Treubia, 49(2): 85–96, December 2022
DOI: 10.14203/treubia.v49i2.4496
https://e-journal.biologi.lipi.go.id/index.php/treubia

TRADE AND THREATS ON *ORNITHOPTERA CROESUS* (LEPIDOPTERA: PAPILIONIDAE), THE WALLACE'S BIRDWING BUTTERFLY IN NORTH MALUKU, INDONESIA

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Received: 7 December 2022; Accepted: 20 December 2022; Published: 30 December 2022

ABSTRACT

Ornithoptera croesus, Wallace's Golden Birdwing butterfly, is one of the most highly-demanded butterflies in the world. Annual trades of this endemic species have been monitored and mechanisms to control the trades have been developed to ensure the sustainability of the species. This paper aims to address and clarify the issues on the trade and threat to the species. The methodology involves the probe into the CITES Trade Database, into the threat to the species based on observation during field surveys, and into the possible solution. The results showed that there were some discrepancies in the data provided by the exporter and importer of the species and that the threats to the species are real. An approach to improve the condition is discussed. The solution to meet the demand for this species is offered through captive breeding and ranching for sustainable use.

Key words: birdwing butterfly, *Ornithoptera croesus*, sustainable use, trade, threats

INTRODUCTION

Ornithoptera croesus Wallace, 1859 can be regarded as the most remarkable butterfly species in North Maluku, Indonesia. The beauty of this magnificent species stunned A.R. Wallace when he discovered the species, which he expressed with his very famous and impressive quote: "The beauty and brilliancy of this insect are indescribable, and none but a naturalist can understand the intense excitement I experienced when I at length captured it. – I had a headache the rest of the day, so great was the excitement produced by what will appear to most people a very inadequate cause." (Wallace, 1869).

Knowledge of birdwing butterflies (*Ornithoptera* Boisduval, 1832, *Troides* Hübner, [1819], and *Trogonoptera* Rippon, [1890]) in general is based on information from better-known common birdwings *O. priamus* (Linnaeus, 1758) (e.g., Straatman, 1969; Heidelberger & Heppner, 1999; Parsons, 1999; Sands & New, 2013; Kazama et al., 2017) and *T. helena* (Linnaeus, 1758) (e.g., Böhm et al., 2018; Nurjannah, 2010; Peggie et al., 2021b). This species is one of the endangered butterflies in the world (Collins & Morris, 1985; New & Collins, 1991; Endo & Ueda, 2004; IUCN, 2022), but further knowledge about *O. croesus* is very limited and has only been recently reported (Mas'ud et al., 2016, 2020; Peggie et al., 2021a). The life history has been reported (Igarashi & Fukuda, 2000) and larvae feed on *Aristolochia* spp. so indeed it is possible to breed this species. In a study at Gunung Sibela Nature Reserve, Bacan, this species was found in very few numbers, only a few individuals seen each sighting time, at four sites of altitude 20 m, 200 m, 400 m, and 800 m asl. (Mas'ud et al., 2016). Assessment on the breeding approach of *O. croesus* was recently presented (Peggie et al., 2021a).

This species has different subspecies on Bacan, Halmahera, and Morotai (Peggie et al., 2005). The subspecies on Bacan is *O. croesus croesus* Wallace, 1859, the subspecies on Halmahera is *O. croesus lydius* (Felder & Felder, 1865), and the subspecies on Morotai is *O. croesus toeantei* Parrott & Schmid, 1984. Some even recognized distinct subspecies from the small islands of Kasiruta and Mandioli.

Despite the limited knowledge about this species, there has been pressure to this species due to habitat deterioration and demand for trade. Direct collections of this species from the natural habitats are prohibited due to the protected status under Indonesian regulation (Lampiran PP7, 1999; Peggie, 2011b; KLHK, 2018). Trades can be allowed for specimens derived from captivity. Butterfly captive breeding and ranching can offer solutions to this matter. A butterfly ranching operation needs to be in-situ at the natural habitat (see Neville, 1993 for the example; Peggie et al., 2021a). In addition, captive breeding can be operated ex-situ, outside of the distributional ranges, but this should be monitored closely to avoid any escape to the outside.

