

Notes on the Biology of the Goby *Kelloggella cardinalis* (Jordan & Seale)¹

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Abstract—*Kelloggella cardinalis* is a small scaleless goby which occurs in small tidal pools on raised coralline algal ridges and cut benches on Guam, Mariana Islands. It possesses several rows of tricuspid teeth and feeds upon copepods, amphipods, marine insects and their larvae as well as filamentous algae. *Kelloggella* is able to withstand a wide range of salinity and temperature. It also has the ability to leave the water and move over damp substrate to a new location.

Introduction

The goby genus *Kelloggella* is known by four rarely-collected species. *Kelloggella* is distributed through the Pacific on oceanic islands from the Ryukyus to Easter Island, and one species (*K. quindecimfasciata*) has been recorded from the Chagos Archipelago in the Indian Ocean (Winterbottom, pers. comm.). Very little has been recorded of these gobies' life history, behaviour or ecological requirements. *Kelloggella cardinalis* (originally described from Samoa) has been recorded from the Philippines, Guam, Okinawa, Taiwan, the New Hebrides and Tonga.

From February 1971 to July 1973, I was able to make intermittent observations on *Kelloggella cardinalis* while undertaking a study of another group of shallow-water gobiids (*Eviota*) on Guam, Mariana Islands.

Study Area

Kelloggella cardinalis was studied mostly on the reef flat and cut bench area at Taogam Point, below the University of Guam Marine Laboratory, Pago Bay, Guam. Other material was collected at various localities where suitable habitat occurred, including Inarajan, Ritidian Point, Gogna Beach and Amantes Point.

Methods

The fish were observed intermittently from March 1971 to September 1973.

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Specimens were collected at irregular intervals, using a plastic bag to scoop them from the very small pools in which they live. Fish were sexed and measured, and gut contents and gonad condition were analysed. Sizes of fish are standard length (SL). Random 30-cm-square quadrat samples were taken (in conjunction with the *Eviota* study) over the reef flat. Thermal tolerance tests were made using small aquaria and immersion heaters, with a probe to check oxygen levels. Further tests were run using higher temperatures and a larger apparatus (described in Jones and Randall 1973) designed to test coral thermal tolerances. Salinities were taken in the field using a handheld American Optical refractometer.

Description

Kelloggella cardinalis, like other species of the genus, is unusual among gobies in possessing tricuspid teeth (several rows in each jaw with the outer row enlarged), and an elongate gut and in lacking scales. It is a very small slender goby, averaging 19 mm SL. The head and body are compressed, the head especially so dorsally. In large specimens, the snout and interorbital region is very fleshy and quite compressed, giving the appearance of a crest. Hoese (1975) gives counts and measurements in his review of the genus.

Colour varies from a deep greenish black to khaki, with eight paired white spots along the middorsal line (Fig. 1). The head and breast are paler than the rest of the body. The eye is silver with dusky marks above and below the pupil. A series of



Fig. 1. *Kelloggella cardinalis* in a small solution pool. The fish is about 15 mm SL.

blackish spots (which may form a bar) extends below the eye to the jaw. This marking is intensified during stress or aggressive behaviour. The anal fin and both dorsals are orange to scarlet, tending to yellow basally. Both dorsals have a submarginal darker line (which may be indistinct). The caudal is orange to scarlet, with a yellowish margin. The pectorals and pelvics are dull yellow. Generally fish with very bright fins are the blackest in body colour.

General Ecology

Kelloggella cardinalis is patchy in distribution on Guam and found only in particular habitats: in small erosional pools which are formed at the back of the limestone platforms known as cut benches (Tracey et al. 1964) that are developed on many of the cliffs around Guam (Fig. 2), in solution pits formed on large boulders thrown up onto the reef platform or which have fallen from nearby cliffs, and on high coralline algal ridges which form on windward reef flat crests and are usually dissected into small shallow pools (Fig. 3). Similar algal crests may develop at the front of cut benches. All these pools are small (roughly 5–20 cm in diameter) and are honeycombed with cracks and holes formed by vermetid molluscs and other invertebrates. There is generally a thick algal cover of low fleshy species such as *Hypnea* and *Gelidiella*. The boulder solution pools and pools at the back of cut benches are generally almost bare of fleshy algae and support a turf of bluegreen and filamentous algae. This may be because the water in these pools is replenished only at

