

## MONITORING of *Cacatua sulphurea abbotti* POPULATION IN MASAKAMBIING ISLAND, INDONESIA

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Received 5 March 2019 / Accepted 29 May 2019

### ABSTRACT

The Critically Endangered *Cacatua sulphurea abbotti* is a unique subspecies of cockatoo, endemic to a single tiny Masakambing Island in Indonesia. Data procurement on the status and distribution of their wild population is necessarily urgent in order to determine the best conservation strategy for this species. Data were collected annually from 2008-2018 by a direct roost count method in a roosting tree. Only 10 cockatoos were recorded in 2008, but the number continually increased up to 22 birds in 2018 (42.86% increase in a decade). The population was distributed in about 71% of the total size of the island, concentrated in the north-western part with a density of 1.56 ( $\approx$  2 birds/km<sup>2</sup>) in 2008 which raised up to 3.44 ( $\approx$  3 birds/km<sup>2</sup>) in 2018. The zero trapping policy enforced by the local government was probably effective in preventing the population decline, although the population is still vulnerable due to nesting failure, presumably low genetic quality and habitat destruction.

**Keywords:** *Cacatua sulphurea abbotti*, critically endangered, decade monitoring, Masakambing, population

### INTRODUCTION

Yellow-crested cockatoos (*Cacatua sulphurea*, Gmelin, 1788) are endemic to Indonesia and Timor-Leste (Sukmantoro *et al.* 2007) and are composed of six subspecies, namely; *C.s. sulphurea*, *C.s. abbotti*, *C.s. djampeana*, *C.s. occidentalis*, *C.s. parvula*, and *C.s. citrinocristata* (Rowley *et al.* 2018). In general, this species has a relatively small population. The *C.s. sulphurea* population at Rawa Aopa Watumohai National Park (RAWNP), Southeast Sulawesi, has about 55 individuals in 2011; seven individuals on a Kadatua Island in Buton, Southeast Sulawesi in 2012, and 14 individuals on Pasoso Island in Central Sulawesi in 2012 (Nandika *et al.* 2013). For *C.s. djampeana* subspecies in South Sulawesi, only 14 cockatoos were observed in Tanahjampea Island and only three cockatoos in Kalao Island during the six-day visit in September 2015 (Basari 2016). In 2012, about 57 - 73 individuals of *C.s. citrinocristata* subspecies

were recorded in 11 survey locations around Manurara, Manupeu Tanah Daru National Park, and about 15 - 18 individuals in two survey locations in Poronombu, West Sumba (Nandika *et al.* 2013). *C.s. occidentalis* subspecies is a split from *C.s. parvula*. This subspecies spreads in Nusa Penida to West and East Nusa Tenggara except Timor and Sumba, while *C.s. parvula* is only found in Timor and its satellite islands. In 2012, three female birds of *C.s. occidentalis* were recorded in Sedihing Village, Nusa Penida Island (Nandika *et al.* 2013). In addition, 500 individuals in Komodo Island, 200-300 individuals in Timor-Leste (BirdLife International 2017) and 17 individuals in Alor Island were recorded (Ashari *et al.* 2018).

Since 2004 the yellow-crested cockatoo has been listed in CITES Appendix 1 (Cabill *et al.* 2006) and has been categorized as Critically Endangered by IUCN (IUCN 2011) because of the illegal bird trade and loss of its habitat. Cockatoos are regularly trapped for the cage-bird trade and, as a result, their populations are considered under serious threat or in danger of

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extinction (BirdLife International 2001; Kinnaird *et al.* 2003). Illegal trade and habitat loss are the main causes of the reduction in cockatoo populations, and they are particularly detrimental to one subspecies, namely *C.s. abbotti*.

*Cacatua sulphurea abbotti* is the only yellow-crested cockatoo that has natural distribution outside Wallacea (Collar & Madsen 2014), a tiny island of Masakambing in the Masalembu Archipelago. This island, a non-protected area, has suffered from major habitat destruction and has been cleared for coconut cultivation and agriculture.

The protected status of *C.s. abbotti* in Indonesia is re-enforced by a local protection regulation, the *Peraturan Bupati Kepala Daerah Tingkat II Sumenep No. 05 Tahun 1995* (Regent of Sumenep's Regulation No. 05 Year 1995). Efforts to conserve *C.s. abbotti* included a dissemination program by Konservasi Kakatua Indonesia – Indonesian Parrot Project are targeted to the local government, particularly the *Camat* (the Head of Masalembu District) who then supported and created a contest in which any villagers who could find a fallen cockatoo and release them again would be rewarded. Similar support came from *Kepala Desa* (the Head of Masakambing Village), and together with the community they issued *Peraturan Desa* or *Perdes No. 1 Tahun 2009* (Village Regulation No. 1 Year 2009) on Masakambing cockatoos and their habitat on May 14, 2009 (Nandika *et al.* 2013).

