

## Article

# Wildlife Trade Influencing Natural Parrot Populations on a Biodiverse Indonesian Island

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**Abstract:** Indonesia has been identified as the highest priority country for parrot conservation based on the number of species, endemics, and threats (trapping and smuggling). It is crucial to understand the current population status of parrots in the wild in relation to the illegal wildlife trade but the ecology and population dynamics of most parrot species in this region remain poorly understood. We conducted a parrot survey around an area of high biodiversity in the Manusela National Park, in Seram Island, Indonesia. We used a combination of fixed-radius point counts and fixed-width line transects to count multiple species of parrots. We recorded nearly 530 wild parrots from 10 species in and around Manusela National Park. The dominant parrot species were *Eos bornea*, *Trichoglossus haematodus*, and *Geoffroyus geoffroyi*. We applied the Savage selectivity index to evaluate poaching of parrot species in proportion to their abundance and which species had higher than expected poaching pressure. This study has important implications for the conservation status of endemic parrots (*Cacatua moluccensis*, *Lorius domicella*, and *Eos semilarvata*) and shows that parrots in the Manusela NP are largely threatened by poaching.

**Keywords:** parrots; conservation; ecology; wildlife trade; density; endemism; poaching; IUCN Red List; CITES



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## 1. Introduction

Parrots (order Psittaciformes) are the most threatened taxon of birds, with one-third of the nearly 400 species classified as threatened under IUCN criteria [1]. In a global analysis, Indonesia was identified as the highest priority country for parrot conservation based on the number of species, endemics, and threats [2]. Further, among CITES-listed species, parrots are by far the most traded and are declining faster than any other comparable groups of birds [2]. In Indonesia, all parrot species (except *Psittinus abbotti*) have been protected by law since 2018 [3], but this legislation is poorly enforced [4]. A higher proportion (almost half) of the parrot species in the Wallacean region of Indonesia are affected by trapping than in neighbouring regions or compared to the world average [5].

Seram Island is in central Wallacea, between New Guinea and Sulawesi. It hosts 11 parrot species, three of which are endemic to the Maluku archipelago: the Salmon-crested Cockatoo *Cacatua moluccensis*, Purple-naped Lory *Lorius domicella*, and the Blue-eared Lory *Eos semilarvata* (Table 1). The island is also home to five subspecies of Wallacean endemic parrots: the Moluccan King-parrot *Alisterus amboinensis amboinensis*, Eclectus Parrot *Eclectus roratus roratus*, Great-billed Parrot *Tanygnathus megalorhynchus affinis*, Red-cheeked Parrot *Geoffroyus geoffroyi rhodops*, and the Chattering Lory *Eos bornea rothschildi* (Table 1). Finally, there are also three non-endemic parrot species: the Red-breasted Pygmy-

parrot *Micropsitta bruijnii*, Red-flanked Lorikeet *Charmosyna placentis*, and the Coconut Lorikeet *Trichoglossus haematodus* (Table 1).

**Table 1.** Endemism and conservation status of the parrot fauna in Seram, Indonesia. Presented are endemism, scientific and English names, national protection [3], CITES status (Appendix I or II), and IUCN Red List conservation status (LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered) [1]. \* The current study includes recommendations to change these statuses (under Section 4.3).

Endemism	Scientific Name	English Name	National Protection	CITES	IUCN RedList
Species endemic to Seram	<i>Cacatua moluccensis</i>	Salmon-crested Cockatoo	protected	I	VU *
	<i>Lorius domicella</i>	Purple-naped Lory	protected	II *	EN *
	<i>Eos semilarvata</i>	Blue-eared Lory	protected	II *	NT *
Subspecies endemic to the Maluku archipelago	<i>Alisterus amboinensis amboinensis</i>	Moluccan King-parrot	protected	II	LC
	<i>Eclactus roratus roratus</i>	Eclactus Parrot	protected	II	LC
	<i>Tanygnathus megalorynchos affinis</i>	Great-billed Parrot	protected	II	LC
	<i>Geoffroyus geoffroyi rhodops</i>	Red-cheeked Parrot	protected	II	LC
	<i>Eos bornea rothschildi</i>	Chattering Lory	protected	II	LC
Non endemic	<i>Micropsitta bruijnii</i>	Red-breasted Pygmy-parrot	protected	II	LC
	<i>Charmosyna placentis</i>	Red-flanked Lorikeet	protected	II	LC
	<i>Trichoglossus haematodus</i>	Coconut Lorikeet	protected	II	LC

Parrot trade in Indonesia is driven by both demand and opportunity-based factors, and serves both national and international markets [4]. In the illegal wildlife market, there is a high demand for at least two parrot species endemic to the Moluccas, *C. moluccensis* and the *L. domicella*. Local authorities have processed cases of illegal parrot trade originating from the outskirts of Manusela National Park in Seram [6]. Although legislation regulating the wildlife trade in Indonesia is in place, law enforcement, monitoring, and awareness are often lacking. Knowledge of trading routes and source populations is sorely needed to help governments shut down the illegal wildlife trade and to aid the rewilding of the increasing number of confiscated parrots.

