defined as exhibiting running water or inundated soils all year round. Cyperaceae, Juncaceae and other wetland species dominate the wet central sections of the mallins. Of the graminoides, *Carex canescens* and *Carex macloviana* (Cyperaceae) and *Juncus depauperatus* are the most prevalent species. The dry areas of the mallin have more xeric graminoid and forb species, such as *Festuca pallescens*, *Hordeum chilense*, *Poa spp, and Ranunculus peduncularis*;
4) grass-dominated steppe *Stipa speciosa* var. *major* and *Festuca pallescens* with variable occurrence of brush species like *Mulinum spinosum*, *Berberis spp*., and *Colletia spinosissima*;
5) riparian habitat with *Salix sp.* and *Nothofagus antarctica* the predominate species.
General observations on the rut behaviour were made over the entire range of habitat types, however, the recorded observations to test male breeding behavior were conducted from a blind overlooking a mallin (total area of 5 ha). Patches of shrubs and a few singular trees dotted the peripheral areas of the mallin, and consisted mainly of *Berberis spp*., introduced European *Rosa mosquesta*, *Nothofagus antarctica*, *Lomatia hirsuta*, *Maytenus boaria*, and a few ancient apple trees, *Malus pumila*.

Methods

Binoculars and scopes were used to observe red deer rutting behaviour from sunrise to sunset from March 9 through April 9, 1995, using *ad-libitum* sampling and focal-animal sampling techniques Altmann (1973). The focal sampling was based on a minimum recording period of 20 minutes. Additionally the study area was scanned once each hour to record total number of individuals present and the age and sex category of each. Number of males holding territories were noted along with harem size and location. Location of males throughout the observation period were recorded on a map with grids to determine temporal use of the area. Sketches of antler configurations for each territorial male helped to distinguish individual males on the study site, later verified with photographs. Vocalization was also used to distinguish locations of males using the mixed brush/forest patch habitat adjoining the mallin. Length of stay, location on study site and dominant status of each identified male on the mallin was determined whenever data allowed.

Males were randomly selected on the mallin to conduct focal-animal scans between the hours of 800 to1100 and 1430 to 2030, corresponding to the daylight hours with highest deer activity. Behavior recorded during these scans were divided into agonistic male-to-male interactions (displacing, chase, thrash, parallel walk, initiating and sparring) and male-to-female herding and courting behaviour (sniffing, licking, flehman, chivying, and mounting) as described by Clutton-Brock et al., (1992) and Geist (2002). Although all occurrences of these behaviours were recorded during the entire focal-animal sampling period, for the statistical tests performed, more than one observation of a particular behaviour performed by the focal animal during a 1-minute unit of observation was tabulated as a single occurrence.

Additional observations were made of daily movement patterns of hinds between the mallin and brushy/forested slopes to the east and west of the main study site. Males responding to the females were noted along with a description of their call, and body and antler size.

To distinguish whether males were defending territories or females, each focal

sampling of an individual male, being the mean of several 1-minute units of observation (Carranza et al., 1990), was used to conduct a Student *t*-test to compare differences in interactions between sedentary males with and without females. To evaluate if the intensity of rut behaviour of focal males might be affected by the number of females in their harem, a Spearman rank correlation was performed on focal sampling data to compare number of females in harem with mean frequency of male-to-male interactions, and also to compare number of females in harem with mean frequency of male-to-female interactions.

Results and Discussion

The population density for the study year, estimated from pellet count transects, was approximately 100 deer per km^2. Males were found to defend territories ranging from 0.8 to 2.5 ha in size. The territorial boundaries established by the focal males shifted occasionally between successive hours and days, similar to observations of Iberian red deer males (Carranza et al., 1990). Number of territorial males in mallin at any one time varied from 0 to 6. Only males of larger body and antler mass held territories (n=13). Moreover, throughout the peak period of the rut, our focal males would remain the entire day in the same general area of the mallin, leaving only if disturbed. Males remained in established territories, even when females were absent, often bedding down in the heat of the day, when calling would continue, though sporadically and with less intensity. An occasional intruding male was cause for the bedded males to rouse, concomitantly increasing the frequency of their calls. The roaring activity also picked up in the late afternoon, stimulated by females entering the mallin. Timing of activity patterns varied daily according to the meteorological conditions.

During the peak of the rutting period, a male's breeding status was influenced by his body mass and antler size (Clutton-Brock et al., 1982). The larger dominant males remained on the mallin through the peak of the rutting period, while the smaller subordinate males remained at the transition zone bordering the mallin. Occasionally these satellite males entered the mallin, causing the dominant territory holders to engage in defense activity. The youngest age class males were the most mobile, moving in and around the territories of the older males. An individual male's strategy sometimes changed during the course of a breeding season due to a social status change or when a territorial site suddenly becoming vacant. If a dominant male, for instance, left the main breeding area to migrate to his winter range, a less dominant stag would replace him. Often males beyond the prime breeding age would move into these sites. It is conceivable that these males, during their prime years, may have held territories in this same mallin.

Males of subordinate status, unable to compete with the bigger males on the mallin, adopted an alternate strategy by taking advantaging of the female's daily movement patterns. Although some females might remain on the open mallin throughout the entire day, many females returned to the brushy forested slopes of the hills to the east and northwest of the main study site to bed down. Once feeding activity commenced in the late afternoon, the position of females groups moving slowly down the vegetated hillside was made evident by males calling as the females approached and passed by their location. These males would follow the female group a short distance, as far as to the next waiting male. Roaring activity was thus highest

on the hillside during the ascent and descent of females in the morning and evening hours, respectively. These subordinate males remained loosely in the same general area along the hillside, with highest densities of males along the lower portion of the slopes near the transition to the mallin. Here was the waiting zone, where satellite males stood ready for transient females to pass on their way to the mallin. This mating strategy would benefit smaller males, allowing them to avoid conflicts with males of larger stature and yet provide them with opportunities to interact with potential estrous females. At the beginning and tail end of the rut, when densities of males were lower on the open mallin, movement by these less dominant stags was greater.

Rates of male agonistic behaviour during the focal-animal samplings varied greatly, triggered by various factors such as occasional male intruders or females crossing the territory. Although frequency of a male=s aggressive interactions towards other males was not affected by the number of females in his harem (r_S = -0.15, n = 37, NS), his frequency of interactions with females positively correlated with number of females in the harem (r_S = 0.50, n = 37, p = 0.002). A focal sedentary male reacted aggressively to other males regardless of the presence of females within his territory (mean ± SD number of defensive activities per min: 0.058 ± 0.075 with females versus 0.096 ± 0.145 without females; t = 1.108, df = 42, NS). Such defensive behavior by the males in the absence of females, which concurs with results of Carranza et al., (1990), indicates that males were not defending a harem but rather their area.

Resource distribution has been suggested as a factor influencing choice of mating systems, afforded by behavioral plasticity (Carranza 1995). In northern Europe, where the main mating strategy for stags is the defense of mobile harems (Clutton-Brock et al., 1982), general food availability is still high during the rut so that females are not forced to clump at particular feeding sites. In contrast in southern Iberia, the mating season takes place during the period of lowest food availability, after the dry and hot summer. Whether the underlying mechanisms for the unique behavioral repertoire observed for the red deer stags in the eastern Andean cordillera are a function of habitat structure (environmental heterogeneity and patchy resource distribution), population densities, herd composition, group size, genetic makeup or combinations of these factors remains to be determined. Studies comparing intraspecific variation of mating strategies between and within populations can lend insight into the functioning mechanisms. It is conceivable that strategies employed by rutting stags during the study period, when the density of the study population in the ecotone was about 100 deer/km^2, would alternate once densities are driven down as was shown for lekking fallow deer (Apollonio 1989). The suggestion by Carranza et al., (1995) that territoriality should arise where resources are scarce and patchy during the rut is supported by findings of this study, in that ecosystem resources, though not scarce like in Iberia, are patchily distributed. The heterogeneous landscape, affecting deer distribution, allows females to use various habitat types during the rut, with large group concentrations in the open mallins and grasslands. Their movement patterns appeared to influence the strategy selected by the males, which was in turn affected by a male's dominance status, a reflection of his body and antler mass. This study, a first to describe mating behaviors of territorial male red deer in Patagonia, did not find any evidence of mobile harem defense in the habitat types studied; instead, territorial

defense, in open areas receiving high female concentrations, was the strategy of choice by the prime breeding males. Non-prime males exhibited various other semblances of mating strategies. Casual observations of rutting by prime males occurring in other habitat types, like closed forest, indicate that several strategies are being employed across this heterogenous landscape. Further investigation focusing on more homogeneous parts of the range, such as the Andean montane grasslands or grass-dominated steppe habitat might reveal males utilizing mobile harem defense. The repertoire of mating strategies employed by prime red deer stags in this Patagonian population appears to show that intraspecific variation in deer mating systems may be more common than previously recognized.

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(Oral presentation.)

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Spatial behavior paths of food search in roe deer (*Capreolus capreolus*).

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The way roe deer exploit resources within their home range is not well known because of cryptic behaviour and dense habitat. Furthermore, radio tracking locations used to

estimate home ranges are insufficient to obtain animal paths. However, the appearance of GPS (Global Positioning System) collars permits a greater number of positions and therefore the determination of movement patterns. Several methods have been developed to characterize habitat structure and animal movements. One of these, the First Passage Time (Fauchald and Tveraa 2003), can be used as a measurement of search effort along a path and is defined as the time required for an animal to cross a circle with a given radius. We applied this analysis to GPS locations of roe deer females in Chizé and Trois-Fontaines Forests (France) to understand how animals change their movement patterns in relation to the environment (autumn 2003: N = 2+5, and spring-summer 2004: N = 9+9). Our results revealed circles of intensive searching measuring 10 to 100 meters, and for every female the majority of zones appeared in all paths. Furthermore, preliminary results about animal activity in these circles, provided by GPS collars, suggested that for some females these were rest zones rather than zones of high activity. However, further analyses are necessary and in progress. Intersections of detected zones with vegetation, i.e. plant species and biomass and percent of habitat opening, are still in analysis. These additional results will be presented during the meeting.
(Oral presentation.)

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Carbon and nitrogen efficiencies in venison production.

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The UK farmed deer industry is relatively small with some 250 farmers and 33,000 deer. A desk study was undertaken during 2003 to assess the environmental impact of venison production in relation to the utilisation of nitrogen and carbon. Agriculture is the main source of ammonia (NH_3) emission (82% of total emissions), and contributes significantly to methane (CH_4) and nitrous oxide (N_2O) pollution, at 35% and 64% of totals emissions respectively. Deer are ruminants and are opportunistic or adaptable feeders with an evolutionary tendency towards fibre digestion (grass and roughage eaters). They are basically diurnal, usually having 5-11 feeding periods in a 24-hour period. Deer have a 30% higher fasting metabolic rate than sheep, but similar to cattle. They have a 38% higher energy requirement for maintenance than sheep, but the higher heat loss in deer is balanced by more fat deposited in sheep. Deer exhibit changes in digestion strategies related to season and metabolism, and may utilise forage with a high content of soluble carbohydrate and protein more efficiently than sheep or cattle at certain times of the year. Methane production is an inescapable consequence of fibre digestion by herbivores. The most effective mitigation strategies to reduce methane emission are likely to be those associated with more intensive production systems, with reduced feed input per unit of product output. The review concluded that there is a paucity of data on the emission of ammonia and nitrous oxide

by deer. Most estimates are derived by assuming similarities with other domestic animals, with estimates scaled to account for differences in body size. Deer calves during their first winter are generally fed conserved silage, and more targeted protein supplementation may improve N utilisation. However, most of the ammonia produced by deer will be at grass, where there is limited scope for altering the protein content of the diet, although tanniferous plants may offer some potential to improve N utilisation. The environmental impact of more deer farming in the UK is difficult to ascertain. In general, deer are somewhat less efficient biologically in converting feed to meat, but the niche product they produce, which commands a premium price, does compensate for this. Our current understanding of the digestive processes in deer does not indicate it is vastly different from that of other ruminants, and therefore a small-medium swing to deer farming is unlikely to have a huge environmental impact.
(Oral presentation.)

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Methane production by farmed red deer.

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Methane emissions from ruminant livestock in New Zealand are expected to increase by 10 to 20% between 1990 and 2010, the beginning of the first commitment period of the Kyoto Protocol. New Zealand's obligations under the Kyoto Protocol require the Government to take responsibility for emissions in excess of the 1990 baseline year. Therefore, methods need to be developed to reduce methane emissions. However, before such methods can be developed, a better understanding of animal and nutrition factors affecting methane emissions across ruminant species is needed. Methane is not only a potent greenhouse gas, but its production represents a loss of energy from the feed consumed by ruminant animals. Assuming a price of ten cents per kilogram of pasture dry matter, it is estimated that the energy lost as methane costs the New Zealand Deer Industry between $5m and $27m per year. Although deer only produce a small proportion of the total methane emissions from ruminant livestock in New Zealand, emissions from the deer industry increased by 60.3% between 1990 and 2001. Numerous experiments to measure methane emissions from sheep and dairy cows have been conducted. However, until recently, there were no direct measurements of methane emissions from farmed deer in New Zealand. Experimental work with adult and weaner deer are summarised and these data indicate that methane emissions from deer are similar to sheep and dairy cattle per kilogram of dry matter eaten. However, this has not been confirmed by a direct comparison with animals of different species fed the same diet at the same time of year.
(Oral presentation.)

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Why the Patagonian huemul deer in Argentina fails to recover: An ecological hypothesis.

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Huemul (*Hippocamelus bisulcus*) had declined drastically by the 20th century. First field studies in Argentina beran in 1988. The 1st Chilean-Argentine meeting (1992) resulted in a preliminary list of hypothetical factors potentially important for huemul recovery. These factors are still claimed dogmatically to cause their declines and failure to recover, though without supportive studies. Efforts still aim to reduce impacts of these factors, but without monitoring, it is not known if these actions are relevant or successful. Huemul are in a precarious state. Only 350-600 animals remain along 1800 km of Andes in Argentina, without known cases of numeric responses or recolonization, yet several populations have vanished in the last few decades, casting doubt on success of earlier actions [1]. Here we evaluate the importance of these factors. We posit that major underlying problems explaining the lack of huemul recovery have not yet been considered: huemul likely are deficient in trace minerals important for recruitment.

