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Diversity, distribution, and conservation status of Betta fish (Teleostei: Osphronemidae) in Aceh waters, Indonesia

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Abstract

The Betta broodfish supply in Indonesia majorly comes from wild populations and fetches a higher price compared to hatchery cross-breeds, especially *Betta rubra*. This condition exerts pressure on the wild populations. Therefore, this study aims to examine the diversity, distribution, and conservation status of Betta fish species list in the study area. A total of 422 Betta fishes were collected from January 2019 to January 2021 from 19 of 59 sampling locations surveyed, consisting of four species, namely, *Betta imbellis* (TL: 14.09–31.98 mm; BW: 0.03–0.39 g), *B. splendens* (TL: 21.09–40.14 mm; BW: 0.05–0.70 g), *B. rubra* (TL: 11.35 to 47.80 mm; BW: 0.02–0.90 g), and *B. dennisyongi* (TL: 20.09–47.81 mm; BW: 0.07–0.91 g). There are four Betta species occurred in Aceh waters, namely *B. dennisyongi*, *B. rubra*, *B. splendens*, and *B. imbellis*. The results showed that *B. dennisyongi* was found at 8 sampling locations and had higher local distribution (13.56% LD) followed by *B. rubra* (8.47% LD), *B. splendens* (6.78% LD) and *B. imbellis* which had the lowest distribution and was only found in two locations (3.39% LD). Furthermore, field measurements (in situ) of water quality in the wild habitat showed temperature ranging from 23.7 to 31.9°C while pH ranged from 5.24 to 8.51. Based on the IUCN Redlist data, *B. rubra* is categorized as being critically endangered.

Keywords: Broodfish, endemic, fighting fish, IUCN Redlist, ornamental fish, wild population

Introduction

Aceh Province is one of the richest ichthyofaunal regions in Indonesia as over 114 species of freshwater fish have been reported from this area (Muchlisin & Azizah 2009). Among these species, 25 reportedly have great potential as ornamental fish including species within the genus *Betta* popularly known as the fighting fish (Muchlisin 2013). Based on Fishbase (2020), 79 species of Betta fish have been described worldwide, where 63 species occur in Asia, of which 52 species are found in Indonesian waters. This fish has a breathing apparatus called

labyrinth (Allen & Nicoletto 1997; Apriliani et al. 2018; Watson et al. 2019), and a wide feeding spectrum (Monvises et al. 2009), therefore, enabling it to occupy both lotic and lentic freshwater ecosystems (Schindler & Schmidt 2006). Furthermore, the adult males provide parental care (Rüber et al. 2004; Forsatkar et al. 2014) divided into nest-builder and mouthbrooder, usually solitary and territorial (Goldstein 2015), have an attractive color pattern and are therefore very popular as aquarium fish (Monvises et al. 2009; Thongprajukaew et al. 2011; Alderton 2012).

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The supply of *Betta* fish in Indonesia, especially in Aceh Province mostly comes from the wild which has a higher selling price compared to cultured population particularly for rare species, such as *B. rubra* and *B. dennisyongi*. This condition threatens wild populations and is further exacerbated by habitat perturbations due to land conversion to plantations, climate change, highways, and settlements including in Aceh Province (Low 2019b; Nur et al. 2020). According to the IUCN data in 2020, a total of 21 *Betta* species were recorded from inland waters of Sumatra, Indonesia, where 28.6% are critically endangered, least concern (28.6%), endangered (19.0%), vulnerable (19%) and deficient data (4.8%) (IUCN 2020).

Studies on the diversity and distribution of *Betta* fish in the Southeast Asian region have also been reported from several countries, for instance, 12 species were reported from Thailand, namely *B. simplex*, *B. prima*, *B. pugnax*, *B. pi* (Tan & Ng 2005; Tanpitayacoop & Na-Nakorn 2005), *B. smaragdina* (Tan & Ng 2005; Monvises et al. 2009), *B. mahachaiensis*, *B. siamorientalis* (Kowasupat et al. 2012a, 2012b), *B. imbellis*, *B. splendens* (Tan & Ng 2005; Kowasupat et al. 2014), *B. pallida*, *B. ferox* and *B. apollon* (Panijpan et al. 2014). Furthermore, three species were also identified in Cambodian waters, namely *B. prima* (Tan & Ng 2005), *B. siamorientalis* and *B. stiktos* (Kowasupat et al. 2012a, 2014), while two species were reported from Brunei (*B. macrostoma* and *B. akarensis*) and two species from Singapore (*B. pugnax* and *B. imbellis*) (Tan & Ng 2005). In addition, 24 species were found in Malaysian waters namely *B. coccina*, *B. pulchra*, *B. stigmosus*, *B. waseri*, *B. ibanorum*, *B. macrostoma*, *B. akarensis*, *B. chini*, *B. gladiator*, *B. lehi*, *B. taeniata*, *B. brownorum*, *B. pi* (Tan & Ng 2005), *B. ocellata*, *B. persephone*, *B. tussyae*, *B. livida*, *B. hipposideros*, *B. pugnax* (Tan & Ng 2005; Kowasupat et al. 2014), *B. imbellis* (Tan & Ng 2005; Kowasupat et al. 2014), *B. kuehnei*, *B. stigmosa*, *B. waseri*, and *B. bellica* (Panijpan et al. 2014).

