# THE RELATIONSHIP OF PURPLE MARTINS TO MOSQUITO CONTROL

HERBERT W. KALE II

RECENTLY articles and advertisements have appeared in newspapers and publications throughout the United States urging the public to erect bird houses in order to establish colonies of Purple Martins (*Progne subis*). The publicity proclaims that a martin consumes 2,000 mosquitoes per day, and either states or implies that martins provide effective biological control of mosquitoes. This is somewhat reminiscent of a controversy raised many years ago over the use of bats as mosquito control agents (see Allen, 1939; Storer, 1926). This paper reviews the scientific and popular ornithological literature regarding the diet and feeding behavior of the Purple Martin, in order to ascertain what if any role martins play in the control of mosquito populations.

## FOOD STUDIES

Only two studies of analyses of stomach contents of the Purple Martin have been published, F. E. L. Beal's (1918) and a recent paper by Johnston (1967). Beal's work is usually cited in most publications that mention the martin's diet (Forbush, 1929; Hausman, 1931; Roberts, 1932; Sprunt, in Bent, 1942; Sprunt, 1954). Beal analyzed 205 stomachs of martins collected from February to September throughout the United States and Canada. He reported no mosquitoes in any of the stomachs and most of the insects found were relatively large ones. Johnston analyzed stomach contents of 34 Purple Martins collected during April through August in Kansas. He reported that 3 per cent of the insects found in seven martins collected in April were culicine mosquitoes, but no mosquitoes were found in stomachs collected thereafter. He concluded coleopterans were the items most frequently taken during this study, that the martins ate considerably more dipterans in April and May than later in the season, and that by August hymenopterans were frequent food items.

I am aware of only one other record of mosquitoes being found in martin stomachs. D. W. Micks recently wrote (in litt.) that he examined the stomach contents of a Purple Martin killed by a vehicle near Gilchrist, Texas one spring approximately 10 years ago and found the stomach full of mosquitoes, most of which were identifiable as *Aedes sollicitans,* a salt marsh species that was present there in huge numbers.

The Toledo (Ohio) Area Sanitary District examined about two dozen martin stomachs obtained from the U. S. Fish and Wildlife Service collection and failed to find any mosquitoes present (P. B. Brockway, in litt.).

McAtee (1926) and Farley (1901) report certain insect items found in stomachs but do not mention mosquitoes.

Several authors have made extensive observations of adult martins feeding their young. Widmann (1922) noted "The youngest birds are fed at longer intervals with crushed insects, mostly small beetles, from the craw. About a fortnight old they are fed from the bill soft insects of the size of large flies, but insects with stings such as bees and wasps, are never brought. When four weeks old, large dragonflies, grasshoppers, and butterflies make their principal food." Cleaves (1966) reports that for the first few days he could not tell what the parents were bringing the young, but as the young grew larger their food consisted of larger insects—damsel flies, butterflies, dragonflies, and an occasional cicada.

## Flight and Feeding Behavior

No observations of martins actively feeding on mosquitoes where and when mosquitoes were seen to occur have been published. Martins are known to fly and feed over water, open fields, and marshes, and above the forest canopy. They fly anywhere from a few inches to 500 or more feet, but most frequently at about 100 or 200 feet above the ground (Johnston and Hardy, 1962). Johnston (1967) suggests an average height of 50 feet in Kansas. Martins are active from shortly after dawn until shortly before dusk. Widmann (1922, cited in Allen and Nice, 1952) observed parents bringing food to the young from 0415 until 2000 on 24 June 1884. Most mosquitoes are crepuscular or nocturnal (see Bidlingmayer, 1967 for references) and spend the day resting on the ground or in vegetation close to the ground. Bidlingmayer (1964) has shown by truck trap collections in Florida that few salt marsh mosquitoes (*Aedes taeniorhynchus*) are flying in open areas during the first quarter-hour after sunset or the last quarter-hour before sunrise. Usually, mosquitoes that take a blood meal out in the open during the day are those nocturnal or crepuscular species that have been disturbed from their resting places by the host animal, and diurnal species rarely fly in open areas (Provost, pers. comm.). Mosquitoes seldom fly above the tree canopy (for references to mosquito behavior see also Bates, 1949; Horsfall, 1955; Laarman, 1959; Kalmus and Hocking, 1960; Clements, 1963). Thus mosquitoes would be available to martins only for brief periods before sunrise and after sunset, if the birds happen to feed near the ground at these times.

