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The biology of the Moluccan megapode *Eulipoa wallacei* (Aves, Galliformes, Megapodiidae) on Haruku and other Moluccan Islands; part 1: scope of the study and preliminary results

Heij, C.J., 1995 - The biology of the Moluccan megapode *Eulipoa wallacei* (Aves, Galliformes, Megapodiidae) on Haruku and other Moluccan Islands; part 1: scope of the study and preliminary results - DEINSEA 2: 145- 155 [ISSN 0923-9308]. Published 30 November 1995.

The Moluccan megapode *Eulipoa wallacei* inhabits forests in the mountains of several Moluccan Islands (Indonesia). The birds only leave this habitat for the purpose of egg-laying in self-dug burrows on sandy beaches, where solar heat incubates the eggs. The eggs are collected, sold and consumed by local people, a tradition that threatens the species' existence. Little is known about the biology of *E. wallacei*. Therefore an extensive study was carried out in the period June 1994 - June 1995 at the largest known breeding ground 'Tanjung Maleo' on the island of Haruku and at breeding grounds on other islands. This article introduces the bird and describes the aim of the study, the methods and the study area. Some preliminary results are also provided. The final report will be published later.

De biologie van het Moluks grootpoothoen Eulipoa wallacei *(Aves, Galliformes, Megapodiidae) op Haruku en andere Molukse eilanden; deel 1: overzicht van de studie en voorlopige resultaten* - Het Moluks grootpoothoen *Eulipoa wallacei* bewoont bergbossen op een aantal eilanden van de Molukken in Indonesië. Ze verlaten dat leefgebied uitsluitend om eieren te leggen in zelfgegraven gaten op zandstranden. De warmte van de zon broedt de eieren uit. De eieren worden door de lokale bevolking opgegraven, verhandeld en opgegeten; een traditie die de soort in zijn voortbestaan bedreigt. Van de biologie van *Eulipoa wallacei* is weinig bekend. Vandaar dat deze soort in de periode juni 1994 - juni 1995 uitvoerig is bestudeerd op de grootste bekende legplaats 'Tanjung Maleo' op het eiland Haruku en op legplaatsen van andere eilanden. Dit artikel geeft het doel van de studie, de onderzoeks-methodieken, een beschrijving van het studiegebied en enige voorlopige resultaten. Het definitieve rapport zal later gepubliceerd worden.

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Keywords: megapodes, Megapodiidae, *Eulipoa wallacei*, breeding biology, Moluccas, Indonesia

INTRODUCTION

The megapodes (Megapodiidae) form a distinct and interesting family within the gamebirds (Galliformes). They are the only birds known to use external heat sources for incubation. Their eggs are laid in mounds or burrows where microbial respiration, geothermal activity or solar radiation generates heat and causes chicks to hatch. Newly hatched chicks are fully self-supporting and receive no parental care. (Jones et al. 1995). The currently recognized 22 species and seven genera of megapodes (Jones et al. 1995) occur on the Nicobar Islands (India), in eastern Indone-

Figure 1 Adult Moluccan megapode *Eulipoa wallacei* photographed at night at the nesting ground Tanjung Maleo near Kailolo village on Haruku Island, Indonesia [photogr. C.J. Heij, September 1994]

sia, New Guinea, the Philippines, on Niuafo'ou Island (Tonga) and the Mariana Islands (South-West Pacific). The centre of their distribution lies in the Indo-Australian region east of Wallace's Line, where the birds inhabit tropical forests.

The Moluccan megapode *Eulipoa wallacei* (G.R. Gray, 1860) is taxonomically closely related to the genus *Megapodius*, but due to a distinct boldly coloured plumage (Fig. 1) and several structural differences it is better placed in the monotypic genus *Eulipoa* (Roselaar 1994; Jones et al. 1995). The birds' range is restricted to the Moluccan Islands (Indonesia) from Halmahera, south to Seram, Ambon, Haruku and Buru, and the Western Papuan Island of Misool (Sibley & Monroe 1990; del Hoyo et al. 1994). *Eulipoa wallacei* generally occurs in mountain forests between 750 and 2000 m altitude (Ripley 1964; Jones et al. 1995). The birds only leave his habitat for the purpose of egg-laying on sun-exposed beaches or in forest-clearings at sea-leavel. Eggs are laid communally at night in self-dug burrows, after which the birds return to their mountainous habitat before dawn. Their habit of laying eggs during the night is unique among megapodes (Jones et al. 1995). *Eulipoa wallacei* is currently under serious threat due to the intensive harvesting of their eggs and to the loss of habitat. Collar et al. (1994) list the species as 'vulnerable'.

