Notes on the Moluccan Megapode *Eulipoa wallacei* (G.R. Gray, 1860) following the rediscovery of two major nesting grounds

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Dekker, R.W.R.J., M. Argeloo & P. Jepson. Notes on the Moluccan Megapode *Eulipoa wallacei* (G.R. Gray, 1860) following the rediscovery of two major nesting grounds.

Zool. Med. Leiden 69 (19), 29.xii.1995: 251-260.--- ISSN 0024-0672.

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Key words: Moluccan Megapode; *Eulipoa wallacei*; Indonesia; Haruku; Halmahera; nesting grounds. Two nesting grounds of the Moluccan Megapode, *Eulipoa wallacei* (G.R. Gray, 1860) located on the islands of Haruku and Halmahera, Indonesia, are described. Together they provide nesting opportunities for more than half of the estimated world population of this endangered megapode. Further information is given on six additional nesting grounds. Data are presented on size and origin of the megapode populations using these sites, egg-laying season, behaviour, and measurements of birds and eggs in relation to their breeding strategy of using solar heat for the incubation of their eggs.

Introduction

Due to its nocturnal breeding behaviour and restricted distribution, the Moluccan Megapode *Eulipoa wallacei* (G.R. Gray, 1860) is one of the least known megapodes (Megapodiidae, Galliformes). Moluccan Megapodes do not build mounds, the most common practize among megapodes, but instead bury their eggs in the soil at sunexposed beaches and possibly even at volcanically heated sites. In this respect, the species resembles the Maleo *Macrocephalon maleo* S. Müller, 1846, from Sulawesi, which Dekker and Argeloo studied as part of a conservation project in 1985/86 and 1990/91, respectively. However, in contrast with the Maleo and all other megapodes, Moluccan Megapodes lay their eggs at night. Literature about its nesting behaviour and its nesting grounds is rare. The most recent publications based on field observations are from Siebers (1930), De Wiljes-Hissink (1953), and Sahulata (1984).

Martin (1894) and De Wiljes-Hissink (1953) described a site on the small island of Haruku, which was famous for its large number of egg-laying "maleo" or "meleo". Based on these accounts R. Dekker and C. Vermeulen visited Haruku on 27 October 1991 (Dekker, 1991). An estimated 200 Moluccan Megapodes were seen on the evening of their visit and the continued existence of this nesting ground confirmed. Subsequent visits to the nesting ground were made by M. Argeloo in January/February 1992, Argeloo, Dekker and Vermeulen in October 1993, and by P. Jepson in April 1994. A monitoring project, executed by C.J. Heij and his Indonesian counterpart, started here in June 1994 and was scheduled to last one year.

A team of the PHPA/BirdLife International Indonesia Programme under the supervision of Jepson visited another site at Galela, Halmahera, in November 1994 as part of 'Project Halmahera' (Anon., 1995). Although nesting had been reported at Galela on earlier occasions (Davis, 1985) and was well known by the islanders, nothing has been published on the status of this nesting ground in the scientific literature. Until this recent survey, the nesting ground on Haruku was presumed to be the largest of its kind, offering nesting-opportunities to more than half of the world population (Dekker & McGowan, 1995). With this recent find by BirdLife, the population seems more than doubled.

This publication describes both nesting grounds and highlights some behavioural aspects and metrical data obtained during our visits. Conservation aspects and notes on other nesting grounds are discussed by Argeloo & Dekker (in press).

Taxonomic controversy

The Moluccan Megapode was discovered in 1858 by Alfred Russel Wallace on Halmahera, and described by George Robert Gray in 1860 as *Megapodius wallacei*, in honour of its discoverer. In 1893, Ogilvie-Grant placed it in a genus on its own, *Eulipoa*, which decision was based on its aberrant plumage and structural differences. Ever since, this species has caused taxonomic controversy. Ripley (1964), and subsequently White & Bruce (1986) and Sibley & Monroe (1990) merged it again with *Megapodius* because 'it resembles *Megapodius* so closely in size and proportion, that only the brighter banding on the wings and back, and white undertail coverts separate it from the other *Megapodius* species'. Most recently, however, Jones, Dekker, & Roselaar (1995) found valid reasons to follow Ogilvie-Grant and to treat *wallacei* as the representative of a distinct genus *Eulipoa*.

