DISPERSAL OF FRESH-WATER GASTROPODS BY WATER BIRDS

by

CHARLES RANDALL MALONE, B.S.

A THESIS

IN

ZOOLOGY

Submitted to the Graduate Faculty
of Texas Technological College
in Partial Fulfillment of
the Requirements for
the Degree of

MASTER OF SCIENCE

Approved

Accepted

ACKNOWLEDGMENTS

I am deeply indebted to Vernon W. Proctor for his direction of this thesis and to the other members of my committee, Thadis W. Box, M. Eileen Lowe, Robert L. Packard, and Donald W. Tinkle, for their helpful criticism. I wish to thank M. M. Moore and E. P. Cheatum for identifications of the snails included in my study.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

For many years birds have been assumed to be important agents of passive dispersal for small aquatic organisms. Only recently, however, have accurate data been presented to support these assumptions. Maguire (1959) and Schlichting (1959) reported viable fresh-water algae, protozoans, nematodes, and rotifers taken from the external surfaces of birds. Löffler (1963), Proctor (1964), and Proctor and Malone (1965) have shown that viable eggs of some crustaceans may be carried via the intestinal tract of birds.

Most isolated bodies of water contain one or several species of fresh-water gastropods. That these organisms are so widely dispersed (Yen, 1947, and Hubendick, 1950) indicates that an effective and readily available means of dispersal exists. Birds have been assumed to be the primary agents of passive dispersal for snails.

Scattered through the literature can be found reports of dead snails taken from the external surfaces of birds (e.g. Kew, 1893, Roscoe, 1955, and Cotton, 1960). Whether the snails became attached to the birds before or during collection is not known. Pascal (1891) suggested that egg masses of snails might pass unharmed through the intestinal tract of water birds. If such were possible, snails could be carried internally by birds and dispersed in this manner. Dispersal of snails either via the external surfaces or via the intestinal tract of birds has not been demonstrated experimentally.

My research was conducted to determine whether water birds can serve as agents of passive dispersal for fresh-water snails. Snails from a variety of isolated habitats in northwest Montana and west Texas were studied. Killdeer (*Charadrius vociferus*) and mallard ducks (*Anas platyrhynchos*) were considered as examples of agents of dispersal.

Once cited by its specific name, an organism is referred to throughout the remainder of the paper only by its generic name. Since only one species in each genus is discussed, no confusion of identity should result. The term "snail", as used here, refers only to forms which have emerged from embryonic membranes (i.e. juveniles or adults and not embryos).

METHODS AND RESULTS

External Transport

During the summer of 1963 a total of 17 glacial pot holes in Flathead County, Montana were sampled. *Promentus exacuous* was the most abundant snail in 11 of the ponds and *Lymnaea obrussa* in 6. These 2 species of snails and killdeer were used for experiments on external transport.

Killdeer were shot and their legs removed and attached to stakes. The stakes were placed in shallow water where killdeer commonly fed. This was done to determine whether snails could become attached to the surfaces of birds. The legs were inspected periodically and never left in one location longer than three minutes. This period was chosen because killdeer feeding in shallow water often pause for that length of time.

If snails became attached to the feet, the feet were removed from the water and suspended in air from a tight line. The length of time that snails remained attached to the legs was recorded. To determine how long snails could survive out of water, groups of 15 were removed for hourly periods ranging from one to 20 hours. The snails were dried with tissue paper and placed on plate glass in open shade 3 feet above ground.

Juveniles and adults of both species of snails crawled onto the killdeer feet. Adult Lymnea usually clung to the feet no longer than 5 minutes before dropping; juveniles remained attached at least 48 hours. All Promentus remained attached at least 48 hours. The size of adult Promentus is about one-twentieth that of adult Lymnaea and is never great enough to force a snail to drop once attached to the feet. All snails released readily whenever the foot again came into contact with water.

Adult Lymnaea removed from water survived at least 14 hours; the juveniles only 2 hours. Promentus commonly survived 5 hours of exposure and in one case several survived after 14 hours. The amount of exposure snails can withstand probably varies with temperature and humidity.

