A Study Of Territorial Aggression Related To Reproductive State Of Nests Of The Male Garibaldi, Hypsypops rubicunda

Lori Rasmussen
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A STUDY OF TERRITORIAL AGGRESSION RELATED TO REPRODUCTIVE STATE OF NESTS OF THE MALE GARIBALDI, HYPSYPOPS RUBICUNDA

Submitted in Partial Fulfillment of the Requirements for Graduation with Honors to the Department of Biology at Carroll College, Helena, Montana

Lori Anne Rasmussen
March 31, 1980
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1980
This thesis has been submitted for honors recognition to the Biology Department of Carroll College in 1980. The content and format have been approved by:

Dr. James J. Manion, Ph.D.

Dr. Jean Smith, Ph.D.

Fr. Jeremiah Sullivan, S.T.L.
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ABSTRACT

The relative degree of aggressive behavior displayed by territorial male garibaldi, *Hypsypops rubicunda* is studied by placing a *Linckia columbia* near the garibaldi's nest. Males guarding reproductive nests show significantly faster reactions to the presence of a *Linckia* starfish than those guarding nonreproductive nests. Other qualitative observations indicate increased defensiveness of males with reproductive nests. The relationship of these findings to the theory of territoriality is proposed as being primarily related to reproduction.
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INTRODUCTION

Territoriality is an animal's aggressive defense of a defined geographical area. This trait is common to many vertebrates; it is best studied in birds and very well developed in the pomacentrid fishes. Ethologists believe territoriality, like most behavior, is a product of organic evolution. The adaptive significance is fourfold: (1) protection of nest site, (2) provision of food supply, (3) defense of an area for courtship display, and (4) allowance of a place for copulation without interference. (Reese, 1964). It is now generally accepted that this trait has evolved to insure reproductive success; density regulation is probably incidental (Clarke, 1970).

Most species of Pomacentridae exhibit territorial behavior. Hypsypops rubicunda is no exception and the garibaldi's life history is well documented. Unlike the rest of the damselfish, the garibaldi defends not only a nesting site, preventing intrusion during mating and egg development, but also a grazing area and shelter crevice. This territory is guarded all year by the male Hypsypops, not just during breeding season as with most other species.

Data regarding increased aggression while eggs are present in the nest have nearly always been observational and qualitative in nature. This paper, and the research it represents, is concerned with finding any quantitative correlation between the degree of aggression and reproductive stage of the nest.
The garibaldi, *Hypsypops rubicundii*, has vivid uniform orange coloration and bears a prominent bump on its forehead for which it is named. The male and female adults are indistinguishable, but the young experience color changes until they breach maturation. Juveniles are characterized by iridescent blue streaks and spots. The distinct coloration of the garibaldi is due to esters of taraxanthin class xanthophylls (Kritzler, et al., 1950). Biological and evolutionary significance, as well as biochemical implications of the developmental pattern of pigmentation are presented in other works (specifically Kritzler, et al., 1950).

These deep bodied fish vary in length from 8 inches at the onset of sexual maturity to a maximum recorded size of 14 inches (Limbaugh, 1964). Twelve spines and sixteen rays constitute the single dorsal fin.

Garibaldi inhabit the Pacific waters along the coast of Southern and Baja California. They prefer clear waters with rocky reefs and bottoms. Rocks provide crevices for nocturnal shelter and substrata for nests and food. The recorded depths of garibaldi sightings vary from four feet to ninety feet, though they are generally found above the thermocline between four and forty feet (Limbaugh, 1964).

Diet of the garibaldi is speculative at this time, but is generally considered to be poriferans, bryozoans, and anemones.
In the area of this study, described later, neither anemones nor sponges were abundant. However, *Membranipora serrilamella*, a bryozoan, is quite common and is the preferred diet constituent according to Limbaugh.

