Comparison of body condition indices in the red fox (Fissipedia, Canidae)

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Summary. – Six indices of body and physiological condition were determined for 330 red foxes *(Vulpes vulpes)* collected in Central Italy from January to May 1992 : (1) subcutaneous fat ; (2) perivisceral fat ; (3) perirenal fat ; (4) residual of the regression of body mass on body length ; (5) spleen mass ; (6) adrenal mass. During this season, females had more fat than males, whereas yearlings (9-13 months old) had the same fat as the adults. All the nutritional indices (1 through 4) were highly related, suggesting that they could be used at least for relative comparisons. Correcting for gut content mass marginally strengthened the relationship, and reproductive status of females had no effect on it. The two stress indices (5 and 6) were little significance, at least during late winter and spring. The index based on body mass residuals may allow an approximate estimation of fat level of live foxes. It is also applicable retrospectively to museum collections and historical data, where body mass and body length were known, but no measure of fatness was taken.

Résumé. – Six indices corporels et physiologiques ont été déterminés chez 330 renards *(Vulpes vulpes)* collectés dans le centre de l'Italie de janvier à mars 1992 : (1) la quantité de graisse sous-cutanée, (2) la quantité de graisse périviscérale, (3) la quantité de graisse périrénale, (4) le résidu de la régression de la masse corporelle sur la longueur corporelle, (5) la masse de la rate, (6) la masse des glandes surrénales. Pendant cette saison, les femelles avaient plus de graisse que les mâles, alors que les jeunes (d'un âge compris entre 9 et 13 mois) en avaient la même quantité que les adultes. Tous les indices nutritionnels (indices 1 à 4) étaient très corrélés, suggérant qu'ils pouvaient être utilisés au moins pour des comparaisons relatives. La correction consistant à prendre en compte le contenu du tube digestif ne renforçait que faiblement la relation, et le statut reproducteur des femelles n'avait aucun effet sur elle. Les deux derniers indices (de stress) avaient peu de signification, au moins à la période considérée. L'indice basé sur les résidus de la masse corporelle semble pouvoir permettre une estimation du niveau de graisse chez les renards vivants. Il est aussi applicable, rétrospectivement, aux collections de Muséum et aux données historiques, quand les données de masse et de longueur ont été prises, mais pas celles concernant la quantité de graisse.

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INTRODUCTION

A large amount of work has been conducted on the evaluation of physical condition in ungulates (e.g. see Huot 1988 for a review), whereas few carnivores have been evaluated in this respect. Body condition in wild Carnivora is often related to reproductive success, diet, and survival (e.g. Boertje and Stephenson 1992, Matlack and Evans 1992). Its evaluation is therefore crucial both for research and for management (Kirkpatrick 1980). The most accurate method to evaluate the energetic reserves of an animal is to measure total body fat content (e.g. Batzli and Esseks 1992, Holand 1992). Also protein catabolism, however, may enhance survival during food scarcity (e.g. Poulle *et al.* 1995). Chemical analyses of fat and protein contents, however, are time consuming for large samples, especially for medium to large animals, and require laboratory equipment not easily available in routine population surveys. For this reason, total fat content of the body has been measured for only a few species of terrestrial Carnivora : the American marten *Martes americana* (Buskirk and Harlow 1989), the arctic fox *Alopex lagopus* (Prestrud and Nilsen 1992) and the coyote *Canis latrans* (Huot *et al.* 1995). Several indices have therefore been developed, including : total dissectible fat (Pond *et al.* 1992), kidney fat (Boertje and Stephenson 1992, LaJeunesse and Peterson 1993), bone marrow fat (Boertje and Stephenson 1992, LaJeunesse and Peterson 1993), omental mass (Buskirk and Harlow 1989), mass of selected fat deposits (Matlack and Evans 1992, Kauhala 1993), fat thickness (Boertje and Stephenson 1992, Prestrud and Nilssen 1992), skinfold thickness (Windberg *et al.* 1991), subjective estimates of perivisceral and/or subcutaneous fat (Windberg *et al.* 1991, Prestrud and Nilssen 1992), length to mass ratios (Kruuk *et al.* 1987, Woodroffe 1995), subjective evaluation of bone protrusions (Thomson 1992), and others (Huot *et al.* 1995). Physiological and biochemical measurements have also been attempted (e.g. Caro *et al.* 1987, Mech *et al.* 1987, Cattet 1990, Farley and Robbins 1994), as well as bioelectrical-impedence (Raphael *et al.* 1991).

