Interaction Between Cleaner and Host: The Black Porgy Cleaning Behavior of Juvenile Sharpnose Tigerfish, *Rhyncopelates oxyrhynchus* in the Seto Inland Sea, Western Japan

Toshihiro Shigeta
Hironori Usuki
National Research Institute of Fisheries and Environment of Inland Sea (F.E.I.S.)
2-17-5 Maruishi, Oono
Hiroshima 739-0452
JAPAN
Email: shigeta@fra.affrc.go.jp

Kenji Gushima
Faculty of Applied Biological Science
Hiroshima University
1-4-4 Kagamiyama, Higashi-Hiroshima
Hiroshima 739-8528
JAPAN

Abstract

The cleaning behavior of a juvenile sharpnose tigerfish, *Rhyncopelates oxyrhynchus* was first observed in the fishing port of Hiroshima Bay in the Seto Inland Sea, Japan. In the port, only five fishes including the black porgy *Acanthopagrus schlegeli* recognized the cleaner and posed. Among these, four were inspected and picked by the cleaner. From both the cleaner and the host respects, the cleaning behavior was divided into three parts: the start of cleaning, the formation of a shoal and the termination of cleaning. From the host side, before the start, the host's soliciting behavior consisted of four parts; detection, recognition, approach and the pose to the cleaner. From the cleaner's side, before the start, the cleaner inspected a host on its body surface.

In particular, a series of black porgy soliciting behavior was investigated in detail. It consisted of four consecutive parts. The host aggregated 0.5-0.8 m apart. The aggregated black porgies were each 10-50 cm in total length (TL). The cleaners were 10 cm $\pm$ 1 SD in TL. No signal behavior from the cleaner for its host to start cleaning was observed. After the cleaner had picked against the host several times, it moved serially to other individuals. Cleaners were not observed to clean hosts smaller than themselves. Cleaning stations were formed in several places located along cleaner foraging migration routes. They were located 0.7 m $\pm$ 0.5 SD in depth on sand-mud or artificial concrete bottoms.

At least thirty-four cleaner fishes, including *R. oxyrhynchus*, were noted as living in Japan.

Introduction

Cleaning symbiosis is a well-known phenomenon among marine fishes (Losey *et al.*, 1999). The cleaners feed on ectoparasites and other material from the body surface of cooperating hosts. During cleaning the host displays a stationary pose. It is assumed that cleaning behavior exists in almost all aquatic environments (Helfman *et al.*, 1997). There has been little study on the behavior of fishes in the sea around Japan, except for the cleaning wrasse *Labroides dimidiatus* which is often used to control ectoparasites on fish exhibited in aquariums (Kuwamura, 1976; Chikasue, unpublished data [1]; Ueharako, unpublished data [2]).

In July 2000, in a fishing port in the Seto Inland Sea of Western Japan, we found that a juvenile sharpnose tigerfish, *Rhyncopelates oxyrhynchus* (Terapontidae) performed cleaning-like behavior with large-sized, black porgies, *Acanthopagrus schlegeli* (Sparidae). Along with a brief review of cleaning fishes in Japan, we report in detail the newly discovered cleaning relationship between the above two fishes.

Materials and Methods

During the daytime from July to October 2000, we observed the behavior of *R. oxyrhynchus* in a fishing port in Hiroshima Bay. The study site was situated in the western part of the Seto Inland Sea (Fig.1). The port is approximately 40,000 m^2 with the deepest place being 5 m, in the center. Except in the center, most areas are exposed to the air at ebb tide.

We observed the tigerfish behavior with host fishes, especially the black porgy, one of the most important fishery and aquaculture species in Japan. We estimated the total length (TL) of the cleaners and hosts using ruler calibration by 0.5 cm size classes for fish less than 15 cm TL or 1 cm size classes for fish 15 cm TL and over. We defined the approaching distance of hosts to cleaners as the distance between the point where a host began to approach a cleaner and the point where the cleaner was located. We recorded the water depth and benthic phase on the cleaning station. The distance and the depth were estimated to the nearest 5 cm.

