Chapter 1

Introduction: Intra And Interspecific Interactions In A Western Himalayan Ungulate Assemblage

1.1. Introduction

Biological interactions are crucial for ecosystem functioning, however, the nature of such interactions, depends on the evolutionary context and the environmental conditions (Lang & Benbow, 2013). Interaction between species can be mutualistic or commensal (++ , +0), competitive or parasitic (-0, +), or neutral (00) (Begon et al., 2009).

Competition is an interaction where one organism or species population reduces the fitness of another by consuming a scarce resource that becomes unavailable to the other individual or species (Hairston et al., 1960; Begon et al., 2009). The limitation of at least one resource (such as food, habitat) used by both usually leads to this type of interaction (Begon et al., 2009). It is believed that interspecific competition over evolutionary time scales can lead to niche differentiation and the coexistence of species with similar resource needs (Begon et al., 2009). Niche differentiation is a process by which potentially competing species may diverge into different niches (Schoener, 1974). Niche differentiation can occur along at least one of the important dimensions of space, habitat, food and time (MacArthur & Levins, 1967; Schoener, 1974). Alternately, there may be species sorting, where any two species with very similar resource requirements are unable to coexist. Further, species coexistence may also be mediated by other factors such as predation that may maintain populations below resource limitation (Connell, 1980).
Ungulates are an economically and ecologically important group of animals, and understanding their ecology and mechanisms of diversity is important. Niche differentiation has often been documented in wild ungulate assemblages (Bagchi et al., 2003; Namgail et al., 2004). Additionally, in relatively more productive ecosystems, facilitation, where one species of ungulate can improve conditions for another species by modifying habitat or improving forage quality through grazing, is also believed to be a mechanism facilitating coexistence (Bell, 1971). However, many grazing systems around the world today are dominated by livestock, where these domestic ungulates share resources with wild species. Livestock introduction in systems with wild ungulates is relatively recent, and therefore, competition rather than niche differentiation is often observed between livestock and wild species (Voeten & Prins, 1999; Mishra et al., 2004). Competition therefore is a potentially important interaction between wild ungulates and livestock, especially in resource-limited systems.

Indeed, of importance in species ecology and ecosystem functioning, are not just interspecific interactions, but also interactions between individuals within a species. For instance, in many dimorphic ungulates, one observes remarkably high levels of ecological segregation between sexes. In fact, competition between the two sexes of a species used to be regarded as an important cause of sexual segregation, which is the separation of the sexes in space, habitat and/or time (Clutton-Brock, 1982). Subsequently, several other mechanisms such as sex differences in reproductive strategies, body-size dimorphism and social affinity are invoked to explain sexual segregation in ungulates (Bowyer, 1984; Bon & Campan, 1996; Main & Coblentz, 1996; Main, 2008).

This thesis is an attempt to explore the nature and mechanisms of interactions in a fascinating Himalayan ungulate assemblage, with the ultimate
goal of being able to assist in their conservation management. Focusing on the endangered wild goat, the markhor (*Capra falconeri*), I examine the mechanisms of sexual segregation, their inter-specific interactions with other wild ungulates, viz, musk deer (*Moschus cupreus*) and goral (*Naemorhedus goral*), and the impact of livestock grazing on this wild ungulate assemblage.

1.2. The Study Species

The endangered *Caprid* markhor, a medium-sized (males-100 kg, females- 55 kg), dimorphic, polygynous, gregarious ungulate considered to be evolutionarily recent or ‘advanced’ among the caprids (Schaller, 1977). The males are almost double the size of females. They have spiraling corkscrew horns, with older males having two to three twists (Schaller, 1977). The females have smaller horns with one and a half twist in the older females (Schaller, 1977). Markhor have a flowing ruff of white to grey hair on the chin, neck and shoulders (Schaller, 1977). The volume of ruff and beard and the size of horns help to classify the markhor into different age-sex groups (Schaller, 1977).