Rump fat thickness was highly correlated with total body fat in the Arctic fox (*Alopex lagopus :* Prestrud and Nilssen 1992), and the ratio of omental mass to skinned-carcass mass was a reliable predictor of body fat in the American marten (*Martes americana :* Buskirk and Harlow 1989). Marrow fat, however, was insensitive to small changes in condition, and was mobilised only during severe nutritional distress (LaJeunesse and Peterson 1993). Similar results have been reported for ungulates (e.g. Torbit *et al.* 1988, Holand 1992). In ungulates, the kidney fat index may not be suitable for the analysis of seasonal trends, because the kidney mass to lean body mass changes seasonally (Anderson *et al.* 1990). The energetic contribution of protein reserves has generally been overlooked (Virgl and Messier 1993).

In the red fox *(Vulpes vulpes)*, several indices have been applied, including : subjective evaluation of fat (Lund 1959, Allen and Gulke 1981), thickness of subcutaneous fat and ratio of mass of intestinal mesenteria to body length (Lindström 1983), a combination of perivisceral and subcutaneous fat (estimated visually ; Kolb and Hewson 1980), and adrenal and spleen indices (ratio of adrenal and spleen mass on total length ; Nelson and Chapman 1982). A comparison among indices has not been attempted in this species, and the error due to the subjective evaluation has never been quantified by comparing the subjective indices with a less subjective measure, such as kidney fat.

The main limitations of the existing indices are : (1) they cannot be used for live Carnivora (with the exceptions of : the rump palpation method for cheetahs *Acinonyx jubatus* [Caro *et al.* 1987] ; the morphological measurements [Cattet 1990], body mass [Samson and Huot 1995] and the isotopic water dilution and bioelectrical impedance analysis [Farley and Robbins 1994] for ursids) ; (2) they cannot be used for historical material (such as museum collections) or for previously collected standard data ; (3) the ratio approach often employed is statistically unsound, and may lead to erroneous results (e.g. Kirkpatrick 1980, Cattet 1990). The regression residual technique is more appropriate in this context (e.g. Virgl and Messier 1993).

The objectives of this study were : (1) to test for coherence among a set of different indices of body condition in a sample of red foxes, and (2) to develop an index suitable for live and dead animals, historical material and standard data.

METHODS

Foxes were killed from January to May 1992 in the Province of Pisa (43°N, 10-11°E), Central Italy, during predator control operations. The area (52 km E-W by 75 km N-S ; 2 448 km^2) is mostly flat and intensively cultivated (mainly cereals) in the north, becoming increasingly hilly (up to 800 m a.s.l.) and wooded towards the south. Climate is Mediterranean, with mild winters and dry, hot summers. Foxes were collected from hunters within 6 hours of death and were kept refrigerated in plastic bags (≤ 48 hours, - 2 °C) until they could be weighed, measured, and dissected. All masses were determined to the nearest mg, except for total body mass (hereafter BM ; nearest 50 g) ; head and body length (hereafter HBL) and chest girth (hereafter CG) were measured to the nearest 5 mm (see Cavallini 1995, for details on the measurements). The following indices were estimated or calculated :

1. subcutaneous fat index (on a 5-point scale : 0 = fat absent, 1 = fat barely detectable, ≤ 0.5 mm thick, 2 = little fat on the sternum, ≤ 2 mm thick, 3 = thick fat on the sternum, 4 = almost continuous layer of fat over abdomen and thorax). This index was not evaluated for skinned foxes ;

