

From Waters to Screens: Looking at Wild Betta *Betta* spp. (Anabantiformes: Osphronemidae) Trading in Indonesia's Online Marketplaces

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Abstract

Indonesia hosts a remarkable diversity of freshwater fishes, including numerous endemic wild Betta *Betta* spp. (Anabantiformes: Osphronemidae). However, the rise of e-commerce has facilitated unregulated online trade of wild Betta species. This study investigates the diversity, conservation status, and trade dynamics of wild Betta species between 1–21 October 2025, in Indonesia's three largest online marketplaces: Shopee, Tokopedia, and Lazada. A total of 38 wild Betta species were identified, including five Critically Endangered, eleven Endangered, and seven Vulnerable taxa. The trade was dominated by species from Sumatra and Kalimantan, which together accounted for over 85% of endemic taxa. Market analysis revealed a positive correlation between rarity and price, with Endangered and Not Assessed species commanding the highest average prices. The presence of Critically Endangered species such as *Betta chloropharynx* and *B. hendra* indicates ongoing extraction from the wild despite conservation risks. Furthermore, nearly 26% of traded species remain Data Deficient or Not Assessed, reflecting critical knowledge gaps that hinder management and policy enforcement. The findings underscore the urgent need for stronger regulation of digital wildlife trade, improved conservation assessments, and promotion of captive breeding programs to reduce wild collection pressure.

Keywords: conservation, fighting fish, Indonesia, online trade, wild Betta.

Introduction

Indonesia boasts an incredible array of freshwater biodiversity, hosting thousands of unique and endemic species, particularly freshwater fishes (Allen 1991; Kottelat *et al.* 1993). The country's diverse freshwater ecosystems, spanning from Aceh Province to South Papua Province, sustain a vast range of species (Windusari *et al.* 2019; Arifah *et al.* 2025; Iqbal *et al.* 2025). Indonesia, a hotspot of freshwater diversity, is home to the diverse *Betta* genus, which belongs to the Osphronemidae family and comprises over 70 species found mainly in Southeast Asia (Tan & Ng 2005a, b). Many wild Betta species (Anabantiformes: Osphronemidae), commonly referred to as “wild bettas,” inhabit peat swamps, forest streams, and blackwater habitats, ecosystems increasingly threatened by deforestation and habitat conversion (Iqbal 2011; Iqbal *et al.* 2018).

The rapid growth of e-commerce in Indonesia has inadvertently fueled the online wildlife trade (Setiawan *et al.* 2019; Baderan *et al.* 2023). Consequently, online platforms have emerged as a prominent marketplace for wildlife, including ornamental fish like Betta species (Kurnia *et al.* 2022; Bagaskara & Anasrulloh 2023). Many fish species, including some Betta species, are being harvested from the wild and sold online without regard for their conservation status or the impact on their populations (Abd

Rahman & Matthew 2021; Nur *et al.* 2022). While domesticated *Betta splendens* are globally popular, the sale of wild and endemic *Betta* species online has raised conservation concerns, especially when species with restricted ranges and threatened statuses appear on digital marketplaces (Rahmatulloh *et al.* 2023; Wibisono *et al.* 2024).

Given the endemic nature of many wild *Betta* species and their representation on the IUCN (International Union for Conservation of Nature) Red List, research is needed to investigate the online trade trends of these species (IUCN 2025). This study aims to address this need by investigating the online trade of wild *Betta* species in Indonesia. We analyzed listings on major e-commerce platforms (Shopee, Tokopedia, and Lazada) to document the diversity, conservation status, and trade patterns of wild *Betta* species, and to assess the potential conservation implications of this online market.

Methods

This study assessed the online trade of wild *Betta* fish in Indonesia through a systematic collection and analysis of data from Indonesian marketplaces, drawing on methodologies established in previous regional online wildlife trade surveys (Iqbal 2015, 2016). Online surveys were conducted between 1–21 October 2025 on three major Indonesian marketplaces: Shopee, Tokopedia, and Lazada. Searches used the keyword “*Betta* liar” or “Cupang liar” (“wild *Betta*”) and scientific names of known *Betta* species. Each unique listing was recorded along with species name, IUCN conservation status, native distribution, endemism (Sumatra, Kalimantan, or Java), selling price (in Indonesian Rupiah), and seller location.

Species were categorized by IUCN Red List status (Critical Endangered/CR, Endangered/EN, Vulnerable/VU, Near Threatened/NT, Least Concern/LC, Data Deficient/DD or Not Available/NA). Average prices were calculated per species and per conservation category to identify market trends. Geographic origin and seller distribution were used to identify potential trade hubs. Descriptive and comparative analyses were applied to interpret diversity and conservation patterns across platforms.