Apart from thorough taxonomical and morphological studies and from some knowledge on the general habits described above, little is known about breeding biology, population dynamics and other aspects of the life history and ecology of this elusive bird (see: del Hoyo 1994; Jones et al. 1995). Most basic data were gathered by the 19th century explorers, and more recent information generally results from rather short encounters with the birds on their communal nesting grounds.

The first written report concerning *Eulipoa wallacei* dates back to 4 January 1576 when the Jesuit priest Nicolau Nuñes reported from Ambon to his superiors in Rome about a bush hen that digs a hole in the ground, lays an egg in it and fills it up. He also wondered about the behaviour of the chicks after hatching and remarked that the eggs as well

as the birds are very tasty (Jacobs 1974). The famous British naturalist and explorer A.R. Wallace first collected the bird in 1859 on the island of Halmahera and forwarded the specimen, among numerous other birds, to the British Museum (Wallace 1860). Based on this specimen G.R. Gray (1860) described the bird as a new species: *Megapodius wallacei*.

The first detailed report of the species' nesting behaviour and the harvesting of its eggs by local people came from Martin (1894) who vividly described two communal nesting grounds: Tanjung Maleo (Kailolo) on Haruku Island (east of Ambon) and Kasa, an islet in the Bay of Piru (West Seram). De Wiljes-Hissink (1953) also reported on the large nesting ground near Kailolo, Haruku and described another large site, the islet of Meiti (north-east Halmahera). Dekker (1991) was the first to rediscover the Kailolo nesting ground which he suspected to be abandoned. The site attracted an estimated 4000-5000 pairs per year, and - despite the harvesting of eggs - the survival of the population appeared to be more or less guaranteed by the strict local rules that prevented (as they still do) the surrounding forest from being cleared and that deliberately leave about 20 % of the eggs untouched (Dekker 1991; del Hoyo 1994).

This article shortly outlines the extensive study of *Eulipoa wallacei* on the Kailolo nesting grounds of Haruku Island and on the other islands within the species' range, carried out during the period June 1994 - June 1995 and provides some preliminary results. A full report will be published later (Heij in prep.).

AIM OF THE STUDY

The following aspects of the species' biology, its environment and its relationship with man were studied:

- arrival of the birds at dusk, and subsequent departure at dawn (direction, time)
- nocturnal behaviour at the nesting ground (digging, egg-laying, intraspecific interactions, vocalisations, activity patterns, interactions with *Megapodius forstenii*)
- depth and clustering pattern of the burrows
- use of the different nesting grounds
- presence of birds during the day
- time interval between visits of individual birds
- numbers of harvested eggs in relation to season and light intensity (lunar cycle)
- numbers and sex-ratio of adult birds at the nesting grounds
- numbers of hatched chicks (breeding success)
- population size
- predation on eggs, chicks and fully grown birds
- temperature of the soil (sand) at different depths
- measurements and weight of the eggs, chicks and adult birds
- duration of the incubation period in relation to abiotical factors
- local methods of egg harvesting
- local rules, habits and rituals concerning the harvesting of eggs
- economic importance of the egg harvesting for the local community
- conservation and re-introduction strategies

Apart from the work on Haruku, several surveys on the Moluccan Islands of Ambon, Buru, Obi, Halmahera and their smaller satellite islands were made in order to check whether nesting grounds known from the literature are still being used by *Eulipoa wallacei* and in order to discover hitherto unknown nesting grounds.

MATERIAL AND METHODS

The study area: Tanjung Maleo

The island of Haruku belongs, together with Ambon, Saparua and Nusa Laut to the Lease Islands of the Maluku (Moluccan) province, Indonesia (Fig. 2 A). Haruku is located south of West Seram and just east of Ambon in the Banda sea between 128° 24′ 30″E and 128° 32′ E and between 3° 30′ S and 3° 35′ S (de Graaff & Stibbe 1918). The surface measures 138 km². There are twelve small villages (desa's) of which Desa Kailolo is the northernmost of the villages located on the west coast (Fig. 2 B). The study area is located just south of Kailolo, on a cape called Tanjung Maleo (Figs. 2 C, 3). It is an area of approximately 12.5 ha (500 x 250 m) where the sun-drenched beaches are bordered by dense secondary forest that changes towards the east into an area with scattered trees and bushes