Hypotheses from 1992 are reevaluated. a) *Extensive livestock raising*: explanations are needed for populations which coexisted with cattle for >110 years, or which have declined, are declining or went extinct without apparent contact with livestock. b) *Replacement of native forest with exotic trees*: no study shows negative impacts on huemul. Replacement of native forest by exotics is illegal, and earlier plantations do not invade native forest. c) *Irrational management of native forests*: no study shows negative impacts on huemul. On the contrary, huemul respond positively to areas formerly logged and burnt, like growing populations in Chile exhibiting the highest known huemul density. Current successful recolonizations in Chile into treeless areas corroborate that huemul may be pastoreal and only secondarily adapted to sylvan habitat. d) *Introduction of exotic animals*: no study shows negative impacts on huemul, only that exotics eat the same plants and have similar preferences as huemul [2]. This is only relevant if it reduces huemul population growth rates. Considering huemul diet studies, they likely shift diet without necessarily affecting reproduction [3], as is known for other cervid species. Besides, in the absence of exotics, huemul went extinct or have declined. Considering high densities of exotics in former huemul areas, it appears unlikely that such habitat is limiting huemul in terms of energy and major plant nutrients [3]. Huemul also form multi-species guild assemblages, thus presence *per se* of other herbivore species is unlikely to be problematic, as evidenced by documented coexistence with livestock. e) *Illegal hunting*: no information exists about extent or effects on populations. It is likely negligible in remote remaining

populations, but may prevent migratory behavior. f) *Diseases*: no study shows negative impacts on Argentine huemul. Records from local government research institutions, animal health authorities and veterinarians would indicate the presence of dangerous diseases near huemul, as livestock raising is of major economic importance. Of 376 red deer necropsied, the only unusual observation was a yet unknown exotic *Taenia* [4]. In Chile, no disease problems have been found in huemul. Anecdotal accounts by settlers are cited to claim that foot and mouth disease (FMD) was responsible for decimating huemul over huge areas 60-70 years ago. Based on behavior of 5 wild cervid species in UK, these are considered unlikely to be important in maintaining and transmitting FMD. At normal cervid densities, FMD is self-limiting. Very low huemul densities and reactions of other cervids to FMD makes those early anecdotal accounts doubtful. Also, considering known growth rates, a population of huemul in only 6 years would have increased by 300%. Others claim that *Cysticercus tenuicollis,* when transmitted by livestock is fatal to huemul, citing Texera [5]. However, that author did not consider presence of *C. t.* to be the cause of death, rather that the condition of the female deteriorated after a premature parturition, aggravated by very little space and little variety of food provided. Furthermore, in other cervids and ungulates, presence of *C. t.* is considered of little significance. g) *Dogs:* no study shows negative impacts on huemul. Anecdotal accounts indicate that huemul is easily killed by dogs, assumed to be related to absence of native cursorial predators, and that they become paralyzed due to panic, and thus become easy prey. However, the evolutionary history of huemul included cursorial predators in North and South America, including *Canis*. These large canids became extinct in South America only in the Holocene. Other Odocoilines employ a hide-and-freeze strategy, bolt or run off at close encounter, and take to water. Mule deer tend to bound uphill, imposing heavy costs on a predator, whereas white-tailed deer bolt down and along hillsides. Huemul are known to snort, stomp the ground, they run, trot or race away uphill or downhill effortlessly; they also bound like mule deer and take to water. Documented interactions of huemul with dogs are rare, and thus the more instructive (B. Thomas, pers. com.). Case 1: a huemul buck ran down a logging trail, bounding side to side to navigate logs while trying to outrun 3 dogs. Case 2: a female with calf were chased by 2 dogs; they did not run to water but contoured a hill feature for about 1,5 km and then climbed to the higher ground, outrunning the dogs. Case 3: a radio- collared huemul doe and her week-old young were observed. The doe suddenly went in front of several approaching dogs and away from the bedded calf. The barking dogs circled away from the area to about 500 m. After 20 minutes the barking stopped. About 4 hours later, just at dark the doe approach the fawn from the other direction, nursing it and then heading back with it the same way she had come, taking the fawn out of the area some 500 m. Certainly, any loss is important for severely reduced groups, including from puma predation (*Puma concolor*), but this is related to small population size and not to predation *per se* [6]. h) *Small population size, fragmentation and genetic isolation*: although no studies on huemul document population size, degree of fragmentation (metapopulation dynamics) or genetic isolation, comparative studies support the importance of these factors when they exist.

What might account for a generalized absence of recolonization or numeric responses? A growing huemul population in Chile had a lambda of 1,21 and life spans of at least 14 years [2]. This numeric response occurred in presence of some dog

predation and natural predators (puma, foxes). As several Chilean populations have been recovering, but no such cases are known from Argentina, we evaluated the potential of nutritional factors which likely could affect reproduction and survival more so on the Argentine than Chilean side of the Andes.

Geology and Pedology: The central Andes occupied by huemul are characterized by acidic rocks, landscapes strongly modified by past glaciations, and acidic soils strongly influenced by volcanic depositions, all of which favor low selenium (Se) and iodine levels. The influence of volcanic ash diminishes to the east due to drier climates. Westerly Pacific winds result in minimal aerial Se input which is highest by the coast and decreases further inland. The gradient of iodine depositions also decreases from west to east, and with increasing altitude in the Andes. Cattle near the Peruvian coast had levels 6 times higher than found inland at higher altitude. Hence, Se and iodine provision in Argentina is expected to be lower than in Chile. Topography modulates soil concentrations as leaching occurs on ridge land and results in a decrease of soil Se and iodine, while adjacent valleys maintain or increase Se and iodine levels [7]. Past and current land use further diminish bioavailable Se and iodine [8].

Biochemical Functions: Only recently discovered, the genetic code had to be expanded and Se forms part of the 21st amino acid, essential in all mammals. Se, an active part of several enzymes, is involved in oxygen metabolism and thus functions at very basic biochemical levels, and deficiency is thus expressed in many ways. In all animal species studied, deficiency impairs reproductive performance of females and males. In ruminant neonates, white muscle disease is typical of deficiency. It also is fundamental for proper immune function, disease resistance and myocardial disease. It is essential in iodine metabolism and causes iodine deficiency secondarily in the thyroid gland which is present in all vertebrates, with its hormones playing an indispensable role in control of the basal metabolic activity. Iodine is essential for gestational development, particularly of the central nervous system, and deficiency during pregnancy has negative and irreversible effects on the developing fetus; postnatal deficiency is associated with cognitive deficits. In ruminants common problems include abortions, young born dead, weak neonates, increased neonatal mortality, prolonged gestation and infertility.

Selenium and Iodine Status in Patagonia: concentrations of Se and iodine in most forages of agricultural systems in southern Chile are deficient, indicating marginal levels in natural habitat. Levels on the east of the Andes are expected to be even lower. There are a still focal areas with endemic goiter in Argentinean Patagonia.

Huemul Migrations as a clue to the current predicament?

In autumn, cattle were commonly herded together with huemul to lower elevations for the winter. Huemul also moved from high Andes down to Pacific coastal areas. Based on telemetry they were shown to spend the evening and night in valley bottoms and to move to higher elevations in the morning in valleys not settled or used by humans. Many huemul lived in bottoms of valleys in Argentina during winters about 60 years ago, though people now residing there have never seen a huemul [2]. In Santa Cruz, huemul groups of 50 used to migrate annually some 50 kilometers from the high Andes into the treeless steppe. Others reported huemul at 200 km from the Andes in treeless grasslands, or wintering groups of 100 huemul 80-100 km from forests,

resembling migratory behavior of other Odocoilines.

Traditional winter ranges and valley bottoms likely were source areas for huemul populations and for migratory behavior. Krieg [9] mentioned the existence of all-year resident huemul in quiet valley bottoms. Migratory huemul in Argentina were likely eliminated by overhunting, easily being killed as they show no fear. Thousands per year were killed at rates of 1-2 deer per km², coincidently the average density where they still occur now [2]. Huemul were used to feed people, dogs, chicken and pigs; their skins were used for shelters for people and domestic animals. With loggers also killing huemul indiscriminately during the colonization, only the most inaccessible areas provided refuges for remaining huemul. In 1897, reports based on many Andean expeditions already mentioned few huemul left due to constant and heavy hunting pressure. All areas useful as winter ranges for livestock were occupied by settlers early on or became private, and often were cleared of forests. Migratory behavior is an acquired trait. Thus, by eliminating the migratory segment of a huemul population, the remaining animals became tied to a refuge. The few dispersers potentially leaving such populations would tend to follow prime habitat like valley bottoms and be at high risk to be eliminated by hunting or dogs.

Discussion

Currently favored reasons for failing huemul recovery in Argentina do not explain several observations. In healthy populations, losses due to predation by puma, foxes and feral dogs, and accidents would not present a problem. Domestic and exotic wild herbivores do not generally affect healthy native cervids elsewhere as most plant-herbivore systems are multi-species guilds. Domestic and exotic wild herbivores as disease agents also do not generally affect healthy populations of native cervids, but undoubtedly increase the risk of introducing epidemiologically important new diseases. These factors might affect individual huemul, thus current conservation efforts aim at reducing or eliminating these, but it is not known if such actions have resulted in improvements. Regardless, populations do not recover even in the absence of one or several supposedly detrimental factors.

Recruitment in Argentina is too low for recolonizations or numeric increases of populations. Remaining refuges occur at high elevations near the continental divide, with high precipitation, far from the Pacific, and in plant communities growing on soils strongly influenced by igneous rocks, glaciation and volcanism. We posit that these areas likely provide suboptimal trace mineral levels to huemul. This affects their reproduction and survival because they lack the opportunity to compensate these nutritional imbalance by migrating to more favorable sites like valley bottoms and historical winter ranges.

Deficient dietary iodine and Se levels result in a plethora of problems. Although ultimate relationships are biochemical, these are expressed in reduced immune functions, reduced systemic growth and reproductive potential, and behavioral changes. Thus, the initial diagnosis might be death due to diseases, whereas the proximate factor might actually be lack of iodine and Se [10]; resistance to diseases is tied to adequate dietary iodine and Se. Similarly, predation rates might be mistaken as the problem, whereas the proximate factor might be behavioral changes due to nutritional deficiency of iodine and/or Se, causing animals to be weak, uncoordinated and behaviorally affected [10].

Increasing Se levels in otherwise deficient wild deer increased the recruitment rate by 260% [11]. *Ovis canadensis* responded drastically to Se mineral licks [10]. Adults shed summer coats much earlier, young were weaned much later, and predation losses diminished. Movement behavior changed once animals had access to Se salt blocks placed on summer ranges: animals no longer made temporary movements to winter grounds and valley bottoms to search for natural mineral licks. In contrast, control sheep without salt blocks continued to make such movements and had lower neonatal survival. In an additional population, salt blocks on summer ranges were also provided, but lacking Se; sheep also stopped movements to lower areas, but recruitment rates were 67% lower than the population receiving Se salt. In comparison, huemul in Chile also was observed to make summer movements to valley bottoms (Saucedo, pers. com.), but they would only survive if those areas were free from people and dog disturbances. The absence of such movement behavior in Argentine populations likely stems from the continuous elimination of huemul reaching lower areas populated with people.

Future efforts must be directed beyond the current belief system. The current lack of science-based monitoring prevents drawing any conclusions about cause and effect. In the worst case, decisions will be made on unreliable data, thereby compromising the future of the species. First and foremost is the need to study huemul populations directly with telemetry as indirect methods will be cost-prohibitive [1]. Specifically, studies should test our hypothesis.

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(Poster presentation.)

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Deer management and private hunting? Turning point for management system in Japan.

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A new deer management system in Japan will discuss based on historical, cultural and social background with comparison between other countries.
At the beginning of modern era, similar to European countries, releasing from feudal system caused exploitation of wildlife by free hunting in Japan. The first hunting law was established in 1895, 28 years after the restoration. The main purpose of this law is to regulate hunting to prohibit exploitation or extermination or wildlife. The law did not function so effective as to prohibit the extinction of wolf. After WWII, the US occupation administration suggests Japanese government reinforcement of hunting regulation and the major revision were made in 1963. The number of hunters, which were increasing rapidly after WWII, have been decreasing after increases of hunting taxes and fees in the 70's. Deer irruptive increase has come out in several prefectures in late 80's. Agricultural and forestry damages become huge and decreasing deer population is urgent issues for many prefectures. Local governments take policy to increase total hunting bag of deer, but they cannot achieve it because of low hunting activities. In Japan hunting is not a popular sport. Venison is not popular diet. It is difficult to pay the management cost by hunting income. Wildlife is not treated as public goods legislatively as same as Germany. Some people advocate that wildlife should be stated as public goods in wildlife law but it would be quite difficult because there is no clear consensus about who pay the managing costs. Though hunters are decreasing, some farmers get hunting licenses to protect their own cultivated fields. Local communities have still thought that hunting by the community member may be more safety than by hunter coming out of the community. Designating deer as local public goods will provide better management system. In deer management districts, members can choose public control killing, private hunting by members, and private hunting by hunter coming from outside of community or mixture of three. Policy promoting game uses as common property, which has been denied in modern Japan, will construct next relationships between wildlife and people.
(Poster presentation.)

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The biology of antler growth in endangered Bawean deer (*Axis kuhlii*).

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Bawean deer (*Axis kuhlii*) is an endemic and endangered Indonesian deer with their natural habitat limited to 4500 ha of protected area in Bawean island. Data on their biology is very limited, similarly to their population status. A study on their biology of antler growth was conducted for three years in two separate captivities, using animals from 3-4 months and 22 months old groups. The study showed that pedicle started to grow at 6 months of age, for 54.7 days, coincide with the testes entering the scrotum. Spiker velvet antler was noticed to grow 1.5 months later and took 72.3 to fully-grown. Length of adult stags in hard antler condition was between 88 to 243 days. Hard antlers morphology was relatively small compared to other tropical deer, where the main beam length was 49% and 25% shorter than sambar and rusa stags, respectively. The results indicated that the period of antler growth in Bawean deer was within the normal range of other tropical deer species.
(Poster presentation.)

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The preservation of rusa stag semen using TRIS egg yolk diluent with different carbohydrate and storage temperature.

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The purpose of this research was to study the viability of the rusa stags (*Cervus timorensis*) semen preserved at 27-28 C and 35 C in tris extender and supplemented with various sources of carbohydrate, i.e. glucose (TG), fructose (TF), and sucrose (TS). Collection of semen was conducted from five adult stags at the hard antler

condition. Semen was collected with electro ejaculator after sedation of the stags using a combination of 1 mg xylazine and 2 mg ketamin i.m. kg-1 body weight. Semen was evaluated by macroscopic and microscopic methods, with the concentration of 100 million motile sperm ml-1 were stored and observed every 3 hours (27-28 C) and 24 hours (35 C). Data were analysed with completely random design, and means were compared by the least significant difference test. The collected fresh semen had a volume of 2.06 ml, pH 7.03, yellow white until cream in color and its consistency ranged from normal to thick. Mass movement was ++ to +++ and percentage of motile spermatozoa (MS) 75.83%, percentages of live spermatozoa (LS) 87.67%, abnormal spermatozoa (NS) 7.31%, intact plasma membrane (IPM) 76.83%, and intact acrosome cap (IAC) 80.17%, with concentration of spermatozoa was 842.35 x 106 ml-1.

At 27-28 C preservation temperature and up to 15 hours of the observations, the glucose treatment (TG) showed a significantly higher ($p<0.05$) in any parameters being evaluated (MS 43.50%, LS 52.50%, IPM 47.67%, IAC 51.50%) than that the fructose (TF) or sucrose (TS) treatments (42.50%; 45.17%; 41.00%; 41.50% vs. 42.50%; 46;00%; 41.33%; 43.33%, respectively). The motility of sperm which was down to 42.50% motile was reached at 12 hours in both TF and TS treatments. At 35 C preservation temperature, the TG and TS showed a significantly different ($p<0.05$) in all parameters being evaluated (MS 42.22%, LS 53.89%, IPM 45.56%, IAC 47.67% and MS 42.67%, LS 48.89%, IPM 45.67%, IAC 46.22%, respectively) than in the TF treatment (MS 33.33%, LS 40.89%, IPM 36.44%, IAC 38.78%). From this study, it was concluded that the preserved rusa stag semen can be used for artificial insemination purposes up to 5 hours post preservation at 27-28 C using TG as carbohydrate sources, while in TS and TF carbohydrate sources were 12 hours. Semen preserved at 3-5 C, in TG and TS can be stored effectively up to nine days, whereas in TF was only for six days.

(Poster presentation.)

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Semen quality of rusa stags (*Cervus timorensis*) during one antler cycle.

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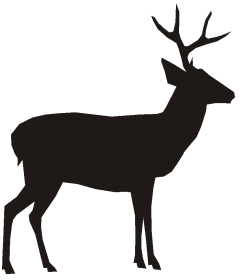
Circanual pattern of the antler cycle correlated with the circanual pattern of testicular function and reflecting changes in semen production. The objective of the research on the reproductive biology of rusa stags (*Cervus timorensis*) was to quantify the semen quality related to the their natural antler cycle, i.e. casting, velvet and hard antler stages. The research was conducted for 18 months in four adult rusa stags (4 to 6 years old). Data were collected at three weeks intervals during the annual antler cycle and semen characteristics were evaluated macroscopically and microscopically. The results indicated that semen quality was significantly lower ($P<0.05$) at velvet antler stage compared to that at hard antler stage (mass movement 0.63 vs. 2.38, motility 32.5% vs. 72.76%, concentrations 199.56 vs. 1055.95 million/ml, live spermatozoa 50.87 vs. 79.40%, abnormality 35.59 vs. 9.80%, respectively). The nutritional quality of seminal plasma in velvet vs. hard antler conditions showed a significant difference ($p<0.05$) in all parameters being observed (3.13 vs. 25.93 calorie, ash content 130 vs. 15140 mg/100 ml, protein 134 vs. 4560 mg/100 ml, fat 204 vs. 212 mg/100 ml, Ca 3.6 vs. 6.5 mg/100 ml, respectively). It was concluded that the best semen quality was produced and obtained at hard antler stage, which was also as the longest stage of the antler cycle, starting from June to February.
(Poster presentation.)

Problems of deer overabundance



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A test of localized management in a white-tailed deer herd.