Results and Discussion

A total of 38 wild *Betta* species were identified across the three marketplaces. Among these, five species were *Critically Endangered* (*Betta burdigula*, *B. chloropharynx*, *B. hendra*, *B. miniopinna*, *B. sp. cf. api*), eleven species were *Endangered*, seven species were *Vulnerable*, and four species were *Least Concern*. The remaining taxa were Data Deficient or Not Assessed (Table 1). The trade was dominated by species from Sumatra (19 species) and Kalimantan (16 species), with Java (1 species) contributing minimally. Endemic taxa such as *Betta unimaculata* from Kalimantan; and *B. chloropharynx*, *Betta schalleri* and *B. raja* from Sumatra (Fig. 1).

Table 1. The list of the wild *Betta Betta* spp. found in three largest online marketplaces in Indonesia (Data per 21 October 2025). Note; CR = Critical Endangered, EN = Endangered, NA (Not Available), VU = Vulnerable, LC =Least Concern, DD = Data Deficient, NT = Near Threatened, Sum = Sumatera, Kal, Kalimantan, E = Endemic, Sh = Shopee, Tk = Tokopedia, Lz =Lazada, IDR = Indonesian Rupiahs, **Betta* sp. *api* and ***Betta* sp. *jade*.

No.	Species	IUCN Status	Native Distribution In Indonesia	Online Marketplace			Price (IDR)	Location of Seller
				Sh	Tk	Lz		
1	<i>Betta albimarginata</i>	EN	Kal, E		+		225.000	Tarakan
	<i>Betta albimarginata</i>	EN	Kal, E		+		95.000	Tarakan
	<i>Betta albimarginata</i>	EN	Kal, E		+		99.999	Jakarta
	<i>B. albimarginata</i>	EN	Kal, E		+		328.000	Bogor
	<i>B. albimarginata</i>	EN	Kal, E	+			380.000	Jambi
	<i>B. albimarginata</i>	EN	Kal, E	+			328.000	Bandung
	<i>B. albimarginata</i>	EN	Kal, E		+		225.000	Bogor
	<i>B. albimarginata</i>	EN	Kal, E		+		135.000	Bogor
	<i>B. albimarginata</i>	EN	Kal, E		+		290.250	Jakarta
	<i>B. albimarginata</i>	EN	Kal, E		+		206.000	Jakarta
	<i>B. albimarginata</i>	EN	Kal, E		+		206.999	Jakarta
	<i>B. albimarginata</i>	EN	Kal, E		+		180.000	Bandung
	<i>B. albimarginata</i>	EN	Kal, E		+		207.000	Bogor

2	<i>Betta balunga</i>	DD	Kal		+	75.000	Balikpapan
3	<i>Betta bellica</i>	LC	Sum, Kal, E		+	25.000	Kudus
	<i>Betta bellica</i>	LC	Sum, Kal, E		+	25.000	Jambi
	<i>Betta bellica</i>	LC	Sum, Kal, E		+	80.000	Jambi
	<i>Betta bellica</i>	LC	Sum, Kal, E		+	65.000	Jambi
4	<i>Betta brownorum</i>	VU	Kal		+	290.000	Kubu Raya
	<i>Betta brownorum</i>	VU	Kal	+		270.000	Kubu Raya
	<i>Betta brownorum</i>	VU	Kal		+	297.000	Kubu Raya
5	<i>Betta burdigula</i>	CR	Sum, E		+	162.000	Bogor
	<i>Betta burdigula</i>	CR	Sum, E	+		340.000	Depok
	<i>Betta burdigula</i>	CR	Sum, E	+		96.300	Jambi
	<i>Betta burdigula</i>	CR	Sum, E	+		15.000	Jambi
6	<i>Betta channoides</i>	EN	Kal, E		+	119.600	Jakarta
	<i>Betta channoides</i>	EN	Kal, E	+		67.500	Jambi
	<i>Betta channoides</i>	EN	Kal, E		+	180.000	Bogor
	<i>Betta channoides</i>	EN	Kal, E		+	180.000	Bandung
	<i>Betta channoides</i>	EN	Kal, E		+	135.000	Sleman
	<i>Betta channoides</i>	EN	Kal, E		+	99.999	Jakarta
7	<i>Betta chloropharynx</i>	CR	Sum, E		+	225.000	Bogor
8	<i>Betta coccina</i>	VU	Sum		+	135.000	Jambi
	<i>Betta coccina</i>	VU	Sum	+		45.000	Jambi
	<i>Betta coccina</i>	VU	Sum	+		31.000	Jambi
	<i>Betta coccina</i>	VU	Sum	+		33.000	Jambi
	<i>Betta coccina</i>	VU	Sum		+	110.400	Jakarta
	<i>Betta coccina</i>	VU	Sum		+	110.400	Jambi
	<i>Betta coccina</i>	VU	Sum		+	75.000	Jambi
	<i>Betta coccina</i>	VU	Sum		+	75.000	Jakarta
9	<i>Betta dimidiata</i>	VU	Kal, E	+		51.000	Jambi
10	<i>Betta edithae</i>	LC	Sum, Kal, E		+	60.000	Bogor
11	<i>Betta falx</i>	LC	Sum, E		+	15.000	Tangerang
	<i>Betta falx</i>	LC	Sum, E	+		260.000	Jambi
	<i>Betta falx</i>	LC	Sum, E	+		46.000	Jambi
	<i>Betta falx</i>	LC	Sum, E	+		31.000	Jambi
	<i>Betta falx</i>	LC	Sum, E	+		51.000	Jambi
	<i>Betta falx</i>	LC	Sum, E		+	70.000	Jambi
12	<i>Betta foerschi</i>	EN	Kal, E		+	180.000	Bogor
	<i>Betta foerschi</i>	EN	Kal, E	+		919.700	Depok
	<i>Betta foerschi</i>	EN	Kal, E		+	670.000	Depok
13	<i>Betta hendra</i>	CR	Kal, E		+	237.600	Tangerang
	<i>Betta hendra</i>	CR	Kal, E	+		157.000	Jakarta
	<i>Betta hendra</i>	CR	Kal, E	+		56.000	Jambi
	<i>Betta hendra</i>	CR	Kal, E		+	322.000	Jakarta
	<i>Betta hendra</i>	CR	Kal, E		+	202.500	Bogor
	<i>Betta hendra</i>	CR	Kal, E		+	135.000	Bogor
	<i>Betta hendra</i>	CR	Kal, E		+	180.000	Bogor
14	<i>Betta hipposideros</i>	EN	Sum		+	225.000	Bogor
15	<i>Betta iaspis**</i>	NA	Sum, E	+		162.000	Bogor
	<i>Betta iaspis**</i>	NA	Sum, E			81.000	Jambi
16	<i>Betta imbellis</i>	LC	Sum		+	35.000	Jakarta
	<i>Betta imbellis</i>	LC	Sum		+	35.000	Grobogan