2. perivisceral fat index (on the same scale : 0 = fat absent, 1 = fat barely detectable, ≤ 0.5 mm thick, 2 = little fat around peritoneum, ≤ 2 mm thick, 3 = thick fat on the omentum, mesenteria, and around kidneys, 4 = kidneys completely covered by fat, lumps of fat around viscera and on the inguinal region). Thickness were measured with a calliper after dissection. To reduce inter-observer variability, both indices were independently evaluated by 3 observers, and results compared. In cases of a discrepancy, the fox was reevaluated ;

3. perirenal fat index (mass of the kidney with surrounding fat, including the *tunica fibrosa*, divided by the mass of kidney trimmed of all fat ; hereafter KFI ; see Kirkpatrick 1980). I calculated the logarithm of the mean KFI for both kidneys, since logarithmic transformation can improve the correlation between KFI and total fat content of the body (Torbit *et al.* 1988). When one of the two kidneys and surrounding fat were damaged, the relative KFI was estimated by regression analysis ; as left KFI was higher than right KFI (mean difference = 0.023 ; t = 2.040, P = 0.043, N = 202), separate regression lines were computed for the estimation of missing left and right

KFI (right KFI = 0.979 left KFI ; $r^2 = 0.995$, $P < 0.0001$; left KFI = 1.010 right KFI ; $r^2 = 0.995$, $P < 0.0001$) ;

4. residuals for the regression of body mass on head and body length (hereafter "BM residuals" ; see below for coefficients of the regression). This value reflects not only total body fat content, but also protein mass, which can provide additional energy during nutritional stress (Buskirk and Harlow 1989). Ash contents (i.e., skeleton) are minor component of the body mass, and may be assumed constant (Huot *et al.* 1995), whereas water content is negatively correlated with fat (Huot *et al.* 1995). It is an index of the general physical structure of an animal : "stocky", fat or muscular foxes will have positive BM residuals, thin or lean foxes will have negative residuals. The weight of gut contents may have an influence on this index. Therefore, a more refined version of the same index has been computed subtracting the mass of gut contents from total body mass (hereafter "CBM residuals") ;

5. spleen mass and residuals for the regression of spleen mass on HBL ;

6. average mass of the two adrenals and residuals for the regression of adrenal mass on HBL.

Regression lines (indices 4, 5, and 6) were calculated separately for the two sexes when the relationship between the variable of interest (body, spleen, or adrenal mass) and HBL was different ($P < 0.05$) between sexes (homogeneity of slopes, as tested by analysis of covariance).

Age was estimated by counting the cementum annuli in the teeth, measuring the pulpar cavity of the same teeth, and weighing eye lenses (Cavallini and Santini 1995a). Owing to the small number of older foxes, they were grouped in two age classes : yearlings (≤ 13 months old at the time of sampling) and adults (≥ 21 months old). In the period studied (late winter and early spring), yearlings were of the same size of adults in my study area (see Cavallini 1995). Guts were removed, opened, and their content was weighed (± 5 g) to calculate a "clean" body mass (i.e. body mass minus gut contents). The number of days since conception was determined for females (non-pregnant females = 0 days) by backdating embryos, examining ovaric bodies and uteri (see Cavallini and Santini 1995b for details).

Parametric statistics (univariate and multivariate general linear hypothesis ; Wilkinson 1990) were used for normally distributed variables (as determined by Lilliefors test ; Lilliefors 1967), non-parametric for non-normal and ordinal variables. Regression residuals were inspected for linearity, normality of distribution, and homoschedasticity (following Wilkinson 1990).

RESULTS

Three hundred-thirty foxes (125 females and 205 males) were collected, but due to physical damage during hunting, sample size was reduced for several variables, as indicated in each test. Most of foxes were in average condition (fat levels 2 and 3 : males between 62 and 70 % ; females 80 % ; Figs. 1 and 2). Fat deposition followed the same pattern described for the Arctic fox (Prestrud and Nilssen 1992). Initial disagreement among observers in the estimation of fat levels was rare (3.6 %).

