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Body mass loss and decrease of horn length in male Alpine ibex *Capra i. ibex* from 1980 to 2005

Key words: *Capra ibex*, body mass loss, horns, hunting

Introduction

Hunting activities in each form of its wide range from poaching to management based on a biological background, influences population density and size, population dynamics, demography and behaviour (social structure, activity). There can result an impact on constitution and condition and on growth of secondary sexual traits as horn and antlers (Harris et al. 2002).
In the case of Alpine ibex *Capra i. ibex* the statement of hunting being responsible for the decline and nearly extinction in the 19th century is widely accepted (Couturier 1962, Giacometti 1988, 2006), but influence of climatic factors can not be completely excluded (Filli 2002).
Reintroduction of this wild goat species started in 1911 in the Swiss Alps with animals originating from the Italian Alps. Later more than 2000 individuals have been captured in the growing so called "colonies" and released in many parts of the Swiss Alpine ridge. The population has increased to more than 14.000 in 2005 (Giacometti 2006). This act of compensation towards a species over hunted in historic times is known as one of the best documented and most successful biological experiments with a large ungulate species.
Only few decades after the first reintroduction damages on alpine meadows and mainly in reforestations were claimed (Nievergelt 1966).
In the 1970ties management plans for a selective hunting to stabilize or reduce population size were established. This form of hunting started in the canton Graubünden in 1977 (Ratti 1981, 1994), in the canton of Berne in 1980 (Brüllhardt & Lüps 1984).
In Graubünden 16.811, in Berne 1.178 animals of this species still protected by law have been shot till 2005. All animals are well documented. A large data set could be built up and enables exploitation on a long term. A lot of data concerning constitution, condition, growth, physiology and morphology have been exploited till today in both cantons.
Most publication concern mainly questions of management in a broad sense (e. g. Giacometti 1988, Ratti 1994, Tataruch & Onderscheka 1996, Buchli & Abderhalden 1998, Filli 2002, Lüps et al. 2007). Less data are available concerning the influence of hunting on the population structure, constitution and condition (Filli 2002). Actually biologists and authorities are worried by observations and census' showing a decrease in size of some subpopulations and animals suffering pneumonia and other diseases.

The aim of this study is to present data on the changes in body mass and horn length between 1980 and 2005 in the Berner Oberland colonies. They should provide information necessary as a basis for discussion of future management.

Material

All data concern animals from 7 of the 13 subpopulations ("colonies"), founded in the years 1924 to 1961 (Zuber et al. 2001, Giacometti 2006). The Berner Oberland is situated on the northern border of the Alpine range, with elevations up to 4274 m a.s.l. The most western colony (Gstaad/Tschärzis) is at a distance of 75 km from the most eastern one (Brienz/Rothorn). All 630 males and 548 females have been harvested by hunters during September and October, following governmental guidelines (for details concerning the management plans see, Zuber et al. 2001). In the first 10 years hunting was restricted to October (when hunting on chamois from 13th to 31 was finished. Only from 1990 onwards, hunting was additionally allowed in September. For questions of condition in this analysis data from October have been selected only, considering that there is a significant increase in body mass and horn length in males from September to October till the age of 7 ½ years (Lüps et al. 2007). The data from 1980 to 2005 have been divided into two groups of 13 years each (1980 to 1992 = period I, 1993 to 2005 = period II). The average date of kill was Oct. 7.5th in 1980–1992, Oct. 11.7th, in 1993–2005. To get groups of "adults" all animals in their 9th to 13th year when they are fully grown but rarely show signs of senescence (Meile et al. 2003, Lüps et al. 2007), have been pooled into two sex groups. In period I much more males have been analysed than in period II. Lactating females and kids of the year are protected. Animals obviously suffering diseases as hoof sickness are excluded.