Several sub-species were earlier recognized, mainly based on horn shape (Roberts, 1997): Sulaiman markhor (*Capra falconeri jerdoni*), Kabul markhor (*Capra falconeri megaceros*), Pir Panjal markhor (*Capra falconeri cashmiensis*) and the Astor markhor (*Capra falconeri falconeri*). After his detailed work in Pakistan, Schaller (1977) reviewed markhor classification and grouped all the sub-species into only two; the larger flare-horned northern population (*C. f. falconeri*, Wagner, 1839) found across the colder mountains and a smaller variety with straight-horns (*C. f. jerdoni*, Hutton, 1842) and a tighter twist distributed along southern, warmer parts of their range.

Markhor occur in moist to semi-arid mountainous habitats of Pakistan, India, Afghanistan, Uzbekistan, Turkmenistan and Tajikistan (Schaller &
Amunallah Khan, 1975) (Figure 1.1a). In India, markhor occur only in the state of Jammu and Kashmir (Schaller & Amunallah, 1975; Ranjitsinh et al., 2005) (Figure 1.1b).

Kashmir markhor is mainly found in Pakistan, PoK, Afganistan and the state of Jammu and Kashmir in India. The state is one of the important areas for markhor globally, and the primary area for the Pir Panjal/Kashmir markhor (Ranjitsinh et al., 2005; Bhatnagar et al., 2009; Ahmad et al., 2011). Historically, it was distributed more or less continuously from Banihal pass in the Pir Panjal range to Shamshabari range north of the river Jhelum (Stockley, 1936) (Figure 1.1). In recent statewide surveys of markhor, only two viable populations totaling approximately 250, were confirmed in Jammu and Kashmir besides identifying a few more markhor potential areas in the state (Bhatnagar et al., 2009; Ahmad et al., 2011). These include the Kajinag National Park and Hirpora Wildlife Sanctuary (Ranjitsinh et al., 2005; Bhatnagar et al., 2009).
a) The geographic distribution of Markhor (Valdez, 2008), b) The distribution of markhor in Jammu and Kashmir, India (adapted from Bhatnagar et al., 2009).

**Figure 1.1.** a) The geographic distribution of Markhor (Valdez, 2008), b) The distribution of markhor in Jammu and Kashmir, India (adapted from Bhatnagar et al., 2009).
The current estimate of global population for Kashmir markhor is about 2000-2200 with Jammu and Kashmir harbouring only the 2nd largest population after Pakistan (Masood 2011). This makes its conservation in Jammu and Kashmir very crucial and every single population may be of high conservation importance. Historically, the markhor population (both subspecies) was estimated to be about 3500-4000 individuals (Schaller and Khan 1975) with about 1800 Kashmir markhor including 250-300 animals found in the state of Jammu and Kashmir (Schaller 1977).

Trophy hunting, which was one of the main threats to markhor, is reported to have killed more than 800 adult animals having bigger horn size, during the 19th century till 1960’s (Masood 2011). In addition there may be other killings due hunting by poachers which are not recorded Masood 2011). However, the recent trophy hunting programme which was initiated in Pakistan, with involvement of local community, has helped to improve the status of markhor in certain areas (Masood 2011).

Musk deer (Moschus spp.) is a primitive deer-like ruminant belonging to the family Moschidae (Green, 1985) and inhabits the forested and alpine scrub habitats of mountains in Asia (Sathyakumar et al., 2013). Earlier, all musk deer were considered to be a single species (M. moschiferus), which was divided up into two groups; the sibirica group with four subspecies and the himalaica group with three (Sokolov & Prikhod’ko, 1997). Recently, Groves and Grubb (2011) reclassified musk deer into seven species:

Alpine musk deer Moschus chrysogaster (Hodgson 1839), Himalayan musk deer Moschus leucogaster (Hodgson 1839), Kashmir musk deer Moschus cupreus (Grubb 1982), Black musk deer Mochus fuscus (Li 1981), Siberian musk deer Moschus moschiferus (Linnaeus 1758), Anhui Musk Deer Moschus anhuiensis
India has the Alpine, Himalayan, Kashmir and black musk deer. Alpine musk deer is distributed in the Greater Himalaya of north Afghanistan, north Pakistan, north and northeast India, Nepal, central Tibet and central China (Duckworth & MacKinnon, 2008b; Sathyakumar et al., 2013). Two subspecies have been identified: *M. c. chrysogaster* (Hodgson 1839) distributed in the alpine zones of India, Nepal, Bhutan and southern Tibet between 2800 and 4000 m, and *M. c. sifanicus* (Buechner 1891) distributed in southern Gansu, western Sichuan, Qinghai, southern Ningxia, southeastern Tibetan and northern Yunan. In India, it is reported to occur in Sikkim and Arunachal Pradesh, and possibly in Uttarakhand. Himalayan musk deer is distributed in Himalayas of Bhutan, northern India, Sikkim, Nepal and China (Grubb, 2005). Black musk deer is distributed in northwest Yunnan, northernmost Myanmar, southeast Tibet and northeast India. *Moschus leucogaster* was previously treated as a subspecies of the Himalayan musk deer, *M. c. leucogaster* and is distributed in the Himalaya from Himachal Pradesh in the west through Uttarakhand, Nepal, Sikkim and Bhutan. Black musk deer is distributed in northwest Yunnan, northernmost Myanmar, southeast Tibet and northeast India. In northeast India, they occur in Sikkim and Arunachal Pradesh (Duckworth & MacKinnon, 2008).

Kashmir musk deer is endemic to Kashmir region of Jammu and Kashmir State (Duckworth & MacKinnon, 2008; Sathyakumar et al., 2013) and is Endangered (IUCN 2012). They mainly occur along the northern bank of Jhelum River (Figure 1.2).

They measure about 50 cm at the shoulder, and weigh about 13–15 kg. Musk deer have long pointed central hooves and enlarged lateral hooves known as dew claws that provide a firm grip on steep ground, even on slanting tree
Figure 1.2. The distribution of Kashmir Musk Deer and Himalayan goral (Duckworth & MacKinnon, 2008; Timmins & Duckworth, 2008). The green and red dots show the distribution of musk deer and goral respectively as updated from our work.
trunks that they climb for forage, and that minimise sinking in soft snow (Sathyakumar et al., 2013). Like other species of musk deer, this species has also been exploited for musk. Goral belongs to sub-family Caprinae. Goral is a primitive caprid and lives in solitary or in small groups (Schaller, 1977). Four species of goral are recognized. These are *Naemorhedus baileyi* (Red Goral), *Naemorhedus caudatus* (Long-tailed Goral), *Naemorhedus goral* (Himalayan goral), *Naemorhedus griseus* (Chinese Goral). In India three species are found viz., Red Goral, Himalayan Goral, Chinese Goral (Duckworth & MacKinnon, 2008). These are *Naemorhedus baileyi* (Red Goral), *Naemorhedus caudatus* (Long-tailed Goral), *Naemorhedus goral* (Himalayan), *Naemorhedus griseus* (Chinese Goral).

Red goral is found in northern Myanmar, China (southeast Tibet and Yunnan) (Duckworth & MacKinnon, 2008), and northeast India (Arunachal Pradesh) (Mishra et al., 2006). This species is found at higher elevations (2,000-4,500 m) than most gorals (Rabinowitz, 1999).

Chinese goral is found in Myanmar (western and eastern), most of China (except the far north and west), northeastern India (east and south of the Brahmaputra), northwestern Thailand, and extreme northern Viet Nam.

Himalayan Goral is endemic to Asia occurring along Himalayan Mountains including Bhutan, China (southern Tibet), northern India (including Sikkim), Nepal, northern Pakistan and possibly western Myanmar (Duckworth & MacKinnon, 2008a; Abbas et al., 2012). In India, it is found in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh (Sathyakumar, 2002). The subspecies *N. goral bedfordi* occurs in Jammu and Kashmir, Himachal Pradesh and Uttarakhand and *N. g. goral* in Sikkim and Arunachal Pradesh (Duckworth & MacKinnon, 2008). In Jammu and Kashmir, Kajinag Natinal Park, Limber WLS, Lachipora WLS, Nagnari Conservation Reserve, Tatakuti-Kalamuund Wildlife Sanctuary and Khara gali Conservation Reserve are the potential goral areas (Ranjitsinh et al., 2005; Bhatnagar et
Himalayan goral (N. goral bedfordi) is listed as near threatened (IUCN 2008). The body mass of goral is 25-30 kgs (Schaller, 1977).