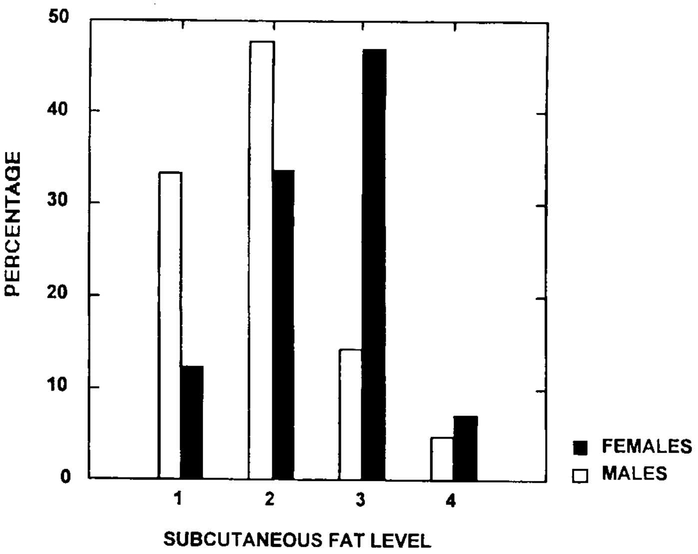

Fig. 1. – Subcutaneous fat levels of 281 red foxes (separated by sex) from Central Italy, January to May 1992.

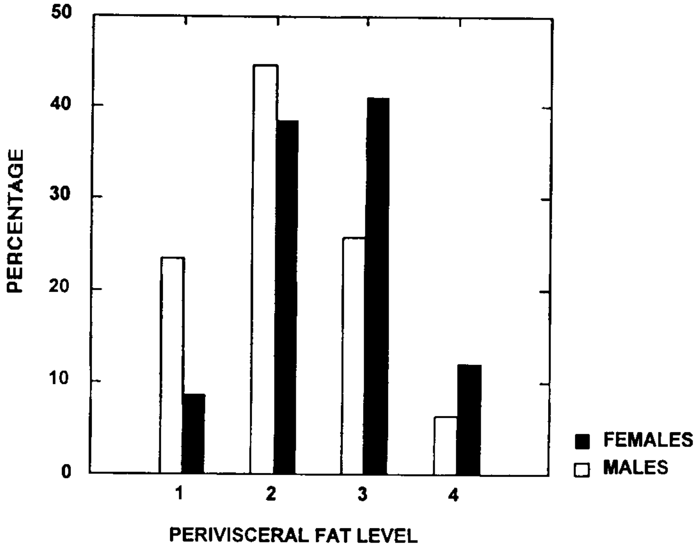

Fig. 2. – Perivisceral fat levels of 292 red foxes (separated by sex) from Central Italy, January to May 1992.

Correspondance between subcutaneous, perivisceral and perirenal fat indices

Subcutaneous and perivisceral fat levels were highly related (66.3 % of concordance between the two indices ; $\chi^2 = 276.395$, df = 9, $P < 0.0001$, N = 267 ; Tab. 1).

TABLE 1. – Correspondence (frequency of individuals) between perivisceral and subcutaneous fat levels in 267 red foxes from Central Italy, January to May 1992.

Subcutaneous fat index	Perivisceral fat index 1	2	3	4	Total
1	46	20	0	0	66
2	4	73	31	2	110
3	0	16	47	12	75
4	0	0	5	11	16
Total	50	109	83	25	267

Both subjective indices (subcutaneous and perivisceral) corresponded well with the quantitative perirenal one (lnKFI ; ANOVA, subcutaneous : F = 41.872, $P < 0.0001$, N = 265 ; perivisceral : F = 37.517, $P < 0.0001$, N = 271 ; Fig. 3). Perirenal fat was significantly higher in foxes with higher subcutaneous and perivisceral fat index (Tukey test, $P < 0.003$) except : (1) between level 0 and 1, both for subcutaneous and for perivisceral fat (only one fox had 0 fat ; Tukey test, $P > 0.35$). Levels 1 and 0 were therefore pooled for subsequent analyses ; (2) between level 3 and 4 (only subcutaneous fat). The difference only approached significance (Tukey test, P = 0.056). This can indicate a less reliable estimation of fat or, more likely, a higher mobility of superficial than deep fat. Subcutaneous fat may therefore be a more sensitive index to small variations of nutritional status (Boertje and Stephenson 1992). The subcutaneous fat index could be correctly predicted on the basis of lnKFI in 42.6 % of cases, whereas the perivisceral fat index correctly classified in only 39.0 % of cases (discriminant function ; Tab. 2).

