by changes in the load necessitated frequent adjustments of the platinum-tipped screws of *E* and *F*. More recently since two large 12-volt storage batteries have been installed there has been little difficulty in keeping the batteries charged, but when fully charged they are capable of overheating and burning the spring of the time bar takeoff *F* if there is a short circuit in the line. Such an accident occasionally happens when one of the students, who is inexperienced in affairs electrical, attaches both wires from the time clock to the frame of the signal magnet, *i.e.*, one to the regular binding post and the other to the screw intended for adjusting the writing point. It is expected that this difficulty will be overcome by the installation of a suitable fuse.

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METHODS OF COLLECTING CARCASSES

THE conducting of a zoological field problem which requires the collecting of bird and mammal carcasses may represent an almost unjustifiable demand in the amount of time and effort required. The matter of securing a quantity of material of such species as fox, mink, weasel and owl (all forms of more or less wide and elusive range habits) and the bringing into the laboratory of the material needed for investigation of such questions as can be determined only by the compilation of data secured from specimens, may most efficiently be accomplished, according to my experience, by employing the help of sportsmen, taxidermists and raw-fur dealers. There are several distinct advantages in securing the material in this way. First, it is a practical impossibility for one worker in a limited time to take in the field or to trap any of our local carnivora, for example, in sufficient numbers to furnish adequate data. Second, something may be contributed to the spirit of conservation if the carcasses of animals secured by these people, otherwise wasted, can be utilized for a laboratory analysis of certain ecological factors. Third, some knowledge as well as sympathy and enthusiasm concerning the biology and conservation of game may be shared by the laymen and the scientific investigator by such cooperative efforts in collecting the necessary material. Fourth, local history of a species and information regarding its local habits as gleaned from sportsmen and farmers, while not always reliable, are often sufficiently accurate to be of material value to the investigator.

In order to enlist the greatest number in getting material the worker must approach the sportsmen and dealers, and present his problem in such a manner as to gain their respect for his project. After that the best technique I have developed in two years of experimenting is to distribute a series of large cans, buckets or kegs—one- to ten-gallon containers—each fitted with a tight cover and tagged with a proper label. Each receptacle should contain a 5 per cent. solution of formalin. Such a container delivered to the sportsman, taxidermist or raw-fur dealer enables him, with the least amount of trouble to himself, to preserve, merely by dropping into this container, the carcasses which he has at hand—a most important consideration for the investigator who wishes to secure a quantity of material.

The first collecting of this kind made by the author consisted of the stomachs and entrails of ruffed grouse. Early in this work it was noted that a rather low per cent. of birds estimated to have been killed was being contributed by cooperating sportsmen. To meet this condition a greater number of formalin jars were distributed, which allowed gunners to save a greater quantity of material without fearing that they were incriminating themselves before the law, in respect to the bag limits on grouse, or shadowing their self-respect in consideration of the growing scarcity of this bird.

Such collecting operations, according to my experience, never increase the kill in a community, but may actually lessen it since the sportsmen know that one phase of the study is that of evaluating the effect of the hunters' kill upon the maintenance of the species. But their knowledge of that aim of the study may spell failure in the securing of any appreciable percentage of the numbers killed during the open season, unless the collector has gained the confidence and respect of these people and is careful to spread the feeling that any contributing effort on their part is valued by him and that the success of his undertaking is of fully as much importance to them as to him.

To secure any field data of value with the individual specimens collected is, I have found, always a difficult matter. Sometimes to insist that labels be attached to the individual specimens results in the falling off of the amount of material secured. Fur dealers and taxidermists from whom I have received the greatest cooperation do not have at hand any exact information regarding many specimens which come into their shop. Many others do not like to be questioned thus closely regarding their field operations.

Two kinds of labels for attaching to specimens have been used with some success. Mr. Perry J. Nickerson, taxidermist at Syracuse, New York, has instituted a very practical method for the use of cooperating taxidermists who book a record of specimens as they come into the shop. He uses a small numbered aluminum tag with a wire attachment. When a specimen is brought into the shop the carcass of which is to be thrown into the formalin jar, one of these tags is attached to a leg and its number recorded with the original entry in the record book. From this record the locality from which the specimen came and its species can be determined. Many times it pays to seek further information concerning a particular specimen by field contact with the man who killed it. Mr. Joseph Buff, raw-fur dealer in Syracuse, who collected for me a generous number of weasel and mink carcasses, used a small shipping tag on which information was written with a soft pencil and then tied to the carcass before placing it in formalin. This method requires a little more time but is of greatest help to the investigator.

