Hystrix, (n.s.) *13* (1-2) (2002): 1-11

ENCOUNTERS BETWEEN ALPINE IBEX, ALPINE CHAMOIS AND DOMESTIC SHEEP IN THE SWISS ALPS

MARIE-PIERRE RYSER-DEGIORGIS*, PAUL INGOLD°, HANNA TENHU*, ANA MARÌA TEBAR LESS*, ANDREAS RYSER*°, AND MARCO GIACOMETTI*

* *Centre for Fish and Wildlife Health, Institute of Animal Pathology, University of Berne, Postfach, Länggass-Strasse 122, CH-3001 Bern, Switzerland*
° *Ethology and Nature Conservation Group, Institute of Zoology, University of Berne, Länggass-Strasse 27, CH-3012 Bern, Switzerland*
*° *KORA, Thunstrasse 31, 3074 Muri bei Bern, Switzerland*

ABSTRACT - Information regarding spatio-temporal relationships and encounters of sympatric domestic sheep, Alpine ibex (*Capra ibex ibex*) and Alpine chamois (*Rupicapra rupicapra rupicapra*) in the Swiss Alps were systematically registered to evaluate the possibility of an interspecific transmission of infectious agents on pastures. Observations were performed in alpine regions of four Swiss cantons during the 1997 and 1998 mountain summer grazing season. In the main study area, Val Chamuera (canton of Grisons), a consistent reduction in the number of ibexes was observed after the arrival of sheep on the pasture. Some ibexes remained for a longer time in the area, but in general, ibexes and sheep did not use the same compartments of the area simultaneously. However, a salt lick for sheep attracted the ibexes, and several encounters were recorded in the compartments close to this salt lick. Several encounters registered in other areas of the Swiss Alps also occurred in the neighbourhood of a salt lick; however, in other cases different species were attracted by rich pastures. The study indicates that encounters (0-50 m) between free-ranging individuals of different Caprinae species, domestic and wild, are not uncommon events in the Alps. Therefore, encounters can be considered to be a predisposing factor for interspecific transmission of infectious agents such as *Mycoplasma conjunctivae*, causing keratoconjunctivitis in chamois, ibex, domestic sheep and goats.

Key words: Alpine chamois, Alpine ibex, domestic sheep, disease, interspecific interactions

INTRODUCTION

In Switzerland, sheep farming has doubled in the past 50 years, while the control of these animals has decreased. The increasing number of free-ranging sheep in the Swiss Alps during the summer grazing season leads to the overgrazing of pastures in a number of areas, and livestock is now considered to be a primary cause of soil erosion. Furthermore wildlife is disturbed and plant variety decreases (Stalder and Wiedmer, 1999). Apart from ecological considerations, sanitary aspects are also of considerable importance since in the Swiss Alps various infectious diseases such as keratoconjunctivitis (IKC), foot rot, orf and pseudotuberculosis occur in domestic as well as in wild Caprinae species (Hammerli *et al.*, 1999). To control these diseases in wildlife it is necessary to consider the possible ways of interspecific disease transmission between domestic sheep, Alpine ibex (*Capra ibex ibex)* and Alpine chamois *(Rupicapra rupicapra rupicapra).*

IKC, an ocular disease caused by *Mycoplasma conjunctivae*, is of particular interest in the Swiss Alps (Gauthier, 1991; Giacometti *et al.*, 1997). IKC is the most com-

mon eye disease in small domestic ruminants (Jones, 1991) and it frequently affects free-ranging chamois and ibex (Gauthier, 1991; Giacometti *et al.*, 1997). While IKC usually provokes mild symptoms in domestic sheep and goats, it can have fatal consequences in wildlife (Giacometti *et al.*, 1997; Degiorgis *et al.*, 2000). On alpine meadows, IKC occurs at the same time in the same regions in several host species (Nicolet and Freundt, 1975; Giacometti *et al.*, 1997), suggesting an interspecific transmission. An experimental infection indicated that sheep-strains of *M. conjunctivae* can indeed induce conjunctivitis in Alpine ibex (Giacometti *et al.*, 1998). Mycoplasmal organisms do not survive for a long time in the environment (Nicolet, 1985), and transmission must occur through direct contact or after a short time delay. According to recent publications, mycoplasms can be spread via aerosol (Stark *et al.*, 1992; Maré and Loveday, 1994) and possibly by eye-frequenting insects (Gouws *et al.*, 1995; Degiorgis *et al.*, 1999). IKC is highly contagious within herds (Baas *et al.*, 1977), and frequent close contacts between animals appear to be a principal cause of outbreaks (Hosie, 1988). However, very limited information is available regarding interactions between different susceptible Caprinae species. Couturier (1938) reported that chamois usually maintain a considerable distance between themselves and livestock, but that they can also be observed grazing in the middle of a sheep herd. Ibexes also tolerate the presence of goats and sheep, staying sometimes very close to flocks (Couturier, 1962). More recent observations from France indicate that chamois, ibexes and sheep can be found close to each other, sometimes at distances which are shorter than 50 m (Laurent, 1996). Male chamois were even observed mating with female sheep (Huboux, 1994). The purpose of the present study was to systematically record information concerning the spatio-temporal relationships and encounters of sympatric domestic sheep, ibex and chamois in the Swiss Alps, in order to evaluate the possibility of an interspecific transmission of infectious agents such as *M. conjunctivae* on alpine meadows.