Similar studies conducted in Indonesia reported 27 species from Kalimantan, namely, *B. breviobesus*, *B. lehi*, *B. balunga*, *B. pinguis*, *B. obscura*, *B. pallifina*, *B. taeniata*, *B. rutilans*, *B. brownorum*, *B. foerschi*, *B. strohi*, *B. anabatoides*, *B. channoides*, *B. dimidiata* (Tan & Ng 2005), *B. albimarginata*, *B. edithae*, *B. enisae*, *B. unimaculata*, *B. patoti*, *B. ocellata* (Tan & Ng 2005, 2006; Sriwattanarothai et al. 2010; Panijpan et al. 2014), *B. antoni*, *B. krataios*, *B. mandor*, *B. compuncta*, *B. ideii* (Tan & Ng 2006; Panijpan et al. 2014), *B. uberis* and *B. anabantoides* (Tan & Ng 2005;

Sriwattanarothai et al. 2010; Panijpan et al. 2014), as well as 16 species from Sumatra namely *B. bellica*, *B. simorum*, *B. pugnax*, *B. schalleri*, *B. coccina*, *B. miniopinna*, *B. burdigala*, *B. hipposideros*, *B. spilotogena*, *B. renata*, *B. edithae*, *B. imbellis* (Tan & Ng 2005), *B. rubra*, *B. chloropharynx*, *B. falx* and *B. fusca* (Tan & Ng 2005; Sriwattanarothai et al. 2010; Panijpan et al. 2014). Furthermore, one species each was found in Java (*B. picta*) and Riau archipelago (*B. aurigans*) (Tan & Ng 2005). However, the total number of *Betta* species in Sumatra Island is probably underestimated as several regions within this island have never been explored intensively. This includes the Aceh Province waters widely known as one of the ichthyofaunal hotspots in Sumatra. Therefore, this study aims to examine the diversity, distribution, and conservation status of *Betta* fish species list in the study area. This information is crucial for the documentation of the Indonesia ichthyofauna and to plan a better conservation strategy in the future.

Material and methods

Sampling period and location

The survey was conducted from January 2019 to January 2021 at 59 sampling sites within Aceh Province, Indonesia, namely Aceh Singkil (8), Kota Subulussalam (5), Aceh Selatan (5), Aceh Barat Daya (3), Nagan Raya (4), Aceh Barat (4), Aceh Jaya (2), Aceh Besar (3), Banda Aceh (1), Pidie (5), Pidie Jaya (2), Bireuen (1), Kota Lhokseumawe (6), Aceh Utara (1), Aceh Tengah (1), Aceh Timur (3), Kota Langsa (3), and Aceh Tamiang (2) (Figure 1). The description for all sampling sites is presented in Table 1, while the field conditions are presented in Figure 2.

Sampling procedure

An exploratory survey was conducted in this study. The study team collected information from the locals on where the *Betta* fish are predicted to be found. These locations were then visited to conduct sampling (purposive), followed by random expansion to other nearby locations (random). The fish was sampled using a scoop net. The samples were kept in a plastic bag filled with water and oxygen and were then transported to the Ichthyology Laboratory of Universitas Syiah Kuala in Banda Aceh for further analysis. In the laboratory, the sampled fish was photographed and a total of 20 samples (n = 5 each species) anesthetized by immersing the fish in cold water (4°C) for 2–5 min, then

Table 1. The GPS coordinates and characteristics of the sites where betta fish were collected.

