

A BLOOD-SUCKING SNAIL: THE COOPER'S NUTMEG, *CANCELLARIA COOPERI* GABB, PARASITIZES THE CALIFORNIA ELECTRIC RAY, *TORPEDO CALIFORNICA* AYRES

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ABSTRACT

Feeding habits of the over 200 living species of Cancellariidae are largely unknown. The Cooper's nutmeg, *Cancellaria cooperi*, was seen by divers on the dorsal surface of Pacific electric rays, *Torpedo californica*. *C. cooperi* was observed to parasitize electric rays in the laboratory. The snails made small cuts on the ray's ventral surface and inserted their proboscises into the wounds. Snails were also observed to insert their proboscises into the mouth, gill slits, and anus, as well as previously existing wounds. After insertion of the proboscis, the snails appeared to suck blood from the ray. In Y-maze experiments, the snails actively sought out electric rays, but not other common California bottom fishes. Host location appeared to be by chemosensory means. In the absence of electric rays, snails remained buried in the sand without moving for at least 12 days. Field observations indicate that snails may travel as much as 24 meters in search of rays.

INTRODUCTION

The family Cancellariidae comprises over 200 species of marine neogastropod mollusks inhabiting subtidal and bathyal sand and mud bottoms (Harasewych and Petit, 1982, 1984). Mechanisms of feeding in the Cancellariidae are almost entirely unknown (Harasewych and Petit, 1982, 1984; Petit and Harasewych, 1986). Early workers suggested that the snails feed on "soft-bodied microorganisms" (Graham, 1966; Olsson, 1970), but the snails' radular structure, relatively simple digestive system, long extensile proboscis, and accessory salivary glands are associated with a carnivorous diet (Harasewych and Petit, 1982, 1984). These and other features suggest that they are piercing fluid feeders (Harasewych and Petit, 1982; Petit and Harasewych, 1986). The snails also possess organs associated with distance chemoreception (Harasewych and Petit, 1982, 1984; Kohn, 1983). Previous reports of feeding are limited to single observations of cancellariids found on a bivalve mollusk, a gastropod, and pieces of fish and squid eggs in an aquarium (Cernohorsky, 1972; Talmadge, 1972; Garrard, 1975). Here we report that *Cancellaria cooperi* GABB, the Cooper's nutmeg, parasitizes the Pacific electric ray, *Torpedo californica* AYRES, by sucking the ray's blood. This is the first known report of gastropod mollusks parasitic upon fishes.

MATERIALS AND METHODS

Field observations and collections were made during scuba dives at depths of 20–22 m at an artificial reef ("Torrey Pines #1" Lat 32°53'12"N Long 117°50'50"W; Cali-



fornia Fish and Game Bulletin 45319-800 4-77-20m.OSP). Individuals of *C. cooperi* of 5–8 cm total shell length were collected by hand at a depth of 20.5 m. Snails were maintained in a 120-l aquarium equipped with running refrigerated seawater—about 14°C—with about 8 cm of sand on the bottom. Rays weighing 1.4–9.1 kg were collected with a hand net by the authors or with gill nets by local fisherman. They were maintained in a 1200-l aquarium equipped with running seawater until use in experiments.

For laboratory observations of behavior, snails were placed in a second 120-l aquarium, also provided with running seawater and 8 cm of sand. Rays were placed in this aquarium with the snails. In some cases, rays were first transferred to a 160-l aquarium and anesthetized by the addition of approximately 0.025 g/l of Tricane Methanesulfonate (Crescent Research Chemicals, Paradise Valley, Arizona).

Experiments were conducted in a plastic Y-maze with walls 5 cm high. The base of the 'Y' was 49.5 cm long and each arm was 25 cm long. Seawater from a tank containing an electric ray or other fish was siphoned into one arm, the "stimulus" arm, of the maze at a rate of 0.7 l/min.; seawater from a tank containing no animals was siphoned into the other, "control" arm at the same rate. The stimulus arm was chosen for each trial by a coin toss. The subject snail was placed in an experimental tray at the base of the 'Y' and allowed to acclimate for 3 min. Snails that did not emerge from their shells after 3 min were allowed to acclimate until they did so, up to a total acclimation period of no more than 5 min. By definition, a "response" occurred when the subject snail moved 5 cm into either arm within 30 min following the acclimation period. In positive responses, snails entered the stimulus arm; in negative responses, they entered the control arm. The maze was washed after each trial.