Material and methods

The nesting ground of the Moluccan Megapode on Haruku was visited by Dekker on 27 and 28 October 1991, by Argeloo on 22, 23, and 24 January and 6 and 7 February 1992, by Dekker and Argeloo on the evening of 27 October 1993, and by Jepson on 16 and 17 April 1994. Jepson and colleagues visited Galela on 19 and 20 November 1994.

On Haruku, adult megapodes were caught at night by hand by villagers who joined us at the site. These birds were released after being measured. Adults and chicks were weighed with a 2 kg (100 g scale) and a 300 g (2 g scale) pesola, respectively. Eggs collected for consumption by the tenant of the nesting ground (see below) were weighed with a 300 g pesola subdived into 2 g scales. Measurements were taken to the nearest 0.1 mm with vernier callipers.

The relative yolk content of nine eggs was measured following the description in Dekker & Brom (1990). Eggs were boiled before separating yolk, albumen and shell. These three components were measured to the nearest gram with a 100 g pesola (Dekker, n = 3 eggs) or 300 g pesola (Argeloo, n = 6 eggs). The relative yolk content is expressed as a percentage of the egg content weight. Differences of a few grams in weight between fresh and boiled eggs were attributed to water loss from the albumen during boiling and were corrected by adjusting the albumen weight.

The relative length of the eggs is defined as egg-length divided by egg-width (L/W) according to Dekker & Brom (1990). The higher the L/W ratio, the more elongated the egg. The L/W-value is positively related to the amount of yolk and can be

regarded as an indirect indicator of the yolk content (Dekker & Brom, 1990). Means are given \pm standard deviation.

Notes on the behaviour of the Moluccan Megapodes are based on random observations at the nesting ground and surrounding beach. In 1993 observations were made from a boat between Ceram and Haruku. Additional information was obtained from the villagers and from a short video made by Jepson on Haruku in April 1994. Tape-recordings of calls were made with a walkman with recording facility.

Results

Description of the Kailolo and Galela nesting grounds

The nesting ground on Haruku is located along the northwest coast of the island, directly opposite Ambon, at the village of Kailolo which counts ± 2800 inhabitants. It covers approximately 1.5 hectare and has four sub-sites: three open areas of pure white sand in beach forest about 30 m from the beach and an abandoned football pitch adjacent to the village. The sites are maintained by the villagers and cleared of stones and invading vegetation. Scattered burrows can be found around the periphery, for example in the village graveyard.

The entrance of the burrow in which the megapode lays her egg looks like the entrance of a rabbit-burrow. It enters the soil under a slight angle and is 50 cm to one metre deep. It should, however, be noted that these holes are not typical megapode burrows since the birds have to dig entirely new burrows every night, because the local egg-collectors fill the holes with sand and equalize the surface every morning after the eggs have been collected.

The nesting ground at Galela is located in Dessa Simau, 2 km north of Galela town, N Halmahera. The main nesting area, Tiabo beach, is a 1.6 km stretch of beach made up of black sand between the mouth of the Kali (river) Hela to the south and Kali Tiabo to the north. A mangrove swamp is situated behind the beach which is thus surrounded by water on all sides. Nesting also continues along the beach to the north of the Kali Tiabo for a distance of approximately 500 m. Tiabo beach is about 70 m wide at its widest point. On the mangrove side it is vegetated with low scrub, the flatter top of the beach is pitted with numerous burrows and kept clear of invading vegetation by the beach owners.

Egg-laying season

According to local information, egg-laying at Kailolo occurs year round but with a clear peak during the dry season, which is, in this part of Indonesia, from Sept/Oct until April/May. Since Moluccan Megapodes make use of radiation heat and thus depend on the sun to incubate their eggs, it is expected that the main period for egglaying coincides with the dry season. Our visits to Kailolo, between October and February, were during the dry season and thus presumably during the peak of the egglaying season.

