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To cite this article: R I Maulany *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **681** 012124

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The Electrochemical Society
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240th ECS Meeting ORLANDO, FL

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Abstract submission due: April 9

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A preliminary study of Maleo (*Macrocephalon maleo*) nesting in Kambunong Cape, West Sulawesi

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Abstract. Maleo (*Macrocephalon maleo*) is an endemic species inhabiting Sulawesi island and is listed as *Endangered* under IUCN Red Data List. However, number of adult individuals of the species found in the wild was predicted to be decreasing. Most data available for the species are scattered and or not reported. Therefore, more published research is needed as regard to population size, distribution, and trends of maleo. One site identified as habitat of maleo (*Macrocephalon maleo*) was located in the coastal area of Kambunong Cape, West Sulawesi Province. This study attempts to examine the nesting site, population trends of the species and to identify anthropogenic and non-anthropogenic threats towards the population in the area. Index point of abundance (IPA) combined with line transect techniques were applied to estimate population of the species. Seven line transects were deployed and combined with 30 circular plots distributed across the lines covering 100 ha of the coastal area in Kambunong Cape. Meanwhile, types of threats posed to the population were explored by using semi-structure interviews to the locals. The results have shown that the total of relative abundance estimated for the species in the area was 5.091 individuals/ha for 30 observation plots or 16.97 (=17) individuals found in 100 ha. There was only one site utilized by the species located in a poor environment. Decreasing trends of the population was mostly due to habitat modification and fragmentation combined with illegal egg hunting/collection as well as high intensity of human activities nearby their home range.

1. Introduction

Maleo (*Macrocephalon maleo*) is a *megapode* species living in terrestrial habitat and known to have a unique communal nesting behavior where they bury their eggs in *geothermally* heated soils in the forest or in solar-heated sandy beaches [1]. No parental care was given during the incubation period and after hatching, the *offsprings* escape from the sand, emerge to the surface and directly enter the forest for foraging [1,2] Physically, this bird can be identified by its black-pinkish color with the size similar with chicken [3] and found to occupy the lowland and lower montane forest [4]. Another magnificent characteristics of the bird is the size of its egg which is larger than normal chicken's egg. Rusiyantono, et al (2011) [5] found that the length of the eggs were ranging between 9.7-10.7cm with the width varied from 5.7-6.2 cm. The weight was around 110-250 gr depending on location, food



availability as well as parental genetic variations [6]. The eggs of maleo have been targeted and hunted for years due to its larger size and higher protein content which have lead population to decline in many nesting sites [7,8].

M. maleo is classified as an endemic species inhabiting Sulawesi island and is listed as *Endangered* under the *International Union for Conservation and Nature* (IUCN) Red Data List due to its decreasing population trend [1,9]. Based on the data obtained from IUCN, number of adult individuals of the species was predicted to be only between 8,000 to 14,000 individuals found in the wild followed by declining number of adults (Birdlife International, 2004). Since 1970, Indonesia has protected the species based on the Decree of Ministry of Agriculture No. 421/Kpts/Um/8/1970 regarding protected wildlife species supported by some local governments' regulations [10]. However, none of those legal frameworks found to be effective in preventing the decline caused by human exploitation and more, habitat destruction and modification have taken place and put the species further at risk. Regarding the population data, most information available for the species are scattered and or not reported. Therefore, more published research is needed as regard to population size, distribution, and trends of maleo generated from different nesting sites. One site identified as habitat of maleo (*Macrocephalon maleo*) was located in the coastal area of Kambunong Cape. Kambunong Cape is located in Kambunong Village, West Sulawesi Province of Indonesia. This study attempts to examine the population trends of the species and to provide information on habitat conditions as well as to identify anthropogenic and non-anthropogenic threats towards the population in the area. The findings can be used as a baseline in formulating effective site-specific conservation strategies for *M. maleo* in the area.