## Discussion

Johnston (1967) and Micks (in litt.) present data showing that martins do eat mosquitoes, although Johnston's study indicates that mosquitoes comprise a very small percentage of the total diet. Beal (1918)

and Brockway (in litt.) failed to find any mosquitoes in 230 martin stomachs examined. Buckner (1966) points out that we should be cautious in drawing conclusions from gizzard analyses alone as "samples are usually so variable in volume, time and locality that no statistical reliance may be placed in the results . . . data from . . . gizzard analyses tend to be qualitative rather than quantitative . . . and give only limited knowledge of feeding behavior." The studies that have been published to date fail to reveal that the mosquito plays even a minor role in the diet of the martin. The reliability of Beal's study is clouded by the lack of data pertaining to locality, date, and time of day of collection. More stomach content and fecal studies are needed throughout the martin season, especially during periods of peak mosquito populations before a definitive statement can be made. Weston (1965: 88) writing about martins in northwestern Florida states "About July 1, adults and young . . . resort to the delta marshes to roost, where enormous gatherings can often be seen up to the commencement of migration in September." Hence, a study conducted in a marsh area at such times might reveal that numerous mosquitoes are being taken by martins.

Several authors (Forbush, 1929; Bowen, 1937; Sprunt, in Bent, 1942; Humphrey, in Wetmore, 1964; Wade, 1966) have attributed a mosquito-feeding habit to the martin, but fail to substantiate their statements with data or a literature reference. Forbush (1929: 142–143) quoted Beal's study (1918), then under the heading of "economic status" wrote "as martins are said to feed heavily at times on mosquitoes, their destruction of dragonflies may be immaterial . . . In some instances a great decrease of mosquitoes is said to have followed the establishment of Martin colonies, but I have had no opportunity to investigate these reports." The fact that Forbush clearly indicates that these reports were unsubstantiated has not deterred others (Sprunt, in Bent, 1942: 496; Wade, 1966: 79) from quoting him. Indeed, Wade erroneously attributes this statement by Forbush to Beal. Sprunt (in Bent, 1942: 496) attempting to add substance to Forbush's remarks writes "certainly it would be logical to suppose that the area about a thriving martin colony would be freer of mosquitoes than one without these birds." It is ironic that our knowledge today of the feeding behavior of mosquitoes and the avidity for avian blood of some mosquito species might even lead one to the opposite conclusion.

Bowen (1937) wrote "From a health standpoint it (the martin) is very beneficial as a preventive agent of malaria and yellow fever. Naturally many mosquitoes are devoured since most of its food is taken on the wing." These statements are not conclusions based on factual data, but gratuitous assumptions. More recently, Humphrey (in Wetmore, 1964:

130) included mosquitoes in a statement of items eaten by martins, but he admits (in litt.) that this was not based upon a study or reference. The same can be said of R. T. Peterson's inclusion of mosquitoes as a martin food item in the National Audubon Society's Leaflet No. 13, entitled "The Purple Martin" (B. C. Peterson, in litt.). It is unfortunate that generalizations without citations concerning food habits appear in the popular ornithological literature, for these references are often quoted as basic scientific sources. Even in several of the state bird books that are supposedly scientific and rigorously edited, it is often impossible to determine whether food habit statements are based upon data collected by the author, or upon the scientific literature, or upon the popular literature.

