How to evaluate body conditions of red deer (*Cervus elaphus*) in an alpine environment?

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ABSTRACT

The aim of this investigation was to compare different indices for evaluating nutritional conditions of red deer (*Cervus elaphus*) in an alpine environment during the autumn in order to detect the most convenient ones for management purposes in our specific situation. Body conditions of 274 red deer were evaluated using kidney fat index, back fat index and body condition scores. Body Condition Scores was the easiest but the least reliable method. Both kidney fat index and back fat index were significantly affected by age and sex class (always lower in younger animals) and, in females, also by lactation status. In stags, a negative regression effect of culling date on both kidney fat index and back fat index was observed. A significant positive correlation between kidney fat index and back fat index was recorded. Both kidney fat index and back fat index were objective indicators of nutritional status and sensitive to changes in physical conditions, but back fat index was both quicker and easier to be measured. As a direct implication, we suggest that back fat index can be a practical and reliable indicator for monitoring red deer conditions in alpine areas during the autumn, provided that the effects of sex, age and date of culling are taken into account.

Key words: Kidney fat index, Back fat, Body condition score, Physical conditions, Ungulate management.

RIASSUNTO

COME VALUTARE LE CONDIZIONI FISICHE DEL CERVO (*CERVUS ELAPHUS*) IN AMBIENTE ALPINO?

Il monitoraggio delle condizioni fisiche dei selvatici a vita libera è essenziale al fine di controllare le popolazioni in relazione all'ambiente nel quale vivono e di evidenziare eventuali squilibri prima che insorgano problemi seri, che possono ripercuotersi sulle dinamiche di popolazione. Le condizioni fisiche di 274 cervi sono state valutate mediante attribuzione di indici soggettivi (BCS) da parte dei cacciatori, calcolo del Kidney Fat Index (KFI) e misurazione dello spessore del grasso lombare (BFI). Il BCS ha potuto essere valutato per il 98,2% dei soggetti esaminati, il BFI per l'86,1% e il KFI per il 53,3%. Il KFI ha mostrato una variabilità più elevata (7,1-368,6%) rispetto al BFI (0-50 mm). Quest'ultimo in molti soggetti era già *completamente esaurito, in quanto mobilizzato prima del grasso perirenale in ordine di tempo. I due indici oggettivi (KFI e BFI) sono risultati significativamente correlati tra loro (r=0,38; P<0,001), mentre hanno spesso dato risultati discordanti rispetto ai BCS attribuiti dai cacciatori, che erano probabilmente influenzati dalla mole apparente dei soggetti esaminati, più che dal loro reale stato di nutrizione. Per esempio, a nessun maschio adulto è mai stato attribuito un BCS scarso; BFI e KFI sono talvolta risultati più elevati in soggetti classificati come "scarsi" o medi" che in quelli classificati come "buoni". Sia il KFI che il BFI sono stati in grado di evidenziare variazioni fisiologiche dello stato di nutrizione dei cervi esaminati: nei maschi, hanno colto lo scadimento delle condizioni fisiche che avviene durante la stagione autunnale, in corrispondenza del periodo riproduttivo (come evidenziato dal trend negativo nell'analisi di regressione quadratica: n=42, R^2=0,48, P<0,001 per il BFI e n=23, R^2=0,50, P<0,001 per il KFI); nelle femmine, hanno messo in luce indici nutrizionali significativamente inferiori nelle lattanti rispetto alle non lattanti (n=64, F=3,28, P=0,07 per il BFI e n=41, F=6,26, P<0,01 per il KFI). L'effetto della classe di sesso ed età è risultato altamente significativo per il BFI (n=189, F=41,96, P<0,001), e in misura meno marcata anche per il KFI (n=119, F=3,70, P<0,05).*

In sintesi, il BCS si è rivelato l'indice più semplice e rapido da rilevare, ma risulta affetto da errore sistematico, in quanto attribuito soggettivamente dai cacciatori ed influenzato dalla mole fisica dell'animale. Gli altri due indici si sono rivelati dei buoni indicatori delle condizioni fisiche dei soggetti esaminati, ma il BFI è risultato più pratico da misurare ed ha potuto essere rilevato su un maggior numero di soggetti. In conclusione, il grasso lombare si è rivelato essere un indicatore pratico e sensibile per la stima delle condizioni fisiche dei cervi in ambiente alpino durante la stagione autunnale; tuttavia, per una sua valida applicazione, devono essere tenuti in considerazione l'effetto del sesso, dell'età, dello stato fisiologico dei soggetti e della data di abbattimento. Il KFI rappresenta un indicatore altrettanto valido, che può essere affiancato al BFI al fine di ottenere una valutazione affidabile e per un periodo temporale più esteso.