Internal Transport

From September, 1963, through September, 1964, 30 playas (temporary lakes) in Lubbock County, Texas and 49 artificial stock ponds in Andrews County, Texas were inspected. All the playas contained Helisoma trivolvis and 18 stock ponds contained Physa anatina. The stock ponds consisted of 2 units: a small metal or concrete tank into which well water is pumped by a windmill and an earthen pond holding overflow from the tank. Physa was present in both units of the 18 artificial stock ponds. Physa and Helisoma along with killdeer and ducks were used for this portion of the study.

Ducks were placed in wire cages and fed aquatic vegetation containing large numbers of snails and egg masses.

Each bird ingested about 75 to 100 egg masses per meal. The number of snails eaten per trial ranged from 50 to 200. After feeding, the birds and cages were inspected for adhering egg masses and snails. Brown wrapping paper was placed beneath the cages and the first several droppings passed by each bird were collected.

Feces were inspected under low magnification. Any egg masses or embryos found were placed in small dishes of water and Chlamydomonas sp. for observation. To provide for undetected snails, the feces were placed in jars of soil and water with Elodea. All cultures were placed in a 27°C light room. Controls treated similarly hatched within 5 or 6 days.

Five ducks were used for 47 trials with Physa. Only 2 intact egg masses were recovered from the feces. The first of these contained 17 embryos, none of which developed further. Seven eggs were contained in the second; 4 developed normally and hatched on the fourth day following recovery. Apparently the egg masses were usually broken and the embryos scattered during passage through the tract. Twenty-eight individual Physa embryos in various stages of development were recovered from feces. An attempt was made to culture these but none was viable. Juvenile and adult snails were never found in the feces. Shell fragments were frequently seen indicating that most if not all had been crushed.

Eight trials were made with ducks and _Helisoma_. Neither embryos nor snails were recovered from the feces. However, one snail was found in a culture of feces 23 days after passage. No other _Helisoma_ was recovered from birds, suggesting that this individual was probably a contaminant.

Decreased exposure to digestive processes might increase the chances of recovery of viable snails. For this reason attempts were made to increase the rate of food passage. These attempts consisted of varying the amount of food given each bird and of feeding birds continuously over periods of 2 hours rather than giving them food only once. A method previously described (Malone, 1965a) was used to observe the rate of food passage. Ducks began defecating _Elodea_ after 30 to 45 minutes and had usually passed an entire meal after 2 hours. This rate of passage was unaltered regardless of how the birds were fed. The number of viable embryos found in the feces remained the same.

Post mortem inspection of the intestinal tract of 10 ducks indicated where the snails were being killed during passage. The birds were fed vegetation with _Physa_ each 15 minutes for one hour. Fifteen minutes after the last meal, the ducks were killed. Material found in all portions of the tract was removed, inspected, and cultured.

Neither snails nor egg masses were found past the gizzard. Portions of 4 egg masses containing 31 embryos were taken from the gizzard. None developed further. Only one snail was recovered from the gizzard. It was found just inside the entrance. The snail's peristome was damaged but the snail was living when recovered. However, it died within the hour. Only shell fragments were found in the lower portion of the gizzard where the grit is contained.

Egg masses were mixed with zooplankton and fed to killdeer. Individual birds were placed in a cage consisting of two compartments. Each was fed in one compartment then moved into the next where feces were collected. Ten killdeer were used for 56 trials with Physa and 20 trials with Helisoma. Each bird ate 10 to 20 masses per meal. No snails were fed nor were post mortem studies conducted with killdeer.

Feces collected from killdeer were placed immediately in well oxygenated water. This procedure was not possible with the bulky duck feces but did not hamper inspection of killdeer feces. Egg masses were quickly separated from the feces by gentle agitation, removed, and cultured in the same manner as those taken from ducks.