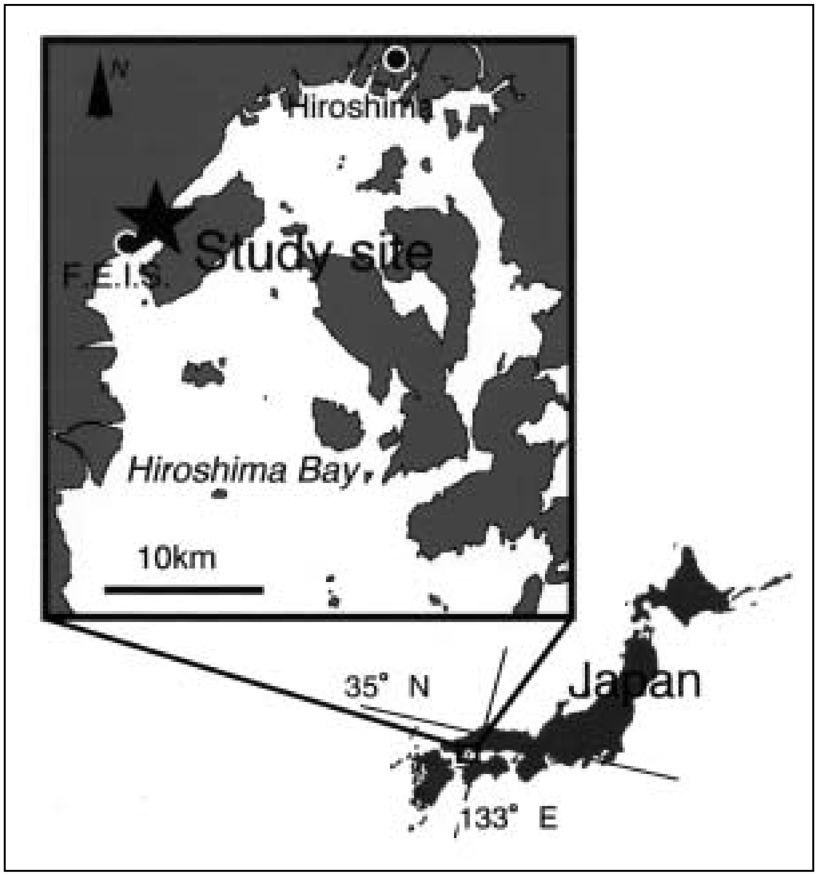

Figure 1. Map shows Hiroshima Bay in the Seto Inland Sea, Japan. The star mark indicates our study site in the fishing port near the National Research Institute of Fisheries and Environment of Inland Sea (F.E.I.S.).

1 **Chikasue, M.** 1989. The influence of ectoparasites on the cleaning symbiosis between a wrasse, *Labroides dimidiatus* (Labridae), and its host fishes. M.Sc. thesis, Ehime University, Ehime, JAPAN, 22 p.

2 **Ueharako, A.** 2000. The influence of ectoparasites on host fishes' behavior. M.Sc. thesis, Ehime University, Ehime, JAPAN, 26 p. (In Japanese).

The classification and scientific names of fishes followed Nakabo (2000) except *Halichoeres bleekeri* and *Coris musume*. *Halichoeres bleekeri* and *C. musume* followed Randall (1999a) and Randall (1999b), respectively.

Results

More than 26 species ranging from Clupeidae to Tetraodontidae were recorded in the fishing port (Shigeta, unpublished data). Only five of these recognized the tigerfish as a cleaner and posed with a species-specific figure against the cleaner (Table 1). The five belonged to Mugiliformes and Perciformes. All but *A. latus* were inspected and picked by the cleaner (Table 2). Three hosts, the black porgy and two mullet species, were observed many times cleaning for long periods.