Parole chiave: *Grasso perirenale, Grasso lombare,* Body condition score*, Condizioni fisiche, Gestione ungulati.*

Introduction

Condition can be defined as the temporary physical state of an animal in relation to its nutrition, health and capacity to cope with diseases and environmental stressors (Pedrotti and Fraquelli, 2001). The condition of an animal can be measured in terms of the amount of muscle and fat depots in its body, which are strictly related to population density through several environmental factors, among which diet and nutrition are of outstanding importance (Kie, 1988). Nutritional conditions may affect the individual survival, health, reproductive performances, calves' winter survival and susceptibility to predation (Albon *et al*., 1986; Gerhart *et al*., 1996; Cook *et al*., 2004a, 2004b; Bender *et al*., 2007, 2008). Evaluating body condition of wild ungulates is therefore essential to monitor the population situation in relation to the environment and to be able to detect possible imbalances before serious problems arise. Changes in both populations and environment, as well as their interactions, are currently considered as essential tools for the successful management of large herbivores (Morellet *et al*., 2007). As this is a crucial point for a correct wildlife management, several methods for assessing wildlife conditions have been developed (Riney, 1955; Kie, 1988; Cook *et al*., 2005). Each method has different advantages and disadvantages, and not all methods are always successfully applicable to any situation (Putman, 2005). Some methods, such body condition scoring systems (BCS; Audigé *et al*., 1998) or estimation of fat reserves by ultrasonography (Stephenson *et al*., 1998) are applicable on live animals, and can be of interest for farmed deer. Most of the other methods are based on access to the dead animal in order to collect the information desired. Fat reserves are some of the most widely used indicators. Among them, kidney fat index (KFI) has been proven to be highly correlated with the percentage of body fat (Finger *et al*., 1981) and it is usually considered the most reliable indicator (Putman, 2005); it has been used for evaluating conditions in several ungulate species, as recently reviewed (Taylor, 2004). Back fat depth can also be used, but its consumption occurs earlier than that of kidney fat, and it is therefore not recommended for populations in a situation of inanition, as it might already be completely depleted in all animals; although in the past in New Zealand this method has been suggested to be a good indicator of body conditions during the autumn (Riney, 1955), its use for red deer in an alpine environment has never been reported. Abdominal fat represents one of the most important fat reserves in the body of ungulates; however, its estimation is achieved only by visual inspection and subjective attribution of scores (Riney, 1955). Furthermore, this index was found to have a rather narrow scale, which makes accurate discrimination difficult (Putman, 2005). Finally, bone marrow fat can be used for the evaluation of nutritional status in animals in poor body conditions, as this is the last fat reserve to be consumed; it can be measured from femur, mandibles, humerus, tibia, radius, metatarsus or metacarpus (Fuller *et al*., 1986) and its absence will indicate a severe and prolonged starving situation (Riney, 1955). Its evaluation is either based on visual inspection or on laborious laboratory analysis (Kirkpatrick, 1980); therefore its use is not widespread. Other methods requiring laboratory techniques are available (e.g. fat, protein or NEFA levels in blood serum; reviewed by Kie, 1988), but their use is not suitable for field work on a large scale. Some biometrical measures have also been used, such as live weight, chest girth or antler length, but these variables are not directly correlated with fat reserves and they are affected by genetic factors; therefore, they cannot be used for direct comparison among different populations (see Langvatn, 1977 for a review).