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Herbivory by white-tailed deer within forest regeneration areas can have profound impacts on stand structure, composition, and biodiversity. Because traditional management strategies (i.e. sport hunting) are not solving the damage problem in many areas, localized management has been proposed as a possible solution. Localized management involves the "surgical" removal of one or more matriarchal social groups in an area deemed sensitive to browsing pressure. Because white-tailed deer females are generally philopatric to their natal area, removal of entire social groups may create low-density zones for ≥5 years. However, this technique has only been tested in a migratory, low-density, and un-hunted deer herd in New York. In that study, deer did not recolonize areas previously occupied for ≥ 2 years after the removal of an entire social unit. Herein, we describe our experimental investigation of localized management in a high-density and non-migratory white-tailed deer herd in the Appalachian Mountains of West Virginia, USA. We used a combination of radiotelemetry, sightings of tagged animals, and genetic data to: 1) investigate the movement ecology and social structures of white-tailed deer, 2) design and conduct an experimental removal of a social group(s) in the vicinity of a selected forest regeneration area(s), 3) monitor movements of adjacent social groups to detect encroachment or dispersal/colonization into the removal area, and 4) determine the relationship of colonizers (both marked and unmarked) to social groups and marked individuals. Between 24 February 1999 and 19 March 2005 we captured 358 individual deer. We collected DNA samples, ear-tagged each animal, and radio-outfitted 275 of the animals. Animals were located 3 times weekly from permanent geo-referenced triangulation stations. A total of 47,282 radio-telemetry locations were obtained between 7 April 1999 and 27 April 2005. We recorded 17,731 visual observations of tagged and non-tagged deer from April 1999 to April 2005. A 1.2 km^2 area was established as an experimental removal area based on social groups delineated via radio-telemetry. The experimental removal was conducted from 7 January to 27 February 2002 and accomplished by trapping and sharpshooting. A total of 51 deer were removed during the seven week removal period. Track counts in the snow conducted before, during, and after the removal indicated that the removal was largely successful. A final removal of deer was conducted from 7 January to 21 February 2005 to determine if animals subsequently occupying the removal area were

survivors of the initial removal, their descendants, or immigrants. A total of 31 deer were removed during the second removal. DNA was extracted from genetic samples using commercially available kits, and amplified through polymerase chain reaction. An ABI Genescan 3130 sequencer was used to examine allele sizes for the panel of 14 polymorphic microsatellite markers. A spatial autocorrelation analyses based on pairwise Moran's I among 229 individual adult (≥1.5 yrs.) females revealed that genetic relatedness was inversely related to the distances between core areas determined by telemetry data or trapping location. Females with core areas separated by less than 1km were more related than expected by random chance. However, autocorrelation became non-significant at distances >1km and declined to 0.0 at 2.1km. The correlogram displayed a stabilizing pattern, suggesting spatial structure at the group level. Using visual observations we were able to delineate 28 social groups that contained at least two members with genetic information. Mean relatedness within groups was 0.1, a value similar to that of first cousins. This evidence of fine-scale social group structuring indicates that the theoretical basis of localized management applies on the study site; females were indeed philopatric to their natal area and were structured in social groups containing related individuals. However, despite evidence for social group structuring of the deer herd, localized management was ineffective in establishing an area of reduced deer density on this study site. When we compared the genetic data collected from the first and second removals, we found evidence of genetic differentiation (significant Fst, and exact tests of differentiation, frequency of private alleles, and Hardy-Weinberg disequilibrium). The large number of animals removed three years after the initial experiment and the evidence of genetic differentiation between the first and second removal groups indicates recolonization by immigrant deer. We therefore conclude that localized management may not be applicable in areas of high deer density.
(Oral presentation.)

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Do wildlife warning reflectors alter white-tailed deer behavior along roadways?

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Deer-vehicle collisions are increasing in frequency throughout much of the United States. Government transportation agencies seek to minimize deer-vehicle collisions through a variety of techniques. However, few mitigation strategies have undergone extensive independent testing of their effectiveness prior to deployment in the field. Wildlife warning reflectors are marketed as an effective and humane technique for reducing wildlife-vehicle collisions. Yet, previous studies have provided a limited

understanding of reflector efficacy. We evaluated the effectiveness of 4 colors of wildlife warning reflectors (red, white, blue-green, and amber) for altering deer behavior that might help prevent deer-vehicle collisions. We observed white-tailed deer (Odocoileus virginianus) behaviors relative to roads before and after installation of wildlife warning reflectors using a forward looking infrared camera. From 18 November 2004-1 May 2005, we recorded 1,370 deer responses to vehicles during 90 nights of observations (4-hr each). Our study contradicted claims by the manufacturer that wildlife warning reflectors deter deer from crossing the highway when reflecting vehicle headlights. Our results demonstrated that deer exposed to each of the 4 colors of reflectors we tested were more likely to be involved in negative deer-vehicle interactions than without the devices present. We concluded that wildlife warning reflectors were ineffective in changing deer behavior such that deer-vehicle collisions might be prevented.
(Oral presentation.)

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Cascading effects of long term chronic browsing on lifehistory traits in white-tailed deer.

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The recent increase in deer populations worldwide is negatively affecting vegetation in many areas, but few studies have assessed the long-term cascading effects on the life histories of Cervids. White-tailed deer were introduced on Anticosti Island (Québec, Canada) in 1896 and expanded rapidly so that evidence on vegetation of severe deer browsing was noticed by the early 1930s. Detailed monitoring of vegetation and deer life histories, however, only started in the mid 1970s. Here, we assessed whether chronic browsing contributed to a decline in the quality of deer summer/autumn diet during the last 25 years, by comparing percentage of nitrogen of rumen contents between 1977-79 and 2002-04. We further assessed the cascading impacts on deer body condition and reproduction. Rumen nitrogen content declined 22% between 1977-79 and 2002-04, suggesting a reduction in forage quality in late summere-arly autumn. We also found a decline in asymptotic autumn body mass for both males and females, and a light decline in foot length for males. When controlling for annual stochasticity, age and date, males were about 9% smaller and also tended to accumulate mass more slowly in 2002-04 than in 1977-79. Similarly, at the end of November, adult does were 6% smaller in recent years than in 1977-79. The probability of ovulation increased 12% between the two periods, but twinning rate declined 7% resulting in a higher ovulation rate (9%) in 2002-04, although not quite significant. Our results suggest that following a persistent decline in forage quality over a period of 25 years white-tailed deer have adjusted their life history traits to

maintain reproduction but at the expenses of growth.
(Oral presentation.)

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Regeneration dynamics of boreal forests along an experimental gradient of deer densities.

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Deer are key components of forest ecosystems where they act as a chronic disturbance modulated by their density. Loosely regulated deer population can alter plant community structure and composition. This is especially critical for late successional forests that are vulnerable to compositional shifts following events that suppress advance regeneration. Although impacts are generally assumed to be proportional to deer density, nonlinearities may emerge e.g. from deer induced modifications to competitive interactions between plants. As a case study, we investigated the relationships between the regeneration dynamics of eastern balsam fir Abies balsamea forests and white-tailed deer *Odocoileus virginianus* density on Anticosti Island, Ca. We hypothesized that the responses of the field layer plants and advance tree regeneration are either: (1) directly proportional to deer density; (2) a smooth nonlinear function of deer density; or (3) a nonlinear function with thresholds. We tested predictions from these hypotheses by experimentally manipulating both deer densities (0, 7.5, 15, 27 and 56 deer/km^{-2}) and forest cover. In clear-cuts, the dominant responses of the field layer plants were growth and reproduction suppression at high deer densities and exponential recovery at densities ~<15 deer/km^{-2}. The mortality rate of balsam fir seedlings increased exponentially with deer densities, with the cumulative mortality reaching 74 8% at 56 deer/km^{-2}. Browse tolerant species such as grasses were positively and nonlinearly related to deer density suggesting an apparent competitive gain. Similarly, the abundance of spruce Picea spp. saplings was unrelated to deer density and increased with time as seedlings were recruited into larger height classes. Such rapid changes in the early successional stages have long term indirect consequences on successional patterns through processes such as seed availability, germination and early establishment of seedlings. Selective browsing at high deer densities over an extended period of time thus sets the conditions for recruitment failure following a stand-replacing disturbance. We propose a conceptual model based on the catastrophe theory to predict the evolution of deer- forest systems. On Anticosti, reduction of local deer densities to levels <15-7.5 deer/km^{-2} in the first three years following a clear-cut appears compatible with the regeneration of native forests.

(Oral presentation.)

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Impacts of cervids on invertebrate communities on forest floor in relation to deer species, density and site productivity.

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The impacts of high ungulate densities on vegetation have been amply studied and the impacts on some popular animal groups, such as birds, have even awoken public concern. The potential impacts of cervids on invertebrates have received much less attention. We studied how moose and reindeer at different densities and seasons affect vegetation and invertebrate fauna on the floor of boreal forest. We simulated browsing, urinating, and faecal deposition corresponding to 4 different moose densities in 8 exclosures along a forest productivity gradient in Sweden. Our results show that moose at higher population densities can have a substantial impact on the ecosystem, and that the effect can be modified by habitat productivity: As a result of these changes both vegetation and vegetation living invertebrate assemblages changed. Richness responses of spiders to browsing were negative at unproductive habitats whereas in the most productive sites moose had a positive impact. The impacts of reindeer grazing were studied comparing heavily grazed Finnish side and ungrazed Russian side of the reindeer fence on the Finnish-Russian border in Lapland. Vegetation was lower, temperature was higher and humidity lower in grazed plots. Soil moisture was higher in ungrazed plots under thick Cladina-lichen cover in winter ranges. In these pine forests we found spider species characterizing boggy habitats from the ungrazed plots and species favouring dry open habitats from the grazed plots. The relationship between site productivity and reindeer impact on invertebrate richness was opposite to that observed for moose: The negative impact of reindeer on spider and beetle richness increased with increasing productivity. The impact on spider abundance and richness differed between moose and reindeer, but in both the impact of browsing/grazing on spiders correlated with the impact of cervids on the abundance of the prey of the spiders.
(Oral presentation.)

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Sustainable population density of red deer in Mediterranean ecosystems.

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How population density translates into overabundance is a complex issue that depends on ecological conditions. Previous information suggests that red deer (*Cervus elaphus*) populations in Mediterranean habitats of Southwestern Spain may reach higher densities than in any other parts of Europe. Our goal in this study was (1) to describe the densities occuring in main areas of red deer distribution in Southwestern Spain, and (2) to explore the relationships between these densities and some indicators of performance and sustainability. We found that population density in hunting estates ranged from 0.1 to 1.0 individuals per hectare, averaging between 0.29 and 0.39 individuals per hectare in three main large regions included in the distribution area. We explored body size of males and females, antler size and fertility for individuals of different ages, as well as impacts on arbustive vegetation, as biological indicators of overabundance. All these parameters related to density, and younger individuals appeared more sensitive to population density. However, in our populations, these biological indicators were only weakly affected by increases in density compared with the case for other European populations. Two main reasons may contribute to explain this difference. First, productivity of Mediterranean ecosystems for wild herbivores is very high, which also corresponds with high levels of biodiversity, and may explain why red deer use so small home ranges in these types of habitats compared to other areas of Europe. Second, natural vegetation can buffer the limiting season in Mediterranean habitats (schrub plants during the summer) better than in northern latitudes, where cold winters may set a very low level for carrying capacity. Moderate densities constitute an appropriate reccomendation for management that can put together objectives of trophy quality and habitat conservation, but the posibility that sustainable densities in Mediterranean areas may be higher than in other parts of Europe, opens up an interesting oportunity to promote the exploitation of wild ungulates in these areas.

(Poster presentation.)

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Influence of population density on white-tailed deer foraging behavior and activity budget.

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At the end of the 19th century, 220 white-tailed deer (*Odocoileus virginianus*) were introduced on Anticosti Island (Québec, Canada), and in the absence of predators the population irrupted. Vegetation communities considerably changed because of the impacts of severe browsing. Generally, available resources per individual decrease when population density increases. To assess the effects of high population density on the foraging behavior of deer in low plant biomass communities, we experimentally manipulated deer density. We used three sites where forest was partially harvested. Each site was composed of 2 experimentally-controlled densities (7.5 deer/km^2 and 15 deer/km^2) in large enclosures, and a natural site where density was estimated at 25 deer/km^2. At each site-density, three deer were equipped with conventional radiotelemetry collars and were located a total of 2936 times by radio-tracking. Vegetation sampling allowed us to compare how deer use available space in relation to deer density and plant biomass. Individuals used clear-cuts and forested areas in a similar proportion. Activity budgets were also continuously obtained using motion sensors and an automatic receiver-datalogger. We compared hourly movements and activity of deer between density treatments. Adults were less active than yearlings at 7.5 but not at 15 deer/km^2. Otherwise, movements, activity budgets and available biomass were similar between 7.5 deer/km^2 and 15 deer/km^2. However, the available biomass increased through years and activity budgets varied accordingly. As biomass increased, deer increased the number of daily activity bouts, which also became shorter. Deer moved more at dawn and dusk than at other periods of the day. Females moved less at high densities than at low densities, but not males. This study demonstrates that relationships between density and foraging behavior are complex and that controlled-density experiments may help to understand the behavior of herbivores in relation to available resources.

(Poster presentation.)

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Trade-off between food and cover: summer movements and activity budget in white-tailed deer.

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Habitat selection in ungulates is frequently viewed as the result of a trade-off between food and cover. During summer, individuals are expected to trade-off forage abundance and escape or thermal cover. White-tailed deer-habitat relationships on Anticosti Island (Québec, Canada) are unique because of the absence of predators and the high deer density (> 20 deer/km^2 locally) in a boreal environment submitted to severe climatic conditions in winter. Our objectives were to determine the relationship between habitat use and deer behavior (foraging or resting) and to assess the influence of forage abundance on movements and activity budget of deer under natural conditions. We evaluated habitat selection and deer behavior using GPS collars equipped with activity sensors from July to November (n=19). We sampled vegetation in clear-cuts, peatlands and forests in deer home ranges to assess forage abundance within each habitat. Our results showed that habitat selection was influenced by type of activity: deer foraging preferred open habitats such as clear-cuts and peatlands, while deer resting increased their use of forested habitats, except at dusk. Spatial variation of forage abundance influenced deer movement rates. When forage abundance was high, i.e. in clear-cuts and peatlands, deer moved less than in forested habitats, suggesting that searching time for forage was reduced. Interestingly, deer moved rapidly when crossing edges between open and forested habitats, maybe because they were relocating. Temporal variation of forage abundance and quality throughout summer did not, however, affect movement rates and activity budget. Forage abundance was the main factor influencing habitat selection when deer were foraging, but while resting deer selected more forested habitats.
(Poster presentation.)

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Relationships between moose (*Alces alces*) pellet groups and characteristics of forests.

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Introduction

Contradictory opinions of moose population size and of methods to estimate population density as well as browsing pressure indicate needs of more accurate information for management purposes. Counting fecal pellet group has for long been analyzed in order to determine habitat use and population density of moose and deer (Neff 1968, Franzmann et. al. 1976). The pellet group method is considered important for smaller deer species which are difficult to observe (Cederlund & Liberg 1995). Winter conditions often restrict seriously aerial census of moose populations and counting of pellet groups is easier for moose owing to better visibility of pellets in varying field conditions. Comparison with aerial counting has shown that reliable information of moose density is possible using pellet group counting (Jordan et al. 1993). However, the important basic factors like behavioral aspects and diurnal defecation rate (Oldemayer & Franzmann 1981) may vary considerably depending on region and habitat quality (Andersen et. al. 1992). Besides indicating behavior, distribution and density of animals, the pellet groups can give related information of the occurrence and influence of browsing on forests (Härkönen & Heikkilä 1999).

The aim of the study is to determine the characteristics of forest stands and moose browsing effects correlating with the occurrence of pellet groups in managed forest area. Special attention is given to possibilities to obtain more information of the relationships between browsing pressure and moose density.

Material and methods

Field inventory was done in 2004 in four different forest areas in Central Finland in early summer, when the disappearance of pellets was not supposed to be problem (Persson 2003). In total 22 lines (92,75 km) were inspected. In Kiltua and Liperi the lines were situated at 0.5 km intervals, and in Lakomäki and Jokimaa the study was done on game triangles (3 x 4 km each), that are yearly used for monitoring game species in Finland (cf. Linden et.al. 1996),. Measurements were done on 50 m^2 plots at 50 m intervals. Following information was collected: number of new (previous winter) and old pellet groups, forest site type, forest stand characteristics (regeneration area, small seedling stand, sapling stand < 4 m, advanced sapling stand, young timber stand, advanced timber stand, old timber stand, open or seed tree stand), main tree species, effect of browsing on different tree species (% removed of foliage). In addition, the height of young trees up to 6 m was measured in height classes of 1 m.