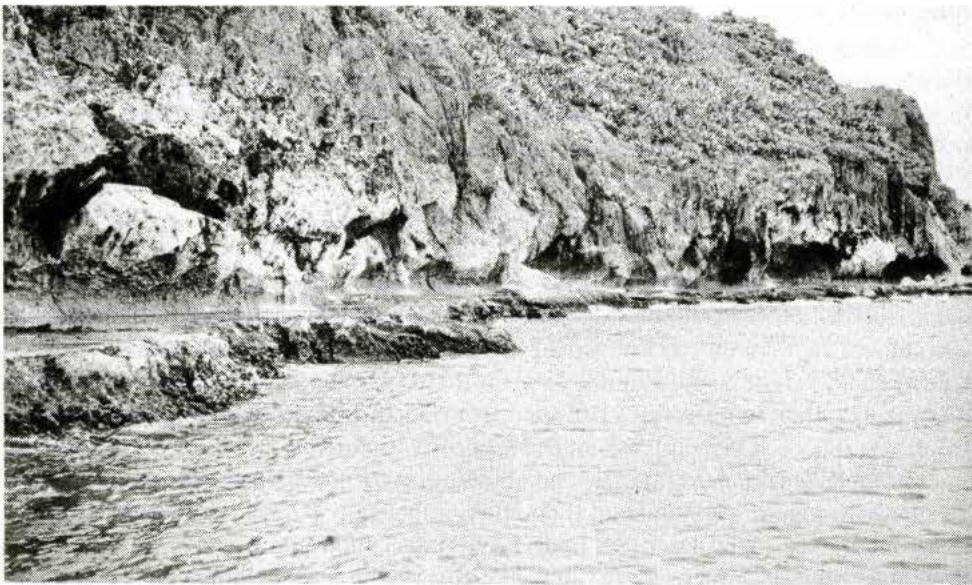


Fig. 2. Cut bench (at Saupon Point) at low tide.



Fig. 3. Pools on reef margin crest in which *Kelloggella* may be found.

high tide and often not at all during times of very calm weather. Temperature and salinity may vary widely in these pools over a very short period of time. *Kelloggella*, together with the blenny *Praealticus natalis*, are usually the only fish found in them. *Rhabdoblennius snowi*, *Eviota saipanensis* and *Bathygobius fuscus* are often found in other pools with *K. cardinalis*.

Kelloggella is not common. It occurred in 3 out of 197 quadrats taken on the reef flat margin and outer reef flat rimmed-pool region and in 9 out of 82 quadrats taken on cut benches. It occurs in patchy groups; if one or two are found in a pool, there are nearly always more in neighbouring pools.

Environmental Conditions and Tolerances

Temperatures encountered by *K. cardinalis* vary according to location of pools (e.g., whether exposed or shaded by an overhanging cliff), amount of solar heating and time of day. Guam reef flat water temperatures range from 27.2° to 33.9°C, with a mean of 29.9° (Jones and Randall 1973), with May to November being the warmest months. Daytime temperatures recorded from pools containing *K. cardinalis* varied from 25° to 35°C. Oxygen levels in these pools varied from 4.46 to 8.79 cc/l.

Kelloggella cardinalis possesses great tolerance for thermal stress. Two lots of 10 *K. cardinalis* kept in experimental thermal tolerance tanks died after 3 hours at 40°C (all fish survived for at least two hours). Of 12 fish subjected to 38°C for 17 hours, three died after 12 hours and two more died over the next 24 hours (during which time the temperature was 29–30°C). Such conditions are extreme and are not likely to

be met within the field. In contrast, of 24 *Eviota saipanensis* which were subjected to 40°C, only two survived for one hour and they both died within the next 30 minutes. Of 24 *E. saipanensis* tested at 38°C for six hours, 16 fish died. (This species occurs with *K. cardinalis* on cut benches and reef margins.)