An effective method should be reliable, in terms of being able to detect changes in depot fat reserves, thus providing valid information on body conditions; furthermore, it should be objective, and it should be repeatable even by relatively unskilled persons in field conditions, without being subjected to inter-observer effect. Finally, it should be easy to be measured, and it should require a minimum of equipment (Riney, 1955). The purpose for which information on conditions is collected also plays an important role in the decision of which index is the best to be used under specific situations (Riney, 1955).

In the Central Italian Alps, the hunting season is concentrated in autumn; therefore culled deer are available for inspection only during that period. The aim of this investigation was to compare the use of three different methods (BCS, back fat index and KFI) for evaluating nutritional conditions of red deer (*Cervus elaphus*) in an alpine environment during the autumn hunting season in order to identify the most appropriate and reliable method (practical and able to detect condition variations) for management purposes under this specific situation.

Material and methods

Two-hundred and seventy four red deer (129 males and 145 females) culled in Val Fontana (Central Italian Alps, Province of Sondrio) during eight hunting seasons (1995-1996; 2001-2006) were taken to a common centre for sanitary inspections. All animals were completely eviscerated and were not skinned. In our study area, the hunting season is concentrated between September and November, starting on September 1st. The estimated pre-reproductive deer density in the study area was 2.9 heads/100 hectares of suitable surface area; variations in deer numbers among years during the study period were small (Ferloni, 2007). The age of the animals ranged from 4-6 months to 13 years (estimated on the basis of teeth wear; Mattiello *et al.*, 1993). According to age and sex, deer were allocated to the following age and sex classes: calves (4-6 month old males and females; n=53), yearlings (16-18 month old males and females; n=86), adult hinds (>2 year old females; n=80), subadult stags (2-4 year old males; n=36) and adult stags (>4 year old males; n=17).

Physical conditions were evaluated using three different methods: attribution of a subjective nutritional index (Body Condition Score, BCS) and two more objective measures (Kidney Fat Index, KFI, and Back Fat Index, BFI). BCS (poor, medium, good) were attributed by the hunters after visual examination of the carcass, paying particular attention to bone prominences (backbone spinous processes, ilium and ischium tuberosities) and to concavity or convexity of the gluteal muscle (Audigé *et al.*, 1998). For the attribution of the BCS, hunters were also supported by illustrations of animals in each condition class (Magnaghi *et al.*, 1986). This index is actually just a simple method for expressing a subjective assessment of subcutaneous fat reserves (Putman, 2005) and it is the routine method that has been carried out by hunters since 1992 in all of Sondrio Province for evaluating body conditions. KFI was calculated following the method described by Monson *et al.* (1974) and it was expressed as the percentage of the total weight of fat around the kidney out of kidney weight. For measuring BFI, a forward cut was made on the back of the deer, starting from the tail, and the maximum depth of fat depot between 5 and 10 cm from tail insertion was recorded. BFI values are expressed in mm. Due to the lack of the internal organs or to the lack of time during the control procedures, not all of the indices could be recorded for all animals.

Descriptive statistics and relative frequencies of BCS were calculated within each age and sex class.

Differences of KFI and BFI depending on BCS level within each age and sex class were compared by One-way ANOVA (SPSS, 2003). KFI and BFI (log transformed data) were submitted to analysis of variance by General Linear Model with 2 fixed factors: age and sex class (4 levels: yearling, subadult stag, adult hind, adult stag) and year of culling (8 levels: 1995-1996, 2001-2006). As fat reserves are subjected to seasonal changes, and the trend and magnitude of these changes may vary according to sex and age, the number of days from September 1st (start of the hunting season) was introduced into the model as covariate nested within the age and sex class (SPSS, 2003).