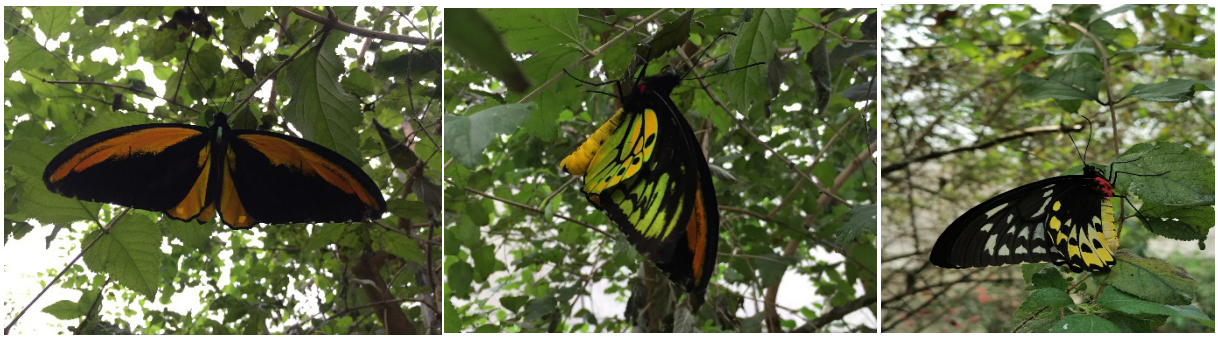
Annual trades of this species have been monitored nationally and internationally, as it is included as one of Appendix II CITES-regulated butterflies. Stakeholders have developed schemes and mechanisms to control the trades to ensure sustainable usage of the species. In recent years, *O. croesus* has been an issue as a candidate of Review of Significant Trade (RST) by CITES due to the high volume of trades and the differences in the source code usage (CITES, 2022). UNEP-WCMC and CITES Secretariat have asked Indonesia to pay close attention to this species since the Conference of the Parties CoP17 of CITES in 2016. The Standing Committee recommended that Indonesia provides a report on the ranching operations of *O. croesus* to the Secretariat and confirms that an NDF will be made prior to authorizing the exportation of any specimens with source code 'R'.

MATERIALS AND METHODS

To understand the issues on *O. croesus*, an approach was pursued to look at the trade data of *O. croesus* which was taken from CITES Trade Database (CITES, 2022) and followed the guide to using it (CITES Secretariat and UNEP-WCMC, 2022). Field surveys were conducted in April 2018 on Bacan and Halmahera, and in September 2019 on Bacan and Morotai, and threats to the species were observed.

RESULTS

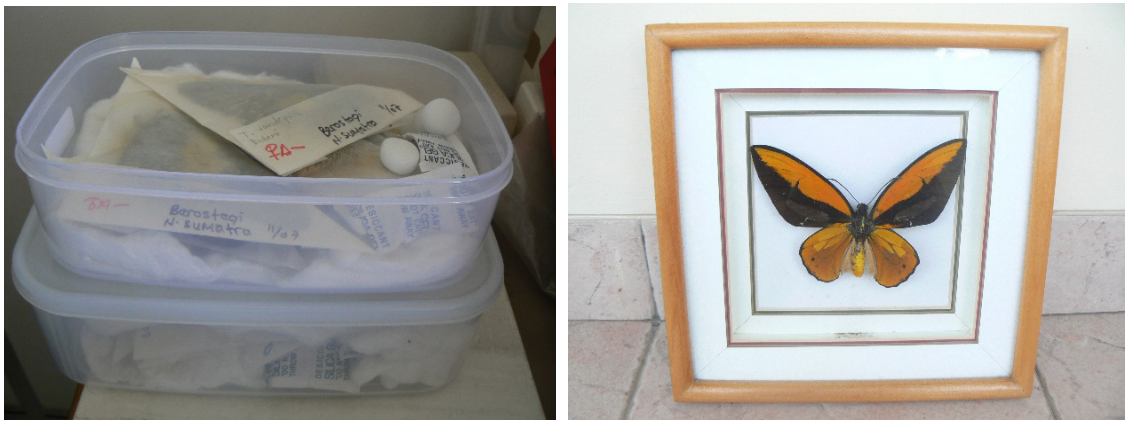
The distribution of this birdwing butterfly is limited only to Bacan, Halmahera, and Morotai; and is very likely extinct from Ternate. Observation during the field surveys indicated that this species is rare, with only very few encounters (Peggie et al., in prep.). On the other hand, the beauty of this butterfly (Fig. 1) has made it very popular among collectors. The demand for this species and other CITES-regulated and protected species (Fig. 2) should be fulfilled through a breeding mechanism as no direct collecting is allowed. In most cases, the specimens are exported as adults, preserved in a folded position, each inside a glassine envelope (Fig. 3a), and occasionally it is mounted and placed inside a glass-top frame (Fig. 3b).



