Distributional Range Extension of *Herklotsichthys quadrimaculatus* (Clupeiformes: Clupeidae) in Southern Japan

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Abstract

Nine specimens (98.1-133.8 mm standard length) of *Herklotsichthys quadrimaculatus* (Rüppell, 1837), previously recorded in Japanese waters only from the southern Ryukyu Islands (Okinawa Prefecture and Yoron-jima island) and Ogasawara Islands, were collected from the northern Ryukyu Islands (Tanega-shima and Amami-Oshima islands), thereby representing a ca. 450 km northward distributional range extension of the species, with the Tanega-shima specimens being the northernmost record. The northern Ryukyu Islands specimens are described in detail.
Key words: Amami Islands, distribution, new record, Osumi Islands, sardine, taxonomy

Introduction

The clupeoid fish genus *Herklotsichthys* Whitley, 1951 is characterized by two fleshy outgrowths on the hind margin of the gill opening, 3-8 front parietal striae on the top of the head, the lower part of the second supramaxilla larger than the upper part, the last dorsal-fin ray not filamentous and the hypo-maxilla toothless (Whitehead 1985, Munroe *et al.* 1999). It is currently represented in Japanese waters by a single species, *H. quadrimaculatus* (Rüppell, 1837) (Aonuma and Yagishita 2013), having been recorded from the Ogasawara Islands, Yoron-jima island and the southern Ryukyu Islands (Aonuma and Yagishita 2013, Hata 2014). However, nine new specimens recently collected from Tanega-shima island (Osumi Islands) and Amami-Oshima island (Amami Islands) represent the first records of the species from those islands, and are described herein.

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Materials and Methods

Counts and proportional measurements, expressed as percentages of standard length (SL), followed Hata and Motomura (2015), except in following cases: head length was measured from the snout tip to the most posterior point of the opercle, and postorbital length from the most posterior point of the orbit to the most posterior point of the opercle. Counts and proportional measurements are shown in Table 1. All measurements were made with digital calipers to the nearest 0.1 mm. The Osumi Islands is treated as a part of the Ryukyu Islands in this study. Institutional codes used in this study are as follows: Bishop Museum, Honolulu (BPBM), Hiwa Museum for Natural History (HMNH), Kagoshima University Museum, Kagoshima (KAUM), Kanagawa Prefectural Museum of Natural History (KPM), National Museum of Nature and Science, Tsukuba (NSMT), and Okinawa Churashima Foundation (URM).

Results and Discussion

Herklotsichthys quadrimaculatus (Rüppell, 1837)
Standard Japanese name: Mizun
Fig. 1; Table 1

Material examined. 9 specimens (98.1-133.8 mm SL) from the Ryukyu Islands, Japan — **OSUMI ISLANDS:** KAUM–I. 62110, 133.8 mm SL, off Hirota Fishing Port, Minamitane, Tanega-shima island, 30°25′29″N, 130°58′50″E, 20 m depth, set net, 13 June 2014, H. Hata and M. Takayama; KAUM–I. 66994, 98.1 mm SL, off Hirota Fishing Port, Minamitane, Tanega-shima island, 30°25′29″N, 130°58′50″E, 20 m depth, set net, 19 Nov. 2014, M. Takayama; KAUM–I. 67210, 107.6 mm SL, off Hirota Fishing Port, Minamitane, Tanega-shima island, 30°25′29″N, 130°58′50″E, 20 m depth, set net, 6 Dec. 2014, M. Takayama; KAUM–I. 67809, 102.6 mm SL, off Hirota Fishing Port, Minamitane, Tanega-shima island, 30°25′29″N, 130°58′50″E, 20 m depth, set net, 7 Dec. 2014, M. Takayama. **AMAMI ISLANDS:** KAUM–I. 62615, 100.4 mm SL, KAUM–I. 63848, 100.6 mm SL, KAUM–I. 63849, 106.0 mm SL, KAUM–I. 63850, 102.8 mm SL, KAUM–I. 63851, 104.4 mm SL, Yui, Setouchi, Amami-Oshima island, 28°10′53″N, 129°17′35″E, 7 m depth, line-fishing, 25 June 2014, B. Jeong.

