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Captive Breeding of Banggai Cardinalfish, *Pterapogon kauderni* (Koumans, 1933) for Exit of IUCN Red List

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Abstract: The present study was carried out to assess the reproduction of Banggai cardinalfish, *Pterapogon kauderni* in captive conditions with artificial features for retinue natural resources of this fish. This species has been proposed for listing as Critically Endangered on the IUCN (International Union for Conservation Nature) Red List due to its extremely limited distribution, low fecundity and heavy exploitation by aquarium fish collectors. Endemic to the Banggai Islands off central-eastern Sulawesi, Indonesia. *P. kauderni* has a lunar reproductive cycle, with a major spawning peak during full moon and a smaller peak during the last quarter. Similarly, it has a major juvenile release (settlement) peak at full moon, with a minor peak at new moon. Live food enriched with probiotic and other additives such as omega 3 proximate affects the survival and reproduction of this species.

Key words: *Pterapogon kauderni* · Captive breeding · Red list · Reef fish exploitation

INTRODUCTION

Pterapogon kauderni Koumans, 1933, is an apogonid endemic to the Banggai Archipelago in eastern Indonesia, restricted to an area of less than 10 000 km^2. It usually inhabits bays on the protected side of the larger islands, but some populations inhabit areas of strong surge and moderate stream. It lives in shallow waters less than 4.5m deep, commonly between 1.5 and 2.5 m, in a variety of habitats including branching-coral fields, sea grass beds, and less frequently in open habitats (low branching corals and rubble). *P. kauderni* is sedentary and uses living benthic substrates as microhabitats, including sea urchins (*Diadema setosum*, *Tripneustes* sp.), soft corals (*Nephthea* sp.), anemones (*Actinodendron* sp., *Entacmaea quadricolor*, *Heteractis crispa*, *Macrodactyla doreensis*, *Stichodactyla haddoni*), hard corals (*Acropora* sp., *Anacropora* sp., *Porites* sp., *Goniopora* sp., etc), hydrozoans (*Millepora* sp.) and mangrove roots (*Rhizophora* sp.) [1, 2].

The Banggai cardinalfish, *Pterapogon kauderni*, is extremely attractive in appearance, very hardy in captivity and exhibits an unusual mode of reproduction in that the males incubate their female partner's eggs in their mouth [3, 4]. They make outstanding tank companions with all fish, coral and other marine ornamentals. For these reasons, they have become very popular in the marine ornamental trade [5]. The remarkable rise in popularity of this species since 1995 has begun to raise concerns amongst the various stakeholders in the aquarium industry; currently between 50,000 and 118,000 individuals are collected from the wild and make their way to overseas markets, per month [2, 6].

Certain aspects of the reproductive life history of this fish, such as unusually low fecundity, lack of a pelagic larval phase and strong site attachment are thought to be the primary reasons for this extremely limited geographic range [1]. Even with the use of so-called "nondestructive" collection techniques, a clearly negative relationship is already demonstrated between fishing pressure on

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the density of this fish, on group sizes and even some collateral impacts such as a decrease in density of the long-spine sea urchin, *Diadema setosum*, that the Banggai cardinalfish associates with in the wild [7].

The mounting body of evidence indicates that the natural populations of this species are clearly under threat due to the demands of the aquarium industry. In light of that information, the species has already been informally proposed for placement on the threatened species list [1]. However, simply regulating the curtailment of the collection of wild-caught individuals is not an appropriate solution as the market demand for the species has not diminished, as socioeconomical issues would also need to be addressed. The collectors of the Banggai cardinalfish and for that matter the majority of marine ornamentals originating from Southeast Asia, are typically small-scale fishermen working either alone or in groups to supply a wholesale distribution chain [8, 9]. While these individuals are usually paid very low prices for their products (in Indonesia US$ 0.10/individual for *Amphripion percula* and US$ 0.03/individual for *Pterapogon kauderni*) they are also among the poorest of the poor income wise in Indonesia [5, 9, 10]. Collection of marine ornamentals for market provides a valuable source of income for this group of people.

With an estimated 99% of the marine ornamental products originating from wild-caught sources [9], it is not a wonder that the aquarium industry has attracted much controversy over the sustainability of the industry. While it is still very difficult to accurately weigh the costs and benefits of the marine ornamental industry, remedial actions can already be taken. One of these actions is to develop a means of artificially propagating one target species ultimately resulting in decreased dependence on wild-caught specimens. Artificial propagation would have the added benefit of providing more employment opportunities for coastal fishermen. Relevant production technology for *Pterapogon kauderni* forms the basis for this work.