*Hypsypops rubicunda* is free of natural predators, though potentially predacious species are prevalent. The California sealion, *Zalophus californicus*, has caused the garibaldi to retreat into the rocks, but whether *Zalophus* eats these fish is not known (Clarke, 1970). Spear fishermen and marine aquarists potentially provide a threat, but the garibaldi is now protected by law under the California Fish and Game Department.

External parasites on gills and scales are removed by *Oxjulis californica*, the senorita wrasse. *Hypsypops rubicunda* and *Chromis punctipinnis* are the only pomacentrid fish on the eastern Pacific coast. Both of these damselfish engage in a symbiotic cleaning relationship with the senorita. The schooling *Chromis punctipinnis*, or blacksmith, forms specific cleaning stations at certain places on a reef. *Hypsypops*, however, generally appear to randomly enter a one on one cleaning relationship with the senorita wrasse. Both pomacentrids assume a sharply inclined head downward attitude while the senorita picks at the parasites.

The garibaldi is not a schooling fish like *Chromis punctipinnis*. Some males define and protect a territory, which includes a nesting site, adequate food, and a crevice for retreat. All other garibaldi tend to swim in small numbers of loosely assembled aggregates. They exhibit no schooling behavior. These aggregates swim about six to ten feet off the bottom during the day. At night, they occupy unclaimed
rocky shelters. Females, non-nesting bachelor males, and older juveniles make up an aggregate. The function of such aggregations is unknown but perhaps is related to sexual recognition. It may be that this behavior represents a form of communal courtship, since there is an increase in aggregation preceding the breeding season. (Clarke, 1971).

Nesting males vigorously defend their territories all year against both intraspecific and interspecific attacks. Most fish and some invertebrates will either be chased or removed from the territory. The male garibaldi recognizes no size factor when abolishing an intruder. Aggressive males will even attempt to chase divers from the area although usually they give up quickly. On one occasion, a particularly defensive garibaldi attacked the faceplate of my mask, while emitting a loud thumping noise. This noise is used during protection and mating. It is probably produced with teeth. If unsuccessful at eliminating an intruder, the male will retreat to his crevice to observe. If the intruder is aggressive, the garibaldi will flee. He remains in close proximity until he can safely reoccupy his territory. Each fish follows a specific route for his return if possible (Clarke, 1970).

Garibaldi preferentially attack certain intruding fish. Other adult Hypsypops rubicunda are vigorously attacked should they approach the area. They have even been observed engaging in jaw locking behavior with neighboring territorial males. (Clarke, 1971). Juveniles are tolerated; however, this trend decreases with the increased maturation of the young. Besides other garibaldi, the defending male will always threaten such fish as the black perch, Embiotica jacksoni,
and the opaleye perch, *Girella nigricans* upon their approach. The only quantitative study of garibaldi aggression was related to the number of attacks per unit time on these fish during specific ages of the nest. Other fish are attacked frequently, though somewhat inconsistently; others are completely ignored (Clarke, 1970). Strafish, rocks, holothurians, snails, and debris are removed as well. Many of my observations are consistent with Clarke's and will be discussed later.

Defense and care of a nesting territory by the male is a common trait among pomacentrids. Apparently, *Hypsypops rubicunda* is the only species which guards the area year round (Reese, 1964). Cleaning of a nest site is also standard among this family of fishes and the garibaldi is no exception. In addition to cleaning the site, the male garibaldi somehow promotes an algae growth for the reception of eggs. The algae patch is elliptical in shape, fifteen to forty centimeters in diameter (Clarke, 1970). The nest is a bushy patch of certain red algae. Limbaugh, in 1964, identified three species of rhodophyta common to the nests he studied: *Ophicleidus californicus* in greatest abundance, *Pterosiphonia dendroides*, and *Spermothamnion snyderae*. It is not known whether these occur naturally on the substrate or were in someway put there by the male garibaldi.

