Feeding methods of the Boat-billed Heron, a deductive hypothesis.—The neotropical Boat-billed Heron, *Cochlearius cochlearius,* has often been assigned to the monotypic family Cochleariidae because of its distinctively wide bill and various features of the skull (Wetmore 1960). More recently, systematists have adopted the view that its bill and unique skull characters are all part of a single adaptive unit, presumably reflecting a different feeding technique (Bock 1956, Cracraft 1967), and therefore place *Cochlearius* in the Ardeidae near the night-herons. Unfortunately no clear descriptions of the natural feeding behavior or diet of Boat-billed Herons are available to explain the suspected specialization. Direct observation of Boat-bill feeding is difficult because of the species' nocturnal habits. New indirect evidence on various aspects of the feeding niche is reported here, suggesting a probable behavioral adaptation that led to the bill's unique shape.

Field studies were conducted in San Blas, Nayarit, Mexico, during July and August 1974. This region was described by Dickerman and Juarez (1971), who showed the onset of breeding in *Cochlearius* to be strongly correlated with the start of the rainy season and consequent flooding of the lagoons where the birds nest. In the present study, stomach contents were examined from 13 breeding adult Boat-bills and 8 Yellow-crowned Night-Herons (*Nyctanassa violacea*). Prey items were identified by Sr. Enrique Lozano, marine biologist of the University of Mexico, who has been studying estuarine ecology of the San Blas region for 2 years.

Only four prey species were found in the 13 Boat-bill stomachs: *Pennaeus vannamei* Boone (common or white shrimp), *Rhynchocinetes* spp. (moya or cock-shrimp), *Gobinellus microdon* Gilbert (a gobiid fish), and *Dormitator latifrons* Richardson (an eleotrid fish locally called "pujeque"). In addition, 11 of the 13 stomachs contained from 1–7 ml of mud. All prey items were approximately the same size: 60–95 mm in total length and 2–4 g wet weight. Individual stomachs held as many as 31 prey items and up to 3 prey species. By contrast the eight Yellow-crowned Night-Heron stomachs contained only one prey type, a large crab (*Callinectes*), and only one of the eight contained mud.

All prey species of *Cochlearius* are specialized for living in the soft mud of estuaries and seasonal lagoons (Lozano pers. comm.). Furthermore all four prey species migrate into the newly formed lagoons as they become flooded with brackish water. The common shrimp enter these lagoons as postlarvals where they grow and molt into juveniles (Saldaña and López 1969). The Boat-billed Herons nest in mangrove thickets in the middle of these same seasonal lagoons.

By late July or early August the lagoons' water level begins to drop. In my study area in 1974, for example, the maximum depth was 90 cm on 8 July and began to decline on 25 July. By 13 August (at which time approximately 20% of the nests had hatching chicks) the maximum depth was only 45 cm, a drop of 50%. This decrease in water depth renders the prey species more vulnerable to the wading Boat-bills and may concentrate prey.

Boat-billed Herons appear to be strictly nocturnal in feeding habits during the nesting season. I saw them away from the colony only at night, when I also heard them calling softly in the mangroves throughout the lagoons. Birds shot at daybreak had stomachs full of fresh, often undigested, food. By contrast I saw Yellow-crowned Night-Herons hunting on the mud flats of the same lagoons at any time of day or night.

As the breeding season of *Cochlearius* (at least in San Blas) is tied to the rainy season, they have little opportunity to use moonlight for hunting. Typically clear daytime skies begin to fill with clouds before sunset and are completely overcast by

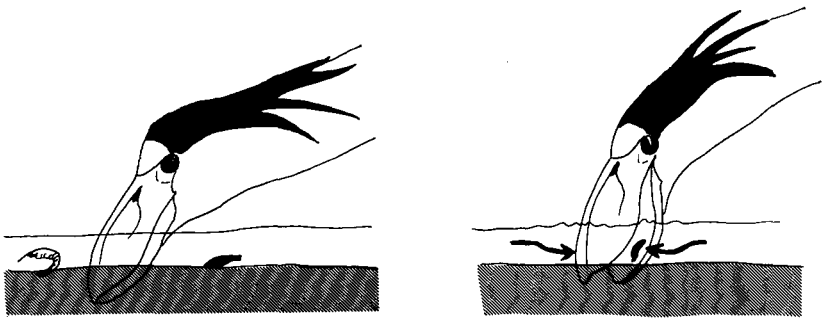

Fig. 1. Hypothetical vacuum action caused by rapid opening of wide bill in *Cochlearius*.

night. On the one exception (a full moon and clear skies until 2300 on 1 August), the Boat-bills did not take advantage of the light: only four birds were found wading at the mangrove edge but many more could be heard calling from deeper in the thickets. Light meter readings taken that night showed that the open, bright spaces offered over 0.032 ft-c, but in the preferred mangrove growth the light intensity was below the meter's sensitivity (0.016 ft-c).