It is important to monitor the trend of wildlife population of cockatoos in order to accurately evaluate wildlife conservation efforts and to properly determine management measures to conserve the species in the area (Barnes *et al.* 2016). Therefore, this study aims to provide baseline data on the *C.s. abbotti* population status and general behavior of the wild population, expecting that in the future

these data would be useful to design a conservation strategy for this endangered species.

## MATERIAL AND METHOD

### Study Area

Masakambing Island covers 7.64 sq. km of land and is part of the Masalembu Archipelago, East Java Province. The island is located at 5°02'-5°37' S, 114°23'-114°38' E on the Java Sea, lies about 90 miles south of Borneo and ± 155 km from Madura Island (Fig. 1). To reach the island, it takes ± 13 hours by pioneer boat from Kalianget Port on Madura Island. Masalembu Island extends approximately 2 by 4 miles, is of volcanic origin, though now surrounded by coral reefs, and has a low but rather uneven contour which culminates in a hill some 250 feet high (Oberholser 1912). Masakambing Island has a similar topography with gently sloping beach front, and also culminates in a hill about 20 m high. Masakambing Island is also the name of the village, which has two Dusun (part or hamlets) namely Ketapang (northwest) at 5°25'39"-5°26'33" S, 114°24'36"-114°26'06" E and Tanjung Selamat (southeast) at 5°26'33"-5°27'42" S, 114°26'24"-114°25'03" E. The residents comprise the Madurese ethnic group from Madura Island and the Buginese group from South Sulawesi. The island is inhabited by about 1,347 residents from both ethnics with 656 males and 691 females (BPS 2018).

Being located near the equator, Masakambing Island tends to experience dry climate with average annual rainfall of < 2000 mm (Nandika *et al.* 2013). East monsoon influences its dry season during June to September, while the west monsoon influences its rainy season during December to February. During the rainy season, heavy rains with strong wind or sudden storm are common.

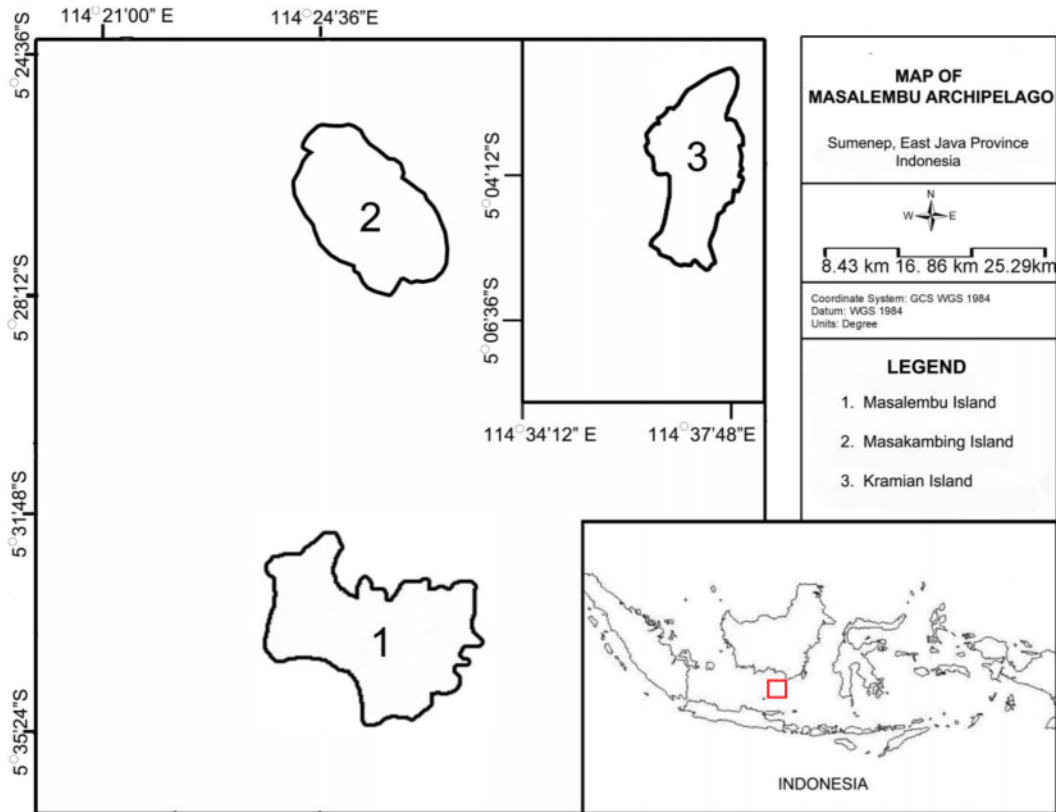


Figure 1 Location map of Masakumbing Island, Masalembu Archipelago (Nandika *et al.* 2013)