Once developed, the nest becomes a permanent structure. It exists not only for the life span of the male currently defending it, but will be used by successive inhabitants. These nests are almost always located on vertically inclined rock faces. I once found a nest at sixty feet which was on a horizontal plane, facing the surface. I tend to agree with Clarke that there is little evidence of an inverse
depth-slope correlation as proposed by Limbaugh, (1964). Slopes may range from $0^\circ$ to $105^\circ$. They are generally always in protected places.

The male begins to prepare the nest for spawning around March. He clears away dirt, debris, and unwanted growth. The algae patch is kept closely cropped to approximately one-half inch. A cleared band surrounding the algae, five to fifteen centimeters wide, may be present. When prepared, the nests are very conspicuous due to the red color and lack of overgrowth characteristic of underwater substrates.

Spawning occurs between May and October, primarily incited by temperature. The ritual as described by Limbaugh, begins when the male challenges a close swimming female. She does not flee from his attack and loud thumping noise, but evasively swims towards the nest. Many such challenges will occur until the female is within one foot of the nest. She deposits the eggs onto the algae patch and the male fertilizes them. The female then departs. A female breeds probably once a season, but each nest may contain more than one clutch of eggs.

The ovoid eggs are attached to the red algae by short filaments. Attachment of eggs by filaments has also been noted in Chromis punctipinnis, whose nest substratum is bare rock. Therefore, since the algae is not necessary for attachment of the eggs, its purpose is suggested to be for signalling the female (Clarke, 1971). When first laid, the eggs are bright yellow, becoming progressively grayer with age. The egg coloration may serve to signify that the male has already bred.

The number of eggs per nest will vary with an average of approximately 129,000 (Clarke, 1970). Morbid eggs are removed constantly by the male during the period before hatching.
Pomacentrid males of the genus *Dascyllus* fan the eggs with their pectoral fins. *Hypsypops* males share this trait. I have observed this characteristic at various times, especially upon the return of a male which had left the nest for defense purposes. Fanning may serve to increase the oxygen tension of the water which is lowered by the increased metabolism of the developing eggs (Reese, 1964). Furthermore, *Hypsypops* eggs will only hatch in the laboratory if agitated (Limbaugh, 1964). No young have survived under laboratory conditions for more than six days.

The eggs hatch in two to three weeks, releasing thousands of larvae into the ocean. Larva specimens can occasionally be obtained in near-shore plankton trawls. The garibaldi exhibit no parental care once the eggs have hatched and the nest is allowed to fall into disrepair.

Transformed juveniles appear from July to November; they are inconspicuous as a result of their blue coloration and cryptic nature. At this stage, they are one-half inch in length and are only found in depths shallower than twenty feet. As the garibaldi mature, the orange fades, the distinctive blue markings disappear, and they inhabit deeper waters. After about five years, the orange brightens into that of mature adults. Garibaldi are sexually mature at six years. Their lifespan lasts twelve to thirteen years minimum and perhaps as long as fifteen to seventeen years (Clarke, 1970). Aquarium raised garibaldi mature earlier. Bachelor males, those without their own territories, quickly occupy territories abandoned by deceased males.
Figure 1: A male garibaldi, *Hypsypops rubicunda* warily watches from inside his territory.

Figure 2: Aggregates of garibaldi vary in number from 2 to 8 individuals and consist of females and bachelor males.
MATERIALS AND METHODS

All observations and data were collected while on SCUBA. Many divers were spent in an attempt to find suitable study sites. When appropriate, reproductive nests were found, they were marked for identification. Strips of white plastic tape were tied to well anchored seaweed clumps near each nest. These were placed about three feet from the nest so that no undue attention would be drawn to the nests. As all three nests existed in very close proximity, the area was marked with a submerged buoy. This buoy was made of a single white bleach bottle filled with fresh water; it was tied to rocks with nylon cord so that it floated six feet off the bottom. This was clearly visible from the surface and was used for anchoring purposes. Compass readings were made from two prominent land markings, position could therefore be determined by their intersection. See study site description for more detail.