On the night of 27/28 October 1991, an estimated 100 - 200 adults were seen. On 7 February 1992, a total of 174 burrows which had been dug the previous night were

counted. An additional 50 burrows were found at the graveyard bordering the nesting ground. On 27 October 1993, 193 eggs were collected which had been laid the night before. In contrast to these large numbers seen by us, the total absence of Moluccan Megapodes here on the night of 25/26 November 1992 (A. Lewis, in litt.) is remarkable. On Haruku as well as elsewhere in Indonesia the story goes that megapodes only lay during the period around full moon. This is, however, not yet substantiated. Unfortunately, all our visits were during full moon, therefore not enabling us to clarify whether this might be true. However, also when Alan Lewis visited the site and megapodes were absent, the moon was full (A. Lewis, in litt.). When Jepson visited Kailolo in April 1994, egg-laying still continued and large numbers of megapodes were present as would be expected based on seasonality and local information. It is not known how many birds visit this site during the rainy season. According to local information, the number of eggs collected throughout the year varies from 100 - 300 eggs/day during the dry season to 20 - 50 eggs/day during the wet season.

Seasonality at Galela is not known from personal observations. According to local information, the egg-laying season is from January to July and the peak months are March, April and May. Two fresh burrows were observed during a brief survey of a 100 m section of the beach in November, confirming the presence of small numbers of megapodes in other months of the year.

Timing

During our visit in 1991 on the evening of October 27th, the first megapodes arriving at Kailolo landed on the beach at 18.40 h, shortly after dusk. In 1992, the first birds were seen at the nesting ground after 21.00 h. As revealed by their vocalizations, birds did arrive before 20.00 h and then slowly proceeded to the nesting ground. In 1993, no megapodes were seen or heard before 20.00 h just off the coast near Kailolo. According to the villagers, the (majority of the) birds arrive after 21.00 h.

Also at Galela the megapodes fly into the site. A beach owner described that when there is a bright moon birds arrive at around 7 pm and leave at 3 am, when there is a dark moon they arrive at 11 pm but stay until 7 am.

Size and origin of the populations

Based on local information, the total number of eggs collected at Kailolo in a single year is said to be as high as 40.000 - 50.000. Under the assumption that a single female produces on average 10 eggs per year, as has been estimated for the Maleo from Sulawesi (Dekker, 1990), the population of Moluccan Megapodes using this site might be as large as 4000 - 5000 pairs. Since Haruku is too small and without sufficient forest to carry such a large population, the majority of megapodes using Kailolo for egg-laying must come from elsewhere, most likely Ceram, as is indicated by the arrival of megapodes on the beach (see above). Some birds may come from Ambon, where megapodes may occur in the extensive tracts of disturbed forest present on the hills. The south coast of Ceram, opposite Haruku, still offers good habitat for the birds, but the coast is unsuitable for egg-laying as it consists of mud and rock, thus forcing the birds to go elsewhere. On 8 November 1991, an adult Moluccan Megapode was seen by Dekker in slightly disturbed primary forest near the border of a clove-plantation at an altitude of 230 m near Kairatu, south Ceram.

According to local information at Galela, the birds fly in from the south across the Gulf of Galela from the direction of Mount Mamuwa. Ca. 500 to 1000 birds are said to visit this beach each night during the peak season, with up to 400 eggs collected the following morning. If true, the megapode population at Galela might be double in size to that of Kailolo.

Other nesting grounds

Very little is known about this secretive species elsewhere within its range on Buru, Ceram, Ambon, Haruku, Bacan, Halmahera, Ternate and Misol. It may occur on Morotai, Kasiratu, Obi-islands and Saparua. The only other nesting grounds known from the literature and personal observations are:

- 1) On Ceram: near the village of Amahai and a nearby site near the mouth of the Tala River (Waiya) (De Wiljes-Hissink 1953, Dekker & Argeloo, pers. obs.),
- 2) Pulau Pombo, between Ambon and Haruku (Dekker & Argeloo, pers. obs.),
- 3) On Haruku: near Dessa Haruku, ± 10 km south of Kailolo (Dekker & Argeloo, pers. obs.),
- 4) On Halmahera: near Dessa Loloda, Dessa Ibu, and Dessa Gamkonora (Jepson, in litt.),
- 5) Meti Island (De Wiljes-Hissink, 1953),
- 6) On Buru: near the mouth of the Wa'Kasi and Wa'Tina River (Siebers, 1930).