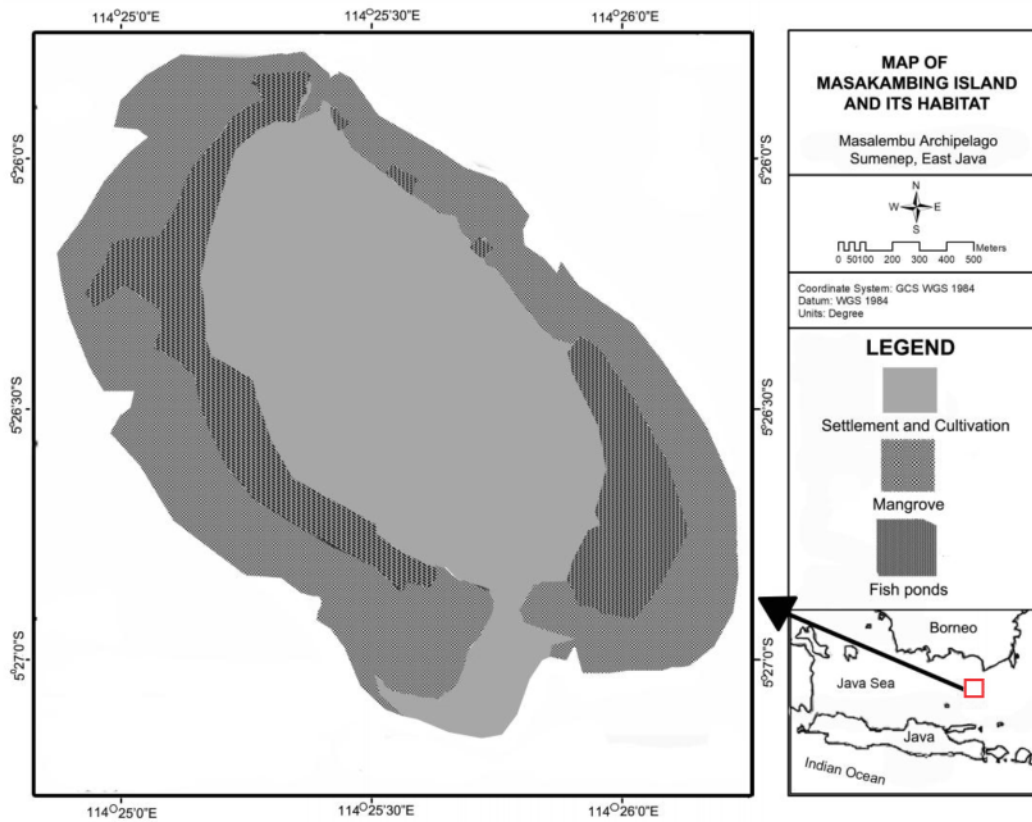


Figure 2 Masakumbing Island & its habitats

Sixty-seven plant species were observed in Masakambing Island (Nandika *et al.* 2013). These plants consisted of 28 mangrove species and 39 cultivated species, such as coconut tree (*Cocos nucifera*), clove (*Eugenia aromatic*), cashew (*Anacardium occidentale*), teak (*Tectona grandis*), banana (*Musa paradisiaca*), and corn (*Zea mays*). The only remaining forest in Masakambing are the mangroves that are located around the island. Most of the habitats in Masakambing Island have been converted into (1) fish ponds areas, about 1.25 km<sup>2</sup> or 16.4% (Fig.2); (2) settlement and cultivation areas, about 3.40 km<sup>2</sup> or 44.5% (Fig. 2); and (3) converted mangrove areas, about 2.99 km<sup>2</sup> or 39.1% (Fig. 2). The mangrove areas have been converted into fish ponds, that made it difficult to find big mangrove trees. Fortunately, due to high tide, the fish ponds were abandoned since 2008 and some mangrove species have been re-grown in the area.