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	<i>Betta imbellis</i>	LC	Sum	+	36.400	Jambi
	<i>Betta imbellis</i>	LC	Sum	+	188.400	Tanjung Balai
	<i>Betta imbellis</i>	LC	Sum	+	10.000	Tanjung Balai
	<i>Betta imbellis</i>	LC	Sum	+	110.400	Jakarta
	<i>Betta imbellis</i>	LC	Sum	+	60.000	Jakarta
	<i>Betta imbellis</i>	LC	Sum	+	40.000	Purwakarta
	<i>Betta imbellis</i>	LC	Sum	+	38.000	Bogor
	<i>Betta imbellis</i>	LC	Sum	+	75.000	Bogor
	<i>Betta imbellis</i>	LC	Sum	+	80.000	Bekasi
	<i>Betta imbellis</i>	LC	Sum	+	60.000	Bogor
	<i>Betta imbellis</i>	LC	Sum	+	75.000	Jakarta
	<i>Betta imbellis</i>	LC	Sum	+	35.000	Tangerang
	<i>Betta imbellis</i>	LC	Sum	+	25.000	Deli, Serdang
	<i>Betta imbellis</i>	LC	Sum	+	135.000	Jakarta
17	<i>Betta lehi</i>	VU	Kal	+	117.000	Jambi
18	<i>Betta miniopinna</i>	CR	Sum, E	+	180.000	Bogor
	<i>Betta miniopinna</i>	CR	Sum, E	+	56.000	Jambi
	<i>Betta miniopinna</i>	CR	Sum, E	+	310.000	Surakarta
	<i>Betta miniopinna</i>	CR	Sum, E	+	188.000	Bogor
19	<i>Betta mulyadii*</i>	NA	Sum, E	+	110.000	Bandung
	<i>Betta mulyadii*</i>	NA	Sum, E	+	90.000	Bogor
20	<i>Betta obscura</i>	DD	Kal, E	+	179.999	Jakarta
	<i>Betta obscura</i>	DD	Kal, E	+	359.999	Jakarta
21	<i>Betta ocellata</i>	LC	Kal	+	193.500	Bulungan
	<i>Betta ocellata</i>	LC	Kal	+	314.100	Bontang
	<i>Betta ocellata</i>	LC	Kal	+	179.999	Jakarta
	<i>Betta ocellata</i>	LC	Kal	+	225.000	Tarakan
	<i>Betta ocellata</i>	LC	Kal	+	495.000	Jakarta
	<i>Betta ocellata</i>	LC	Kal	+	179.000	Tarakan
	<i>Betta ocellata</i>	LC	Kal	+	79.999	Jakarta
	<i>Betta ocellata</i>	LC	Kal	+	180.000	Tarakan
22	<i>Betta pallifina</i>	DD	Kal, E	+	290.000	Polewali
	<i>Betta pallifina</i>	DD	Kal, E	+	359.999	Jakarta
	<i>Betta pallifina</i>	DD	Kal, E	+	99.999	Jakarta
23	<i>Betta patoti</i>	EN	Kal, E	+	255.600	Jakarta
	<i>Betta patoti</i>	EN	Kal, E	+	360.000	Balikpapan
	<i>Betta patoti</i>	EN	Kal, E	+	292.500	Balikpapan
	<i>Betta patoti</i>	EN	Kal, E	+	135.600	Paser
	<i>Betta patoti</i>	EN	Kal, E	+	255.000	Jakarta
24	<i>Betta persephone</i>	EN	Sum	+	188.000	Pekanbaru
	<i>Betta persephone</i>	EN	Sum	+	96.300	Jambi
25	<i>Betta picta</i>	NT	Java, E	+	25.000	Jakarta
	<i>Betta picta</i>	NT	Java, E	+	255.575	Jakarta
	<i>Betta picta</i>	NT	Java, E	+	39.999	Jakarta
	<i>Betta picta</i>	NT	Java, E	+	25.500	Jakarta
	<i>Betta picta</i>	NT	Java, E	+	7.500	Sukabumi
	<i>Betta picta</i>	NT	Java, E	+	10.000	Magelang
	<i>Betta picta</i>	NT	Java, E	+	40.000	Bandung
	<i>Betta picta</i>	NT	Java, E	+	78.000	Jakarta
	<i>Betta picta</i>	NT	Java, E	+	80.000	Bogor