Description. Body oblong, depth about equal to head length, deepest at origin of dorsal fin. Dorsal profile of head and body convex from snout tip to caudal-fin base. Ventral profile of head and body convex from lower-jaw tip to end of anal-fin base, straight at caudal peduncle. Belly slightly rounded, covered by 30 to 32 scutes from isthmus to anus. Predorsal scute absent. Head large, compressed. Snout rounded. Mouth terminal, small, posterior tip of maxilla reaching to level with anterior margin of iris. Second supramaxilla spoon-shaped, lower part larger than upper part. Premaxilla and hypomaxilla without teeth. Lower edge of

maxilla toothed. Lower jaw with several conical teeth anteriorly. Posterior ramus of lower jaw elevated. Orbit elliptical, eye and pupil round. Eye large, covered with adipose eyelid; visible in dorsal and ventral views. Interorbital space flat. Nostrils elliptical, close to each other, positioned anterior to orbit. Upper point of pectoral-fin insertion between vertical lines through posteriormost points of preopercle and opercle. Lower point of pectoral-fin insertion posterior to a vertical line through posteriormost point of opercle. Posterior tip of pectoral fin pointed. Pectoral-fin axillary scale present. Dorsal-fin origin posterior to a vertical line through posterior tip of pectoral fin. Posterior end of dorsal-fin base posterior to a vertical line through posterior end of pelvic fin. Origin of pelvic fin located below origin of 9-10th dorsal-fin ray. Posterior end of pelvic-fin base below 11th dorsal-fin ray. Posterior end of depressed pelvic fin behind that of dorsal-fin base. Pelvic-fin axillary scale present. Anal-fin origin positioned just below 24-25th lateral scale. Posterior end of anal-fin base below 30-31st lateral scale. Bases of dorsal and anal fins sheathed in a row of deciduous scales. Caudal fin forked. Anus situated just anterior to anal-fin base, posterior to midpoint of body. Scales cycloid, thin and deciduous except ventral scutes; body scales with 7 continuous striae across center and a slightly serrated posterior edge without perforations;

Fig. 1. Fresh specimens of *Herklotsichthys quadrimaculatus*. A, KAUM–I. 62110, 133.8 mm SL, Tanega-shima island, Kagoshima Prefecture, Japan; B, KAUM–I. 62615, 100.4 mm SL, Amami-Oshima island, Kagoshima Prefecture, Japan.

predorsal scales paired; elongate, wing-like scales present beneath normal paired predorsal scales; no lateral line; no scales on head; no scales on fins, except a broad triangular sheath of scales on caudal fin. 3-5 frontparietal striae on top of head. Gill rakers long, slender, rough. Pseudobranchial filaments present. Two fleshy outgrowths on posterior border of gill opening and a large papilla on lower edge of gill opening. Posterior margins of preopercle and opercle smooth.

Color when fresh (Fig. 1): Head and body dark blue dorsally, whitish-silver ventrally. A single dark blue stripe running from upper end of gill-opening to caudal-fin base. Two yellow blotches on posterior margin of gill-opening. Tip of lower-jaw, lower edge of upper-jaw and pupil black. Dorsal and caudal fin rays yellowish-black. Pectoral, pelvic and anal fin rays white. All fin membranes translucent. Iris silver.

Color in alcohol: Head and body dark purple dorsally, elsewhere pale brown.

Remarks. The nine specimens were identified as *H. quadrimaculatus* on the basis of the following combination of characters, which closely match the diagnostic features of *H. quadrimaculatus* given by Wongratana (1980), Whitehead (1985) and Munroe *et al*. (1999): body depth 25.9-29.2% of SL; elongate, wing-like scales present beneath normal paired predorsal scales; no black spots on flank; lower gill rakers 32-34; no dusky tips on dorsal and caudal fins; two yellow blotches on posterior margin of gill opening; and a single dark blue stripe running from upper end of gill opening to caudal-fin base.