TABLE 2. – Univariate discriminant functions that allow to predict subcutaneous or perivisceral fat index of an individual on the basis of the ln of the kidney fat index (lnKFI) or the residuals for the regression of body mass on head and body length (BMres).

Fat level	Subcutaneous	Perivisceral	Subcutaneous	Perivisceral
1	15.94 lnKFI –3.70	15.41 lnKFI –3.37	–0.490 BMres –1.440	–0.688 BMres –1.495
2	20.02 lnKFI –5.04	20.91 lnKFI –5.05	–0.027 BMres –1.386	–0.108 BMres –1.389
3	28.24 lnKFI –8.66	29.90 lnKFI –7.94	0.292 BMres –1.405	0.369 BMres –1.418
4	33.94 lnKFI –11.89	36.40 lnKFI –12.48	0.986 BMres –1.604	0.850 BMres –1.552

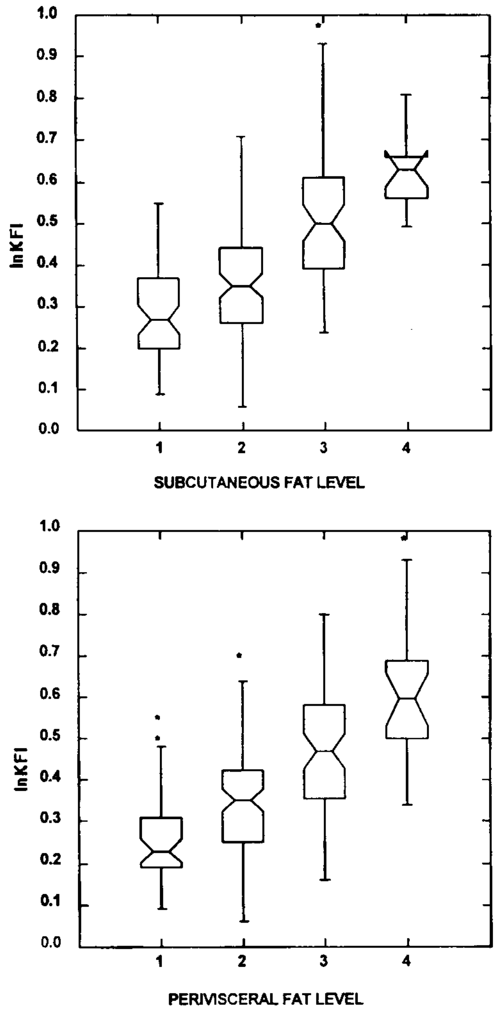

Fig. 3. – Relationship between visually estimated fat levels (subcutaneous and perivisceral) and the natural logarithm of perirenal fat index for 281 and 292, respectively, red foxes collected in Pisa province, Central Italy, January to May 1992. The box-and-whiskers plots show the median (with notches indicating confidence intervals), upper and lower quartiles (limits of the box), range excluding outliers (whiskers) and outliers (indicated by asterisks ; Wilkinson 1990).

Body mass residuals

The relationship between HBL and BM was different between males and females (ANCOVA for slopes, F = 18.761, P <0.001, N = 271) ; the analogous model corrected for gut contents was very similar (Tab. 3). The fit of the regression was not higher when using logarithms (log of BM on log HBL ; $r^2 = 0.355$ for males, $r^2 = 0.265$ for females) or the cube of length (BM on HBL^3 ; $r^2 = 0.344$ for males, $r^2 = 0.250$ for females). The linear model explained therefore more variance than the curvilinear ones (Fig. 4). Head and body length was not related to either perirenal, subcutaneous or perivisceral fat (Tab. 4). The multiple regression of HBL and CG on BM explained more variance than simple regressions (Tab. 4). The residuals of these regressions, however, were unrelated to lnKFI (Tab. 4), and were therefore not a suitable index of condition.