The area was then mapped. Measurements were taken with plastic waterproof tape measure and common wood meter stick. Lead weights were attached to the meter stick to prevent floating. Slopes were measured with an inclinometer. The inclinometer was constructed of an inexpensive protractor glued to an underwater slate; a metallic bead chain hung from the center point. Readings were made by position of the chain with reference to the protractor when the edge of the slate was placed against the substrate.
Algae samples were collected from the nests for later identification.

Temperatures were recorded with a laboratory thermometer encased in a plastic tube to prevent breakage. An oil-filled divers depth gauge measured depth. All depth readings were standardized to Mean Lower Low Water.

Sizes of fish studied were approximated by fixing a meter stick next to the nest. Length was estimated as fish swam by this marker. It was undesirable to spear the garibaldi for this purpose.

All data was recorded on high impact plastic slates with soft pencils. An underwater Nikonos system was used with high speed film and natural lighting for all photographs.

The small Asteroidean, Linckia columbia, was the object which elicited response in the territorial males. These were collected on separate dives. Each Linckia was used repeatedly unless retrieval was impossible. Between dives, the starfish were kept in a laboratory aquarium; they were transported to the study site in specimen collecting bottles. Generally, I kept about twelve Linckia available at all times.

Two consecutive dives were made on each day beginning at 10:00 a.m. Each morning, the equipment was placed on the bottom with lead weights in a position from which I could observe two of the three nesting sites. This observation point was somewhat separated from the garibaldi by several stipes of giant kelp, Macrocystis pyrifera. At this time, temperature, visibility, direction of current, and relative strength of surge were noted.
The Linckia was then placed at a specified distance from the edge of one nest. To facilitate quickness, these distances were marked off on a length of nylon cord at two inches, four inches, six inches, twelve inches, and eighteen inches. Reaction time was considered to be from this point to the instance when the garibaldi first touched the starfish. This was measured with a pressurized diving watch with a sweep second hand. Times were recorded to the nearest multiple of five seconds due to difficulty in reading and coordination of my swimming and observation. Removal distance was measured, using the plastic tape measure, from the nest edge to the point where the garibaldi released the starfish. Pathway to and from the nest were also noted.

After retrieval of the Linckia, the same procedures were followed alternating among the three nests. This process would continue for fifteen minutes followed by a five minute break until cylinder air was low. Average length of such a dive was sixty minutes. Another cylinder would then be obtained and the procedure repeated.

Two consecutive experiments were attempted: one dealing with frustration, the second with attempts to lure the garibaldi away from his territory. In the former, the above procedure was followed with two differences. The distance the Linckia was placed from the nest was kept constant and each trial was repeated on the same nest with separation time as short as was physically possible for me to swim to the starfish release site and back.

The final study was qualitative in nature. Crushing open sea urchins causes a feeding congregation among most species of fish
present in the area, including garibaldi. Once while the nest was reproductive and again when non-reproductive, an urchin would be opened about fifteen feet from the nest. The reaction of the garibaldi to the food source and sudden increase in the number of fish in the vicinity were noted.
Figure 3: An opaleye perch is chased from garibaldi's territory by an aggressive male.

Figure 4: A protective male garibaldi removes a Linckia columbia, which was placed near the garibaldi's nest.
STUDY SITE DESCRIPTION

The study nests were found on the northwest face of the Harbor Reef high spot of Santa Catalina Island's Isthmus Cove. *Haligeres* sp. and other vegetation growing on the shallow reef make this area highly visible from the surface. The top of the high spot is at a depth of less than two feet; the surrounding bottom varies, but is twelve feet on the northwest side.

Lionhead Point and Ship Rock, two locally well known landforms serve as compass heading positions. The study site is 280° to Lionhead Point and 343° to Ship Rock.