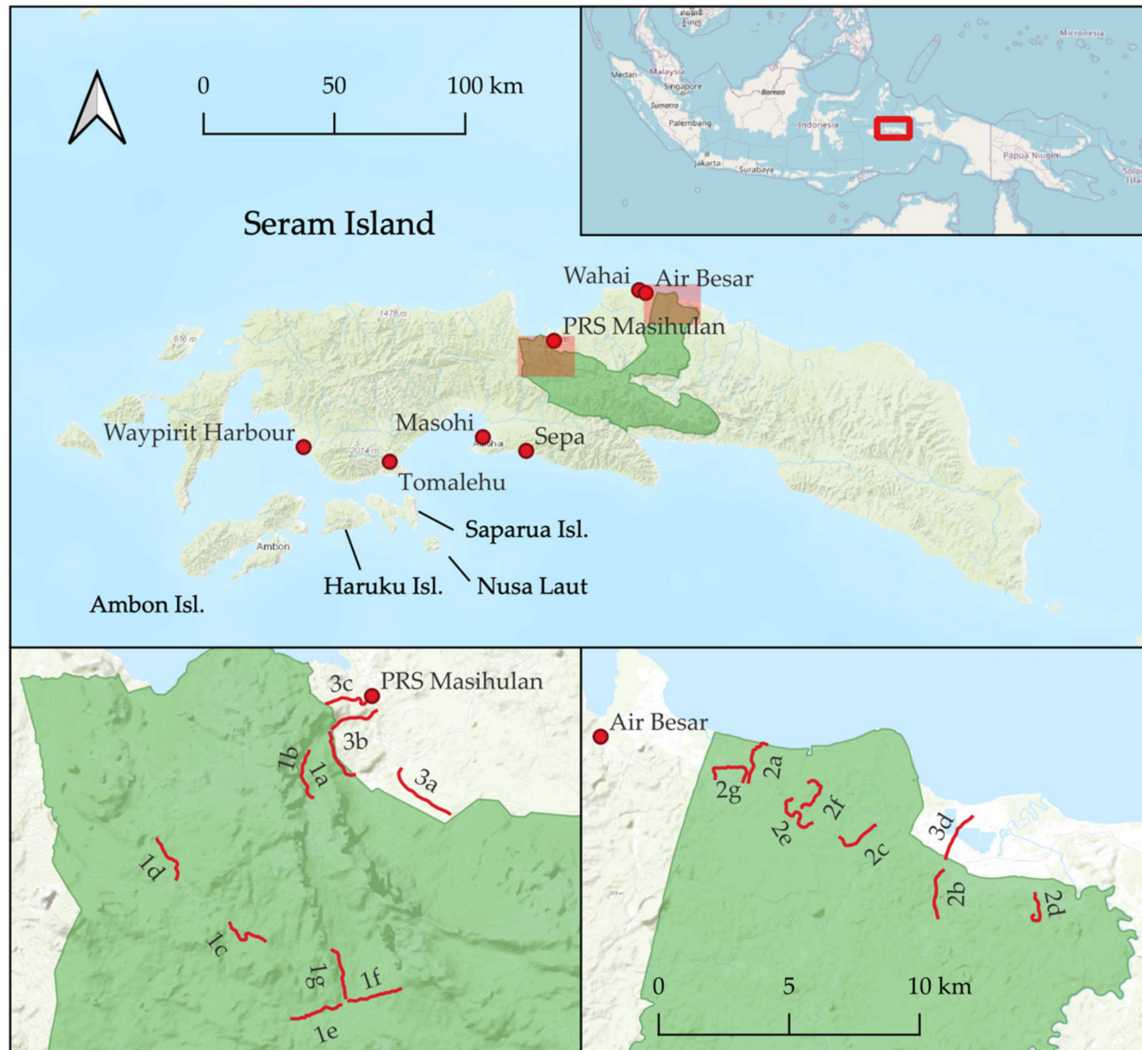
The high demand for parrots in the illegal trade threatens parrot populations in the wild, so it is crucial to understand the current population status of parrots in their natural habitat and how the trade affects them directly. We conducted a two-month population census of parrots in 2020 at three locations throughout Seram. The aims of this study are to (1) record current demographic measures of wild parrot populations, including density, species richness, diversity, and evenness, and (2) investigate the effects of poaching on the wild populations. Our results will serve as an important reference for the local authorities in making decisions and management programs regarding law enforcement in the local parrot trade and future rewilding work.

