

## STOMACH ANALYSIS OF A GROUP OF SHOREBIRDS

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Aside from scattered reports, the food habits of shorebirds have been very poorly documented. Bent (Bull. U. S. Nat. Mus. 142, 1927; *ibid.*, 146, 1929) lists insects, marine worms, crustaceans, leeches, snails and minnows as comprising the dominant food staples of the shore feeders. Grinnell, Bryant and Storer (The Game Birds of California, Univ. Calif. Press, 1918) are equally general in their analysis of the food habits of this group. Apart from the ornithological interest, knowledge of the feeding habits of shorebirds is necessary in order to determine the extent of predation on invertebrate animals of the marine intertidal zone. Great numbers of migratory birds are present periodically on the coast of southern California. The invertebrate animals of the mud and sand flats and marsh areas undoubtedly are the primary foods of these birds, which appear on the coast in July and reside there until May. Thus the predation is carried on during and after the breeding season of many of the invertebrate forms.

In this study, twenty-seven birds of eight species were collected. Of these, fifteen were taken while feeding on tidewater mud-flats near Sunset Beach, Orange County, California, on May 6 and May 19, 1949. The remainder were obtained while feeding on the sandy beach at Point Mugu, Ventura County, California, on May 8, 1949. The animals were shot and frozen immediately on dry ice and were retained in frozen condition until the alimentary tract was dissected. The stomach and proventricular contents of each bird were preserved in 95 per cent alcohol. Intestinal contents revealed few identifiable body parts of animal prey and thus these were not analyzed.

In the avian digestive processes, soft-bodied animals are almost immediately reduced to fragments, many of which are not recognizable. For this reason, accurate percentage composition data are almost unobtainable. The number of invertebrate individuals comprising the bulk of the stomach contents is often impossible to determine. However, the species forming the predominant food of an individual bird is usually obvious. In most of the shorebirds taken one animal or group of animals dominated the diet of each bird. The proportion of each item in the food mass of a bird has been estimated. The percentage of sand found in the alimentary tract varied from approximately 10 to 60 per cent of the total contents. It was not apparently correlated with species or food habits of the birds.

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*Charadrius semipalmatus*. Semipalmated Plover. One specimen; Point Mugu. Twenty-two distinct individuals of *Emerita analoga*, the sand crab, were recovered. All were immature animals, reaching a length of three to five millimeters. The material comprising the greater part of the food mass was evidently finely ground particles of this decapod. Fragments of several varieties of beetles were present, most of which represented the family Tenebrionidae, or darkling beetles, which are typical of dry, warm regions.

*Charadrius nivosus*. Snowy Plover. Three specimens; Point Mugu and Sunset Beach. In both specimens from Point Mugu, sand crabs were recovered, with fragments of this species comprising about 80 per cent of the stomach contents. Identifiable elytra indicated the presence of beetles of the families Buprestidae, the woodborers, of the Tenebrionidae, the darkling beetles, and of the ground beetles, Carabidae. These three groups of beetles are common near the vegetation of the sand dunes and also in the areas just above the strand, the woodborers often being found in driftwood. The color of the contents was whitish yellow and no algal filaments were noted, indicating little or no mud-flat feeding. The specimen from the mud-flats of Sunset Beach contained fifteen larvae of ephydrid

brine flies, elytra of four ground beetles, and the remains of three unidentified winged insects. Chitinized jaws of seventeen nereid polychaetes were recovered. Undoubtedly this portion of the animal is retained for considerable periods within the gizzard. Three chelipeds of *Pachygrapsus*, the lined shore crab, were also identified.

*Ereunetes mauri*. Western Sandpiper. Seven specimens; Point Mugu. In each individual, by far the most prominent food animal was the sand crab, *Emerita*, which, in all cases, made up at least 75 per cent of the total food mass. The contents of each stomach were ivory-white, indicating little exploitation of mud-flats. Larvae and adults of the shore fly, *Ephydra*, were present in three of the seven stomachs examined. This fly is often found in immense numbers, as adults, swarming over a marshy or water surface, and as larvae and pupae, beneath the water surface or in windrows along the edge of brackish water. Remains of darkling and ground beetles were recovered from two of the birds, while midges or small flies and true bugs were identified in one stomach.

*Crocethia alba*. Sanderling. Two specimens; Point Mugu. Immature sand crabs, *Emerita*, made up the entire food mass in both birds. There was no evidence of predation on any other animals of the marine intertidal zone.

*Limosa fedoa*. Marbled Godwit. Six specimens; Sunset Beach. In five of the six specimens examined, cirratulid polychaetes, most of them identifiable as *Scoloplos* and *Cirriiformia*, were the dominant food item. In these stomachs, nereid and other polychaete types were present in lesser numbers, usually comprising less than one-third of the entire contents. The gizzard of one of the birds was about one-third filled with the polychaete *Cirriiformia*, while the remaining portion was packed with the proglottid strings of parasitic cestodes. The scolices were attached in the small intestine, which, unfortunately, was excised before examination was completed. The proglottid strings penetrated the pyloric valve, the bulk of the body being situated in the stomach. In the other five specimens, from one to ten shells of the small snail *Melampus* were found. This univalve is typical of mud-flat surfaces and is often found in great numbers in this environment. The univalve *Olivella*, and the bivalves, *Donax* and *Pecten*, were each found as minor constituents of one food mass. In one stomach, the predominant food animal was the larvae of the shore fly, *Ephydra*, of which there were 324 individuals in the one bird. Apparently this individual had been feeding along the edges of a wet *Salicornia* marsh or at a point where shallow saline water was in close proximity to vegetation.