The genus *Herklotsichthys* contains 10 valid species (Whitehead 1985, Wongratana 1987). Although *H. quadrimaculatus* is most similar to *H. collettei* Wongratana, 1987 in sharing elongate wing-like scales beneath normal paired predorsal scales and lacking black spots on the flank (Wongratana 1987, Munroe *et al*. 1999), the former is distinguished from the latter by having a lower count of lower gill rakers on the first gill arch (30-36 vs. 38-40 in *H. collettei*), yellow blotches on the posterior margin of the gill-opening (vs. no blotches), and dorsal fin without prominent markings (vs. tip of dorsal fin jet black; Wongratana 1987, Munroe *et al.* 1999).

Meristic and morphometric data for the present specimens were within the range of those for comparative specimens from Yoron-jima and Okinawa-jima islands, Japan, Phuket, Thailand, and the Vava'u Islands, Tonga. However, the former (from Tanega-shima and Amami-Oshima islands) had higher ranges of lower gill rakers on the second (33-38 vs. 27-37) and third gill arches (27-30 vs. 21-29), in addition to a slightly shorter head (25.0-27.8% of SL vs. 26.5-30.5%), smaller orbit diameter (11.8-12.9% of SL vs. 12.1-15.8%) and shorter mandible (12.1-13.8% of SL vs. 12.7-16.2%) (Table 1). These minor differences are regarded herein as intraspecific variations of *H. quadrimaculatus*.

Kishinouye (1907) described *Clupea mizun* as a new species from Okinawa-jima island and proposed a Japanese name "Mizun" for the species. *Clupea mizun* is currently recognized as a junior synonym of *H. quadrimaculatus* (Wongratana 1980, Whitehead 1985). The Kishinouye's (1907) record of *C. mizun* representeds the first voucher specimen-based record of *H. quadrimaculatus* from Japanese waters. Subsequently, Kamohara (1965) and Kurata *et al*. (1971) reported *H. quadrimaculatus* (as *Harengula ovalis*) from Ishigaki-jima and Okinawa-jima islands, and the Ogasawara Islands, respectively. Although Yoshino

Table 1. Counts and measurements, expressed as percentages of standard length, of *Herklotsichthys quadrimaculatus*. Modes for counts and means of measurements are in parentheses.