That vision plays an important role in prey capture for *Cochlearius* during the breeding season is unlikely. This is supported by three lines of evidence: (1) The prey species live in soft mud (as shown by the ingested mud and ecological characteristics of the prey species), (2) very little light is available on the cloudy nights of the rainy season when the breeding Boat-bills choose to forage, and (3) the Boat-bills seem to avoid moonlit areas even when they are available, selecting instead dark covered places under the mangroves.

If vision can be ruled out (or relegated to a minor role), then the sense of touch may be the best means of finding prey. The bill of *Cochlearius* seems to be far more sensitive than those of other herons as supported by the following: (1) Boat-billed Herons regularly scratch their bills during comfort activities whereas other herons only rarely do, and (2) Boat-bill pairs commonly perform mutual bill-clappering (*sensu* Hudson 1965) on each others' bills but other known herons do not contact the mate's bill during this display.

These different lines of evidence all point to the likelihood that breeding Boat-bills hunt by touch. What, then, is the advantage of the enormously wide bill? I propose that a bird hunting by touch in soft mud might benefit two ways from evolving a wider bill. First, it would increase the total capturing area of the bill, creating a kind of "catcher's mitt" structure that would improve the success rate for blind grabbing. Second, there is the possibility that a wide bill opened suddenly would create a vacuum to draw water, prey, and mud into the mouth (Fig. 1). Snapping the bill shut immediately would then trap the prey within the "catcher's mitt." One might predict further that the hunting Boat-bill also moves the snapping bill sideways toward the touch stimulus to improve its success.

In summary, evidence from the diet, nocturnal habits, timing of reproduction, environmental characteristics, bill sensitivity, and ecology of the prey species all suggest that *Cochlearius* uses its bill as a special organ to locate and capture small marine prey during the breeding season. The bill is thus considered as a touch-

feeding specialization that evolved as the species shifted its food niche to exploit the ephemeral abundance of marine life in the mud of brackish lagoons. Because feeding structures are subject to particularly rapid evolutionary modification (e.g. Amadon 1950) the bill of *Cochlearius* and the associated changes in skull morphology should probably be given little weight taxonomically, and assigning the species to a monotypic family obscures rather than clarifies its phylogenetic relationships.

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Literature Cited

Amadon, D. 1950. The Hawaiian honeycreepers (Aves, Drepaniidae). Bull. Amer. Mus. Nat. Hist. 95: 151–262.

Bock, W. J. 1956. A generic review of the family Ardeidae (Aves). Amer. Mus. Novitates No. 1779.

Cracraft, J. 1967. On the systematic position of the Boat-billed Heron. Auk 84: 529–533.

Dickerman, R. W., and L. C. Juarez. 1971. Nesting studies of the Boat-billed Heron *Cochlearius cochlearius* at San Blas, Nayarit, Mexico. Ardea 59: 1–16.

Saldaña, H. C., and R. S. López. 1969. Resultados preliminares del estudio ecológico y pesquero de las lagunas litorales del sur de Sinaloa, México. Lagunas costeras, un symposio. Mem. Simp. Intern. Lagunas Costeras. UNAM-UNESCO. Nov. 28–30, 1967. México, D.F.: 653–662.

Hudson, M. J. 1965. Bill-clappering display in the Common Heron *Ardea cinerea*. Ibis 107: 460–465.

Wetmore, A. 1960. A classification for the birds of the world. Smithsonian Misc. Coll. 139: 9–10.

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New avifaunal records from Eniwetok.—We visited Eniwetok Atoll, Marshall Islands, in northeastern Micronesia (approximately 11° N, 162° E) during July 1973. Coincident to fieldwork dealing with the reproductive biology of shorebirds, we obtained three new records for the atoll. The specimens are in the National Museum of Natural History, Smithsonian Institution (USNM). Each islet of the atoll has an original native name plus a military designation (Woodbury 1962). In the discussion below, military names are included parenthetically.

Black-winged Petrel, *Pterodroma hypoleuca nigripennis* (USNM 536588). This species, heretofore unrecorded either at sea or on land in the Marshall Islands, has been observed only as a migrant at sea in the Gilbert Islands (Amerson 1969). It breeds on island groups off the coast of New Zealand and migrates to the north central Pacific during the nonbreeding season (King 1967). Our specimen was found dead on 6 July along a road on Eniwetok (Fred) islet. Apparently