2. Study sites and methods

The study was conducted in August-September 2018 in Kambunong Area, West Sulawesi (Figure 1). To survey population of maleo (*Macrocephalon maleo*) in Kambunong Cape, a field orientation was carried out to identify sites utilized by the species to nest followed by measuring the width of the areas of each site by marking the outer parts using a handheld GPS. Index point of abundance (IPA) combined with line transect techniques were applied to estimate the abundance. There were 7 line transects enacted and one line had 500 m length which was divided into 5 points ranged 100 m. The recordings were conducted twice a day (morning and night time). In each point, the observer stopped for 20 minutes of observation and recorded all individual sightings, sounds, or mark lefts by the animals as well as measured the distances from the observers. Habitat conditions of surrounding the nesting ground were assessed descriptively by using a series of GIS data from the years of 1988, 1998, 2008, 2018. In providing information on types of threats posed to the population of maleo, semi-structure interviews were carried out to the several key informants.

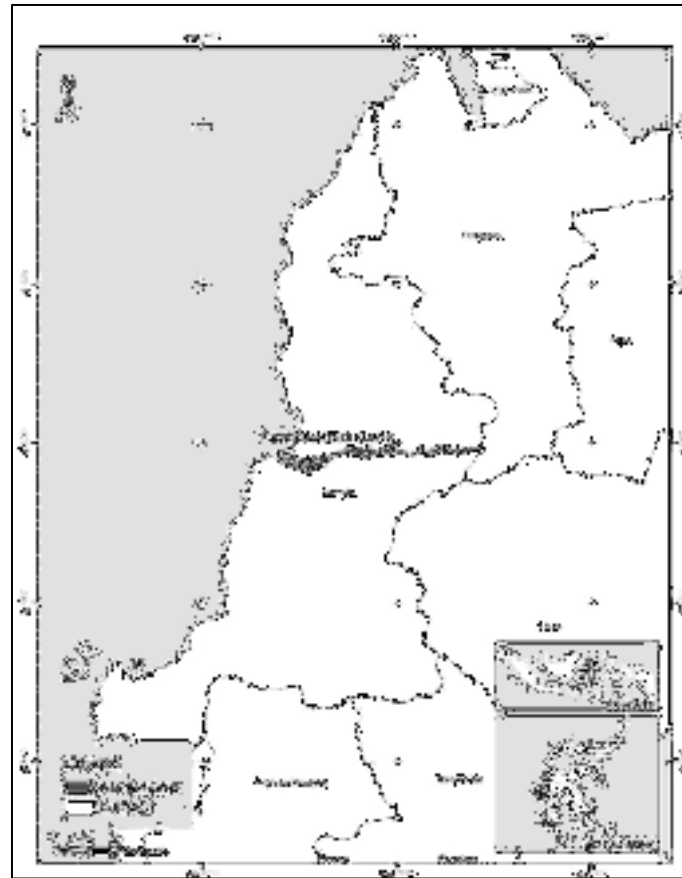


Figure 1. Map of maleo (*Macrocephalon maleo*) nesting sites in Kambunong Cape, West Sulawesi

3. Results

The field orientation had identified two nesting grounds of maleo (*Macrocephalon maleo*) in Kambunong, one was located in coastal areas of Kambunong Cape with the total width of 22.27 ha and the other was located in the land nearby the main road of Kambunong Village (3.68 ha) (Figure 2). The area of nesting ground in Kambunong Cape was mostly covered by coastal vegetation with sandy area while in Kambunong Village, the area was dominated by secondary forest with sloppy topography. As can be seen from Figure 1, both nesting grounds were also surrounded by human-made landscape such as fish ponds, human settlement, and community-owned gardens.