Methods

The following measurements have been taken in the field by professional game keepers the day of kill: body mass (eviscerated, with skin, head and horn), gird circumference and body length (from tip of snout along the back to begin of tail). Left horn length (measured along the front), length of annual increments on the left horn (see Nievergelt 1966, Lüps et al. 1986) and skull breadth (greatest breadth across the orbits, von den Driesch 1976) were measured by game keepers and biologist at the trophy exhibition in Thun in February of the year following hunting (skulls and head-mounts have to be presented and exhibited there as one of the conditions of the permission for this selected hunting).
From the statistic packet SPSS version 13.0 t-Test and regression have been used. Level of significance was defined at $p = 0.05$.

Results

Males in the 9th to 13th year ($n = 97/96$) hunted in period I were heavier (4.8 kg, 7.89 %, t-test $p < 0.01$) and had longer horns (5.3 cm, 6.9 %, $p < 0.01$) than males ($n = 52/51$) from period II (table 2). No such differences 1980–1992/1993–2005 could be found for the other measurements and no for males in their 4th year of life ($n = 33/7$). No differences at all were visible for females ($n = 73$ in period I/ $n = 15$ in period II, all $p > 0.05$, table 1).
A negative regression in body mass and horn length (see fig. 1) in 148 males 9th to 13th year is significant, but it is not in skull breadth. No regression ($p > 0.05$) could be detected in

Table 1 Capra ibex. Berner Oberland, hunting October 1980–2005

age structure males 9th to 13th year		
age	period I	period II
9th	8	13
10th	20	17
11th	21	6
12th	23	7
13th	22	9
total	94	52

Table 2a Mean values for males 9th to 13th year, shot in October period I = 1980–1992, period II = 1993–2005

	period	n	mean	reduction %	sd	significance
body weight	I	95	66,1	7,2	7,2	< 0.01
	II	51	61,3		7,5	
girdle circum-ference	I	97	106,7	0,4	5,5	≥ 0.05
	II	50	106,3		5,2	
body length	I	96	141,9	1,12	9,3	≥ 0.05
	II	50	140,3		7,3	
skull breadth	I	73	11,8	1,69	0,4	≥ 0.05
	II	36	11,6		0,5	
horn length	I	96	82,9	6,41	6,2	< 0.01
	II	51	77,6		8,8	

Table 2b Mean values for females 9th to 13th year, shot in October period I = 1980–1992, period II = 1993–2005

	period	n	mean	increase	sd	significance
body weight	I	73	29	2,4	4,6	≥ 0.05
	II	15	29,7		3,9	
girdle circum-ference	I	97	82,2	2,5	4,8	≥ 0.05
	II	50	84,9		4	
body length	I	73	119,3	2,3	6,4	≥ 0.05
	II	15	122,1		6,2	
skull breadth	I	60	9	2,2	0,4	≥ 0.05
	II	15	9,2		0,2	
horn length	I	71	26,8	-4,3	2,8	≥ 0.05
	II	14	25,7		2,7	

Table 3 Capra ibex, hunting in Berner Oberland, September and October 1980–2005 males 9th to 13th year

	Periode I	Periode II	total
males with lesse than 70 kg	85	144	229
males of 70 kg and more	39	8	47
total	124	152	276

females, neither in body mass (n = 88), nor in horn length (n = 85) and skull breadth (n = 75). The full grown 4th annual horn increment (measured in males in their 6th year and older) has decreased from period I to period II (n = 163/191; -5.9 %, $p < 0.01$). A slight increase of length shown by the 9th increment (11th year and older) is not significant (n = 68/55, 4.6 %, $p = 0.1$).
Out of 124 males in their 10th year or older in period I a total of 39 (31.4 %) weighted 70 kg or more. From 152 males of the same age class hunted in period II only 8 (5.3 %) had a weight of at least 70kg (Chi-square, $p < 0.01$). Despite the fact of lacking increase of body mass from September to October at this age the data from period I and II have additionally been compared for males shot in October only: in period I 31.5 % of the males had a weight of ≥ 70 kg, in period II only 8.2 %.