No	District/City	Lat (N)	Long (E)	Locality	Description of General Habitat	Coll. Date
1	Aceh Tamiang	04° 16.751'	098° 03.902'	Peat swamp in Tanjung Rambut village, Kuala Simpang City	The waters are brownish cloudy with muddy substrates	5 Aug 2019
2	Banda Aceh	05° 31.437'	095° 18.364'	Ponds in Gueece komplek village, Banda Raya subdistrict	The waters are brownish cloudy with muddy substrates	8 Dec2020
3	Aceh Barat	04° 11.681'	096° 12.761'	Swamp marshes with various vegetation in Krueng Balee village, Meureubo sub district	The waters are brownish cloudy with muddy substrates	14 Apr 2019
		04° 09.086'	096° 08.204'	Swamp marshes in Terendam, Rundeng village, Johan Pahlawan sub district	The waters are brownish cloudy with muddy substrates	16 Apr 2019
		04° 09.752'	096° 08.210'	Peat swamp along road in Kampong Darat Village, Johan Pahlawan sub district	The waters are brownish cloudy with muddy substrates	20 Mar 2019
		04° 14.194'	096° 09.130	Peat swamp in Simpang Peunia village, Kaway 16 sub district	The waters are brownish cloudy with muddy substrates	20 Mar 2019
4	Nagan Raya	04° 16.936'	096° 27.023'	Swamp marshes with hydrilla vegetation in Blang Neuang village, Beutong subdistrict	The waters are clear with muddy substrates	31 Jan 2019
		04° 16.515'	096° 24.147'	Swamp marshes with hydrilla vegetation in Blang Baro village Beutong subdistrict	The waters are clear with muddy substrates	31 Jan 2019
		04° 16.135'	096° 24.030'	Swamp marshes along road in Babah Krueng village, Beutong, subdistrict	The waters are clear with muddy substrates	31 Jan 2019
		04° 03.154'	096° 27.591'	Irrigation channel of the oil palm plantation in Ujong Lamie village, Darul Makmur Subdistrict	The waters are clear with muddy substrates	17 Jan 2021
5	Aceh Besar	05° 23.618'	095° 25.645'	River with various vegetation in Krueng Jreu, Indrapuri subdistrict	The waters are clear with muddy substrates	16 Jul 2019
		05° 23.285'	095° 25.447'	River with various vegetation in Reukh Keupula village, Indrapuri sub district	The waters are clear with muddy substrates	17 Jul 2019
		05° 29.895'	095° 27.939'	River with various vegetation in Bira Cot village, Montasik subdistrict	The waters are clear with muddy substrates	8 Jul 2019
6	Aceh Barat Daya	03° 40.218'	096° 55.079'	A tributary with various vegetation along road in Gunong Cut village, Tengan-Tangan subdistrict	The waters are clear with muddy substrates	20 Aug 2019
		03° 53'21.2"	096° 42'32.6"	A tributary in Pantee Cermin village, Babah Rot sub district	The waters are clear water with gravel substrates	17 Jan 2021

(Continued)

Table I. (Continued).

No	District/City	Lat (N)	Long (E)	Locality	Description of General Habitat	Coll. Date
7	Aceh Jaya	4°33'49.4"	095° 47.110	A tributary in Alue Abet village, Panga subdistrict	The waters are brownish with muddy substrates	17 Mar 2019
8	Aceh Selatan	04° 37.794'	095° 40.028'	Irrigation canals at Paya Seumantok village, Krueng Sabee subdistrict	The waters are clear water with gravel substrates	17 Mar 2019
9	Aceh Singkil	02°52'25.3"	097°43'21.9"	Irrigation channel at Pinto Rimba village, Trumon Tim sub district	The waters are brownish with muddy substrates	21 Jan 2021
		02°26'01.2"	097°59'22.3"	Irrigation channel in Lipat Kejang Atas village, Simpang Kanan sub district	The waters are brownish with muddy substrates	21 Jan 2021

Results

Species composition, distribution, and conservation status

Only 19 sites of the 59 sampling locations surveyed were found to contain *Betta* fish with a total sample of 422 belonging to four species, namely *B. imbellis*, *B. splendens*, *B. rubra* and *B. dennisyongi* (Table II and Figure 3). *B. imbellis* had a total length ranging from 14.09–31.98 mm, and body weight 0.03–0.39 g while *B. splendens* total length ranged from 21.09–40.14 mm, and body weight 0.05–0.70 g. Furthermore, the *B. rubra* total length ranged from 11.35 mm to 47.80 mm with 0.02–0.90 g body weight, while *B. dennisyongi* total length ranged from 20.09–47.81 mm, and body weight of 0.07–0.91 g (Table II).