## 2. Materials and Methods

### 2.1. Study Area

The study was conducted in the Manusela National Park, on Seram Island, Central Maluku District, Maluku Province, Indonesia (129°9'3''–129°46'14'' E and 2°48'24''–3°18'24'' S). Manusela NP was established in 2014, covering an area of 174,545.59 ha in the central region of the island (Figure 1; map was constructed with QGIS 3.20). The topography of Manusela NP consists of lowland (0–500 m), highland (500–1500 m), mountain (1500–2500 m), and

sub-alpine (up to 3000 m) habitats [7]. The extraordinary biodiversity of the Manusela NP includes endemic and unique flora and fauna [8], including a high diversity of orchids, pteridophytes [9], ferns [7], marsupials, bats [9], reptiles [10], and insects [11]. Bowler and Taylor [12] recorded 197 species of birds in the national park, including 124 resident species and 73 migrant bird species.



**Figure 1.** Map of the study area in Seram Island, Indonesia with the Manusela National Park (green). Census transects represent (1) Masihulan Camp sites: (1a) Masihulan camp track, (1b) Pos pantau, (1c) Km 20, (1d) Hatusaka track, (1e) Illie Camp track 2, (1f) -track 3, (1g) -track 1; (2) Sasarata Camp sites: (2a) Mangrove track, (2b) Wae Masin, (2c) Wae Mual, (2d) Pasahari fire track, (2e) Wae Patan, (2f) Wae Faung, (2g) Wae Masinatu; and (3) Manusela NP buffer zone (BZ) sites: (3a) Negeri Masihulan (NM) Galian C, (3b) NM shelter track, (3c) NM cultivation, (3d) Negeri Pasahari Wae Masin. Red dots represent locations mentioned in the main text.

The census was conducted from late March to early May 2020 at three locations including seven observation tracks in Masihulan Camp (1) covering 1.25 km<sup>2</sup>; seven observation tracks in Sasarata Camp (2) of 1.25 km<sup>2</sup>; and the buffer zone of the Manusela NP (3) including three observation tracks in Negeri Masihulan of 0.54 km<sup>2</sup> and one observation track in Negeri Pasahari of 0.18 km<sup>2</sup> (Figure 1). The survey locations also represented different habitat types, including mountain forests (in Masihulan- and Illie Camp tracks) [13], habitats over 1000 m dominated by mosses and ferns, lowland habitats (alluvial land, mangrove, and savanna in Sasarata Camp and Pasahari), secondary forest, seashore, and cultivated

land (in the buffer zone with plants including clove *Syzygium aromaticum* nutmeg plant *Myristica fragrans*).

## 2.2. Survey Methods

The surveys were conducted using a combination of fixed-radius point counts (FRPC) [14] and fixed-width line transects (FWLT) [15]. We counted multiple species of parrots as targets, using two skilled teams of two parrot specialists to identify location and species, and to minimise observer error rate. The teams included experts with 30 years of experience with visual and auditory identification of parrot species and with excellent local knowledge of nesting and roosting locations. We encountered the birds along the transects with 2 km distance between tracks and 50 m of visibility at each point. We conducted the census on seven transects in Masihulan Camp and Illie Camp, on seven transects in Sasarata Camp and Pasahari, on three transects in the buffer zone of the Manusela NP at Negeri Masihulan, and one transect in Negeri Pasahari (Figure 1). Between each transect there was at least 2 km distance. In total, we conducted 180 FRPC transects and 180 FWLT transects.

Parrot censuses were carried out in the early mornings during a consistent time period from 07:30 to 12:00, but in some locations, we spent more time (until 15:00) because of the difficult path and remoteness. Data were collected by two teams to estimate population size by direct count with the birds. We detected and identified the birds by means of their calls, because parrots are noisy birds and have a specifically distinct loud call [16]. Moreover, no other birds have calls similar to those of parrots in the location. The best time for observation was 30 min after sunrise and closer to the sunset as these times are the peak of activity in birds [17]. In cockatoos, activity begins as soon as the sun rises, and they immediately start looking for food [16]. Competition between species of birds that have the same types of food will lead to separation of resource use and ecological niches. The FRPC data were collected for 15 min on each occasion, identifying all parrot species visually and by their calls. During the FWLT method we walked slowly and steadily, while detecting parrot species.