Discussion

Animals from the seven different colonies have been pooled to get more data per year. This procedure has been chosen unregarded the fact that there probably exist some differences in horn development (Nievergelt 1966). On the other hand it is known that all these animals originate directly or indirectly (from so called "daughter-colonies") from the same source (Augstmatthorn, Lüps & Zuber 1986) and have the same genetic basis (Biebach & Keller 2009). Therefore only environmental factors as climate change or a diverging hunting strategy could cause differences. The selection of animals to be culled per year and colony has been more or less stable throughout the two periods 1980–1992 and 1993–2005 and no differences in management between colonies were planned. Therefore pooling seems a usual tool to get information in this context.
In the young French population of Beldonne environmental conditions in the year of birth affect chest girth and first annual increment of males, but not of females (Toïgo et al. 1999). All these data suggest that males are more vulnerable to environmental changes than females (Lüps et al. 2007) and that they have less possibilities to compensate a bad first year. This aspect needs further investigation.

In period II the males 9th to 13th year have been hunted on average 4 days later than in period I (could theoretically result in a minimal increase of app. 1 %, unpubl. data). They are 6.9 % lighter and have shorter horns (6.6 %). It seems astonishing that gird circumference does not show this trend, for in these animals a correlation between circumference and body mass can be observed (unpublished data). The differences in age structure (see table 1) explains only a minor part of the decrease.
The difference in length of 4th and 9th annual increment is in some correspondence with the observation that environmental factors and population density have stronger influence on young age classes that on older ones (Nievergelt 1966, Giacometti 1988, Buchli & Abderhalden 1998, Toïgo et al. 1999, Giacometti & Ratti 2003). Our results lead to the conclusion that climatic influence and population density may be responsible mainly for the decline in body mass, and horn length (Giacometti et al. 2002), both known to be influenced by the actual condition.
Body length, gird circumference and skull breadth more reflect constitution than the former ones. They are probably less affected by short time influences of harsh winters or wet spring.

The following hypotheses for deterioration in male condition should be taken in mind, when new management plans are to be discussed

