THE PELLET ANALYSIS METHOD OF RAPTOR FOOD HABITS STUDY

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This article has to do with the progress to date (July 15, 1930) of a series of experiments carried on under the quail research fellowship established July 1, 1929, at the University of Wisconsin by the Sporting Arms and Ammunition Manufacturers' Institute and the United States Biological Survey. One of the objects of the fellowship is the determination of quail-predator relationships, and, in this connection, need was felt of testing the reliability of the pellet analysis method of studying raptor food habits. The experiments have not been wholly concluded, but recent discussions of this question make it timely to present a résumé of the data already at hand.

Experimental work was done with four Great Horned Owls, a Barred Owl, a Long-eared Owl, a Red-tailed Hawk, a Red-shouldered Hawk, and a Marsh Hawk. The aforementioned were young birds taken from this season's nests and raised to full or to approximately full size. Their growth was normal as compared with that of the nest-reared young in the wild. No young falcons or Accipiters were available, although a Cooper Hawk nestling is now being kept for future experiments.

Discussion of pellet formation by species follows.

Great Horned Owl. Owlet aged 21 days (calculated), about one-fourth grown and with primaries just coming out, seemed to retain the residue of its meals (cottontail rabbit) so long in the stomach that the bones were digested and the fur passed out in the feces. At the age of 28 days the first creditable pellet was produced. Parts of a robin and a rat had been fed the day before, both of which were evident in the pellet. From this time on, pellets gradually improved in quality, bony material showing less and less digestion as growth of the owlet progressed. Acknowledgment is hereby made of the liability to error in the initial experiments with this three-weeks horned owl, for only the one bird was had at first, and the technique was by no means flawless.

As grown juveniles, four horned owls were fed cottontails, rats, mice (*Microtus, Peromyscus,* and *Mus*), mallard ducks, domestic chickens, domestic pigeons, pheasants, quail, flickers, English sparrows, miscellaneous birds, snakes, and frogs. Much of this material was taken directly from horned owl nests. Emphasis was laid upon offering them the game upon which they preyed in nature, allowing them to eat it in any manner that they wished. Later they were permitted to do their own killing. No differences in digestion were noted among the four horned owls when given the same type of food.

Examples 1 to 5 might be considered representative of the horned owl experiments.

(1) Owl fasted for 85 hours. Live English sparrows then put in cage and replenished at intervals to keep available for the owl a constant supply that he could catch as he wanted them. This he was able to do without difficulty. In 74 hours he had eaten 32 sparrows; in 84 hours he had disgorged 6 pellets, in which remains of 28 out of the 32 sparrows were easily discernible.

(2) Owl fed 6 sparrows and 15 house mice (some of the latter were very immature) in 13 hours. Pellet in 24 hours, in which pellet the six sparrows and the 12 largest of the 15 mice could be recognized.

(3) Owl stuffed with 3 sparrows and 8 house mice (some very immature as

in above experiment) at one feeding. Pellet in 19 hours showing the 3 sparrows and 6 out of the 8 mice.

(4) Owl fed entire part-picked English sparrow and much meat (beef). Fed more meat after 14 hours. Twenty-four hours later fed meat with cat fur to bring up sparrow remains—if remains existed after having been retained in stomach this long. Cat fur fed also during following 24 hours. Pellet of cat fur showing no trace of the sparrow fed 70 hours previously.

(5) Owl left in cage 30 hours with adult mallard. Two pellets of unmistakable mallard composition, showing bill, feathers, and the larger broken bones rather characteristic of horned owl work.

Barred Owl. The early experiments with the young barred owl were similar to those with the young horned owl and gave similar results; pellets were retained in the stomach until the bony parts were well digested. As in the case of the horned owls, the barred owl pellets improved in quality with the growth of the young bird. The pellets of the owl at plumage maturity showed remains of practically all small game in recognizable condition. In one experiment 55 English sparrows (released alive in cage) were eaten in 154 hours. From these sparrows 17 pellets were produced in 168 hours, in which 49 sets of mandibles out of a possible 55 were counted in a hasty sorting over of the bone and feather débris. It is probable that a careful re-examination might have brought out 2 or 3 more, or even all of the missing 6.

Long-eared Owl. This owl was killed in a freak accident before much work had been done with him, but the few pellets obtained yielded the most perfect bone remains of all.