The data on confiscated parrots were collected by the Maluku office of the Natural Resource Conservation Center of the Ministry of Forestry (Balai Konservasi Sumber Daya Alam (Kota Ambon, Indonesia), BKSDA Maluku hereafter) from 2016 to 2018 [6]. We also included data on birds confiscated by BKSDA Maluku in the Manusela NP and sent to the Pusat Rehabilitasi Satwa Kembali Bebas Avian Rehabilitation and Reintroduction Center Masihulan (PRS Masihulan hereafter) between 2019 and 2020. Currently, these data represent the best available measure of the recent poaching pressure on parrots in Seram Island.

## 2.3. Data Analyses

Density of birds ( $D$ ) was calculated based on the total birds observed for each species and divided by the total plot area ( $A$ ). If the total number of birds observed is  $S$ , and the total number of individuals observed in each transect is  $N$ , then the index of species richness follows the Menhinick index [18]:

$$R_2 = S/\sqrt{N} \quad (1)$$

If total individuals observed of a species is  $n$  and the species proportion is  $pi$ , then the species diversity follows the Shannon-Wiener index [19,20]:

$$H' = - \sum \frac{n}{N} \ln \frac{n}{N} = - \sum pi \ln pi \quad (2)$$

The Pielou index was used to calculate species evenness [21]:

$$E = H'/\ln S \quad (3)$$

Species frequency ( $F$ ) was calculated based on the total number of each species divided by the total number of birds observed in a sample plot [22].

In order to evaluate if parrot species were poached proportionally to their abundance in the wild, we calculated the Savage selectivity index ( $W$ ) [23], following a previously established protocol for the parrot trade [24]:

$$W = u_i/p_i \quad (4)$$

where  $u_i$  is the proportion of a given species recorded on the trade (by BKSDA Maluku and PRS Masihulan) and  $p_i$  is the proportion of the same species observed in the wild (by the current study). We tested the null hypothesis that parrot species are poached in proportion to their availability in the wild by comparing the statistics of  $W$  to the corresponding critical value of the chi-squared distribution after Bonferroni correction, with one degree of freedom [24]. We excluded *E. semilarvata* from this analysis, given that we have not observed any individuals in the wild.

### 3. Results

#### 3.1. Wild Parrot Populations on Seram

During the surveys we recorded 530 individual parrots from 10 species. Of these, 97 individuals were observed at Masihulan Camp, 294 at Sasarata Camp, and 139 in the buffer zone of the Manusela NP (105 in Masihulan and 34 in Sasarata buffer zones; Figure A1). The dominant parrot species observed were *E. bornea*, *T. haematodus*, and *G. geoffroyi*. The encounter rates for each species at each transect were: *E. bornea* 25.7%, 29% and 24.5%; *T. haematodus* 23%, 26.4%, and 18.7%; and *G. geoffroyi* 14.4%, 29.6%, and 17.1% respectively.

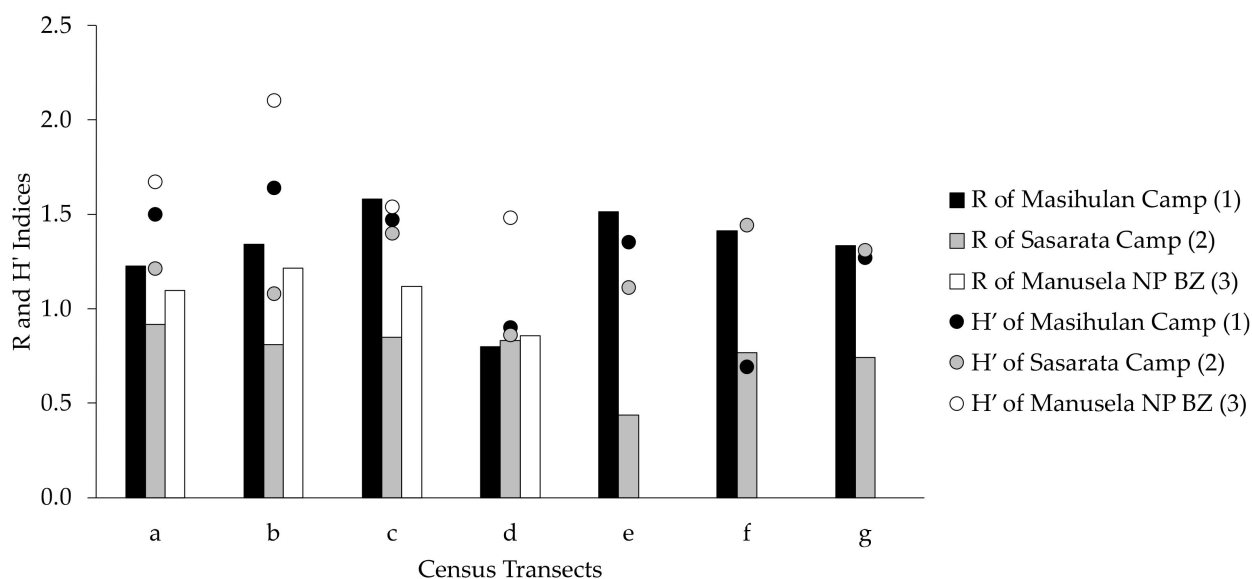
During our study, we detected *E. bornea* with the highest density ( $D$ ) of 51.8 individuals/km<sup>2</sup> (ranged between 19.2 and 104.8 individuals/km<sup>2</sup>; in Table 2, we also recorded high densities for *G. geoffroyi* (39.9 individuals/km<sup>2</sup>), *T. haematodus* (37.1 individuals/km<sup>2</sup>), and *C. moluccensis* (10.8 individuals/km<sup>2</sup>). The lowest density was for *L. domicella* (2.3 individuals/km<sup>2</sup>).