	Tanega-shima island, Kagoshima, Japan	Amami-Oshima island, Kagoshima, Japan	Yoron-jima island and Okinawa, Japan, Thailand, and Tonga
	n = 4	*n* = 5	*n* = 24
Standard length	98.1-133.8	100.4-106.0	24.9-121.4
Counts			
Dorsal-fin rays (unbranched)	4	4-5 (4)	3-5 (4)
Dorsal-fin rays (branched)	15-16 (15, 16)	14-15 (15)	13-16 (15)
Anal-fin rays (unbranched)	3	3	2-3 (3)
Anal-fin rays (branched)	14-16 (14)	14-15 (14)	14-17 (16)
Pectoral-fin rays (unbranched)	1	1	1
Pectoral-fin rays (branched)	14-16 (15)	15-16 (15)	14-16 (15)
Pelvic-fin rays (unbranched)	1	1	1
Pelvic-fin rays (branched)	7	7	7
Caudal-fin rays (upper + lower)	10 + 9	10 +9	10 + 9
Gill rakers on 1st gill arch (upper)	15-16 (15, 16)	15-16 (15)	11-16 (15)
Gill rakers on 1st gill arch (lower)	32-34 (33)	33-34 (34)	28-34 (32)
Gill rakers on 1st gill arch (total)	48-49 (48, 49)	48-49 (49)	40-50 (46)
Gill rakers on 2st gill arch (upper)	14-15 (14)	14-15 (15)	12-16 (15)
Gill rakers on 2st gill arch (lower)	33-35 (33, 35)	37-38 (38)	27-37 (36)
Gill rakers on 2st gill arch (total)	47-49 (49)	51-53 (53)	39-53 (51)
Gill rakers on 3rd gill arch (upper)	14-15 (14)	14-17 (17)	10-15 (14, 15)
Gill rakers on 3rd gill arch (lower)	27-30 (28)	27-29 (27)	21-29 (29)
Gill rakers on 3rd gill arch (total)	42-44 (42)	42-44 (43, 44)	31-44 (43)
Gill rakers on 4th gill arch (upper)	12-14 (13)	12-13 (13)	8-14 (12, 13)
Gill rakers on 4th gill arch (lower)	19-21 (19)	20-22 (22)	16-23 (21)
Gill rakers on 4th gill arch (total)	31-35 (31, 32, 33, 35)	32-35 (35)	24-35 (34)
Gill rakers on posterior face of 3rd gill arch	10-11 (10)	8-9 (9)	7-11 (9)
Prepelvic scutes	17-18 (17)	18	17-19 (18)
Postpelvic scutes	13	12-14 (13, 14)	12-14 (13)
Total scutes	30-31 (31)	31-32 (32)	30-32 (31)
Branchiostegal rays	broken	6-7 (7)	5-7 (6)
Lateral-scale series	40-41 (41)	38-40 (38)	38-41 (40)
Pseudobranchial filaments	19-20 (20)	20-21 (20)	14-21 (20)
Measurements (%SL)			
Total length	124.6-124.9 (124.8)	123.2-125.8 (124.4)	123.1-130.9 (126.4)
Head Length	25.0-27.2 (26.5)	26.7-27.8 (27.2)	26.5-30.5 (28.1)
Body depth	25.9-28.6 (27.2)	26.0-29.2 (27.5)	18.5-29.5 (25.6)
Pre-dorsal-fin length	44.7-47.1 (45.8)	45.4-47.3 (46.4)	44.2-50.1 (46.6)

Snout tip to pectoral insertion	24.9-27.7 (26.6)	27.6-28.9 (28.0)	26.1-32.8 (28.3)
Snout tip to pelvic insertion	52.9-54.1 (53.4)	55.5-57.7 (56.9)	52.4-60.9 (55.5)
Pre-anal-fin length	77.7-79.8 (79.2)	80.1-81.3 (80.9)	77.7-82.6 (80.0)
Dorsal-fin base length	15.6-15.9 (15.7)	15.4-17.0 (16.0)	15.3-18.3 (16.4)
Anal-fin base length	12.9-15.4 (13.8)	12.9-13.5 (13.1)	12.9-16.1 (14.2)
Caudal-peduncle length	8.7-9.4 (9.0)	8.3-10.0 (9.5)	6.3-9.8 (8.3)
Caudal-peduncle depth	8.2-9.8 (9.1)	8.4-9.3 (8.8)	7.7-10.8 (8.9)
Orbit diameter	11.8-12.8 (12.3)	12.5-12.9 (12.7)	12.1-15.8 (13.1)
Eye diameter	7.5-7.9 (7.7)	8.0-8.7 (8.3)	7.4-10.5 (9.1)
Snout length	3.7-4.3 (4.0)	3.6-4.6 (4.2)	3.4-4.7 (4.1)
D-P1	29.8-32.8 (31.3)	30.1-32.1 (31.1)	26.1-33.0 (30.4)
D-P2	25.2-27.3 (26.2)	25.7-28.5 (27.2)	17.3-30.1 (25.1)
D-A	39.9-41.1 (40.4)	39.4-40.6 (39.9)	26.5-41.6 (38.7)
P1-P2	28.3-29.9 (29.1)	29.8-31.1 (30.4)	19.6-31.3 (28.5)
P2-A	26.7-27.7 (27.2)	25.1-26.6 (25.9)	23.7-28.2 (26.3)
Pectoral-fin length	17.6	18.9-19.9 (19.4)	16.1-21.4 (19.6)
Pelvic-fin length	12.4-13.0 (12.7)	12.3-13.1 (12.8)	11.1-13.6 (12.5)
Interorbital width	3.9-4.4 (4.1)	3.6-4.2 (3.9)	3.1-4.5 (4.1)
Postorbital length	10.2-11.1 (10.7)	10.1-11.1 (10.6)	10.1-12.5 (10.9)
Upper-jaw length	12.0-13.0 (12.4)	12.7-13.4 (13.0)	11.9-14.7 (13.3)
Mandible length	12.1-13.4 (13.0)	12.9-13.8 (13.2)	12.7-16.2 (13.6)
1st unbranched dorsal-fin ray length	1.4-1.7 (1.6)	0.8-2.4 (1.6)	0.8-4.6 (1.8)
2nd unbranched dorsal-fin ray length	3.9-4.9 (4.3)	3.6-7.2 (5.1)	3.0-9.6 (5.0)
3rd unbranched dorsal-fin ray length	7.1-9.2 (8.2)	8.1-15.8 (10.5)	5.6-16.7 (9.6)
1st unbranched anal-fin ray length	1.2-1.3 (1.3)	0.7-1.9 (1.2)	0.6-2.6 (1.3)
2nd unbranched anal-fin ray length	2.7-2.7 (2.7)	2.8-5.2 (4.0)	2.0-5.8 (3.5)
3rd unbranched anal-fin ray length	6.0-6.8 (6.5)	5.7-6.7 (6.2)	5.5-7.0 (5.9)
1st pectoral-fin ray length	broken	18.5-19.7 (19.1)	18.4-21.4 (19.2)
1st pelvic-fin ray length	11.9	12.5-13.1 (12.9)	11.1-13.5 (12.3)