This paper is not intended to be a repository of all that is known about the Banggai cardinalfish and its culture, but rather an attempt to document a process currently being practiced to commercially produce this species as part of a diversified tropical ornamental fish producing enterprise. It is hoped that the information will be useful to others to create or improve production capacity of this species with the long-term goal of relieving the dependence on wild-caught individuals. The production process described herein is economically viable in tropical and requires little or no sophisticated equipment. It is a semi-intensive process which is forgiving in its day-to-day management and takes advantage of food stuffs produced on site. The technology may also be readily adopted by small family farms in coastal areas throughout the tropics. The present research was embedded in a paper in order to enrich the literature with data on reproduction of Banggai cardinalfish (*P. kauderni*) in captive conditions.

Banggai Cardinalfish: The cardinalfishes of the family Apogonidae are characterized as possessing two separate dorsal fins. The first dorsal fin contains 6 to 8 spines and 8 to14 soft rays in the second dorsal fin. There are two spines in the anal fin and the number of soft rays ranges between 8 and 18 [11]. Males are mouth-brooders with most species being nocturnal, feeding on zooplankton and small benthic invertebrates. This family is thought to be one of the largest families of fishes with about 27 genera and 250 species. The largest genus, *Apogon* (which means without a barb) accounts for the highest number of species in the family. There is, however, only one species, *kauderni*, found in the genus *Pterapogon* and that is the Banggai cardinalfish.

Establishing Broodstocks: In acquiring Banggai cardinals for bloodstocks, it should be made a priority that captive-raised fish should be sought. From experience, it is clear that the cultured individuals easily adapt to a new facility and in the long run were found to be less expensive than wild-caught stocks. Standard size of the mature fish maximum is 55 mm in length and 80 mm long totally; according to the location of the pair. The most characteristic prespawning display was the ‘side by side trembling’ by the female; while the male remained almost motionless, the female, trembling vigorously, approached the male from behind, placed herself alongside him and started inclining outwards from her body’s vertical plane until reaching an angle of about 30°. At this position the male and female’s caudal and anal fins came into contact.

Broodstocks' Tank: Once a compatible pair is found, they readily spawn in captivity as reported by both hobbyist and researcher [4]. Mating pairs are maintained in separate bloodstocks' tanks. Obviously this avoids having to separate mating pairs again, avoids the territorial interactions and eases the monitoring of behavior and reproductive outputs.

Reproducing pairs have been maintained in cages and glass aquaria with equal success. It is thought that the fish probably like the cages, but it makes observation

of the male holding eggs difficult while in a cage as they can only be viewed from above. The smallest volume of the cage or tank that has been tried for holding mating pairs is 15-gal (60-L) or a 2-3ft cage (approximately 60-L). Alternatively, a 29-gal (110-L) aquarium with a partition can be used to house two pairs. A 20-gal (76-L) aquarium works for a single mating pair and a 55-gal (210-L) aquarium with two partitions can be used to house three mating pairs. The partitions are made of plastic egg crate material and a shade cloth covering is used to maintain water movement between the partitions but not to have fishes see their neighbors on the other side of the partition. Without the shade cloth, the males will be preoccupied with making sure the male next door is not trying to invade his area.

Each cage or tank is equipped with an air stone for continuous aeration. Aquaria are supplied with a constant supply of saltwater trickling in from a reservoir that consists of a nearby saltwater pond or large tank. The dilution factor and the macrophyte and microbial community which develop in the reservoir insure that water quality parameters such as ammonia, nitrite and nitrate do not deviate from zero. Using a pond or large tank as a reservoir has one disadvantage in that salinities may vary depending on the amount of rainfall. Salinities have been observed to fluctuate from 18 to 40 ppt without changes in reproductive performance, water temperature between 26 to 28°C.