Counting the pellet groups was done in early summer, as they could be easily determined before vegetation cover. The new groups dropped in the previous winter were separated from the old ones. Determining was done according to the differences in the position of pellets in relation to the ground vegetation and/or their deformations.

Those pellet groups of which the main part was inside the plot were included. Calculation to estimate moose density was done using the formula (D/A)(TxF), where D is the number of pellet groups, A the total area sampled, T the days of pellet groups accumulation, and F the defecation rate per day and individual (Olsson 1997). As the accumulation period was used 250 days, and as defecation rates 21 and 24 pellet groups per day were compared (cf. Jordan et.al. 1993, Andersen et. al. 1992). Mortality during accumulation period was not included in calculation.

Statistical comparisons were done using the Pearson correlation and one way ANOVA programs of the SPSS-procedure.

Results

Moose pellet group density varied significantly between the stand age classes in three study areas ($p < 0.001$, one way ANOVA). 60-75 % of pellet groups were found in the seedling stands and advanced young forest stands. The Liperi study area differed somewhat with no respective correlation between stand classes. In that more spruce dominated area the middle-aged, young timber stands also had relatively high numbers of pellet groups. In Liperi the forest peatland areas had on average more pellet groups than the mineral soil forests ($p < 0.05$), contrarily to the other areas with more groups in the latter kind of forests ($p < 0.001$ for each area).

The fecal output of moose in winter had most consistently occurred close to young Scots pines (*Pinus sylvestris*). Both the number of pines and the effect of moose browsing in terms of damage caused to the tops of pines correlated well with pellet groups (Table 1). Both silver birch (*Betula pendula*) and downy birch (*Betula pubescens*) appeared also to be often used by moose in the close vicinity of pellet groups. In Lakomäki and Liperi areas even overbrowsing of pines by moose correlated significantly with pellet groups. Overbrowsing of both birch species was consistently correlated with pellet groups in all study areas excluding Lakomäki, where only downy birch correlated. These results obviously reflect also browsing pressure depending on food availability in tree species.

Table 1. Characteristic of forests correlating with the number of moose pellet groups in four study areas in Central Finland. Statistical significance * = 0.05, ** = 0.01. x = browsing data is included in "top damage".

Characteristics measured on 28 study lines	Kiltua	Liperi	Jokimaa	Lakomäki	% of lines with correlation to pellet groups
No. of pine	0.142**	0.327**	0.375**	0.203**	50
No. of silver birch		0.093*	0.220**		11
No. of downy birch		0.120**		0.323**	29

Characteristics measured on 28 study lines	Kiltua	Liperi	Jokimaa	Lakomäki	% of lines with correlation to pellet groups
No. of aspen			0.167**		7
No. of juniper	0.073*				4
Height of young pines	0.190**				7
Height of young spruces	-0.134*				4
Height of young D. birches	-0.145**			-0.229**	7
Browsing on pine	0.272**	0.287**	x	x	39
Browsing on S. birch	0.230**	0.116**	x	x	21
Browsing on D. birch	0.338**	0.123**	x	x	25
Browsing on willows	0.078*				7
Browsing on juniper	-0.105**				7
Top damage of pine	0.245**	0.351**	0.345**	0.277**	61
Top damage of S. birch			0.239**		7
Overbrowsing of pine		0.188**		0.282**	14
Overbrowsing of S. birch	0.240**	0.154**	0.183**		21
Overbrowsing of D. birch	0.256**	0.146**	0.142*	0.356**	25

Characteristics measured on 28 study lines	Kiltua	Liperi	Jokimaa	Lakomäki	% of lines with correlation to pellet groups
Overbrowsing of aspen	0.073*		0.156**		11
Condition of pine	-0.191**	-0.266**			7
Condition of D. birch			-0.273**		4

The deciduous tree species known to be selected by moose were not commonly correlating with pellet groups. Aspen (*Populus tremula*) appears to be to some extent associated with pellet groups, but willows (*Salix spp*) only rarely and for instance rowan (*Sorbus aucuparia*) is lacking. It can be noticed that aspen is included as overbrowsed by moose.

According to the numbers of pellet groups moose density estimations in the study areas were between 1.7 and 3.2 moose/km^2 with daily output of 21 groups, and between 1.5 and 2.8 moose/km^2 with the output of 24 groups per day. The highest moose density was calculated in Lakomäki and the lowest in Kiltua and Liperi.

Discussion

Pellet group counts have mostly been used in habitat selection analyses (Cairns & Telfer 1980) as well as for comparison between aerial counting in order to find alternatives to accurate moose density estimation (Jordan et. al. 1993). In the present study pellet groups were used to obtain related information of the forest stands under the effect of browsing. Analyzing pellet groups and habitat preferences include uncertainties i.e. in time spent by animals (Guillet et. al.1995). On the other hand, correlation has been found between the occurrence of pellet groups and deer bedding sites (Collins & Urness 1981). Studies of moose browsing show that pellet group density correlates significantly with the amount of browsing in young pine stands (Heikkilä & Härkönen 1993).

The lack of correlation between pellet groups and certain tree species can be explain simply by their reduced number in the studied forest areas. In the moose winter ranges population density and consequently browsing pressure on selected tree species can be relatively high. The effect of browsing depends also on the available food resources. Considerable difference was found for instance between the Liperi and Lakomäki study areas. The former one is more spruce dominated than the latter one, which as relatively dry forest is typically dominated by pine forests. Estimating moose population density with pellet group counts includes uncertainty factors such as defecation rate in different habitats (Andersen et. al. 1992) and accurate timing of defecation (Persson 2003). However, in the present study the comparison between areas suggests that at similar moose density the effects of browsing can differ indicating difference also in the sustainability of forest to browsing.

Determining more accurately relationships between moose population size and

browsing damage is a relevant management question. In Finland suggestions have been made of using pellet group counts for population density estimates in the wildlife triangle network (Tiainen 1998). Planning an efficient sampling method for pellet group counts also other possibilities than triangle sampling could be taken into account, including monitoring the effects of moose browsing pressure.

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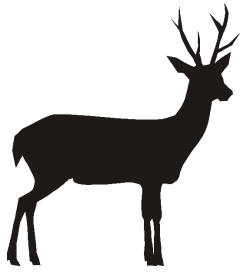
(Poster presentation.)

Conservation of free ranging populations: conflicts of interest



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Status, distribution and conservation of musk deer (*Moschus chrysogator*) in Kedarnath Wildlife Sanctuary, Uttranchal Himalayas, India.

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Out of the four species of musk deer *i.e*. Himalayan musk deer (*Moschus chrysogaster* Hodgson), Siberian musk deer *Moschus moschiferus* Linnaeus), Dwarf Musk deer (*Moschus berezovskii* Flerov) and the Black musk deer (*Moschus fuscus* Linnaeus), only one species *Moschus moschiferous* is present in Himalayan range of India. The musk deer has been exploited for the musk a secretion of the preputial gland of the male, which is used in perfumery and medicine for centuries. The musk been very expensive animal product fetching up to US$ 65000/kg in the international market is clear inducement to the human greed to put enormous pressure on the animal pursuing them towards the extinction. The species is listed as "Vulnerable" by IUCN (1974) in Red data book. Similarly the Wildlife Protection Act (1972) of India put them under Schedule I species. The first ever-ecological study was done by Green (1985) and later by Satyakumar (1994) in Kedarnath Wildlife Sanctuary and this study (Ilyas, 2004). However it is highly desirable that status, distribution, and threats to conservation of musk deer should be given due importance. To understand the status distribution and conservation status an intensive survey was conducted at three sites of Kedarnath Wildlife Sanctuary during premonsoon 2004, between the altitudinal range from 2500m at sea level to 4000 m a.s.l. The direct as well indirect methods were used and found that the pellet group density of musk deer was found to be maximum in Saukhark (53.14±9.6) followed by Tungnath (14.86±8.71) and Madhmaheshwer (10.19±3.2). Principal Component Analysis (PCA) was performed to understand the habitat use of musk deer. Due to illegal poaching and hunting the population of musk deer has declined and now confined small fragmented patches and needs urgent attention for the conservation.

(Oral presentation.)

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Seed dispersal by the reintroduced Persian fallow deer in the Judean Mountains, Israel.

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The introduction of an animal to a new environment can have significant effects on the plants population density and distribution. The Persian fallow deer (*Dama dama mesopotamica*) has been gradually reintroduced in Israel since 1996. Here we report a recent study on the potential of the Persian fallow deer as a seed disperser via endozoochory, and the influence of the deer ingestion on tree seeds. 160 samples of faeces were collected from the Judean Mountains, near Jerusalem, over a one year period. Each sample of feces was divided into three parts: the contents of one third were analyzed in the lab, and the seeds were identified and counted. Another third of each sample was sown in a greenhouse, and the viability of the seeds was determined by the proportion which germinated. The last third of the sample was sown in the field, to test if the process occurs in nature as well. More than 30 species of herbs germinated from the feces, and germination was stronger (both in the number of species and in the proportion of germinating seeds) in the greenhouse than in the field. The species that germinated were from all range of habitat types used by the deer. Of the trees, carob (*Ceratonia siliqua*) seeds were the only intact seeds found in our feces samples. The ingestion had a significant positive effect on the carob seeds compared to seeds either from intact carob pods, exposed carob seeds, or carob seeds that were collected beneath trees, and even from carob seeds that were collected from jackal feces. Our results provide evidence to the great influence that the reintroduced Persian fallow deer may have on the local Mediterranean flora by contributing to the long-distance seed dispersal mechanism and specifically to the distribution of carob trees.
(Oral presentation.)

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Deer management and monitoring of browsing impacts in Austrian national parks.

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In national parks (IUCN Kat. II) humans theoretically should convert from managers to observers of natural processes. However, in Europe such parks are mostly small islands in multiple used landscapes with strong ecological connection to the areas outside of the park. Wildlife populations, particularly wide ranging red deer, mostly use habitats that are much larger than the park area. Parks often function as a red-deer source area for the surrounding region, partly with game-damage problems in agriculture and forestry. This situation needs a minimum management of red-deer populations in national parks focused on the aims existing inside as well as outside of the park. Wildlife management should be oriented on the results of objective monitoring systems and threshold values which justify management activities in the park. A park-specific tolerance level for the impact of browsing on forest regeneration has to be defined because in national parks economic aspects cannot be argued any more. Operational criteria and indicators are required for monitoring and management. Ways to manage red-deer populations in Austrian national parks under the conditions shown above are presented and the following questions are discussed. 1) Can "game damage" be defined for a national park? 2) How can red-deer populations be regulated by shooting considering the aims of national parks? 3) How is red deer managed in national parks during winter if natural winter habitats are lacking? 4) Which experiences exist on the cooperation between wildlife managers of the parks and wildlife management of neighbouring land owners and hunters?
(Oral presentation.)

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Wildlife trade in deer species: A need for developing wildlife forensic techniques.

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Efforts for conserving biological resources in South Asia have been one of the major focus because of richest regions in the world and are the abode of many rare, endangered and endemic species. Illegal poaching has been one of the major conservation threats leading to decline of a number species. Of the 830 wildlife offenses received, 44.8 per cent cases are of deer species. Out of nine deer species in

India, five species are in *Schedule I (*Kashmir stag, Thamin, Swamp deer, Mouse deer, Musk deer) and other four (Chital, Sambar, Hog deer and Barking deer) in *Schedule III* of the *Wildlife Protection Act, 1972*. Most of the items seized in wildlife offences of deer species are of meat (58%), hair/skin (11.4%), antlers (4.4 %), bone and skull (3.5) and others. Thus for controlling illegal trade in wildlife parts and products in Southeast Asia, WII has initiated the work of establishing Wildlife Forensic Facility for proper implementation of Indian Wildlife (Protection) Act-1972. Hair characteristics of Indian deer species based on cuticular, and medullar patterns have been prepared. We have also standardized the protocols of identifying species from antler based on morphological features, scan electron microscopy and analytical techniques (TGA, XRD, XRF, ICP-MS). Extraction of DNA is the main challenge for forensic DNA works. Sometimes the samples are either in very bad quality and quantity or fixed in formalin which in turn may inhibits Polymerase Chain Reaction. Isolation of DNA from various tissue samples was done using different protocols viz. phenol/chloroform (PC) (n=54), DNeasy tissue kit (Qiagen, Germany) (n=100), Chelex-100 (n=100) and Bio-Robot (n=16) with necessary modifications whenever required. 28 per cent samples examined (n=275) did not yield any DNA. Quality of the DNA obtained from these samples was in the order of DNA-Bio robot > DNeasy tissue kit, (Qiagen, Germany) > PC > Chelex. 48% amplification was achieved in Polymerase Chain Reaction with mitochondrial cytochrome b universal primers. We developed the Restriction Fragment Length Polymorphism (RFLP) based profiles for identifying deer species from meat samples suitable to yield at least 359 bp PCR products from mt DNA region. Among these restriction enzymes, NlaIII, Ssp1, Stu1 and XhoI are suitable to identify most common Indian deer species. The DNA yield from some of the degraded meat samples of deer species, antler, and bone was highly degraded and yield was always < 200 bp. Therefore, we re-designed the PCR primers and standardized the other protocols for identifying species from such products. We have also developed DNA based protocols for identifying species from antlers.
(Oral presentation.)

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Habitat use of pampas deer (*Ozotoceros bezoarticus*) at agricultural areas in southern Brazil.

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The studied aimed at the evaluation of habitat use by *Ozotoceros bezoarticus* pampas deer in modified areas by agricultural activities, in two private estates in Southern Brazil. The roads of the studied estates were travelled by car through circuits in order to identify agricultural areas and grasslands, in sixteen monthly field phases, realized between Feb/01 and May/02. There were computed 1065 observations, the average

size of the groups was 2.29 + 0.55, and the sexual ratio was 0.83. Thirty-four deaths were recorded and the main causes of death were predatory actions, hunting and individuals being run over by motor vehicles. There were recorded high search rates for oats and wheat (1.0), oats mixed with rye grass (1.0), soy (0.91), and grasslands(0.87), whereas maize showed the lowest search rate (0.54). Resources availability was 100% for grasslands, 75% for maize and soy, 43.75% for oats and wheat, and 31.25% for oats mixed with rye grass. The rates for substratum utilization were 0.52 for oats, 0.45 for soy, 0.26 for wheat, 0.22 for grasslands, 0.17 for oats mixed with rye grass and 0.04 for maize. There was spacial segregation between pampas deer and cattle. Only 14.6% of the sights in the grasslands occurred when cattle were sharing it. The grasslands proved to be of much importance at the beginning of the birth peak, whereas soy was intensely used during lactation, and oats were an important resource during severe frosts. The results of this study indicate that crops and grazing land are an alternative source of food that may meet certain wants of the species or act as an alternative source when cattle limits the use of grasslands. The pampas deer also take into account other features such as rare human interference, distance to forested areas, also to roads that present heavy traffic and nearness to areas that may be used as shelter and refuge. The studied population is seriously endangered and it will not escape extinction unless certain policies to guarantee its conservation are adopted. These policies should include the handling of areas and control of pressure vectors.
n unless certain policies to guarantee its conservation are adopted. These policies should include the handling of areas and control of pressure vectors.
(Poster presentation.)

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Impact of red deer browsing on the understory of Hungarian forests.

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In many European countries large herbivore-forest relationships causes conflicts between game and forest managers and nature conservers. Overpopulated red deer are named as primary factor for the forest damages. However, forest habitat improvement is hardly-considered as a solution against game damages. To describe the problem, availability of different plant forages and browsing on them by ungulates were seasonally investigated by sprig counting in the understory of five forested areas in Hungary. Biomass of available sprigs was also calculated. Our results show that natural food supply can reach 1500 and 3000 kg per ha during the vegetational period.

Some species were generally preferred (e.g. locust, elderberry or blackberry), but many other plant species in the understory was also browsed. Proportion of the browsed sprigs was always between 0 and 10 percent, but in one area with very low forage availability this proportion was 35-50 percent. The highest browsing was found during the vegetational period not in winter. There was no strong relationship between the proportion of sprigs browsed and the local intensity of area use of ungulates. Our results show that browsing damages could be much more effectively reduced by establishing rich understory besides local red deer population control.
(Poster presentation.)