et al. (1975) also reported the species (as *Harengula ovalis*) from the Ryukyu Islands, detailed locality and voucher specimens were not indicated. Senou and Suzuki (1980) reported *Herklotsichthys quadrimaculatus* (as *Harengula ovalis*) from the mouth of Nakama River, Iriomote-jima island on the basis of six specimens (61.3-141.3 mm total length). Subsequently, Whitehead (1985) showed that applicable scientific name for this species is *Herklotsichthys quadrimaculatus*.

Herklotsichthys quadrimaculatus was recorded from the southern Ryukyu Islands (Okinawa Prefecture) by the following authors on the basis of voucher specimens and/or photographs: Kon *et al*. (1998): Nakagusuku Bay, Okinawa-jima island, URM-P 38640, 60.8 mm SL; Tachihara *et al.* (2001): mangrove estuary of Gesashi River, Okinawa-jima island, 4 specimens; Maeda and Tachihara (2006): mouth of Teima River, Okinawa-jima island, juvenile specimens; Senou *et al*. (2006): Ie-jima island, underwater photograph,

KPM-NR 36550; Senou *et al*. (2007): Miyako Islands, underwater photographs, KPM-NR 68271, 69489, 69807, 69969; Watai *et al*. (2009): Tokashiki-jima island, 1 specimen, KPM-NI 21601, underwater photograph, KPM-NR 44033; Sakai *et al.* (2001): Iriomote-jima island, NSMT-P 28501; Ohta (2007): Yaeyama Islands, 17 kg catches in 2006; Nanjo *et al.* (2008): Urauchi River, Iriomote-jima island, 7 specimens, 30-40 mm SL; Kanda *et al.* (2009): Hirakubo River, Ishigaki-jima island, 1 specimen; Miura (2012): Chinen Fish Market, Nakagusuku Bay, Okinawa-jima island, photograph; and Oka and Miyamoto (2014): Okinawa-jima island, 2838 juvenile specimens, 11.5-29.7 mm SL.

Randall *et al*. (1997) reported four specimens (BPBM 35347, 107-127 mm SL; NSMT-P 46670, 84 mm SL; NSMT-P 46673, 99 mm SL) of *Herklotsichthys quadrimaculatus* from the Ogasawara Islands and Yoshigou and Nakamura (2002) noted six specimens (HMNH-P 2816-2819, 2952, 2953) from Haha-jima and Chichi-jima islands, Ogasawara Islands. Hata (2014) reported two specimens (KAUM–I. 52218, 52219) of *H. quadrimaculatus* from Yoron-jima island, in the mid latitude of the Ryukyu Islands.