a **b** **c**

Figure 1. Photos of *O. croesus* in the enclosure: (**a**) male showing the upperside surface; (**b**) male showing the underside surface; and (**c**) female showing the underside surface.

Figure 2. The harvested butterflies just eclosed from pupal case, showing primarily *O. priamus* and an individual of *O. croesus* male on the right with unfolded wings showing the upperside surface.



a **b**

Figure 3. Preserved butterflies can be sent as: (**a**) dried specimens folded inside triangular glassine envelopes placed inside a plastic box as shown here for some other birdwing butterfly species; or (**b**) mounted specimen with the wings spread as shown here of *O. croesus* male inside a glass-top frame.

Trade Data of *O. croesus*

Based on the trade database of *O. croesus* (CITES, 2022, see Table 1), there were specimens exported from Indonesia to various countries with source code 'R' (ranched specimens, specimens reared in a controlled environment taken as eggs or juveniles from the wild), 'C' (captive bred specimens, animals bred in captivity), 'F' (animals born in captivity as F1 or subsequent generations that do not fulfill the definition of "bred in captivity"), and even 'I' (confiscated or seized specimens). The data presented here are from the year 2011 until 2017. The search was allowed to include until 2022 but apparently, there was no trade of this species recorded after 2017 due to the Indonesian policy to voluntarily suspend the trade since 2017.

Table 1. Comparative Tabulation Record of the trade of *O. croesus*, derived from the CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK.

Year	Importer	Exporter	Importer reported quantity	Exporter reported quantity	Term	Purpose	Source
2011	AU	ID	42	290	bodies	T	R
2011	BE	ID	2	20	bodies	T	R
2011	CA	ID		1446	bodies	T	R
2011	CH	ID		30	bodies	T	R
2011	CH	ID	10		specimens	T	R
2011	CN	ID		63	bodies	T	R
2011	CZ	ID	106	106	bodies	T	R
2011	DE	ID	484	484	bodies	T	R
2011	ES	ID	5	12	bodies	T	R
2011	FR	ID	20	248	bodies	T	R
2011	HK	ID		2	bodies	T	R
2011	HU	ID		60	bodies	T	R
2011	JP	ID	396	1365	bodies	T	R
2011	LT	ID		30	bodies	T	R
2011	MY	ID		660	bodies	T	R
2011	MY	ID	260		trophies	T	R
2011	NL	ID		20	bodies	T	R
2011	NZ	ID	1	121	bodies	T	R
2011	TW	ID		67	bodies	T	R
2011	US	ID	251	1089	bodies	T	R
			1577	6113			
2012	AT	ID	350	350	bodies	T	R
2012	AU	ID	56	202	bodies	T	R
2012	CA	ID		305	bodies	T	R
2012	CN	ID		130	bodies	T	R
2012	CZ	ID	10	10	bodies	T	R
2012	DE	ID		306	bodies	T	C
2012	DE	ID	721	845	bodies	T	R
2012	ES	ID		20	bodies	T	R
2012	FR	ID		40	bodies	T	C
2012	FR	ID	100	213	bodies	T	R
2012	HU	ID		4	bodies	T	R