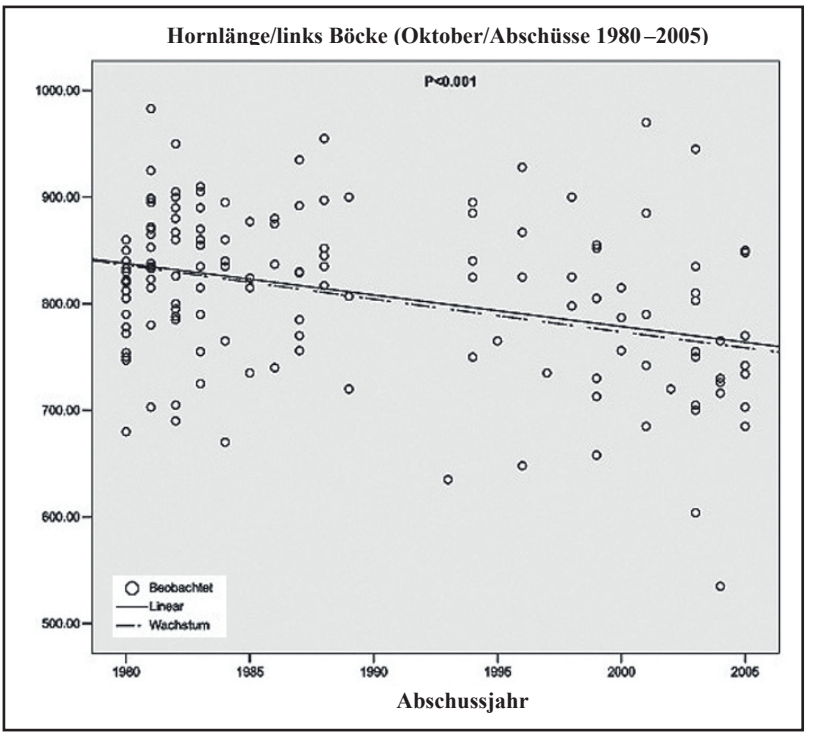

Fig 1a Body mass (kg) for males 9th to 13th year, shot in October 1980–2005

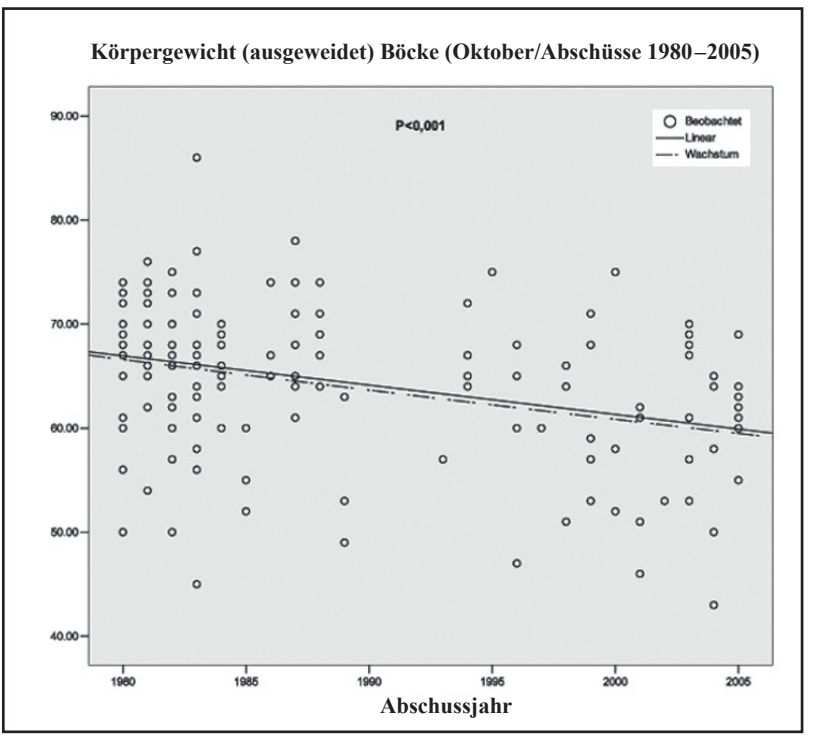

Fig 1b Horn length (mm) for males 9th to 13th year, shot in October 1980–2005

when management strategies need revision (Willisch & Neuhaus 2009):
1) A late response to four *genetic bottlenecks* the species suffered from 18th to 20th century (Hartl 1986, Stüwe & Scriber 1989, Biebach & Keller 2009). Alpine ibex shows a high variability in body and skull measurements. This variability is most expressed in body mass and horn length (Lüps et al. 2007), with low differences in variability between the sexes. Our results show a decrease in body mass and horn length. These two measurements seem to express more condition than constitution. There is no decrease in body size, a fact which seems to contradict in some way the existence of a genetic bottleneck.

2) *Increasing numbers* of individuals within the "colonies" (as subpopulations) could have the effect of a reduction in body condition, as it was demonstrated in several colonies in Canton Graubünden (Nievergelt 1966, Buchli & Abderhalden 1998, Filli 2001, Giacometti & Ratti 2003). The colonies in the Bernese Oberland, mainly the seven managed since 1980, don't show an increase of the number of ibexes (governmental wildlife statistics).