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Effects of small barriers on habitat use in red deer.

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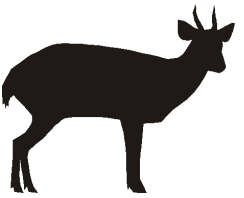
The establishment of fences is a common management practise not only in farming but also in protected areas. These artificial barriers are mainly aimed to protect vegetation from the grazing and browsing impact of large mammalian herbivores. Despite the potential benefit of protecting vegetation and landscape from herbivory, barriers also constrain animal movements at medium and large scale, which has been demonstrated to be the cause of serious problems in habitat and species conservation. However we still know little about their effect on the biology and ecology of plant and animal communities. The aim of this study is to assess the effect of fences on the spatial distribution, movement and sociology of Red deer in Doñana National Park (Andalucía, South-East of Spain). The study was carried out in an ecotone area between shrub land and marshland. Red deer daily movements take place between the shrub land, where they rest, and the ecotone where they forage. Most fences and human constructions are placed in a way that constrain the movement of red deer between these two habitats. During the rut of 2003 we carried out censuses in the ecotone area to assess the effect of adjacent fences . We also tested the effect of experimentally placed fences. Results from censuses show that areas with natural access affected by permanent fences or obstacles are less used by red deer. On the other hand, the experimental placing of barriers produced a decrease in the number of red deer using the areas of the ecotone affected by the experimental barriers. Also, the placement of the experimental barriers decreased the number of females per harem on both areas, affected or non affected by the barriers, showing that any management during the rut could have unknown and unexpected effects. So, we conclude that the placing of fences and obstacles in the ecotone cause the underutilization of the

adjacent habitats. This can produce the overuse of other areas and can affect parameters of the mating system of the red deer through the effect on the spatial distribution of females.
(Poster presentation.)

Feeding ecology



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Botanical composition of taruka (*Hippocamelus antisensis*) diet during rainy season in Huascaran National Park, Peru.

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The taruka distributes in the high Andes from north Peru to northwest Argentina. It lives in mountainous rocky rugged terrain, using also grasslands and scrubland, between 2500 m in the south to up to 5200 m in the centre and north of its distribution. Studies on taruka feeding ecology and diet allow us to understand the relationships between taruka and its ecological niche, as well as the possible overlapping with diets of free ranging domestic ungulates. The field data were collected on the southwest of Huascaran NP, central Andes of Peru, throughout puna grasslands and rocky slopes, during February 2003. The rainy season in the area occurs from December through March. Samples from all vegetative species were collected, including flowering parts when present. Tissues were taken from the epidermis of leaves, stems and flowers, applying them a soft chemical treatment. The tissues were boiled and dyed. The tissue samples were photographed through the microscope, creating a reference collection. All fresh pellets found in the field were collected and conserved in alcohol, dried up in the lab. One gram from each sample was diluted in distilled water and centrifuged, boiled with NaOH. Sodium hypochlorite was added and the samples were washed on a 40¾ mesh. Alcohol was added to the samples and dyed. Fragments were identified by microscope. Grass species eaten by taruka during the rainy season comprised close to 57% of the consumed fragments. More than 20 plant species were identified as eaten by tarukas. Among the species that were represented with more than 4% of the fragments each, are *Poa gymnatha*, *Bromus villosissimus*, *Calamagrostis* sp., *Trisetum spicatum* and *Poa spicigera* (*Poaceae*), *Luzula racemosa* and *Distichia muscoides* (*Juncaceae*), *Werneria nubigena* and *Senecio comosus* (*Asteraceae*), and *Ephedra americana* (*Ephedraceae*, *Gymnospermae*). This is the first study to find the importance of grasses for tarukas, which may select them when soft, during the rainy season. Thus, a possible overlap with domestic ungulates diets should be explored, eventually helping in the conservation of taruka, and generating an adequate management of the species and the ecosystem.
(Oral presentation.)

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Habitat use by two large deer species (*Hippocamelus antisensis* and *Odocoileus virginianus*) and one small deer species (*Mazama bricenii*) in the Apolobamba Integrated Management Natural Area (La Paz-Bolivia).

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The distribution and habitat use of two large deer species, *Hippocamelus antisensis* (taruka) and *Odocoileus virginianus* (luichu), and one small deer species, *Mazama bricenii* (chuñi taruka), was determined in the Apolobamba Integrated Management Natural Area (Bolivia). The research was conducted between January and October 2001 and covered an altitudinal range of 2950 to 4760 meters above sea level. In order to determine the distribution of the three species, direct and indirect observations were taken, including observation of remains. Study data was also complemented by surveys carried out with local populations and park guards. Habitat use was determined via analysis of fecal remains (pellets) collected during transects. Transects were followed in 10 points, distributed proportionally in four different habitats in accordance with the area covered by each habitat within the protected area. In each point, four parallel transects (1km x 2m) were followed, totaling 44 transects. Because it was not possible to differentiate between *H. antisensis* and *O. virginianus* pellets, all pellets encountered were considered as those of large species. This was not the case with pellets of M. bricenii as their droppings are easy to differentiate. The four habitats where the transects were set are: Snowline, Semi-humid High Andean, Yungas Paramo and Yungas Edge-Cloud Forest. There are no significant differences in habitat use by the two large deer species. They use three habitats: Snowline, Semi-humid High Andean, and Yungas Paramo. These results may indicate a sympatric relationship between the species, particularly in the Semi-humid High Andean habitat, where climatic and topographic present conditions appropriate for both species. The small species used only the Yungas Edge-Cloud Forest and was not present above the highest limits of this habitat.

(Oral presentation.)

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Impact of deer browsing and other environmental factors upon growth and development of fir saplings (*Abies alba* Mill.) in the Bieszczady Mountains, southern Poland.

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Growth and development of fir saplings is influenced by deer browsing and by other factors such as climatic variables, pests, improper planting technique and others. Therefore, in order to estimate browsing impact of deer population upon fir saplings, the following experiment in the Bieszczadzy Mountains was carried out. In spring 2000 four fir plantations (1.5 ha each) were established and half of each plantation was fenced by metal netting. Then using systematic placement 13 sapling plots (2 x 8 m) in each fenced and each unfenced plantation were established. Each sampling inside sampling plots was marked with number using plastic sticker. During spring 2002, autumn 2002 and spring 2003 the following measurements for each sapling were taken: number of twigs, number of damaged: all twigs, leading shoots and others twigs, diameter of crown and sapling height.
In spring 2002 sampling plots data showed presence of 1122 saplings (6743/ha) in the fenced areas and 1062 fir saplings (6 611/ha) in the unfenced ones. This means that probably due to deer feeding 5.34% of fir saplings died during 2 years after the plantations were established. From spring 2002 to autumn 2002 mortality of saplings during growing season was higher in unfenced plots (0.53 % vs. 1.13%). Measurements in spring 2003 indicated also higher winter mortality of saplings in unfenced areas (0.90% vs. 1.9%). Spring 2003 survey showed that leading shoot of 0.9% saplings was damaged while in unfenced plots this index was equal to 15.9%. Saplings from the fenced plots were higher (38.9 cm vs 34.3 cm) and their diameter of crown radical was larger (0.85 cm vs. 0.75 cm). According to ANOVA test the above differences were statistically significant. Excluding saplings with the leading shoot damaged it was documented that significant growth of sapling is reduce if more than 15% of twigs were damaged. Data analysis between spring 2002 and 2003 provided information, that participation of deer in mortality of saplings is 34.9%, but remaining 65.1% mortality is caused probably by pest, improper planting technique, wrong soil preparation and climatic factors. However, deer were responsible for 94.3% damage of leading shoots and for 74.7% of damage of all twigs of saplings. In the study area population density of red deer amounted to 29.5 animals/1000 ha and local societies do not agree to reduce number of red deer. Recent publication from the area showed that chemical protection of sapling is much less effective than fencing. Therefore in order to mitigate conflict between deer management and forest management fencing of small size young plantation of fir would be most suitable in the Bieszczady Mountains.
(Oral presentation)

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Why deer strip bark? -two case studies of bark stripping by sika deer in central Japan.

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Bark stripping by cervids occurs worldwide. In many cases, the occurrences of bark stripping are frequent in winter and early spring, and explained that are caused by food shortages. On the other hand, in some cases, cervids seems to eat bark without food shortages. In Japan, sika deer, Cervus nippon, also strip bark. We give a presentation about two investigations of the bark stripping by sika deer in central Japan. We carried out our studies held at two regions to clarify the relationships between the seasonal changes of bark stripping and food quality. These investigations gave contorastive results. (1) In Mt. Ohdaigahara, bark stripping is most intensive during summer (July to September), when Sasa nipponica, the deer's main forage in here, is abundant. It suggests that bark stripping is not due to food shortages. The nutritive value of bark is lower with much lignin, and that of S. nipponica, is higher with much crude protein and hemicellulose contents in summer. Sika deer seems to eat the bark to balance the digestible nutrients of summer forage. (2) In Northern Mount Fuji district, planted veitch fir were stripped the bark. Bark stripping occurred from December to May or June with a peak in March April. The stripping period overlapped with the periods of low food availability and poor food nutrition of sika deer, from January to April. February is the worst forage period in terms of both quantity and quality. There was a time lag of 1 to 2 months in the peak of bark stripping in March April when compared with the poor forage period in February. This time lag may suggest that sika deer need more nutritious and easily digested food from March due to increased nutrient demands that result from depleted body condition in both sexes, gestation of pregnant females, and the recovery of active metabolism. These two cases suggest that there are several seasonality and reasons of bark stripping by sika deer in each habitat although they are the same species, and also suggest that the quality and quantity of other available foods are concerned with the bark stripping occurrence.
(Poster presentation.)

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Influence of an extreme climatic event on the winter diet of red and roe deer in northeastern France.

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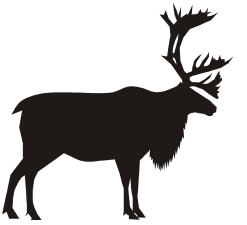
Extreme climatic events may profoundly affect herbivore population dynamics and habitat use by returning tracts of mature forests to early seral stages where food and cover resources rapidly develop. In December 1999, hurricane Lothar struck France, Switzerland and Germany, and caused widespread destruction to forests. Studies carried out in France suggest that roe deer (*Capreolus capreolus*) may have benefited from the creation of hurricane-related clearings, at least in the short term. It has been suggested that the combination of a reduction in hunting due to hunters' inability to access the areas and an improvement in habitat characteristics in clearings resulted in Lothar having a positive effect on roe deer population dynamics. Here, we studied the winter diet of red (*Cervus elaphus*) and roe deer before and after hurricane Lothar in a heavily damaged forest, assuming that the hurricane, by creating numerous clearings in which food availability for herbivores increased rapidly, allowed deer to specialize on preferred plant species that benefited from habitat modifications, particularly bramble and grasses. According to their feeding types and ecology, we expected that the increase in the availability of grasses and bramble after the hurricane would result in an increase in the proportions of these plants in the diet of red deer and an increase in the proportion of bramble in the diet of roe deer. Analysis of stomach contents revealed that consumption of grasses by red deer almost doubled following the hurricane, but no effect on bramble consumption by either deer species could be detected. Our study also revealed a significant annual variation in bramble consumption, which suggests that its availability as a food resource for deer varies from year to year, and this may have masked the hurricane effect. We then discuss the role of disturbances in improving habitat for forest ungulates, and the role of key alternative food resource in helping forest managers to find solutions for mitigating ungulate impact on tree regeneration.

(Poster presentation.)

Seasonal and non-seasonal deer: (Arctic to Tropic)



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Seasonal migration pattern of red deer (*Cervus elaphus* L.) in the central Slovakian mountains.

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Red deer is a common species and the current contigous range encompasses 39,054 km^2, or 80 % of the country with numbers estimated up to 38,000 individuals. A proportion of red deer in the western Carpathian mountains seasonally migrate between wintering areas and higher altitude grazing grounds. In 1998 2005, the movement and migration pattern of 13 red deer in the Nízke Tatry and Poana mountains were studied by VHF telemetry. The study area elevations ranged from 430 metres to 1,660 metres and composed of a great diversity of forest ecosystems. In total 8 stags and 5 hinds were individually
radio-tracked, the duration of telemetry varying from 6 to 56 months. Spatiotemporal behaviour of red deer was described by 6 characteristics: migratory status, migration date, size of seasonal home range, average distance between seasonal ranges, altitude of telemetry locations and direction of migration. Migration was defined as the date upon which migrant red deer left their seasonal home range to the date they established their summer home range. 5 stags migrating from winter range for non-overlapping summer ranges had migration dates from April 11 to May 4 and return dates in the fall ranged from November 11 to January 17, which particularly depended upon the depth of snow covering the summer ranges. Spring migration peaked and concentrated more than the fall migration. Two stags and five hinds were classified as resident and a young stag classed as a transitional type, between migrant and resident, used a winter home range which overlaped an extrordinary large summer home range. The size of the seasonal home ranges was derived by an MCP estimator. Migrants had larger winter and summer ranges than residents (winter 13.2 km^2 vs. 5.6 km^2, summer 11.2 km^2 vs. 3.2 km^2) with the size of winter ranges differing significantly. Surprisingly the size of winter and summer home ranges (migrants 13.2 km^2 vs. 11.2 km^2; residents 5.6 km^2 vs. 3.2 km^2) were not statistically different. Daily movements in the search for widespread supplementary food, possibly increased and enlarged winter home ranges. Average distances between the centres of summer and winter ranges were significantly larger for migrants (9.4 km; range 2.9-14.7 km) than for residents (0.9 km; range 0.1-2.6 km). It appears that spring migration can be well characterised by both change of altitude and direction of movement. It was obvious that in spring red deer migrated from lower winter ranges to higher altitudes and that their direction of movement was also important as indicated by the span of bearings which ranged from 308 to 100 approximately northwest to east.
(Oral presentation.)

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Scale-dependent habitat selection of GPS-collared Alpine red deer the role of food availability and quality.

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Understanding habitat selection usually requires a scale-conscious approach. On the behavioural level, habitat selection may be seen as an animals trade-off between responding to different needs such us feeding, social contacts, predator avoidance, and others. Habitat selection in mountain ungulates may be especially fine-tuned as difficult topography and harsh climate often restrict access to food resources with sufficient nutritional value. We studied variation in habitat and diet selection of GPS-collared red deer *Cervus elaphus* in the northern Swiss Alps, and measured both availability and use of food resources with respect to biomass and nutritional value over an area of 250 km^2. We defined selectivity at two scales, home-range scale and site scale. We hypothesized that during winter, selectivity would be strongest, and that requirements for highly nutritious food would be the main driving factor in habitat selectivity across seasons and spatial scales. At both scales, selectivity in habitat selection decreased from winter to summer. Forest was consistently preferred over open land at home-range scale, while at site scale, preference for open land declined from winter to summer. With respect to forest structures, red deer exhibited seasonally different preferences for structural properties in choosing home ranges. About half of all preferences were associated with habitat offering better forage, either in terms of higher biomass or higher content of crude proteins, or both. Overall diet was dominated by graminoids (41%), but tree browse (29%) and forbs and Rubus (18%) were also important. Variation in diet composition was mostly associated with season, but effects of habitat at home-range scale and sex were also detected. Diet selection was consistent with the findings from the analysis of habitat selection, reflecting strong use of plant groups with high biomass, easy availability and high nutritional quality (low cellulose/lignin, low lignin, high organic matter, and high crude protein contents).

(Oral presentation.)

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Photic modulation of the temporal pattern and rate of activity in reindeer.