MATERIAL AND METHODS

The observations were performed in alpine regions of Switzerland, mainly in Val Chamuera, in the canton of Grisons, and also to a lesser extent in the cantons Freiburg, Berne, and St. Gallen during the 1997 and 1998 mountain summer grazing season.

Number and distribution of Alpine ibexes and domestic sheep in Val Charnuera

The principal part of the study was conducted in June 1997 in Val Chamuera (Grisons, Switzerland; 46°33' N, 9°58' E), on alpine pastures situated between 2000 m and 2700 m. The study area (234 ha), called Munt da la Bes-cha, is characterized by a steep slope exposed to the south-west, on the right side of the Chamuera valley. Munt da la Bes-cha comprises rock faces and alpine meadows which are frequently subdivided by scree slopes. A small shepherd cabin is situated on the lowest part of the grass fields. A salt lick is located in the front of the cabin, with a water supply point situated 15 m above it (Fig. 1).

About 200 ibexes and 50 chamois spend the winter period and the first part of spring in the study area (Grison's Hunting Authority, pers. comm.). In May, more than 50% of the ibexes leave the area to populate other summer ranges. Approximately 500 domestic sheep use the study area from mid-June to mid-September. During this time, a shepherd is sometimes present with his dog.

The observations of the study area were performed from Alp Burdun, a hill located on the left side of the Chamuera valley, with binoculars magnifying up to 60 x. The observation period started on June 3, 1997, in order to study the location and behaviour of

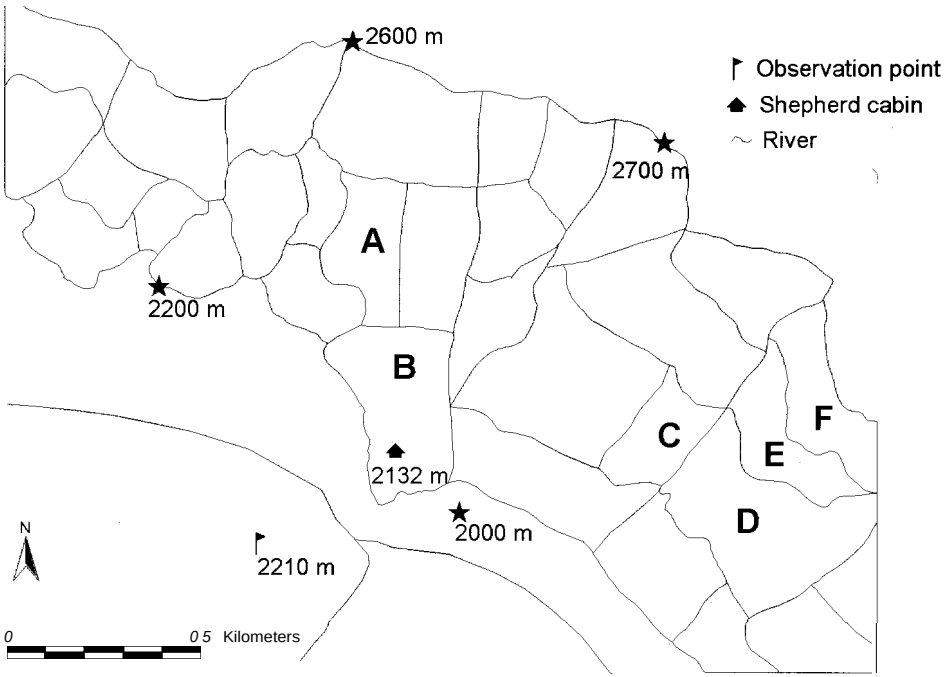

Figure 1 - Val Chamuera, Switzerland. The study area, on the right side of the valley, is characterized by a steep slope exposed to the south-west. The observations were performed from a hill located on the left side of the valley.

ibexes before the arrival of sheep, and finished on June 26, when sheep used the largest part of the alpine meadows. From July 22 to 24, the same observations were performed again. Since chamois were present in low number and only in areas which were inaccessible to sheep, they were not considered in this study.