Salinities on Guam reef flats vary according to tides, weather (both from rainfall and from evaporation on hot days) and seepage from the Ghyben-Herzberg lens. Salinities taken from cut bench pools where *K. cardinalis* was present varied from 19.5‰ to 34‰. Other reef flat pools containing *Kelloggella* had salinities of 34.5‰ to greater than 42‰. One tiny solution pool on a boulder had a salinity of 1.1‰ which increased to 3.9‰ two days later (during very low tides). One *K. cardinalis* (which shared this pool with a fluctuating population of *Praealticus natalis*) was observed from July to December 1972, which meant that it survived a major reef kill during October 1972. This reef kill occurred during a time when the windward reefs of Guam were severely affected by a period of low tides combined with westerly winds and a temporary drop in sealevel (Yamaguchi 1975). Low tides fell to a record -2.3 instead of the expected -0.7 feet. Seas were very calm and the weather was clear and hot, so that organisms of the outer reef flats, cut benches and parts of the inner reef lagoons were almost completely eliminated. Outer reef flats and benches were practically dry; at high tide, water exchange was limited. Thousands of benthic organisms, including forty species of fish, were found dead and dying from 16 to 26 October on the reef flat at Pago Bay by Taogam Point. *Praealticus natalis* and *K. cardinalis* were not found dead, even though they were present in pools containing dead fish and/or dead invertebrates. Temperatures in these pools varied from 36-39°C. Reef flat oxygen levels were anaerobic or 1.46 cc/l when measured on 17 October (Yamaguchi 1975). Most reef flat fish were destroyed in the Taogam Point area but for *Eviota saipanensis*, *E. smaragdus*, *Bathygobius fuscus*, *Rhabdoblennius snowi*, *Istiblennius lineatus*, *Alticus saliens*, *Praealticus natalis* and *Kelloggella cardinalis*. All these species spend their juvenile and adult lifetimes or entire life cycle on the reef platform and must be adapted to withstand high temperatures and some oxygen stress.

Kelloggella is capable of moving over damp substrate from one pool to another, using a blennioid-like wriggling of the body. One fish was observed to leave a drying-up pool and enter a hole 20 mm above the waterline (the hole was covered with water 3 hours previously). The same individual was observed the next day back in the tide-filled pool. Another fish was seen to emerge from a hole above the waterline and drop into the pool below. Two individuals have been observed wriggling among tiny solution pits at the back of a cut bench, their bodies mostly exposed. Another was found wriggling along a fleshy algal mat (on an algal reef crest), completely exposed but seemingly unstressed. This behaviour undoubtedly contributes to the ability of individuals of this species to withstand extreme conditions.

Food Habits

The specialised tricuspid teeth, the simple, somewhat elongate gut and the

restricted habitat of *Kelloggella* suggest that it may have unusual food habits. Few gobies (such as *Stiphodon* and some apocryptines) have tri- or bi-lobed teeth.

Gut contents of 164 *Kelloggella* were analysed for food items. Copepods, algae, ostracods, amphipods, small gastropods, marine midges and their larvae and polychaetes were the most important food items based on the percentage of stomachs containing these items (Fig. 4). Over 58% of the stomachs contained algae (11 contained 95–100% algae), mostly *Microcoleus lyngbyaceus*, *Enteromorpha clathrata*, *Ectocarpus indicus* and *Sphacelaria indica*. These species, especially *Microcoleus* and *Enteromorpha*, are common in the bench rock pools in which *K. cardinalis* is most frequently found. *K. cardinalis* was observed to either pick items from the water column or bite at benthic animals or the substrate itself. When feeding on small

