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INTEROCEANIC COLONIZATION OF A MARINE GOBY THROUGH THE PANAMA CANAL

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THE Panama Canal (Fig. 1) represents a potential pathway for the interoceanic dispersal of marine fishes. The fresh waters of Lakes Gatun and Miraflores have, however, effectively maintained the isolation of all but a few of the marine shore fishes which are found on both coasts of the isthmus, those species which are able to cross this barrier are not known to breed on the opposite coast[1].

The neotropical genus *Lophogobius* is represented in Panama by two species, *Lophogobius cristulatus* (Ginsburg) from the Pacific coast of Panama and Costa Rica and *Lophogobius cyprinoides* (Pallas) which is widespread throughout the Caribbean. We report here a breeding population of *L. cyprinoides* in the Pacific, and examine some aspects of this successful colonization through the canal.

The Miraflores Third Lock area (Fig. 2), in which this population was found, is unique in many ways. The Third Locks project was begun by the Panama Canal Company in 1941 in an effort to provide an auxiliary set of locks for the canal. When the project was abandoned in 1943, a large excavation 4,400 ft. long, 300–500 ft. wide and 60–85 ft. deep was left adjacent to the Pacific entrance of the Canal. The excavation was filled with sea water from the nearby canal entrance and with fresh water from run-offs. At present the exchange of water between this lagoon and Panama Bay is maintained only at high tides by means of several underground culverts. As a result of this arrangement the water in the Third Lock is brackish, being about 12‰ at the surface and 18‰ at 50 ft. This is in contrast to the figure of approximately 30‰ in adjacent areas of Panama Bay. The Third Lock experiences only a few inches rise and fall of water level as compared with the Pacific tidal oscillation which averages 16 ft. This relatively low tidal amplitude is analogous to that found on the Atlantic coast where the average tidal range is less than 1 ft. The steep basalt sides of the Third Lock are covered with oyster shells which provide the major habitat for *Lophogobius*. The presence of adherent oyster shells in a non-tidal situation is unusual on the Pacific coast; in most cases, their periodic exposure during low tides renders them unsuitable cover for fishes.

Lophogobius cyprinoides seems to be the dominant species in the Third Lock. Other goby and eleotrid genera, centropomids and lutjanids are sometimes found along the occasional shallow mangrove areas, but only the latter group seem to be present in significant numbers.

Numerous individuals of *Lophogobius* from the Third

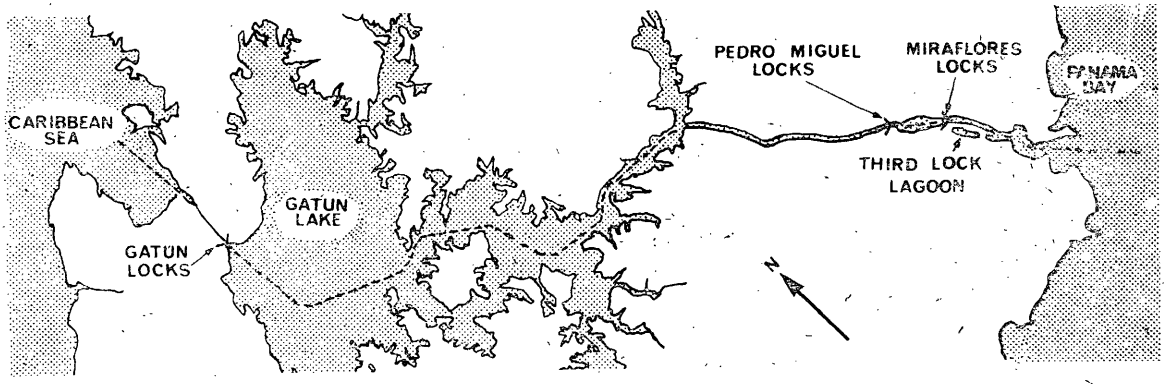

Fig. 1. The Panama Canal. The distance between the Atlantic and Pacific termini is approximately 50 miles.