1.3. The Study Area

This study was conducted in the Kaj-I-Nag National Park (NP), henceforth referred to as the Kajinag National Park in Kashmir region of Jammu and Kashmir state, India. Kashmir lies in the western extreme of the Himalayan Mountains along a valley between Pirpanjal and Greater Himalayas. It has a drier and a distinctly Palaeartic faunal assemblage (Das 1966). However, Palaeartic elements such as the markhor (Capra falconeri) are sympatric with oriental ones such as the musk deer (Moschus cupreus) and goral (Nemorhaedus goral).

In Kajinag NP, people are important part of the system with relatively long history of resource use. The people belong to different ethnic groups with the Kashmiri, Pahadis, Gujjars as the prominent groups, who are the permanent resedents. The migratory graziers; the Bakkarwals come to graze their livestock during summer. The Bakkarwals herd primarily goats and migrate from Poonch and Rajourie of Jammu Division and travel a few hundred kilometers to spend summer in high altitude pastures of Kashmir (Rao, 2002). Bakkarwals started using Kajinag and nearby areas since the late 1940’s after the closure of the border with Pakistan and some more after 1965 war between India and Pakistan, when the Gurez area was closed for them (based on interviews with bakkarwals). These Kajinag Bakkarwals initially reared their goats and some sheep from local villagers. At present however, they graze sheep from several villages of the district and rear them in Kajinag in exchange for a fee. Some local shepherds also take sheep from the local villages to graze in the alpine areas. During summer markhor and other two wild ungulates, numbering approximately 400 individuals, share resources with about 15,000 livestock (Ahmad unpublished data).
1.4. Thesis structure

In this thesis, I explore intra and interspecific interactions among wild and domestic ungulates in a Western Himalayan ungulate assemblage (Figure 1.1). I first provide some ecological background to the study area. Kajinag NP is a temperate system with coniferous forests dominating the middle elevations, mixed forests and subalpine forest in subalpine areas at higher elevations, alpine meadows and subalpine and alpine scrub at the highest elevation. Vegetation forms an important component of the habitat and critical resource providing both forage and cover for the animals. Chapter 2 describes the ecological setting of the study area with details of geography, vegetation and human use. Here I describe the different vegetation types and their composition in relation to the different plant groups such as grasses, herbs, shrubs and trees. The chapter also provides details about the different ethnic groups living around the Kajiang NP and the migratory bakkarwals who come for summer grazing.

Markhor is an endangered species, but poorly studied. It is highly dimorphic with males being double the size of females (Schaller, 1977). Dimorphic polygynous ungulates generally segregate outside the rutting season (Clutton-Brock, 1982). Many studies have explored the causes of sexual segregation (Main & Coblentz, 1996), as understanding this has important management and conservation implications (Main, 2008). Chapter 3 investigates sexual segregation in markhor. I examine the suitability of the Reproductive Strategy Hypothesis, the Forage Selection Hypothesis, and the Social Affinity Hypothesis in explaining sexual segregation in markhor.
The resource use of a species may be influenced by the presence of other species in the assemblage. Species coexist by partitioning their resources along important axes of space, food, habitat and time (Schoener, 1974). In ungulates, niche differentiation is associated with the intrinsic characteristics such as body size, and the specific morphological and physiological adaptations of the gut and mouth (Prins, 1998). Besides the biotic environment, the abiotic environment such as physical habitat (slope, elevation) also plays a role in the resource use and distribution of large herbivores especially in less productive and temperate systems (Namgail, 2009). Markhor in Kajinag shares habitat with two wild mountain ungulates, the goral and musk deer, both smaller in size. **Chapter 4**, examines the interactions between three co-occurring
species; the markhor, musk deer and goral. I identify the important factors or axes along which the three wild ungulates partition resources, enabling coexistence.

In **Chapter 5**, I examine how the large herds of livestock accompanied by herders and dogs use the temperate and alpine areas, and examine the response of wild ungulates to their presence. While Chapter 4 highlights the extent of niche differentiation among wild ungulates, this chapter brings to light the high overlap and potential competitive interactions between livestock and the markhor, and the potential for coexistence between livestock and the other two wild ungulates, the goral and musk deer.

I revisit the key results in the ‘**Synthesis**’. I also discusses the conservation implications of this study.
1.5. References


