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Review

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Biogeographical history of Japanese freshwater fishes: Phylogeographic approaches and perspectives

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Abstract The biogeography of freshwater fishes in Japan was reviewed in terms of achievements and perspectives. In the last three decades, biogeographic studies have changed from earlier descriptions of the freshwater fish fauna, based on the Linnean classification system, to phylogenetic approaches using various molecular markers. Especially, the phylogeographic approach, which explores the formation of geographic distribution patterns of genealogical lineages within species, has become predominant. Analyses of genuine freshwater fishes have disclosed their speciation and dispersal patterns throughout temperate East Asia since the Neogene, along with the formation of the Japanese Archipelago. In particular, molecular clocks of mitochondrial DNA have played an important role in examinations of biogeographic relationships between the Japanese Archipelago and Chinese continent/Korean Peninsula, and vicariance by Fossa Magna in central Honshu Island. Patterns of range expansion through the sea and landlocking in cold-temperature euryhaline fishes have indicated their speciation and distribution dynamics under the fluctuating climatic conditions of the Plio-Pleistocene. Likewise, phylogeographic implications of unusual biological entities arising from interspecific hybridization or gynogenesis have been discussed. Nevertheless, despite the emphases given to some groups, the present knowledge of phylogeographic patterns of Japanese freshwater fishes is for the most part still insufficient for quantitative

analyses of the overall history of the freshwater fish fauna and geographic regions of Japan. Improved research techniques and methodologies for the integration of findings from multiple taxa and/or genes are essential. Further, evolutionary formation of distributional ranges should be considered together with ecological biogeography, including the processes of local adaptation, interspecific interaction and extinction. Modern day disturbances of freshwater fish distributions, including fish transportation, are rapidly leading to artificial distribution patterns and extinctions. Exhaustive phylogeographic analyses should be necessary as a primary requirement for conserving freshwater fish biodiversity in Japan.

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Full Papers

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Distribution and habitat of the Ajime-loach, *Niwaella delicata*, in the Ai River, Osaka Prefecture, Japan

Kazuya Hiramatsu and Kazumi Hosoya

Abstract Relationships between the distribution and habitat variables of the endangered Ajime-loach, *Niwaella delicata*, were investigated in the Ai River, part of the Yodo River system, Kinki District, Japan. The fish were distributed in reaches totalling 1.9 km of the 13 km surveyed, between 110 m and 160 m above sea level. Comparison and principal component analysis of sections where the Ajime-loach was present or absent demonstrated that major variables influencing distribution are low summer water temperatures, variable channel units, an abundance of loose stones and abundant groundwater discharge, all being necessary for future conservation of the species. And the consequences of the study suggest the importance of riparian forest, streambed disturbance by flooding and control of fine sediment input from the watershed to the habitat of the Ajime-loach.

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Egg and larval development of the bitterling, *Rhodeus pseudosericeus* (Cyprinidae)

Nobuhiro Suzuki

Abstract After hatching from eggs deposited in the gill cavity of freshwater bivalves, bitterling larvae undergo initial development in the bivalve before adopting a free-swimming mode. This study examined the early ontogeny of *Rhodeus pseudosericeus*, collected from the Som River, part of the Namhan River system in South Korea. Ripe unfertilized eggs and larval development were observed in a controlled water temperature ($22\pm 1^\circ\text{C}$), the eggs being rather pear-shaped with an opaque yellow yolk, measuring ca. 3.1 mm in length and 2.2 mm in breadth. Larvae of *R. pseudosericeus* are characterized by a pair of wing-like processes on the yolk, which is anteroventrally convex, as in other *Rhodeus* larvae, until an advanced stage (i.e., 9 day-old). The anterior region of the yolk sac at hatching is hollowed, unlike the spherical triangular shape in most other *Rhodeus* larvae and broad spheroid in *R. spinalis*. *Rhodeus pseudosericeus* larvae began to feed when the free swimming stage was reached. Dorsal and anal fin rays were formed completely by 24 or 25 days after hatching. Melanophores aggregated anteriorly on the dorsal fin became a trapezoid-like black spot in the juvenile stage (i.e., 54 day-old), elliptical in *R. atremius atremius*, *R. atremius suigensis*, *R. notatus*, crescentic in *R. ocellatus ocellatus*, *R. ocellatus kurumeus*, roughly rectangular in *R. sinensis* and round in *R. spinalis*. Minute tubercles on the skin surface in *R. pseudosericeus* shared similar morphology with those of other *Rhodeus* species.