Red-tailed and Red-shouldered Hawks. These two Buteos gave the least satisfactory pellet returns of any of the raptors. Sometimes pellets were not thrown up for protracted periods of time, depending upon the amount of roughage fed. Pellets were disgorged when they became about so big, whether the next day or the next week. Fur and feather material proved to be in fair shape, though as a rule no particles of bone could be detected.

Marsh Hawk. The marsh hawk was taken when but a few days old. He threw up pellets from the beginning, regularly before 8 o'clock each morning—provided he had been fed pellet-forming material. However, if fasted subsequent to a meal, he would disgorge a pellet of any size as soon as he had extracted the nourishment.

One experiment consisted of giving the hawk access to as much food as he wanted. In 130 hours he ate a meadow mouse (*Microtus*), 2 striped ground-squirrels, a red-winged blackbird, a migrant shrike, a bluejay, and 29 English sparrows, from which he threw up 8 pellets in 149 hours. The pellets revealed qualitatively though not quantitatively the species eaten.

Compared with the owl pellets those of the marsh hawk were of poorer quality. Fur and distinctively marked feathers usually came through in recognizable condition, but the bony substance was largely digested. It might be pointed out that most of the prey fed was of this season's increase; bones of fully matured animals doubtless would better withstand digestion than the bones of juveniles. This criticism can be made of all the experiments in which sparrows were used.

What is the value of pellets in raptor food habits study? The pellet record of the common owls, to all appearances, can be accepted virtually at par; whatever an ordinary southern Wisconsin owl is apt to eat stands an excellent chance of being represented in pellets, notably in those of the smaller and medium-sized

owls. This statement is meant to include the short-eared, saw-whet, screech, and barn owls, for, while no experiments were conducted with these species, their pellets collected in the wild differed to no radical degree from the pellets of the experimental birds. A greater or less loss of delicate osseous structures—as the skeletons of *Sorex* and immature mice—can be expected in all owl pellets, but some resistant parts like lower mandibles usually persist. Feathers tend to become ground up—not invariably—in the stomachs of the larger owls; as concerns these owls, the main reliance in pellet study should be placed upon bone determination.

It is suggested that the saw-whet, long-eared, short-eared, barn, and great horned owls lend themselves especially to pellet food studies, because of the comparative partiality individuals often show toward favored roosts, under which their pellets accumulate. No such favoritism toward roosts was noted during the past winter, with respect to barred and screech owls. Incidentally, the above suggestion is intended to apply to the winter and spring months, since no first-hand information is had dealing with summer owl behavior.

The owls observed in captivity and in the wild bolted their prey whole or in the most convenient chunks they were able to get loose. Scarcely any attempts were made at skinning or picking other than the pulling out of large primaries and tail feathers and the eating of flesh away from hide too tough to tear. Heads of victims killed by the owls were almost without exception among the first portions ingested, thus rendering even more probable the likelihood that something of diagnostic importance would be contained in the pellets. Horned owls eating rabbit, duck, or domestic chicken bit through bone and all and gulped any piece that they could force down their capacious throats; pigeons, flickers, jays, rats, and ground squirrels were completely eaten at one sitting, save for a scattering of primaries, etc.; mice and sparrows were swallowed whole, or first decapitated.

As to the hawks, the pellet value seems to vary with the genus. The pellets of the red-tail, red-shoulder, and presumably other Buteos might be of some utility in supplementing data gathered by less doubtful methods, assuming that the pellets were of unquestionable origin. Bona fide Buteo pellets proved extremely difficult to find, except in nests. This was not because identifiable material wasn't swallowed, for the Buteos observed were not careful feeders. The reason was that identifiable bony material did not satisfactorily survive digestive processes, and the pellets were distributed promiscuously about the country-side. Large-scale pellet study of Buteos, therefore, is not deemed practicable.

Now let us consider the marsh hawk, principal focus of the current raptor controversy. Marsh hawk pellets, as previously indicated, generally told *what* but not *how much* prey was taken. Suppose, for instance, that a marsh hawk had been preying upon mice, ground squirrels, blackbirds, and meadowlarks. His pellets would disclose the species eaten but not necessarily the number of each species. Bones, as illustrated by pellets of free and captive birds, suffered more decomposition than fur or feathers; nevertheless, some bones or bone fragments characteristic of a species were often to be found, especially the well ossified bones of adults. The quarry last eaten before the ejecting of the pellet was always the most recognizable, whether mammal, bird, or reptile. Batrachians were a total loss by the time that any of the hawks got through with them.