### Survey Method

The surveys were conducted twice a year between March and November, from June 2008 to January 2018. Data from 2008 to 2016 were collected by Perkumpulan Konservasi Kakatua Indonesia (Indonesian Parrot Project/KKI/IPP) in which Dudi Nandika (DN) and Dwi Agustina (DA) were involved. This study continued to collect data from 2017 to 2018. Preliminary location survey was done from June to July 2008 to indicate the number of groups and roosting trees before marking their positions around the island. Distribution data were recorded by marking the location of encountered birds using GPS in the whole island (7.64 km<sup>2</sup>). The cockatoos gender is distinguished by the iris color, since it is quite difficult to distinguish between males and females by its morphology. The females have red iris and the males have black iris. The birds were also divided into three age classes: adult (> 3 years, in pair or single), juvenile (1 - 3 years, already independent, but still together with the parents), and chicks (0 - 1 year, under parental care). Only the adult birds were distinguished as males and females.

The surveys were conducted using a combination of direct count and roosting count methods. Direct count is applied by counting

the bird rather than relying on some related objects, such as tracks (Lewis 1970), while direct roosting count is carried out by groups of observers stationed at designated positions relative to a colony or survey area (Kunz *et al.* 1996). The combination of those methods focused on counting only the cockatoos in a roosting tree as they roost in a group. It is known that cockatoos sleep in groups and do not move to other trees, unless being disturbed, such as when the tree fell down. Flocks may maintain a permanent roosting site and may occupy it for many years (Lamm & Calaby 1970; Frith 1976; Taylor & COG 1992 in Lindenmayer *et al.* 1996). This methodology provide a quantitative, accurate, and a comparable source of data for the number of birds which occupy certain roost sites (Pérez-García 2012).

Bird census was carried out in the early morning from 04:45 to 05:30 (before sunrise or before the birds flew to start their daily activities) and late afternoon from 17:00 to 17:45 during sunset (when the birds arrived at the roosting tree). Data were collected by two teams (uphill and lowland teams) to estimate population size and the timing of direct interaction with the cockatoos. Hand walkie-talkie was used for communication between the two teams in order to minimize biases and to avoid duplications. During the census, the bird species was detected by means of bird calls because cockatoos are noisy birds and have a specifically distinct voice call (Nandika *et al.* 2013), and their presence was easily detected from their voice. Moreover, no other birds have similar voice with this cockatoo in Masakambing Island. Counting was done on birds leaving the roosting tree in the morning and birds arriving at the roosting tree in the evening. To reduce biases or duplication no bird counts were conducted outside roosting tree areas. In addition to direct observation on bird population, all information and data regarding bird-related incidents were also collected; such as being brought out from Masakambing like sold as a gift, falling from a nest tree, and natural deaths.

### Data Analyses

If the total number of birds in survey area is  $N$ , and total habitat used by cockatoo is  $A$ , then

the estimate of birds density is  $D = N/A$ . Density of cockatoo was calculated based on the total area of Masakambing Island (7.64 km<sup>2</sup>) deducted with total area of fish ponds 1.25 km<sup>2</sup>. Settlements and cultivations were included as habitat of cockatoo because the houses were located sparsely and each is surrounded by cultivations. *Cacatua sulphurea* was obviously not restricted to primary forests and this bird has never been encountered inside deep forest (Jones *et al.* 1995).

## RESULTS AND DISCUSSION

### Distribution according to Roost Tree

Almost every year the birds had to choose a different roosting tree as a result of cultivation and harvesting activities, tree cuttings by villagers, or tree falls because of gusty wind. Unless being disturbed, a group of cockatoos would remain on the same roosting tree. About 18 roosting trees (34%) have been used continuously for two years, while 35 roosting trees (66%) were abandoned because the birds

had to move to other roosting trees over a period of one decade (Fig. 3).

Initially, the distribution range of *C.s. abbotti* was about 46% (3.54 km<sup>2</sup>) of the size of Masakambing Island in 2008 - 2009 and increased in proportion with the population number to 56.9% (4.35 km<sup>2</sup>) in 2010 - 2011, 63% (4.85 km<sup>2</sup>) in 2012 - 2014, and 71% (5.4 km<sup>2</sup>) in 2015 - 2018. During the 2008 to 2011 surveys, the birds were concentrated in Dusun Ketapang on the north-western part of the island (Nandika *et al.* 2013). However, since 2012 the distribution range of the cockatoos expanded to several areas in Dusun Tanjung Selamat on the south-eastern part of the island.

Each group of cockatoos has their own home range in Masakambing, but overlaps among home ranges of different bird groups frequently happen in a small area. The home range distribution for all bird groups was about 71% (5.4 km<sup>2</sup>) of the total area of Masakambing Island. All groups often mix together when feeding, sunbathing, or performing other social interactions. Occasionally, more than six birds were observed to perch together (Fig. 4).