26	<i>Betta pugnax</i>	LC	Sum	+	35.000	Tangerang
27	<i>Betta raja</i>	LC	Sum, E	+	25.000	Labuhan Batu
	<i>Betta raja</i>	LC	Sum, E	+	46.000	Jambi
	<i>Betta raja</i>	LC	Sum, E	+	22.000	Jambi
	<i>Betta raja</i>	LC	Sum, E	+	21.000	Jambi
	<i>Betta raja</i>	LC	Sum, E	+	22.000	Bandung
	<i>Betta raja</i>	LC	Sum, E	+	21.000	Bandung
	<i>Betta raja</i>	LC	Sum, E	+	80.000	Bogor
28	<i>Betta renata</i>	VU	Sum, E	+	225.000	Bogor
29	<i>Betta rubra</i>	EN	Sum, E	+	120.000	Jambi
	<i>Betta rubra</i>	EN	Sum, E	+	180.000	Bogor
	<i>Betta rubra</i>	EN	Sum, E	+	56.000	Jambi
	<i>Betta rubra</i>	EN	Sum, E	+	135.000	Banda Aceh
30	<i>Betta rutilans</i>	EN	Kal, E	+	180.000	Bogor
	<i>Betta rutilans</i>	EN	Kal, E	+	180.000	Kotawaringin
31	<i>Betta schalleri</i>	EN	Sum, E	+	207.000	Depok
32	<i>Betta simorum</i>	VU	Sum, Kal, E	+	25.000	Kudus
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	25.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	46.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	36.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	50.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	80.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	65.000	Jambi
	<i>Betta simorum</i>	VU	Sum, Kal, E	+	100.000	Jambi
33	<i>Betta sp. kaltara</i>	NA	NA	+	220.000	Jambi
	<i>Betta sp.</i>	NA	NA	+	15.000	Jambi
	<i>Betta sp.</i>	NA	NA	+	25.000	Pontianak
34	<i>Betta sp. antuta</i>	NA	Kal, E	+	100.000	Jakarta
	<i>Betta sp. antuta</i>	NA	Kal, E	+	130.000	Jambi
	<i>Betta sp. antuta</i>	NA	Kal, E	+	108.000	Jambi
	<i>Betta sp. antuta</i>	NA	Kal, E	+	237.600	Jambi
	<i>Betta sp. antuta</i>	NA	Kal, E	+	127.000	Pontianak
	<i>Betta sp. antuta</i>	NA	Kal, E	+	225.000	Bulungan
	<i>Betta sp. antuta</i>	NA	Kal, E	+	850.000	Bulungan
	<i>Betta sp. antuta</i>	NA	Kal, E	+	550.000	Bulungan
	<i>Betta sp. antuta</i>	NA	Kal, E	+	450.000	Bogor
	<i>Betta sp. antuta</i>	NA	Kal, E	+	79.999	Jakarta
	<i>Betta sp. antuta</i>	NA	Kal, E	+	549.999	Jakarta
	<i>Betta sp. antuta</i>	NA	Kal, E	+	630.000	Bogor
	<i>Betta sp. antuta</i>	NA	Kal, E	+	650.000	Tarakan
35	<i>Betta spilotogeta</i>	EN	Sum, E	+	225.000	Bogor
36	<i>Betta splendens</i>	VU	Sum	+	136.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	50.000	Bandung
	<i>Betta splendens</i>	VU	Sum	+	50.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	110.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	136.000	Jakarta