**Table 2.** Parrot densities ( $D$  = individuals/km<sup>2</sup>) and species evenness ( $E$ ) at different transects conducted in the Manusela National Park, Seram, Indonesia, including Masihulan Camp (1), Sasarata Camp (2), and Manusela NP buffer zones (3). For exact locations, see Figure 1.

Scientific Name	N	D			E		
		1	2	3	1	2	3
<i>Alisterus amboinensis amboinensis</i>	18	8	0.8	9.72	0.49	0.04	0.18
<i>Cacatua moluccensis</i>	26	10.4	1.6	15.28	0.74	0.06	0.31
<i>Chamosyna placentis</i>	6	-	-	8.33	-	-	0.13
<i>Eclectus roratus roratus</i>	41	4.8	16.8	19.44	0.36	0.52	0.33
<i>Eos bornea rothschildi</i>	184	19.2	104.8	40.28	1.08	1.14	0.57
<i>Eos semilarvata</i>	0	-	-	-	-	-	-
<i>Geoffroyus geoffroyi rhodops</i>	96	9.6	40.8	45.83	0.6	1.06	0.57
<i>Lorius domicella</i>	3	0.8	-	2.78	0.11	-	0.05
<i>Micropsitta bruijnii bruijnii</i>	6	-	-	8.33	-	-	0.1
<i>Tanygnathus megalorhynchus affinis</i>	16	0.8	7.2	8.33	0.06	0.3	0.18
<i>Trichoglossus haematodus</i>	134	24	63.2	34.72	0.8	1.2	0.52

The transects with the highest richness ( $R_2$ ) in the Masihulan Camp area were Km 20 ( $R_2 = 1.6$ ) and Illie Camp ( $R_2 = 1.5$ ; Figure 2). The highest parrot richness in the Sasarata Camp was recorded in the mangrove track ( $R_2 = 0.9$ ) and Wae Mual ( $R_2 = 0.9$ ; Figure 2). Finally, in the buffer zone of the Manusela NP the highest parrot richness was in the shelter track ( $R_2 = 1.2$ ) and the cultivation track ( $R_2 = 1.1$ ; Figure 2). Our data showed that the highest parrot species diversity ( $H'$ ) is in secondary forest, ecotone areas, or in a transition area between primary forest and cultivation. The lowest parrot diversity was detected in

the Masihulan Camp on the Hatusaka track ( $H' = 0.9$ ) and Illie Camp ( $H' = 0.7$ ), and in the Sasarata Camp in Negeri Pasahari ( $H' = 0.9$ ; Figure 2).