Year	Importer	Exporter	Importer reported quantity	Exporter reported quantity	Term	Purpose	Source
2012	IT	ID		30	bodies	T	R
2012	JP	ID	286	508	bodies	T	R
2012	LT	ID		20	bodies	T	R
2012	MY	ID	400	19	bodies	T	R
2012	NC	ID		6	bodies	T	C
2012	NZ	ID		10	bodies	T	R
2012	RU	ID		2	bodies	T	R
2012	US	ID	250		bodies	E	I
2012	US	ID		10	bodies	T	C
2012	US	ID	14		bodies	T	I
2012	US	ID		687	bodies	T	R
			2187	3717			
2013	AT	ID		100	bodies	T	R
2013	AU	ID	67	190	bodies	T	R
2013	BE	ID		12	bodies	T	R
2013	CA	ID		77	bodies	T	R
2013	CL	ID		2	bodies	T	R
2013	CN	ID		20	bodies	T	R
2013	CZ	ID		4	bodies	T	R
2013	DE	ID	908	956	bodies	T	R
2013	FR	ID		21	bodies	T	R
2013	HU	ID		15	bodies	T	R
2013	IT	ID		74	bodies	T	R
2013	JP	ID	140	296	bodies	T	R
2013	LT	ID		200	bodies	T	R
2013	MY	ID		260	bodies	T	R
2013	NZ	ID		20	bodies	T	R
2013	PL	ID		100	bodies	T	R
2013	SE	ID	20	20	bodies	T	R
2013	US	ID	220		bodies	T	C
2013	US	ID		1292	bodies	T	R
			1355	3659			
2014	AT	ID		20	bodies	T	F
2014	AU	ID		290	bodies	T	F
2014	AU	ID	80		bodies	T	R
2014	CN	ID		272	bodies	T	F
2014	CZ	ID		220	bodies	T	F
2014	DE	ID		127	bodies	T	F
2014	DK	ID		676	bodies	T	F
2014	DK	ID	115		bodies	T	R
2014	FR	ID	6		bodies	P	R
2014	FR	ID		144	bodies	T	F
2014	GB	ID		80	bodies	T	F
2014	JP	ID		328	bodies	T	F
2014	JP	ID	223		bodies	T	R

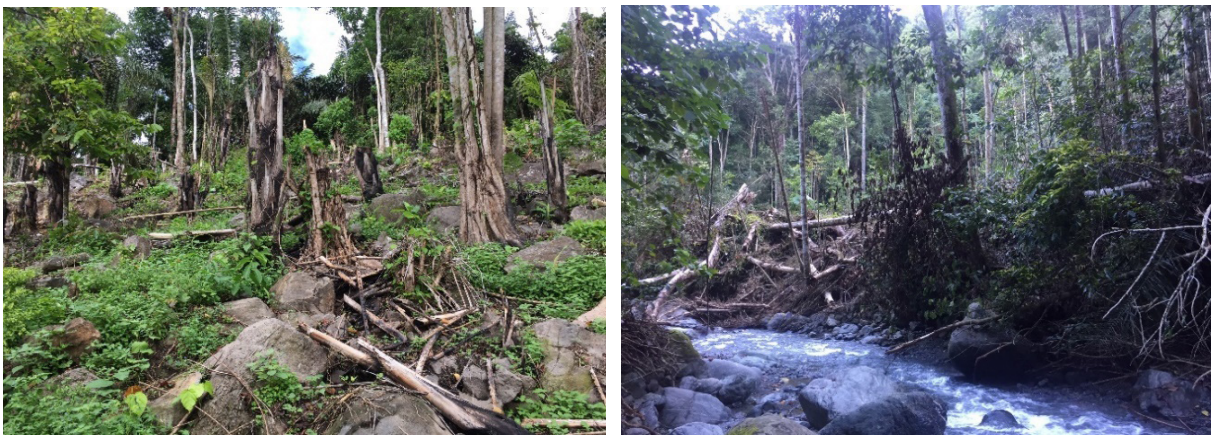
Year	Importer	Exporter	Importer reported quantity	Exporter reported quantity	Term	Purpose	Source
2014	KR	ID		100	bodies	T	F
2014	LT	ID		100	bodies	T	F
2014	MY	ID	260		bodies	T	R
2014	NZ	ID		7	bodies	T	F
2014	NZ	ID	7		bodies	T	R
2014	PL	ID		10	bodies	T	F
2014	SE	ID		53	bodies	T	F
2014	US	ID	60		bodies	T	C
2014	US	ID		533	bodies	T	F
2014	US	ID	200		bodies	T	R
			951	2960			
2015	AT	ID	300	300	bodies	T	F
2015	AU	ID	410	170	bodies	T	F
2015	CA	ID		420	bodies	T	F
2015	CN	ID		110	bodies	T	F
2015	DE	ID		790	bodies	T	F
2015	ES	ID		20	bodies	T	F
2015	FR	ID		8	bodies	T	F
2015	JP	ID	232	504	bodies	T	F
2015	KR	ID	50	100	bodies	T	F
2015	MY	ID	60	308	bodies	T	F
2015	MY	ID	148		trophies	T	F
2015	NZ	ID		34	bodies	T	F
2015	US	ID		47	bodies	T	F
			1200	2811			
2016	CN	ID		90	bodies	T	F
2016	CN	ID	90		specimens	T	F
2016	DE	ID		5	bodies	T	F
2016	FR	ID		308	bodies	T	F
2016	GB	ID		50	bodies	T	F
2016	JP	ID	20	65	bodies	T	F
2016	JP	ID	5		bodies	T	R
2016	KR	ID		90	bodies	T	F
2016	MY	ID		12	bodies	T	F
2016	NZ	ID	12	230	bodies	T	F
2016	RU	ID		390	bodies	T	F
2016	US	ID		669	bodies	T	F
2016	US	ID	100		specimens	T	F
			227	1909			
2017	GB	ID		60	bodies	T	F
2017	JP	ID	36	236	bodies	T	F
			36	296			