Table 1. List of fishes that displayed a pose for the cleaner *R. oxyrhyncus* in the fishing port.

Order	Family	Species
Mugiliformes	Mugilidae	*Mugil cephalus cephalus*
		Chelon haematocheilus
Perciformes	Sparidae	*Acanthopagrus schlegeli*
		Acanthopagrus latus[1]
	Terapontidae	*Rhyncopelates oxyrhynchus*

1: Only one individual of this species was found and its pose was observed only once.

Table 2. List of fishes that received cleaning from *R. oxyrhyncus* in the fishing port.

Order	Family	Species
Mugiliformes	Mugilidae	*Mugil cephalus cephalus*
		Chelon haematocheilus
Perciformes	Sparidae	*Acanthopagrus schlegeli*
	Terapontidae	*Rhyncopelates oxyrhynchus*

Cleaning behavior was divided into three parts: the start of cleaning, the formation of a shoal and the termination of cleaning (Fig. 2). Before the beginning of cleaning, hosts solicited the cleaner. This behavior generally consisted of four parts: detection of a cleaner, recognition, approach and pose. Before the start of cleaning, the cleaner inspected the body surface of the posing host.

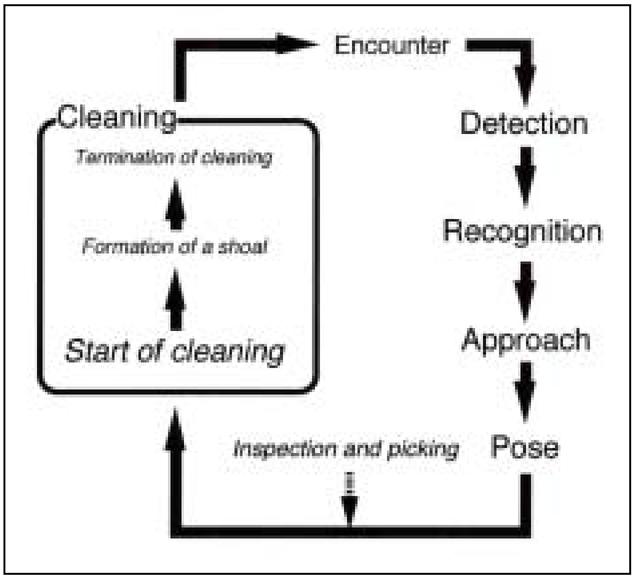

Figure 2. General process of the cleaning behavior of *R. oxyrhynchus* from the view of its host. Each item indicates the host's performance mainly. Italic items in the box show the three cleaning periods. The italic item with the broken arrow shows the cleaner's behavior.

Black porgy (10-50 cm TL) soliciting behaviors consisted of four movements. When a host detected a cleaner, the host that wished cleaning rapidly changed its direction toward the potential cleaner. The host aggregated from 0.5-0.8 m apart (n=3). That is, the approaching distance was 2.2-5.7 times the host's TL. Next, the host moved close to the cleaner and prevented the cleaner from bottom feeding by closely intruding in front of the cleaner's head. The host then showed its lateral side to the cleaner and assumed a slight head-down position, spreading wide its bilateral pectoral, pelvic, anal, and occasionally dorsal fins, while hovering motionlessly (Fig. 3). Blanching in color or opening of the mouth or gill covers was not observed in any host. In a shoal some hosts seemed to lose control and gradually revealed a curious vertical posture (Fig. 3).

As a result of solicitation by the black porgy, the tigerfish stopped foraging on the bottom. After leaving the bottom, as a true cleaner, it began to inspect the surface of the host and to clean. These bouts were the beginning of cleaning behavior. Total lengths of the cleaners were 10 cm ±1 SD (range 6-12, n = 20). No signal behavior of the cleaner for its host to start cleaning was observed. The tigerfish inspected the host's body surface carefully, and then picked on several parts. The cleaner especially preferred near the top of the head, and the base and upper parts of the caudal fin. However, cleaning into the host's mouth or its gill cover was not observed. After the cleaner picked against the host several times, it moved to other individuals. No cleaner chose a host smaller than itself (n = 17).