The results showed that *B. dennisyongi* was widely distributed at eight sites (LD 13.56%), followed by *B. rubra* (LD 8.47%), *B. splendens* (LD 6.78%), and *B. imbellis* which had the lowest distribution and was only found in two locations, namely Aceh Tamiang and Barat (LD 3.39%) and also had the least number of samples (64 individuals), while the largest number of samples was recorded for *B. splendens* (168 individuals). Based on the IUCN Red List database, among the four species of fighting fish found in Aceh waters, one is categorized as an endangered species (*B. rubra*), two in the Vulnerable category (*B. dennisyongi* and *B. splendens*), and one in the Least Concern category (*B. imbellis*) (Table III).

Habitat. The in-situ main parameter measurements of water quality showed a temperature ranging from 23.8–31.9°C, where the highest temperature was found in the peat swamp of Aceh Barat, while the lowest was found at Aceh Barat Daya. Furthermore, the pH values ranged from 5.24–8.50, where the lowest pH was recorded in Aceh, while the highest was found at Nagan Raya. Dissolved oxygen (DO) ranged from 4.1 to 9.1 mg L, where the lowest DO was recorded in the oil palm plantation areas in Aceh Selatan District, while the highest was recorded at Aceh Jaya (Table IV).

B. imbellis was found in peat swamps, with depths ranging from 50 to 70 cm, particularly among aquatic plant roots (Figure 2(a)). In Aceh Barat, *B. splendens* were found in blackwater peat swamps (Figure 2(b)) with depths ranging from 10 to 25 cm, while in Banda Aceh, this species was also found in blackish-brown waters associated with the water plant, *Eichhornia crassipes* at water depths of 35–70 cm (Figure 2(c)). Furthermore, *B. rubra* in Aceh Besar was found in Blang Bintang and



Figure 2. Representative habitats of *Betta* in Aceh Province. (a) Aceh Tamiang; (b) Aceh Barat; (c) Banda Aceh (d) Aceh Besar; (e) Aceh Jaya; (f) Aceh Barat Daya; (g) Nagan Raya (h) Aceh Singkil and (i) Aceh Selatan.

Table II. The ranges and average total length and body weight of *Betta* samples were collected from Aceh Province, Indonesia. N = total sample, SD = standard deviation.

No.	Species	Total length (Mean \pm SD) (mm)	Body weight (Mean \pm SD) (g)	N
1.	<i>Betta imbellis</i>	14.09–31.98 (22.67 \pm 4.58)	0.03–0.39 (0.15 \pm 0.09)	64
2.	<i>Betta rubra</i>	11.35–47.80 (29.26 \pm 9.56)	0.02–0.90 (0.30 \pm 0.26)	72
3.	<i>Betta dennisyongi</i>	20.09–47.81 (29.68 \pm 7.34)	0.07–0.91 (0.28 \pm 0.23)	118
4.	<i>Betta splendens</i>	21.09–40.14 (29.54 \pm 4.12)	0.05–0.70 (0.22 \pm 0.14)	168

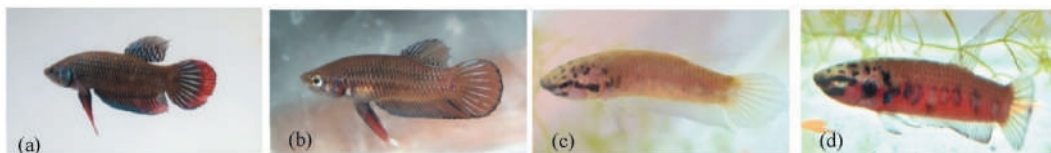


Figure 3. *Betta* spp. from Aceh waters, (a) *Betta imbellis*, (b) *Betta splendens*, (c) *Betta dennisyongi* and (d) *Betta rubra* (Nur et al. 2022).

Indrapuri, both habitat areas are tributary streams (Figure 2(d)) with a depth of 30–70 cm, characterized by clear and flowing water. *B. rubra* was found to be frequently associated with *Puntius oligolepis*, *P. binotatus*, *Danio albolineatus*, *Rasbora sumatrana*, and *Lepidocephalichthys hasselti*. It was found specifically among plant roots or litter. Meanwhile, in Aceh Jaya, *B. rubra* was found in irrigation canals

and creeks with flowing, clear and slightly brownish-yellow waters at a depth of 10–40 cm (Figure 2(e)). Moreover, *B. dennisyongi* had the widest distribution and lives in several types of waters, for example in Aceh Barat Daya, it was found in mountain springs (Figure 2(f)), clear water with depths of 10–15 cm, while in Nagan Raya, this species was found in a drainage channel (Figure 2(g)) of clear water

Table III. List of *Betta* species, total number of individuals and distribution at 19 sites in Aceh Province based on sampling sites. Meanwhile, other 34 sites were not displayed in the table because no sample was recorded.

