NATURE IN SINGAPORE 2010 **3**: 327–332
Date of Publication: 25 November 2010

APLOCHEILUS LINEATUS, A NON-NATIVE KILLIFISH (ACTINOPTERYGII: CYPRINODONTIFORMES: APLOCHEILIDAE) IN SINGAPORE

Darren C. J. Yeo* and **Kelvin K. P. Lim****
Department of Biological Sciences, National University of Singapore
14 Science Drive 4, Singapore 117543, Republic of Singapore
(E-mail: dbsyeod@nus.edu.sg, dbslimkp@nus.edu.sg**)*

INTRODUCTION

Aplocheilus lineatus (Valenciennes) belongs to the killifish family Aplocheilidae. This species is recognisable by its slender body with a rather straight dorsal profile, short-based dorsal fin, long-based anal fin, and oval-shaped caudal fin. Viewed dorsally, the mouth is broadly curved, and there is an iridescent white spot on top of the head between the rear edges of the eyes. The scales are large, 32 to 34 in longitudinal series. The pelvic fins have the second branched ray elongated into a filament that may stretch to the middle of the anal fin when pressed against the belly. Adult males are olive-brown on the dorsum. The flanks are paler with rows of metallic greenish-gold and red spots which, on many individuals, are linked into stripes (Fig. 1). Females and juvenile males (Figs. 2, 4 & 5) are darker coloured with seven to 11 narrow black bars on the sides. The upper and lower margins of the caudal fin are red, or red and bluish-white (Fig. 3). Although it is reported to attain 10 cm total length (TL), most individuals grow to 7 cm (Talwar & Jhingran, 1991: 752; personal observations).

The native distribution of *Aplocheilus lineatus* covers western and south-eastern peninsular India; from near Mumbai and the Malabar districts to Coorg, Wyanad and the states of Cochin and Travancore. It has been reported to inhabit streams and reservoirs in the hills as well as rivers, canals, ponds, tanks, wells, paddy fields and swamps in the plains. It is tolerant of a wide range of environmental conditions, and is even found in brackish water in estuaries (Scheel, 1990: 261; Talwar & Jhingran, 1991: 752). This fish lives just under the water's surface where it feeds primarily on aquatic insects and their larvae, terrestrial insects that fall onto the water's surface, as well as on small juvenile fish (Jacob & Nair, 1982; Talwar & Jhingran, 1991; personal observations). Although this species is not solitary by nature, adult males do behave aggressively toward each other. The eggs are deposited near the water's surface among fine-leafed aquatic vegetation, and they hatch after 12 to 14 days (Lambert, 2001: 53; Sandford, 1995: 158; Schliwen, 2005: 206).

This species has commercial value as an aquarium fish, being first introduced into the trade in 1909 (Scheel, 1990: 261). It is known under various English names, including 'sparkling panchax', 'striped panchax' and 'Malabar killie'