The spatial location and activity of ibexes and sheep were recorded at a rate of four times a day: just after sunrise (6h-8h), at midday (10h-12h), in the afternoon (15h30-17h30), and before sunset (19h-21h). The locations of the different animal groups were reported on a map. Animals were counted and classified as inactive when they were lying, and as active when they were standing, moving or foraging. Ibexes were classified as kids (newborn), juvenile animals (1 to 2 years old), adult females and adult males on the basis of morphological characters (Ratti and Habermehl, 1977). Sheep were classified as either lambs (until approximately 3 months of age) or adults, depending on the size of the animals. All information was recorded using a standardized protocol.

To describe the distribution of ibexes in Val Chamuera, the study period was divided in two parts: period I (from June 3 to 12, 1997), when only ibexes and chamois were present in the study area, and period II (from June 13 to 26, 1997), when the area was partially used by sheep. The study area

was divided in 32 compartments (Fig. 1) in order to describe spatial utilization patterns. Borders were drawn considering geomorphologic uniformity, scree slopes and contour lines.

To compare the proportion of ibexes present in different compartments of the study area during period I and period II, an index of utilization IU_{cr} was calculated for each period:

$$IU_{cr} = \frac{\bar{n}_{cdr}}{\sum (\bar{n}_{1dr} - \bar{n}_{32dr})} \times 100$$

were n_{cdr} was the number of ibexes counted in compartment c on day d at day record r (morning, midday, afternoon and evening records).

Encounters in Val Chamuera and other alpine areas

To determine the occurrence of interspecific encounters and the circumstances in which they occurred, observations were performed in June and July 1997 in Val Chamuera, from May to November 1997 and from April to October 1998 in other alpine areas of four Swiss cantons where ibexes and chamois were susceptible to have contacts with sheep. An "encounter" was defined as an approach between animals of two different species, the distance separating both animals being less than or equal to 50 m. The minimum distance observed (estimated with animal length and field marks), the duration of the encounter, and the reaction of the animals to each other (which animal moved away) were recorded in a questionnaire. Data records were standardized, and encounters were recorded by the authors and selected state game-keepers.

RESULTS

Number and distribution of Alpine ibexes and domestic sheep in Val Chamuera

During period I, 45 ± 4 ibexes ($\tilde{x} \pm \tilde{D}$, n=10 days) were counted in the study area: 12 ± 5.5 were males, 12 ± 5.5 females, 17 ± 2 juveniles, and 5 ± 2 undetermined. Ibexes were most active in the morning and evening, while at midday approximately 50% of recorded animals were inactive. Female, juvenile, and rarely male ibexes moved almost daily down to the salt lick (in compartment B) in the evening, and went back to higher areas in the morning, always going through compartment A. These salt lick-associated compartments (A and B), presented an index of utilization which was particularly high (IU > 10, Fig. 2).

During the first week after the arrival of sheep, most of them were fenced in the lower part of the pastures. Later, they were all free to use the whole area, but the shepherd gathered them together around the cabin every 2-3 days to count them. Immediately after the arrival of sheep, the number of ibexes dropped to 21 ± 8 ($\tilde{x} \pm \tilde{D}$, n=7), which corresponds to a reduction of 53.3%. The reduction was especially high for adult males with 75%, against 25% for adult females. Between June 13 and 19, only a few sheep were sometimes present in the upper part of the pasture; when they were not present, the number of ibexes observed was again around 40.

The activity pattern of ibexes did not differ after the arrival of sheep. In the early morning and in the evening, there was still a high concentration of ibexes in the lower part of the study area, particularly in salt lick-associated compartments: ibexes still moved to the salt lick in the evening, although sheep were often present on their way. The presence of ibexes close to the salt lick was even observed once when the shepherd and his dog were gathering the sheep around the cabin. Thirteen of 32 compartments were used by ibexes as well