*Totanus melanoleucus*. Greater Yellow-legs. One specimen; Sunset Beach. The stomach contents of this bird were made up entirely of the bones, scales, and otoliths of a mud-burrowing fish, family Gobiidae. One hundred and twenty otoliths were present, indicating that at least thirty fish had recently been ingested. The otoliths and vertebrae undoubtedly collect like sand in the gizzard and remain within the stomach for a considerable time, this circumstance accounting for the large number of these remains found. The presence of fish in the diet of the yellow-legs has been reported previously (Bartsch, 1899). It was stated that *Fundulus* was eaten by a single bird to the exclusion of other fare. Although these may be instances of individual preference for a particular food type, the role of shorebirds as predators of shallow water and slough dwelling fish has undoubtedly been underestimated. *Clevelandia ios*, which very probably makes up the greater part of the fragments, is an inhabitant of shallow water and mud and is extremely common in certain restricted localities. The yellow-legs, having longer legs than most other shore birds, has the opportunity of capturing prey at greater depths in the mud and water. Only one other bird used in this investigation, namely the Short-billed Dowitcher, contained fish fragments. It will be necessary to collect specimens of yellow-legs during their fall and winter residence in California to determine the extent of their predation on the gobiid fishes. The possibility of seasonal change of food habits must be investigated.

*Catoptrophorus semipalmatus*. Western Willet. Two specimens; Sunset Beach. Fragments of the shore crab, *Hemigrapsus*, dominated the contents of both birds. This crab is very abundant in the *Salicornia* marshes and on the mud-flats. In its activities as a predator, the shore crab reveals itself prominently and is undoubtedly easy prey for willets and others of the large shorebirds. The defense of these crabs consists of retreat into their elliptical burrows. The efficient hunting of the willets makes this defense ineffectual. The large numbers of these crabs available and their large reproductive potential make them an ideal food animal, which is present in numbers throughout the year. About half of the total bulk of one stomach was formed of fragments of cirratulid sandworms.

*Limnodromus griseus*. Short-billed Dowitcher. Five specimens; Sunset Beach. Nereid and cirratulid fragments together formed the greater portion of the food material of four of the five birds

examined. Spionid polychaetes, often found on sandy areas on rocky shore lines, were found in but one individual. Small gastropods, including *Melampus*, were a minor constituent of three of the stomachs. Shore fly larvae comprised an identifiable portion in but one stomach. Twenty-seven otoliths, representing at least seven individuals of the mud-burrowing goby, probably *Clevelandia*, were recovered from one stomach. While these fish are evidently available to them, the chief foods taken by the dowitcher are polychaete worms, of any of several families.

#### DISCUSSION

The differences in feeding habits of the sand or shore feeding shorebirds and those found on the mud-flats are significant. The birds are, in most instances, adapted to prey on the more common of the available forms. On the beaches, immature sand crabs were by far the principal food item. The season at which these immature decapods are common coincides with the period of the year when the shorebirds are on these southern feeding grounds.

Those birds feeding on the mud-flats existed almost entirely on polychaete annelids. These animals are abundant locally in the soft muds and may be found at all seasons of the year. The reproductive rate of the polychaetes and of the decapod *Emerita* is great. Thousands of young are produced each season. Many factors combine to reduce these numbers and maintain a normal population size. Feeding of the enormous numbers of charadriiform birds probably is one of the more important of these factors.

Small mollusks seemingly are eaten in addition to the basic diet; in no instance were they ingested to the exclusion of other animals. Their infrequency of occurrence in the stomachs as compared with the large number of several gastropod species present on the mud-flats indicates that as a group the mollusks are disturbed very little and are reduced almost insignificantly by predation of these shorebirds.

Insects and their larvae occur in a significant part of the stomachs involved. Especially in the plovers, sandpipers, and sanderlings, which feed over *Salicornia*, and on the perimeter of sand and mud-flats, is this group found prominently. Larvae of the Ephydriidae, a dipteran family, were commonly found. Flies of this family are characteristic of salt and brackish water. The larvae, being relatively sedentary, form large groups, which are ideal food sources for wading birds. In season, these larvae must form a large part of the diet of the inland mud feeders (Fisher, N. Amer. Fauna No. 7, 1893:25-26).

Of importance was the finding of fish in the stomach contents of two genera of shorebirds. Very little has been known or even suspected regarding predator-prey relationships between these two groups. The fact that two individuals out of twenty-seven had eaten quantities of fish indicates that, while not a prominent food habit, the taking of fish could be a significant control of the mud burrowing goby, *Clevelandia*. These small fish are often found in great numbers, but their limited and specialized habitat largely precludes predation by the larger piscivorous fish. They are well protected except from the ciconiiform and charadriiform birds. The former assume a prominent role in predation of fish of the *Salicornia* and mud-flat areas. Predation by the charadriiforms on these same fish has previously been far underestimated. This goby inhabits mud covered with water to a depth which probably protects them from most shorter legged waders.

Predation on crabs, other than *Emerita* is uncommon in the shorebirds examined, except the willets, which apparently feed primarily in the *Salicornia* marshes. The crab taken exclusively by these willets was *Hemigrapsus*, which maintains very large populations in the saline marsh areas.

Algal filaments were found in the food masses of most birds feeding on the mud-flats. Whether they were ingested directly or taken in secondarily as a constituent of the polychaete stomach contents is not known.

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