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Breeding ecology of bluegill *Lepomis macrochirus*, an invasive alien species, in the north basin of Lake Biwa, central Japan

Hiroyuki Nakao, Kentarou Fujita, Taketo Kawabata, Katsuki Nakai, and Hiroichi Sawada

Abstract The breeding ecology of bluegill, *Lepomis macrochirus*, an invasive alien species in Japan, was studied in the north basin of Lake Biwa in 2002 and 2003. In both years, breeding colonies became established when the water temperature reached at 20°C. In 2002 and 2003, 380 and 192 nests in 55 and 32 colonies, respectively were found at 7 spawning sites, colonies occurring at 1–3 m depth along the shore. Although the colony size became smaller as the season advanced, large-scale colonies comprising 30 or more nests were found in June (early part of the breeding season). The period of parental care became shorter as the water temperature increased. Breeding success was significantly higher in June than in July and August, also being slightly higher in nests belonging to larger colonies. Predation of eggs in nests by other bluegill, *Rhinogobius* spp. and *Tridentiger brevispinis*, was observed, possibly being one of the most important mortality factors of early stage bluegill in Lake Biwa.

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Ontogeny of the freshwater goby *Odontobutis hikimius* in an aquarium

Toshio Doi and Shigeru Aoyama

Abstract Embryonic, larval and juvenile morphologies of the freshwater goby *Odontobutis hikimius*, reared in an aquarium, were observed and described. The egg mass (ca. 200 eggs), spawned on the glass wall of the tank, were cared for by the male. The eggs were ellipsoid in shape, 3.74–3.80 mm (long axis) by 2.20–2.35 mm (short axis), and attached to the glass wall with adhesive threads. Larvae hatched out 14–16 days after spawning. Just-hatched larvae were 6.04–6.11 mm in body length (BL), with 18+12=30 myomeres, completed notochord flexion, and all fins represented. However fin ray numbers were not completed. Melanophores were present on the head, cheek, trunk below the first and second dorsal fins, and caudal peduncle. Eleven days after hatching, juveniles of ca. 8.45–8.75 mm BL had full fin ray complements. They grew to

ca. 11–12 mm BL after one month from hatching, ca. 50–60 mm BL after 6 months and ca. 70–115 mm BL after one year. The cephalic sensory papillae developed in 11-day-old juveniles at ca. 8mm BL. Opercular papillae group 17 was clearly connected with group 19 over ca. 11 mm BL, such being an important character for distinguishing adults of this species from similarly-sized *O. obscura*. Sensory canal c was apparent in specimens over ca. 70 mm BL.

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Longitudinal distribution and dietary habits of the genus *Rhinogobius* in the Genka River of northern Okinawa Island, Japan

Kentarou Hirashima and Katsunori Tachihara

Abstract The longitudinal distribution and dietary habits of five and four *Rhinogobius* species were investigated in the Genka River of northern Okinawa Island, Japan. Two sampling points for the assessment of food habits, and locations for determining longitudinal distribution ($n=13$), were identified along the length of the Genka River. Habitat preference was observed to be relatively discreet among the five *Rhinogobius* species sampled: *R. giurinus* was distributed from the tidally influenced river reaches to the lower river reaches, *R. sp. MO* was commonly found in the middle river reaches, *R. sp. CB* was found in riffles along the length of the river without the lowest and uppermost stations, *R. sp. DA* occurred from the middle to the uppermost river reaches, and *R. sp. BB* was commonly found in pools from the middle to the uppermost reaches of the Genka River. Four *Rhinogobius* species (MO, CB, DA, BB) were found to feed primarily on Trichoptera, with *R. sp. CB* and *R. sp. BB* also observed to feed on terrestrial insects. *R. sp. DA* observed to feed on molluscs (snails). These findings suggest that the members of *Rhinogobius* species assayed in the Genka River have become somewhat specialized with respect to habitat (5 species) and food preference (4 species).