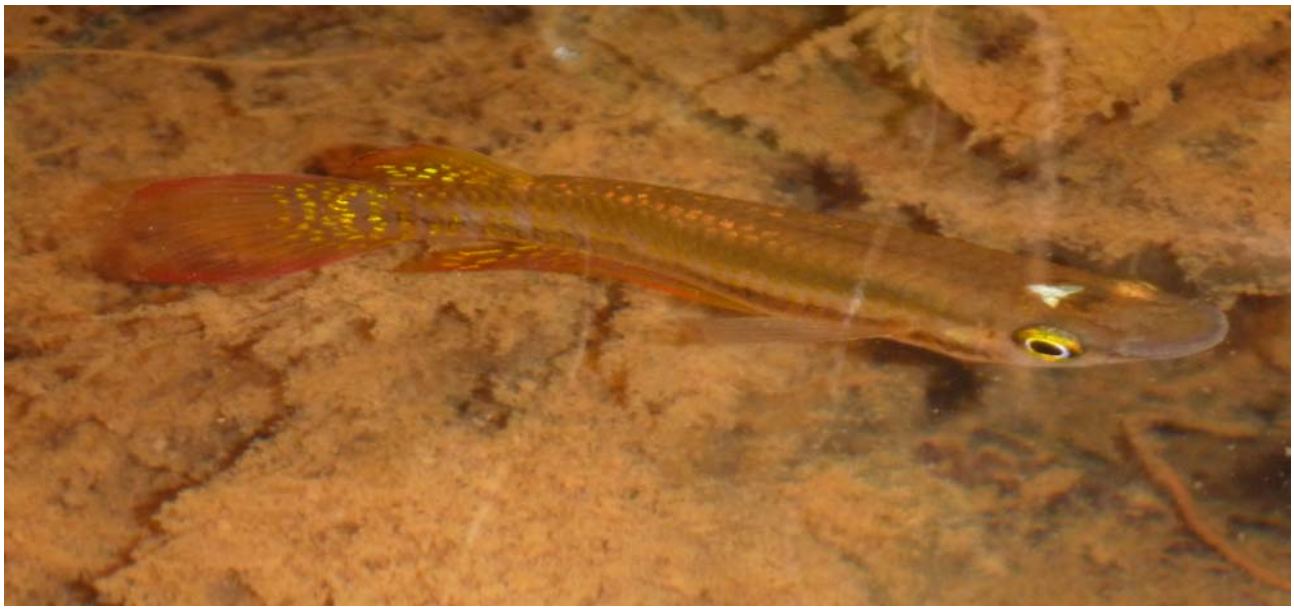

Fig. 1. Dorso-lateral view of adult male *Aplocheilus lineatus* of about 6 cm TL photographed in a stream at the Bukit Batok Nature Park on 23 Oct.2010. Note the reddish fins with bright yellow flecks. (Photograph by: Kelvin K. P. Lim).

Fig. 2. Dorso-lateral view of female or juvenile male of about 4 cm TL photographed in a stream at the Bukit Batok Nature Park on 23 Oct.2010. Note series of narrow black bars on the sides of the posterior half of the body. (Photograph by: Kelvin K. P. Lim).

Fig. 3. Dorso-lateral view of male of about 5 cm TL photographed in a stream at the Bukit Batok Nature Park on 26 Oct.2010. Note red flecks on the body and bluish-white upper and lower margins of the caudal fin. (Photograph by: Benjamin Y. H. Lee).

(Lambert, 2001: 53, Schliwen, 2005: 206; Talwar & Jhingran, 1991: 752). *Aplocheilus lineatus* is not difficult to maintain and breed in captivity, and there are several colour varieties in the aquarium trade, including a bright yellow one known among hobbyists as the 'gold wonder' (Lambert, 2001: 53). In India, this fish is recognised as a voracious predator of aquatic insect larvae, and therefore valued as a natural control of mosquitoes, and mosquito-borne diseases (Talwar & Jhingran, 1991: 752).

This article reports the presence of *Aplocheilus lineatus* in Singapore based on the recent discovery of two separate established feral populations of the species. The present records are based on in-situ observations and photographs (Figs. 1–3) and voucher specimens deposited at the Zoological Reference Collection (ZRC), Raffles Museum of Biodiversity Research (RMBR) at the National University of Singapore. SL refers to standard length, TL refers to total length.

OBSERVATIONS

In Singapore, *Aplocheilus lineatus* is presently known from two localities, both under the jurisdiction of the National Parks Board. As the native range of this species does not include Southeast Asia, its local presence is certainly due to introduction by humans. The source is likely to be the ornamental fish trade as this species is imported into Singapore for sale as aquarium pets.

Aplocheilus lineatus was first observed in the wild in Singapore on 27 Jun.2004, in a small and shallow stream at the Bukit Batok Nature Park (BBNP), by KKPL. Only two individuals were sighted, and they were believed then to

Fig. 4. Lateral views of voucher specimens from Bukit Batok Nature Park (ZRC 52054): male of 47.0 mm SL (above), and female of 37.5 mm SL. (Photograph by: Tan Heok Hui).

Fig. 5. Dorso-lateral view of female or juvenile male *Aplocheilus lineatus* of about 5 cm TL from the Singapore Botanic Gardens, photographed at the marsh pond on 16 Oct.2010. Note the upper and lower margins of its caudal fin are red. (Photograph by: Kelvin K. P. Lim)

represent an isolated example of randomly abandoned pets rather than an established alien population. On our recent visits to the same stream six years later, on 23 and 26 Oct.2010, no fewer than 20 individuals of sizes ranging from around 2 to 7 cm TL were observed, some were photographed in situ (Figs. 1−3), and several voucher specimens obtained (Fig. 4). The semi-natural stream, no wider than 1.5 m and no deeper than 30 cm, flows parallel to Bukit Batok East Avenue 6 at the southern edge of the park, and has been modified by artificial channelisation and concretisation in the lower reaches. Approximately 150 m from where the stream becomes concretised and flows by the car park in the

southwest corner of the park, the water was clear and moderately fast flowing, and the sandy substrate and any submerged surfaces (e.g., vegetation or debris) were coated in a layer of rust- or orange-coloured precipitate that likely represents iron (ferric) phosphate and hydroxide floc. The fish occur in the non-concretised stretch of about 250 m, the upstream half is within secondary forest and the other half is along the edge of a grassy lawn. Sympatric fishes include guppy (*Poecilia reticulata*) and platy (*Xiphophorus maculatus*), both feral species from the Neotropics. Individuals of *Aplocheilus lineatus* frequent the surface waters of the channel as well as the sides of the stream, but seeking shelter under overhanging vegetation and debris along the banks if disturbed. They were quick to pounce on small terrestrial insects such as grasshoppers and crickets that fell onto the water. Males in breeding colours (bright red fins with bright yellow flecks and only faint or no black bars) were also observed displaying to females. The courtship activities and the presence of juvenile specimens (ca. 2 cm TL) indicate that this is an established population of the species within the stream. Five voucher specimens obtained on 26 Oct.2010 are deposited at the Raffles Museum of Biodiversity Research under the catalogue number ZRC 52054 (Fig. 4). They range from 19.2 to 47.0 mm SL (26.5 to 60.5 mm TL).