For several years biologists have been mystified over the origin and source of the oft-quoted figure "a martin eats 2,000 mosquitoes per day." The publication of Wade's book (1966: 38) has put an end to this mystery. Wade states:

> This figure was originated by me after extensive study of the birds' feeding habits.... My studies showed that a martin, whose digestive process and metabolism rate are extremely rapid, must on an average consume its own weight in insects each day. Its average weight is four ounces, and this equals approximately 14,000 mosquitoes.... There is little doubt that a martin could easily consume its weight in mosquitoes each day. Although the digestion of soft-shelled insects is so rapid that it is virtually instantaneous, and consequently the contents of a martin's stomach could not be accurately analyzed to prove this, I felt it reasonable to assume that martins often consume 10,000–12,000 mosquitoes per day where mosquitoes are plentiful . . . I felt the estimate of 2,000 mosquitoes per day was conservative.

Wade's conclusions are unsubstantiated by any factual data. As he was unable to show any evidence that mosquitoes were eaten by martins he rationalized this by stating that mosquitoes are so rapidly digested in martin stomachs that they cannot be identified. Sufficient evidence exists to show that this is not the case. The hard mouth parts, wings, and legs of insects remain relatively intact in the gizzard and are easily identified. Very often these same items can be seen in the feces, especially in feces of nestlings. Indeed, Johnston's study (1967) and Micks' findings (reported here) confirm that mosquito remains can be identified in martin stomachs.

In addition to his own allegations Wade (1966) presents evidence in the form of testimonials of numerous people to the martin's effectiveness in control of mosquitoes and other insects. These testimonials are from persons with little or no background of special knowledge that would enable them to render an authoritative opinion. Although their observations concerning reduction in insect annoyance may be correct, so many

factors affect mosquito density and activity that no single correlation can be made safely without detailed studies.

Biological control of several insect pests has been receiving more attention (van den Bosch and Stern, 1962) in recent years. A large literature on fishes that eat mosquito larvae already exists (see Gerberich and Laird, 1966). According to E. S. Hathaway (in litt.) "aside from fishes, we known very little about how effective predators are in control of mosquito populations." Some mosquito control districts have established Purple Martin colonies on an experimental basis. One of these, the Toledo Area Sanitary District maintained martin houses in Lucas County, Ohio from 1953 until 1967 (see Mayfield, 1964). The project was terminated in 1967 because the district could find no way to show what effect, if any, the martins had upon the mosquito populations.

A. S. Gaunt (in litt.) points out that one aspect people often overlook when considering food habits of swallows is that how a swallow feeds influences what it takes. A selective method is effective and economical against large insects, while a sweep method is effective only against swarming insects. Mosquitoes are so small that only by taking them en masse would the bird be able to gain much. The martin apparently is primarily a selective feeder, judging from the number of large insects found in stomachs and observed being brought to the young. On the other hand, when a small insect is present in very large numbers the martin can utilize a sweep method.

If, for the sake of argument, we assume that martins did feed upon mosquitoes to the extent that it might be worthwhile to consider using them in a control program, we would still be faced with the difficult problem of ascertaining the effect the martin would have upon the mosquito population. To exert any effective control martins would need to consume huge numbers of mosquitoes within a 2- or 3-day period after emergence, before the mosquitoes became widely dispersed and began taking blood meals. The mosquitoes must be flying in the open and above the vegetation during periods when the martins are active in order for the martins to capture them. As I have already pointed out this rarely occurs outside of crepuscular or nocturnal periods.

Presently most mosquito control efforts are directed against floodwater mosquitoes, those species that appear periodically in huge numbers after heavy rains or tidal flooding. A conservative estimate of production of these mosquitoes is several million adults per acre of habitat for each brood. Several broods per season are possible. In a polluted environment, i.e. in an area of sewage and rich nutrient outfall, producton of mosquitoes of some species may be several orders of magnitude greater (J. Beidler, W. Bidlingmayer, M. Provost, pers. comm.; Breeland and Pickard, 1967).