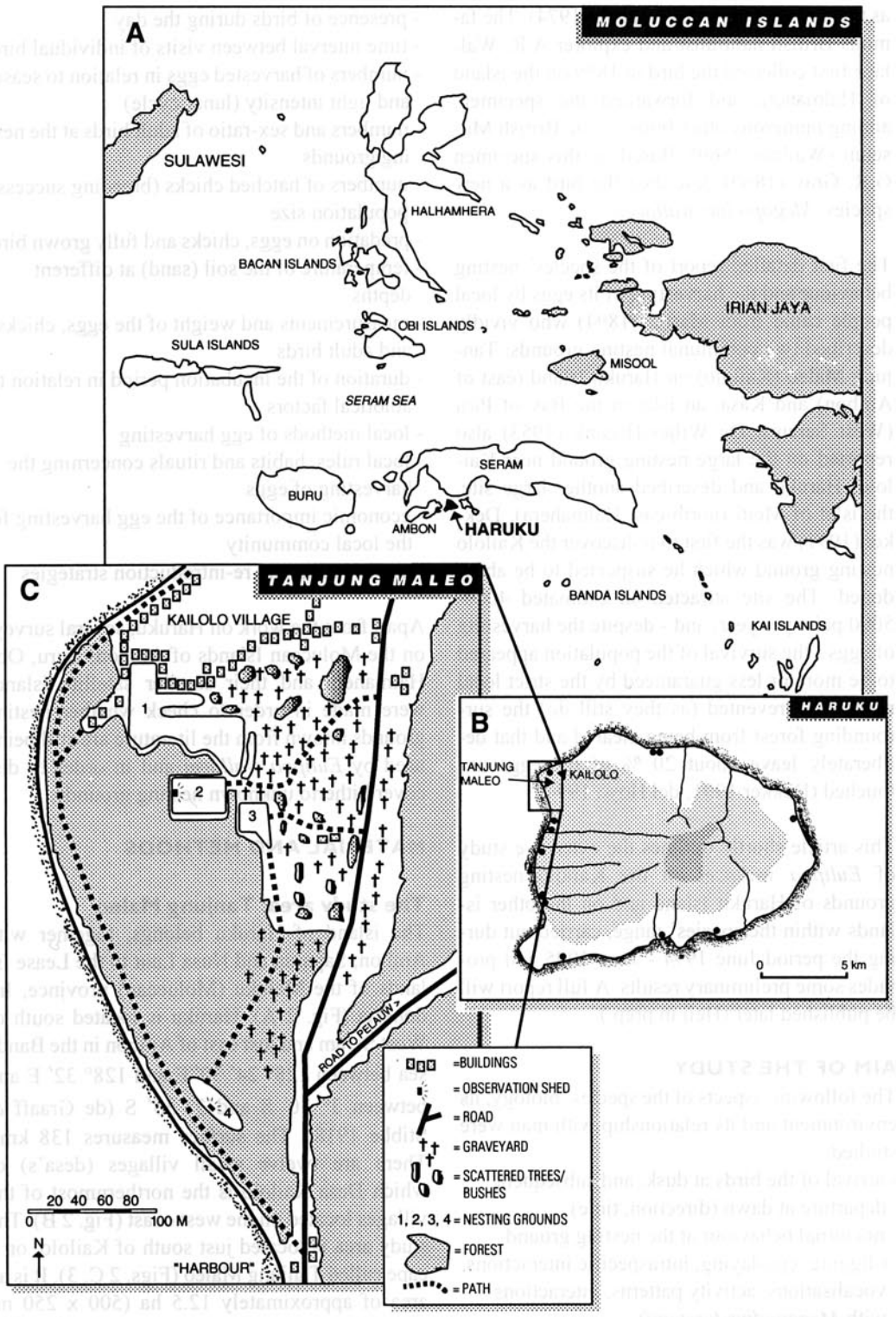

Figure 2 Map of the study area: **A** the Moluccan Islands and the bordering islands of Sulawesi, Misool and western Irian Jaya (Indonesia) with the location of Haruku Island; **B** Haruku Island with the location of Kailolo village and Tanjung Maleo; **C** Tanjung Maleo (the main study area) with the location of the nesting grounds [map graphics: Jaap van Leeuwen Design]

Figure 3 Tanjung Maleo and Kailolo village (Haruku Island) seen from the air [photogr. C.J. Heij, December 1994]

where the local islamic graveyard is situated. The areas used as nesting grounds by *Eulipoa wallacei* are four open fields with a substrate of fine white sand. Field 1 (the largest: 3000 m^2) is bordered by the southernmost houses of Kailolo, the graveyard in the east and the forest in the south (Figs. 2 C, 3). It has been in use as the local soccer field. Field 2 (1300 m^2) lies directly south of field 1 and is almost completely surrounded by forest. Here an observation shed was built, from which nocturnal observations were carried out. Field 3 (250 m^2) lies just outside the forest next to field 2 in the half-open graveyard area. Field 4 (900 m^2) is located at the southern end of Tanjung Maleo, close to the 'harbour', about 10 m from the beach but completely surrounded by forest. Here a second observation shed was built, from which most of the nocturnal observations were done. This particular nesting site was described by Martin (1894).