Ad 1) The site near Amahai, south Ceram, is situated along the local airstrip, six metres above the high water mark. The burrows are widely scattered, dug in small open areas of sand and gravel, surrounded by secondary vegetation. Some burrows are dug into the steep wall bordering the beach. The heat necessary for the incubation of the eggs might come from the sun only, since heat of volcanic origin, such as hot springs, seems absent. The site is visited daily by egg collectors. No management system, as described for Kailolo (see Argeloo & Dekker, in press), is operational here. According to local information the number of eggs, and therefore the number of megapodes, has decreased significantly over the past decades due to uncontrolled exploitation of the eggs. In November 1991 and January 1992, truckloads of sand and gravel were collected here for the improvement of roads, thus destroying newly laid eggs. The megapodes are attracted by these man-made gravel-pits though, because they give easy access to the soil which is free of vegetation and roots and fully exposed to the sun. At present, the site is probably visited by no more than 10 - 20 pairs per night during the peak of the egg-laying season. The megapodes fly to the nesting area from the forest which is situated several kilometers inland. It seems likely that this site came into use as a nesting ground after the construction of the airstrip (De Wiljes-Hissink, 1953), when the area was equalized, flattened, and vegetation removed, making it suitable for burrow-nesting.

Ad 2) The nesting ground on the northern tip of Pulau Pombo, a tiny islet between Ambon, Ceram and Haruku and less than a mile off Kailolo, can hardly be considered a true nesting ground. It is probably used by a few birds only which belong to the Kailolo population.

Ad 3) The nesting ground on the beach near Dessa Haruku, Haruku, ± 10 km south of Kailolo, is very small and used by a small number of birds. The site is managed in a similar way as the Kailolo nesting ground and eggs are collected according to strict rules (Argeloo & Dekker, in press). The megapodes using this nesting ground either belong to the Kailolo population or are birds which originate from the island itself instead of coming from Ceram.

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Ad 4) According to local information, nesting grounds are said to occur on the beaches of Loloda (300 - 400 birds) and Ibu (100 birds) on Halmahera (P. Jepson, in litt.). The local name for the species in 'Bahasa Tobelo' (Tobelo language) is 'Mamor'.

Ad 5) No information is available about a possible nesting ground on Meti other than it is mentioned in De Wiljes-Hissink (1953).

Ad 6) A map illustrating the location and vegetation types of the nesting ground at the mouth of the Wa'Kasi is given by Siebers (1930). Four adult females were collected here on 22 and 23 December 1921 and one on 23 February 1922. One chick was taken on 22 December 1921, and 10 eggs were collected during that month. A much smaller nesting site at the mouth of the Wa'Tina River only counted five burrows, indicating usage by only a few megapodes. Local name "man'lato" or "man'titin" (Siebers, 1930).

Measurements

At Kailolo, one adult female was caught on the night of 27/28 October 1991, and three on 23 January 1992, three of which were carrying an egg which was gently massaged out of the egg-cavity by the tenant. Two chicks were found in the sand in January 1992. Measurements are presented in table 1.

Table 1. Age, sex, body weight, egg weight, relative egg weight and wing length of four adult and two juvenile Moluccan Megapodes.

age	sex	body weight (g)	egg weight (g)	egg weight/body weight (%)	wing (mm)	measured by
adult	female	505	93	18.4	-	Dekker
adult	female	490	101	20.6	206	Argeloo
adult	female	490	97	19.8	204	Argeloo
adult	female	465	-	-	208	Argeloo
chick	unknown	68	-	-	-	Argeloo
chick	unknown	78	-	-	-	Argeloo

Table 2. Relative yolk content in % of nine eggs of the Moluccan Megapode, including the weight in grams of the three main components, yolk, albumen and shell, in relation to the weight of the fresh egg.