Covering most of the rocky and bottom surfaces are many red algae including: *Lithothamnion* sp., *Lithothrix aspergillum*, and *Chondria pacifica* are most common. Abundant brown algae species are *Colpomenia sinuosa*, the giant kelp *Macrocystis pyrifera*, and a large bed of *Eisenia arborea*. Other principle bottom organisms represented in the area are *Membranipora sertilamella* and *Rhyncozoan rostratum*, both bryozoans; two species of sponge: *Axinella mexicana* and *Verongia aurea*; phoronid worms, tunicates, and several species of sea urchins. Many other species in this location are typically representative of those found in the Catalina Isthmus on the Channel side.

Current and surge were generally consistent; only two days out of the eighteen days was the surge too strong for working. The surge was fairly strong, due in part to the shallowness of the water.
Experiment was conducted in late August, when temperatures averaged 21° C. Visibility was good owing to the shallow depths and rocky, sandless bottoms. Average visibility was approximately 30 feet or better.

Three nests were studied. Nest A was located four feet from the surface, nestled in a semicircular rock formation, not a crevice. The algae patch itself was partially hidden behind a boulder in the center of this circular formation. The nesting surface was inclined at 90° vertical. The algae nest was irregularly shaped fitting the substrate topography, approximately 8 inches by 18 inches in size.

Nest B was situated at a depth of seven feet, growing on the north wall of a deep crevice. The algae path grew on this surface and part of a rock overhang; the inclinometer readings were 76° and 89° respectively. The nest was circular in shape measuring 13.75 inches by 9 inches.

The third nest, Nest C, grew on the north face of a crevice, covering an area 9 inches by 8 inches and inclined at 90°. This was the deepest site at 3.5 feet.

Each nest had one associated crevice, presumably for the garibaldi's shelter. Crevices were inhabited by many bottom dwellers: urchins, snails, sponges, and cryptic fish such as gobies. The crevice of Nest C was occupied by a California moray eel and a spiny lobster as well. Stipes of *Macrocystis pyrifera* grew in front of the nests nearly obscuring them.
Figure 5: Map of California coast identifying Santa Catalina Island and relative location of study site.
Figure 6: Chart of Catalina Isthmus area identifying study site.
RESULTS

Nests were considered reproductive if eggs were present. At the beginning of the experiment, all three nests had bright yellow eggs. This indicates that they were freshly laid. After two weeks the eggs began to hatch. Three days later, all the eggs had hatched, the nests were empty, and fouling was evident.

The data obtained from the several reaction trials are tabulated in Table 1. Results were combined for ease of analysis into four categories related to nest age and distance the response-eliciting specimen was placed from the nest. All three fish were observed to have preferred pathways to and from their territories. Alternate routes were used only under three conditions: (1) my position, (2) strong surge, or (3) presence of other fish which elicit aggressive response in garibaldi.

The frustration experiment of the garibaldi guarding a reproductive nest was quite surprising. Good data were obtained. The non-reproductive nest's fish would not consistently react. Therefore, no data was really available. This garibaldi was not interested or would be away from the nest for more than three minutes after removal of the starfish from the previous trial. The garibaldi which did react to the rapid succession of trials were observed to chew or mouth the arms of the Linckia. This behavior was noticed only towards the last few of the twenty-five trials.
As the nest aged, the eggs turned from a bright orange-yellow color to a dull gray before hatching. After hatching, small threads of white material remained, which looked like boiled albumen. Fouling of the nest began one day after release of the larvae. The fouled nest is characterized by dirty brown appearance, bushy and unkempt. Catalina gobies, *Lythrypnus dali*, were observed resting on hatched nests, but not on reproductive and well kept ones.

Algae specimens taken from the nest reveal the presence of three rhodophytes. *Trailliella intricata* and *Triffaniella mydeniae* were most abundant. *Falkenbergia hillibrandii* may also have been present, but in such small amounts that positive identification was difficult. However, this red alga often grows associated with *Trailliella*. 
TABLE 1: Reaction time related to distance of response-eliciting object from reproductive nest.