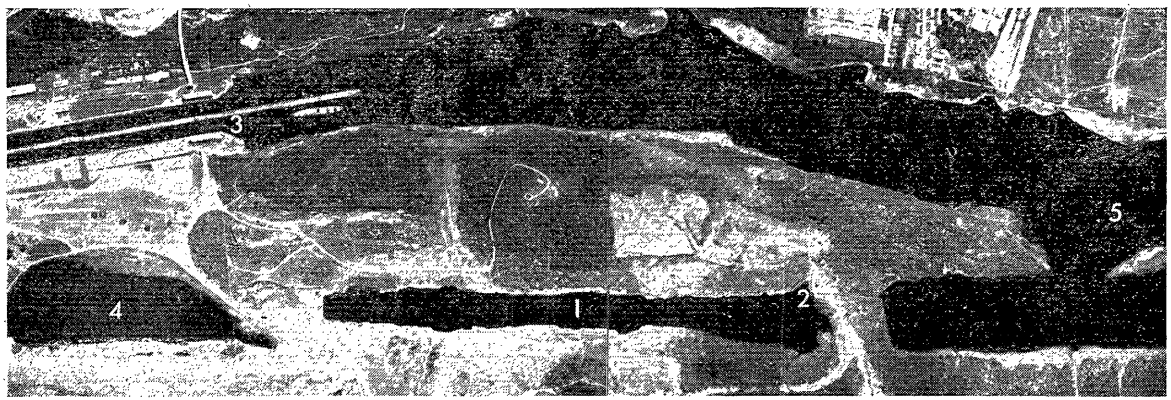

Fig. 2. Mosaic aerial photograph indicating: (1) Third Lock Lagoon; (2) position of underground culverts connecting Third Lock Lagoon with Pacific Ocean; (3) Miraflores Lock; (4) fresh water lake; (5) Pacific terminus of the Panama Canal leading into Panama Bay.

Table 1. RESULTS OF BREEDING EXPERIMENTS WITH PANAMANIAN SPECIES OF *Lophogobius*

Species crossed	No. of pairs examined	Total days paired	No. of spawnings observed
L. cyprinoides × *L. cyprinoides* Atlantic Atlantic	3	167	12
L. cyprinoides × *L. cyprinoides* Third Lock Third Lock	2	90	10
L. cristulatus × *L. cristulatus* Pacific Pacific	7	371	5
L. cyprinoides × *L. cyprinoides* Atlantic Third Lock	5	286	22
L. cristulatus × *L. cyprinoides* Pacific Atlantic	3	311	0
L. cristulatus × *L. cyprinoides* Pacific Third Lock	3	160	0

Lock and Atlantic localities were examined to determine whether any morphological differences existed between the two populations. The evidence indicated that the specimens from both localities constituted one homogeneous population.

Breeding tests were designed to detect the presence of any reproductive isolating mechanisms which could have evolved in these two groups. Control pairs of *L. cyprinoides* from both localities as well as pairs of the Pacific species *L. cristulatus* were established in 10 and 20 gallon aquaria which were continuously supplied with running sea water. Pairs of the six possible combinations between these three populations were also isolated. Fishes were fed minced shrimp and clams daily and each pair was provided with a triangular clay tile nest site. The results of these breeding experiments are summarized in Table 1. All the control groups, particularly those of *L. cyprinoides*, bred freely in the laboratory. All the crosses between individuals of *L. cyprinoides* from the Atlantic and Pacific localities produced frequent spawnings. No spawnings were obtained from the hybrid pairs of *L. cyprinoides* × *L. cristulatus*. This is not surprising because *L. cristulatus* is morphologically quite distinct from *L. cyprinoides*. It does indicate, however, that species of *Lophogobius* are unlikely to spawn indiscriminately when confronted with a no-choice mating situation. The larvae of both control (Atlantic × Atlantic) and experimental (Atlantic × Third Lock) spawnings of *L. cyprinoides* have now been raised past metamorphosis with no apparent differences in viability. It should be possible to determine the fertility of the F_1 generation in order to investigate further the presence of possible incipient genetic differences between the parental and colonizing population of *L. cyprinoides*.

This is the first record of a species of fish passing through the Panama Canal and successfully colonizing the opposite coast. The fauna of this region is not well known, however, and therefore it is quite possible that a careful survey would reveal other similar cases of successful amphi-American migrations. The success of *L. cyprinoides*

in colonizing the Miraflores Third Lock and its failure to colonize other areas along the Pacific coast may be the result of a number of factors. When it was completed, the Third Lock represented an unoccupied habitat with a relatively large area capable of supporting demersal fishes. A euryhaline species such as *L. cyprinoides* was pre-adapted to colonize successfully a brackish water area[2,3]. At the same time the reduced salinity of this area undoubtedly prevented many of the stenohaline species which inhabit adjacent areas of Panama Bay from invading the Third Lock. The lack of competition from other bottom dwelling species, particularly Blennidae and Gobiidae, could account for the dense population of *L. cyprinoides*. In spite of the abundance of *L. cyprinoides* in the Third Lock, the species does not seem to have dispersed further into adjacent Pacific coastal areas. The factor limiting their distribution could be the lack of a suitable unoccupied niche rather than either the inability of the species to adapt to the Pacific environment or the fact that the numbers of individuals are insufficient to constitute a propagule. No indications of any morphological changes or presence of reproductive isolating mechanisms were found, and at present the colonizing population seems to be identical to the parental stock. This is not surprising because the founding population could have been large and only a short isolation period has elapsed. Indeed, it is quite probable that gene flow is still maintained through the canal.

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