The second population of *Aplocheilus lineatus* was observed at the Singapore Botanic Gardens, in the marsh pond next to the Swan Lake near the Tanglin entrance. At least 10 individuals, ranging from about 1.5 to 6 cm TL were observed on 16 and 23 Oct.2010. All of them have the diagnostic black bars indicative of females and juvenile males (Fig. 5). No adult males in courtship coloration were observed. Nevertheless, the presence of small juveniles also suggests that breeding does occur there and the population is similarly established in the pond. In contrast to the Bukit Batok site, however, the water in the pond is relatively still and the substrate is a thin layer of mud over a concrete base. The irregularly-shaped pond is no larger than 20 m long and 5 m wide and the water depth does not exceed 30 cm. The water is not artificially filtered and is generally clear unless it rains, in which case the water becomes turbid. Individuals of *Aplocheilus lineatus* were observed in the open and along the concrete edges and under overhanging vegetation. There were lush growths of submerged macrophytes such as *Hydrilla* that provide additional shelter. Unlike the Bukit Batok site, large predatory fishes were observed to be present in this pond, e.g., a spotted gar (*Lepisosteus oculatus*), a sebarau (*Hampala macrolepidota*), a few sharp-toothed walking catfish (*Clarias gariepinus*) and common snakehead or aruan (*Channa striata*), as well as medium-sized boisterous species such as Mayan cichlid (*Cichlasoma urophthalmum*) and Mozambique tilapia (*Oreochromis mossambicus*). The only other comparatively small fish in the pond are juvenile cichlids, red-tailed rasbora (*Rasbora borapetensis*) and mosquitofish (*Gambusia affinis*). With the exception of the aruan, none of the fish species in the pond are native to Singapore.

DISCUSSION

It appears unlikely that the *Aplocheilus lineatus* at the BBNP originated from the random abandonment of a couple of individuals. To establish a breeding population, it would have had to be deliberately stocked in sufficient numbers. Due to its larvivorous habits, this species is valued as a biological control agent of mosquito larvae in its native range (Talwar & Jhingran, 1991: 752). Hence, it could have been intentionally introduced in the stream for this purpose; although this seems unlikely as there were already guppies there [the guppy (*Poecilia reticulata*) was introduced in Singapore prior to 1937 for the same purpose (Herre, 1940; Alfred, 1966: 44 as *Lebistes reticulatus*)]. Furthermore, a check with the National Parks Board confirms that the species has never been deliberately released in BBNP by park managers (B. Y. H. Lee, pers. comm.). This leaves us with the distinct possibility that *Aplocheilus lineatus* may have been intentionally released by members of the public into the stream either as an ornamental fish with the intention of improving the perceived aesthetics of the stream, or as a 'mercy release' to gain spiritual merit. This happens often in Singapore with other exotic ornamental species such as the brightly coloured varieties of common carp or koi (*Cyprinus carpio*) that almost invariably 'appear' in unmanaged freshwater bodies in Singapore that have public access (Tan et al., 2010; Yeo & Chia, 2010; Ng & Tan, 2010). In this case, *Aplocheilus lineatus* could have been purchased from the aquarium trade and released into the BBNP stream, which is open along some stretches and highly accessible.

It may seem inappropriate for *Aplocheilus lineatus* at the Botanic Gardens to be considered a population of wild fish since the pond is man-made, and the fish were artificially introduced. We are nevertheless regarding it as a feral population because it is self-sustaining despite the fish not being fed or protected from the many predators in the same pond. It remains to be seen if this population will continue to thrive in the years to come.

Aplocheilus panchax (Hamilton), the whitespot or blue panchax, is the only congener of *Aplocheilus lineatus* that is native to Southeast Asia and Singapore. It is locally widespread in streams in open, usually coastal areas, and also in some inland reservoirs (Ng & Lim, 1996: 112; Baker & Lim, 2008: 41). We have no records of *Aplocheilus panchax* from the two sites populated by *Aplocheilus lineatus*. *Aplocheilus panchax* was recorded from the Botanic Gardens four decades ago (Alfred, 1966: 43) but it is presently extirpated there. Both species occupy the same niche and are likely to compete with each other if placed together. However, it seems unlikely that the disappearance of *Aplocheilus panchax* from the Botanic Gardens was caused by the introduction of *Aplocheilus lineatus,* as the native species had not been seen there long before *Aplocheilus lineatus* was first observed. We do not know if the introduction of *Aplocheilus lineatus* would have any detrimental impact on other small native fishes. The two sites where it is currently found are devoid of such small native fish taxa.