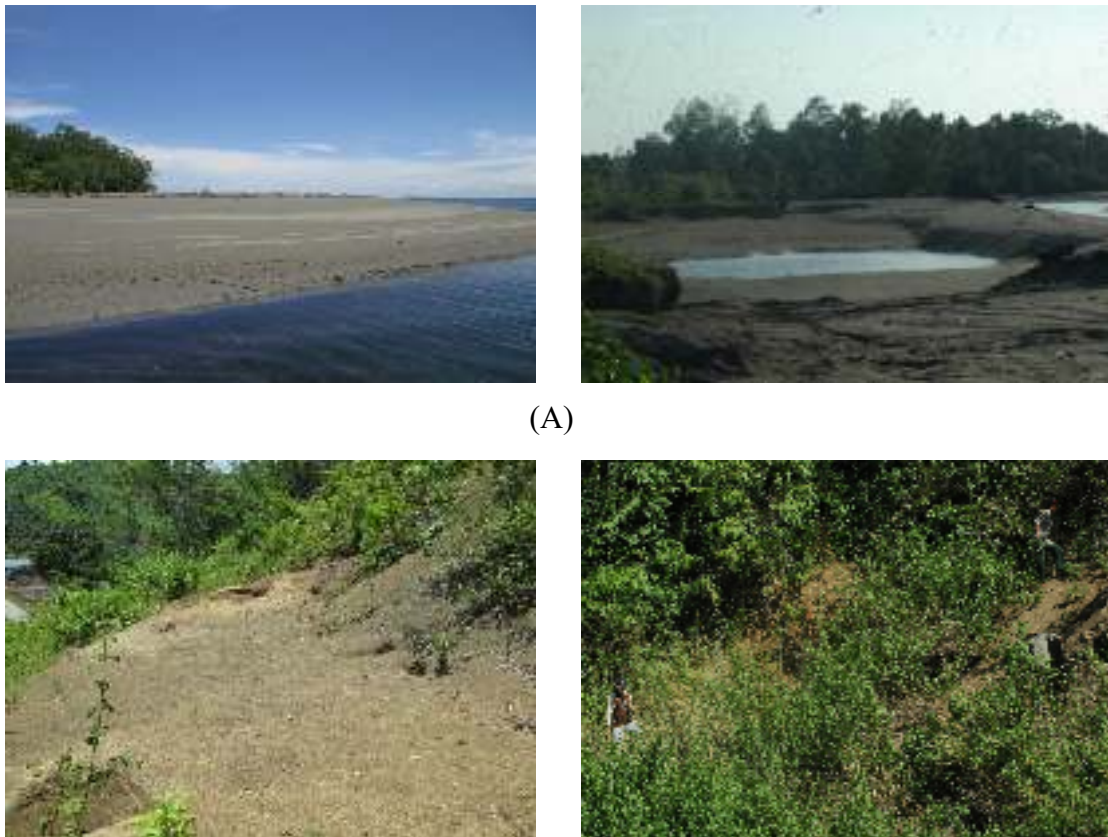
Figure 2. Two major nesting sites in Kambunong (Kambunong Cape and Kambunong Village), West Sulawesi Province

3.1. Population Estimate

In total, there were 7 line transect deployed with 30 circular plots distributed across the lines covering 100 ha of the coastal and inland areas in Kambunong. It was revealed that out of 30 plots assessed, there was only one plot found with four individuals of maleo (*M. maleo*) sightings during the survey. The plot was located in the inland areas (secondary forest) nearby the main road of Kambunong Village. It was found in an open areas laid on the sloppy area with some parts of the land have been eroded. By using the equation for Index point of abundance (IPA), the estimate abundance of maleo was calculated. The estimate abundance of maleo in the area was found to be 16 individuals per 100 ha.

3.2. Habitat Conditions

The two nesting ground conditions of maleo (*M. maleo*) in Kambunong were also surveyed. From the observation and survey results, it was shown that the coastal area of Kambunong Cape was used to be an active spot to nest. However, during the observation, none of maleo individuals were seen again using the coastal areas. High activities of human in the area including fishing, farming, and fishpond-related activities were captured. In addition, accesses for maleo to travel from the forest to nesting ground in the coastal sandy beach were difficult due to land changes converted into fishponds, community-owned gardens, and human settlement (figure 3A). Therefore, most of the birds were found utilizing the second nesting area to nest which was located in the land nearby the main road of Kambunong Village not far from the secondary forest. This area was an open area of bare sands on the eroded slope (figure 3B).



