*PISCIVOROUS GASTROPODS OF THE GENUS CONUS**

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Many marine snails are known to feed saprophytically on dead fishes.[1, 2] The observations reported here are believed to represent the first known instances of the attacking, killing, and eating of live fishes by gastropod mollusks. It will also be shown that live fishes are the dominant and apparently exclusive food of one, and probably both, species of *Conus* to be discussed. This paper thus reports on an ecological niche not previously known to be occupied by gastropods.

Feeding Mechanism.—Members of the family Conidae (Prosobranchiata: Stenoglossa) are predacious and feed by injecting a venom into the prey organism with a detachable, dartlike radula tooth (Fig. 1). There are but few reports of the observation of this process in the living animal. Most of our knowledge has been gained from anatomical studies of fixed specimens[3] and from accounts of human injuries inflicted by these snails.[4] A more complete account of the feeding process, based on current studies of the ecology of the group, will be published elsewhere.

Food in Nature.—Fish remains were first discovered in the alimentary tract of a specimen of *Conus striatus* L. from Hawaii dissected by Kondo.[4] Additional fish remains were found in several specimens of this species from Hawaii and Guam dissected by the present author.[5] In each case, however, remains were insufficient to permit identification of the fishes, even to family. No other types of prey organism were found in alimentary tracts of *C. striatus*.

No previous reports are known of fish remains in *C. catus* Bruguière. Examination of alimentary tracts of twenty specimens of this species collected by the author in Hawaii revealed bones, otoliths, scales, and other remains of fishes in nine. The alimentary tract of one contained a discharged radula tooth, and those of the remaining ten specimens were empty.

Three of the fishes were identified as the blenny *Istiblennius gibbifrons* Quoy and Gaimard. Two others are probably *Bathygobius fuscus* Rüppell. The remains of four were insufficient to permit identification.

Feeding of C. striatus in the Laboratory.—Specimens of *C. striatus* have been fed *Kuhlia sandvicensis* Steindachner, *I. gibbifrons* Quoy and Gaimard, and *Entomacrodus marmoratus* Bennett in the laboratory.

Abbreviations: *b* = barbs; *k* = terminal knob; *l* = ligament; *m* = mouth; *p* = proboscis; *rt* = position of radula tooth within proboscis; *s* = siphon; *sh* = shell; *t* = tentacle, which bears the eye.

FIG. 1.—Photograph of radula tooth of *Conus striatus*. Length of tooth, excluding ligament, 10.6 mm.

FIG. 2.—Drawing of *C. striatus* with proboscis extended. External organs labeled.

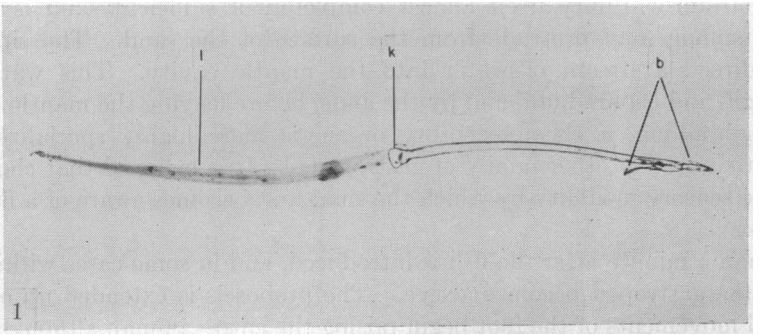
FIG. 3.—Feeding process in *C. striatus*. Proboscis is extended toward fish (*Entomacrodus marmoratus*).

FIG. 4.—Feeding process in *C. striatus*. Proboscis in contact with fish.

FIG. 5.—Feeding process in *C. striatus*. Fish is stung and impaled on ejected radula tooth.

FIG. 6.—Feeding process in *C. striatus*. Fish is drawn into distended buccal cavity.

