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Mandible versus Long Bone Marrow Fat in Red Deer

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Okarma H., 1989: Mandible versus long bone marrow fat in red deer. Acta theriol., 34, 39: 537—544 [With 1 Table & 2 Figs]

Mandible and long bone marrow fat content of red deer *Cervus elaphus* Linnaeus, 1758 hinds (N=21) and calves (N=17) killed in the Carpathian Mountains from 1984 to 1988 were examined. In general mandible fat content was lower than long bone fat. However, when femur fat was <40%, femur and tibia fat levels were lower and only metatarsus fat exceeded the mandible fat level. Fat content in the mandible marrow was positively correlated with that in long bones. The highest correlation was found between mandible and tibia, then mandible and femur, and mandible and metatarsus. These correlations were considerably stronger in hinds than in calves. Mandible fat content is recommended for determination of red deer condition.

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1. INTRODUCTION

Long bone marrow fat has been widely used as an indicator of ungulates nutritional status (Ratcliffe, 1980; Fong, 1981; Carbyn, 1983; Peterson *et al.*, 1984; Cederlund *et al.*, 1986; Fuller *et al.*, 1986). However extracting particular bones from carcasses can be laborious and frequently impossible. Extracting the femur, which is most sensitive to fat mobilisation (Okarma, 1984), decreased the commercial value of the carcass according to Polish regulations.

Snider (1980) and Ballard *et al.*, (1981) found that marrow fat in the femur and metatarsus was positively correlated with mandible marrow fat in moose *Alces alces* Linnaeus, 1758 and reindeer *Rangifer tarandus* Linnaeus, 1758 from two North American populations. Cederlund *et al.*, (1986) confirmed that mandibles of Swedish moose can be used for determining fat levels of femur and metatarsus marrow. The relative simplicity of the mandible marrow fat technique and the possibility of collecting mandibles from a large number of animals during the hunting season suggest that this method could be a useful tool for determining fat content of long bone marrow.

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The aim of this study was to determine the relationship between marrow fat content in mandibles and long bones of red deer *Cervus elaphus* Linnaeus, 1758.

2. MATERIAL AND METHODS

The study was conducted in the Carpathian Mountains (southeastern Poland) within the forest administration districts of Komańcza, Cisna and Baligród. The study area has been described in detail by Okarma (1984).

During the winters of 1980 to 1984, 38 paired mandible and long bones were collected from red deer killed by wolves *Canis lupus* Linnaeus, 1758. The sample comprised 17 calves and 21 hinds.

The red deer were aged on the basis of tooth wear in the lower jaw (Dzięgielewski, 1970). Specimens up to 12 months were classified as fawns, and older ones as adults.

The bones of one hind leg were removed from the carcass. Marrow samples of 20-30 g were taken from the middle part of the femur, tibia and metatarsus (Mt_3+Mt_4). Mandible marrow was extracted by splitting the right or left mandible and then the entire section of marrow was taken.

The weighed marrow samples were placed in Petri dishes and oven-dried at 70°C to constant weight. The percentage of fat in a sample was calculated as dry weight/fresh weight ×100 (Neiland, 1970).

Two-way ANOVA and Scheffe's test were used to determine differences in marrow fat content between femur, tibia, metatarsus and the mandible (Sokal, 1981). Relationships between mandible and legbone fat contents were calculated using a "reducted major axis equation" (II model of reduced regression) (Weiner, 1985).

3. RESULTS

The marrow fat content showed a wide variation in all long bones: femur (6.3–93.5%), tibia (6.2–95.8%), metatarsus (10.2—95.0%) and mandible (11.8—80.3%).

The lowest fat content was found in the femur, intermediate in the tibia and the greatest in the metatarsus (Table 1). Fat levels in mandi-

Table 1
Femur, tibia, metatarsus and mandible marrow fat (%) in red deer calves and hinds killed in Komańcza, Cisna and Baligród forest administration districts during winters 1984—88.

Femur marrow fat	N	Femur		Tibia		Metatarsus		Mandible	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Above 40%									
Calves	7	77.3	14.3	76.3	13.3	80.2	14.5	55.3	11.5
Hinds	17	82.8	13.2	83.1	13.5	87.2	10.2	65.2	11.8
Below 40%									
Calves	10	14.5	9.2	16.0	10.7	35.4	23.6	25.8	12.7
Hinds	4	14.9	6.4	17.7	8.0	33.5	14.8	22.8	6.5
Pooled									
Calves	17	40.3	33.7	40.8	32.6	53.8	30.1	37.9	19.1
Hinds	21	69.9	29.8	70.6	29.1	76.9	24.1	57.1	20.2

bles were on average lower than that of long bones both in calves and in adult red deer (Table 1). However, both calves and adults had consistently less fat in the femur and tibia than in the mandible when femur fat levels were low (<40%, N=13). Simultaneously as many as 10 of those animals showing heavy femur fat depletion had more fat in the metatarsus than in the mandible (Table 1).