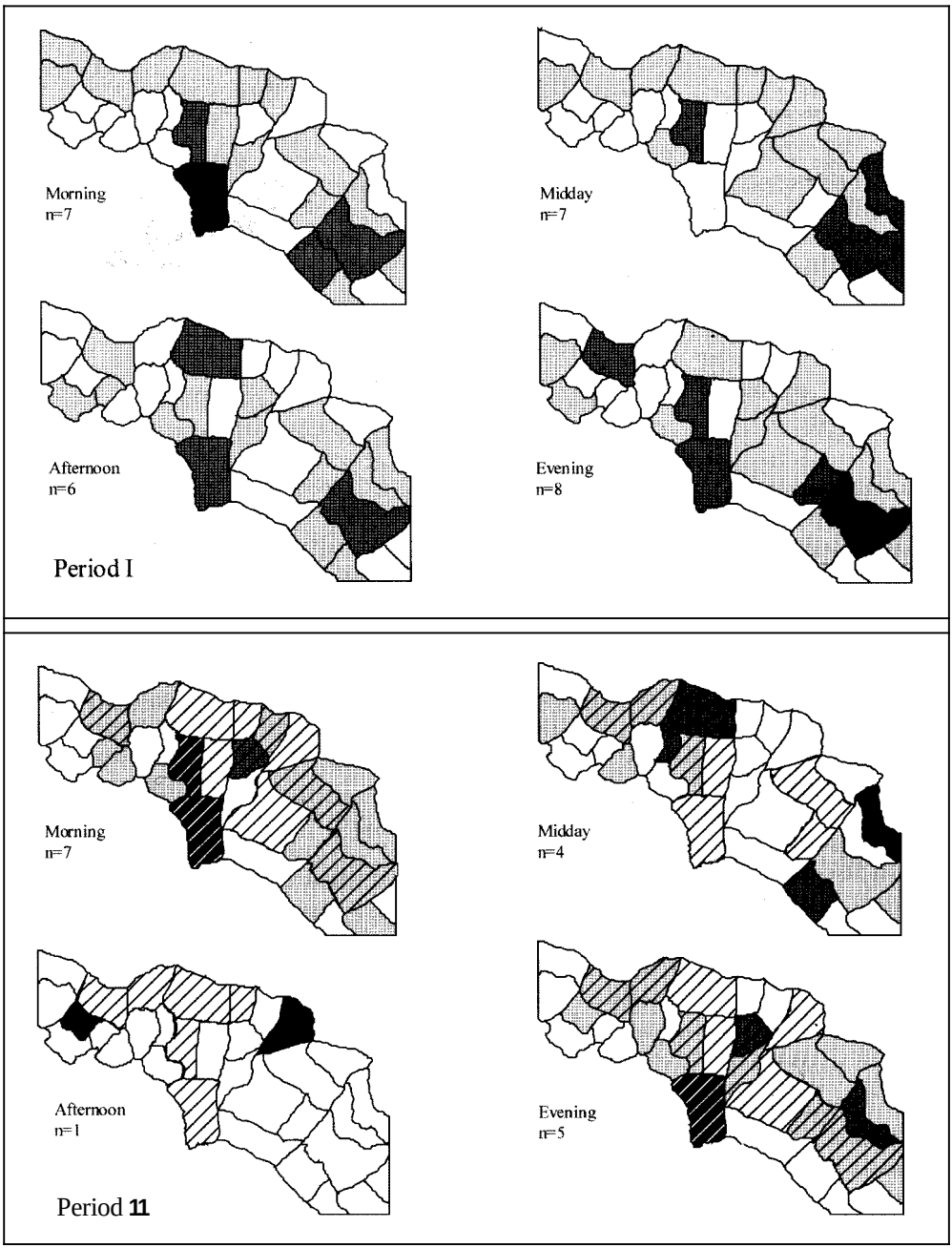

Figure 2 - Spatial occupation of the study area (in Val Chamuera, Switzerland) by Alpine ibexes during period I (June 3 to 12, 1997), and by Alpine ibexes and sheep during period II (June 13 to 26, 1997). Shades of grey of the compartments refer to the index of utilization IU, defined as described in the text (white: IU=0; light grey: IU>0-10; dark grey: IU>10-20; black: IU>20). Hatched compartments indicate the presence of sheep. The number of observations (n) is given for each time period.

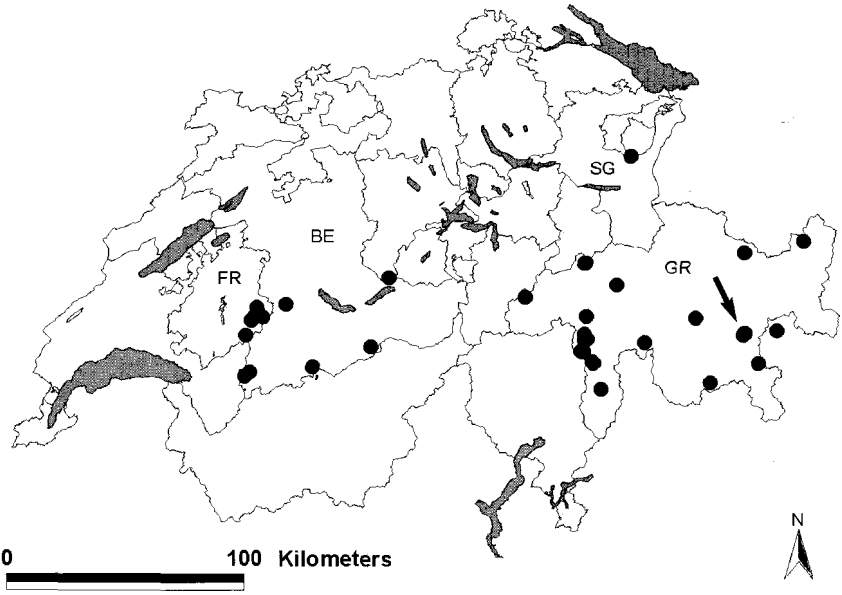

Figure 3 - Map of Switzerland with main lakes and canton borders (FR: Freiburg, BE: Berne, **SG:** St. Gallen, GR: Grison). Black points indicate the areas of the Swiss **Alps** where encounters were recorded during the 1997 and 1998 mountain summer grazing season. The arrow shows the location of **Val** Chamuera. (This figure was drawn with the data of the Swiss Federal Office for Statistics.)