(A)

(B)

Figure 3. Habitat conditions of Maleo (*Macrocephalon maleo*) in coastal vegetation areas of Kambunong Cape (A) and on the eroded land nearby the main road of Kambunong Village (B)

An analysis in land cover changes over 30 years (1988-2018) in Kambunong Village, West Sulawesi Province was also carried out by mapping the area out using GIS data extracted in 10 years' periods. The data reveals that in the late of 80s, 25% of the area was originally covered by mangrove forest and it then slowly decreased in ten years time. In the late 90s, some of the mangroves have changed into shrub-swamps area while in 2008-2018, more than 70% of the lands have been converted into fish ponds leaving only 5-10% as mangrove and shrub area (Figure 4).

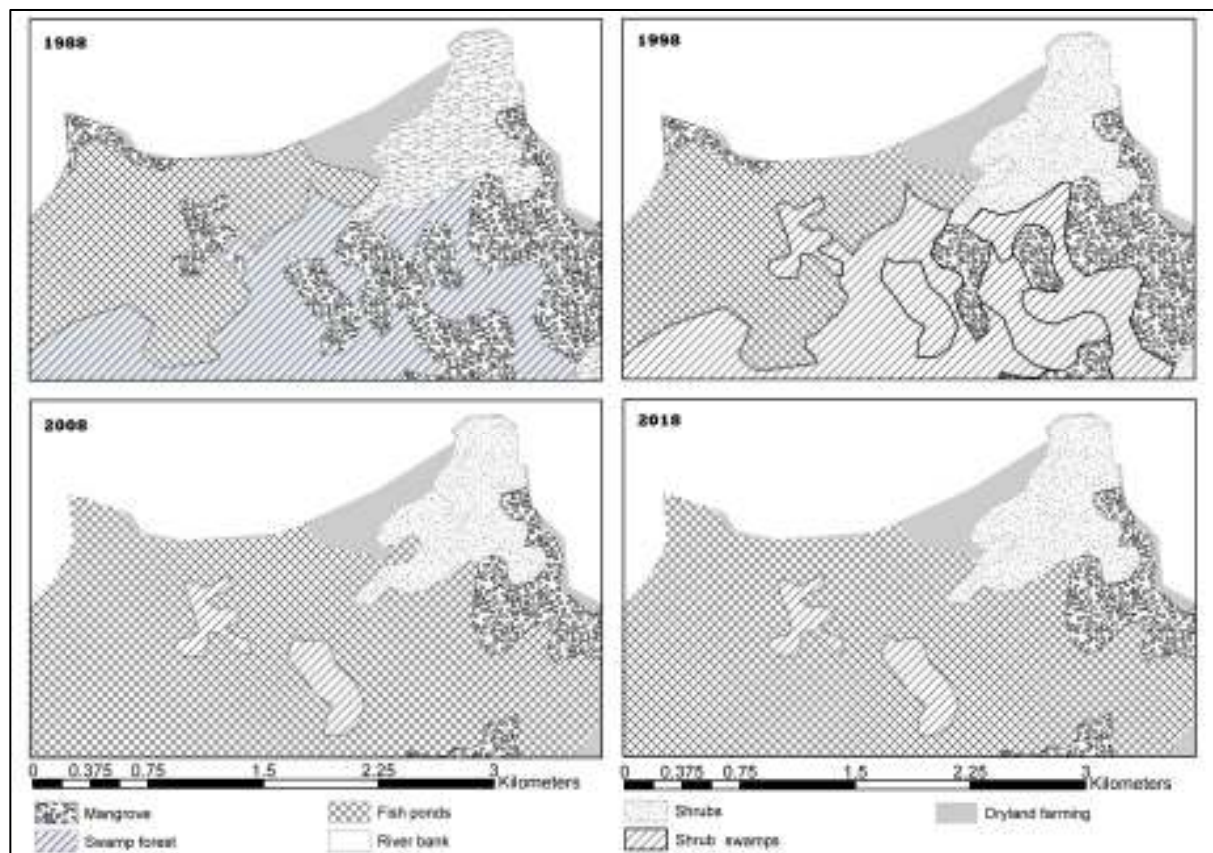


Figure 4. Habitat Changes nearby the Nesting Grounds of Maleo (*Macrocephalon maleo*) over 30 years (1988-2018) in Kambunong Areas of West Sulawesi Province