Among calves the marrow fat content in the mandible was significantly different only than that in metatarsus ($p<0.01$). In adults these differences were significant for all long bones: femur ($p<0.01$), tibia $p<0.01$) and metatarsus ($p<0.01$).

The percentage of fat in the mandible correlated significantly with

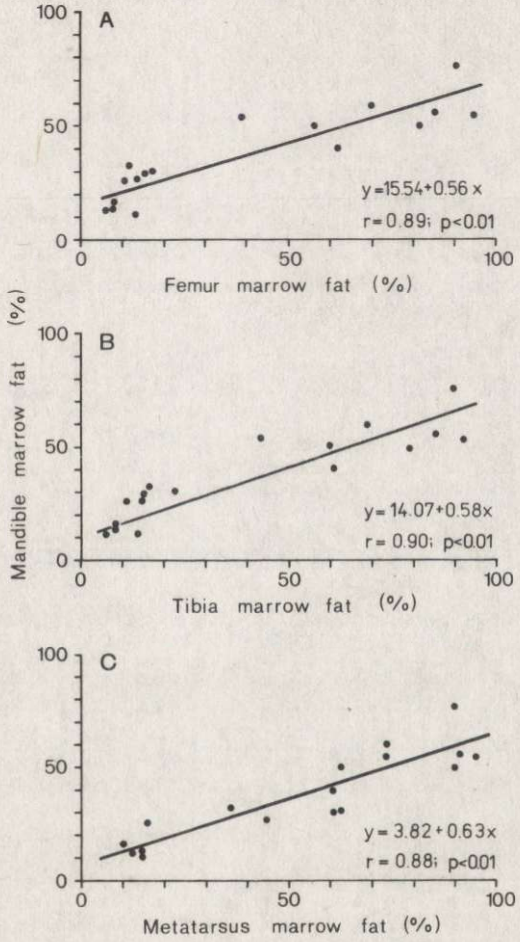

Fig. 1. The relationship between marrow fat (%) in mandible and femur (A), mandible and tibia (B), and mandible and metatarsus (C) of red deer calves killed in the Carpathian Mountains from 1984—88.

long bone fat content, and correlations were stronger in adult red deer than in calves (Fig. 1, 2). The highest correlation coefficient (r) was found in both age classes between mandible and tibia fat content (0.90 in calves and 0.93 in adults), then femur (0.89 and 0.92, respectively) and metatarsus (0.88 and 0.88, respectively).

4. DISCUSSION

The wide range of marrow fat content in long bones and mandibles of red deer was consistent with data obtained for moose by Cederlund *et al,,* (1986). However, the minimum marrow fat values were consider-

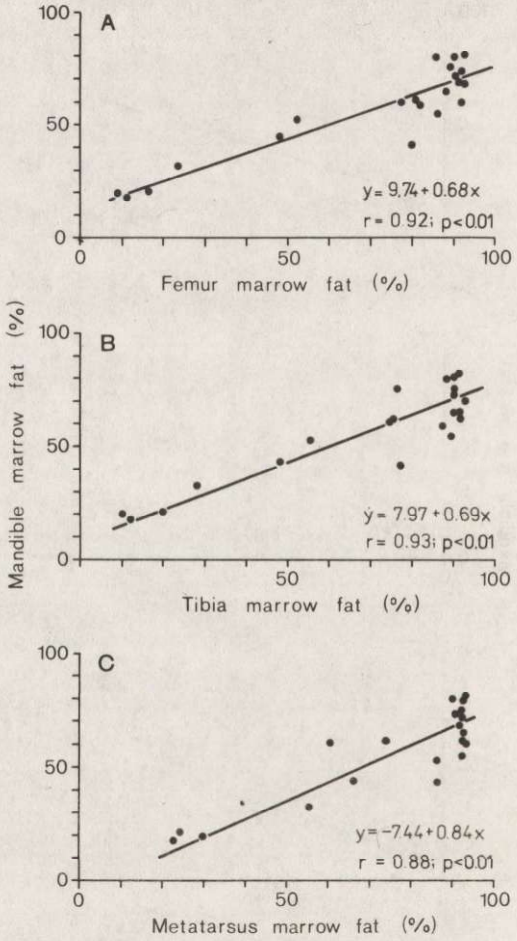

Fig. 2. The relationship between marrow fat (%) in mandible and femur (A), mandible and tibia (B), and mandible and metatarsus (C) of red deer hinds killed the Carpathian Mountains from 1984—88.

ably lower, corresponding with those indicating a state of starvation both in red deer (Okarma, 1984) and moose (Franzmann & Arneson, 1976; Bergström & Danell, 1982).