R. A. JOHNSON

SPECIAL ARTICLES

THE FUNCTION OF THE AIR SACS IN HOLOPNEUSTIC INSECTS

AIR sacs are present in probably all of the flying and in many of the non-flying insects. In the past, two different functions have been ascribed to these structures in holopneustic forms, but the evidence offered has been far from convincing. Newport[1] observed that the number and volume of the air sacs were correlated with the powers of flight of the insect, and was led to the belief that they serve for buoyancy during flight by lessening the specific gravity of the body. Such a function is manifestly impossible, but is still held at the present time. A late text-book of entomology[2] states (p. 119):

> As the air sacs lessen the specific gravity of the insect they probably aid in flight, as filling the lungs with air makes it easier for a man to float in water; in each case there is a greater volume for the same weight.

Another and more logical view is that the air sacs are merely reservoirs or stores for air, especially well developed in those forms which consume a great deal of oxygen in flight or active movement. There are several reasons for considering such a simple explanation inadequate. There would seem to be no advantage to an insect in having air reservoirs within the body when the whole atmosphere is a reservoir just a few millimeters away through the open spiracles. The air in the sacs, unless constantly renewed, could not serve as a store for very long, since less than 20 per cent. of it is oxygen, and the total volume of the sacs is small as compared with the volume of oxygen the animal uses in an hour. There would also seem to be little advantage in having a great number of small sacs rather than a few large ones.

The explanation suggested here avoids these difficulties and accounts for the parallel development with the powers of flight and activity. This explanation is that the function of the air sacs is chiefly mechanical in allowing a considerable volume of air to be inhaled and exhaled, thereby causing a ventilation of the larger tracheal trunks. In so far as the mechanics of respiration is concerned, the insect could be compared in several respects with the bird or mammal. The active expansion of the abdomen of the insect is analogous to the increase in size of the body cavity in the bird or of the thoracic cavity in the mammal. During the expansion of the abdomen the hemocoele of the insect becomes larger and the intracoelomic pressure must decrease and become less than atmospheric. The outside air, having free access to the tracheal system through the spiracles, will then cause the thin-walled and elastic air sacs, *wherever they are located,* to dilate and fill. During expiration the abdomen is compressed and made smaller, the intracoelomic pressure becomes greater than atmospheric, and this increased pressure, transmitted by the blood to all parts of the body, will cause the air sacs to collapse and empty. The greater the total capacity of the air sacs the greater must be the possible ventilation at each respiration, within the limits of expansion of the abdomen.

The walls of the ordinary tracheae contain a spiral chitinous thickening, and offer a considerable resistance to pressure tending to collapse or distend them. The cavities of the insect's body have no connection with the lumina of the tracheae. Hence, in an insect possessing no air sacs or such distensible structures, both the inspiration and expiration of air would be impossible. The ventilation of the tracheal trunks could be accomplished only by the mechanism of diffusion.

The number of air sacs in an insect may be surprisingly great. Landois[3] stated that there are about 550 in the male of *Melolontha vulgaris.* Packard[4] counted fifty-three sacs in the head alone of *Melanoplus femur-rubrum.* According to Newport[1] there are air sacs even in the mandibles of the stag beetle. In some of the very active insects the sacs form a veritable complex in the thorax and abdomen. It is noteworthy that many of the sacs arise from the smaller tracheal branches at a considerable distance from any spiracle. Even the largest ones usually do not open immediately from the spiracular trunks, but from the transverse or longitudinal trunks. Neither are the air sacs blind pockets at the ends of tracheal tubes, but

1 *Trans. Linn. Soc.,* 20: 419, 1851.

2 Comstock, "An Introduction to Entomology," Ithaca, N. Y., 1925.

3 *Zeitschr. f. wiss. Zool.,* 17: 105, 1867.

4 First Report U. S. Entomol. Comm., p. 269, Washington, 1878.