Note: importer countries include the following in accordance to the ISO code used by CITES trade guidelines: AT: Austria, AU: Australia, BE: Belgium, CA: Canada, CH: Switzerland, CL: Chile, CN: China, CZ: Czech Republic, DE: Germany, DK: Denmark, ES: Spain, FR: France. GB: United Kingdom of Great Britain and Northern Ireland, HK: Hong Kong - SAR China, HU: Hungary, IT: Italy; JP: Japan, KR: Republic of Korea, LT: Lithuania, MY: Malaysia, NC: New Caledonia - France territory, NL: Netherlands, NZ: New Zealand, PL: Poland, RU: Russian Federation, SE: Sweden, TW: Taiwan - Province of China, US: United States of America.
Purpose: T: commercial, E: educational, P: personal.
Source code: R: Ranched specimens: specimens of animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood; C: Animals bred in captivity in accordance with Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof, exported under the provisions of Article VII, paragraph 5; F: Animals born in captivity (F1 or subsequent generations) that do not fulfil the definition of 'bred in captivity' in Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof; I: Confiscated or seized specimens (may be used with another code).

The quantities reported by importers and those reported by exporters were in most cases not the same. The purpose of the transactions was mostly reported as T (commercial), except for the data in 2012 in which 250 bodies imported by the US were listed as E (educational) purpose, and data in 2014 in which 6 bodies imported by France were listed as P (personal) purpose. The source code of the transactions of *O. croesus* varied from 2011 to 2017. In 2011, the source code R was used in all transactions. In 2012, source code R was used in most transactions, except for three transactions which were listed as source code C by the exporter country, and two transactions were listed as confiscated or seized specimens (source code I), of which most were used for E (educational) purpose, but 14 bodies of confiscated or seized specimens were used as T (commercial) purpose. In 2013, most transactions were listed as source code R, except 220 bodies were listed as C by the US as the importer. In 2014, Indonesia as the exporter used the source code F, but importers used the source code R on 7 transactions and used the source code C on one transaction. In 2015, source code F was used in all transactions. In 2016, source code F was used for almost all transactions except one which was listed using source code R by Japan as the importer. In 2017, source code F was used in both transactions.

Threats to *O. croesus*

Surveys in April 2018 and in November 2019 have shown that *O. croesus* was indeed difficult to find (Peggie et al., 2021a) and detailed data on the occurrence of this species will be presented separately (Peggie et al., in prep.). During the surveys, some extractions of trees in the forests were seen. In some areas, the land use changes took place in the concession forests (Fig. 4a), meaning that it was done legally. However, at lower elevations at Gunung Sibela nature reserve, the trees were also cut down (Fig. 4b).



a **b**

Figure 4. Extractions of trees in the forests: (**a**) at the concession, (**b**) at low elevation of Gunung Sibela nature reserve, Bacan Island.