This study supports the positive correlation between marrow fat in the mandible and long bones found previously in moose (Snider, 1980; Ballard *et al.*, 1981; Cederlund *et al.*, 1986) and reindeer (Ballard *et al.*, 1981). However, none of the above cited studies examined mandibles versus a whole set of long bones (3 bones). Snider (1980) studied only the mandibular to femur fat relationship. Ballard *et al.*, (1981) collected femurs, metatarsals or metacarpals, then combined them and compared them with mandibles. It is known that mobilization of fat proceeds from proximal to distal long bones in various ungulate species (Brooks *et al.*, 1977; Reich, 1981; Peterson *et al.*, 1982; Okarma, 1984). Thus combining results from different long bones could produce quite incorrect information on mandible-long bone relationships. Cederlund *et al.*, (1986) analyzed mandible-metatarsus-femur fat relationships. As no tibias and only a few femurs were collected that study focused mainly on mandible-metatarsus comparisons.

Results obtained for red deer support a phenomenon of different fat mobilization in long bones for juveniles and adults found earlier for moose (Ballard *et al.*, 1981; Cederlund *et al.*, 1986). Both for calves and hinds the mandible-long bone fat correlations were best for tibia, then for femur and last of all for metatarsus (Fig. 1, 2) but differences between them were not significant.

Snider (1980) suggested that the femur was a more sensitive indicator of moose condition than the mandible at low femur fat levels (below the 50% level). However, Cederlund *et al.*, (1986) stated partly in the contrary that "the mandible might be more sensitive at extremely low and high fat levels since the mandible depleted fat at a higher rate when the metatarsus fat levels were <25 and >80%". Results obtained in this study may clear up this inconsistency. Indeed at very low marrow fat levels (<40% in the femur) the mandible fat exceeded femur and tibia but was lower than that of metatarsus (Table 1).

Bone marrow fat was determined in both above cited studies using Neiland's (1970) dry-weight method. Neiland reported for femur marrow in caribou only very small non-fat residue which has been ignored by all authors using Neiland's method (Franzmann & Arneson, 1976; Snider, 1980; Ballard *et al.*, 1981; Okarma, 1984; Cederlund *et al.*, 1986). Preliminary data on red deer marrow fat composition indicated that the amount of non-fat residue was much higher in mandibular than long bone marrow fat (Okarma, unpubl. data). It might explain both the fact that at very high long bone marrow fat levels the fat con-

tent in the mandible was considerably lower than that in long bones and at extremely low levels the mandible fat was higher than metatarsus fat (Table 1) using Neiland's method. Obviously, femur and tibia fat contents were lower than mandible and metatarsus at very low fat levels since fat mobilization in red deer occurs from proximal to distal bones (Okarma, 1984).

Estimation of ungulates condition on the basis of marrow fat content has been recently criticized (Mech & DelGiudice, 1985; Torbit *et al.*, 1988). It was beyond the scope of this study to evaluate the usefulness of marrow fat depots as indicators of physiological and nutritional status of ungulates. However, the marrow fat technique could be quite useful for various comparisons, for example between animals killed by predators and those taken randomly from a population (predators frequently utilize carcasses heavily and only some bones remain).

Mandible fat technique makes it possible to determine the fat content of long bones marrow with relatively little effort and at low cost. Moreover, in specific conditions of Polish wildlife management this method enables the collection of large amounts of material without lessening the commercial value of red deer carcasses. It means that it may be used widely in studies of deer populations.

Further research is required to compare long bone and mandible fat mobilization rates in various red deer populations living in different environmental conditions. Comparisons must take into account both sexes and all age cohorts of specimens since considerable differences were found in moose (Franzmann & Arneson, 1976; Snider 1980; Ballard *et al.*, 1981; Cederlund *et al.*, 1986). Although this study provides only preliminary data it can be concluded that the mandible fat content is useful for determining red deer nutritional status to the same degree as long bone fat content.

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KORELACJE ZAWARTOŚCI TŁUSZCZU W SZPIKU ŻUCHWY I KOŚCI DŁUGICH KOŃCZYN U JELENIA SZLACHETNEGO

Streszczenie

Badano zawartość tłuszczu w szpiku kostnym kończyn i szpiku żuchwowym cielaków (N=17) i łań (N=21) jelenia szlachetnego (*Cervus elaphus* Linnaeus, 1758) zabitych w Bieszczadach w latach 1984—88. Poziom tłuszczu był niższy w szpiku żuchwowym niż w szpiku kostnym kończyn. Jednak gdy poziom tłuszczu w kości udowej był niższy od

40%, wtedy zawartość tłuszczu w szpiku żuchwy przewyższała taką w kości udowej i piszczelowej a była niższa tylko od kości śródstopia (Tabela 1). Zawartość tłuszczu w żuchwie była pozytywnie skorelowana z taką w szpiku kostnym kończyn. Najwyższe współczynniki korelacji stwierdzono między żuchwą a kością piszczelową, potem udową i kością śródstopia (Ryc. 1, 2). Współczynniki korelacji były nieco wyższe wśród łań niż wśród cielaków. Metoda oceny zawartości tłuszczu w żuchwie jest prosta i bardzo dokładnie określa zawartość tłuszczu w szpiku kostnym kończyn. Technika ta ponadto nie obniża wartości tuszy, dzięki czemu może być szeroko używana jako wskaźnik kondycji w badaniach populacji jeleni.