<table>
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<tr>
<th>Distance Linckia is placed from nest</th>
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<th>4&quot;</th>
<th>6&quot;</th>
<th>12&quot;</th>
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<tr>
<td>Reaction time in seconds</td>
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<td>Trial 1</td>
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<td>55s</td>
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<tr>
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<td>15s</td>
<td>30s</td>
<td>20s</td>
<td>65s</td>
<td>40s</td>
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<tr>
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<td>60s</td>
<td>50s</td>
<td>70s</td>
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<tr>
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<td>25s</td>
<td>15s</td>
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<td>Trial 13</td>
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TABLE 2: Reaction time of garibaldi related to distance of response-eliciting object from nonreproductive nest.

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DISCUSSION

To undertake this project, I required many new skills. Two months were spent learning to dive on SCUBA and acquiring knowledge and techniques useful for underwater research. Once familiar with the ocean environment, I became interested in the behavioral characteristics of the garibaldi. A garibaldi removing a *Linckia columbia* starfish was shown to me. I decided to use this natural inhabitant after several unsuccessful trials with other objects, i.e. pencils, fingers, rocks, etc. Several dives were spent searching for reproductive nests. These are nests with eggs present, or before spawning when the nest is clean and prepared. The study was begun in early August, rather late in the breeding season; therefore, nests at this stage were difficult to find. Most had been fouled for some time.

Finally, the three nests were found, each within close proximity of the others. All had eggs attached, but the bright yellow color indicated that they had recently been deposited. Observations and data collections took more than 25 hours of underwater time between August 4 and August 22. At the end of this time, all nest clutches had hatched; the algae was overgrown and dirty. Gobies rested on the bushy vegetation.

Results were obtained when the *Linckia* placement distances were those specified previously. However, for ease and clarity of analysis, two separate classes were used: within six inches of the
algae patch and over twelve inches, for both reproductive and nonreproductive stages.

Statistical analysis consisted of tests for comparison of means for normal distribution. The hypothesis was that at a specific starfish placement distance no difference existed between reaction time of nests at reproductive and nonreproductive stages. A one-tailed test was used to reject the hypothesis if the reaction times are longer for nonreproductive age nests. The 95% significance level has a corresponding statistic of 1.645. Therefore, should the comparison of means between the two nest ages indicate a z value greater than 1.645, one could conclude that there exists a significant difference of reactions for the fish of the two nest ages.

For Linckia position less than or equal to six inches from the nest site, the corresponding z value was 2.16. This indicates that reaction time is significantly longer for garibaldi whose nests have fouled. Surprisingly though, the z value for means comparison of test distances one foot or more is only 0.48, which is quite far from being significant at any confidence level. Therefore, it may be concluded that starfish placed farther from the nest elicit the same aggressive response from the garibaldi regardless of the nesting state. To further test this conclusion, two more statistical tests were executed. For the reproductive stage, comparison of the mean reaction times for close (six inches or closer) and far (twelve inches or more) starfish distances gave a 2.6 z statistic. The same test carried out for nonreproductive age nests provided another significant value of z equal to 1.96. The conclusion, therefore, is that
the garibaldi recognize less of a threat from a starfish this far from the nest and they need not react as quickly.

Experiments concerned with Linckia placement distance and the distance the garibaldi removed the starfish were too inconclusive to be of any use. Many factors contributed to this. Primarily, the presence of other fish near the territory would alter the action of the defensive male and shorten the removal distance. My presence would alter reaction of fish if I was either very close to the territory or in direct line of the garibaldi's return route. On two separate occasions during the study, the current was quite strong. On these days the Macrocystis pyrifera stipes were forced into the crevices of the garibaldi's territories. Because of this, neither Hypsypops nor I could maneuver adequately; the fish would generally remove the Linckia swimming in the direction of the current and return by very roundabout pathways. Fish A, due to the shallowness of the site, was occasionally affected by surge caused by nearby outboards. Inaccuracy of measurement, too, was a big factor. When the garibaldi let go of the Linckia, it would drop through the water column, and therefore the actual release point was difficult to identify as it would move due to surge and current effects.