3.3. Threats toward population of maleo

To identify types of threats posed to the population of maleo (*M. maleo*), semi-structure interviews were employed to 6 key informants comprised of the head of the village (1), local traditional leader (1), local peoples of Kambunong Village (2), and opportunist hunters (2). Apart from nesting ground's conditions and legal status, all respondents mentioned that threats to maleo population in the area were due to habitat changes, home range disturbance, egg hunting, and natural egg depredation. The reasons on egg hunting activities were found to be economic reasons as well as for daily consumption related with protein intake and cultural reasons. The average selling price from hunters to the consumers were around USD 1.80 per egg and this was found to be seasonal activities of the local hunters between April to October every year (Table 2).

Table 1. Interview results with key informants of Kambunong Village, West Sulawesi

Questions addressed	Results
Previous active nesting grounds	Coastal Forest in Kambunong Cape (22.27 ha) (A)
Current active nesting grounds	Only found in the open sandy area at the eroded slope (3.68 ha) nearby the main road of Kambunong Village (B)
Legal Status of nesting locations	A) Coastal Forest of Kambunong Cape = Limited Production Forest and B) area nearby the main road of

	Kambunong Village = designated as other land uses
Threats to maleo population	1) Habitat destruction/changes 2) Egg hunting by the locals 3) Disturbed home range of maleo 4) Egg predation by monitor lizards
Purposes of maleo's egg hunting	1) Daily Consumption 2) To be sold as an additional income
Reasons for egg consumption by the locals	1) High protein intake 2) Economic incentives 3) Cultural reasons (eggs used to celebrate religious occasion)
Selling price of males's egg	USD 1.80 per egg
Number of maleo's egg hunted per (week)	8 eggs
Egg hunting seasons	April – October each year
Main job	Fishing and Wood collecting - Most of respondents declared egg hunting as side job
Natural predator	Monitor lizards

4. Discussion

In Kambunong Village, only one nesting ground was known to be actively used by the maleo during the study which was located in open sandy area of a sloppy secondary forest nearby the main road of the village. The other, located in the coastal areas, was abandoned as a result of rapid land conversion over 30 years combined with high activities of human in the area which might halt the maleo to nest and also potentially reduce the home range of the species. This related with the nature of maleo's behaviour in nesting which required disturbance-free environment prior, on, and post nesting activities. The birds usually monitor the situation in the surrounding areas for 1-3 hours before nesting and were also known to be sensitive towards the presence of human or natural predators such as monitor lizards, snakes, and hawks/eagles [10]. Therefore, sometimes the nesting activities were cancelled and the birds returned back to the tree branches.

Abandonment of nesting sites by the maleo in most cases occurred if the sites were closed to coastal areas, near settlements or roads, and located not in protected areas [11] which was also assumed to be occurred in the coastal areas of Kambunong Village. Over the 30 years, the landscape of Kambunong Village was heavily changed and converted as artificial fish pond areas. These have created barriers for maleo during their travel from the forest to nest in the coastal areas due to fragmented landscape. Then, the birds had to move their nesting site to the most accessible land which was located in an open area of bare sands on the slope forest nearby the main road of the village. Due to erosion, the slope was eroded and over time, created a residue of bare sands which was then used by maleo to nest. However, this might not provide suitable environment for an ideal incubation and hatching process.