as by sheep (spatial overlap of 40.6%), but in general these overlapping compartments were used successively. Except in salt lick-associated compartments, ibexes and sheep were observed only twice simultaneously in the same compartment (C and E). However, wild and domestic animals were separated in both cases by a large distance (>50 m).

At the end of July, 6 ± 5 ibexes ($\tilde{x} \pm \tilde{D}$, n=3) were registered: only a few females with newborn kids, occupying two compartments (E and F) in the upper part of the study area, were present. Sheep were still distributed over the whole study area, but used less compartments than in period II, concentrating on the pastures in the western and central parts of the area. The only compartments used by sheep on the eastern part were D, E and F. However, sheep and ibexes were never observed there simultaneously.

Encounters

During both 1997 and 1998 summer grazing seasons, 26 encounters were recorded between ibexes and sheep, 27 between chamois and sheep, and 17 between ibexes and chamois. The areas where encounters were registered are shown in Fig. *3*. The shortest recorded distances were 3-5 m between wild Caprinae and domestic sheep (n = 5 with ibex, and n = 4 with chamois, Fig. 4), and 0-3 m between ibexes and chamois (n = 5, Fig. 4).

The duration of encounters varied from a few seconds to more than 1 h (Fig. 5), depending on the activity of the animals involved and on the circumstances which led to encounters. Physical contact was observed once between an ibex kid and a chamois kid, who played together for >15 min. Long-lasting encounters, associated with short distances, were recorded three times between ibexes and

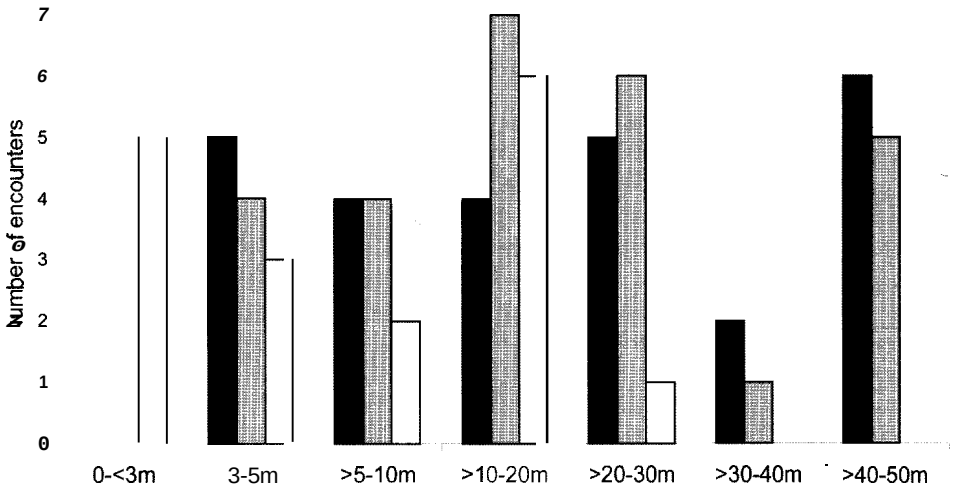

Figure 4 - Minimum distances recorded in encounters between Alpine ibex and chamois (white), Alpine ibex and sheep (black), and chamois and sheep (grey).

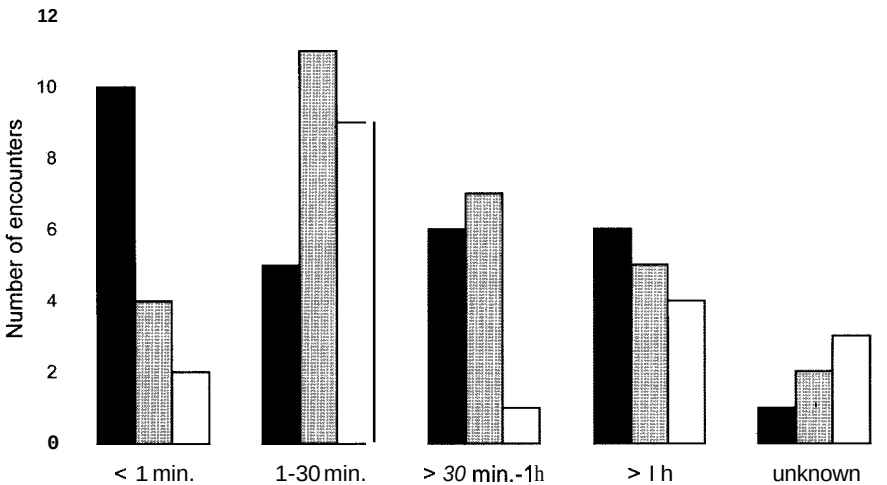

Figure 5 - Duration of encounters recorded between Alpine ibex and sheep (black), chamois and sheep (grey), and Alpine ibex and chamois (white).