Fig. 6. Dorso-lateral view of *Aplocheilus panchax* of about 5 cm TL from Upper Peirce Reservoir. Note absence of narrow black bars and filamentous extension of the pelvic fins. (Photograph by: Kelvin K. P. Lim).

Fig. 7. Dorsal view of individual of about 5 cm TL from a stream in Sime Road forest, Central Catchment Nature Reserve. Note the pale blue upper and lower margins of its caudal fin. (Photograph by: Kelvin K. P. Lim).

When viewed directly from the top, *Aplocheilus lineatus* is surprisingly similar in appearance to *Aplocheilus panchax*. They share the olive-brown dorsum, the distinctive white spot on top of the head and a narrow blackish stripe on the mid-dorsum (Figs. 1–3, 5–7). However, they are easily distinguished from the lateral view. *Aplocheilus panchax* (Figs. 6 and 7) lacks the filamentous extension on the pelvic fins as well as the narrow black bars and iridescent yellow spots on the sides of its body. *Aplocheilus panchax* in Singapore does not grow larger than 6 cm TL (Baker & Lim, 2008: 41), so it tends to be smaller than the largest examples of *Aplocheilus lineatus*.

CONCLUSIONS

Aplocheilus lineatus is an established introduced species in Singapore, with two separate small populations that appear to be locally restricted to the Bukit Batok Nature Park and the Singapore Botanic Gardens. It is not known if there are any impacts on the natural environment as it occurs in an artificial pond and a highly modified semi-natural stream already devoid of small native fishes. *Aplocheilus lineatus* is the latest alien freshwater fish to be added to the fauna of Singapore, following 54 other non-native fishes recently recorded from local reservoirs (Ng & Tan, 2010: 95).

ACKNOWLEDGEMENTS

We are grateful to Benjamin Y. H. Lee (National Parks Board) for help and permission to sample the Bukit Batok Nature Park stream, and for the use of one of his photographs. We also thank Tan Heok Hui for the photography of the voucher specimens.

LITERATURE CITED

Alfred, E. R., 1966. The fresh-water fishes of Singapore. *Zoologische Verhandeligen* **78**: 1–68, 8 pls.

Baker, N. & K. K. P. Lim, 2008. *Wild Animals of Singapore. A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Draco Publishing and Distribution Pte. Ltd. and Nature Society (Singapore). 180 pp.

Herre, A. W., 1940. Additions to the fish fauna of Malaya and notes on rare or little known Malayan and Bornean fishes. *Bulletin of the Raffles Museum, Singapore* **16**: 27–55.

Jacob, S. S. & N. B. Nair, 1982. Food and feeding habits of the larvivorous fish *Aplocheilus lineatus* (Cuv. & Val.) in its natural habitat. *Journal of Fish Biology* **20**: 329–339.

Lambert, D., 2001. *A Practical Guide to Breeding your Freshwater Fish*. Barron's Educational Series, Inc., New York, USA. 77 pp.

Ng, H. H. & H. H. Tan, 2010. An annotated checklist of the non-native freshwater fish species in the reservoirs of Singapore. *Cosmos* **6**(1): 95–116.

Ng, P. K. L. & K. K. P. Lim, 1996. The freshwater fishes of Singapore. *Journal of the Singapore National Academy of Science* **22–24**: 109–124.

Sandford, G., 1995. *An Illustrated Encyclopedia of Aquarium Fish*. Quintet Publishing Ltd., London, United Kingdom. 256 pp.

Scheel, J. J., 1990. *Atlas of Killifishes of the Old World*. T.F.H. Publications, Inc., Neptune City, New Jersey, USA. 448 pp.

Schliewen, U., 2005. *Tropical Freshwater Aquarium Fish from A to Z*. English language translation. Barron's Educational Series, Inc., New York, USA. 256 pp.

Talwar, P. K. & A. G. Jhingran, 1991. *Inland Fishes of India and Adjacent Countries. Volume 2*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India. p. 543–1158.

Tan, H. T. W., L. M. Chou, D. C. J. Yeo & P. K. L. Ng, 2010. *The Natural Heritage of Singapore. 3rd edition.* Pearson Prentice Hall. 323 pp.

Yeo, D. C. J. & C. S. W. Chia, 2010. Introduced species in Singapore: an overview. *Cosmos* **6**(1): 23–37.