It is recognised that there are two important factors affecting the successfulness of hatching, biological and environment factors [12]. Maleo birds required certain physical conditions that were environmental driven such as soil temperatures and humidity [13]. In the wild, the soil temperatures acceptable for the eggs of maleo to hatch were between 32-35°C with soil humidity ranging between 96.5% in the morning and around 70.7% in the afternoon while in the evening the content of water in the soil was around 89.5% [14]. Both temperatures and humidity can be difficult to be controlled in the wild situations as they can fluctuate based on seasonal changes and in turn might reduce the hatchability of the eggs [5]. In birds, sex determination is driven by genotype factors not environment. As in sea turtles, the environmental factors may contribute to sex ratio and emergence success [15],

and even the quality of hatchlings generated from unfavorable temperature conditions during the incubations [16]. High temperature above 34°C for three consecutive days in turtles may be detrimental to the embryo's development as it decreased the emergence success and if the temperatures was above 30°C, the sex ratio of the hatchlings was skewed into female biased [15].

It is assumed that even though up to now there is still no firm study yet on the relation between the environment and the quality of chicks generated from different environment for maleo but studies on other birds has reflected that lower temperature produced smaller nestling with longer incubation period and affected growth and survival [17,18]. In fact higher temperatures have found to kill the embryo and force the hatchlings to be prematurely born [19]. Viewing the facts that current nesting site resulted from eroded land, the quality of nesting site can be predicted to be poor. In addition, the risks of being covered by another eroded land are very high particularly during the rainy season which may impact the emergence success of the birds. Another issue of the current site, the location is prone towards predation both natural predators as it is positioned in the secondary forest and and human as the nesting site laid nearby the main road.

During the study, the nesting activities were concentrated in the inland areas. The survey of maleo in the area has shown that in two months of observation, the sightings of the birds were consistently occurred in one plot where the nesting site located with four individuals seen. Using the estimate equation, the animal density was predicted to be 16 individuals left over 100 ha which was considered very low. The decreasing trend of maleo in Kambunong Village was also closely related with high intensity of egg hunting by the locals as well as reduced home range due to habitat fragmentation and changes over the years. These are the common problems that might bring the species towards the extinction [7,20].

The protection of nesting habitat in Kambunong Village has become imperative and urgently needed to prevent more jeopardizing effects to the population that has already decreased. The local government in collaboration with the Nature Conservation Agency must protect the site along with the enactment of local regulation along with a strict law enforcement in the area. To raise community awareness on the importance of maleo is also crucial. Other stakeholders can also be involved in creating alternative sources of income as well as finding ideas on how to obtain other sources of protein that can be consumed by the local. This will allow the local people to gradually change their habits for egg hunting/collecting. Implementing zonation in Kambunong Village can also provide understanding and limitation to the locals who are conducting activities nearby the nesting sites. Regular monitoring towards the nesting site may reduce the probabilities of the nests being depredated. As the last resources, establishing a hatchery and relocated the eggs to the hatchery may provide better chances of hatching and emergence success if in situ protection failed. However, prior to the establishment, pre-eliminary studies on the quality of current nesting sites including risk of predation should be carried out.

5. Conclusion

The problems and challenges for the conservation of maleo (*Macrocephalon maleo*) in Kambunong Village, West Sulawesi Province lay not only due to the loss of one nesting site in the coastal area caused by massive land conversion and habitat fragmentation over the years but also contributed by high activities of human in the surrounding areas. Limited access to the nesting site and high disturbances have influenced the reduction of home range and decrease in population of maleo. Meanwhile, the current micro habitat of the nesting site located inland on eroded sloppy area might not be supportive for good quality chicks/hatchlings generated from the site not including the high risks of predation as it was located nearby the main road and secondary forest. The nests could also be potentially washed or drowned by erosion during the rainy season. Apart from that, the on-going practice of egg hunting/collection by opportunist hunters and the presence of natural predators had negatively impact on the population of maleo in Kambunong.