3) Information about a *reduced habitat quality* is lacking. Concerning climatic condition a delay in the begin and end of winter has been observed within the last years. Late fall of wet snow towards spring can bring ungulates wintering in high altitudes into critical situation. Snow cover can be a limiting factor for ibex populations. As Giacometti et al. (2002) have shown, conditions in spring play an important role in development of annual increments (which reflect condition in the year in question, Filli 2002). If Alpine ibexes have evolved the possibility to reduce energy expenditure by behavioural strategies (Willisch & Neuhaus 2009) and adapt their metabolism (Steineck & Onderscheka 1995, Signer in prep.), the rapid change of climatic condition towards spring can bring them into an energetic conflict when winter condition changes towards spring with snow covering the growing vegetation. Females showed no decrease in any measurement. That means that they stayed in a more or less stable condition during the 26 years, what can be explained by less influence of environmental factors than by males. One explanation is the different selection of foraging habitats (Couturier 1962; Nievergelt 1966), even in winter (Abderhalden 2005). In favor of predation avoidance females use steeper and more structured slopes than males, where snow covers potential food plants (Francisci et al. 1985, Ruckstuhl & Neuhaus 2001).

4) Disturbances and stress by *tourism activities* in the mountains (Ingold 2005), mainly paragliding (Szemkus et al. 1998), can lead to increased energy expenditure (Hüppop 1995). In some of the colonies, paragliding is a trend sport for several years now (Schütz et al. 1995, Ingold 2005). One exception is the Augstmatthorn (Szemkus et al. 1998) where no hunting is allowed (therefore no animals are included in this dataset).

5) *Overhunting of males with long horns*. The aim of the management plan (1980, with later adaptations, Zuber et al. 2001) is to maintain a sex and age structure as it exists in non hunted subpopulations. It offers the hunter little possibility to select for large trophies within the given age category. The case of the Alpine Ibex in the Berner Oberland can in no way be compared with the situation of the bighorn sheep on Ram Mountain, Canada (Coltmann et al. 2003).

It seems convincing to explain the deterioration of condition parameters as body mass and horn length in adult males by changes in various environmental factors, as caused by climatic changes. A population level above carrying capacity on a long term scale (see Filli 2002, Murray et al. 2006) needs to be discussed.
A postponement of winter conditions towards spring seems one plausible explanation. This *Capra* species is probably more adapted to hard winters in high altitudes than it has been realised before. But rapid climatic change brings problems to this evolved metabolic system. Selective hunting offers possibilities for research and therefore a better understanding of this species still protected by law. On the other hand it is important to find resolutions to reduce disturbances by sport activities in these sensitive habitats.

Abstract

In 7 colonies of Berner Oberland (Swiss Alps) ibex were shot by hunters following a governmental management plan. 630 males and 548 females were harvested during the months of September and October 1980 to 2005.
In males a decline of body mass and horn length within these 26 years is significant. No such process was found in females and no decline exists in skull breadth, body length and girth circumference. Five hypotheses are discussed.

Zusammenfassung

Verminderte Körpermasse und Hornlänge des Alpensteinbocks *Capra ibex ibex* von 1980 bis 2005

Zählungen und Beobachtungen im Feld durch die Wildhut wie auch die Feststellungen an erlegten Tieren ließen in verschiedenen Kolonien der Schweizer Alpen die Vermutung einer Abnahme der Individuenzahlen und einen Rückgang der Kondition im Verlauf der letzten Jahrzehnte aufkommen. Im letztgenannten Punkt wurden bisher kaum Auswertungen der Abschüsse vorgenommen.
Im Kanton Bern wurden im Rahmen der vom Bundesrat erlassenen Richtlinien zur Regulierung der Steinwild-Bestände in den Monaten September (ab 1990) und Oktober 1980–2005 insgesamt 630 Böcke und 548 Geissen erlegt. Die Analyse der gewonnenen Daten anhand verschiedener Kriterien lassen auf eine leichte Abnahme von Körpergewicht, Hornlänge und Hornzuwachs (im 4. Lebensjahr) bei den Böcken schließen. Bei den Geißen sind solche Tendenzen allerdings nicht erkennbar.
Für diese Abnahme werden verschiedene Gründe als (mit)verantwortlich diskutiert. Genannt wurden u.a. Störungen durch zunehmende Freizeitaktivitäten, genetische Flaschenhälse und klimatische Faktoren. Eine Beeinflussung durch Trophäenjagd kann weitgehend verneint werden.

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