chamois (21 h, 1-10 m), twice between ibexes and sheep (>1 h, 3-5 m), and four times between chamois and sheep (>30 min, 3-10 m). In these cases, animals were observed grazing on the same pasture. All other registered long-lasting encounters were associated with minimum distances >10 m. Short-lasting encounters (< 1 min) occurred when animals were moving from one place to another, and met individuals of another species on

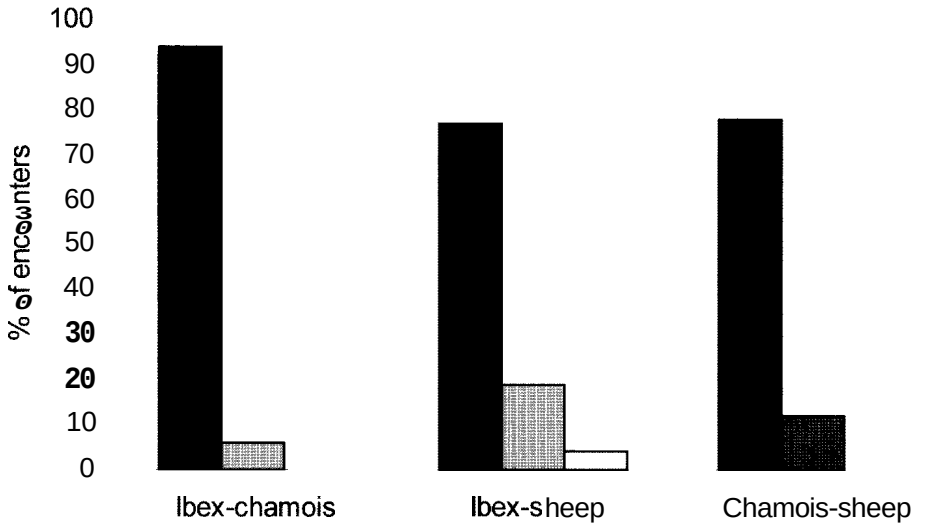

Figure 6 - Interactions between animals during encounters. Black: no change was discernible in the behaviour of involved animals; light grey: ibex went away; dark grey: chamois went away; white: sheep went away.

their way. In Val Chamuera, all encounters recorded between ibexes and sheep (n = 9) were observed in salt lick-associated compartments, and 10 of the 60 encounters registered in other alpine areas also occurred in the neighbourhood of a salt lick.

In the majority (58%) of encounters between sheep or chamois and ibexes, adult male ibexes were involved. In contrast, differences between the considered sex and age classes were not obvious in chamois. However, those could not be identified in several encounters. In most encounters (81.4%), no change was discernible in the behaviour of the animals involved (Fig. 6).

Discussion

In Val Chamuera, the reduction of the number of ibexes started in May, suggesting that the cause of migration was independent of sheep. However, the sudden reduction observed immediately after the arrival of sheep, and the higher number registered as soon as all sheep were fenced outside of the study area, indicate that the presence of sheep had an influence on the spatial distribution of ibexes. Furthermore, generally ibexes and sheep did not use the same compartments of the area simultaneously. Therefore, segregation of ibexes by sheep seemed to occur in the present study. Dubost (1986) and Rebollo ***et al.*** (1993) also described segregation of Pyrenean chamois ***(Rupicupra pyrenaica pyrenaica)*** by domestic sheep, and Bassano ***et al.*** (1996) reported that the contemporary presence of chamois or ibexes with cattle can rarely be observed despite a significant overlap of ranges of wild ruminants and cattle. However, in contrast to our results, Bassano ***et al.*** (1997) observed a difference in the activity pattern of ibexes after the arrival of livestock. Interestingly, the index of utilization of salt lick-associated compartments remained very high despite the presence of sheep, and several encounters occurred in these compartments. Involved animals did not move very close to

each other, and these encounters were all short-lasting, but the attraction of the salt lick was apparently strong enough for ibexes to put up with the proximity of sheep.