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Northern species of deer have adapted to the relatively predictable seasonal variation in food supply characteristic of temperate environments through the evolution of annual cycles of appetite and growth. These cycles persist under constant conditions, indicating their endogenous basis, but are normally entrained by the annual cycle in day length. Several species also display a pronounced annual cycle in the daily rate of activity (h.24h-1). Increased activity in summer reflects the permissive effect of a long photo period on activity and, in particular, on time spent feeding while marked peaks of activity around dawn and dusk indicate that the activity pattern is under photo periodic control. Reindeer/caribou live at high latitudes where the light/dark (LD) cycle of night and day is weak or absent for much of the year and several reports suggest that neither the temporal pattern nor the rate of activity in this species is under photoperiodic control. These results, if confirmed, would indicate that the activity of reindeer may be independent of the seasonal fluctuations in metabolic demand associated with the annual cycle of growth. We examined activity in reindeer in relation to ambient photic conditions using continuous records collected across one calendar year in free-living *Rangifer tarandus tarandus* (NR) and *R. t. platyrhynchus* (SR) at 70º and 78º N, respectively. In both sub-species, alternating ultradian bouts of activity and inactivity persisted across the 24h day throughout the year. However, in contrast with earlier suggestions, the LD cycle, when present, imposed a diel rhythm in the otherwise continuous 24h pattern. All the reindeer displayed a pronounced annual cycle in the daily rate of activity which was closely in phase with the appetite cycle. The amplitude (A) of the activity cycle was greater in SR (A = 2.4h) compared with NR (A = 1.5h) reflecting the larger amplitude of the appetite cycle in this sub-species. We conclude that the monthly rate and the 24h pattern of activity in reindeer are modulated by the photic environment. Weaker diel rhythmicity in SR compared with NR results from a latitudinal decrease in circadian organisation and photic responsiveness in *Rangifer*.

(Oral presentation.)

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Habitat use and selection of fallow deer (*Dama dama* L.) in a Mediterranean environment.

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The distribution and quality of resources as well as the habitat structure play an important role in determining the spatial behaviour of deer. The knowledge of the relationship between habitat and ranging behaviour is essential for the management of wild populations. At the present time the ecological requirements and habitat selection of fallow deer (*Dama dama* L.), in spite of its wide distribution, is scarcely known especially in Mediterranean region where is the original range of the species. We studied the habitat use and selection of fallow deer in the Castelporziano Estate near Rome (Italy) characterized by a Mediterranean climate with mild winters and warm and dry summers. The vegetation is mainly composed by evergreen oak forest (44%), deciduous and mixed oak forest (21%), pine woods (7 %), Mediterranean maquis (20%) and open areas (8%). Twenty-two (13 males and 9 females) adult fallow deer were caught, from January 2000 to December 2003, in vertical nets, in cage traps or immobilized by using a dart gun and fitted with radio-collars. We collected 6638 locations in 4 years, and those with a 95% confidential ellipse greater than 1 ha was discharged (33,5%). Compositional analysis was performed in order to assess the habitat use and selection a two kind of geographical level: 1) home range vs. study area; 2) location vs. home range. Data were investigated at two different temporal scales (annual and seasonal). Differences between sex, daytime period, and activity state were tested. At annual scale only differences between sexes emerged. At II level of selection females avoided open areas whereas males evaded pine woods. Therefore, at seasonal scale, both differences among sexes and year resulted. Females selected maquis and evergreen oak forest, while males preferred deciduous oak forest and open areas. At the II level of selection males actively preferred open areas that were placed at the lowest rank by the females.

(Poster presentation.)

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Function of habitat segregation in regulation of isolated sika deer population.

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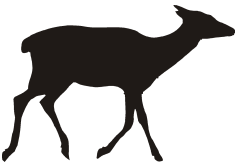
In ungulate populations, there are many reports on the phenomenon of habitat segregation, but little on its function in population dynamics. To study the mechanism and function of habitat segregation in population dynamics, a long-term seasonal census has been carried out for fifteen years on a Mage sika population *Cervus nippon* mageshimae of Mage-shima island (31N, 131E, 12 square-km), which has been maintained at least for a thousand years without predators, competitors, snowfall, nor human disturbances. In this closed and long-maintained population, obvious habitat segregation in sex-age classes was observed ordinarily, namely females and fawns use forest area, prime males open-rich grassland, and yearling males open-poor grassland at seashore. The total density (13-52 animals/square-km) and its seasonal variation (SD=.16-.29) have fluctuated yearly, and a density-depended regulation has detected in this population. This strict and agile density fluctuation has brought by drastic changes in natality (10.9-62.9 fawns/females) and mortality of yearling males (0-36.1 %), and these two demographic parameters were skewed spatially corresponding to the property of habitat segregation in sex-age classes. This tendency of spatial skew in the mortality was remarkable especially in "sinked" years. Consequently, spatial segregation in sex-age classes is considered to reinforce the density dependence in this closed population, and hence, to contribute higher sustainability to this small insular deer population.

(Poster presentation.)

Venison and its potential contribution to diet



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Venison and the history of early European hunting enclosures.

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The prey of hunting primates is often supposed to have been pivotal in the evolution of large brained hominids. This was not only as nutrition but also because, as perhaps the first valued possession, meat endowed the successful hunter with the power of bestowing gifts and bribes. Thus the prestige associated with a productive hunt has a long ancestry. In this context the prodigious effort made by rulers throughout Eurasia from prehistory to modern times to ensure prolific hunts becomes comprehensible. One of the best ways to achieve this was by the creation of the hunting reserve or enclosed deer park. Recent hypotheses on the parkland nature of the original European woodland suggest that "haga" were barriers surrounding groves. In Anglo-Saxon England the hay" was a deer enclosure. By the time of the 11th century Norman invasion there were several hundred such hays which became known by the Latin word "park" which in itself shares roots with the Old Persian word "pairidaeza". The Persian paradises not only became associated with Eden, heaven and a state of supreme bliss but also, essentially, incorporated hunting preserves.England, and to a lesser extent Scotland, would appear to be unique in the number of deer parks which were created during the medieval era, two to three thousand at a time when the human population was only around three to four million. England still possesses more deer parks than any other region in the world. Since all deer belonged to the monarch the establishment of a deer park depended on royal patronage. Venison from those parks could not be sold until the eighteenth century but was frequently gifted, echoing the "gifts" of prey made by the hunting primates.Many parks existed for almost a thousand years evolving to meet contemporary fashions and becoming the designed landscapes which have been described as England's greatest contribution to art. This paper discusses the origin and development of the British deer park, the ways in which they were used and their deer managed to produce venison, and their present and future value.

(Oral presentation.)

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Fatty acid profiles in Javan rusa (*Cervus timorensis russa*) stags.

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Rusa deer are an important commercial species in the subtropics and tropics (Sinclair, 1997; Maudet, 1999). However, although they are reared almost exclusively for venison, there are few data on the quality of their meat. The fatty acid profile of meat influences its palatability, proneness to rancidity and nutritional value. There are several reports of the fatty acid profiles of other deer species (e.g. Manley and Forss, 1979; Rule and McCormick, 1998; Ishida et al., 2001; Volpelli et al., 2003) but none for rusa deer. This experiment was conducted to investigate the fatty acid profiles of the intramuscular lipid and fat depots of rusa venison. Because castration will control undesirable behaviour in stags and may improve dressing percentage without affecting growth in young stags (Sookhareea et al., 2001) we also investigated the effects of castration on venison fatty acids.

Rusa stag calves, born in autumn (March), were surgically castrated after weaning (four animals) or left entire (seven animals) and the effects of these treatments on fatty acid profiles were examined in deer slaughtered at 25 months of age. The deer grazed pastures of Pennisetum clandestinum and Trifolium repens from autumn to early spring, and of predominantly Cynodon dactylon and Panicum maximum in late spring and summer. Supplements of Medicago sativa and grass hay and sorghum (Sorghum bicolor) grain were given during periods of pasture shortage in the winter. Details of the animals and management are given in Sookhareea et al. (2001b). Deer were slaughtered and processed using standard procedures (Sookhareea et al., 2001a). Samples of visceral, kidney, subcutaneous, and intermuscular fat were taken after processing the carcase. At 24 h postmortem, the m. longissimus dorsi (LD) was excised and samples taken for fatty acid analysis. All samples were stored frozen (-20 ^{o}C) until analysed. Fatty acids were determined by GLC procedures. Total lipids from the sample tissue were extracted from the homogenates of 0.5 to 1g samples using chloroform-methanol (2:1 v/v) according to Folch et al. (1957). The lipid extracts were methylated (5 % sulphuric acid in methanol) overnight at 60 ^{o}C and the FAME were extracted with petroleum spirit, evaporated under nitrogen and diluted. FAME were isolated by gas-liquid chromatography (Packard-Becker Model 419 fitted with a flame ionisation detector and a 50 m × 0.25 mm Chrompack CP-Sil-88 capillary column, and using N_2 as the carrier gas), using standard FAME mixtures (Sigma, St. Louis, MO) as standards. Data were subjected to analysis of variance using the general linear model (Statistical Analysis Systems, 1989).

Fatty acid profiles are presented in Tab. 1. Castration had no effect on any fatty acid profile. The depot fats were significantly ($P<0.01$) more saturated than the intramuscular lipid. Palmitate plus stearate was 62% in kidney fat and 43 to 46% in

the other depot fats, compared to 34% in the intramuscular lipid. In all depots and in the LD intramuscular lipid the quantitatively important fatty acids were palmitic (23 to 34% of detected fatty acids), stearic (12 to 28%) and oleic (14 to 25%) acids. Intermuscular and subcutaneous fats had most (24%) oleic acid, significantly ($P<0.01$) more than the other depot fats (15 and 19%) and the intramuscular lipid (14%). Saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) were respectively 40 to 70% and 26 to 46% of the total fatty acids. Polyunsaturated fatty acids (PUFA) were approximately 2% of the depot fatty acids but were 23% of the intramuscular lipid. Traces of trans fatty acids (16:1t and 18:1t(11)) were found in all of the fat depots and the intramuscular lipid.

A saturation gradient was apparent in the depot fats, with the fatty acids in the interior depots (kidney and visceral fats) being more saturated than those in the intermuscular and subcutaneous fats. Much (72.5 and 67.1% respectively) of the kidney and visceral fats was saturated and there were only traces of PUFA. The subcutaneous fat was the least saturated depot fat; SFA were 51.1% of the total fatty acids.

In contrast to the depot fats, the intramuscular lipid of LD had significantly ($P<0.01$) more unsaturated fatty acids. The MUFA contained palmitoleic (12.0%) and oleic acids (13.9%). While linoleic and linolenic acids were found in the other tissues in trace amounts, they occurred in the intramuscular lipid at 11.3 and 3.3%. In contrast to the depot fats, the long-chain polyunsaturated acids arachidonic (6.3%) and docosapentaenoic (1.8%) acids were detected in the LD.

This study is consistent with data from red deer and reindeer (Garton and Duncan, 1971) and white tailed deer (Rule and McCormick, 1998) in that it showed that the fat depots of deer are highly saturated. The saturation gradient observed in our experiment has been reported previously in steers (Ashes et al., 1993) and deer (Rule and McCormick, 1998).

The fatty acid composition of the intramuscular lipid in the LD of rusa stags was similar to other deer species (Manley and Forss, 1979; Sinclair et al., 1982; Ishida et al., 1991; Volpelli et al., 2003). It is interesting that the fatty acid profile for these rusa deer resembled that of sambar (C. unicolor) deer in the study of Sinclair et al (1982). Rusa and sambar are genetically close (Emerson and Tate, 1993) and they may have similar capacities for chain elongation and desaturation.

The higher proportion of PUFA in the intramuscular lipid than in the depot fats can be attributed to the relative contributions of triglycerides (high SFA, low PUFA) and membrane phospholipids (low SFA, high PUFA) in these tissues (Manley and Forss 1979). The presence of appreciable quantities of PUFA in the LD suggested that some dietary PUFA must escape microbial hydrogenation, as the linoleic and linolenic acids must have originated from the diet. The presence of 18:1 isomers reflects the synthesis of these by rumen bacteria (AbuGhazaleh et al., 2005).

Other studies have shown that the intramuscular lipid of venison contains more PUFA than other livestock species (Sinclair et al., 1982; Ishida et al., 2001; Rule et al., 2002). The main SFA in the intramuscular lipid were palmitic and stearic acids, with some myristic acid. Palmitic and myristic acids are considered undesirable as they increase LDL cholesterol in humans if the diet is low in linoleic acid (Grundy, 1994; French et al., 2002). On the other hand, this muscle has high proportions of MUFA and PUFA, which are nutritionally desirable. The fatty acids of the fat depots

are highly saturated, but as these are primarily extra-muscular and can be removed by trimming, this feature of venison need not reduce its overall desirability.

Table 1. Fatty acid composition (least squares means, % of total fatty acid) of the intramuscular lipid of m. longissimus dorsi, and the kidney, visceral, intermuscular and subcutaneous fats of rusa stags, reared on pasture and slaughtered at 25 months.

Fatty acid	Fat depots				Longissimus dorsi	sem
	Kidney	Visceral	Intermuscular	Subcutaneous		
Saturated fatty acids						
12:0	0.4a	0.3b	0.3b	0.2b	--	0.02
14:0	7.7a	8.5a	7.5a	6.4b	4.3c	0.34
15:0	1.3a	1.1b	1.1b	1.0b	0.4c	0.08
16:0	33.6a	32.9a	29.0b	29.4b	22.9c	0.44
17:0	1.5a	1.1b	1.0b	0.8b	0.4c	0.09
18:0	28.0a	23.2b	15.4c	13.3d	11.5e	0.90
Monounsaturated fatty acids						
14:1	0.4c	0.9c	2.1b	1.7b	2.9a	0.25
16:1t	0.6a	0.4b	0.6a	0.6a	0.4b	0.05
16:1c	2.7b	4.5b	9.5a	10.2a	12.0a	0.57
18:1c(9)	14.5c	18.5b	23.2a	25.1a	13.9c	0.69
18:1t(11)	6.0a	4.0b	3.4b	3.5b	1.1c	0.24
18:1c(11)	1.5d	2.9d	4.3c	5.2b	6.9a	0.24
Polyunsaturated fatty acids						
18:2c	0.9b	1.1b	1.2b	1.4b	11.3a	0.33
18:3c	0.9b	0.8b	0.9b	0.9b	3.3a	0.11
20:4	--	--	--	--	6.3	

Fatty acid	Fat depots				Longissimus dorsi	sem
	Kidney	Visceral	Intermuscular	Subcutaneous		
22:5	--	--	--	--	1.8	

We thank Prof. K.A. Woodford for making these deer available, and he and Dr. D.G. Taylor for helpful advice. Mr. R. McAllister assisted with slaughtering and carcase processing, and we thank Mr. T. Larsen for assistance with the fatty acid analyses.

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(Oral presentation.)

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The effect of pelvic suspension on the biochemical and sesnory quality of venison from red deer (*Cervus elaphus*) and fallow deer (*Dama dama*).

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The need to link carcass production with eating quality has long-term implications for acceptance of venison as a favoured consumer selection. Hence, definition of the link between post slaughter carcass management and the relationship with cooking and eating quality will increase opportunities for target marketing, which should increase farm profitability and consumer satisfaction if product consistency is enhanced. It is acknowledged that factors such as body condition, pre slaughter management, methods of slaughter and methods of meat storage can have a significant impact on eating quality of the final product (Mulley et al, 2006). Texture, flavour and tenderness are attributes valued by consumers as very important in relation to the eating quality of meat (Lundesjo et al 2003). Different populations of consumers have different preferences for these quality attributes, something that affects the market for all types of meat. However, regardless of the consumer group, the consistency of meat quality is very important, and the product should be of the same quality every time it is purchased. In the Australian beef grading system Meat Standards Australia (MSA) these consumer important sensory quality attributes have been weighted in an overall score where tenderness represents 40%, flavour 20%, juiciness 10% and overall liking 30% (MSA, 2001).

Tenderness is an important meat quality characteristic for consumers. Muscles in the butt and loin of a carcass can be restrained from shortening (toughening) by hanging the whole carcass by the aitchbone (obturator foramen) or the pelvic ligament. This process is referred to commercially as tenderstetching or pelvic suspension, and has been shown to increase meat tenderness in several other species (Sims et al 2004). Tenderness is one of the most important parameters as rated by consumers, in terms of eating quality. Major factors which affect tenderness include cut of meat, animal age, cold shortening that can occur during chilling and pre-slaughter animal stress leading to high pH. Toughness can be prevented by the use of techniques such as electrical stimulation, which accelerates rigor and pH decline (Wiklund et al 2001), or hanging the carcass in such a way that muscles will be stretched and not allowed to contract, hence the term 'tenderstretch'. Pelvic suspension, if found to be beneficial in producing consistently tender venison may be a useful alternative technique to electrical stimulation in Australia, where electrical stimulation is generally unavailable for deer processing.