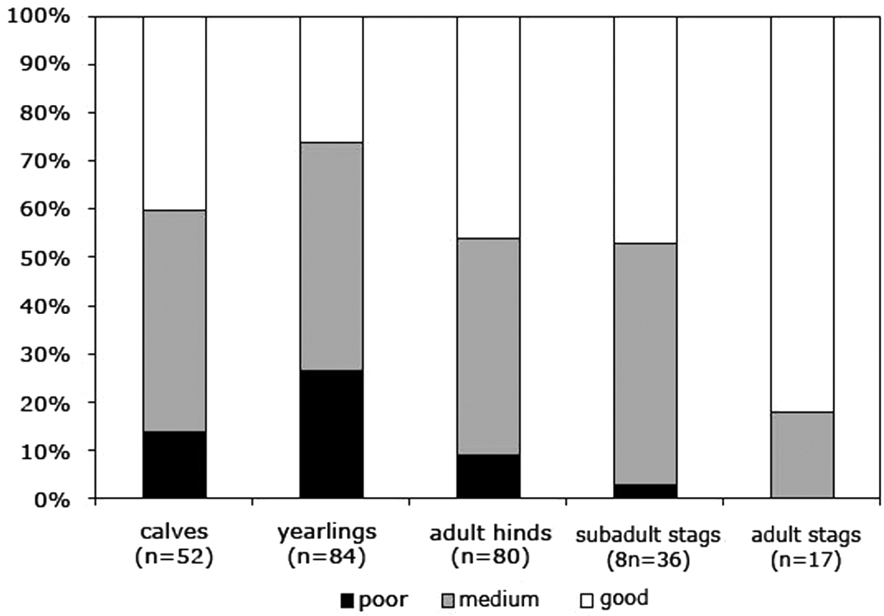
Partial correlation coefficients controlled for the effect of age and sex class were calculated between KFI and BFI (SPSS, 2003). For adult hinds and for stags (>2 years old), regression analysis was performed in order to point out the effect of culling date (expressed in number of days from September 1st) on KFI and BFI. For adult hinds, One-way ANOVA was also performed in order to point out the effect of reproductive status (lactating *vs* non-lactating) on fat reserves.

Results

BCS was recorded for 98.2% of the animals, BFI for 86.1% and KFI only for 53.3%.

Relative frequencies of BCS within each age and sex class are reported in Figure 1. No adult stag was ever classified as in “poor”

Figure 1. Relative frequencies of body condition score (BCS) within each age and sex class.



condition, while younger age classes (calves and yearlings) recorded the lowest BCS.

Descriptive statistics of BFI and KFI in relation to BCS for each age and sex class are presented in Tables 1-2. KFI ranged from 7.1 to 368.6, while the variation of BFI was smaller, between 0.0 and 50.0. No significant differences were ever detected for BFI (Table 1) nor for KFI (Table 2) among different BCS levels within each age and sex class. In some cases, BFI and KFI were higher in "poor" or "medium" animals, rather than in "good" ones. In calves, BFI was particularly low and in 73.9% of cases back fat was completely absent. This is the reason why calves were excluded from subsequent GLM analysis of variance.

GLM analysis pointed out no significant variation among years. The effect of age and sex class was highly significant for BFI (n=189, F=41.96, d.f. 3 and 174, P<0.001), and to a lesser extent also for KFI (n=119, F=3.70, d.f. 3 and 104, P<0.05).

A significant correlation was found between BFI and KFI (r=0.38; P<0.001).

Physiological variations of fat reserves were detected both by BFI and KFI. Both indices were significantly affected by date of culling in stags, and the regression analysis fitted a quadratic curve (R^2=0.48, P<0.001 for BFI and R^2=0.50, P<0.001 for KFI; Figures 2-3). Fat depots dramatically decreased from the beginning of the hunting season (September 1st) until the middle of October, and then showed a light trend to increase again. No significant effect of date of culling was detected in adult hinds. Both BFI and KFI were considerably lower in lactating than in non-lactating females (Figure 4), although differences were statistically significant only for KFI (n=41, F= 6.26, d.f. 1 and 39, P<0.01) and approached statistical significance for BFI (n=64, F=3.28, d.f. 1 and 62, P=0.07).

Table 1. Descriptive statistics for BFI in relation to BCS within each age and sex class.