Collecting eggs of *E. wallacei* on Tanjung Maleo is a long tradition that is strictly controlled by local rules ('adat'). Every year at the beginning of the rainy season (on 31 March) an auction takes place during which the highest bidder gets the exclusive right to harvest the eggs in the following twelve months. 75 % of this lease price (in 1994: 6.150.000 RP = circa 3.500 US$) has to be given to the mosque and 25% to the village authorities. The price for which the eggs are sold, is fixed by these authorities. In 1994 the price of one egg was Rp 300 (US$ 0.15). Eggs are sold (for consumption) locally as well as exported to other islands in the region. An administration is kept of the daily number of eggs harvested, of the numbers sold and of the large orders and the debtors. The lease holder employs, depending on the season and his spirit of enterprise, about 4 - 6 egg-collectors who harvest the eggs during the night or early morning. During the day these men, locally known as 'the maleo-team', keep the nesting grounds tidy and devoid of any vegetation. They also guard the entire Tanjung Maleo: collecting timber or fire-wood from the surrounding forest is strictly forbidden by local 'adat'. No trespassing by strangers is allowed.

Methods

During the study period (June 1994 - June 1995) most of the time was spent on Tanjung Maleo. The author lived in Kailolo in the house of the lease holder Pede Tuanaya and was treated (and

felt) like a member of his family and of his maleo-team. Due to this good relation, observations, counts and experiments carried out on the nesting grounds could be done without problems and with full cooperation. This situation was privileged, as the occasional visiting birdwatchers or other tourists were (and are) not allowed access to the nesting grounds or could only do some limited nocturnal observations under guidance of the maleo-team and the village authorities. Pede Tuanaya and one of his egg-collectors accompanied the author on most occasions during surveys in search of *Eulipoa* nesting grounds on other islands. This proved to be very fruitful as they could easily get local information and were trained to identify *Eulipoa* burrows. Their skillful digging provided the best possible proof of the occurrence of *E. wallacei*: the egg. The special bond between the author and the lease holder not only provided full acceptance by the (islamic) village community, but also all the information on the 'adat' and rituals concerning the egg-harvest. Eventually, the former lease holders gave their daily harvest results, accurately kept on calendars, and dating back to the 1987 lease (the 1990 data are lacking because, due to a quarrel in the village council, the right to harvest was not leased and everybody collected eggs). The original material is in possession of the author.

For reasons of convenience, a year starts at 1 April (the beginning of the lease period and the rainy season) and ends 31 March. The rainy season runs from April - September, the dry season from October - March.

Basic data such as the number of hatched and fledged chicks (indicated by little round craters or chicks actually seen emerging from the sand) and the number, pattern and depth of the burrows were obtained and noted daily during the first daylight and just before the maleo-team started to harvest the eggs. The number of eggs collected was established after the last egg was unearthed and the nesting grounds looked like an exploded mine field. Eggs and chicks were measured and weighed. Data were separately gathered for each of the four fields. During the day the study area was also searched for fledged chicks, presence of adult birds and (signs of) predators. For daylight-observations a 10x40 binocular was used.

Several experiments were conducted in order to establish the duration of the incubation period and the influence of temperature. On field 2, freshly laid eggs were reburied in the sand under protecting 'cages' at different depths. Temperatures of the substrate were measured by digital thermometers at standard depths. Another experiment was done to test whether eggs that are reburied in a reversed or horizontal position could hatch (i.e., a chick emerges from the sand and fledges). Accidentally unearthed eggs that had been incubated for an unknown period (and that were thus not suitable for sale and normally destroyed by the maleo-team) were reburied by the author at safe places at the edges of the fields.

The arrival of birds at dusk and later in the evening was regularly observed from the beach and from the road east of the nesting grounds. The numbers of the birds and their flying directions were noted. The same observations were done at dawn and during the late night when the megapodes are supposed to leave the nesting grounds. A total of 25 nocturnal observation sessions between 21.00 - 06.00 hour were carried out, most of these from the shed at field 4 (Fig. 2 C). The numbers of birds present at the field in the course of the night, their activities, behavourial patterns and vocalisations as well as the weather and the light intensity (moonlight) were either noted or spoken into a tape recorder. Obervations were made with the aid of a night-vision scope or with a pair of 10x40 binoculars during very bright nights and at dawn.

Twenty one adult birds were caught while digging a burrow and subsequently marked with coloured rings in order to establish the time interval between visits to the nesting grounds. These and other birds caught were also checked for their sex through cloacal inspection or by observing the presence of an egg.

Searches for *Eulipoa* nesting grounds on other Moluccan Islands were carried out by little vessels, by motorbike and local transport, and on

foot. Beaches were searched for burrows and eggs, local people were interviewed to gather data on the habits and extent of the egg-harvesting.