A total of 45 Physa egg masses were recovered from the feces of killdeer. Only 3 of these contained viable embryos. Seventeen of 26 embryos contained in the 3 egg masses hatched. Embryos contained in the remaining 42 egg masses were killed during passage. One hundred and thirty-two individual embryos from broken egg masses were recovered, but, as with ducks, none was viable.

Only 8 Helisoma egg masses were recovered from the feces of killdeer. None of the embryos contained in these developed. Thirty-seven individual embryos were found in the feces; none survived passage.

Egg masses could be recovered from killdeer in as little as 4 minutes after being ingested. The majority were passed within 15 minutes. Despite the rapid rate of passage in comparison with ducks, the number of viable embryos recovered from killdeer was about the same as with ducks.

Transplant Studies

An additional phase of my study consisted of transplanting Physa into isolated habitats where the species did not occur. This was undertaken to determine whether snails were previously absent because they had not reached the habitats or because the environments were unfavorable.

In February, 1964, 100 snails were placed in the tank portion of each of 10 stock ponds not containing Physa. The tank rather than the earthen pond was chosen to reduce the difficulty of finding snails at later dates. To serve as a control 100 snails were introduced into a tank which, before cleaning and drying, had supported a large population of Physa. The tanks were inspected monthly through September by looking for adults along the sides of the tank and by scraping the sides with a sampling net to remove juveniles.

The success of the transplanted snails is given in Table 1. One month following introduction snails were absent in only one tank. During the second month snails were absent in an additional 5 tanks. No snails were recovered during the fourth month, but they were undoubtedly present in small numbers in Tank #10, for they were found there in July and August. Snails were again absent in Tank #10 in September.

Over the entire 7 months period the snails were successful only in Tank #10. The degree of success in that tank, however, was not great. A stable population level was never attained and much fluctuation in numbers occurred. With each successive visit to the control tank the snail population had increased. Thus, the transplants were highly successful only in the habitat previously known to be favorable to *Physa*.

TABLE 1

SUCESS OVER A SEVEN MONTH PERIOD OF SNAILS
TRANSPLANTED INTO TANKS

Tank	Month						
	March	April	May	June	July	August	September
1	-	-	-	-	-	-	-
2	+	+	-	-	-	-	-
3	+	-	-	-	-	-	-
4	+	-	-	-	-	-	-
5	+	-	-	-	-	-	-
6	+	-	-	-	-	-	-
7	++	+	-	-	-	-	-
8	++	+	+	-	-	-	-
9	+	-	-	-	-	-	-
10	++	+++	++	-	++	+++	-
Control	+++	+++	+++	+++	+++	+++	+++

Symbols: - = no snails recovered

+ = less than 10 recovered

++ = 10 to 100 recovered

+++ = over 100 recovered

DISCUSSION

Transport via the external surfaces of birds appears to be a means of dispersal available to *Lymnaea* and *Promentus* (Malone, 1965b). These species readily attached to severed killdeer legs. Moreover, they remained attached and viable for sufficient lengths of time to effect dispersal, had they been attached to living birds. Reports by Roscoe (1955) and Cotton (1960) of finding dead snails on the surfaces of birds suggest that gastropods do become attached to living wild birds.

The recovery of some viable *Physa* embryos from the feces of ducks and killdeer indicates that dispersal of this species via the intestinal tract of birds is possible. Dispersal of *Helisoma* in this manner is less likely (Malone, 1965c).

Physa ingested by a mallard duck are apparently unharmed prior to passage into the bird's gizzard. Dispersal could be accomplished if snails were carried within the crop of a duck and liberated. The snails could be set free if the bird carrying them were to vomit or be killed and ripped apart by a predator.

External transport by birds probably could be a more effective means of dispersal for *Lymnaea* and *Promentus* than internal transport could be for *Physa* and *Helisoma*. *Lymnaea* and *Promentus* often became attached to killdeer feet. On the other hand, the passage of viable *Physa* embryos through the intestinal tract of killdeer and mallard ducks was rare. *Helisoma* embryos probably cannot survive passage through the tract of either bird. The maximum time that *Lymnaea* and *Promentus* attached to birds could retain their viability was 2 and 14 hours respectively. Viable *Physa* embryos were never recovered from the feces of ducks and killdeer after 30 minutes following ingestion. Thus, a flying bird could disperse attached *Lymnaea* and *Promentus* farther than it could *Physa* embryos contained within its gut.