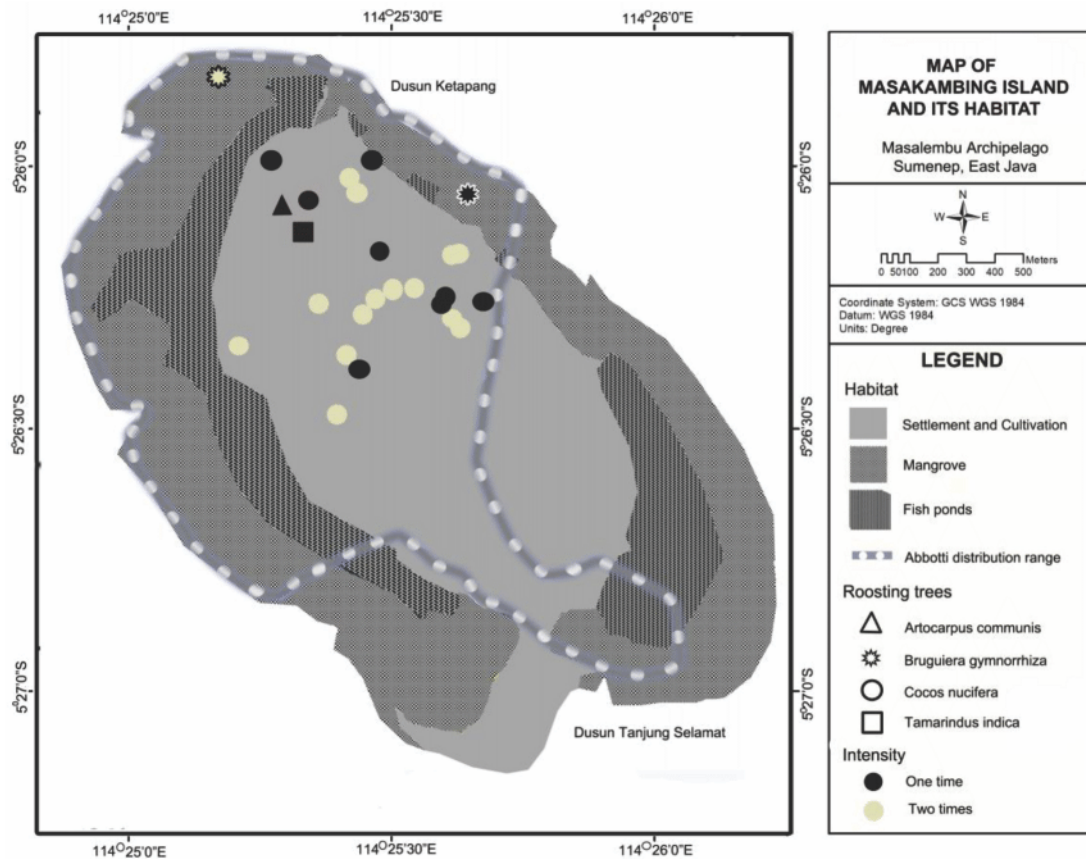


Figure 3 Distribution map of *Cacatua sulphurea abbotti* and their roosting trees in Masakambing Island



Figure 4 Several bird perching situations: A. Eleven *Cacatua sulphurea abbotti* were sunbathing together in a flock on a mangrove tree; B. Eight *C.s. abbotti* were enjoying sunrise together in a flock after moving from a roosting tree; C. Eleven *C.s. abbotti* were in their nest on a cotton silk tree (*Caiba pentandra*) to protect the chicks from raptors (eight) (Photo by: DN)

The cockatoos preferred the habitat in Dusun Ketapang over Dusun Tanjung Selamat because the vegetation in Dusun Ketapang was relatively denser. It was observed that the availability of feeding trees, roosting trees, and nesting trees in the area provided the cockatoos with their needs. Dusun Ketapang provided the birds with the needed food trees, nest trees and flocking areas. The roosting trees were also concentrated in a cultivation area in Dusun Ketapang, while most trees in cultivation area of Dusun Tanjung Selamat, such as cashews and cloves, were not as tall as those in Dusun Ketapang. The mangrove area in Dusun Tanjung Selamat was dominated by *Nypa fruticans* while *Sonneratia caseolaris*, known to be a feeding tree, was less common. The distribution range of *C.s. abbotti* increased in line with the population number of those birds. The distribution range area is proportional with the increase of population size (Sinclair *et al.* 2006). The expansion of distribution range is in line with the increase of population size related to dispersion of population from higher density area to the periphery (Schowalter 2016).