Spawning: Once adults are large enough to pair off they readily reproduce in captivity [12, 13; 4] under tropical conditions, they will reproduce year-round as long as they receive a suitable diet; this topic will be covered in a later section. The actual spawning has reportedly taken place at night [13] and also during the daytime hours, e.g., 10:00-15:00 o'clock [4]. As with other apogonids, the spawning event is preceded by several hours of elaborate courtship behaviors, that will be described elsewhere [4, 14, 15]. The courtship activities during actual spawning of *P. kauderni* that were observed and videotaped occurred between 13:00-15:00 o'clock [4]. As described by Vagelli [4] egg release and transfer was completed when both individuals were in very close proximity with each other (within one to two cm) and within a few centimeters above the bottom of the tank. At the time of spawning the male was usually situated ahead of the female and when approximately three-quarters of the egg mass was protruding from her body the male would turn and quickly gulp the clutch of eggs and pull them from the female. Although it has yet to be observed, it is assumed that sperm release must take place before the eggs were taken by the male as the egg mass when removed from the male's mouth a couple of hours after the spawning event are fertilized. The transfer of eggs from female to male occurs very rapidly, taking place within one to two seconds. It is reported that the removal of the eggs from the female requires a bit of pulling and not the entire eggs end up in the male's mouth, so it is common to see several eggs fell to the bottom of the tank. Between 10 and 20 eggs are reportedly lost during the egg transfer process. A male Banggai cardinalfish holding eggs in his mouth is easily distinguished from others by the distended (puffed-out) jaw line and the fact that he suddenly becomes reclusive and refuses to eat when offered food.

Fecundity: The size of the egg mass varies with the size (and probably condition) of the female. One egg mass which was removed from the male and examined was found to consist of 40 eggs averaging 3.0-mm in diameter which is consistent with previous reports [4, 16]. Each egg had a strong fibrous attachment to a stringy matrix. These attachments keep the egg mass intact and the entire mass can be teased or rolled about under water without dislodging any eggs. It is not known whether these attachments persist until hatching, but it helps to explain how the male can keep the eggs in his mouth while simultaneously providing them with enough movement to insure they are properly aerated.

Larval Development: Larval developmental stages leading up to hatching have been thoroughly described by Vagelli [4] and will not be presented here. In summary, development of the larvae takes place over the course of 19 to 20 days at which time hatching occurs. However, the larvae are not immediately released into the water column after hatching but remain in the male's mouth for an additional six to ten more days. If hatched larvae are expelled prematurely, they are not capable of swimming and generally exhibit slow growth if they survive. Premature juveniles have never been observed in the wild [2]. Normal release of the juveniles occurs at night over the course of one to three days. One must remain vigilant during these crucial days, as after the last offspring is released, the male may attempt to eat the juveniles. The mating pair may spawn again in five days or up to several weeks and the whole process is repeated.

Release of Juveniles: Upon release from the male's mouth, the juveniles are approximately eight-mm in standard length (SL) with most of their yolk already

utilized. The number of offspring per release ranges from one to 50 individuals and the number of offspring is positively correlated with brood stock size. Just after release from the male the offspring will immediately seek shelter. In the wild, the preferred shelter appears to be among the spines of a sea urchin belonging to the genus *Diadema*. There are several reports of using a facsimile of a sea urchin in aquaria to attract the offspring and protect them from predation by larger fishes [13]. Artificial "urchins" can be made using 1-1/2-inch or 2-inch PVC pipe caps and solid plastic wire. Fifty to seventy holes are drilled in the top of a cap and a six to eight-inch piece of plastic wire is inserted into each hole and secured with a dab of hot glue inside the cap. Alternatively, plastic weed-whacker line can replace the plastic wire. It has been found that the weed-whacker line is a little more flexible and the "spines" stick out better. When using this type of material, cut the line twice as long as the desired length of a spine. Thread the line down one hole and back up another hole. In that way there is no need for glue to hold it in place. One disadvantage, from an aesthetic point of view, is that the weed-whacker line currently is not produced in a black color. At any rate, this does not seem to bother the juveniles with regard to using the artificial urchin as a shelter.

Larval Nutrition: Newly released offspring is able to eat relatively large prey like rotifers and brine shrimp nauplii [4, 13]. Whenever possible, enrichment of rotifer or *Artemia* nauplii with Omega 3 and probiotics would be effective [17-20]. Once released from the male, the offspring actively seek their prey and are proficient hunters. In six weeks they grow to about 15-mm SL. In four to five months they will be ready for market. Although already widely understood, it should be re-emphasized that growth rate is largely influenced by water temperature. There is a distinct winter season where grow-out may take several weeks longer than during the summer months.

It should be noted that the mesh openings in the grow-out cages are 1.5-mm. From experience we have found that even when the mesh is partially fouled by algae and detritus, there is sufficient free flow of water into and out of the cage caused by the water movement generated by the aeration from the air stone in the cage. Zooplankton also flow into the cage and will be quickly consumed by the young Banggai juveniles. With good pond management and barring any catastrophes such as stormy weather there will always be sufficient zooplankton to support good nutrition and rapid growth. In many cases, no other sources of feed are necessary until the Banggai individuals are "large" juveniles. From that point on and until they reach market size they are provided a diet of live feeder guppy fry.