To test the alternate hypotheses that snails locate rays by chemoreception or via the rays' electric field, we performed Y-maze experiments as described above, except that in one treatment—the "ray water" treatment—seawater from a ray's aquarium was transferred by bucket to a reservoir, then siphoned into the stimulus arm of the maze; plain seawater was siphoned into the other arm. In the control treatment, plain seawater was siphoned into both arms of the maze.

Movements by snails in the maintenance aquarium were monitored by placing toothpicks upright in the sand directly adjacent to buried snails and checking the position of the snails relative to that of the toothpicks daily for 12 days. Movements during the intervening periods could be detected because the snails leave distinct trails in the sand.

## RESULTS

During scuba dives, we observed *Cancellaria cooperi* individuals resting on the dorsal surface of partially buried Pacific electric rays (*Torpedo californica*). As many as seven snails were seen on a single ray, and 16 of the 23 individuals of this rare snail which we collected were found in the presence of rays.

When maintained in an aquarium with an electric ray, *C. cooperi* individuals approached the ray and repeatedly touched its surface with extended tentacles. Within a few minutes, the proboscis was extended and used to probe the ray's surface. In most cases, snails made small cuts on the ray, presumably with the radula which is well suited for piercing (Fig. 1), and inserted the proboscis into the resulting wound. Sometimes the proboscis was inserted in the ray's mouth, gill slits, anus, or into open wounds, if already present. The proboscis was usually inserted on the ventral surface of the ray even if the ray was anesthetized and placed on its back. After being inserted, the proboscis appeared to pulsate, as if pumping fluid. This behavior was maintained



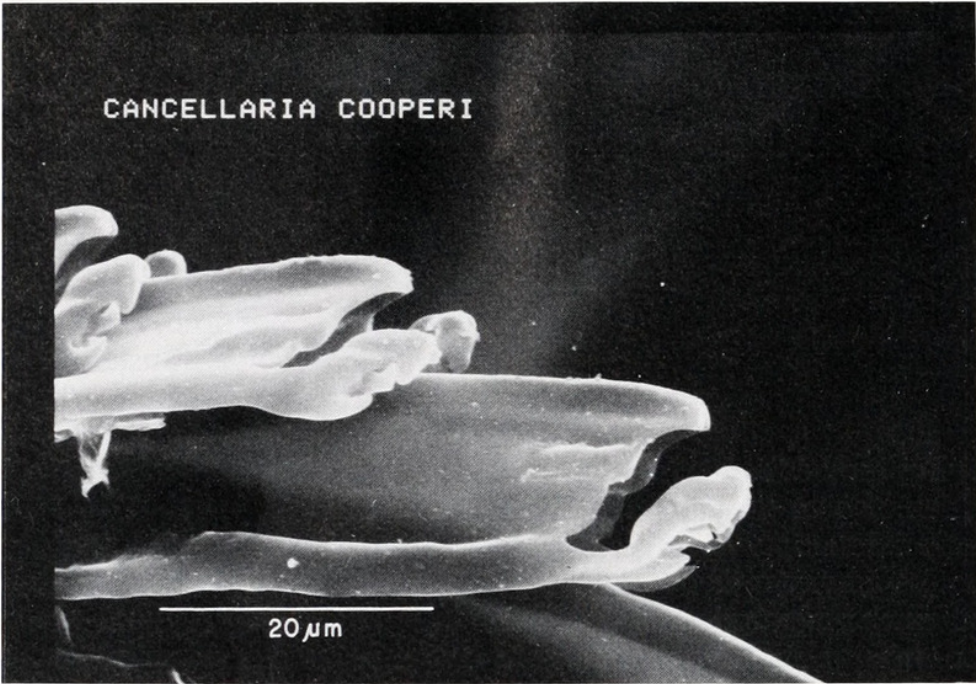


FIGURE 1. Lateral view of the central radular teeth of *Cancellaria cooperi*. Distal end of the radular ribbon is shown. No lateral teeth are present. Scale bar represents 20  $\mu$ m. Scanning electron micrograph courtesy of M. G. Harasewych.

for periods of up to 40 minutes. On a few occasions, snails which were subsequently forced by rough handling to retract into their shells exuded a red fluid which appeared to be ray blood upon microscopic examination. Rays showed no apparent response to the snails' activities.