	<i>Betta splendens</i>	VU	Sum	+	95.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	65.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	52.000	Jakarta
	<i>Betta splendens</i>	VU	Sum	+	100.000	Jakarta
37	<i>Betta uberis</i>	VU	Kal, E	+	95.000	Jambi
	<i>Betta uberis</i>	VU	Kal, E	+	56.000	Jambi
	<i>Betta uberis</i>	VU	Kal, E	+	352.000	Jambi
38	<i>Betta unimaculata</i>	DD	Kal, E	+	179.999	Jakarta

Price Variations

Price variations ranged widely from IDR 15,000 to over 900,000, with higher prices generally associated with endemic or rare taxa (e.g., *B. sp. antuta*, and *B. foerschi*). The majority of listings originated from Bogor, Jakarta, and Jambi, which appear to be major trade centers. The data reveal a clear trend, species with higher conservation concern tend to be more expensive in the online market, suggesting a link between rarity and economic value within the ornamental fish trade. Courchamp *et al.* (2006) warn that the human tendency to value rarity can have devastating consequences, driving species towards extinction. This phenomenon poses a significant threat to species that are already rare or may become coveted due to their uniqueness or appeal, highlighting the need for urgent conservation action. Among the categories, Endangered (EN) species exhibit the highest average price (IDR 250,000), followed closely by Not Assessed (NA) species (IDR 280,000) and Data Deficient (DD) species (IDR 210,000). Critically Endangered (CR) taxa are also relatively high-priced, averaging around IDR 180,000. In contrast, species listed as Vulnerable (VU), Near Threatened (NT), and Least Concern (LC) show noticeably lower market values, ranging between IDR 75,000–120,000.



Figure 1. Endemic wild Betta *Betta* spp. species recorded in Indonesia's online markets include: 1a. *Betta unimaculata* from Kalimantan; as well as 1b. *B. schalleri*, 1c. *B. chloropharynx*, and *B. raja* from Sumatra (Photographs: Muhammad Iqbal).

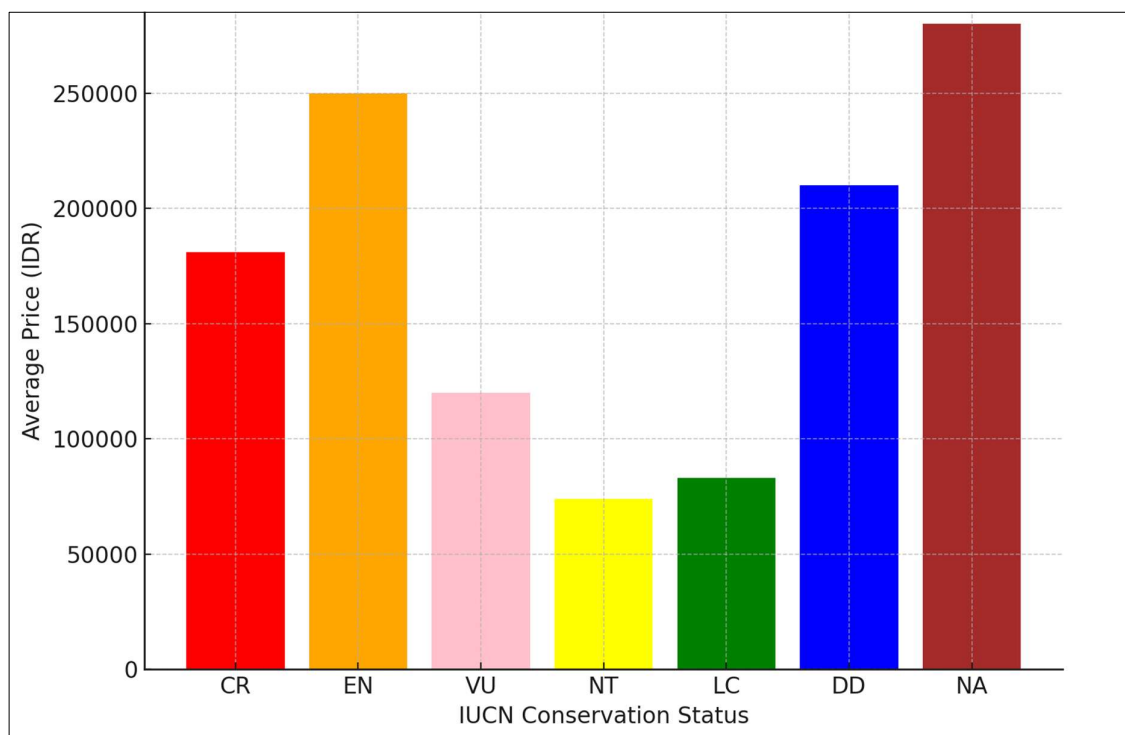


Figure 2. The bar chart illustrates the relationship between the IUCN conservation status of wild Betta species and their average online selling price on Indonesian e-commerce platforms.