FIG. 7.—Feeding process in *C. striatus*. Engulfment is complete.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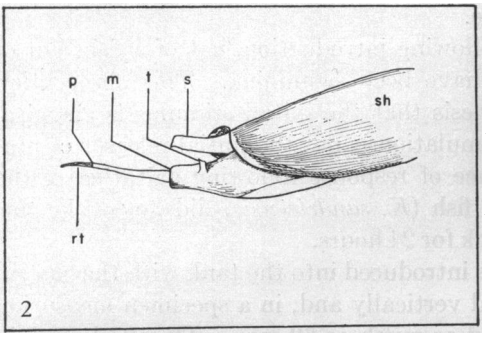
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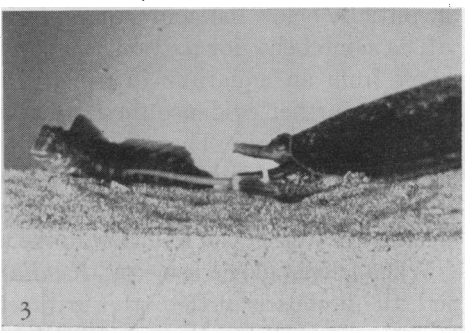
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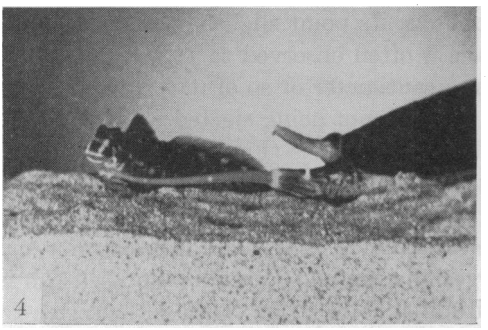
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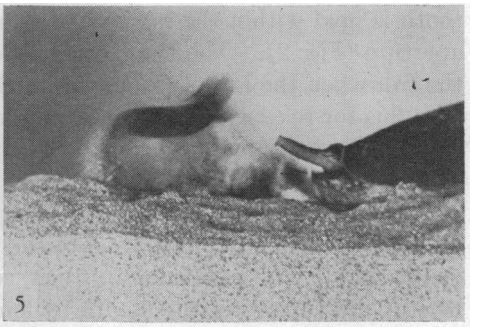
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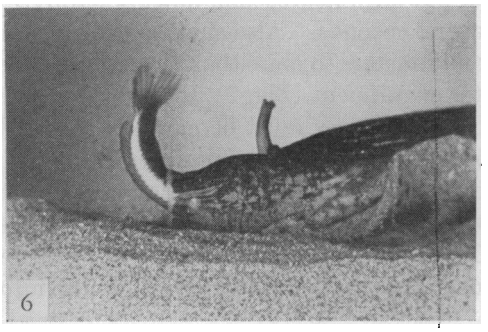
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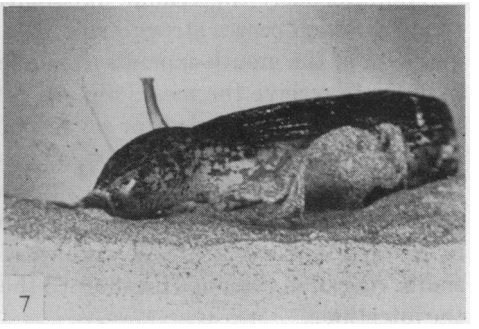
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Conus striatus normally occurs on sandy bottoms, on shallow reef platforms as well as in deeper water, throughout the Indo-Pacific region. A specimen placed in an aquarium will bury itself almost completely if sufficient sand is provided. Only the siphon may protrude from the surface of the sand. The siphon continually directs a stream of water into the mantle cavity. This water passes over the gill and osphradium, and by the anus, before leaving the mantle cavity.

The osphradium, a chemoreceptory organ, is more highly specialized in the Conidae than in any other family of gastropods.[1] It is believed that chemoreception is the sensory modality by which the snail first becomes aware of a fish placed in its tank.

Less than a minute after the fish is introduced, and in some cases within several seconds, the gastropod becomes active. The proboscis is extended up out of the sand, and movements of the foot begin raising the entire animal, although the eyes are initially below the sand-water interface.