	No.	Mean	SE	Min	Max
		Calves			
Poor	7	0.43	0.30	0	2
Medium	19	0.42	0.30	0	5
Good	19	4.00	1.84	0	30
Overall	45	1.93	0.82	0	30
		Yearlings			
Poor	21	1.14	0.39	0	5
Medium	36	2.19	0.47	0	10
Good	17	2.12	0.63	0	10
Overall	74	1.88	0.29	0	10
		Adult hinds			
Poor	5	1.60	1.17	0	6
Medium	32	5.28	1.84	0	50
Good	34	8.12	1.39	0	30
Overall	71	6.38	1.08	0	50
		Subadult stags			
Poor	1	0.00	-	0	0
Medium	15	6.07	2.02	0	24
Good	13	12.15	3.89	0	40
Overall	29	8.59	2.09	0	40
		Adult stags			
Poor	0	-	-	-	-
Medium	2	15.00	15.00	0	30
Good	11	23.00	5.80	0	50
Overall	13	21.77	5.22	0	50

Discussion

The amount of data collected for the different indices reflects the easiness and rapidity that we experienced in the field for each method. It is obvious that the attribution of BCS was the best method under this point of view, followed by BFI and finally by KFI. It has to be remarked that in Val Fontana the hunters have been trained for many years to take the deer to the control centre with as many organs as possible, in order to allow a complete sanitary inspection. In spite of this, even during the last years of this research, some kidneys were not delivered to the control centre. This is the main reason why KFI is missing for nearly half of deer, and this represents a clear obstacle to the evaluation of body conditions based on this index. As to BFI, it was very easy to be measured and its recording demanded little labour and equipment. Furthermore, the damage to the carcass was practically absent and therefore it was possible to collect this information for most of the animals without complaints from the hunters, except when they delivered the animal to the control centre very late in the evening and they did not want to wait for the inspection. Visual scoring (BCS) was possible for almost all the animals, as it was the easiest and quickest index to be recorded.

The ranges of variation of BFI and KFI were similar to those recorded for red deer in New Zealand (BFI: min 0 - max 42, KFI=min 5 - max 300; Riney, 1955). KFI showed a wider variation and kidney fat was never completely absent, while back fat reserves were sometimes completely worn out, especially in calves. This is in agreement with the order of fat mobilization (Riney, 1955), where back fat is the first fat reserve to be consumed, followed by the fat around the intestines, the stomach and the kidneys, and finally by bone marrow fat. Therefore, if a red deer population is in good condition, in autumn some back fat is still present, and a considerable variation in its depth can be found, but it will be completely consumed in winter or during inanition. Our deer population shows good health conditions, as confirmed by the regular sanitary monitoring carried out over many years in our study

Table 2. Descriptive statistics for KFI in relation to BCS within each age and sex class.

	No.	Mean	SE	Min	Max
			Calves		
Poor	6	33.24	15.26	8.0	108.6
Medium	12	39.41	4.08	21.3	68.2
Good	8	54.47	12.12	11.1	125.6
Overall	26	42.62	5.43	8.0	125.6
			Yearlings		
Poor	14	74.88	23.45	15.2	368.6
Medium	25	41.62	4.04	13.8	95.8
Good	11	52.28	8.80	18.8	102.1
Overall	50	53.278	7.24	13.8	368.6
			Adult hinds		
Poor	4	38.76	12.00	11.3	69.5
Medium	21	78.88	9.43	19.1	193.3
Good	19	63.71	7.31	7.1	140.0
Overall	44	68.68	5.80	7.1	193.3
			Subadult stags		
Poor	1	50.31	-	50.3	50.3
Medium	8	51.11	11.49	15.1	115.7
Good	8	42.95	9.50	13.2	92.2
Overall	17	47.22	6.84	13.2	115.7
			Adult stags		
Poor	0	-	-	-	-
Medium	1	56.11	-	56.1	56.1
Good	5	116.71	32.07	41.4	191.2
Overall	6	106.61	28.06	41.4	191.2

area (Andreoli *et al*., 2006), and it seems to be in balance with the environment. This statement is supported by the fact that KFI and BFI values are similar to those of other deer populations in balanced situations (Riney, 1955) and by the absence of significant inter-year variation in the recorded indices. This suggests that in Val Fontana we are not experiencing a high density situation close to the limits of carrying capacity, although this lack of year effect might also be attributed to the small changes in deer density during the study period.