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Short Reports

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First record of slender barracudina, *Lestidiops ringens*, (Aulopiformes: Paralepididae), from Japan

Makoto Okamoto, Hiroya Sugisaki, Masatoshi Moku, and Yuji Okazaki

Abstract Two specimens of slender barracudina, *Lestidiops ringens* (Jordan and Gilbert, 1881) (198-204 mm in standard length), were collected by midwater trawl (0-750 m) from east of Aomori and Iwate, northern Japan, Oyashio and transition waters, respectively. *Lestidiops ringens* is distinguished from other congeners by having the following combination of characters: short snout (ca. 8-10 % of standard length), dorsal fin posterior to pelvic fins, lateral line segments 96-130, terminating at caudal fin base, anal fin rays 26-32, and vertebrae number 82-91. This is the first record of the species from Japan, and it is given a new Japanese name, Kita-namehadaka.

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First record of two leiognathid fishes, *Gazza achlamys* and *Leiognathus aureus*, from Japan (Perciformes: Leiognathidae)

Ryoko Kimura, Seishi Kimura, Hidenori Yoshigo, and Tetsuo Yoshino

Abstract Two leiognathids, *Gazza achlamys* and *Leiognathus aureus*, were reported here for the first time from the waters around Japan, based on the specimens collected from Okinawa Prefecture. The descriptions of the specimens were provided and new Japanese names for those species were proposed. The specimens are the northernmost records of both species. *Gazza achlamys* can be distinguished from the other confamilial species in having a pair of large canine-like teeth on symphysis of premaxilla and naked dorsolateral surface anterior to base of sixth or seventh dorsal fin

spine. *Leiognathus aureus* is also distinguishable from the other confamilial species in having forward-protruding mouth without canine-like teeth, 67–85 lateral line scales, 12–18 scales above lateral line, 32–41 scales below lateral line, a black line between anteroventral margin of eye and the lower jaw articulation when mouth closed, and dark blotches neither on nape nor below spinous dorsal fin base.

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Record of a cottid fish, *Icelinus pietschi*, collected from Hokkaido and Miyagi Prefecture, Japan

Osamu Tsuruoka, Takuzo Abe, Hiroyuki Munehara, and Mamoru Yabe

Abstract Seven specimens of cottid fish, *Icelinus pietschi*_Yabe, Soma and Amaoka, 2001, were collected from the shallow waters off Oshoro Bay and Usujiri (western Hokkaido) and Onagawa (Miyagi Pref.), Japan. This species was previously known only from the Iturup Island of southern Kuril Archipelago. The present specimens were secondly recorded to be the southernmost record for this species. In addition, colorations of fresh specimens, reproductive ecology of this species, and the intraspecific variation of the dorsal scale rows were briefly commented.

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Occurrence of *Merluccius productus* from the western North Pacific (Gadiformes: Merlucciidae)

Hiromitsu Endo and Daiji Kitagawa

Abstract A single merlucciid specimen (BSKU 70615, 472 mm in standard length), trawled off Hachinohe, Aomori Prefecture, Japan, was identified as *Merluccius productus* (Ayres, 1855) based on the following combination of counts: number of

anal-fin rays (41), gill rakers on first arch (20/19), vertebrae (23+31=54), ribs (3), and lateral line scales (135). All other characters are consistent with those of the species previously described. *Merluccius productus* is distributed widely on the Pacific coast off North America from California to the Gulf of Alaska. It is also known from three records from Tatar Strait (the Sea of Okhotsk), Bering Sea, and Attu Island (west end of Aleutian Islands). The specimen is therefore the first recorded from Japan, and the western North Pacific. This occurrence from outside of the normal distribution may be the result of some biological traits of the species such as strong swimming ability and offshore migration.

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