Besides habitat deterioration, the threat to the species is also due to direct capture, possibly through illegal operations. Direct capture may be avoided by introducing ranching and captive breeding operations.

Possible Solution through Ranching or Captive Breeding

A breeding facility at Labuha, Bacan and a few potential sites for ranching operations at Halmahera and Morotai were visited to assess whether the in-situ semi-natural breeding method meets the criteria for sustainable use of *O. croesus* (Peggie et al., 2021a). On other islands in North Maluku, *i.e.,* on Halmahera and Morotai, there were some areas (Fig. 5) with the potential occurrence of *O. croesus*. In the past, before the species is protected, certain villagers had harvested pupae from host plants in forests nearby the villages.

With the protected status of the species, breeders would need a harvest permit issued by the Forestry office to take parental stocks from the wild. The eggs or caterpillars were placed on the leaves of the host plants which had been planted to enrich the habitat. Then the parts of plants that had eggs or caterpillars were covered with a large net sleeve to avoid any predators and parasites. Every day, the breeder would check if the caterpillars had enough leaves and would need to move the caterpillars to other branches if needed. This practice is quite common among breeders to optimize the usage of host plants (Fig. 5). When the caterpillars reach the pupation stage, they can be moved to the pupal chamber. After they emerge into adults, they can be harvested and some are released to the wild for restocking to comply with the Indonesian regulation.

a **b** **c**

Figure 5. A potential site for butterfly ranching at Halmahera Barat: (**a**) Host plants in front of the house of a villager; (**b**) eggs; and (**c**) caterpillars placed inside the net sleeve.

DISCUSSION

This birdwing butterfly species is urgently in need of serious attention. It was suspected to become extinct from Ternate since the volcanic eruption of Mount Gamalama in 1983 (Peggie et al., 2005) as confirmed by a field survey in 2009 (Peggie, 2011a). However, detailed data on the distribution of this species is lacking, thus further research is needed to confirm the IUCN status. The beauty and the rarity made this species a highly demanded species. Though schemes and mechanisms to control the trades are available, the implementation needs improvement to ensure the sustainable use of the species.

There were discrepancies in the quantities reported by importers and exporters at the Trade Database for *O. croesus*, the numbers were in most cases not the same. As noted by CITES Secretariat and UNEP-WCMC (2022), many of the annual reports submitted to the Secretariat do not clearly state whether the data were derived from the actual number of specimens traded or from the quantity for which the permits or certificates were issued. The numbers were often considerably different. The term used to indicate the piece might be different and this has somewhat added problems to the data, in this data the exporter country used 'bodies' but there were 5 entries in which the importers used the term 'specimens' and 'trophies'. This difference in the term used might create a discrepancy in the quantities, for example, the data in 2016 of 90 specimens reported by China as the importer was most likely the same as the data of 90 bodies reported by Indonesia as the exporter, but somewhat appeared as two transactions.

The usage of different source codes (R, F, and C) has created confusion. Since 2014, Indonesia has produced individuals with source codes 'F' and 'C' (no more with code 'R'). This was done in conjunction with the suggestion from the CITES authority to use F source code for specimens derived from captive breeding operations that have not fully met the requirements. Indeed, the Indonesian management and scientific authorities had checked the facilities and confirmed the captive breeding operations but due to the lack of traceability of parental stocks, which are understandable for fast-growing insects, we agreed upon the usage of F as the source code for those time periods. It was suggested that the breeders should improve their management including the tracing of parental stocks. However, when the condition of the documentation and reporting did not improve, and the confusion of the different source code applications continued, the Indonesian management and scientific authorities decided to voluntarily suspend the trade of *O. croesus* in 2017. This decision was based on the consideration to improve the management of the species, primarily on the confusion about the usage of source codes.