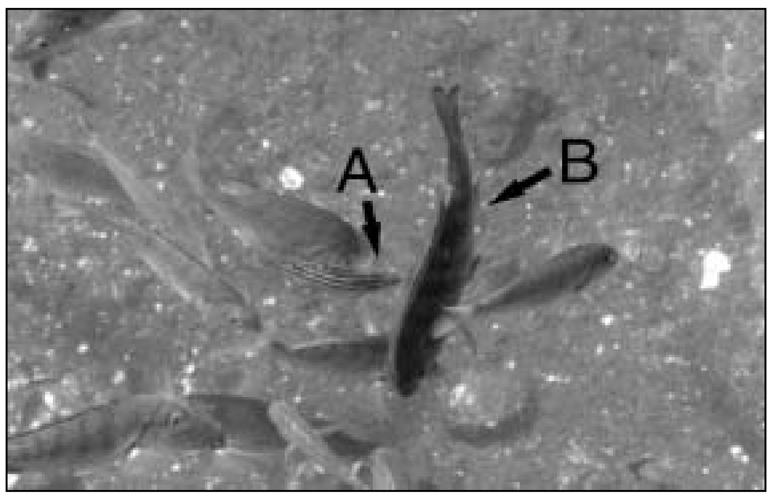

Figure 3. Cleaner *R. oxyrhynchus* (A, 10 cm TL) is inspecting the body surface of a black porgy, *A. schlegeli,* and picking off ectoparasites. Each host, *A. schlegeli,* displays a stationary pose. Among them, the central largest porgy loses its balance and shows a vertical posture (B).

All porgies aggregated prior to cleaning, forming a shoal of porgies (Fig. 4). Cleaning stations formed in several places located along consistent foraging migration routes. These stations were located 0.7 m ± 0.5 SD (range 0.3-2.0, n=6) in depth on sand-mud or concrete bottoms, in weak current areas, such as points where boats were moored, spaces behind large pipes and in the step hollows of a concrete seawall.

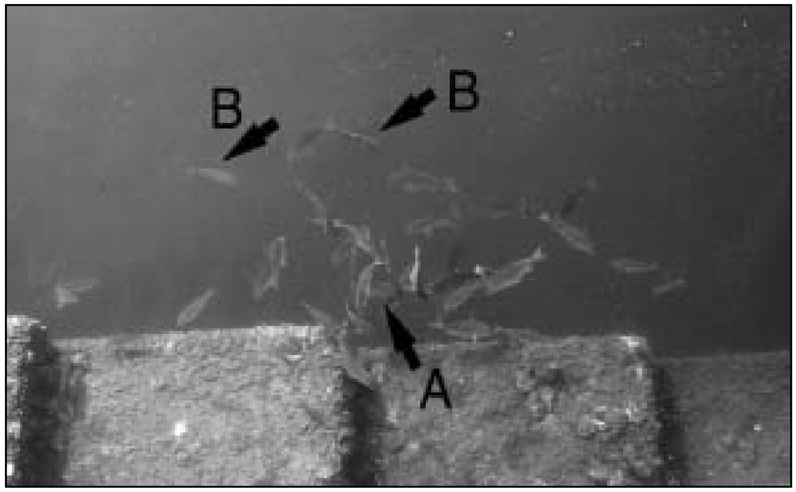

Figure 4. A shoal of cleaning black porgies (12-38 cm TL) near steps on the seawall. The two gray mullet *Mugil cephalus cephalus*, 25 cm TL (B), can never intrude into the center of the shoal because of interspecies hierarchy. Only one cleaner, the same individual as shown in Fig. 3, exists in the center (A).