Although Hata and Motomura (2011) reported four specimens (KAUM–I. 1014, 79.8 mm SL; KAUM–I. 1015, 83.7 mm; KAUM–I. 7390, 38.7 mm; KAUM–I. 7391, 39.8 mm) from the mainland of Kagoshima, southern Kyushu, re-examination of those specimens revealed them to be *Sardinella lemuru* Bleeker, 1853. However, Aonuma and Yagishita (2013) cited Hata and Motomura's (2011) records, including the Kagoshima mainland, in the distributional range of *H. quadrimaculatus*. Although Kawano *et al*. (2011) listed *H. quadrimaculatus* from the Sea of Japan (coast of Yamaguchi Prefecture), no specimens were retained.

Accordingly, *H. quadrimaculatus* has been recorded in Japanese waters only from the Ogasawara Islands, Yoron-jima island, and Okinawa Prefecture, on the basis of voucher specimens. Thus, the present (voucher) specimens from Tanega-shima and Amami-Oshima islands represent a northward distributional range extension for the species, the Tanega-shima specimens representing the northernmost record of the species.

Comparative material examined. *Herklotsichthys quadrimaculatus* (24 specimens, 24.9-121.4 mm SL): KAUM–I. 28792, 83.6 mm SL, reservoir tank of Okinawa Yambaru Seawater Pumped Storage Power Station, Kunigami, Okinawa Prefecture, Japan (26°40′25″N, 128°15′56″E), 0.5 m depth, 11 July 2008, hand net, Idea Consultant Incorporated; KAUM–I. 52218, 104.2 mm SL, KAUM–I. 52219, 110.1 mm SL, off Hakibina beach, south coast of Yoron-jima island, Kagoshima Prefecture, Japan (27°01′45″N, 128°25′07″E), 1.5 m depth, seine net, 23 Oct. 2012, Frlm Fish Team; KAUM–I. 55086, 37.5 mm SL, KAUM–I. 55118, 35.8 mm SL, Chabana Port, west coast of Yoron-jima island, Kagoshima Prefecture, Japan (27°02′57″N, 128°24′19″E), 0.5 m depth, fishing light, 30 June 2013, H. Hata *et al.*; KAUM–I. 60969, 104.3 mm SL, off Phuket Island, Thailand; KAUM–I. 71459, 56.8 mm SL, Itoman Fishing Port, Itoman, Okinawa-jima island, Okinawa Prefecture, Japan (26°07′N, 127°39′E), 3 Oct. 1988, fishing light, M. Kimura; KAUM–I. 71460, 24.9 mm SL, KAUM–I. 71461, 30.4 mm SL, Itoman Fishing Port, Itoman, Okinawa-jima island, Okinawa Prefecture, Japan (26°07′N, 127°39′E), 17 Sept. 1992, fishing light, M. Kimura; URM-P 33372, 121.4 mm SL, URM-P 33373, 115.5 mm SL, URM-P33374, 113.3

mm SL, URM-P 33419, 94.8 mm SL, URM-P 33420, 86.1 mm SL, URM-P 33421, 90.8 mm SL, URM-P 33422, 74.4 mm SL, URM-P 33490, 115.6 mm SL, URM-P 33491, 114.8 mm SL, Vava'u Islands, Kingdom of Tonga; URM-P 43968, 118.6 mm SL, URM-P 43969, 101.2 mm SL, URM-P 43970, 104.0 mm SL, URM-P 43971, 99.2 mm SL, URM-P 43972, 99.1 mm SL, Ou-jima island, Tamagusuku, Nanjo, Okinawa Prefecture, Japan, 19 June 2007; URM-P 44695, 83.7 mm SL, Chinen-umino, Nanjo, Okinawa-jima island, Okinawa Prefecture, Japan, 18 Nov. 2008.

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