Species	Sampling sites																			Current IUCN Category	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S		N
<i>Betta imbellis</i>	1	63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	64	LC
<i>Betta rubra</i>	-	-	-	-	-	-	-	-	-	9	10	31	11	11	-	-	-	-	-	72	EN
<i>Betta dennisyongi</i>	-	-	50	-	-	-	19	22	8	-	-	-	-	-	5	9	3	2	118	VU	
<i>Betta splendens</i>	-	-	-	3	108	52	-	-	-	-	-	-	-	-	5	-	-	-	168	VU	

A = Krueng Balee; B = Tanjung Rambut; C = Gn. Cut; D = Gampong Rundeng; E = Simpang-Peunia; F = Kp. Darat; G = Blang Baro; H = Blang Neuang; I = Babah Krueng; J = Alue Abet; K = Paya Seumantok; L = Bira Cot; M = Krueng Jere; N = Reukih Keupula; O = Geuceu Kompleks; P = Ujong Lamie; Q = Babah Roet; R = Pinto Rimba; S = Pinto Rimba, LC = Least concern, VU = Vulnerable, EN = Endangered, N = Total sample

Table IV. Temperature, pH and dissolved oxygen of the respective habitats of *Betta* in the waters of Aceh, Indonesia.

Parameters	<i>Betta splendens</i>		<i>Betta imbellis</i>		<i>Betta rubra</i>		<i>Betta dennisyongi</i>	
	Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD
Temp ($^{\circ}$ C)	26.6–31.9	29.3 \pm 3.75	27.5–28.5	28.15 \pm 0.49	27.4–27.8	27.6 \pm 0.28	23.8–28.6	25.7 \pm 2.22
pH	5.24–6.95	6.1 \pm 1.21	7.13–7.59	7.36 \pm 0.33	7.12–8.50	7.8 \pm 0.98	6.3–7.2	6.7 \pm 0.44
DO (ppm)	6.5–7.9	7.7 \pm 0.99	7.3–7.9	7.6 \pm 0.42	8.5–9.1	8.75 \pm 0.49	4.1–9.7	6.8 \pm 2.06

with a depth of 5–20 cm. This species was also found in swamps with brownish-yellow water in Aceh Singkil with a depth of 15–40 cm (Figure 2(h)), and in tributaries with brownish water with a depth of 20–45 cm in Aceh Selatan (Figure 2(i)).

Discussion

A total of four *Betta* species were recorded during the study, namely *Betta imbellis*, *B. splendens*, *B. rubra*, and *B. dennisyongi* (Figure 3). Based on the total number of samples, *B. splendens* was most predominant (39.81%), followed by *B. dennisyongi* (27.96%), *B. rubra* 17.06%, and *B. imbellis* 15.17%. Although *B. splendens* were high in numbers, this species was only found in four locations, while *B. dennisyongi* had a wider local distribution. *B. imbellis* which had a narrow distribution and the least number of samples, and was only found in two locations (at Krueng Balee and Tanjung Rambut).

Betta fish were found in 19 out of the 59 locations visited, and each location was occupied by only one species. This is probably related to the territorial and habitat preferences of the fish. According to Rainwater (1967) and Bronstein (1982), *Betta* fish is territorial and aggressive during the spawning season and egg incubation. These territorial and aggressive habits are related to self-defense and offspring protection from predators, competition for mates,

and maintaining social hierarchies (Polgardani et al. 2017).

The results showed that the total number of fish sampled was dependent on the habitat type. The tributary areas with flowing water (lotic) had less sampled fish compared to stagnant waters (lentic). For instance, *B. imbellis* and *B. splendens* were predominant in numbers compared to the other two species where they were more easily caught since the habitats of these species are swamps and ponds where the water is relatively stagnant. Although swamp waters are slightly acidic, these two species adapt well and thriving. Meanwhile, *B. rubra* and *B. dennisyongi* were found in locations with flowing waters, hence, the fish were difficult to catch due to their agility and being hidden among the roots of the aquatic plants. These waters generally range from neutral to alkaline.