This price pattern reflects a common dynamic in wildlife trade, the rarer the species, the higher the demand and price. According to Moyle & Cech (2004), rarity can enhance a species' value in the ornamental fish trade, making it more desirable and prized. Collectors and hobbyists often associate rarity with prestige and exclusivity, leading to inflated prices for species that are at greater risk of extinction. For example, *Betta hendra* (CR) and *Betta foerschi* (EN) are among the most sought-after species, commanding premium prices due to their limited distribution and striking coloration. Interestingly, species under the Not Assessed (NA) and Data Deficient (DD) categories have prices comparable to or even higher than recognized threatened species. This trend suggests that market demand is not necessarily driven by official conservation assessments but rather by perceived rarity or aesthetic appeal. In many cases, NA or DD species may represent newly described taxa or undescribed variants marketed as rare, which can increase their desirability. However, because their population status is unknown, trade in these species poses significant risks, exploitation may occur before adequate conservation evaluation can be completed. Harris *et al.* (2016) highlighted that the allure of rare species fuels demand and inflates prices in the wildlife trade.

The relatively low prices of Near Threatened (NT) and Least Concern (LC) species indicate that common *Betta* species, such as *B. imbellis* and *B. pugnax*, are more readily available and possibly bred in captivity. Their abundance reduces wild collection pressure, making them less valuable in terms of market price. Nonetheless, these species still play an important role in sustaining the trade by reducing demand for rarer taxa. From a conservation standpoint, this pricing structure highlights several key concerns. First, the high market value of threatened species (CR, EN) creates economic incentives for illegal collection from the wild, especially in regions like Sumatra and Kalimantan where endemic species occur in small, isolated populations. Second, the unregulated sale of NA and DD species underscores a critical data and policy gap, without formal conservation assessments, it becomes difficult to implement trade restrictions or monitor exploitation. Therefore, strategies to ensure sustainable trade should include strengthening legal protection for threatened species, improving traceability and certification systems, and promoting captive breeding programs as an alternative to wild capture. Public education and buyer awareness campaigns are also essential to shift consumer preferences toward legally and ethically sourced fish.

In summary, the bar chart (Fig. 2) underscores a troubling paradox, the very species most in need of protection are often those most highly valued in trade. This underscores the urgency of integrating

market monitoring, conservation policy, and community-based management to ensure that economic interests do not undermine biodiversity conservation. The ornamental fish market, if properly regulated, can evolve from a threat into a potential ally for species preservation through responsible breeding, certification, and awareness-driven demand.

Endemism

The distribution of endemic wild *Betta* species across Indonesia's major islands reveals clear biogeographical patterns that reflect both evolutionary history and ecological specialization. Based on the analysis (Fig. 3), Kalimantan (Borneo) hosts the highest number of endemic species (12 species, 44.44%), followed closely by Sumatra (11 species, 40.74%). A smaller portion of species are shared between both islands (3 species, 11.11%), while Java contributes only a single endemic species (3.70%).

Sodhi *et al.* (2004) emphasized the Sundaland region's exceptional biodiversity significance, highlighting its rich array of endemic species and ecosystems that are facing significant threats. The dominance of Kalimantan and Sumatra as centers of *Betta* endemism highlights their importance as biodiversity hotspots within the Sundaland region. These two islands share similar ecological conditions, particularly in the presence of peat-swamp forests, blackwater streams, and lowland river systems, which serve as ideal habitats for many *Betta* species. Such habitats are characterized by acidic, low-oxygen waters where *Betta* species have evolved specialized adaptations such as the labyrinth organ, enabling them to breathe atmospheric air. de Bruyn *et al.* (2014) revealed that geological and climatic events, such as Pleistocene sea-level fluctuations, have driven the evolution of unique species in Southeast Asia, resulting in high levels of endemism due to long-term evolutionary isolation.