Several encounters recorded in other areas of the Swiss Alps also occurred in the neighbourhood of a salt lick, but in other cases animals of different species were attracted by rich pastures. In general, it seemed that animals showed tolerance to each other near attractive resources, supporting the observations reported by Couturier (1962). Between ibexes and chamois, very short minimum distances, and once even body contact, were recorded, which was not observed between individuals of wild Caprinae species and domestic sheep. However, several long-lasting encounters associated with short distances were recorded between ibexes or chamois and sheep. In contrast, in a study performed by Pépin and N'Da (1991), a passive tolerance was observed between Pyrenean chamois and sheep until the minimum limit of only 50 m. However, these observations were conducted in only one area, and the present study shows that the presence or absence of attractive resources has an influence on the behaviour of animals present on alpine meadows. The present results support the observations of Laurent (1996) who reported interspecific encounters at distances shorter than 50 m.

Interestingly, more male than female ibexes were involved in encounters. This apparent higher tolerance of males towards sheep contradicts the observations performed in Val Chamuera, where males left the study area first. This suggests that in this last case the presence of sheep was not the only cause of migration of ibexes. Ibexes might have left the area even if sheep had not arrived, but the presence of livestock might have accelerated their migration to other summer ranges.

In conclusion, ibexes and chamois can stay in the proximity of domestic sheep, especially in situations where attractive resources influence their behaviour. Our study indicates that encounters between free-ranging individuals of different Caprinae species, domestic and wild, are not uncommon events in the Alps. However, interspecific body contacts are rare, and the probability of interspecific transmission of infectious agents by physical contact appear to be low. As regards IKC, encounters can nevertheless be considered to be a predisposing factor for the interspecific transmission of *M. conjunctivae* since aerosol infection or transmission by eye-frequenting insects is possible. Further studies are needed to better understand the mechanisms of interspecific transmission of pathogens and to improve management practices in order to control diseases shared by domestic and wild Caprinae species.

ACKNOWLEDGEMENTS

The authors are grateful to P. Ratti, F. Zindel (deceased), H.-J. Blankenhorn, and W. Meier (deceased) who initiated and supported the study. The authors also acknowledge P. Juesy and P. Demierre who supported the study in the cantons Berne and Fribourg. Special thanks go to the state game-keepers G. Sutter and J. Schaniel for their precious help during the observations in Pigniu and in Val Chamuera, and to H. Buob for making accomodation in Alp Burdun possible. The authors also acknowledge the game-keepers P. Albrecht, R. Bass, R. Bernhard, A. Berri, U. Buchler, D. Bundi, S. Camastral, A. Caminada, G. Denoth, A. Eggenberger (deceased), E. Eggenberger, M. Eichhoff, H. Feuz, R. Fuchs, D. Godli, D. Hunger, G. Largiadèr, J. M. Grass, S. Jager, C. Michael, M. Michael, G. Monn, E. Peissard, M. Rieder, K. Sax, P. Schwendimann, D. De Tann, N. De Tann, A. Weber, J. Wieland, R. Zala, R. Zumbrunnen, and P. Zysset for their help in the field and for recording encounters. Also many thanks to R. Schnidrig-Petrig for hi5 helpful comments concerning the interpretation of the results, to C. Schutz for providing literature, to G. Haerer for computer assistance in

drawing the figures, and to D. Bernet for his statistical advice.

This study was supported by the Fund for Research on Infectious Keratoconjunctivitis, Chur, and by the Swiss Federal Office for the Environment, Forests and Landscape, Berne.

REFERENCES

Baas, E.J., Trotter, S.L., Franklin, R.M. and Barile, M.F., 1977. Epidemic caprine keratoconjunctivitis: Recovery of *Mycoplasma conjunctivae* and its possible role in pathogenesis. Infect. Immun., 18: 806-815.

Bassano, B., Peracino, V. and Peracino, Val. Spatial interactions between wild ruminants (Alpine ibex and chamois) and cattle on high altitude grassland. Proc. Int. Conf. on the Sustainable Use of Biol. Res., August 26-29, 1996, Budapest, Hungary, Abstract book 83: In press.

Bassano, B., Geronutti, E., Martinet, M. and Peracino, V., 1997. Niche overlap between Alpine ibex *(Capra ibex ibex)* and cattle on alpine pasture. Gibier Faune Sauvage, Game Wildl., 15: 793-801.

Couturier, M.A.J., 1938. Le chamois. B. Arthaud-Editeur, Grenoble, 855 pp.

Couturier, M.A.J., 1962. Le bouquetin des Alpes. B. Arthaud-Editeur, Grenoble, 1564 pp.

Degiorgis, M.-P., Obrecht, E., Ryser, A. and Giacometti, M., 1999. The possible role of eye-frequenting flies in the transmission of *Mycoplasma conjunctivae.* Mitt. Schweiz. Entomol. Ges., 72 : 189-194.

