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TECHNIQUES FOR DIFFERENTIATING PELLETS OF SHORT-EARED OWLS AND NORTHERN HARRIERS[1]

DENVER W. HOLT[2]
Massachusetts Natural Heritage Program, Division of Fisheries and Wildlife, Boston, MA 02202

L. JACK LYON
Intermountain Research Station, Missoula, MT 59807

ROBERT HALE
Department of Biology, University of Massachusetts, Boston, MA 02202

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Short-eared Owls (*Asio flammeus*) and Northern Harriers (*Circus cyaneus*) are sympatric throughout much of their ranges. In Massachusetts these species usually co-exist temporally, may have overlapping territories, and are both dependent on meadow voles (*Microtus pennsylvanicus*) for food (Holt and Melvin, in press). Because of similarities in appearance and content, pellets of the two species are often difficult to separate. In this note we describe techniques for differentiating pellets of the Short-eared Owl and Northern Harrier.

STUDY AREA AND METHODS

Field and laboratory techniques were developed over a 7-year period (1980 to 1986) by the senior author in southeastern Massachusetts and western Montana. The sample of pellets reported here was collected in 1985 on Nantucket Island, Nantucket County, Massachusetts. We collected 180 pellets of each species at winter roost sites. At least six Short-eared Owls and six Northern Harriers were present throughout the collecting period. Regular roost sites were visited frequently.

Pellets were identified in the field on the basis of observations of the species flushed from roosts. Pellets were collected, and fecal waste color and feather evidence (if any) were recorded. General shape of the pellets was recorded. Only complete pellets were used for the laboratory comparison (i.e., no broken ends, no fragmentation, no splitting or loosening of pellets).

Pellets were open-air dried for at least 30 days. They were then measured for length and diameter to the nearest 0.1 mm, using an Edmund dial face caliper. Pellets were weighed whole on a Mettler single arm balance to the nearest 0.01 g and then carefully dissected to separate fur, feathers, and bone material.

Bones (skulls, bones, bone fragments) and teeth were reweighed to determine percentage of bone weight per pellet. The number of prey individuals per pellet was also recorded.

Analyses of data included statistical comparisons of means for measured parameters of the two groups and discriminant function evaluation (Nie 1975) for separation of the groups.

RESULTS

We compared weight, length, diameter, bone weight, length/diameter ratio, and percentage bone by weight in the two kinds of pellets (Table 1). Bone weight and percentage bone weight per pellet were of greatest statistical significance, but *t*-test comparisons of group means demonstrated highly significant differences between owl and harrier pellets for all parameters measured.

We developed a discriminant function equation incorporating the six variables listed in Table 1. Of 180 pellets per species, over 90% were classified correctly. However, a useful discriminant function should be no more complex than necessary and not include any highly intercorrelated independent variables. In these data we found that second and third variables improved predictions by only 3 to 5% and that four pairs of variables had linear correlations greater than 0.600: weight with length, length/diameter, and bone weight, and length with length/diameter. Arbitrary elimination of equations with more than three variables or these particular pairs reduced potential solutions substantially.

Within these stated limitations, the three-variable equation presented in Table 2 was the most powerful discriminant function discovered. This equation correctly identified 90.8% of the owl and hawk pellets in our analysis. However, it is interesting that the three-variable combination provides little improvement over equations using two variables, or even those using one variable.

Use of these equations can result in classification errors ranging from 10 to 25%. However, examination of our raw data for misclassified pellets demonstrates that many potential errors probably can be recognized and avoided by questioning any Z score between zero and the Z mean.

In this study, for example, 33 of 360 pellets examined for both species were misclassified. In over half the misclassified pellets, bone material, or lack of bone material, could have provided adequate reason to question the discriminant function result. Of 14 owl pellets

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[2] Present address P.O. Box 8335, Missoula, MT 59807.

TABLE 1. Means, standard errors, and t-test comparisons of measurements taken, Short-eared Owl and Northern Harrier pellets, $n = 180$ each species.