Discussion

It is assumed that cleaning behavior exists in almost all aquatic environments. Thirty-four cleaner species, including *R. oxyrhynchus*, are noted as living in Japan (Table 3). However, there have been no detailed Japanese reports on their behavior, except for *L. dimidiatus*. Among these thirty-four species, *R. oxyrhynchus*, *Psedolabrus japonicus*, and *H. bleekeri* are common in the Seto Inland Sea, a typical temperate area of Japan.

Table 3. List of cleaning fishes in Japan.

Order	Family	Species	Source
Siluriformes	Plotosidae	*Plotosus lineatus*	Okata (1994)
Gasterosteiformes	Syngnathidae	*Doryrhamphus excisus excisus*	Myers (1989)
		Doryrhamphus japonicus	Yanagita (1990)
Perciformes	Echeneidae	*Echeneis naucrates*	Cressey and Lachner (1970)
		Phtheirichthys lineatus	Cressey and Lachner (1970)
		Remora remora	Cressey and Lachner (1970)
		Remora osteochir	Cressey and Lachner (1970)
		Remora brachyptera	Strasburg (1959)
		Remora pallida	Strasburg (1959)
	Chaetodontidae	*Heniochus monoceros*[1]	Shigeta (unpubl. data)
		Heniochus acuminatus[1]	Shigeta (unpubl. data)

Table 3, Continued

Order	Family	Species	Source
		Heniochus diphreutes	Randall (1985)
		Chaetodon plebeius[2]	Sadovy and Cornish (2000)
	Pomacanthidae	*Pomacanthus imperator*	Hirata *et al.* (1996)
	Terapontidae	*Rhyncopelates oxyrhynchus*	Our present study.
	Labridae	*Pseudodax moluccanus*	Randall (1992)
		Bodianus axillaris	Randall (1992)
		Bodianus diana	Randall (1992)
		Labroides dimidiatus	Randall (1958)
		Labroides bicolor	Randall (1958)
		Labroides pectoralis	Randall and Springer (1975)
		Labroides rubrolabiatus	Randall (1958)
		Labrichthys unilineatus	Debelius (1993)
		Labropsis manabei	Masuda and Kobayashi (1994)
		Labropsis xanthonota	Randall (1981)
		Pseudolabrus japonicus[3]	Chikasue (unpubl. data) [4]
		Thalassoma cupido	Kuwamura (1976)
		Thalassoma amblycephalum	Debelius (1993)
		Thalassoma lunare	Okata (1994)
		Halichoeres bleekeri[5]	Chikasue (unpubl. data) [4]
		Coris musume	Hirata *et al.* (1996)
	Acanthuridae	*Prionurus scalprum*	Kuwamura (1976)
Pleuronectiformes	Pleuronectidae	*Pleuronectes schrenki*	Ho *et al.* (2001)
Tetraodontiformes	Ostraciidae	*Ostracion immaculatus*[1]	Shigeta (unpubl. data)

1: Observation of cleaning behavior in an aquarium.

2: Observation in captivity.

3: *P. japanicus* is divided into two species, *P. sieboldi* and *P. eoethinus*, by Mabuchi and Nakabo (1997). Only *P. sieboldi* inhabits the Seto Inland Sea. However, we do not differentiate these in this paper, a review would be necessary .

4: See text's footnote 1 shown before.

5: *H. tenuispinis* is divided into two species, *H. tenuispinis* and *H. bleekeri*, by Randall (1999 a). Only *H. bleekeri* inhabits Japan. On the basis of the report, the fish, *H. tenuispinis* which Chikasue observed is *H. bleekeri*.

Most cleaner species maintain conspicuous color patterns on their lateral sides, such as stripes on the body or fins. Juvenile *R. oxyrhynchus* have a yellowish, silvery body color with four clear black longitudinal stripes. More than twenty-six fish species living in the fishing port, except *H. poecilopterus*, usually have sober color patterns. According to Hidaka (1998) the tigerfish dorsal color pattern may serve as a camouflage from birds, while the lateral pattern may advertise itself as a cleaner.

