Assessment of nutritional condition in sika deer by color of femur and mandible marrows

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Nutritional condition of ungulates is affected by habitat quality. As habitat quality declines, reproductive activity decreases while individual survival increases. These demographic parameters correspond to the nutritional condition of individuals. Fat deposition is one of the best indicators of condition, and has been often used in studies of cervids (red deer, *Cervus elaphus*, Riney 1955; Caughey 1971; mule deer, *Odocoileus virginianus*, Anderson et al. 1972; roe deer, *Capreolus capreolus*, Holand 1992) and other ungulates. Of the fat indices, the kidney fat indices (KFI)s are the most often used because they cover a broad range of ungulate conditions, and sampling is relatively easy (references above, and red deer, Batcheler and Clarke 1970; moose, *Alces alces*, Cederland et al. 1986; Himalayan thar, *Hemitragus jamalacus*, Caughey 1970; some African ungulates, Hanks 1981, Japanese serow, *Capreolus capreolus*, Maruyama 1985). However, since the mobilization of fat deposits begins from subcutaneous fat, continues with mesentery fat, and ends with proximal bone marrow fat (Riney 1955; Ransom 1965; Bear 1971, Cederland et al. 1986), the KFI sometimes cannot fully describe poor condition. In such cases, bone marrow indices should also be used (Ransom 1965; Anderson et al. 1972; Kie et al. 1983). In management-related field studies, however, the quality of the biological data gathered must be balanced against the difficulty and cost of sampling and processing samples. Because population level assessment requires many samples, time-consuming collection methods are not preferable, and convenient methods to process them are needed.

For bone marrow fat indices, the most accurate method is to measure the fat, water, and residue weights (Ransom 1965), but this is very time-consuming. Neiland (1970) developed a more convenient “dry weight method”, which is widely used (Hunt 1979). Greer (1968) devised the “compression method”, but it is not often used. These two methods provide reliable results, but they also require a long time to process many samples. Meanwhile, Riney (1955) compared several methods of measuring fat deposits of red deer. In his study, he described the visual method to describe the color and texture of femur marrows. This method, however, is not widely used, probably because the categorization is too complicated. Nevertheless, the ease of this approach makes it possible to process a large numbers of samples in a short time. Therefore, I compared Riney's (1955) “color method” with the marrow fat index (MFI) to test the validity of the former for sika deer, *Cervus nippon*, at Mt. Goyo, northern Japan.

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Materials and methods

Riney (1955) described four categories of color and four categories of texture in femur marrow of red deer as follows.

For color;
0 = reddish or brownish in color
1 = intermediate between 0 and 2
2 = light, but with faint wash of color
3 = white, or white streaked with small red vessels

For texture;
0 = gelatinous or watery
1 = slightly greasy
2 = soft and thickly greasy but not waxy
3 = firm and waxy

I had difficulty applying these categories because they are complicated. Since many people are usually involved in the collection and assessment of samples, the subjectivity of the categories reduces their practical use. From field experience, I combined the color and texture categories as follows:

1 = gelatinous deep red
2 = red
3 = pink
4 = white or creamy white

According to this simple categorization, even beginners can easily categorize marrow samples.

I collected 57 femurs and 286 mandibles from sika deer of Mt. Goyo, Iwate Prefecture, northern Japan. Deer were harvested for pest control, and were brought to check stations where sex was determined, body weights were recorded, and bones were sampled. All samples were frozen at $-20^\circ\text{C}$ before analyses. Samples were thawed at room temperature for several hours before colors were assessed and recorded. Fat contents were then assessed by the dry weight method (Neiland 1970) to derive marrow fat index (MFI) values.

Results and discussion

Figure 1 shows the mandible fat index (MFI) values for femur marrow of different colors. MFI values increase as marrow color changes from deep red to whitish. Most combinations of MFI value classes were significantly different (Fisher's PLSD, white and pink, $P=0.0117$, white and gelatinous red, $P<0.0001$, pink and gelatinous red, $P<0.0001$, red and gelatinous red, $P<0.0001$) except one (red and pink, $P=0.0551$).

Figure 2 shows the MFI values of mandible marrows of different colors. Differing from the femur marrows, the MFI values of red-, pink-, and white mandible marrows were not different, and only values for gelatinous red marrow were significantly smaller (Fisher's PLSD, $P<0.0001$). Several reasons may account for this difference. Mandible marrow appears more fibrous than femur marrow, and contains more residues that are presumably composed of fibrous materials. Because of lower fat volumes, small differences in fat mobilization would not be reflected in total marrow weights.
Fig. 1. MFI (marrow fat index) values for sika deer femur marrow of four different colors. Vertical lines indicate SE. Different letters above the bars indicate significant differences.

Fig. 2. MFI values for sika deer mandible marrow of four different colors. Vertical lines indicate SE. Different letters above the bars indicate significant differences.

When processing a large number of marrow samples for nutritional condition in sika deer, the visual assessment of femur marrow color is promising, but that of mandible marrow color is not. The relative proportion of white and gelatinous red femur marrow can be a good indicator of general condition in deer populations. For maximum sampling efficiency and application by a number of field workers, color categorization should be simple. The four categories proposed in the present study can be quickly learned and easily applied in the field.
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References


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