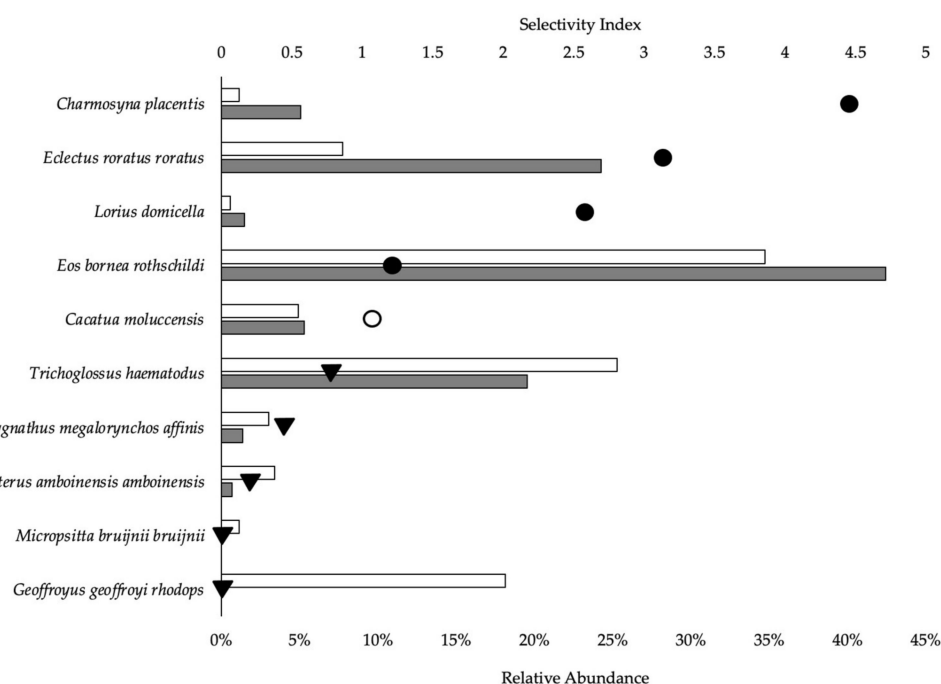
**Figure 2.** Comparison of species richness ( $R$ ) and species diversity ( $H'$ ) across transects. The location of each census transect is shown in Figure 1.

Parrot species evenness ( $E$ ) showed relative homogeneity in the buffer zone of the Manusela NP, because no particular species dominated this area. However, in both the Masihulan and Sasarata Camp parrot species evenness revealed higher heterogeneity. The dominating parrot species in the Masihulan Camp were *E. bornea* ( $E = 1.08$ ), *T. haematodus* ( $E = 0.8$ ), *C. moluccensis* ( $E = 0.7$ ), and *G. geoffroyi* ( $E = 0.6$ ; Table 2). The dominated species in the Sasarata Camp were *T. haematodus* ( $E = 1.2$ ), *E. bornea* ( $E = 1.1$ ), and *G. geoffroyi* ( $E = 1.1$ ; Table 2), while the evenness index was very low for *C. moluccensis* ( $E = 0.1$ ). We found similar results for both *E. bornea* and *T. haematodus* that are captured in high numbers for the wildlife trade (Table 2).

### 3.2. Parrot Trade and Poaching Pressure

In the past five years, BKSDA Maluku confiscated a total of 891 parrots, including 378 individuals of *E. bornea*, 216 *E. roratus*, 174 *T. haematodus*, 47 *C. moluccensis*, 45 *C. placentis*, 13 *L. domicella*, 12 *T. m. affinis*, and six *A. amboinensis*. Based on the confiscation data, the intensity of parrot poaching shows a decreasing tendency since the new government regulation (Republic of Indonesia, 2018) that protects all Indonesian parrot species by law.

The selectivity index ( $W$ ) showed significant positive poaching selection for the following four species: *C. placentis*, *E. roratus*, *L. domicella*, and *E. bornea* ( $p < 0.005$ ; Figure 3). In the case of five other species (*T. haematodus*, *T. m. affinis*, *A. amboinensis*, *M. buijnii*, and *G. geoffroyi*) we observed significant negative selection for poaching ( $p < 0.005$ ; Figure 3). For *C. moluccensis*, we could not reject the null hypothesis that they are poached in proportion to their availability in the wild (Figure 3).



**Figure 3.** Relative abundance of parrot species in Seram, Indonesia as confiscated from the trade (dark gray bars) and observed in the wild (white bars), and selectivity index (W; black dots: significant positive selection; black triangles: significant negative selection; white dot: non-significant selection).

## 4. Discussion

### 4.1. Wild Parrot Populations on Seram

Seram is a highly biodiverse Indonesian island that hosts many endemic species including a high diversity of parrots. The Manusela NP is supposed to safeguard this high parrot diversity, including three species only found on this island (Table 1). However, poaching pressure for illegal trade is a significant threat to their existence both inside and outside the national park [6], where law enforcement is scarce. Illegal logging and fires also occur locally, but this forest damage covers only 10% of the area of Manusela NP [13].

The data presented in this study are from the most detailed parrot census conducted on Seram Island in recent years. *E. bornea*, *T. haematodus*, and *G. geoffroyi* were found in highest frequency and not limited to high elevation. These species are locally nomadic [25] and their populations can extend from very small to large areas, depending on the habitat carrying capacity [26]. We found *M. b. bruijnii* and *C. placentis* in the lowest frequencies and showed that both species have specific habitat and food requirements. Low evenness values in species may have been related to several limiting factors such as altitude, like in the case in *E. semilarvata* and *L. domicella*, which are difficult to find  $\geq 700$  m. Both *M. bruijnii* and *C. placentis* were closely related to the presence of certain species of trees. Species evenness was significantly associated with bird density, indicating a positive relationship with disturbed habitats as well as vertical heterogeneity with high bird density [27].