In this study post slaughter management of carcasses compared Achilles tendon and pelvic suspension methods of hanging to determine effects on venison quality. Red stags (n=14) and fallow deer bucks (n=20) and fallow deer does (n=10) of between 12 and 36 months of age and in prime slaughter condition were examined.

Animals were assessed ante-mortem to determine suitability of coition for slaughter. They were then slaughtered by captive bolt stunning and exsanguinated within 3 seconds of the stun. Carcasses were split down the spine and assigned to one of the two hanging methods. Carcasses were then evaluated for pH (decline and ultimate) and core body temperature. After 24 hours samples were removed and vacuum packaged prior to being frozen at -21°C. Once thawed, samples were analysed in triplicate for intra muscular fat (Soxhlet method), tenderness (Warner Bratzler Shear force), colour (Minolta Lab), moisture (air oven) and freeze/thaw stability.

There are a number of biochemical measurements commonly used by meat scientists for meat description that can also indicate changes to meat quality for eating, cooking, storage and processing. It is well known for instance that muscle pH is associated with muscle tenderness. The colour of meat is an important characteristic for marketing, as customer selection is often associated with the appearance of the product. Water holding capacity is another characteristic of meat that is connected to consumer perception.

Descriptive and consumer preference sensory testing was undertaken with 42 panelists. There was a balance of male and female participants and a balanced age distribution from the target market, being 25 to 55 years of age. Panellists were screened to determine if they were eaters of red meat and were willing to try venison or were current venison consumers. Panellists were asked to refrain from smoking one hour prior to and during the sessions. Panellists undertook a familiarisation session to assist in identifying quality parameters for venison i.e. liver/game flavour, colour, tenderness and juiciness and use of the survey tool. Samples were prepared to reach an internal temperature of between 68-72°C, which is determined to produce a product which remains palatable and safe for consumption. Panellists were presented the sample identified by random three digit codes and answered questions on the descriptive test by indicating on a 10cm line scale how they rated the sample for flavour, colour, juiciness, tenderness and overall liking. Panellists were seated in individual isolation booths with a drinking cup of water (90%) and apple juice (10%) to cleanse the palate between tastes.

There were no statistical differences between Achilles hung and tenderstretched carcasses for the meat quality parameters of pH, colour, moisture or fat. While there was no detectable difference of hanging method on raw shear ($p=0.06$), tenderstretched carcases had significantly lower cooked shear force values than Achilles hung carcasses ($p =<0.001$). (Table 1)

Table 1: Meat quality attributes of fallow bucks hung by the Achilles tendon and Pelvic Suspension method for M. Longissimus dorsi.

Hanging	**Achilles Hung**	**Pelvic Suspension**
PH	5.80a (0.04)	5.80a (0.03)
Cooked Shear(g)	5889.5a (341.7)	4402.2b (157.8)
Raw Shear(g)	2177.4a (115.2)	2598.4a (165.6)

Hanging	Achilles Hung	Pelvic Suspension
Colour L*	20.46a (0.39)	21.21a (0.55)
Colour a*	12.29a (0.52)	11.56a (0.36)
Colour b*	0.088a (0.20)	0.117a (0.11)
Moist (%)	75.70a (0.17)	76.02a (0.15)
Fat(%)	2.74a (0.16)	3.06a (0.24)
Water (%)	13.56a (0.98)	13.69b (0.76)

Means and standard error of means (in parenthesis) are shown Treatments followed by the same letter in the rows are not significantly different ($p<0.05$)

Fallow does exhibited a significant difference between methods of suspension for cooked shear ($p=0.015$) but not for other parameters tested. (Table 2)

Table 2: Meat quality attributes of fallow does hung by the Achilles tendon and Pelvic Suspension method for M longissimus dorsi.

Hanging	Achilles Hung	Pelvic Suspension
pH	5.73a (0.03)	5.69a (0.02)
Cooked Shear (g)	4558.6a (217.2)	3778.6b (155.9)
Raw Shear (g)	2545.9a (277.3)	2721.6a (271.5)
Colour L*	22.13a (0.45)	22.24a (0.43)
Colour a*	13.56a (0.39)	13.56a (0.37)
Colour b*	1.68a (0.28)	1.68a (0.35)
Moist %	75.49a (0.47)	74.35a (0.28)
IM Fat %	1.78a (0.18)	1.89a (0.17)
Freeze Thaw loss %	16.67a (1.04)	13.76a (1.08)

Treatments followed by the same letter in the rows are not significantly different ($p<0.05$)

In the red stags there was a significant difference between carcasses hung by the Achilles tendon compared with pelvic suspension for cooked shear ($P<0.001$). (Table 3)

Table 3: Meat quality attributes of carcasses of red deer stags hung by the Achilles tendon and Tenderstretch method after slaughter for M. Longissimus dorsi.

Hanging	Achilles Hung	Pelvic Suspension
PH	5.63a (2.67)	5.63a (2.67)
Cooked Shear (g)	5475.8a (298.1)	4124.1b (154.5)
Raw Shear (g)	3535.1a (184.0)	3761.8a (167.9)
Colour L*	23.01a (0.39)	23.19a (0.28)
Colour a*	2.96a (0.22)	3.05a (0.15)
Colour b*	2.96a (0.22)	3.05a (0.15)
Moist %	75.95a (0.14)	75.96a (0.2)
IM Fat %	1.72a (0.28)	1.47a (0.22)
Freeze Thaw loss %	12.06a (0.67)	10.39a (0.57)

Treatments followed by the same letter in the rows are not significantly different ($p<0.05$)

When the data were analysed for differences between consumers evaluation of venison from carcasses hung by either pelvic suspension or Achilles tendon the pelvic suspension methods scored significantly higher for tenderness ($p=0.004$) and juiciness ($p=0.011$). (Table 4)

Table 4: Mean sensory evaluation scores for venison from fallow deer hung by either the Achilles tendon or by pelvic suspension

Hanging	Achilles Hung	Pelvic Suspension
Colour	8.74a (0.18)	8.09b (0.19)
Aroma	8.39a (0.16)	8.80a (0.15)
Aroma Strength	7.80a (0.17)	7.46a (0.18)
Flavour	9.74a (0.16)	9.91a (0.19)
Flavour Strength	8.52a (0.16)	8.25a (0.19)
Game Flavour	6.71a (0.20)	6.75a (0.21)
Tenderness	8.82a (0.21)	9.64b (0.19)

Hanging	Achilles Hung	Pelvic Suspension
Juiciness	7.64a (0.21)	8.39b (0.20)
Overall Liking	9.92a (0.18)	10.38a (0.20)

Treatments followed by the same letter in the rows are not significantly different ($p<0.05$)

Red deer carcasses hung by pelvic suspension were preferred by panelists for tenderness ($p<0.001$), juiciness ($p=0.001$) and overall liking ($p=0.007$). (Table 5)

Table 5: Mean sensory evaluation scores for venison from red deer hung by either the Achilles tendon or by pelvic suspension

Hanging	Achilles Hung	Pelvic Suspension
Colour	8.37a (0.27)	7.93a (0.29)
Aroma	8.98a (0.24)	8.90a (0.24)
Aroma Strength	7.52a (0.27)	7.46a (0.28)
Flavour	9.97a (0.25)	10.36a (0.25)
Flavour Strength	8.01a (0.24)	8.22a (0.24)
Game Flavour	6.58a (0.31)	6.57a (0.30)
Tenderness	8.87a (0.33)	10.85b (0.24)
Juiciness	8.90a (0.29)	10.22b (0.29)
Overall Liking	10.37a (0.28)	11.38b (0.24)

Measurements in columns with the same later are not significantly different

The technique to hang carcasses by the pelvic bone (obturator foramen) instead of the normal position by the Achilles tendon resulted in more tender meat in the M. Longissimus dorsi for fallow deer bucks, does and red deer stags; determined by shear force measurements and consumer preference. It is well known that the conditions during rigor development (e.g. muscle pH decline, temperature/pH relationship and carcass treatment) are very important in controlling meat tenderisation (Dransfield, 1994). Therefore, carcass suspension techniques have been studied for beef (Hostetler et al., 1970: Lundesjo Ahnstrom et al., 2003) where variation in tenderness is considered to be the main reason for consumer dissatisfaction (Koohmaraie, 1996). The positive effect of pelvic suspension on tenderness in venison from fallow and red

deer in this study is important information to consider for the Australian deer industry. In addition, the important commercial cuts from female deer were generally more tender than the same cuts from males. The slaughter of female deer therefore provides a good option for farmers wishing to supply chilled venison year-round, especially at times of the year when the quality of venison from male deer may be affected by the breeding season. Given the consistency of this result in this and other studies (Sims et al 2004) and the importance of meat tenderness in the meat retail sector (MSA, 2001) this technique should be adopted by the deer industry. Inconsistency of product appears to be a major difficulty in establishing repeat purchasing of venison by consumers in Australia (Cox et al, 2006). Equalising meat quality characteristics and sensory evaluations using a technique such as pelvic suspension should bring about greater consistency of product.

For this study, consumers clearly distinguished their preference for venison derived from carcasses treated with pelvic suspension post slaughter, with the important characteristics of tenderness and juiciness improved by this technique. This finding is consistent with the biochemical data and indicates that pelvic suspension should be adopted by the deer industry to produce venison that consumers have an increased preference for and to bring about more consistency in product quality. Use of this post slaughter carcass treatment is likely to provide significant return on investment because of the anticipated improvements to product quality and consistency. The need to adopt such processes in carcasses of all ages, sexes and condition is unequivocal if enhanced tenderness and juiciness of venison is desirable. The sensory panels in this study validated the biochemical tests. The technique for pelvic suspension can be easily installed as routine practice in abattoirs by altering the mechanics of how a carcass is manipulated on the meat rail in and out of the chiller. Carcasses can be rehung by the Achilles tendon for ease of transportation once a core body temperature below 7°C is reached.

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(Oral presentation.)

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Contents of toxic metals (Cd, Pb, Hg) in tissues of the red deer (*Cervus elaphus*) living in the wild.

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Dynamic development of industry and transport, increasing use of chemicals in the agriculture, and emergence of large urban agglomerations resulted in constantly growing accumulation of toxic metals such as mercury, cadmium, and lead in various components of the natural environment. The threat posed by accumulation of those metals stems from their high toxicity and increasing environmental loads. Toxic effects of the metals on living organisms have resulted in the necessity of monitoring metal levels in the environment and in animal tissues. The amount of toxic metals absorbed by an organism depends on numerous factors, including the extent of environmental contamination, physical and chemical properties of compounds that include the metals, and on animal age and physiological condition. Moreover, toxic metals are a serious problems related to game meat consumption, as game animals contribute significantly to human nutrition in many countries. The study was aimed at determining contents of toxic metals in tissues of wild red deer and to determine the resultant threat, at prolonged exposures, to humans and animals. Analyses were performed on organs (kidneys and liver) and muscle and nervous tissue collected from 25 red deer shot in north-western Poland in the 2005/2006 hunting season. The organs (livers, kidneys) as well as samples of the muscle and nervous tissue (the latter from the telencephalon)were collected directly after the animals were shot by hunters and

were analysed for the content of cadmium (Cd), mercury (Hg), and lead (Pb). The cadmium contents found were high, as opposed to those of lead and mercury. The highest cadmium contents were found in kidneys (3.212.19 mg/kg wet weight). The mean liver and muscle cadmium contents were 0.310.19 and 0.150.09 mg/kg wet weight. The lowest mean cadmium content (0.130.05 mg/kg wet weight) was recorded in the brain tissue, but the content was highly in excess of the admissible level. The high cadmium content in the red deer may be a result of environmental contamination, as the animals assayed were shot in an area featuring a large power station and its waste dumps.
(Poster presentation.)

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Variations in characteristics of fat, free amino acids and taste of meat of Japanese deer.

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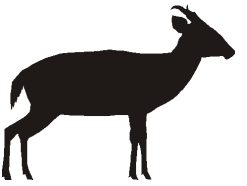
Variations in characteristics of fat, free amino acids and taste of meat of Japanese deer reared at three different farms are reported in this study. Comparisons were made among; a doe fed lucern hay cube, beat pulp and barley (deer 1) and another doe fed these with additional egoma seeds (perilla seeds) (deer 2), both reared for 50 days at farm A; four each of stag and doe fed tofu residue and beat pulp (deer 3) and three does fed grass hay with dried sea weed (deer 4) reared for 14 months at farm B; two stags fed grass hay and lucern hay cube (deer 5) for 5 months at farm C. Total lipid contents in loin were 3.81%, 6.86%, 4.91%, 3.19% and 2.89% for deer 1,2,3,4 and 5, respectively. In fatty acid composition, levels of palmitic acid were higher ($P<0.01$) for the deer of farm B than those of other farms while the deer of farm A had a much higher ($P<0.01$) mean alfa-linolenic acid content (2.31%) due to adding egoma seeds to the diet compared with other deer (0.56% and 0.79% for farm B and C, respectively). The deer of farm C had a higher mean level of conjugated linoleic acid than that of farm A (0.18mg/g vs 0.02mg/g). For free amino acids, the deer of farm A and B tended to have elevated levels of amino acids related to bitterness than those of farm C. The deer of farm C had higher ($P<0.05$) levels of glutamic acid and lower ($P<0.01$) levels of leucine and they also obtained higher scores for tenderness and strength of taste by a sensory panel while other deer were regarded to be juicier, fatter and better overall. It is noted that the higher the levels of palmitic or palmitoleic acids the stronger the flavour or the better overall taste. The meat having higher levels of stearic and linolenic acids tended to have reduced flavour.
(Poster presentation.)

Deer zooarcheology and history



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Stable isotopes evidence of seasonality effects on diet and locomotor adaptations of Pleistocene deer from southern Spain.

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Studies of feeding strategies using stable isotope distributions in skeletal tissues are well known (Cerling and Sharp, 1996). In fact, stable isotope records ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) are powerful, established tools for reconstructing paleodiets and paleoenvironmental conditions (Bocherens et al., 1994; Zazzo et al., 2002). By observing seasonal variation in isotopic ratios, we should be able to asses whether specific forage (browse or graze) is always preferred, or whether a diet fluctuates between browsing and grazing conditions. By using $\delta^{13}C$ ratios in animal tissues, and since the isotopic ratio of the ingested plant will be there recorded, we can infer the photosynthetic pathway of plants, and therefore, vegetation type. Several factors might explain variations in $\delta^{18}O$ values of carbonate hydroxylapatite, but water ingested and leaf water, in consequence the diet, should play a prominent role in causing different ranges in $\delta^{18}O$ ratios. These values of animal tissues can be used to infer the $\delta^{18}O$ of ingested water, which is in turn related to that of climate and precipitation, although leaf water can be isotopically modified relative to precipitation due to evaporation at the leaf surface (Fricke et al., 1998). In this study, water sources may have included the nearby lagoons, fruits and leaves of terrestrial plants. Mostly browsers are drought tolerant species, and, on the other hand, grazers use to be obligate drinkers (Cormie and Schwarcz, 1996). Seasonal temperature changes can also be assessed by analyzing oxygen isotope variation. In mid to high latitude continental areas, there is a strong positive correlation between $\delta^{18}O$ ratios and temperature. Warmer temperatures would result in a heavier $\delta^{18}O$ ratio, while cooler temperatures would result in lighter $\delta^{18}O$ values.

From a morphological point of view, feeding strategies can be established based on craniodental characteristics. Mammalian herbivores with short-crowned (brachyodont) teeth are usually assigned as predominantly browsers, which mainly consume leaves and fruits of trees and shrubs in forested environments or woodlands (e.g. *Eucladoceros giulii* and *Stephanorhinus etruscus*). On the other hand, mammalian herbivores (e.g. *Equus altidens* and Bovini aff. *Leptobos*) with high-crowned (hypsodont) teeth are classified as predominantly grazers, which are defined as consumers that feed primarily, or exclusively, on abrasive grasses or other low

herbs typically associated with more open grassland biomes (MacFadden, 1997; Palmqvist et al., 2003).

In the study here presented, we have further re-examined existing carbonate hydroxylapatite $^{13}C/^{12}C$ and $^{18}O/^{16}O$ data variability in four different large bodied species of mammal herbivores (*Stephanorhinus etruscus, Eucladoceros giulii, Equus altidens* and Bovini aff. *Leptobos*) from the fossil rich early Pleistocene (ca. 1.3Ma) assemblage of Venta Micena in the Guadix-Baza Basin, southern Spain (Palmqvist et al., 2003). In this lithological section, vertebrate remains have been rapidly deposited in a swampy/lacustrine sequence, under savanna type climate conditions (Palmqvist et al., 2003). Our aim was to compare the stable isotopic ratios and dental morphology in order to characterize diet and feeding behavior. In principle, these species exhibit two different dietary adaptations: browsers and grazers feeders (Tab. 1).