Only five fishes living in the port were observed to pose in cleaning behavior. The result may show that there are fish that do not recognize *R. oxyrhynchus* as a cleaner. For example, although the numbers in the port of large *Tribolodon hakonensis* equal those of black porgy or mullet, this fish never takes an interest in cleaning.

After a host's recognition, the approach and pose are conducted. This behavior may be the result of the host's desire to rid itself of ectoparasites. The soliciting behavior of black porgies for cleaning indicates the high intention to clean. If a tigerfish removed scales or a piece of the fins from the black porgy's body, the porgy would more than likely avoid it. Past studies on the proximate causes of posing against *Labroides* spp. have suggested that the hosts are attracted to the cleaner wrasse to obtain gentle tactile stimulation (Losey, 1971; Losey and Margules; 1974; Losey, 1979). However, recent studies of cleaning wrasses have shown that parasitism on the host is positively correlated to the frequency of the pose (Chikasue, unpublished data [1]; Ueharako, unpublished data [2]; Grutter, 2001). In all cases, the eagerness of a host for cleaning is essential for the series of cleaning behavior.

The sharpnose tigerfish obviously performed cleaning behavior. Its diet includes not only small benthic invertebrates such as copepods, ostracods and gammarids in the substrate, but also caligid copepods that usually inhabit the body surface of fish (our unpublished data). The feeding habits also strongly support cleaning behavior. It is necessary to analyze the feeding habits to see if the cleaner is picking off anything other than ectoparasites. In certain conditions, this opportunistic predator may change its feeding habitat from the bottom to the surface of the host body. The biomass of both the benthic animals and the ectoparasites on the host needs to be investigated in detail to clarify this switching mechanism.

European sea lice are parasites on Atlantic salmon that cause serious problems in aquaculture (MacKinnon, 1997). European wrasses are used to help reduce ectoparasite infestations on salmon kept in aquaculture pens (Sayer *et al.*, 1996). Ectoparasites also cause substantial damage to aquaculture in Japan. For the extermination of these ectoparasites, medicated or fresh-water bath methods have been adopted. However, the former causes environmental pollution around aquaculture pens, whereas the latter involves extensive handling. The utilization of the symbiotic cleaning relationship detailed here may resolve those problems, and may in the future help attain an environmentally benign aquaculture system for Japan. Further research on this phenomenon would clarify this possibility and its application in aquaculture.

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Literature Cited

Cressey, R.F., and E.A. Lachner. 1970. The parasitic copepod diet and life history of disk fishes (Echeneidae). *Copeia*. 2:310-318.

Debelius, H. 1993. Indian ocean tropical fish guide. IKAN-Unterwasserarchiv, Frankfurt, Germany, 321 p.

Grutter, A.S. 2001. Parasite infection rather than tactile stimulation is the proximate cause of cleaning behavior in reef fish. *Proc. Roy. Soc. Lond.* 268:1361-1365.

Helfman, G.S., B.B. Collette, and D.E. Facey. 1997. The Diversity of Fishes. Blackwell Science, Oxford, UK, xii+528 p.

Hidaka, T. 1998. Colors and patterns of the fishes: What is their function? *Aquabiology* 119:451-456 (In Japanese with English abstract).

Hirata, T., T. Yamakawa, A. Iwata, S. Manabe, W. Hiramatsu, and N. Ohnishi. 1996. Fish fauna of Kashiwa-jima Island, Kochi Prefecture, Japan. *Bull. Mar. Sci. Fish., Kochi Univ.*, 16:1-177 (In Japanese with English abstract).

Ho, J-S., K. Nagasawa, and T. Takatsu. 2001. The juvenile Cresthead flounder (*Pleuronectes schrenki*): an occasional cleaner occurring in Lake Notoro, Hokkaido. *Bull. Fish. Sci. Hokkaido Univ.* 52(1):1-3.