During the authors absence from Haruku some basic data were noted on standard forms by the lease holder or by members of the maleo-team.

PRELIMINARY RESULTS

Number of collected eggs

The number of eggs collected in the course of the period 1987-1995, as well as the course of the solar cycle and the accompanying dry and rainy seasons, are given in Fig. 4. An increase of the total number of eggs collected is apparent (see also Table 1). Most eggs are harvested (found) during the dry season. The key question concerning these figures is whether the increasing number of eggs collected is either the result of more birds using Tanjung Maleo as a nesting ground, or of increasing and more intensive collecting activities and better techniques of the lease holders. The latter seems to be the case. The economical progress in the Ambon region results in a higher demand for eggs (pers. obs.). The lease holder simply acts like any other keen entrepreneur would do: he hires more personnel and intensifies his activities. As many eggs as possible are collected. The assumption that about 20% of the eggs are left untouched with the purpose to keep the population size in balance (Dekker 1991; del Hoyo 1994), proved to be wrong. Calculations (Heij in prep.) do indicate that about 10-15 % of the eggs are not collected; not deliberately, but as they are simply not found by the maleo-team.

A detailed account of the number of eggs collected during the 1994 season is given in Fig. 5. The daily maximum amounts to 211 eggs in February. This provides a clear picture of the

Table 1 Yearly totals (1 April - 31 March) of harvested *Eulipoa wallacei* eggs on Tanjung Maleo, Haruku Island

year	1987	1988	1989	1990	1991	1992	1993	1994
eggs	18260	27978	22934	no data	27648	26886	32722	36263

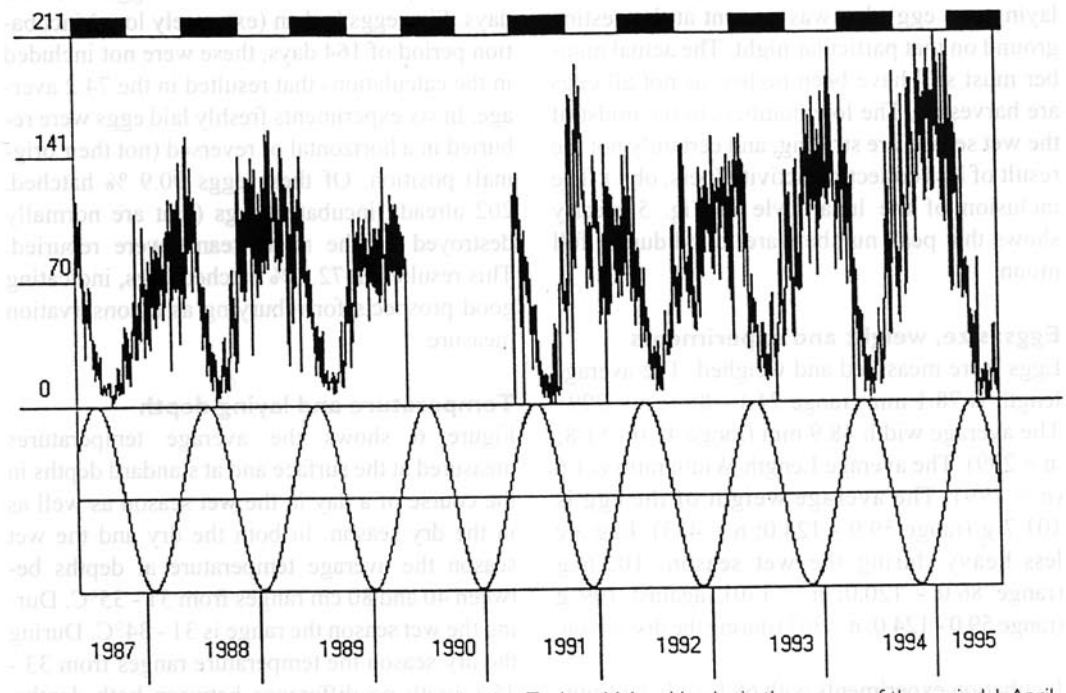

Figure 4 Number of collected eggs of *Eulipoa wallacei* at Tanjung Maleo, Haruku in the course of the period 1 April 1987 - 31 July 1995 (see Table 1) together with the course of the solar cycle (sinusoid line) and indications of the rainy season (black bars). Data from the 1990/1991 lease-period are lacking.