Variations among age and sex classes were highly significant for BFI, but they could be detected also for KFI. This is in contrast with earlier beliefs that, being expressed as the percentage of the weight around the fat out of the kidney weight, KFI could be a valid method for measuring body conditions in animals of different ages and sex (Riney, 1955). In our situation, neither BFI nor KFI make it possible to perform a direct comparison among animals of different sizes (i.e. different age and sex classes).

No significant differences of BFI or KFI were observed depending on the assigned BCS. This means that the hunters were not able to describe the real condition of the animals based on subjective condition scores, as they are probably biased by the size of the animal. In fact, younger animals show a higher percentage of individuals scored as being in poor condition, while adult stags were always scored as in medium or good conditions, probably due to the apparent impressive body weight of the animals, and therefore their conditions were usually overestimated by BCS.

Both KFI and BFI were able to detect physiological variations in body conditions. This is shown by the significant decline in fat depots which was detected in males throughout the hunting season, which corresponds to the normal decline in body condition that occurs during the mating season in red deer stags (Bobek *et al*., 1990), as well as in other sexually dimorphic ungulate species (Forsyth *et al*., 2005), and which is usually followed by an attempt to rebuild some reserves after the rut (normally after October 15th in Val Fontana; Mattiello *et al*., 2007), to get ready for the winter. These

Figure 2. Relationship between back fat index (BFI) and number of days from the start of the hunting season (September 1st) in stags >2 years old (n=42).

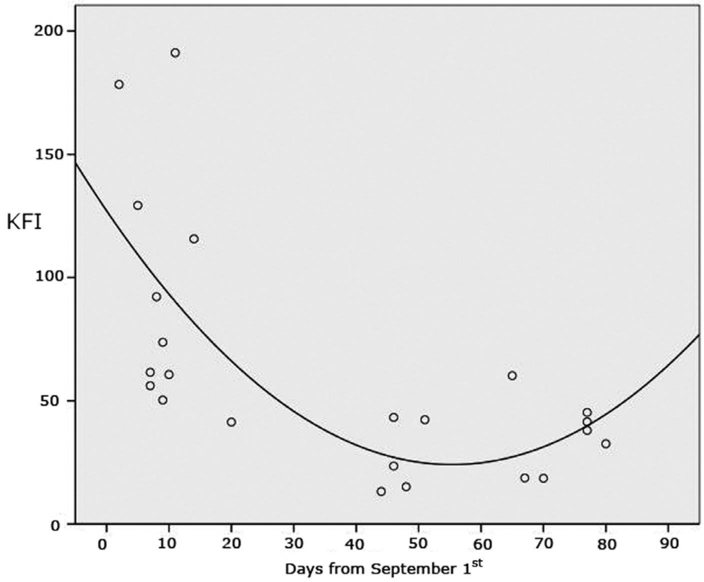


Figure 3. Relationship between kidney fat index (KFI) and number of days from the start of the hunting season (September 1st) in stags >2 years old (n=23).