Measurement	Short-eared Owl		Northern Harrier		t	P
	$\bar{x}$	(SE)	$\bar{x}$	(SE)		
Weight (g)	4.15	(0.120)	2.86	(0.069)	9.35	<0.001
Length (mm)	49.44	(0.844)	36.93	(0.687)	11.50	<0.001
Diameter (mm)	22.38	(0.174)	23.51	(0.185)	4.42	<0.001
Bone weight (g)	1.53	(0.048)	0.50	(0.025)	18.93	<0.001
Length/diameter (mm)	2.22	(0.038)	1.58	(0.029)	13.50	<0.001
% bone	37.33	(0.678)	18.31	(0.900)	16.89	<0.001

misclassified, one pellet contained white-footed mouse (*Peromyscus leucopus*) remains and one contained short-tailed shrew (*Blarina brevicauda*) remains. These are smaller mammals than the meadow vole—mammals whose bone content in pellets is usually minimal and fragmented. Six owl pellets did not contain meadow vole skulls, though other bone material was present. Thus, eight owl pellets were misclassified because normally expected bone weight was missing. Of the 19 Northern Harrier pellets misclassified, two pellets contained three meadow vole skulls and seven pellets contained two meadow vole skulls. Thus, nine harrier pellets were misclassified because of unusually heavy bone weight.

TABLE 2. Discriminant function equations for differentiating pellets of Short-eared Owls and Northern Harriers.

$Z = -4.829 + 0.3038$ bone weight $+ 1.374$ length/diameter $+ 0.0686$ % bone
Mean $Z = 1.251$ for Short-eared Owl pellets, and $Z = -1.251$ for Northern Harrier pellets
$Z = -5.135 + 0.0778$ % bone $+ 1.564$ length/diameter (90.6% correct)
Mean $Z = 1.244$ for Short-eared Owl pellets, and $Z = -1.244$ for Northern Harrier pellets
$Z = -5.197 + 0.0670$ length $+ 0.0828$ % bone (88.9% correct)
Mean $Z = 1.206$ for Short-eared Owl pellets, and $Z = -1.206$ for Northern Harrier pellets
$Z = -1.979 + 1.947$ bone weight (87.8% correct)
Mean $Z = 0.997$ for Short-eared Owl pellets, and $Z = -0.997$ for Northern Harrier pellets
$Z = -2.603 + 0.0936$ % bone (83.6% correct)
Mean $Z = 0.890$ for Short-eared Owl pellets, and $Z = -0.890$ for Northern Harrier pellets
$Z = -4.192 + 2.206$ length/diameter (77.8% correct)
Mean $Z = 0.712$ for Short-eared Owl pellets, and $Z = -0.712$ for Northern Harrier pellets
$Z = -4.185 + 0.097$ length (73.3% correct)
Mean $Z = 0.606$ for Short-eared Owl pellets, and $Z = -0.606$ for Northern Harrier pellets

In all, 16 pellets (six Short-eared Owl; 10 Northern Harrier), or 4.4%, were truly misclassified by the discriminant function, but another 17 might at least have been questioned.

In the field, Short-eared Owls and Northern Harriers select favored roost sites. Flushing either species provides the most accurate pellet identification, but fecal waste and feathers of roosting birds are often present as well. Fecal waste of owls is buff/creamy and often contains a black, solid bead. Fecal waste of the harriers is white to white/green and often contains some blackish waste. Feathers of the two species are quite different and with minimal practice can be differentiated easily.

At times, pellets may be found singly or in small groups with no evidence of the species responsible. In this case, it should be noted that Short-eared Owl pellets tend to be longer (range = 27.8–119.0, $\bar{x} = 49.4$ mm) and of more uniform diameter (range = 17.4–30.8, $\bar{x} = 22.3$ mm), while Northern Harrier pellets are shorter (range = 22.6–82.2, $\bar{x} = 36.9$ mm) and distinctly rounded in diameter (range = 18.2–43.2, $\bar{x} = 23.5$ mm).

