Observations on the Migration of a Marine Goby Through the Panama Canal

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TABLE 1. SUMMARY OF MERISTIC CHARACTERS OF *Gobiosoma nudum* FROM TWO HABITATS.

	Total Dorsal Elements				
	18		19		20
Pacific	4		21		2
Atlantic			4		1
	Anal Rays				
	9		10		11
Pacific	5		24		
Atlantic	2		2		1
	Pectoral Rays (Left + Right)				
	36	37	38	39	40
Pacific	7	1	9	2	5
Atlantic	1		2	1	1
	Gill Rakers				
	6	7	8	9	10
Pacific	2	9	9	6	4
Atlantic			1	5	

OBSERVATIONS ON THE MIGRATION OF A MARINE GOBY THROUGH THE PANAMA CANAL.—On 20 June 1962 six fish which appeared to be *Gobiosoma* (*Garmannia*) *nudum* (Meek and Hildebrand) were collected from the reef flats at Galeta Island on the Atlantic coast of Panama. This species, previously known only from the Pacific coasts of Panama, Peru, and Costa Rica was distinguished from other members of the genus by the presence of two scales at the base of the caudal fin and a bilobed mental frenum (Ginsburg, 1933; Böhlke and Robins, 1968).

Materials examined: Galeta Island, Atlantic coast of Panama, 6 specimens (8.4–21.1 mm SL) MCZ 42785 collected June 1962; Paitilla Point, Pacific coast of Panama, 45 specimens (13.0–33.5 mm SL) including USNM 81834 (holotype), USNM 81833 (5 paratypes), and CNHM 8461–8467 (7 paratypes) collected March 1912, and 32 specimens taken in April 1962, September 1964, January 1967, and February 1968 deposited in the collections of the Smithsonian Tropical Research Institute Marine Laboratory; Paita, Peru, 1 specimen (31.4 mm SL) USNM 88786 collected October 1926.

Tables 1 and 2 compare the meristic and measurable characters of the Atlantic speci-

TABLE 2. SUMMARY OF MEASURABLE CHARACTERS OF *Gobiosoma nudum* FROM TWO HABITATS.

	N	Range	$\bar{x}$	S.E.
	Standard Length			
Pacific	41	13.0–33.5		
Atlantic	6	8.4–21.1		
	Ventral Length/S.L.			
Pacific	22	25.1–34.2	29.1	0.54
Atlantic	5	28.4–31.2	29.5	0.61
	Body Depth/S.L.			
Pacific	22	18.0–24.2	20.4	0.37
Atlantic	5	18.0–22.0	19.9	0.57
	Caudal Peduncle Depth/S.L.			
Pacific	22	10.6–14.6	12.8	0.23
Atlantic	5	10.4–12.6	11.2	0.17
	Head Length/S.L.			
Pacific	23	28.4–32.8	30.1	0.25
Atlantic	5	29.4–33.3	30.7	0.10

mens with specimens taken from the Pacific coast of Panama. With a single exception, the characters examined suggest there are no morphological differences between the Atlantic and Pacific populations. The number of Atlantic specimens is too small to attach much significance to the apparent difference in caudal peduncle depth. Specimens were examined by C. Richard Robins who confirmed this diagnosis.

The question that arises is whether the six specimens represent an undiscovered population (present since before the rise of the Isthmus of Panama) or a range extension of the Pacific population, possibly through the Panama Canal. Present evidence indicates that the former is improbable.

Numerous collections of western Atlantic (including Panamanian) shore fishes have failed to reveal additional specimens of *G. nudum*. In addition, one would expect some morphological change to have evolved in populations isolated for at least 3–4 million years. There are no "geminate" marine species in the family Gobiidae that are considered identical on both coasts of the isthmus, and of approximately 1000 species of fishes found in isthmian waters, only 12 are considered common to both coasts (excluding circumtropical species) (Briggs, 1967). These factors led us to investigate the more plausible theory of recent immigration.

There are few examples of marine fishes migrating through the Panama Canal. Hildebrand (1939) recorded some Atlantic euryhaline species that were taken from Pacific locks. Rubinoff and Rubinoff (1968) reported the only case of an actual interoceanic colonization known; a large population of the Atlantic goby, *Lophogobius cyprinoides* (Pallas) that had established a breeding colony in the Miraflores third lock lagoon, a Pacific locality. *Lophogobius* is frequently found in brackish water and has been collected from the fresh waters of Lake Forsyth in the Bahamas (Breder, 1932). The ability of this species to tolerate fresh water preadapted it to migration through the Panama Canal by sufficient numbers of individuals to effect colonization. Dawson (1966) collected a number of *Gobiosoma* (*G. robustum, G. longipala, G. bosci*) from very low salinities in Mississippi Sound. However, *G. nudum* has not been reported from brackish waters. We have attempted to determine experimentally the likelihood of *G. nudum* migrating through the Panama Canal.

G. nudum were easily collected from the basalt reefs at Paitilla Point on the Pacific coast of Panama. They were found in burrows occupied by the sea urchin *Echinometra vanbrunti*. Quinaldine, diluted with acetone, was squirted into these burrows to obtain living specimens. The coral reef flat from which the Atlantic specimens of *G. nudum* were collected had many similar burrows produced by a closely related urchin *Echinometra lucunter*. However it was impossible to determine if the six specimens (taken in a rotenone station) had been occupying these burrows. Subsequent collecting with quinaldine applied directly to the burrows of *E. lucunter* failed to produce additional specimens of *G. nudum*.

Adult males and females of *G. nudum* were placed in 150 mm finger bowls containing water recently collected from Lake Gatun. No salinity could be detected in the lake with a Beckman RS5-3 portable salinometer. Control individuals were placed in bowls containing sea water (34‰) collected from the laboratory pier on Naos Island in Panama Bay. All of the specimens placed in fresh water were dead or moribund within 2 hr and none survived 8 hr. Controls in sea water remained in good health. Since the average ship transit through the canal is 8 hr, it would seem that even attached to the underside of a vessel it would be impossible for adult *G. nudum* to survive in fresh water long enough to reach the Atlantic coast.

It is known that some developing teleost eggs are able to withstand broad salinity ranges after the post-gastrular stage (Smith, 1957). Therefore the ability of *G. nudum* to tolerate fresh water while still in the embryonic stage was also tested. Pairs of *G. nudum* were established in 10 gal acrylic aquaria supplied with continuously running sea water (approximately 30‰). Rectangular unglazed tiles were provided as nest sites. When a spawning occurred the tile was removed and half of the attached eggs were scraped off and placed into several 90 mm finger bowls containing fresh water from Lake Gatun. After 8 hr the eggs were removed and returned to bowls of sea water. Controls were incubated in sea water during the entire experiment. All of the bowls received daily water changes and were treated with 20,000 units of potassium penicillin G. On the fourth day after spawning, hatching was initiated in both groups.

A total of 38.5% of the fertilized eggs hatched in the control dishes, while, in the experimental dishes 22.4% of the fertilized eggs hatched. No attempts were made to rear the larvae. Although there was a lower hatching rate in the experimental group, it was meaningful that some of the embryos did survive fresh water conditions and were able to continue development. Therefore it is quite possible that eggs deposited by *G. nudum* among the hull fouling of a ship about to transit the canal would be able to survive and hatch on the Atlantic coast. Although we cannot be certain that this was how our specimens of *Gobiosoma* reached the Atlantic, the ability of certain fertilized eggs to tolerate conditions under which the adult can not survive increases the possibilities of fishes using the Panama Canal as a migratory route.

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