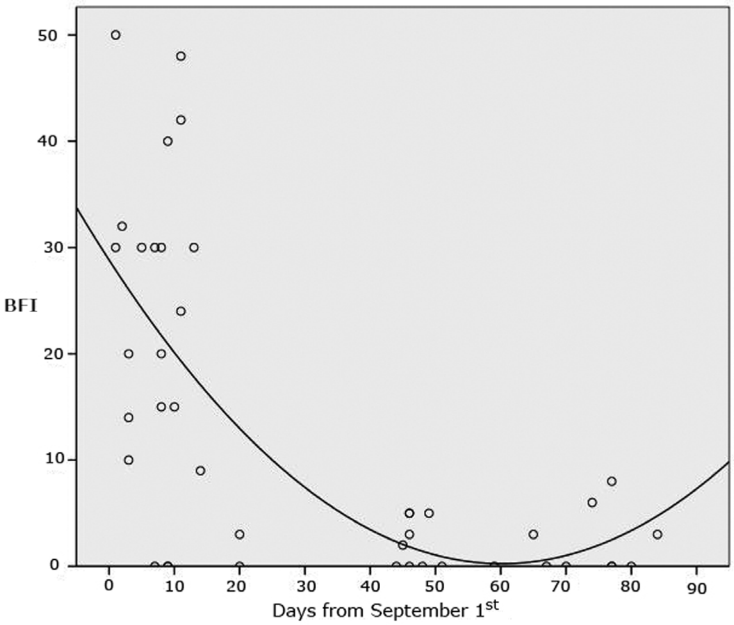
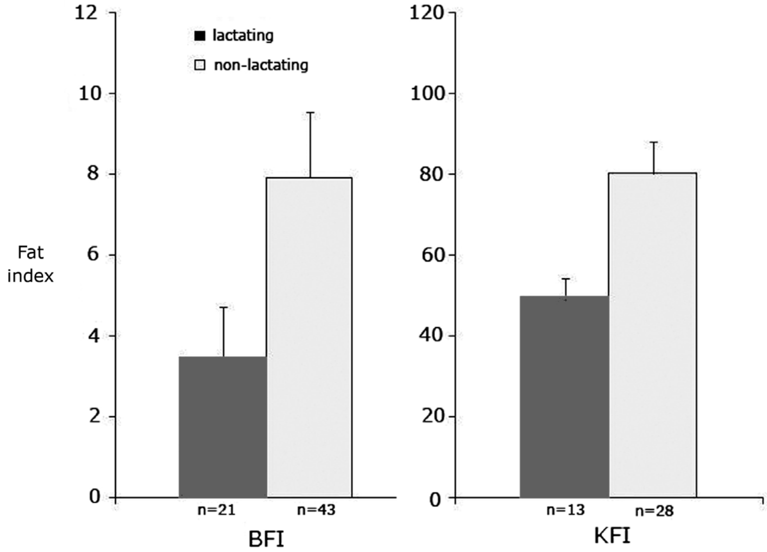


Figure 4. Least square means (±SE) of kidney fat index (KFI) and back fat index (BFI) in lactating and non-lactating hinds >2 years old.



changes were not significant in females, whose conditions did not vary during the whole hunting season. Significant differences in fat depots were recorded in hinds depending on lactation status. This is in agreement with the results of other authors (Cook *et al*., 2004a), who found that lactating Yellowstone elk cows (*Cervus elaphus nelsoni*) were in significantly poorer conditions than non-lactating cows, and this can easily be explained by the energetic effort required for milk production.

Conclusions

Our results suggest that subjective nutritional indices attributed by the hunters (BCS) seem to be biased by the size of the animal (Figure 1), and cannot be used to evaluate red deer body condition. KFI was confirmed to be a valid indicator of body condition, as it showed a wide range of variation (and it is therefore able to detect small changes in conditions), and it was sensitive to physiological changes both in males and in females. However, it was not completely independent from individual characteristics such as age and sex; moreover, its measurement was not always possible in our field situation, mainly because many hunters did not deliver the kidneys to the control centre, or they delivered them without fat. Although it showed a narrower range of variation and it was affected by age and sex class, BFI could still be reckoned in most yearling and adult deer. Its main advantage compared to KFI was the possibility to measure it for more animals, as it did not require any specific commitment from the hunters, and the effort that we experienced for its recording was more limited than for KFI, especially in terms of time. Furthermore, BFI was correlated with KFI and was sensitive to changes in physical conditions.

It has to be emphasised that our data represent the first report on the use of BFI in an alpine environment.

One of the characteristics required for the methods used in condition evaluation is the possibility of being used at all times of the year (Riney, 1955). However, in our study area, autumn is the only period when the collection of data on a sufficiently representative number of animals is possible, as this corresponds to the hunting season. During the rest of the year it would be impossible to record enough data for monitoring conditions of our red deer population. As a conclusion, it is suggested that, for general management purposes, BFI measured between 5 and 10 cm from tail insertion in yearlings, adult hinds and pre-rutting stags can be a valuable and easy-to-collect indicator for monitoring the condition of red deer in Alpine populations during the autumn, provided that the effects of sex, age and date of culling are taken into account. However, for a more reliable evaluation, the use of more than one index is desirable. KFI could represent a useful additional index to be used simultaneously with BFI, and hunters should be encouraged to deliver kidneys to control centres.

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