If we accept the statement that a martin eats 2,000 mosquitoes per day, then over 2,000 martins would be required to control the mosquitoes produced by an acre of marsh immediately after a brood has emerged. Andrewartha and Birch (1954: 487) point out that "Many species of insects in which a vulnerable stage in the life-cycle occurs only at one season of the year may be preyed on by birds without this influencing their ultimate abundance very much, for the simple reason that the birds are too few." Lack (1954) refers to numerous studies showing that birds might possibly retard an increase of an insect population at very low levels, but where insects are abundant birds remove an extremely small proportion—even though the average number eaten by the birds may be greater—and thus are ineffective in controlling high pest densities.

So few mosquitoes are flying when Purple Martins are feeding, the majority of them in an area are not available to the martins. Our present knowledge of the habitats and flight habits of mosquitoes and of the food habits and feeding behavior of the martin can lead us only to the conclusion that for the largest part of the day Purple Martins and mosquitoes simply do not occupy the same space at the same time.

ACKNOWLEDGMENTS

I am grateful to numerous individuals who have assisted me in locating literature references, particularly Maurice W. Provost, John D. Edman, T. E. Musselman, W. Wilson Baker, Barbara C. Peterson and George E. Mobus. Robert E. Bartnett kindly sent me a voluminous file of correspondence dealing with the subject. Thanks go to Don W. Micks for permission to report his observations on *Aedes sollicitans* in the stomach of a Texas martin. I am grateful to Maurice Provost, John Edman, and Roger W. Meola for helpful discussions and review of the manuscript. Financial support was provided by NIH grant AI-06587 to the Florida State Board of Health.

SUMMARY

A review of the pertinent scientific and popular ornithological literature leads to the following conclusions:

(1) Mosquitoes appear to be a negligible item in the diet of the Purple Martin.

(2) Behavior patterns of mosquitoes and martins are such that most mosquitoes are not flying in martin feeding areas when martins are active; contact between the two is minimal during daylight hours.

(3) None of the published statements appearing in the popular ornithological literature that attributes a mosquito-feeding habit to the Purple Martin is based on a factual study; the oft-quoted statement "a martin eats 2,000 mosquitoes per day" has no evident means of support.

(4) No evidence exists that any avian species can effectively control a species of insect pest upon which it feeds when that pest is at or near peak abundance.

(5) The Purple Martin is one of our most beautiful and friendly birds. It daily consumes a large number of insects. Its aesthetic qualities alone recommend it highly to man. There is no need to ascribe to the martin abilities greater than those it already possesses in order to encourage its protection and propagation.

## LITERATURE CITED

ALLEN, G. M. 1939. Bats. Cambridge, Massachusetts, Harvard Univ. Press (available in a Dover Publications reprint).

ALLEN, R. W., AND M. M. NICE. 1952. A study of the breeding biology of the Purple Martin (*Progne subis*). Amer. Midl. Nat., 47: 606–665.

ANDREWARTHA, H. G., AND L. C. BIRCH. 1954. The distribution and abundance of animals. Chicago, Univ. Chicago Press.

BATES, M. 1949. The natural history of mosquitoes. New York, Macmillan Co.

BEAL, F. E. L. 1918. Food habits of the swallows, a family of valuable native birds. Washington, D. C., U. S. Dept. Agr., Bull. 619.

BENT, A. C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. U. S. Natl. Mus., Bull. 179: 496–497.

BIDLINGMAYER, W. L. 1964. The effect of moonlight on the flight activity of mosquitoes. Ecology, 45: 87–94.

BIDLINGMAYER, W. L. 1967. A comparison of trapping methods for adult mosquitoes: species response and environmental influence. J. Med. Entomol., 4: 200–220.