TABLE 3. – The relationship between head and body length (HBL) and body mass (either whole mass, BM or body mass corrected for gut contents, CBM) in males and females. Coefficients are given ± standard error. SEE = standard error of the estimate (i.e. the error made in predicting body mass from the equation).

Sex	Equation	r^2	SEE (kg)	p	N
males	BM = 0.148 ± 0.014 HBL –3.969 ± 0.942	0.360	0.769	< 0.0001	192
females	BM = 0.096 ± 0.015 HBL –1.067 ± 0.936	0.265	0.575	< 0.0001	115
males	CBM = 0.145 ± 0.014 HBL –3.892 ± 0.934	0.362	0.758	< 0.0001	185
females	CBM = 0.089 ± 0.015 HBL –0.743 ± 0.954	0.237	0.571	< 0.0001	110

TABLE 4. – Relation (r^2 : regression ; F : ANOVA) between various fat indices and body measurements. HBL = head and body length ; lnKFI = logarithm of the kidney fat index ; CG = chest girth ; BM residuals = residuals for the regression of body mass on head and body length ; CBM residuals = same, with body mass minus gut content ; HBL + CG residuals = residuals for the multiple regression of body mass on head and body length and chest girth ; conception = N days since conception.

Variable 1	Variable 2	Sex	Statistics	p	N
HBL	lnKFI	males	$r^2 = 0.005$	0.37	155
HBL	lnKFI	females	$r^2 = 0.001$	0.70	99
HBL	subcutaneous fat index	pooled	F =1.01	0.39	263
HBL	perivisceral fat index	pooled	F = 1.22	0.30	273
BM	HBL + CG	males	$r^2 = 0.506$	< 0.001	163
BM	HBL + CG	females	$r^2 = 0.395$	< 0.001	97
lnKFI	HBL + CG residuals	males	$r^2 = 0.012$	0.22	128
lnKFI	HBL + CG residuals	females	$r^2 = 0.021$	0.19	97
lnKFI	BM residuals	males	$r^2 = 0.048$	0.007	155
lnKFI	BM residuals	females	$r^2 = 0.063$	0.012	99
lnKFI	CBM residuals	males	$r^2 = 0.050$	0.006	150
lnKFI	CBM residuals	females	$r^2 = 0.094$	0.002	97
lnKFI	BM residuals + conception	females	$r^2 = 0.079$	0.70	92

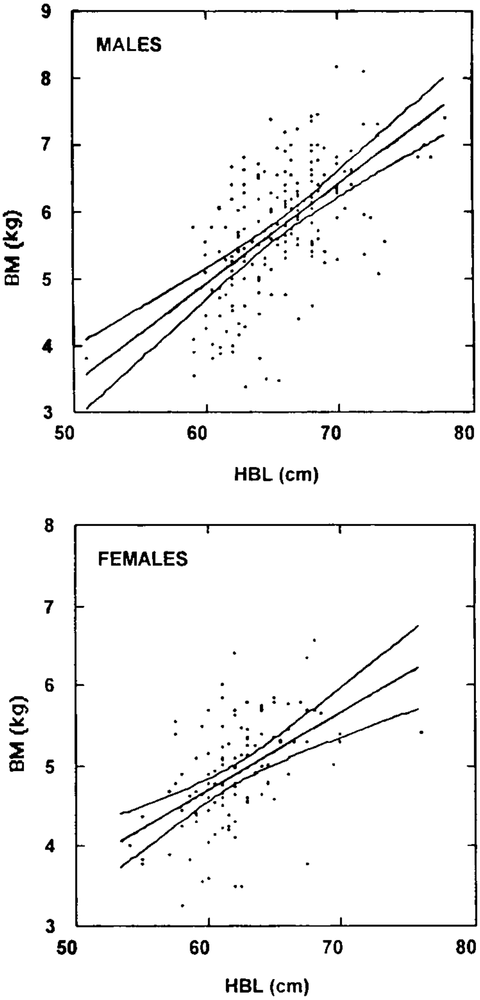

Fig. 4. – Relationship between head and body length (HBL) and body mass (BM) for 192 male and 115 female red foxes collected in Pisa province, Central Italy, January to May 1992. The regression lines with 95 % confidence intervals are shown.