Bone content in the owl pellets tends to be near the surface and readily felt by hand, whereas bone content of the harrier pellets is usually within the pellet, covered by the mass of fur.

In this study, owl pellets generally had one skull per pellet, while harrier pellets had fewer than one. Skulls were present in 161 (89.4%) of 180 owl pellets, representing 218 prey individuals; skulls representing 143 prey individuals were present in 113 (62.7%) of 180 harrier pellets. The average prey per pellet for owls and harriers was 1.21 and 0.79, respectively.

DISCUSSION

We compared our methods and results (Table 1) with Clark (1972), Glue (1977), and Mikkola (1983). We found that Clark's method of preparing pellets by soaking in water for 24 hr, teasing apart with forceps, and rotating the dissected pellet in a dish of water until the bone content sank and the fur floated was unsatisfactory for us. We soaked several pellets for 2 days and found teasing them apart more difficult than teasing dry pellets.

Further, separating fur from bone of wet pellets did not ensure that all bone fragments could be found. We believe the dry method is less time consuming, although we did not compare the NaOH method of pre-

paring pellets (Longland 1985) because of inexperience with the technique and fear of damaging fragile fragmented bones.

Our mean lengths and diameters for Short-eared Owl pellets (49.4 mm × 22.3 mm, $n = 180$) are similar to those reported by Glue (1977) (45.0 mm × 22.0 mm, $n = 740$) and Mikkola (1983) (48.0 mm × 22.0 mm, $n = 200$) in their European studies. In North America, our mean diameters for pellets of Short-eared Owls (22.4 mm) and Northern Harriers (23.5 mm) were not statistically different than those presented by Clark (1972) (23.2 mm for owls and 22.9 mm for harriers, $n = 24$). Clark did not measure pellet lengths.

Our mean bone weight per pellet was lower than reported by Clark (1972) for Short-eared Owls (37.3 g vs. 44.0 g) but similar to his mean for Northern Harriers (18.3 g vs. 17.0 g). Clark's table 1 indicates prey per pellet of Short-eared Owls and Northern Harriers as 1.7 and 1.3, respectively. He did not state how individuals were tallied, but both figures appear to be about 0.5 prey item per pellet greater than recorded in our study. These differences may be related to Clark's small sample size ($n = 24$) or simply to differences in the way prey individuals were tallied. Differences in pellet composition between Short-eared Owls and Northern Harriers have been attributed to more complete digestion of bones by harriers (Errington 1932, Glading et al. 1943, Dodson and Wexler 1979), or a greater tendency by harriers to break bones while feeding (Shelley 1935, Craighead and Craighead 1969, Clark 1972).

Clark (1972) suggests assessing the pellets of these two species in the field by "squeezing the pellet between the thumb and forefinger, the owl pellets are firm, the harrier pellets tend to be spongy." This is a good field technique but should not be used alone. "Hard" and "spongy" are subjective terms, and pellet texture often varies with freshness, weather, and age. Other field observations should be included if possible.

CONCLUSION

We have attempted to develop a procedure that separates Short-eared Owl and Northern Harrier pellets using measured variables, field techniques, and observational data when appropriate. Significant differences between means of large samples are of little value to field biologists who find single or small collections of pellets.

The initial step for the field biologist is to select a discriminant function equation using parameters easily collected in the field. Bone weight is clearly the most useful single parameter for identifying pellets, but it can be obtained only in laboratory analysis. Bone percentage, on the other hand, might easily be estimated as less than 20% or greater than 33% by inspection. In combination with length or length/diameter, such an estimate could provide correct identification most of the time. Where bone percentage lies between 20 and 33%, or when the discriminant Z is weak, the observer has recourse to evaluation of the number of skulls per pellet or even to collecting borderline pellets for laboratory study. However, we believe that by using only the field techniques described here, the probability is that over 90% of collected pellets will be identified correctly. Further, we believe that these techniques can be used in other geographic areas based on the similarities with the European and North American studies. Where the discriminant function equation could vary interspecifically or geographically, the field techniques would more than suffice.

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