Marsh hawk pellet analyses should have their chief value for the determination of *general food habits* in somewhat hurried surveys, rather than for exhaustive researches, to work out problems of economic status. The pellets are frequently available in moderate numbers at strategic locations where the hawks eat their prey—

around the bottoms of fence posts, on hay cocks, old windrows, grassy elevations, and the like. The technique of skilled analysts having adequate reference collections is required to identify the various feathers and bone fragments found in the pellets, should the utmost accuracy be demanded.

Perhaps in view of the marsh hawk's debated status, it might be permissible to digress from the subject of pellets in order to offer some data pertaining to this raptor's food habits in the vicinity of Madison, Wisconsin. For the sake of avoiding possible criticism, pellet and stomach data will be omitted. The submitted list of prey relates only to that *retrieved from the birds themselves,* either from adults irritated into dropping what they had, or forced fresh out of the gullets of juveniles in nests. Such data were acquired incidental to the study of seven marsh hawk nests (one broken up early) from June 9 to July 11, 1930. Efforts were made to visit nests every two to four days.

During this period 82 specimens were actually recovered from marsh hawks: 39 striped ground squirrels (*Citellus tridecemlineatus*), ranging in size from one-third grown to adults; 12 meadow mice (*Microtus*); 11 young cottontails (one-sixth to one-fourth grown); 8 frogs; a chipmunk; a field sparrow; a red-winged blackbird; a meadowlark; remains of 3 not positively identified mammals, two of which appeared to be ground squirrels; and 5 small finch-like birds, at present awaiting specific determination. Some hundreds of pellets gathered contemporaneously (not yet subjected to careful examination) appear to bear out the same broad ratio of mammalian to avian prey.

Did the marsh hawks kill any poultry or game birds? Occasionally they did; but poultry and game birds made up a negligible percentage of the items recorded as far as the study has progressed in the Madison environs. Evidence was seen about the nests that a couple of part-grown domestic chickens and a young ring-necked pheasant had been brought in, and an incalculable number of injurious rodents. Let attention be drawn to the possibility that easily detached feathers from a lone bird might linger several days in the nest, whereas the apportionment of a dozen or more small mammals between the nestlings might leave less visible sign to tell the story.

Returning to the topic of pellet study, it might be well to mention that the approximate status of raptors other than the owls and the marsh hawk might conceivably be ascertained by this method. Falcons (duck hawk and sparrow hawk) deposited about their feeding places pellets corresponding to their observed food habits. Duck hawks studied in the field fed exclusively upon bird life, yet their pellets were full, fairly firm, of mixed bone and feather composition, and displayed to casual scrutiny the pigeons, bluejays, blackbirds, flickers, etc., of peregrine diet.

On account of a scarcity of Accipiter data, experimental and observational, no conjecture will be advanced bearing upon the feasibility of applying pellet study methods to this genus. Note has been made, withal, that the Cooper hawk is not nearly as clean a picker as is popularly supposed; indeed the nestling now in possession spat out a very fine pellet of flicker feathers on his first morning in captivity. The mother Cooper hawk seemingly had not been overly dainty in feeding her offspring, though the youngster had been hatched no longer than four days. A nestling under observation in the wild has been yielding a good pellet about every two days. It is likely that Accipiter pellets might be of considerable value if one knew how to find them.

This article has tried to make clear that raptor pellet analysis is not advocated to the exclusion of other research methods. No single method yet introduced

is absolutely fool-proof—not even that of field observation—nor can we presume that perfection will be achieved in this respect for some time to come. We must use *all* of the most effective methods at our command, checking one against another, if our data are to be of the highest grade.

Pellet analysis might reasonably be the most important of the investigator's approaches in the study of owl food habits; in the study of marsh hawks and falcons (peregrines, at least), it might be employed to excellent advantage in conjunction with observation and nest visits; in the study of Buteos, it probably can be used only slightly, if at all. At any rate, whatever its defects with regard to some species, it certainly has its place in the study of others—particularly in winter studies. In winter, pellets of many raptors are easiest to obtain and are also of the best quality because of the absence of soft juvenile bones at this season. Again, one does not have to shoot or trap interesting and valuable birds to amass voluminous pellet data.

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