Correspondence between body mass residuals and fat indices

Perirenal fat was significantly related to BM residuals, both for males and for females (Tab. 4). Coefficients (with SEE : Standard Error of the Estimate) for estimating perirenal fat index from BM residuals were : y = 0.039 ± 0.014 x + 0.346 for males and y = 0.072 ± 0.028 x + 0.464 for females. Stomach content mass is small compared to total body mass (average = 72.7 g ± 70.5 SD ; range = 0.467 g, i.e. 1-2 % of BM). Not surprisingly, using CBM residuals instead of the simple BM residuals marginally improved the fit (Tab. 4). The reproductive status of females did not influence this relationship (multiple regression of BM residuals and number of days since conception on lnKFI ; Tab. 4).

BM residuals corresponded with both subcutaneous (F = 5.312, P = 0.001, N = 262) and perivisceral fat levels (F = 6.740, P = 0.0002, N = 271) without any relation with sex or of interaction between fat and sex (F < 0.736, P > 0.392). An univariate discriminant function predicting the subcutaneous fat index from BM residuals correctly classified 30.5 % of cases ; a similar analysis based on the perivisceral fat index was less effective, classifying correctly 24.4 % of cases (Tab. 2) ; using corrected (CBM) residuals marginally improved these results (subcutaneous : F = 7.046, P = 0.0001, N = 255 ; 32.9 % of correct classifications ; perivisceral ; F = 9.083, P = 0.00001, N = 267 ; 25.0 % of correct classifications).

Spleen and adrenal indices

The relationship between HBL and spleen mass was highly significant (Tab. 5) and similar for the two sexes (ANCOVA for slopes, F = 1.554, P = 0.21, N = 194), Whereas the relationship between HBL and adrenal mass differed between sexes (ANCOVA for slopes, F = 8.147, P = 0.005, N = 249). Therefore, sexes were pooled for analyses of the spleen index, whereas they were analysed separately for the adrenal index. Adrenal mass was not correlated with the mass of the spleen, either in males or in females (Tab. 5). The spleen index was correlated with the BM residual index, but not with the lnKFI ; it was also unrelated to fat levels (Tab. 5).

Adrenal mass was related to HBL for females but not for males (Tab. 5). Absolute adrenal mass was therefore used for further analyses instead of residuals of adrenals on body length. The adrenal mass was unrelated to either lnKFI or to BM residuals ; it was also unrelated to fat levels (Tab. 5).

Sex- and age-related differences

On average females were fatter than males, according to lnKFI (males : 0.345 ± 0.144 SD ; females : 0.464 ± 0.159 SD), subcutaneous fat (Fig. 1), and perivisceral fat (Fig. 2 ; Tab. 6). Yearlings had the same fat as adults, according to lnKFI (mean for yearlings : 0.403 ± 0.164 SD ; for adults : 0.379 ± 0.153 SD), subcutaneous fat, and perivisceral fat (Tab. 6). Neither BM nor CBM residuals were different between the two age classes (Tab. 6).

DISCUSSION

Owing to the closed hunting season, foxes were collected during 5 months only. However, this period encompassed a variety of phases in the biological cycle of the red fox : the non-reproductive, mating and breeding seasons. Furthermore, the large sample ensured that a wide range of individual condition was represented. The main limitation of this study is the lack of an absolute measure of total body fat by which indices can be calibrated. The concordance among nutritional indices (subcutaneous, perivisceral, and perirenal fat ; BM residuals) was however high. The two stress indices (spleen and adrenal) were not related either to each other or to the nutritional indices, at least during the season considered. In a Mediterranean area, with mild climate, stress may be more related to social factors than directly to nutritional condition (see also Cavallini and Santini 1996) ; in colder areas, where fox populations are food-limited (Lindström

TABLE 5. – Relation (r^2: regression; F: ANOVA) between various fat indices and body measurements. Abbreviations as in Table 4.