RESULT AND DISCUSSION

Using the cage grow-out system, survival has averaged 88% from time of release of juveniles from the male to market size which varies between 125 and 130 days. In some cases, all of the offspring survive to market-size. the best source of production data on the Banggai cardinalfish was from Marini [12], who raised Banggai offspring in indoor aquaria on enriched brine shrimp nauplii and weaned them to adult brine shrimp and enriched ghost shrimp (*Palaemonetes* sp.). Marini reported survival rates averaging 66% at 100 days. Survival from intensive larval rearing experiments under laboratory conditions that assessed the impacts of using enriched versus non-enriched *Artemia* reported average survival of 95% over a 116-day grow-out period [16]. Clearly the prototype system developed at Rain Garden Ornamentals is consistent with laboratory scale outputs and is felt to be competitive in commercially producing this specie. Its greatest asset is that it minimizes the day-to-day labor costs and incorporates the advantages of the extensive culture system (e.g., natural productivity to produce food).

There are opinions that marine resources were not exploited enough [21]. Even if they be right in part (algae, minerals, water etc), the exploitation of marine ornamental fish from the wild would lead to the over exploitation of the coral seas [22]. Uncontrolled fishing for trade or even for scientific purposes may have unpredictable effects for the aquatic ecosystems [23]. The indiscriminate methods of capture or collection can damage the coral reef ecosystem, which provides the microhabitat requirement for the recruitment of the different species of coral reef fishes. By scientific cooperation and international experience exchanges, under the most recent educational concepts [24], using the present technologies of natural feeds production and water quality control [25-27], cardinalfish (but also many other marine species) can be breed in captive conditions for commercial purposes and it can be helpful for wild life conservation [28, 29]. The breeding and rearing of Banggai cardinalfish is promising due to the production of large eggs and larvae, frequent spawning in captivity and the hardy nature of the fish. Dufour [30] showed that many millions of fish are 'caught' worldwide and that the export of 100,000 ornamental fish would bring approximately 200,000 U.S. dollars in business.

CONCLUSION

This species can be breed in vast number and exported to all over the world. The tolerance of this species to environmental factors change makes this fish the best between other cardinal fishes and the variation color either improved their attention. Ability to breeding in different conditions, most important characteristics of this species for commercial production and prevent fishing. Live food is the most important factor in production of this species and enrichment of their live prey with probiotcs improve the nutritional value of fish's diet.