Kuwamura, T. 1976. Different responses of inshore fishes to the cleaning wrasse, *Labroides dimidiatus*, as observed in Sirahama. *Publ. Seto Mar. Biol. Lab.* 23:119-144.

Losey, G.S. 1971. Communication between fishes in cleaning symbiosis. In: Aspects of the biology of symbiosis. C. Cheng (ed.), p. 45-76. Univ. Park Press, Baltimore, MD, USA.

Losey, G.S. and L. Margules. 1974. Cleaning symbiosis provides a positive reinforcement for fish. *Science* 184:179-180.

Losey, G.S. 1979. Fish cleaning symbiosis: proximate causes of host behavior. *Anim . Behav*. 27:669-685.

Losey, G.S., A.S. Grutter, G. Rosenquist, J.L. Mahon, and J.P. Zamzow. 1999. Cleaning symbiosis: a review. In: Behaviour and Conservation of Littoral Fishes, V.C. Almada, R.F. Oliveira and E.J. Goncalves (eds.), p. 379-395. Instuto Superior de Psichologia Aplicada, Lisbon, Portugal.

Mabuchi, K. and T. Nakabo. 1997. Revision of the genus *Pseudolabrus* (Labridae) from the East Asian Waters. *Ichthyol. Res*. 44(4):321-334.

MacKinnon, B.M. 1997. Sea Lice: a review. *World Aquaculture*, September, p. 5-10.

Masuda, H. and Y. Kobayashi. 1994. Grand Atlas of Fish Life Modes, Tokai Univ. Press, Tokyo, Japan, 47+465 p. (In Japanese).

Myers, R.R. 1989. Micronesian reef fishes. Coral Graphics, Barrigada, Guam, USA, vi+298 p.

Nakabo T. (ed). 2000. Fishes of Japan with pictorial keys to the species, 2nd ed., Tokai Univ. Press, Tokyo, Japan, lvi+1748 p. (In Japanese).

Okata, Y. 1994. The world of fishes: my field notes of underwater observation. Kaiyuusya, Tokyo, Japan, 421+13 p. (In Japanese).

Randall, J.E. 1958. A review of the labrid fish genus *Labroides*, with descriptions of two new species and notes on ecology. *Pac. Sci.* 12:327-347.

Randall, J.E. 1981. Revision of the Labrid fish genus *Labropsis* with descriptions of five new species. *Micronesica* 17(1-2):125-155.

Randall, J.E. 1985. Guide to Hawaiian reef fishes. Harrowood Books, Newtown Square, PA, USA, 74 p.+177 pl.

Randall, J.E. 1992. Diver's guide to fishes of Maldives. Immel Publishing, London, UK, 193 p.

Randall, J.E. 1999 a. *Halichoeres bleekeri* (Steindachner & Döderlein), a valid Japanese species of labrid fish, distinct from *H. tenuispinis* (Günther) from China. *Ichthyol. Res.* 46(3):225-231.

Randall, J.E. 1999 b. Revision of Indo-Pacific Labrid fishes of the genus *Coris*, with description of five new species. *Indo-Pacific fishes* 29:1-74.

Randall, J.E., and V.G. Springer 1975. *Labroides pectoralis*, a new species of Labrid fish from the tropical western Pacific. *Uo* 25:4-11.

Sadovy, Y., and A.S. Cornish 2000. Reef fishes of Hong Kong. Hong Kong Univ. Press, Aberdeen, Hong Kong, China, xi+321 p.

Sayer, M.D., J.W. Treasurer, and M.J. Costello (eds.). 1996. Wrasse: biology and use in aquaculture. Fishing News Books, London, UK, ix+283 p.

Strasburg, D.W. 1959. Notes on the diet and correlating structures of some central Pacific echeneid fishes. *Copeia* 3:244-248.

Yanagita, M. 1990. The fishes inhabiting the inlet in Okuridashi. *I.O.P. Diving News* 1(8):2-3. (In Japanese).