The same behavior pattern is noted following introduction, not of a fish, but of water from an aquarium in which fish have been swimming. This observation provides further evidence for the hypothesis that the initial stimulus is chemical rather than visual. That mechanical stimulation is not the initial releaser of proboscis activity is indicated by the absence of response following agitation of the water with a glass rod. Recently killed fish (*K. sandvicensis*) did not evoke this behavior pattern, even when left in the tank for 24 hours.

When a live pelagic fish (e.g., *Kuhlia*) is introduced into the tank with the gastropod, the proboscis of the latter is directed vertically and, in a specimen measuring 115 mm. in shell length, may be extended as much as 60 mm. The single radula tooth is held within the lumen of the proboscis, its point slightly posteriad of the aperture (Fig. 2). The tip of the proboscis is often observed to "track" or follow the fish when the latter swims past within a centimeter or so of it. However, the stimulus for release of the dart is tactile, the dart not being ejected until the body of the fish comes in contact with the tip of the proboscis (Fig. 4).

When injected into the fish, the dart is not completely freed from the proboscis, but its posterior end is held tenaciously within the latter, apparently by circular muscles which contract anteriad of the terminal knob (Fig. 1) at the posterior end of the dart. The radula tooth, then, serves as a harpoon, and the impaled fish is rapidly drawn toward the mouth by longitudinal contraction of the proboscis.

Simultaneously the venom, apparently a powerful neurotoxin, quickly paralyzes the fish, which ceases struggling within several seconds. Also simultaneously, the diameter of the mouth expands from a few millimeters to more than two centimeters in order to receive the meal (Fig. 6). After engulfment (Fig. 7), the buccal cavity remains greatly distended for several hours, as the prey must be partially digested before being passed on to the less extensible regions of the alimentary tract.

In dissecting specimens of *C. catus* which had recently fed, it was noted that fishes in the pharynx and anterior crop were already partially digested. This is in marked contrast to those species of *Conus* which feed on annelids. In these snails, digestion does not begin until the food is pushed from the posterior crop into the intestine.[5]

In order to photograph the feeding process in *C. striatus*, demersal fishes (the blennies *I. gibbifrons* and *E. marmoratus*) were used as prey organisms, since they

would remain more quiescent in the tank. In these cases the proboscis of *C. striatus* was extended along the surface of the substrate (Figs. 3 and 4) rather than vertically, as when a pelagic fish was the potential prey. The feeding process is shown in Figures 3–7 in photographs taken from a 16-mm. moving picture.

The venom of *C. striatus* did not affect the blennies as rapidly as it did *Kuhlia*. Blennies often struggled for a minute or more before breathing ceased and paralysis occurred.

A specimen of *E. marmoratus* 90 mm. in total length was easily consumed by a large (115-mm.) *C. striatus*. A smaller snail (shell length 81 mm.) easily consumed an *E. marmoratus* 85 mm. in total length. A specimen of *E. marmoratus* 100 mm. in total length struggled free, however, after being stung by the larger snail. Movements of the mouth and gills of this fish ceased within 2 minutes, and death followed within 5 minutes of stinging.

In the latter case the fish tore free of the dart, which remained held by the proboscis. In this instance as well as in several in which darts were ejected unsuccessfully, the proboscis, still holding the dart, was rapidly withdrawn into the mouth. Several minutes later the same dart was forced slowly out of the mouth, the process lasting 10–30 minutes. Each radula tooth, then, is used only once. If the prey is successfully captured, the tooth is swallowed with it; if not, the dart is later completely ejected and a new one is moved into place from the radula sheath.

Feeding in C. catus.—This is a smaller, intertidal species, often found on the reef flat in shallow pools isolated by the receding tide. Such pools are commonly frequented by the small blennnies and gobies on which this snail feeds.

In the laboratory, specimens were fed on the goby *B. fuscus*. The gastropods paralyzed and consumed with ease gobies equal to and somewhat greater than their own length (20–30 mm.). The feeding process is essentially identical with that described above for *C. striatus*.

Conclusion.—Two species of the gastropod genus *Conus* have been shown to prey on live fishes as their normal, and probably exclusive, source of food. This represents an ecological niche not previously known to be occupied by gastropods.

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