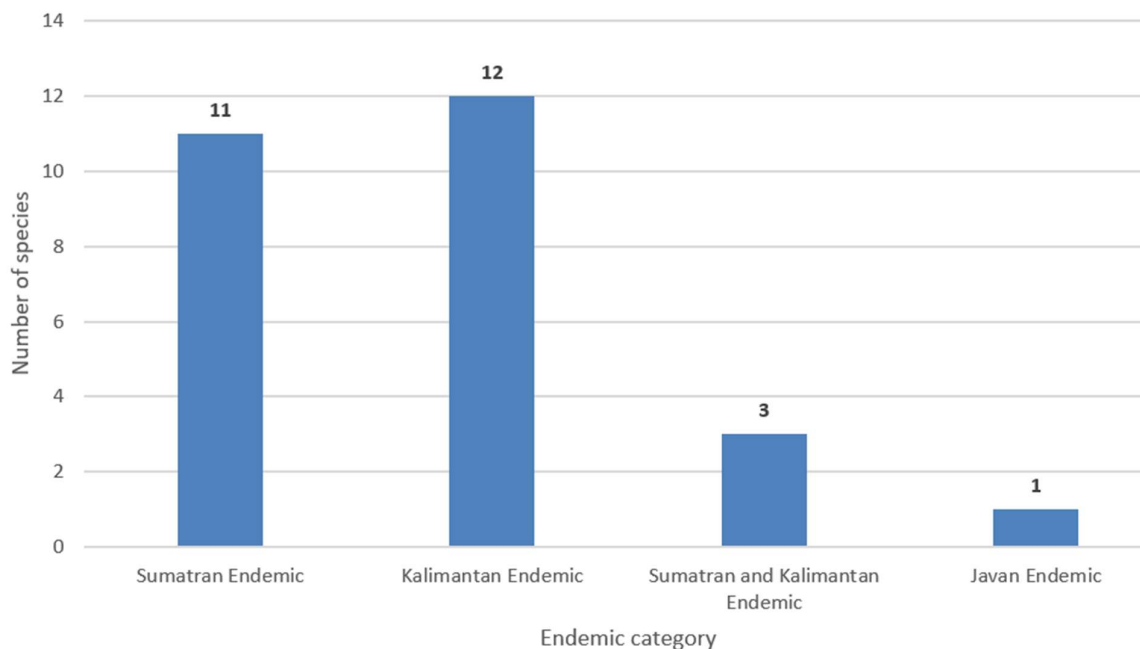


Figure 3. Bar chart showing the number of endemic wild *Betta* species by island category (Sumatran Endemic, Kalimantan Endemic, Sumatran and Kalimantan Endemic, and Javan Endemic).

The smaller proportion of shared endemism between Sumatra and Kalimantan (11.11%) likely represents species that once had a wider distribution during historical land connections but later became fragmented as sea levels rose. This pattern supports vicariant speciation, where geographic isolation leads to the formation of new species, consistent with Lomolino *et al.*'s (2010) explanation, where isolation between populations led to the formation of distinct endemic lineages on each island. In contrast, Java's limited representation (only one endemic species, *Betta picta*) can be attributed to its more disturbed freshwater ecosystems and smaller area of peat-swamp habitat compared to Sumatra and Kalimantan. Java's long history of human settlement and land-use change has resulted in substantial habitat loss, reducing opportunities for species diversification. The low number of endemics on Java therefore reflects both ecological constraints and anthropogenic pressures.

Brooks *et al.* (2006) emphasized the importance of integrating conservation strategies to protect biodiversity hotspots. From a conservation perspective, the results emphasize that Sumatra and Kalimantan are critical for the long-term survival of Indonesia's wild *Betta*. These islands not only harbor the majority of endemic species but also face the most severe threats from deforestation, peatland drainage, and conversion of wetlands into agriculture or oil palm plantations. The high degree of endemism means that habitat destruction in these areas could result in irreversible species loss, as many *Betta* species have extremely localized distributions. In addition, several endemic species from these islands, such as *Betta hendra*, *B. burdigula* and *B. miniopinna*, are already listed under threatened categories in the IUCN Red List (Critically Endangered or Endangered). Their simultaneous ecological sensitivity and popularity in the ornamental fish trade further compound their vulnerability. Conservation efforts must therefore integrate habitat protection, captive breeding programs, and sustainable trade regulations, particularly within the regions of high endemism identified in this study.

Conservation Implications of *Betta* Species' IUCN Status

The IUCN status distribution of *Betta* species in online marketplaces, as shown in the Fig. 4, reflects a concerning pattern of trade pressure on species with varying levels of conservation concern. The chart highlights that 25.6% of traded *Betta* species are classified as Endangered (EN), representing the largest proportion. This indicates that a significant portion of the online market involves species facing a high risk of extinction in the wild. The presence of such a large percentage of endangered species in trade suggests weak regulation and enforcement of wildlife protection laws, particularly for ornamental fish in digital marketplaces. Following the Endangered group, 20.5% of *Betta* species are categorized as Vulnerable (VU). This group is also at risk, though to a slightly lesser degree, and their continued presence in online markets may accelerate population declines. The overlap between vulnerable and endangered categories suggests that commercial demand is not limited to a few iconic species but spans across multiple taxa within the genus. The popularity of these species for their unique colors and fin shapes drives collectors to source them from wild populations, intensifying exploitation and reducing genetic diversity in native habitats. For example, ornamental fish like the Boeseman's Rainbowfish *Melanotaenia boesemani* is highly prized by collectors for their striking colors and appearance, making them vulnerable to overexploitation (Ho *et al.* 2025).

Interestingly, 17.9% of the species are listed as Least Concern (LC), showing that not all *Betta* species traded online are currently threatened. However, their inclusion in the trade still poses potential future risks, especially if harvesting becomes unsustainable or habitats continue to degrade. Sustainable fishing practices need to be promoted locally (Syafutra *et al.* 2025). The online aquarium trade can rapidly shift market preferences, and species currently abundant may soon face pressure similar to those already in decline. Monitoring and regulating the trade of even common species is therefore crucial to prevent their conservation status from worsening. Another key aspect revealed by the chart is the 12.8% of species categorized as Not Assessed (NA) and 10.3% as Data Deficient (DD). These categories emphasize the significant gaps in scientific understanding of many *Betta* species. Without proper population assessments, it is difficult to determine whether their exploitation is sustainable or if they are silently declining. The lack of data is particularly problematic in the context of online trade, where unidentified or misidentified species can easily enter the market, undermining conservation efforts. According to Soriano-Redondo *et al.* (2023), the online wildlife trade is a pervasive issue affecting thousands of species, yet research efforts to quantify its scope have been limited to a few online platforms and specific taxonomic groups.