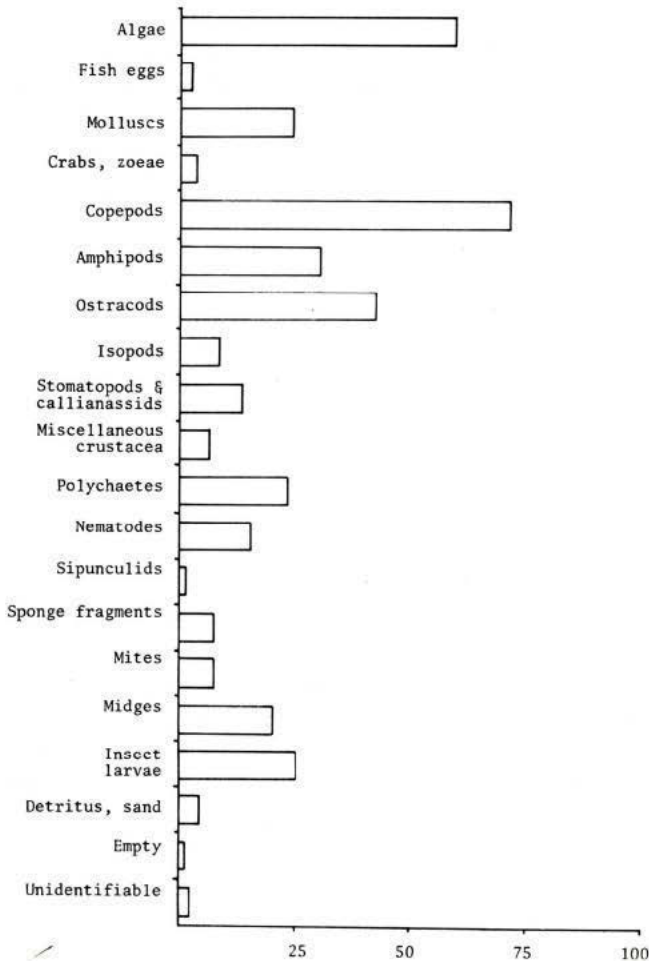


Fig. 4. Percent frequency occurrence of food items from 164 fish.

filamentous algal clumps, the fish would take up to six rapid bites. *Kelloggella* was observed to attack small xanthid crabs; the fish would dart about in front of the crab and attempt to wrench off a leg or claw.

The small goby *Eviota saipanensis*, which often occurred with *K. cardinalis* in algal ridge pools, fed mostly upon copepods with algae taken infrequently (10% occurrence in 557 stomachs examined). An 11.5 mm SL *K. cardinalis* was found in the stomach of a 33.5 mm *Bathygobius fuscus* collected from a raised terrace pool in which very few *K. cardinalis* were seen. No other predators of *K. cardinalis* were observed, although reef herons and shorebirds are also potential predators.

Reproduction

Sex was determined in a total of 171 fish; 107 were females and 64 were males. Juveniles 10 mm SL or less could not be sexed. The smallest mature male was 17 mm; mean size at maturity was 20.9 mm. The smallest mature female was 14 mm; the mean size at maturity was 17.9 mm. The largest male collected was 25 mm, the largest female was 22 mm.

The shape of genital papillae is sexually dimorphic in fish over 10 mm. The male papilla is slender, thin and somewhat pointed (Fig. 5A). The female papilla is short, usually fleshy and bulbous, and the posterior margin has a series of small lobes or folds on it. Occasionally the papilla appears to be folded in upon itself, with a groove or concavity on the ventral surface (Fig. 5B).

Because collecting was sporadic, only forty ripe females were obtained, from February to September inclusive. The greatest number of ripe females per month (six) was during June, July and August. Eggs from ripe females are bright orange, rounded and 0.70 to 0.75 mm in diameter. Twenty-eight ripe females had total egg numbers vaying from 97 to 333, with a mean of 187 eggs. Nests were never observed.

Recently settled juvenile (translucent or pale brown) *K. cardinalis* were not often

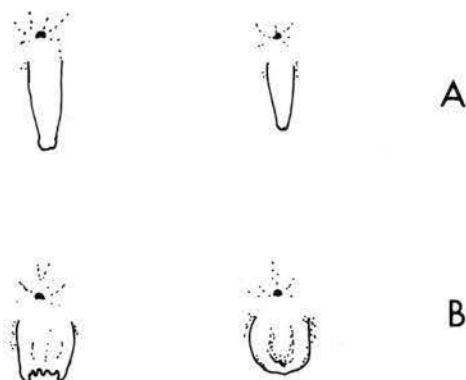


Fig. 5. *Kelloggella cardinalis* genital papillae: A, male; B, female (left is the most common form, right is the "grooved" form).

observed; most juveniles seen were dark in colour with red to orange fin pigment beginning to show. Between 1 and 11 July 1973 (after the October reef kill) many translucent or very light brown juveniles appeared in the Taogam Point reef flat, many of them in boulder solution pools. These juveniles may have been able to survive because of reduced numbers of predators and competitors for food and space (i.e., *Eviota* and *Bathygobius* which cooccurred in the habitat of *K. cardinalis*).

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