Variable 1	Variable 2	Sex	Statistics	p	N
spleen mass	HBL	pooled	$r^2 = 0.094$	< 0.0001	194
adrenal mass	spleen mass	males	$r^2 = 0.160$	0.080	121
adrenal mass	spleen mass	females	$r^2 = 0.067$	0.57	175
spleen index	BM residual	pooled	$r^2 = 0.167$	0.020	193
spleen index	lnKFI	pooled	$r^2 = -0.030$	0.68	188
spleen index	subcutaneous fat index	pooled	F = 1.362	0.25	164
spleen index	perivisceral fat index	pooled	F = 0.119	0.95	178
adrenal mass	HBL	males	$r^2 = 0.052$	0.52	154
adrenal mass	HBL	females	$r^2 = 0.090$	0.003	95
lnKFI	adrenal mass	males	$r^2 = -0.087$	0.27	158
lnKFI	adrenal mass	females	$r^2 = -0.176$	0.09	93
BM residuals	adrenal mass	males	$r^2 = -0.022$	0.78	153
BM residuals	adrenal mass	females	$r^2 = 0.050$	0.62	95
adrenal mass	subcutaneous fat index	males	F = 1.586	0.19	137
adrenal mass	subcutaneous fat index	females	F = 0.813	0.49	90
adrenal mass	perivisceral fat index	males	F = 0.817	0.49	147
adrenal mass	perivisceral fat index	females	F = 1.616	0.19	90

TABLE 6. – Sex- and age-related (yearlings vs. adults) differences in body condition indices. Abbreviations as in Table 4.

Variable	Statistics	p	N
Sex differences			
lnKFI	t = 6.352	< 0.0001	271
subcutaneous fat	U = 5781	< 0.0001	281
perivisceral fat	U = 7525.5	< 0.0001	292
Age differences			
lnKFI	t = 1.242	0.22	265
subcutaneous fat	U = 8510	0.23	272
perivisceral fat	U = 10360	0.51	282
BM residuals	t = 0.879	0.38	296
CBM residuals	t = 1.083	0.28	285

1989), the two types of indices examined (nutrition and stress) might therefore prove more correlated. Nutritional and stress indices, however, were not related in Maryland, USA, an area cooler than that of the present study (Nelson and Chapman 1982), which suggests that this hypothesis may be unlikely. Definite conclusions, however, may be reached only by extending sampling over the whole year, and by comparing indices with a more reliable measure of stress (yet to be developed for the red fox). My estimate of the average perivisceral fat index (2.33) is close to that (2.30) calculated for North Dakota foxes, when applying the same scale (Allen and Gulke 1981). It appears therefore that even subjective estimates of fat levels may give consistent results, at least when observers have access to large samples of foxes.

The index based on the BM residuals is correlated with other estimates of fatness, i.e. the natural within-population in physique is small relative to the variation in fatness, and it may therefore be used to evaluate condition of live animals (e.g. those trapped and released for radio-tracking studies), museum collections and previously collected data. As reported for Ursidae (Cattet 1990), the BM residual value is more reliable than the "mass/length" ratio as an index of nutritional condition, allowing separate estimations for the two sexes. However, its predictive value is limited, and not significantly improved by including additional variables (age ; chest girth ; reproductive status ; mass of stomach contents) in the model (as it happens for Ursidae : Cattet 1990). Furthermore, the inclusion of additional variables would limit the generality of the index, because some of these measurements may not be available for historical material and data, and some may be difficult to measure or estimate in live foxes. Estimates of regression coefficients for a small sample ($N = 51$) of foxes from Scotland were partly different (user defined contrasts ; Wilkinson 1990) from those found in the present study (slope = 0.133 vs. 0.148 ; $P = 0.29$ and intercept = + 5.67 vs. -3.97 for males ; $P < 0.001$; slope = 0.139 vs. 0.096 ; $P = 0.005$ and intercept = -2.60 vs. -1.07 ; $P = 0.10$ for females ; rescaled as kg/cm ; Kolb 1978). This procedure overestimates significance, since it assumes that the coefficient to be compared (in this case, that of Kolb 1978) is without error (Wilkinson 1990). The regression equations for males and females computed in this study may therefore be used (at least as a first approximation) for other European fox populations.

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