Open areas of lowland forest types, mangrove forests, savannas, and areas bordering cultivation had low species richness, though the figure may be influenced by the fruiting and flowering seasons. The majority of food sources were located inside forests [28] but parrots used cultivated and mangrove areas for foraging as well. Groups of parrots had an increasing species richness in forest types with open canopies and vertically heterogeneous vegetation structures. Frugivorous, granivorous, and nectarivorous species were closely related to disturbed areas [27]. The presence of frugivorous species is important because of their function to help plants with pollination and spreading of seeds [29,30]. The dominance of cockatoos in Masihulan Camp area is closely related to the rewilding process of confiscated birds that are concentrated in the region. The existence of PRS Masihulan

(Figure 1) possibly plays an important role in the increasing population of cockatoos in the region, and rewilded birds can be identified as they are banded.

#### 4.2. Parrot Trade on Seram

Poaching is one of the biggest threats faced by parrots as many people buy them as pets, generating demand for illegal trapping and smuggling [4]. In Indonesia, BKSDA Maluku reported birds as the highest ranked smuggled taxon for trade accounting for 86% of species in Maluku, of which 96% were parrots [6]. Between 2016 and 2018, a total of 1135 individuals of 16 parrot species were confiscated, and about 44% came from Seram [6]. During a bird market survey in Jakarta, three out of 13 parrot species (32%) were registered as originating from Seram, including *T. haematodus*, *C. placentis*, and *E. bornea* [31].

Applying the selectivity index in this study allowed us to evaluate the differences in poaching pressure suffered by the parrot species in Seram. The highest pressure was found to be on *C. placentis*, *E. roratus*, *L. domicella*, and *E. bornea* (Figure 3), meaning that these species were found in the trade more frequently than expected given their abundance in the wild. On the other hand, the non-significant selective pressure on *C. moluccensis* does not indicate that poaching is not a risk for this species, but that their frequency on the trade corresponds to their abundance in the wild. Moreover, the rewilding of confiscated individuals possibly skewed this index, as without these activities, there would have been fewer individuals observed in the wild, hence the index value would have been higher, i.e., the species positively selected. *C. moluccensis* is also hunted for traditional tribal ceremonies by the Huaulu, Naulu, and other tribes. Although birds account for only 6% of the wildlife consumed by the villagers in terms of the amount of protein [32], wild birds are especially important for them during certain periods.

Based on non-structural observations of communities in the area including Wahai, Air Besar, Sepa, and Masohi (Figure 1), people keep parrots as pets, such as *E. bornea*, lorikeets, and even cockatoos (D.N. unpublished data). Almost 90% of the households in Sepa keep parrots as pets (three or four individuals per family) and may sell the birds (Dr La Eddy, Pattimura University, unpublished data). *C. placentis* has also been observed for sale (20–30 individuals in small boxes) at Masohi (Figure 1). In the Manusela village, six species of parrots were caught in the forest strictly for the purpose of wildlife trade [33]. However, not every parrot species is at equal risk of being traded, and there is controversy concerning the role of demand and the opportunity-based factors driving the illicit wildlife trade [4]. The major source of income for people living in central Seram is seasonal migrant work (mainly harvesting cloves) but this income is unstable because of the fluctuation in production and the price. Hence, their dependency on wild parrots is enhanced during times of hardship caused by the decrease of their main income [32].

In order to involve local people in parrot conservation and rehabilitation, PRS Masihulan (Figure 1) was established in 2004, in the buffer zone of the Manusela NP. It has been employing former parrot trappers as caretakers who are also involved directly in the monitoring of the re-wilded birds [34]. These activities have greatly affected the decrease of direct poaching by local villagers [35]. An undercover investigation determined that trapping of cockatoos had essentially stopped in close to vicinity of PRS Masihulan [36]. For instance in 1998, the density of *C. moluccensis* was 7.9 individuals/km<sup>2</sup> on Seram [37]. Their density is now 20.4 individuals/km<sup>2</sup> near PRS Masihulan, while it remained low in other parts of Manusela NP (Figure 1, Table 2). This figure is probably due to their reproductive success and the decreased impact of direct poaching around PRS Masihulan. Sadly, the poaching of *C. moluccensis* still occurs in other parts of the island, including Manusela NP. For example, in May 2020, BKSDA Maluku confiscated 10 individuals from Tomalehu (Figure 1), and the team of the Konservasi Kakatua Indonesia tagged two birds (*C. moluccensis* and *L. domicella*) seized by BKSDA Maluku at Waypirit Harbour (Figure 1). The *L. domicella* individual had been banded before and this is the second time this bird has been trapped for the illegal parrot trade. Banding is important for recording the origin



and the history of the birds and also for rewilding purposes. Other methods could include genetic tagging [38] that can aid assigning the provenance of the confiscated parrots [39].