egg weight (g)	yolk weight (g)	albumen weight (g)	shell weight (g)	% yolk	measured by
96	58	31	7.0	65.2	Dekker
104	64	32	8.0	66.7	Dekker
111	67	36	8.0	65.0	Dekker
101.5	62	33	6.5	65.3	Argeloo
102.5	65	29.5	8.0	68.8	Argeloo
105.3	69	29	7.3	70.4	Argeloo
95.0	58	30	7.0	65.9	Argeloo
110.3	72	31	7.3	69.9	Argeloo
105.5	70	28	7.5	71.4	Argeloo

Nineteen newly laid eggs from Kailolo measured 75.4 - $83.0 \times 46.9 - 50.5$ mm (80.0 ± 1.99 × 49.0 ± 1.04 mm, n = 19) and weighed 92 - 116 g (106.4 ± 5.98 g, n = 42; Oct 1991). The relative length of the eggs, the L/W-value (see Dekker & Brom 1990), is 1.63. Fifty-seven eggs from the same location weighed 91 - 119 g (102.8 ± 6.69 g; Jan/Feb 1992). The relative yolk content of nine eggs ranged from 65.0 - 71.4% (67.6 ± 2.51%) (table 2).

Behaviour

While arriving at the nesting ground or on the surrounding beach, the megapodes are single. At Kailolo, we were under the impression that such single birds were often followed soon by another individual, together forming a pair. Shortly after landing on the nesting ground, the megapodes were often seen walking and digging in couples of two, although due to the large number of birds and their agonistic behaviour this was not always obvious. Even while digging in clusters of 10 or 20 birds, they seem to be working in pairs, suggesting that male and female visit the nesting ground together. However, four adults which were caught at the nesting ground were all females. Also Siebers (1930), who collected five birds at a nesting beach on Buru, only had females. Both data may have been biased by the way in which the birds were caught. In our case, the megapodes were trapped while inside the burrow. Possible differences in behaviour between the sexes at the nesting ground, with females doing the majority of the digging, might cause males to be underrepresented. Whether males do visit the nesting ground remains therefore to be studied.

Whether clustering in groups, as mentioned above, is for protection against predators or triggered by soil- and temperature conditions of the nesting ground is unknown. Since there is no proof yet that males accompany their females, it can not be excluded that, e.g. for safety or efficiency, females seek each others company and dig in pairs. This could mean that more than one egg is laid in a single burrow on a single night. According to local information, this sometimes is the case and up to three eggs have been found in a single burrow. The question then remains whether these were all laid in the same night or whether some where laid in previous nights and not collected the following day. Without any further evidence, such discoveries have to be considered as incidents. It is possible, therefore, that the number of burrows can be an underestimation of the number of eggs laid.

When disturbed, the megapodes find safety in the trees surrounding the nesting site, only to come down to continue digging after the area is considered safe again. Agressive behaviour was commonly observed when the distance between 'pairs' was small. The individual outside the entrance of the burrow was usually engaged in defending it, as also observed in the Sulawesian Maleo.

At Galela, the story goes that during the 20 nights of dark moon, eggs are buried close to the surface, while during the 10 nights of bright moon eggs are burried much deeper. It is believed that at nights of dark moon the birds are scared of predators and therefore lay their eggs quickly. At nights of bright moon they can see potential predators and would therefore spend longer over nesting.

Voice

While at the nesting ground, the megapodes continuously utter a noise, either linked with agonistic behaviour and/or as contact-call. It consists of an irregular and rapid series of sharp, nasal 'kèw' 'kèw' or 'kép' 'kèp'. Also 'ki-ouw kouw', 'kou-kouw-kouw-kouw' or 'kùk - kuk-uk - (uk)' with the first note lasting longer than the remaining two or three notes. Sometimes, the initial and longer-lasting note is omitted.