REFERENCES

1. Allen, G.R., 2000. Threatened fishes of the world: *Pterapogon kaudneri* Koumans 1933 (Apogonidae). Environ. Biol. Fish., 57: 142.
2. Vagelli, A.A. and M.V. Erdmann. 2002. First comprehensive ecological survey of the Banggai cardinalfish, *Pterapogon kaudneri*. Environ. Biol. Fish. 63: 1-8.
3. Tullock, J., 1999. Banggai cardinalfish alert. Aquarium Frontiers. http:// www.aquariumfrontiers.net/ Environmental Aquarist//html.
4. Vagelli, A.A., 1999. The reproductive biology and early ontogeny of the mouth brooding Banggaai cardinalfish, *Petrapogon kauderni* (Perciformes, Apogonidae). Environmental Biology of Fishes, 56: 79-92.
5. Michael, S., 1996. The Banggai Cardinalfish: A newly available species that may become to popular for its own good. Aquarium Fish Magazine, 8(8): 86-87.
6. Lunn, K.E. and M.A. Moreau, 2004. Unmonitored trade in marine ornamental fishes: the case of Indonesia's Banggai cardinalfish (*Pterapogon kauderni*). Coral Reefs, 23: 344-351.
7. Kolm, N. and A. Berglund, 2003. Wild populations of a reef fish suffer from the "Nondestructive" aquarium trade fishery. Conservation Biology, 17(5): 910-914.
8. Green, E., 2003. International trade in marine aquarium species: Using the global marine aquarium database. In: J.C. Cato and C. L. Brown (Editors). Marine Ornamental Species: Collection culture and conservation. Iowa State Press, pp: 31-47.
9. Olivier, K., 2003. World trade in ornamental species. In: J.C. Cato and C. L. Brown (Editors). Marine Ornamental Species: Collection culture and conservation. Iowa State Press, pp: 49-63.
10. Hemdahl, J., 1984. In defense of current marine fish prices. Freshwater and Marine Aquarium, 7(9): 56-58.
11. Nelson, J.S., 1994. Fishes of the world. 3rd ed. John Wiley & Sons, Inc., New York, pp: 600.
12. Marini, F., 1998. Frequently asked questions and answers on Banggai cardinals. Reef. Org. archives. http://www.reefs.org/library/article/f_marini.html.
13. Marini, F., 1999. Captive care and breeding of the Banggai cardinal fish "*Pterapogon kauderni*". http://www.reefs.org/library/talklog/f_marini_020799.html
14. Kuwamura, T., 1983. Spawning behavior and timing of fertilization in the mouth brooding cardinalfish *Apogon notatus*. Japan. J. Ichthyol., 30: 61-71.
15. Kuwamura, T., 1985. Social and reproductive behavior of three mouth brooding cardinalfishes, *Apogon doederleini*, *A. niger* and *A. notatus*. Env. Biol. Fish., 13: 17-24.
16. Vagelli, A.A., 2004. Significant increase in survival of captive-breed juvenile Baggai cardinalfish *Pterapogon kaudneri* with an essential fatty acid-enriched diet. J. World Aqua. Soc., 35(1): 61-69.
17. Jafaryan, H., M.M. Taati and N.M. Makhtoumi, 2010. The effects of probiotic bacillus for promotion of growth and feeding parameters in beluga (*Huso huso*) larvae via feeding by bioencapsulated Artemia. AACL Bioflux, 3(4): 273-280.
18. Sahandi, J. and H. Jafaryan, 2011. Rotifer (*Brachionus plicatilis*) culture in batch system with suspension of algae (*Nannochloropsis oculata*) and bakery yeast (*Saccharomyces cerevisiae*). AACL Bioflux, 4(4): 526-529.
19. Olivotto, I., M. Di Stefano, S. Rosetti, *et al,* 2011a. Live prey enrichment, with particular emphasis on HUFAs, as limiting factor in false percula clownfish (*Amphiprion ocellaris*, Pomacentridae) larval development and metamorphosis: Molecular and biochemical implications. Comparative Biochemistry and Physiology A-Molecular & Integrative Physiology 159(3):207-218. DOI: 10.1016/ j.cbpa.2011.02.004
20. Divya, S.P., T.T.A. Kumar, R. Rajasekaran, *et al*, 2011. Larval rearing of clownfish using *Brachionus plicatilis* rotifer as starter food. Scienceasia 37(3):179-185. DOI: 10.2306/scienceasia1513-1874.2011.37.179
21. Doroftei, E., M.M. Antofie, D. Sava and M. Arcus, 2010. Cytological features of some macrophytic algae from Mediterranean Sea. Annals of the Romanian Society for Cell Biology, 15(1): 316-323.

22. Harsan, R. and I.V. Petrescu-Mag, 2008. Endangered fish species of the world – a review. AACL Bioflux, 1(2): 193-216.
23. Pricope, F., K.W. Battes, D. Ureche and I. Stoica, 2004. The method of monitoring ichtiofauna from the natural and anthropic aquatic bassins (pools). Studia Universitatis Vasile Goldis Arad, Seria Stiintele Vietii, 14: 27-33.
24. Darabaneanu, I., 2004. Textbook for educational ichthyology (Project)]. Studia Universitatis Vasile Goldis Arad, Seria Stiintele Vietii, 14: 167-168.
25. Raja, P., S. Velmurugan, M. Natarajan and S. Rajagopal, 2009. Evaluation of the microbial population from recirculating marine aquarium. AES Bioflux, 1(1): 55-63.
26. Sugumar, V., 2010. Reproduction in the brine shrimp artemia leach, 1819 (Branchiopoda, Anostraca) from South India: Laboratory cross fertility tests and mating behavior. North-West J. Zool., 6(2): 162-171.
27. Dragos, N., V. Bercea, A. Bica, B. Druga, A. Nicoara and C. Coman, 2010. Astaxanthin production from a new strain of *Haematococcus pluvialis* grown in batch culture. Annals of the Romanian Society for Cell Biology, 15(2): 353-361.
28. Rhyne, A.L., 2010. The importance of open access in technology transfer for marine ornamental aquaculture: The case of hobbyist-led breeding initiatives. AACL Bioflux, 3(3): 269-272.
29. Olivotto, I., M. Planas, N. Simões, G.J. Holt, M.A. Avella and R. Calado, 2011b. Advances in breeding and rearing marine ornamentals. Journal of the World Aquaculture Society 42:135–166. doi: 10.1111/j.1749-7345.2011.00453.x
30. Dufour, V., 1998. Marketing survey of aquarium fish and their exploitation in country islands. Marine resources and marketing. Bull CPS, 2: 6-11.