BOWEN, T. O. 1937. Some common South Carolina birds and their economic importance to the South Carolina farmer. Clemson Agr. Coll. and U. S. Dept. Agr. Ext. Serv., Bull. 98.

BREELAND, S. G., AND E. PICKARD. 1967. Field observations on twenty-eight broods of floodwater mosquitoes resulting from controlled floodings of a natural habitat in the Tennessee Valley. Mosq. News, 27: 343–358.

BUCKNER, C. H. 1966. The role of vertebrate predators in the biological control of forest insects. Ann. Rev. Entomol., 11: 449–470.

CLEAVES, H. H. 1966. Purple Martins at Lemon Creek. Proc. Staten Island Inst. Arts Sci., 22: 19–23.

CLEMENTS, A. N. 1963. The physiology of mosquitoes. New York, Macmillan Co.

FARLEY, J. A. 1901. Massachusetts bird notes. Auk, 18: 398–400.

FORBUSH, E. H. 1929. Birds of Massachusetts and other New England states. Part 3, Land birds from sparrows to thrushes. Massachusetts Dept. Agr.

GERBERICH, J. B., AND M. LAIRD. 1966. An annotated bibliography of papers related to the control of mosquitoes by the use of fish. WHO/EBL 66.71, WHO/MAL 66.562.

HAUSMAN, L. E. 1931. The swallows, goatsuckers, and swifts of New Jersey. New Brunswick, New Jersey Agr. Exp. Station, Bull. 520.

HORSFALL, W. R. 1955. Mosquitoes: their bionomics and relation to disease. New York, Ronald Press Co.

JOHNSTON, R. F. 1967. Seasonal variation in the food of the Purple Martin, *Progne subis,* in Kansas. Ibis, 109: 8–13.

JOHNSTON, R. F., AND J. W. HARDY. 1962. Behavior of the Purple Martin. Wilson Bull., 74: 243–262.

KALMUS, H., AND B. HOCKING. 1960. Behavior of *Aedes* mosquitos in relation to blood-feeding and repellents. Entomol. Exp. et Appl. (Amsterdam), 3: 1–26.

LAARMAN, J. J. 1959. Host-seeking behavior of malaria mosquitoes. Proc. 15th Intern. Congr. Zool. (1958): 648–649.

LACK, D. 1954. The natural regulation of animal numbers. Oxford, England, Clarendon Press.

MAYFIELD, H. 1964. Yearly fluctuations in a population of Purple Martins. Auk, 81: 274–280.

MCATEE, W. L. 1926. The relation of birds to woodlots in New York State. Roosevelt Wild Life Bull., 25: 7–152.

ROBERTS, T. S. 1932. The birds of Minnesota, vol. 2. Minneapolis, Univ. Minnesota Press.

SPRUNT, A., JR. 1954. Florida bird life. New York, Coward-McCann, Inc. and National Aud. Soc.

SPRUNT, A., JR., AND E. B. CHAMBERLAIN. 1949. South Carolina bird life. Columbia, Univ. South Carolina Press.

STORER, T. T. 1926. Bats, bat towers and mosquitoes. J. Mamm., 7: 85–90.

VAN DEN BOSCH, R., AND V. M. STERN. 1962. The integration of chemical and biological control of arthropod pests. Ann. Rev. Entomol., 7: 367–386.

WADE, J. L. 1966. What you should know about the Purple Martin. Griggsville, Illinois, Trio Manufacturing Co.

WESTON, F. M. 1965. A survey of the birdlife of Northwestern Florida. Tallahassee, Florida, Tall Timbers Res. Station, Bull. no. 5.

WETMORE, A. 1964. Song and garden birds of North America. Washington, D. C., Natl. Geogr. Soc., p. 130.

WIDMANN, O. 1922. Extracts from the diary of Otto Widmann. Trans. Acad. Sci. St. Louis, 24: 1–77.

*Entomological Research Center, P. O. Box 308, Vero Beach, Florida 32960.*