In Y-maze experiments, snails were attracted to water siphoned from tanks containing rays (Table I). Snails did not approach other benthic fishes common to the habitat (Table II), though recently we observed *C. cooperi* feeding on the angel shark, *Squatina californica*, in the laboratory.

Snails were attracted to ray water even if it was not siphoned directly from the ray's aquarium to the maze (Table III). Snails in the aquarium also moved to a microscope slide which had been scraped over the ray's surface to collect mucus, though

TABLE I

Results of Y-maze experiments with *Cancellaria cooperi*, using the California electric ray, *Torpedo californica* as the stimulus

Snail no.	+	Response NR	-
1	4	2	1
2	2	4	1
3	4	1	2
4	4	2	1
5	4	3	0
Total	18	12	5

There was no significant difference in behavior among snails (rows by columns *G*-test). Positive responses were significantly more frequent than negative responses (two-tailed binomial  $P < 0.01$ ).



TABLE II

Results of Y-maze experiments with various common California bottom fishes used as stimuli

Species	+	Response NR	—
<i>Torpedo californica</i> (electric ray)	21	6	1
<i>Urolophus halleri</i> (stingray)	0	8	0
<i>Platyrrhinoidis halleri</i> (thornback ray)	0	8	0
<i>Eptatretus stoutii</i> (hagfish)	0	8	0
<i>Paralichthys californicus</i> (halibut)	0	8	0

Differences in snail response among fish species are statistically significant (rows by columns  $G = 49.8$ ,  $P < 0.01$ ).

they did not respond when pieces of fresh ray flesh, with skin attached, were placed in the aquarium.

When maintained in aquaria in the absence of rays, snails remained buried in the sand without moving for the entire 12 days of observation, but snails moved at speeds of over  $14 \text{ cm min}^{-1}$  when approaching rays in the maze. In the field, we have retraced the trails left by moving snails for distances of as much as 24 meters from rays.

### DISCUSSION

We conclude that *Cancellaria cooperi* is a specialized suctorial parasite of the Pacific electric ray, *Torpedo californica*, and perhaps of certain other bottom fishes such as *Squatina californica*. Though rare, the snails have been observed on electric rays by other divers (M. Tegner, Scripps Inst. Oceanography, pers. comm.; R. Kiwala, Monterey Bay Aquarium, pers. comm.). Location of rays is by chemosensory means, rather than by detection of the ray's electric field, since snails are attracted to ray water even if not directly connected by siphon to the ray tank. The chemical(s) sensed by the snails are apparently contained in the ray's surface mucus.

The snails probably remain buried in the sand for long periods until rays come

TABLE III

Results of Y-maze experiments with *Cancellaria cooperi* in which seawater from a ray's tank was transferred by bucket to a reservoir, then siphoned into the stimulus arm of the maze; plain seawater was siphoned into the other arm. In control experiments, plain seawater was siphoned into both arms of the maze

Treatment	+	Response NR	—
Ray water	7	1	0
Control	0	8	0

The differences in response between treatments are statistically significant (rows by columns  $G = 15.9$ ,  $P < 0.01$ ).



within chemosensory distance. By minimizing movement, snails presumably also minimize expenditure of energy in the absence of a food supply. The snails are capable of chemoreception over long distances, and can move rapidly to locate the ray once it is sensed. The ray, like the angel shark, is well suited as host for the snails since both fishes commonly remain on the bottom, partially buried, for long periods of time. The ray's apparent lack of response is in keeping with its behavior: Rays often will not respond even when prodded by divers. Furthermore, at least some cancellariids possess a hypobranchial gland which may be involved in toxin production (Harasewych and Petit, 1984). It is possible that the secretions of the hypobranchial gland of *C. cooperi* act as a local anesthetic and/or anticoagulant.

This appears to be the first published report of a gastropod mollusk parasitizing a fish (C. Hickman, University of California, Berkeley, pers. comm.; R. Robertson, Academy of Natural Sciences, Philadelphia, pers. comm.).

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