Degiorgis, M.-P., Frey, J., Nicolet, J., Abdo, E.-M., Fatzer, R., Schlatter, Y., Reist, S., Janovsky, M. and Giacometti, M., 2000. An outbreak of infectious keratoconjunctivitis in Alpine chamois (*Rupicapra r. rupicapra*) in Simmental-Gruyères, Switzerland. Schweiz. Arch. Tierheilk., 142: 520-527.

Dubost, M., 1986. Relations entre espbces sauvages et domestiques: isard-mouton. Bull. Mens. ONC, 100: 31-34.

Gauthier, D., 1991. La kérato-conjonctivite infectieuse du chamois / Etude épidémiologique dans le Département de **la** Savoie 1983-1990. Thesis Veterinariae Medicinae, Univ. Claude Bernard, Lyon, France, 107 pp.

Giacometti, M., Degiorgis, M.-P., Mayer, D., Krawinkler, M., Meier, W. and Nicolet, J., 1997. Epidémiologie des infections a *Mycoplasma conjunctivae* chez le bouquetin, le chamois et le mouton dans les Alpes suisses. Bull. Soc. Neuchâtel. Sci. Nat., 120: 24-34.

Giacometti, M., Nicolet, J., Frey, J.. Krawinkler, M., Meier, W., Welle, M., Johansson, K.-E. and Degiorgis, M.-P., 1998. Susceptibility of alpine ibex to conjunctivitis caused by inoculation of a sheep-stain of *Mycoplasma conjunctivae.* Vet. Microbiol., 61: 279-288.

Gouws, J.J., Coetzer, J.A., Howell, P.G., 1995. A comparative microbiological study of clinically healthy eyes and those affected by ophthalmia in cattle and the association of noctuid eye-frequenting moths. Tydskr. S. Afr. vet. Ver., 66: 160-169.

Hammerli, M., Krähenbühl, P., Rothenbühler, D., Schefold, S., Vogeli, Y., Zimmermann, L. and Giacometti, M., 1999. Schafe auf der Alp: Verkannte Landschaftspfleger? Interdisziplinäre Projektarbeit in Allgemeiner Okologie, Interfakultäre Koordinationsstelle fur Allgemeine Okologie der Universitat Bern, Berne, Switzerland, 41 pp.

Hosie, B.D., 1988. Keratoconjunctivitis in a hill sheep flock. Vet. Rec., 122: 40-43.

Huboux, R., 1994. Un comportement anormal: l'accouplement de chamois avec des brebis. Bull. Mens. ONC, 190: 26-29.

Jones, G.E., 1991. Infectious keratoconjunctivitis. In: Martin, W.B. and Aitken, I.D. (eds.), Diseases of sheep, Blackwell Scientific Publications. London: 280-283.

Laurent, O., 1996. Gestion pastorale et faune sauvage en Vanoise, rapport d'un stage d'été. Laboratoire Départemental d'Analyses Vétérinaires, Université de Savoie, Lyon, France, 54 pp.

Mart, C.J. and Loveday, R.K., 1994. Mycoplasmal pneumonia of pigs. In: Coetzer, J.A.W., Thomson, G.R. and Tustin, R.C. (eds), Infectious diseases of livestock, Oxford University Press, New York: 1498-1500.

Nicolet, J., 1985. Kompendium der veterinär-medizinischen Bakteriologie. Pareys Studientexte 45, Berlin, Hamburg, 280 pp.

Nicolet, J. and Freundt, E.A., 1975. Isolation of *Mycoplasma conjunctivae* from chamois and sheep affected with keratoconjunctivitis. J. Vet. Med. B, 22: 302-307.

Pépin, D. and N'Da, L., 1991. Interactions between wild and domestic ungulates during the mountain summer grazing season in a French Pyrenean reserve. Proc. 20th Congress of the Int. Union of Game Biol.: 483-488.

Rebollo, S., Robles, L. and Gbmez-Sal, A., 1993. The influence of livestock management on land use competition between domestic and wild ungulates: Sheep and chamois *Rupicapra pyrenaica parva* Cabrera in the Cantabrian Range. Pirineos, 141-142: 47-62.

Ratti, P. and Habermehl, K.H., 1977. Untersuchungen zur Altersschatzung und Altersbestimmung beim Alpensteinbock (*Capra ibex ibex)* im Kanton Graubünden. *Z.* Jagdwiss., 23: 188-213.

Stalder, F. and Wiedmer, E., 1999. Sömmerung von Schafen - Vorschlage zur Lösung der Probleme aus landschaftsökologischer Sicht. Schweiz. *Z.* Forstw., 150: 341-353.

Stärk, K.D.C., Keller, H. and Eggenberger, E., 1992. Risk factors for the reinfection of specific pathogen free pig breeding herds with enzootic pneumonia. Vet. Rec., 131: 532-535.