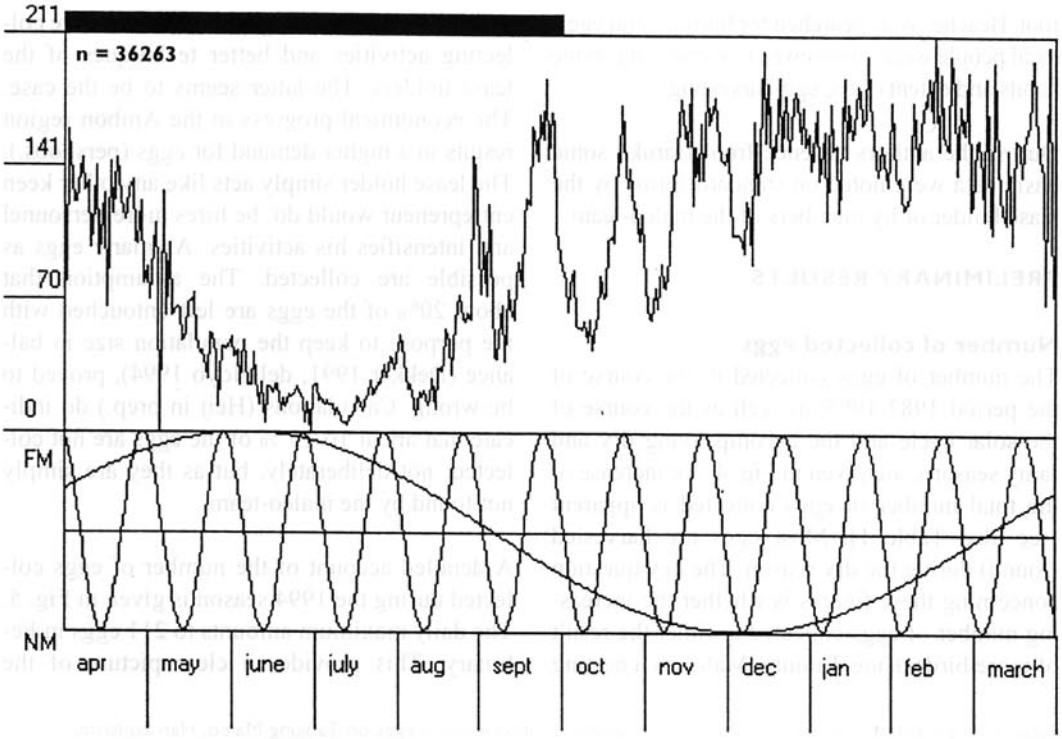

Figure 5 Number of collected eggs of *Eulipoa wallacei* at Tanjung Maleo, Haruku in the course of the 1994 lease year (1 April 1994 - 31 March 1995) together with the solar cycle (long sinusoid line), the lunar cycle (short sinusiod line; FM = full moon, NM = new moon) and an indication of the rainy season (black bar)

minimum number of female megapodes (each laying one egg) that was present at the nesting ground on that particular night. The actual number must still have been higher, as not all eggs are harvested. The low numbers in the midst of the wet season are striking, and certainly not the result of less collecting activity (pers. obs.). The inclusion of the lunar cyle in Fig. 5 clearly shows that peak numbers are found during full moon.

Eggs: size, weight and experiments

Eggs were measured and weighed. The average length is 78.1 mm (range 74.1 - 85.5; n = 299). The average width 48.9 mm (range 42.0 - 51.8; n = 299). The average Length/Width ratio is 1.6 (n = 299). The average weight of the egg is 101.7 g (range 59.0 - 124.0; n = 433). Egg are less heavy during the wet season: 103.6 g (range 86.0 - 120.0; n = 130), against 109 g (range 59.0 - 124.0; n = 303) during the dry season.

Incubation experiments with 68 freshly laid eggs resulted in 92.7 % hatched eggs. The average incubation period of these hatched eggs was 74.2 days. Five eggs had an (extremely long) incubation period of 164 days, these were not included in the calculations that resulted in the 74.2 average. In six experiments freshly laid eggs were reburied in a horizontal or reversed (not their original) position. Of these eggs 90.9 % hatched. 202 already incubated eggs (that are normally destroyed by the maleo-team) were reburied. This resulted in 72.6 % hatched eggs, indicating good prospects for reburying as a conservation measure.

Temperature and laying depth

Figure 6 shows the average temperatures measured at the surface and at standard depths in the course of a day in the wet season as well as in the dry season. In both the dry and the wet season the average temperature at depths between 40 and 80 cm ranges from 31 - 35°C. During the wet season the range is 31 - 34°C. During the dry season the temperature ranges from 33 - 35°C with no difference between both depths. The maximum temperature at these depths is