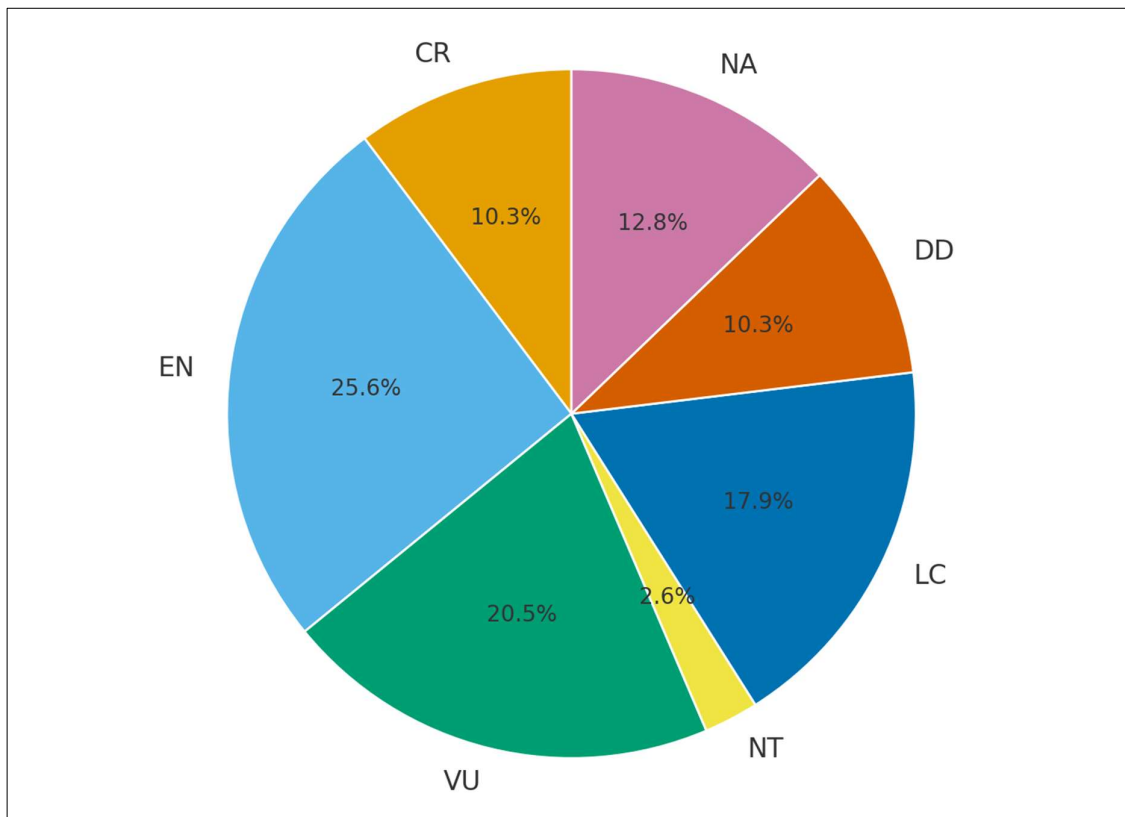


Figure 4. Proportion of wild *Betta* species by IUCN conservation status recorded from Indonesia's online marketplaces in 2025.

The 10.3% of wild *Betta* species classified as Critically Endangered (CR) warrant immediate attention, as their online presence signals a critical breakdown in conservation efforts. To mitigate this, international cooperation is crucial to monitor and regulate digital wildlife trade. Effective management of wildlife trade, particularly in biodiversity hotspots like Indonesia, hinges on aligning national laws with international conservation agreements (Chotimah 2024). Implementing measures like captive breeding programs, certification systems, and stricter trade policies can help reduce demand for wild-caught specimens. Ultimately, this data highlights the urgent need for regulation, as unmonitored digital marketplaces pose a significant threat to *Betta* species biodiversity. Our analysis reveals alarming trends in the online trade of wild *Betta* species. Notably, nearly 54% of traded species are threatened (CR, EN and VU), with Endangered species like *Betta channoides*, *B. foerschi*, and *B. rubra* dominating the trade. Furthermore, around 26% of listed species lack sufficient conservation evaluation, highlighting significant data gaps that complicate management efforts. The sustained market demand for these species, despite conservation risks, underscores the need for urgent attention and action to mitigate the impact of online trade on wild *Betta* populations.

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