### Roost Tree

Most of the recorded roosting habitats were coconut palms (*Cocos nucifera*) (90%); others were breadfruit (*Artocarpus communis*) (1.67%), tamarind (*Tamarindus indica*) (1.67%) and large-leaf orange mangrove (*Bruguiera gymnorhiza*) (6.67%) (Table 1). Cockatoos in Masakambing Island probably preferred coconut palm tree over other trees as the roosting tree because it has deciduous bracts or spathes that envelop the inflorescence and is rather woody, huge, strong and thick, and thus, is suitable for hiding. The trunk is also strong enough against wind and adverse weather. Trees that were usually chosen as roosting places are the strongest and tallest ones in the habitat with average height of 17.85 m (range between 12.38 m to 25.22 m) which can provide protection from strong wind. Besides being strong, those roosting trees have a dense canopy used for hiding and camouflaging from predators.

Table 1 The roosting trees of *C.s. abbotti*

Year	Number of individuals	Σ Group	Roosting tree				Total roosting tree
			<i>Cocos nucifera</i>	<i>Artocarpus communis</i>	<i>Tamarindus indica</i>	<i>Bruguiera gymnorhiza</i>	
2008	10	3	1	1	1		
2009	8	3	3				
2010	11	3	4				
2011	13	4	4				
2012	15	5	6				
2013	17	6	6				
2014	18	6	6				
2015	21	6	6			1	
2016	23	7	6			1	
2017	23	7	6			1	
2018	22	7	6			1	
Percentage of roosting tree			90.00%	1.67%	1.67%	6.67%	60

A similar strategy is also applied by other parrots when choosing a specific roosting tree. A study on the red and blue lorries (*Arini et al.* 2017) discovered that several characteristics of trees were related to roost tree selection, i.e., bole length, canopy diameter, canopy density and the number of trees around the roost tree having a diameter of 20 to 40 cm and > 41 cm. Breadfruit trees (*Artocarpus communis*) have huge leaves, which is good enough for cockatoos to hide and camouflage, but this tree is too fragile against wind.

### Population Size and Density

Only 10 *C.s. abbotti* cockatoos were recorded in 2008 (Table 2), and then two birds were taken out from Masakambing reportedly as being sold as a gift in 2009 (Tables 2 & 3). After 2010 the number continued to increase up to 24 cockatoos in 2017 and then decreased in early 2018 because of death resulting from tree falling incidents (Fig. 3). Nonetheless, a significant population growth was documented in a decade of monitoring.

Although there was an increase in population size in a decade, the annual increase was relatively low, ranging from 20% to 38%. In 10 years there was a double increase in the number of pairs from four in 2008 to eight in 2018 (Table 2). Some adult birds did not have mate; either because they did not have any pair yet, or their mates already died. Some birds cannot be identified as pairing, especially outside the breeding season. Also, the overlapping of distribution range among groups or family in flocks also made it difficult for identifying pairs.

Commonly, cockatoos fly in a group of 2 to 6 individuals. The density of *C.s. abbotti* was 1.56 ( $\approx 2$  birds/km<sup>2</sup>) in 2008, but this decreased to 1.25 ( $\approx 1$  birds/km<sup>2</sup>) in 2009 and then rose to

3.44 ( $\approx 3$  birds/km<sup>2</sup>) in 2018. Mortality markedly contributed to the decrease in population density (Alikodra 2002).

Although the mortality rate was 21.43% (6 birds) in a decade, the total population increased by 42.86%. The increase was about 1.2 birds per year, while the mortality rate was 0.6 birds per year, implying that the population is developing, as indicated by this research. This 10-year increase in the population density of *C.s. abbotti* did not differ much from that of another subspecies, i.e., *C.s. citrinocristata* from Sumba Island, which increased from 2 birds/km<sup>2</sup> in 1992 to > 4 birds/km<sup>2</sup> in 2002 (Cabill *et al.* 2006). Population increase or decrease in an island like Masakambing were basically influenced by natural birth rate and death rate, which in turn were influenced by available resources, such as food and nesting sites, and threats such as predation and bad weather.

Small population increase showed by cockatoo in Masakambing has indicated that the conservation efforts done by the local government and NGO, such as the critically important zero trapping intervention, have been successful in halting bird population decline in Masakambing. Undoubtedly, many factors contributed to the population increase or decrease, including food, space (habitat decrease or increase), season, cavity available in the nesting tree, natural disaster, illegal trade, human interventions, etc. Therefore, all of these factors need to be assessed for their contribution to the population increase. Illegal trapping of yellow-crested cockatoos are no doubt the most critical factor in the three decades of population fluctuations and played a major role in limiting the population recovery (PHPA/LIPI/BirdLife-IP 1998).