#### 4.3. Conservation Status of Endemic Parrot Species

The result of our current analysis of direct observations combined with recent parrot confiscation data [4,6] have important implications to the conservation status of three parrot species endemic to Seram. It is important to note that confiscations only represent a small fraction of the poached individuals, so actual figures for these species could be much higher and more worrying for their conservation status.

*Cacatua moluccensis* is currently considered Vulnerable (VU) on the IUCN Red List [1] and our analysis supports their uplisting to Endangered (EN). Their population size has been decreasing at least since 1994, based on previous IUCN evaluations [40]. Although its distribution previously covered some satellite islands of Seram, based on BirdLife data it has been declared extinct from Haruku, Saparua, and Nusa Laut islands (Figure 1). In Ambon, it is very difficult to find these cockatoos (D.N. pers. obs.) and they may only remain in the western part of the island. Based on abundance data in the past (7.9 individuals/km<sup>2</sup>), their population size decreased by over 50% in some parts of the Manusela NP (currently 1.6 individuals/km<sup>2</sup> in Sasarata Camp), probably due to exploitation (see Section 4.2). Our selectivity analysis showed that poaching levels are consistent with their abundance in the wild (Figure 3). BKSDA Maluku and PRS Masihulan reported 47 confiscated individuals in the past five years in Maluku alone. Data from our direct field survey showed that the frequency of encounters was relatively low in Masihulan NP and its buffer zone (15.3% and 9.7% of all parrot individuals respectively) and that it was difficult to find them in the Sasarata area (relative frequency of 1.3%). These results support the IUCN criteria A2bd+3bd+4bd of EN [41].

*Lorius domicella* is currently considered Endangered (EN) on the IUCN Red List [1] and our analysis supports its uplisting to Critically Endangered (CR). They have a very limited distribution only in Seram in habitats above 800 m, and their population has been decreasing at least since 1994 according to IUCN evaluation [42]. Our survey showed very low relative frequency of all parrot individuals in the Masihulan NP (1.3%) and its buffer zone (1.6%). The number of mature individuals might be below 250 with fewer than 50 in each subpopulation. These results support the IUCN criteria C2a(i) of CR [41]. In addition, the threat of poaching is of concern as there were 13 recorded individuals confiscated in the past five years in Maluku and our selectivity analysis showed significant positive poaching pressure on the remaining population (Figure 3). Hence, we recommend the urgent inclusion of the species to CITES Appendix I.

*Eos semilarvata* is currently listed as Near Threatened (NT) on the IUCN Red List [1] and our analysis supports its uplisting to Vulnerable (VU). It has a limited distribution at altitudes above 800 m in Seram, with a decreasing population size since at least 2019 based on IUCN evaluation [43]. We did not register this species during our census activity on the transects, but recorded one foraging flock of 10 individuals while in the field. Their area of occupancy is possibly less than 2000 km<sup>2</sup> in 10 or fewer locations in Seram with a continuing decline, and the number of mature individuals is potentially less than 10,000 with 1000 or fewer individuals in each subpopulation. These trends support the IUCN criteria B2a, B2b(ii), and C2a(i) of VU [41]. Although BKSDA Maluku confiscation data did not record this species in the past five years, 40 wild-caught birds were exported in 2019 from Soekarno Hatta airport [44], indicating that poaching activity can threaten the wild population. Hence, we also recommend the inclusion of the species to CITES Appendix I.

## 5. Conclusions

Manusela National Park and its buffer zone have high parrot diversity. Over the last five years confiscation data showed that nine out of the 11 parrot species of Seram Island were poached. Illegal poaching activities do not only threaten parrot populations but are also very likely to contribute to forest decline given the extremely important ecological

role of parrots as seed dispersers [29,45,46]. The decline in parrot populations, as an apparent result of high demand on the wildlife market, may lead to the extinction of some species from the island. In this context, we have highlighted arguments for the uplisting on the IUCN Red List of three parrot species. We also showed that proper management and rehabilitation of confiscated parrots, and the inclusion of local communities into conservation efforts with environmental education campaigns can have positive effects on parrot conservation in the area. Our results contribute important information to local and international authorities and wildlife management programs that may help reduce the local parrot trade and inform future rewilding projects.

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