Table 1. Published feeding strategies, mean $\delta^{13}C$ and $\delta^{18}O$ values, standard errors of the mean, and number of sampled individuals. Data from Palmqvist et al., 2003.

		$\delta^{13}C$			$\delta^{18}O$		
Specimen	Codea	Mean	S.E.Mb.	n	Mean	S.E.Mb.	n
Equus altidens	G	-7.7	0.2	12	-3.1	0.2	12
Bovini aff. Leptobos	G	-7.5	0.3	8	-3.3	0.2	8
Eucladoceros giulii	B	-6.9	0.2	8	-3.6	0.2	8
Stephanorhinus etruscus	B	-7.5	0.2	5	-4.2	0.2	5

[a]G: grazers; B: browsers.
[b]S.E.M.: standard error of the mean.

We have found patterns that can be interpreted in terms of diet due to vegetational and seasonal climatic changes. Isotope $\delta^{13}C$ values in carbonate hydroxylapatite have a mean of -7.1±0.1‰ for browsers (n=20) and –7.6±0.2‰ for grazers (n=13), suggesting a predominant C_3 feeding diet, mainly composed by trees, shrubs and grasses from relatively cool/humid climates (Tab. 1 and Fig. 1). If the skeletal tissue has $\delta^{13}C$ values that are less than -10‰ then animals have consumed C_3 plants; if $\delta^{13}C$ values are more than -2‰, then they have feed C_4 plants (Lee-Thorp and van der Merwe, 1987). More specifically, vertebrate hervibores with $\delta^{13}C$ values lower than -8‰ has been described as pure C_3 feeders, requiring no C_4 contribution to the diet (Cerling et al., 1997). However, in a C_3-dominated region, it is rather difficult to distinguish between browsers and grazers only based on $\delta^{13}C$ values (Zazzo et al., 2002).

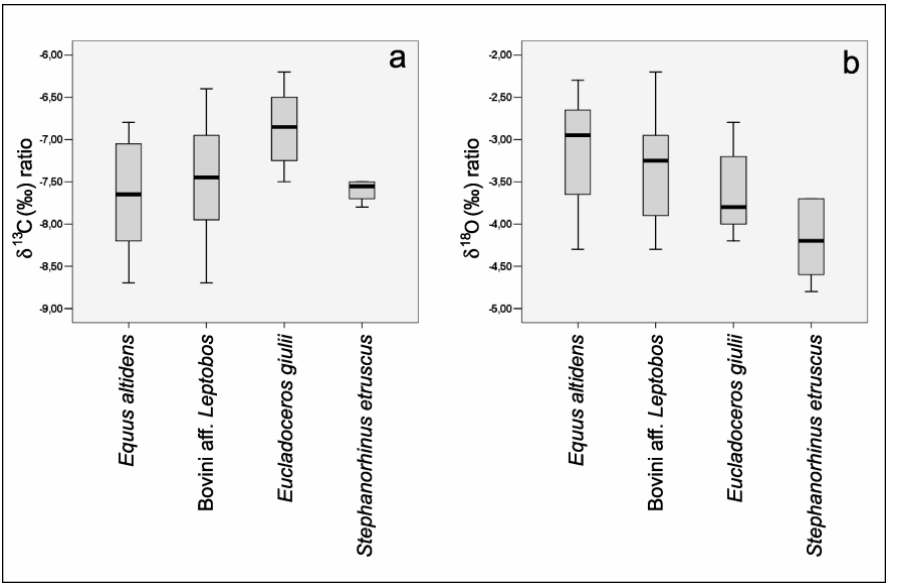

Figure 1. $\delta^{13}C$ and $\delta^{18}O$ values in carbonate hydroxylapatite of herbivores from Venta Micena (southern Spain). Data from Palmqvist et al., 2003.

The $\delta^{18}O$ values from browsers range from -4.8 to -2.8‰, and values from grazers are at -4.3 to -2.2‰ (Fig. 1). Nevertheless, if lighter (winter) $\delta^{18}O$ values characterized by a first quartile of -4.0‰ are similar among the browsers and grazers, the heavier (summer) $\delta^{18}O$ ratios (third quartile -2.9‰) are only present in three out of the four species (*E. giulii, E. altidens* and Bovini aff. *Leptobos*). Two major factors affect the isotopic composition of leaves: the isotopic composition of the soil water and the degree of evaporative enrichment of this water after it reaches the leaves. The effect of leaf water is greatest during summer months since evaporative enrichment is affected by humidity and temperature. Grasses, which are abundant during this season in savanna environments, are often highly enriched in ^{18}O as a result of the evapotranspiration. Therefore, and under these conditions, the isotopic composition of a diet rich on grasses should be distinguished by heavier $\delta^{18}O$ values, as we have observed in measurements from grazers. Although C_3 plants constitute about 90% of all plants, today 80 to 85% of the savanna-grass species in tropical and temperate climates are C_4 plants, and only less than 10% are C_3. These are predominantly found near closed forests (Schwartz, 1991). Based on this, we suggest that the environment at Venta Micena was mainly characterized by an open savanna woodland, rather than by an unforested savanna (Palmqvist et al., 2003).

Eucladoceros giulii is an extinct cervid with a body mass ca. 300kg and magnificent antlers conformed by many irregularly branched tines. Despite its dental morphology, isotope data comparisons between browsers and grazers suggest a feeding strategy for *E. giulii* different to the already described. The similarity with grazers could be due to the fact that this species may tend to be a grazer rather than a browser during the summer, with high herbage mass availability. Therefore, this

large deer should probably be a mixed feeder, like most of modern deer, especially during the summer when body and ornamentation size forced them to live in more open habitats, instead of inhabiting forests. Feeding adaptations and locomotion strategy of the species depend on the landscape features and body weight. We suggest that *E. giulii* was probably adapted to relatively open environments. It has been proposed that deer ingest grasses in areas with relatively high summer temperatures, although switching to a diet based on grasses, with potentially lower water content, could lead to water stress, since deer obtain most of the water necessities from leaves (Cormie and Schwarcz, 1996). Consequently, although dental characters have been frequently considered to determine feeding preferences, tooth variability can be difficult and controversial to interpret as a dietary proxy.

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Biometry and palaeoecology of the Red deer (*Cervus elaphus* Linné, 1758) during middle and upper Pleistocene in Western Europe. The example of the Lazaret cave (Alpes-Maritimes; France)

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In order to characterize the morphological variations of the red deer during middle and upper Pleistocene, we intend to establish a link between biometrical data and a palaeocological approach. On the biometrical point of view, we are using, for the first time with the red deer, the methodological approach of J. Weinstock, the V.S.I. (Variability Size Index). The environmental reconstitution of the middle where the red deer evolved is made possible by the use of several complementary palaeocological methods. Even if we are aware of their limits, we try to understand our results through a naturalist but careful approach. The second part of our doctoral research is to describe, for each studied site, the palaeoethnological aspect of the relationship between humans and deer. The zooarcheaological approach also allows us to estimate the impact of the human factor within the bone accumulation, using this aspect of their behaviour to illustrate the potential changes towards hunting. The site of the Lazaret cave, with an exceptional stratigraphy, allows us to examine the case of a pre-Neanderthal group. Moreover, the interdisciplinary analysis undertaken since the beginning of the excavation, give us the opportunity to approach more closely the everyday life of this disappeared specie.
(Oral presentation.)

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Fallow deer of Rhodes: an ongoing, comprehensive study about ecology, genetics and conservation.

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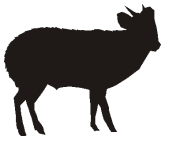
Unlike other parts of the world where fallow deer are widespread due to human activity, and treated as a park animal or pest on some occasions, fallow deer has had a distinct historical course on the island of Rhodes, in Greece. The fallow deer population of Rhodes is considered to be the only free-ranging population of ancient origin that survived on a Mediterranean island, and the only wild population in Greece. Besides the great research interest that it has presented (as an insular population living in a vulnerable Mediterranean ecosystem), its severe population decrease in late 1980s - early 90s and its recognition as a protected species by Greek law, as well as its cultural and symbolic value for the island of Rhodes pushed the need for thorough research to be conducted to identify and apply appropriate conservation practices. Three years ago the first systematic recording of past and present fallow deer distribution and habitat was begun, and progressively was enriched by data about fallow deer feeding ecology and genetic structure. Recently, a pilot telemetry study has been being conducted, and conservation measures, such as the creation of a compensation system for damages caused by fallow deer on summer crops, are in process. The current presentation is actually an activity report, which aims at giving a comprehensive picture of fallow deer of Rhodes through the objectives, the methods, some results and the future goals of the ongoing study.
(Poster presentation.)

Contributions received and accepted after the deadline



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Conservation of huemul (*Hippocamelus bisulcus*) deer in Chilean Patagonia: a new research initiative.

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The huemul or southern Andean deer is a flagship species of the mountainous and forested habitats of Chile, principally in the southern Patagonian region. It is listed by the IUCN as critically endangered and it has declined to under 2000 animals. Possible proposed causes of this decline are habitat loss, poaching, diseases and competition from livestock, and predation. However, we just begin to understand the ecology of huemul and much more need to be done. The reality is that nothing is known about metapopulation structure and connectivity, recruitment rates and survival of juveniles, population dynamics and genetic diversity, and the limiting factors that negatively affects the growth of remaining populations. These uncovered important issues for huemul conservation motivated this new research in southern Chile, located at "Lago Cochrane National Reserve", Aysén District.

The goals of the study are to determine possible limiting factors for huemul population persistence and growth. The initial actions include the increment of the amount of marked animals by a previous project in order to be more accurate with our measurements of population sizes, survival rates, ranging behaviour, patterns of habitat use, population genetics, and social organization. Huemul present an unusual social organization for a mid-sized sexually dimorphic ungulate, forming small mixed groups with high site fidelity of both sexes that would make them more susceptible to fail reproduction. However, we know little about the relationship between the mating system of huemul and the variation in demographic parameters, such as population density. Mating strategies are studied through behavioural observations of known individually marked animals and corroborated through modern genetic tools to study genetic relationships and hence mating successes in the study huemul populati ons. We are also tagging newborn deer to determine survival of young animals and recruitment into the adult cohort, this action allows us to know the whole life of an individual animal since is born. The ultimate goal is to provide relevant quantitative data to improve management strategies for the Chilean government through CONAF and the IUCN/SSC Deer Specialist Group for the conservation of *Hippocamelus bisulcus* in Chile.

(Poster presentation.)

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Translocation and semi-captive breeding of huemul (*Hippocamelus bisulcus*) with purpose of reintroduction in Chile.

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The huemul has experienced a strong reduction in its distribution in Chile and Argentina and its number is no more than 2000 individuals. Due to this grave situation the Huilo-Huilo Foundation, a Chilean NGO, planed the creation of a huemul breeding centre. The main goal of this initiative was the reintroduction in the western side of the Andes range in southern Chile (39ºS), which is part of a private protected area, the Huilo-Huilo Biological Reserve. We planed to extract a unit of six huemul (1 adult male, 1 juvenile male, 2 adult females, and 2 juvenile females) to form a founder population and to prevent a large impact on donating populations. The extraction area was the Aysén District (Patagonia), which has the healthiest and largest huemul populations. We selected places where huemul survival is critical because of the presence of domestic livestock and dogs, roads, outside protected areas were poaching is stronger. The first 2 deer (1 male and 1 female) were captured in late April. The adult couple were chemically immobilized, accommodated in boxes, and awaked with a reversal agent to be transported via helicopter and airplane. Each deer was measured and health checked, radio-collared, and sampled. The couple was released in a 64 ha enclosure of suitable habitat after 4 and half hours of flying. This initiative is a landmark for conservation in South America, but generated controversy among local political authorities. The major of local village set a demand against the Foundation and SAG (Chilean Agricultural Service), and the project was stopped. In June 2005 the judge failed in favour of the Foundation. Today governmental authorities are conditioning the initiative through several requirement and restrictions.
In December 2005 we recorded the first offspring born in semi-captivity for this project. In February 2006 we added another adult female taken by SAG from a peasant that illegally kept it. Actually, the 4 animals are in excellent conditions and we are expecting 2 fawns to be added in late November.
(Poster presentation.)

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So similar and yet so different: The surprising polyphyletic origin the genus *Mazama* (Mammalia: Cervidae).

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The systematic relationships of the extant Neotropical deer and their evolutionary history in South America have been poorly studied. We undertook a molecular genetic analysis using cytochrome b gene sequences of all representative genera of neotropical deer in order to resolve the controversial systematic relationships among this group of New World deer species. Here we combine morphological and cytogenetic data and find that morphologically conservative species show high levels of molecular and cytogenetic divergence. Our phylogenetic analysis revealed that brocket deer of the genus Mazama have undergone an amazing morphological convergent evolution with a highly divergent phylogenetic history. The evolutionary history of this group began with various ancestral forms in North America that gave rise to red brockets, gray brockets, marsh deer, pampas deer, pudu, huemul, and white tailed deer that entered South America via the Panama land bridge (2.4 MYA) and evolved separately but the ancestral form of the red brocket group continued an explosive speciation process generating various independent forms (*M. nana*, *M. bororo*, *M. americana*, and *M. temama*). The high levels of genetic divergence between gray and red brockets suggests a polyphyletic origin. Furthermore, we found such high levels of genetic divergence between *Mazama nemorivaga* and *M. gouazoubira* that we recommend that they be placed in different genera (Coassus and Cariacus). The example we present here describes one of the most amazing cases of morphological convergent evolution in mammals where brocket deer with very similar morphologies show high levels of molecular and chromosome differentiation and evolutionary diversification.
(Oral presentation.)

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Factors affecting the composition of autumn diet of red deer (*Cervus elaphus*) in Alpine environment

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The effect of sex, lactation stage, date and place of culling on the autumn diet composition of red deer in Central Italian Alps (Val Fontana, Province of Sondrio) was evaluated by analysis of vegetal fragments in rumen content of 47 individuals. Percentage volume (% v), percentage frequency (% f) and the relative importance index [$I_i = (\%f_i + \%v_i)/2$] were estimated for each food item. Trophic diversity (H´) and equitability index (J´) were calculated. Grasses were the most important components of deer diet in terms of volume (41% v), followed by shoots and leaves from broadleaved species (28% v). Herbs (10% v, 28% f, I = 19%) and *Rubus* sp. (8% v; 4% f, I = 6%) were additional important components of deer diet, and some items of ferns, seeds and dwarf shrubs species were also found in the rumens. Only 4 %v of the diet was represented by concentrated food (i.e. seeds and fruits). In spite of the prevalence of grasses, diet diversity (H´ = 2.63) and equitability (J´ = 0.56) were high, probably because of the wide altitudinal range used by red deer in this alpine valley (from 700 to above 2200 metres a.s.l.). Neither sex nor lactation stage significantly affected diet composition. Significant differences were found in response to the date of culling: in late autumn (October-November) deer made a higher use of grasses and a lower use of broadleaved and *Rubus* species than in early autumn (September), probably in response to the progressive fall of leaves from the trees, which induced the deer to be more grazers than browsers (early autumn: 35% v of grasses, 31% v of broadleaved species, 11% v of *Rubus* sp.; late autumn: 57% v of grasses, 18% v of broadleaved species, 1% v of *Rubus* sp.). Place of culling seemed to affect diet composition: deer harvested at higher elevations (above 1940 m a.s.l.; 6 individuals) showed a higher presence of grasses (74% v in average, max. 90%). These results confirm the high level of adaptation of red deer to different environmental conditions and to the related changes in food availability.

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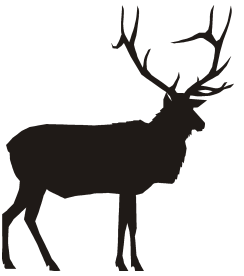

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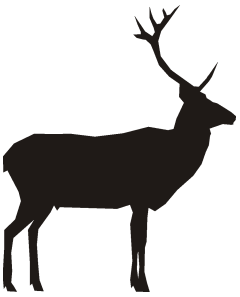


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