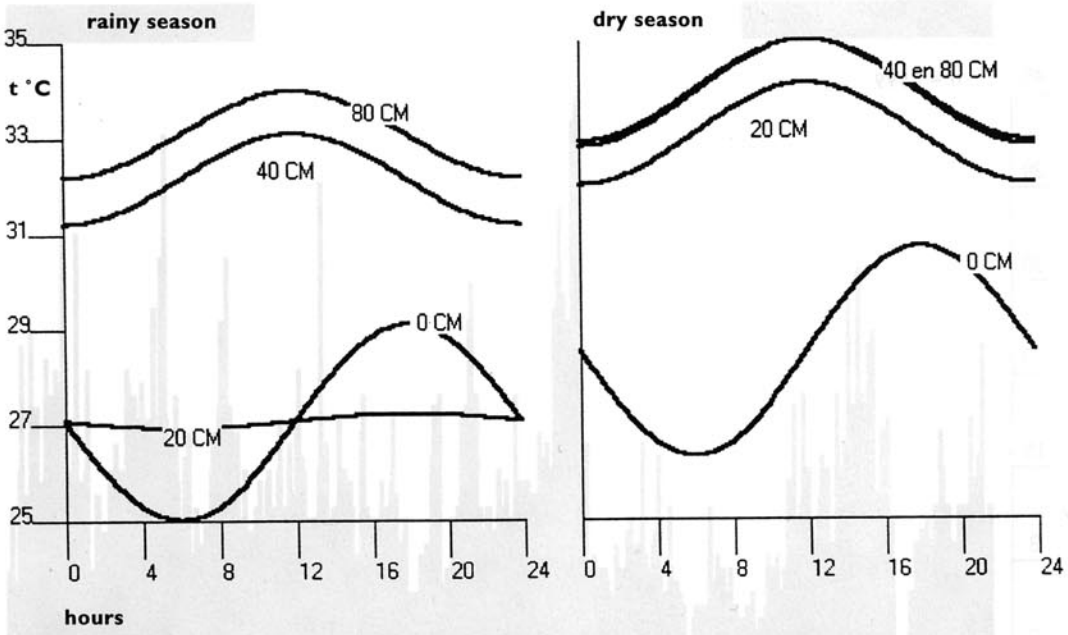

Figure 6 The 24 hour path of the average soil temperature, measured at the surface (0 cm) and at different depths (20, 40 and 80 cm) at field 2, Tanjung Maleo, Haruku, during the rainy season and the dry season (measurements taken daily at standard times during the period july 1994 - june 1995)

reached around noon in both seasons. The difference in temperature between depths of 20 and 80 cm is about 7°C during the wet season. In the dry season the difference is just 1°C. Measurements of the burrow-depths revealed that during the dry season the eggs are laid less deep (average depth 60 cm) than in the wet season (average depth 90 cm). This could indicate that burrow-depths are adapted to temperature of the soil. Nocturnal observations revealed that the light-intensity (moonlight, cloudy or clear skies) influenced the time spent by the birds at the nesting grounds and the depth of the burrows: during dark nights the eggs are laid less deep.

Hatchlings

Figure 7 shows the number of (fledged) hatchlings in the course of the period July 1994 - June 1995. A total of 4599 hatchlings is involved. The numbers show distinct peaks in the midst of the dry season (first decade of December) and during the first months of the wet season. Lowest numbers of hatchlings are found between the second half of September and the end of November. The few distinct peaks are most likely caused by less intensive harvesting during a certain period through chance events, for example the nightly TV broadcasting of the 1994 soccer worldchampionship. Also the muslim fasting has some influence on the collecting activities of the maleo-team. This allows more eggs to hatch after about 10-11 weeks of incubation. The low numbers of hatchlings in October mark the dip in egg-laying during the rainy season (see Fig. 5)

The following observations concerning the behaviour and weight of the chicks after hatching, are worth mentioning. In the dry season the chicks struggle towards the surface with an average speed of 20 cm per day. No observations of this kind were made in the rainy season. The average weight of the hatchlings during the upward struggle is 69.1 g (range 59.0 - 92.0; n = 15). The hatchlings reaching the surface had an average weight of 57.0 g (range 48.0 - 79.0; n = 35). It is apparent that the hatchling loses weight during its way up. Section on hatchlings that were found dead on the surface revealed no subcutaneous fat, whereas the ones found below the surface in the sand had a thick layer of it (voucher specimens are in the collection of the Natuurmuseum Rotterdam).