One of the major problems encountered was minimizing the garibaldi's reaction to me as an observer. I could not swim far enough nor fast enough from the nest and still be able to observe and record data. The final solution worked only because of the shallowness of the study sites. Once I had measured and placed the Linckia in the appropriate position. I would add a slight amount of
air to my buoyancy control device. This inflation caused me to rise to and float on the surface directly above the nest. My presence on the surface created no visible reaction in the garibaldi, and was a perfect vantage point as I never lost sight of the fish. I was also better prepared to make accurate time recordings: I did not have to worry about missing the garibaldi picking up the Linckia while I was swimming. In addition, the decrease in my physical activity increased my air supply and allowed for longer dives and study sessions. For Nest A, the shallowest site, some of the data was gathered free diving with a snorkel.

Using this method, I attempted to study possible frustration in Hypsypops. Primarily I was concerned with the effects that constant intrusion of this nature would cause. By free diving when possible, major factors in removal distance were eliminated. Distances were approximated to save time from measuring, and the Linckia was generally picked up before it reached bottom. Time between trials was generally less than thirty seconds. This experiment was tried on both reproductive and nonreproductive nesting males. No consistent reaction could be obtained from the males whose clutches had hatched. They seemed disinterested after a few trials, swimming off to feed or join an aggregation for a few minutes. If placement of the Linckia persisted, they would then deposit the starfish in a neighboring territory and allow themselves to be chased out. This occurred three times.

Results from the garibaldi of the reproductive nest were interesting. The first trial made the garibaldi remove the starfish
nearly fifteen feet from the nest. By the twenty-fifth trial, the distance had decreased to only three feet. The trend was that the more trials carried through, the shorter the removal distance, as though the fish were in a hurry to return to his territory. Another notable point was direction taken in removing the Linckia. The garibaldi altered his direction after every eight trials, about three times in all.

In conclusion, there seems definite tendencies toward the consternation of the two fish when faced with rapidly repeated intrusion. The garibaldi no longer guarding eggs is definitely more likely to give up than one whose brood has not yet hatched. Also, the latter shows a change in behavior as placement of the starfish continues. This is evidenced by changes in direction, removal distance, and the peculiar previously noted chewing of the Linckia's arm.

In discussing pathways taken to remove the asteroidean from the territory, the garibaldi's route of return should be mentioned. The return path is nearly always the same, even if not the most direct route. If this choice is blocked, for example, by a diver, the Hypsypops male follows the most direct alternative back to the nest. This was substantiated in the literature as well (Clarke, 1970).

The final experiment executed tried to tempt fish from their nests. An opened sea urchin, approximately fifteen feet from the territory, drew large numbers of various species of fish to feed. Garibaldi, whose eggs had hatched, quickly joined the feeding congregation leaving their territory unguarded. On the other hand, males still caring for eggs were slower to leave the nest area and constantly darted back to chase away other fish. These garibaldi left the feeding
site long before most other fish did. They seemed to stay very close to the nest at this time, still threatening fish but not to the length they had previously. The increased population of possible predators seemed to increase the defensive behavior in *Hypsypops* males.

Other observations tended to verify those in the literature. *Garibaldi* consistently attacked the following species whenever they entered into or near the nest and territory: *other Hypsypops rubicunda*; *Pimelometopon pulchrum*, the sheephead; *Paralabrax clathratus*, the kelp bass; *Medialuna californiensis*, the half moon; *Embiotica jacksoni*, the black perch; and *Cirella nigricans*, the opaleye perch. The latter two are also noted by Clarke as always causing defensive behavior in *male* garibaldi, though he classifies the former three as causing frequent but inconsistent attacks. Into this category, I would place *Halichoeres semicinctus*, the rock wrasse, and the senorita, *Oxjulis californicus*. The fish never attacked were *Heterostichus rostratum*, the kelp fish; *Allocinus holderi*; all species of goby present, *Lythriypnus sp.* and *Coryphopterus sp.*; and the blacksmith, *Chromis punctipinnis*.