References

- [1] Butchart S H M and Baker G C 2000 Priority sites for conservation of maleos (*Macrocephalon maleo*) in central Sulawesi *Biol. Conserv.* **94** 79–91
- [2] Jones D, Dekker R W and Roselaar 1995 *The megapodes* (Oxford: Oxford University Press)
- [3] Dekker R R J 1990 The distribution and status of nesting grounds of the maleo *Macrocephalon maleo* in Sulawesi, Indonesia *Biol. Conserv.* **51** 139–50
- [4] MacKinnon J 1978 Sulawesi megapodes *J. World Pheas. Assoc.* 96–103
- [5] Rusiyantono Y, Tanari M and Mumu M I 2011 Conservation of maleo bird (*Macrocephalon maleo*) through egg hatching modification and ex situ management *Biodiversitas J. Biol. Divers.* **12**
- [6] Sumangando A 2002 *Developmental biology of Maleo (Macrocephalon maleo, Sall Muller 1846) hatched ex situ. Institut Pertanian Bogor* (Bogor: Institut Pertanian Bogor)
- [7] Argeloo M and Dekker R W R J 1996 Exploitation of megapode eggs in Indonesia: the role of traditional methods in the conservation of megapodes *Oryx* **30** 59–64
- [8] MacKinnon J 1981 Methods for the conservation of maleo birds, *Macrocephalon maleo* on the island of Sulawesi, Indonesia *Biol. Conserv.* **20** 183–93
- [9] International. B 2004 *Macrocephalon maleo. IUCN Red List Threat. Species*
- [10] Poli Z, Polii B and Paputungan U 2016 Tingkah laku bertelur burung maleo (*Macrocephalon maleo*) di Muara Pusian, Taman Nasional Bogani Nani Wartabone, Kecamatan Dumoga Timur, Kabupaten Bolaang Mongondow (Nesting behaviour of maleo - *Macrocephalon maleo* in Muara Pusian, Bogani Nani Wartabone Na *ZOOTECH* **36** 289–301
- [11] Gorog A J, Pamungkas B and Lee R J 2005 Nesting ground abandonment by the Maleo (*Macrocephalon maleo*) in North Sulawesi: identifying conservation priorities for Indonesia's endemic megapode *Biol. Conserv.* **126** 548–55
- [12] Tanari M, Rusiyantono Y and Hafsa H 2008 Hatching technology of maleo bird eggs *Agrol. J. Ilmu-ilmu Pertan.* **15** 336–42
- [13] Dekker R and Brom T G 1990 Maleo eggs and the amount of yolk in relation to different incubation strategies in megapodes *Aust. J. Zool.* **38** 19–24
- [14] Wirioesopartha A S 1980 Using habitat in various activities by *Macrocephalon maleo* Sal Muller *Panua Nat. Reserv. North Sulawesi. For. Res. Institute, Dep. Agric. Bogor.[Indonesia]*
- [15] Maulany R I, Booth D T and Baxter G S 2012 Emergence success and sex ratio of natural and relocated nests of olive ridley turtles from Alas Purwo National Park, East Java, Indonesia *Copeia* **2012** 738–47
- [16] Maulany R I, Booth D T and Baxter G S 2012 The effect of incubation temperature on hatchling quality in the olive ridley turtle, *Lepidochelys olivacea*, from Alas Purwo National Park, East Java, Indonesia: implications for hatchery management *Mar. Biol.* **159** 2651–61
- [17] Eiby Y A and Booth D T 2009 The effects of incubation temperature on the morphology and composition of Australian Brush-turkey (*Alectura lathami*) chicks *J. Comp. Physiol. B* **179** 875–82
- [18] Ospina E A, Merrill L and Benson T J 2018 Incubation temperature impacts nestling growth and survival in an open-cup nesting passerine *Ecol. Evol.* **8** 3270–9
- [19] Cornejo J, Iorizzo M and Clum N 2014 Artificial incubation of *Macrocephalon maleo* eggs at the Bronx Zoo Wildlife Conservation Society, New York *Int. zoo Yearb.* **48** 39–47
- [20] Froese G Z L and Mustari A H 2019 Assessments of Maleo *Macrocephalon maleo* nesting grounds in South-east Sulawesi reveal severely threatened populations *Bird Conserv. Int.* **29** 497–502