Table 2 Population dynamics of *Cacatua sulphurea abbotti* in one decade (2008 - 2018)

Year	Number of individuals	Pair	Male	Female	Unidentified sex	Juvenile	Chick	Habitat use (km <sup>2</sup> )	Density (individuals/km <sup>2</sup> )
2008	10	4	4	4	0	0	2		1.56
2009	8	4	4	4	0	0	0		1.25
2010	11	4	4	4	0		3		1.72
2011	13	4	4	4	0	3	2		2.03
2012	15	5	6	5	0	2	2		2.35
2013	17	6	7	6	0	2	2	6.39	2.66
2014	18	5	5	5	4	2	2		2.82
2015	21	7	7	7	2	2	3		3.29
2016	23	8	8	8	2	3	2		3.60
2017	23	8	8	8	4	2	1		3.60
2018	22	8	8	8	4	1	1		3.44

### Threat and Conservation

Extreme weather conditions had caused bird falls from the nesting trees, and this became a high risk death factor in Masakambing Island. The habitat is characterized as cultivated vegetation with wide gaps between canopy trees which may be unreachable for fledglings when they start learning to fly during the fledging period. In December 2014, a female parent and a chick were found dead (Fig. 5; Table 3) because the nesting tree fell down after a strong wind. In January 2018, an adult male cockatoo with a broken wing also fell down and died. A decade long data on the historical records of the incidents of Masakambing cockatoos were collected from notes and information from villagers (Table 3).

The bird falls took place between October and February (Table 3). In a decade of monitoring, about 10 incidents with 10 bird falls occurred; 60% of them were dead; 30% were released after the birds were taken care of and displayed an ability to survive; and 10% were still being taken care of as of January 2018.

Data and information on weather conditions in the study area were obtained from the recorded weather data from January 2008 to December 2017 collected by the nearest Weather Meteorological Station in Kalianget, Madura, about 155 km from Masakambing. The 10-year weather data revealed that the strongest wind speed at 9.3 knots was recorded in February 2008, and the highest rainfall at 400.7 mm occurred in January 2017 (BMKG 2017).

The west wind season which brings extreme weather was recorded from December to February of each year within the recorded 10-year weather data.

Cockatoos are in fact under considerable threat, and when concentrated into flocks, a significant number of the species may be susceptible to extreme weather events, such as extremely hot days and storms (Saunders *et al.* 2011).

*C.s. abbotti* vigorously adapted to cultivation and mangrove habitats despite its small distribution range, large human population of the island, and extreme weather conditions. This subspecies displayed its survival potential in these human-modified island ecosystems (Cahyadin *et al.* 1994). With this successfully strong adaptability, this bird species showed its ability to survive in various kinds of habitat.

Approximately 3.40 km<sup>2</sup> (45%) of the total habitat area of cockatoos in Masakambing has been transformed into human settlements and cultivations, and only around 4.24 km<sup>2</sup> (55%) has been left for mangroves, most of which has been converted into fishponds. This species, having a limited distribution and in need of a specific habitat for gathering food, is probably at higher risk of extinction as a result of the fragmentation of the native vegetation (Saunders 1986). Various human activities, such as tree cutting which jeopardizes the birds' nests and food supply, plant cultivation, and plant harvesting, as well as predators, are considered as great threats to Masakambing cockatoos.



Figure 5 Several situations causing dead bird: A. One adult *C.s. abbotti* with a broken wing fell and died on 30 January 2018; B. One chick was dead after falling from its nesting tree on 31 December 2016 and bruises were found on its chest; C. Two cockatoos were dead (a female parent and a chick) because their nesting tree fell down due to strong wind in December 2014 (Photo by: Taufik Ilahi)



Table 3 Decade long historical record of *Cacatua sulphurea abbotti* events (2008 - 2018)