I also noted that garibaldi would open their mouths wide while apparently extending their gill opercula, when chasing fish from their territory. On occasion the *Hypsypops* would emit a clucking sound during defensive activities, although this behavior was quite infrequent. The latter trait is well documented in the literature by both Limbaugh, 1964, and Clarke, 1971. The former attitude, however, has not been mentioned in any of the literature cited. I would hesitate to call it unusual as all three of the *Hypsypops* studied...
exhibited this frightening image consistently as part of their threat toward intruding fish.

Also observed was the characteristic fanning of the eggs by the garibaldi. They would swim within an inch of the nest and fan the water in front of the eggs with their pectoral fins. This was observed often immediately upon return from removing the Linckia. Perhaps it is a check on what occurred in the nest during garibaldi's momentary absence. In addition to fanning, and not previously noted by researchers, was an occasional precursor to fanning. This ritual began when the garibaldi would chew on some crunchy material like Lithothrix aspergillum, which he would then spit over the eggs. This was followed by vigorous fanning of the eggs. At present, I have no explanation for this behavior.

My observations differed from Clarke's on two points, besides the aforementioned. No jawlocking behavior was noted by any of these three garibaldi. The males would occasionally threaten a neighbor should he inadvertently enter the other's territory, but never was any sort of physical contact made. Secondly, I noted no band of cleared substrate surrounding the algae patch on any nest. Perhaps this is characteristic of those garibaldi farther south or in deeper waters.

Aggregations were noted in the vicinity of the project, usually in groups of two to five individuals. Several juveniles of varying size and age moved in and out of the aggregations. Cleaning situations with the senorita wrasse were common occurrences.

As stated previously, the three possible algae species in these garibaldi nests were: Trailliella intricata, Triffaniella
mydeniae, and possibly *Falkenbergia hillbrandi*, which was not positively identified. The second is in the order Ceramiales. This is the order of alga which contain all of the species identified by Limbaugh. Actually, *Triffaniella mydeniae*, is recent nomenclature for *Spermothamnion snyderae*, a common alga in *garibaldi* nests according to Limbaugh's study.

My observations, therefore, agree with those of previous researchers. *Garibaldi* defend their territory all year, but exhibit increased aggression, proportional to the threat involved, when eggs are present in the nest. This is indicated in the interspecific fish attack study by Thomas Clarke and the *Linckia* studies described here. No indication of behavior trends prior to spawning has been proposed and this would be an important aspect for a rounded outlook on the defending male *garibaldi*'s life history. Hopefully in the future behavior studies will be done earlier in the breeding season to more fully complete the present record. Such evidence as is available tends to suggest that reproduction is indeed the primary function of territoriality, more so than food or shelter. The year long defense insures proper nest upkeep and reproductive success for more than one breeding season.
CLARKE, THOMAS A.

CLARKE, THOMAS A.

CRANE, SHELDON, DENIS L. FOX, CARL, HUBBS, and HENRY KRITZLER.

EBERT, EARL E., and CHARLES H. TURNER.
1962 The Nesting of Chromis punctipinnis (Cooper) and a Description of Their Eggs and Larvae. California Fish and Game Resources 48(4): 243-248.

LIMBAUGH, CONRAD.
1964 Notes on the Life History of Two California Pomacentrids: Garibaldi, Hypsypops rubicunda (Girard), and Blacksmiths, Chromis punctipinnis (Cooper). Pacific Science XVIII (1): 41-50.

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