Other nesting grounds

Surveys on other islands revealed that most nesting grounds known from the (old) literature are either abandoned or just marginally used by

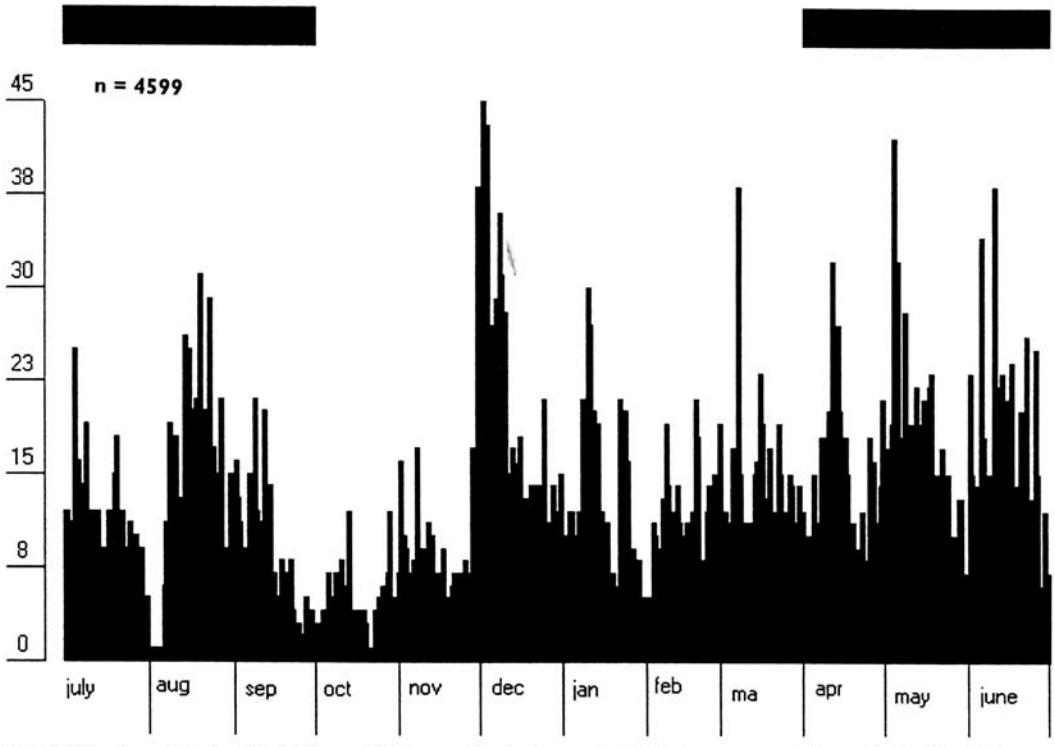

Figure 7 Number of fledged hatchlings of *Eulipoa wallacei* observed daily in the course of the period 1 july 1994 - 30 june 1995 at Tanjung Maleo, Haruku (horizontal black bars indicate the rainy season)

Eulipoa wallacei. For example, the large site found by De Wiljes-Hissink (1953) on Meiti Island (north-east Halmahera) has been completely abandoned. Some new nesting grounds, e.g. on Buru and Seram, were discovered. Tanjung Maleo on Haruku appears to be the nesting ground that attracts the highest number of birds, certainly when the relatively small surface is taken into account. The nesting grounds at Galela (north-east Halmahera) also still attract a large number of birds, but they are spread over seven kilometers of beach. Large stretches of beach on the north coast of Buru an Seram (Wahai area) also hold scattered nesting grounds of *Eulipoa wallacei*. A full list of the current nesting grounds of *Eulipoa wallacei* will be given in the final report (Heij in prep.)

ACKNOWLEDGEMENTS

This study would not have been possible without the help of numerous people and institutions. They supported me not only with expertise, goods and enthousiasm, but also financially. A full list will be given ulteriorly (Heij in prep.), but a few exceptions have to be made here. Dewi Soenarijadi, head of the Inter-Institutional Cooperation Division of the Indonesian Institute of Sciences (LIPI), Jakarta; Prof. Dr Nawangsari-Sugiri from the Life Sciences Inter University Centre of the Agricultural University Bogor; M. Akip Latuconcina, governor of the Moluccas and Mgr. A. Sol, bishop of Ambon, are to be thanked for their personal advice and support. I also wish to thank Christny Rompas (IPB, Bogor) for her friendship and loyal cooperation in the field, and Pede Tuanaya and his maleo-team for allowing me to work on Tanjung Maleo and for assistance in the field. Dr R.W.R.J. Dekker assisted with the preparation of the research proposal and M. Argeloo introduced me to the Kailolo nesting ground some years before I even thought about studying it. I thank H.F. de Jong for critically reading the manuscript of this article, R.M. Biesheuvel for writing the software that computed and produced Figs. 4-7, and Jaap van Leeuwen for the production of Fig. 2. Finally, I wish to thank my wife Lydi for giving me the possibility to do this study.

Figure 1 Adult Moluccan megapode *Eulipoa wallacei* photographed at night at the nesting ground Tanjung Maleo near Kailolo village on Haruku Island, Indonesia [photogr. C.J. Heij, September 1994]

Figure 3 Tanjung Maleo Kailolo village (Haruku Island) seen from the air [photogr. C.J. Heij, December 1994]

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received 14 September 1995
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