The absence of *Physa* from many of the stock ponds in Andrews County, Texas seems to be due to unfavorable environments in those habitats. Killdeer, mallard ducks, and other water birds are often available to serve as agents of dispersal. The transplant studies indicated, however, that if snails reached some of the habitats, they could not establish a population.

Some means of passive dispersal must be available to fresh-water gastropods explaining their occurance in most isolated bodies of water. My research indicates that water birds may provide effective means of dispersal for some snails. Apparently birds may disperse either embryonic, juvenile, or adult snails of some species.

This study was conducted only with captive or dead birds. Thus, the data presented offers only suggestive evidence and not conclusive evidence of the dispersal of snails by birds. The significance of dispersal of snails by birds and the comparative importance of external and internal transport must await data furnished by field work.

SUMMARY

The wide and uniform distribution characteristic of most fresh-water gastropods attests to their great vagility. Water birds have been assumed to be primarily responsible for the passive dispersal of snails. However, little experimental evidence is available supporting this view.

In my research mallard ducks and killdeer were used as examples of agents of dispersal for some fresh-water gastropods. The ability of snails to be carried on the external surfaces of water birds and the possibility of transport of snails and egg masses via the intestinal tract were considered.

Water birds may provide an effective and readily available means of dispersal for snails. Although snails may be transported both by adhering to the surfaces of birds and via the intestinal tract, the former method seems to be the more effective. Both the frequency of events of dispersal and the distance of dispersal can probably be greater with external transport.

Transplant studies were conducted to determine whether the absence of snails in some isolated bodies of water is indicative of unfavorable habitats or failure of the species to disperse. Results suggested that the snails could not colonize the habitats if they reached them. The apparent reason is unfavorable environments.

LITERATURE CITED

Cotton, B. C. 1960. Mollusca eaten by birds. S. Aust. Orn. 23: 44-47.

Hubendick, Bengt. 1950. The effectiveness of passive dispersal in Hydrobia jenkinsi. Zool. Bidr. Uppsala. 28: 493-504.

Kew, H. W. 1893. The dispersal of shells. Kegan Paul, French, Trubner, and Company, Ltd. London. 291 p.

Löffler, Heinz. 1963. Vogelzug und Crustaceenverbreitung. Deut. Zool. Ges. Verhandlungen, Munchen. p 311-316.

Maguire, Bassett Jr. 1959. Passive overland transport of small aquatic organisms. Ecology 40: 312.

Malone, Charles R. 1965a. Marking food for studying its rate of passage in poultry. Poul. Sci. 44: (in press)

_______. 1965b. Killdeer (Charadrius vociferus L.) as a means of dispersal for aquatic gastropods. Ecology 46: (in press)

_______. 1965c. Dispersal of aquatic gastropods via the intestinal tract of water birds. Nautilus 79: (in press)

Pascal, L. 1891. Comment les etangs artificiels peuvent se peupler de Mollusques d'eau douce. Jour. Conch. 31: 9-15.

Proctor, Vernon W. 1964. Viability of crustacean eggs recovered from ducks. Ecology 45: 656-658.

Proctor, Vernon W. and Charles R. Malone. 1965. Further evidence of the dispersal of small aquatic organisms via the intestinal tract of birds. Ecology 46: (in press)

Roscoe, Ernest J. 1955. Aquatic snails found attached to feathers of White-faced Glossy Ibis. The Wilson Bull. 67: 66.

Schlicting, Harold E. Jr. 1960. The role of waterfowl in the dispersal of algae. Trans. Amer. Microscop. Soc. 79: 160-166.

Yen, T. C. 1947. Distribution of fossil fresh-water molluscs. Bull. Geol. Soc. Amer. 58: 293-298.