Discussion

Based on available information, the nesting grounds of the Moluccan Megapode at Galela and Kailolo are by far the largest of their kind for the species. We now have the strong impression that these two sites provide nesting opportunities for more than half of the world population. By "putting all their eggs in just one or two baskets", the species is inherently of conservation concern. At both sites the majority of eggs are collected (Argeloo & Dekker, in press) and are of great economic importance to the Galela and Kailolo communities. Both nesting grounds have been managed and harvested according to traditional rules for eighty years or more, and the populations of megapodes remain strong; this suggesting a sustainable balance exists. However, it may be a delicate balance; no long-term data exist on annual harvest rates, on the number of successful hatchlings from these beaches, and on the effects of land use changes on the population away from the nesting grounds. The number of eggs at Maleo nesting grounds in N Sulawesi has declined rapidly for a variety of reasons, and the majority of nesting grounds is now abandoned (Uno, 1949, Watling, 1983, Dekker, 1990, Argeloo, 1994). Maluku is a focus area for development during Replita VI, the sixth national development plan RI, 1994 - 1999, and without scientifically based conservation programmes these unique nesting grounds may be damaged or lost. Only the communal nesting grounds of the Melanesian Megapode Megapodius eremita Hartlaub, 1867, from the islands east of New Guinea, and especially those on New Britain are known to exceed in size the nesting grounds described in this paper.

Measurements.— The L/W ratio of 1.63, as calculated from the average length and width of 19 eggs, is similar to the value given in Dekker & Brom (1990).

As predicted by Dekker & Brom (1990), the average yolk content of eggs of the Moluccan Megapode (67.6%) turns out to be much higher than for the mound-building Malleefowl *Leipoa ocellata* Gould, 1840, Australian Brush-turkey *Alectura lathami* J.E. Gray, 1831, and Wattled Brush-turkey *Aepypodius arfakianus* (Salvadori, 1877), and exceeds the value of 61% given as the lower limit for megapodes which incubate their eggs by means of geothermal and/or radiation heat (Dekker & Brom, 1990). It is also significantly higher than for the burrow-nesting Maleo (average 61.9%), the ranges of the two species (60.7 - 64.4% for the Maleo; 65.0 - 71.4% for the Moluccan Megapode) not even overlapping. The average yolk content of eggs of the Moluccan Megapode is similar to that of the Melanesian Megapode (67.3%; range 65 - 69%) (Dekker & Brom, 1990, 1992, Meyer, 1930), clearly illustrating the positive correlation between the yolk content of eggs in megapodes (which is a measure for the degree of precociousness of the chicks) and the incubation strategy of the various species (Dekker & Brom, 1992).

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Relative egg weight of the Moluccan Megapode, here recorded as 18.4 - 20.6% of the female body weight, is much higher than for any mound-building megapode (upper limit 13.3%), higher than for the Maleo (average 13.8%; range 11.8 - 15.1%), and slightly above the relative egg weight recorded for the Melanesian Megapode (average 18.0%; range 15.2 - 18.6%) (Dekker & Brom, 1990). It is only surpassed by the smaller burrow-nesting Polynesian Megapode Megapodius pritchardii G.R. Gray, 1864, of which the eggs weigh on average 24.2% (range 18.6 - 25.8%) of the hen's body weight (Göth, 1995). Relative egg weight increases with decreasing body weight and increasing relative yolk content. Since the yolk content is related to the breeding strategy in megapodes, relative egg weight is related to it (Dekker & Brom, 1990). Earlier studies have shown that relative egg weight increases from the large, moundbuilding Malleefowl, Australian Brush-turkey, and Wattled Brush-turkey to the burrow-nesting Maleo and the smaller mound- or burrow-nesting Megapodius spp. (Dekker & Brom, 1990). The high relative egg weight of the small sized, burrow-nesting Moluccan Megapode fits therefore perfectly well in the above mentioned series, where it should be placed together with *Megapodius* to which it is systematically most closely related (Jones et al., 1995).

Acknowledgements

We wish to thank Kepala Dessa (= mayor) Bp Ali Jamal Marasabessy and the villagers of Kailolo for their kind hospitality and the information they have given us during our visits. Furthermore we would like to thank Charlotte Vermeulen and Mark van der Wal as well as Tiny Luiten, Janine van Rossum, Kees Heij, Kees Moeliker and Hans de Iongh for their pleasant company. Paul Jepson wishes to thank his colleagues Yusup Cahyadin, Demianus Bagali, Amir Samoli, Yoseph Watenlawa, and the tenants of the Galela nesting ground, Pak Yunus, Haji Fedous, Pak Amin, Haji Uman, and Pak Kota for their hospitality and information.

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Received: 9.vi.1995 Accepted: 23.viii.1995 Edited: J.C. den Hartog