This species has been classified as NT – near threatened of the IUCN status (Böhm, 2018), based on the conditions of (1) relatively localized threats of logging, (2 likelihood of occurrence in more than ten locations, (3) possible fragmentation of the distribution of the species, and (4) continuing habitat decline. It has been suggested that the primary threat to wildlife is habitat deterioration. Habitat alterations as seen during the surveys and as reported by Mas'ud et al. (2016) indicate the real threat to this endemic species and may have affected the spatial distribution of this species. Obtaining detailed information in regard to the distribution and the rarity of this species should be a priority and become a major concern to all stakeholders. Smiet (1982) reported that the commercial logging operations in northern and central Maluku might put wildlife including *O. croesus* in declining populations. Data on the status and trends of the populations of *O. croesus*, and the impact of the threats is urgently needed.

Data on life history and other aspects of the species can be obtained through captive breeding operations (Matsuka, 2001; Daniels et al., 2020). Important data such as the reproductive capacity of this species needs to be revealed and taken into consideration for the conservation of this species. An effort has been made to take some pupae of this species to the Butterfly Research Facility in Cibinong but they were not successful in mating at that time.

As for the few villagers who had harvested pupae from host plants in forests nearby the villages, rearing or captive breeding operation can be encouraged. Incentive needs to be given to villagers so that they can breed the butterfly legally with source code R or even C for sustainable use of the species.

Indonesia is required to have an NDF assessment before the exportation of specimens with source code 'R'. Meanwhile, Indonesia has not developed an NDF for any species of birdwing butterflies, and we will follow the recommendation to prepare an NDF and notify the NDF result to CITES Secretariat before authorizing the exportation of specimens with source code 'R'.

Regarding the question of whether there is a mechanism in place to ensure that exports of ranched butterfly specimens under the source code "R" consist only of specimens collected at a very early developmental stage (eggs or the first larval stage), I would like to confirm that this has been the case. Breeders usually planted many host plants to attract female butterflies to lay eggs on the leaves of the host plants. The eggs will then be covered with a net sleeve (in the case of ranching) or protected from natural enemies in the butterfly enclosure (in the case of captive breeding). The hatched caterpillars will feed on the leaves of the host plants, undergo 5 instars, and pupate. The chrysalis, or the pupae, will then be selected upon emerging to adults, i.e., some will be harvested and some others will be kept alive as the parent stocks of subsequent generations. In the case of *O. croesus*, it was difficult to find parent stocks in the wild. Therefore, it is natural to think that breeders would ensure to keep sufficient individuals for parent stocks and not harvest too many. Otherwise, they would need to spend extra resources (efforts, time, money for transportation, etc.) to go to the forests and obtain parent stocks. Considering the challenges of walking up the river at Gunung Sibela Nature Reserve that we also experienced during the field surveys (Peggie et al., 2021a), sparing decent numbers of individuals will be a viable option that the breeders would take. Therefore, it is recommended that an in-situ semi-natural butterfly breeding approach can be developed for butterfly conservation and sustainable use of *O. croesus* with "R" source code or with "C" source code for the breeding facility inside a butterfly enclosure (Peggie et al., 2021a).

Domestic and international trading (Soehartono & Mardiastuti, 2002) may add to the threats. Excessive trades, mostly uncontrolled direct collecting, may lead to a threat to endemic and rare species like *O. croesus*. Much better alternatives such as harvesting through captive breeding and ranching operations should be encouraged.

In conclusion, the trade and threat issues of *O. croesus* need to be considered thoroughly based on the viability to implement conservation strategies. The demand for the trade of *O. croesus* can be fulfilled through good understanding and cooperation to achieve the expected goals of sustainable use. An approach such as ranching and captive breeding practices need to be encouraged and supported, within the boundaries of international trade compliance. More importantly, the remaining forests on the islands of North Maluku need to be preserved to spare the future of this magnificent species and many others.

ACKNOWLEDGMENTS

The field surveys were carried out with DIPA funds from KSK CITES 3400.002.051A, Research Center for Biology - LIPI. I am grateful to KSK CITES and the director. I also thank the head of BKSDA Maluku and his staff for the access given to enter the areas on Bacan Island. I thank Sarino, Sih Kahono, and all those who have assisted during the field surveys. I appreciate insights provided by reviewers to improve an earlier version of the manuscript.

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