Year	Notes
2008	First survey
2009	Two birds were lost from Masakambing, reported as being sold as a gift. During this period the District Head ( <i>Camat</i> ) announced a contest that whoever could find fallen cockatoos and released them again would be rewarded. Perdes No. 1 Year 2009 on Masakambing cockatoos was issued.
2010	No bird fell.
2011	In February, one chick fell and was taken care of by the community until it could fly again. The District Head gave a reward, and he retired.
2012	In early November, one chick was found dead; only the carcass was left, eaten by a lizard.
2013	In October, one chick fell, was taken care of, and was given the name 'Anak Berani' (Brave Kid). However, it suffered from disabilities and had to be continuously hand-fed for the next four years. It died in October 2017.
2014	In December, two cockatoos were dead (a female parent and a chick) because their nesting tree fell down due to strong wind.
2015	In February, one adult cockatoo fell, but it flew again.
2016	On 31 December, one chick died after falling from its nesting tree. Bruises were found on its chest.
2017	On 11 October, one chick fell; no feather has grown on its face and neck. Tried to release the chick several times but was not successful. Therefore, the bird was kept and taken care of.
2017	October, 'Anak Berani' (Brave Kid) died; the chick which fell in 2013 and had been taken care of for four years. The name was given because this chick was still alive two days after its nest tree fell down.
2017	On 6 November, one chick fell but already had complete feathers and so was able to fly again.
2018	On 30 January, one adult male cockatoo with a broken wing fell and died.

The population of cockatoos in the tiny island is facing a potentially higher risk than the population of other birds in the mainland Java because island populations are highly susceptible to extinction (Groombridge 1992 in Wikelski 2004). The long distance from Masakambing to mainland Java causes isolation and prevents the natural genetic exchange. There were two birds with a strange eye condition, both having only the right eyes. They were a male adult and a juvenile which came from the same family and can be physically identified morphologically. Several birds also have unusual feather-like scratch on the cheek or neck. On 11 October 2017, one chick fell, and it was found to have fewer feathers on the face and neck. After one year of rehabilitation, the chick's feathers still did not grow. Furthermore, it was released several times, but the efforts failed because the bird could not fly high and far, suggesting a more detailed research on the possibility of inbreeding.

In 2010 a villager in Masakambing took an initiative to release some snakes (i.e., pythons) to act as mice predators and as pets in the cultivated areas. The snakes were brought to Masakambing from Sumenep and have since become an invasive species that had negatively impacted the cockatoos. Another new threat came in early 2018 when some members of the community started to build a poultry farm in

Masakambing which could be a reservoir of bird diseases. These anthropogenic activities resulting in the demise of island taxas are complex and had included habitat destruction, predation by humans, and the introduction of exotic predators, competitors, and pathogens (Diamond & Veitch 1981; Holmes 1996 in Wikelski 2004). Population growth is affected by habitat conditions, disturbances of the nesting places, season, food availability, and the cockatoo population composition (age and sex) (Setiawan *et al.* 2001).

#### Potential Bias

In each survey the bird counts were conducted in four to eight roosting sites in this study. The ideal way to do roost count is to count birds at the roosting sites at once (Casagrande & Beissinger 1997). Therefore, more than one team should do the count. However, in this study only two teams conducted the counts. Based on information from local poachers, unless being disturbed, cockatoos seldom changed their roosting sites, so it was assumed that each roosting site was occupied by different groups. The roosting tree survey may also be erroneous if the surveyor came late in the morning or leave fast on late afternoon, before the birds truly sleep on the correct trees.

## CONCLUSION

From the period of 2008 to 2018, a small increase in the cockatoo population was observed as well as an expansion of its distribution range in Masakambing Island. The population was concentrated in Dusun Ketapang on the northwestern part of the island where the dominant coconut trees served as roosting sites in the cultivation area. The Cockatoo density was affected by natural natality, mortality and exploitation. Unfortunately, the extreme weather and anthropogenic activities were the major causes of mortality in cockatoo population in Masakambing. The zero trapping policy enforced by the local government was observed to be effective in regulating the population decline. However, a more detailed study of factors that might influence the survival of those *C.s. abbotti* is necessary. The monitoring activities have generated an important pool of primary data on the wild populations of cockatoos, which can serve as the basis for designing strategies for conserving this species and preventing it from extinction. Active community involvement in conserving both the birds and habitat is also needed.

## ACKNOWLEDGMENTS

The authors would like to thank Institut Pertanian Bogor, the Head of Kesbanglinmaspol Sumenep, the Head of Masalembu District, Masalembu Police and Military Command, and the Head of Masakambing Village who gave the permission to carry out this study. Special gratitude were also delivered to the Head of Kalianget Meteorology Station who provided the weather data, and East Java BBKSDA and Sumenep Tourism Department for the collaboration program. The project was funded by the Indonesian Parrot Project. Many thanks also go to the late Stewart A. Metz, M.D., Bonnie Zimmermann (Director of IPP), and the other IPP Board of Directors for all valuable inputs, and to all members of the local community in both Masakambing and Masalembu Islands, especially Juriah, Satria Sam Setia Utama, Taufik Ilahi, Herli, Husaili and Mathudi for their valuable assistance in the field.

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