Based on the survey, *B. dennisyongi* is the most widely distributed and was found in several habitats. For example, in Aceh Barat Daya, this fish was found in small streams from mountains with clear waters, while in Nagan Raya, it was found in several locations with different habitat types, namely, drainage or irrigation canals, swamps and creeks. In addition, this fish was also found in water puddles in oil palm plantation areas where the water was cloudy and yellowish. Therefore, this study shows that *B. dennisyongi* is highly adaptable in various types of waters, hence its wider distribution

compared to the other three species. This distinctive adaptability is probably related to the presence of a breathing apparatus (labyrinth), which enables oxygen (O₂) absorption directly from the atmosphere (Chapman & Chapman 1994; Alton et al. 2013; Tate et al. 2017). The field observations showed that this fish often swim to the water surface, possibly to obtain free oxygen in the air.

B. rubra was found in two districts, namely Aceh Besar and Aceh Kaya. In Aceh Besar this species was found in Blang Bintang and Indrapuri where it occupied creeks and often associated with other fish species such as *Puntius oligolepis*, *P. binotatus*, *Danio albolineatus*, *Rasbora sumatrana*, and *Lepidocephalichthys hasselti*. Meanwhile, in Aceh Jaya, this species was also found in tributaries and irrigation canals.

B. splendens is a native fish in the Mekong Delta (Irawan & Afiati 2006) and was introduced to Indonesia from Thailand in the 1970s (Dewantoro & Rachmatika 2020; Panijpan et al. 2020). It is usually found in standing waters, including shallow ponds, swamps, rice fields, creeks, and rivers (Taki 1978; Rainboth 1996; Jaroensutasinee & Jaroensutansinee 2001; Watson et al. 2019). Based on the current results, it is suspected that this fish was released either intentionally or unintentionally by hobbyists and managed to successfully breed in the wild in Aceh waters. However, there have been no reports or evaluations of the impact of the presence of *B. splendens* in Indonesian waters. However, we suspect that the presence of these species may not have an adverse impact on the native *Betta* species because based on the finding of this study it was shown that there was no more than one species of *Betta* found at any one location, thus each species of *Betta* fish inhabits different habitats and does not compete for habitat occupation. However, the adverse impact on other fish species is unknown, and therefore these speculations need clarification by further intensive studies. Meanwhile, *B. imbellis* is a native species in Indonesia, and usually inhabits puddles and ditches ranging from clear water to yellow-brown (Tan & Ng 2005) both in lowland swamps and rice fields. Based on interviews with local hobbyists, *B. rubra* and *B. dennisyongi* have high selling prices up to 10–16 USD per pair because these two fish are endemic, *B. rubra* to Sumatra (Schindler & van der Voort 2011), and *B. dennisyongi* to Aceh (Tan 2013). Therefore, they are the main targets for hobbies.

Regarding the conservation status, the IUCN Red List data showed that *B. rubra* is listed as an endangered species (Low 2019a). This species was only recorded in two areas, namely Aceh Besar and Jaya districts. Furthermore, the field observations

indicated that the *B. rubra* habitats in these two areas are threatened by perturbation due to highways and warehousing development. Meanwhile, *B. dennisyongi* and *B. splendens* have been listed in the Vulnerable category (Vidthayanon 2011; Low 2019b). In addition, *B. imbellis* was listed in the Least concern category (Low 2019c). However, based on field observations and interviews with local hobbyists, *Betta* fish are becoming rare as population continues to decline in the wild as evident in this study where low number of samples were collected. We believe that the status of these species may actually be under greater threat than classified in the IUCN Red List. Therefore, the IUCN conservation status of this species has to be updated immediately. Moreover, there is a need for comprehensive studies on the bioecological aspects as the basis for planning a better conservation strategy and breeding program in the future.

Conclusions

It is concluded that there are four *Betta* species in the Aceh waters, namely *B. splendens*, *B. imbellis*, *B. rubra* and *B. dennisyongi*, the last two species being endemic to Aceh and Sumatra. *B. rubra* is categorized as an endangered species while *B. dennisyongi* has a wider distribution compared to the other three species although listed in the vulnerable category. In addition, *B. imbellis* has the narrowest distribution and was found only in Aceh Tamiang and Aceh Barat districts. Meanwhile, *B. splendens* is an introduced species found in Banda Aceh and Aceh Barat districts, and is categorized as a vulnerable species. However, these four *Betta* fish were very difficult to find during the course of this study, and possibly the degree of threat has increased. Therefore, the IUCN status of all these fish species needs to be updated. In addition, conservation action for all *Betta* species that occurs in Aceh has to be initiated immediately to ensure their germplasms are sustained.

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Disclosure statement

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