# Threatened Birds of Asia:

## The BirdLife International Red Data Book


Editors

N. J. COLLAR (Editor-in-chief),
A. V. ANDREEV, S. CHAN, M. J. CROSBY, S. SUBRAMANYA and J. A. TOBIAS

Maps by

RUDYANTO and M. J. CROSBY


Principal compilers and data contributors

■ ***BANGLADESH*** P. Thompson ■ ***BHUTAN*** R. Pradhan; C. Inskipp, T. Inskipp ■ ***CAMBODIA*** Sun Hean; C. M. Poole ■ ***CHINA*** ■ *MAINLAND CHINA* Zheng Guangmei; Ding Changqing, Gao Wei, Gao Yuren, Li Fulai, Liu Naifa, Ma Zhijun, the late Tan Yaokuang, Wang Qishan, Xu Weishu, Yang Lan, Yu Zhiwei, Zhang Zhengwang. ■ *HONG KONG* Hong Kong Bird Watching Society (BirdLife Affiliate); H. F. Cheung; F. N. Y. Lock, C. K. W. Ma, Y. T. Yu. ■ *TAIWAN* Wild Bird Federation of Taiwan (BirdLife Partner); L. Liu Severinghaus; Chang Chin-lung, Chiang Ming-liang, Fang Woei-horng, Ho Yi-hsian, Hwang Kwang-yin, Lin Wei-yuan, Lin Wen-horn, Lo Hung-ren, Sha Chian-chung, Yau Cheng-teh. ■ ***INDIA*** Bombay Natural History Society (BirdLife Partner Designate) and Sálim Ali Centre for Ornithology and Natural History; L. Vijayan and V. S. Vijayan; S. Balachandran, R. Bhargava, P. C. Bhattacharjee, S. Bhupathy, A. Chaudhury, P. Gole, S. A. Hussain, R. Kaul, U. Lachungpa, R. Naroji, S. Pandey, A. Pittie, V. Prakash, A. Rahmani, P. Saikia, R. Sankaran, P. Singh, R. Sugathan, Zafar-ul Islam ■ ***INDONESIA*** BirdLife International Indonesia Country Programme; Ria Saryanthi; D. Agista, S. van Balen, Y. Cahyadin, R. F. A. Grimmett, F. R. Lambert, M. Poulsen, Rudyanto, I. Setiawan, C. Trainor ■ ***JAPAN*** Wild Bird Society of Japan (BirdLife Partner); Y. Fujimaki; Y. Kanai, H. Morioka, K. Ono, H. Uchida, M. Ueta, N. Yanagisawa ■ ***KOREA*** ■ *NORTH KOREA* Pak U-il; Chong Jong-ryol, Rim Chu-yon. ■ *SOUTH KOREA* Lee Woo-shin; Han Sang-hoon, Kim Jin-han, Lee Ki-sup, Park Jin-young ■ ***LAOS*** K. Khounboline; W. J. Duckworth ■ ***MALAYSIA*** Malaysian Nature Society (BirdLife Partner); K. Kumar; G. Noramly, M. J. Kohler ■ ***MONGOLIA*** D. Batdelger; A. Bräunlich, N. Tseveenmyadag ■ ***MYANMAR*** Khin Ma Ma Thwin ■ ***NEPAL*** Bird Conservation Nepal (BirdLife Affiliate); H. S. Baral; C. Inskipp, T. P. Inskipp ■ ***PAKISTAN*** Ornithological Society of Pakistan (BirdLife Affiliate) ■ ***PHILIPPINES*** Haribon Foundation for Conservation of Natural Resources (BirdLife Partner); N. A. D. Mallari, B. R. Tabaranza, Jr. ■ ***RUSSIA*** Russian Bird Conservation Union (BirdLife Partner Designate); A. V. Andreev; A. G. Degtyarev, V. G. Degtyarev, V. A. Dugintsov, N. N. Gerasimov, Yu. N. Gerasimov, N. I. Germogenov, O. A. Goroshko, A. V. Kondrat'ev, Yu. V. Labutin, N. M. Litvinenko, Yu. N. Nazarov, V. A. Nechaev, V. I. Perfil'ev, R. V. Ryabtsev, Yu. V. Shibaev, S. G. Surmach, E. E. Tkachenko, O. P. Val'chuk, B. A. Voronov. ■ ***SINGAPORE*** The Nature Society (Singapore) (BirdLife Partner); Lim Kim Seng ■ ***SRI LANKA*** Field Ornithology Group of Sri Lanka (BirdLife Affiliate); S. Kotagama; S. Aryaprema, S. Corea, J. P. G. Jones, U. Fernando, R. Perera, M. Siriwardhane, K. Weerakoon ■ ***THAILAND*** Bird Conservation Society of Thailand (BirdLife Partner); U. Treesucon; R. Jugmongkol, V. Kongthong, P. Poonswad, P. D. Round, S. Supparatvikorn ■ ***VIETNAM*** BirdLife International Vietnam Country Programme; Nguyen Cu; J. C. Eames, A. W. Tordoff, Le Trong Trai, Nguyen Duc Tu.

With contributions from: S. H. M. Butchart, D. S. Butler (maps), P. Davidson, J. C. Lowen, G. C. L. Dutson, N. B. Peet, T. Vetta (maps), J. M. Villasper (maps), M. G. Wilson

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Wellbrook Court, Girton Road, Cambridge, CB3 0NA, United Kingdom
Tel: +44 1223 277318 Fax: +44 1223 277200 Email: birdlife@birdlife.org.uk
Internet: www.birdlife.net

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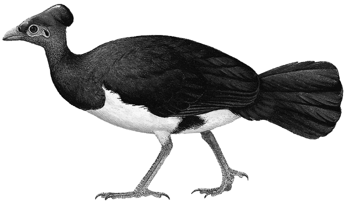
## MALEO

## *Macrocephalon maleo*

Critical □ —
**Endangered ■ A1a,c,d; A2b,c,d**
Vulnerable □ C1; C2a



*This distinctive megapode is classified as Endangered because it has undergone an observed very rapid decline, which is projected to continue based on actual levels of exploitation and decline in extent and quality of habitat, combined with the fact that it has a small population, which is continuing to undergo severe fragmentation.*

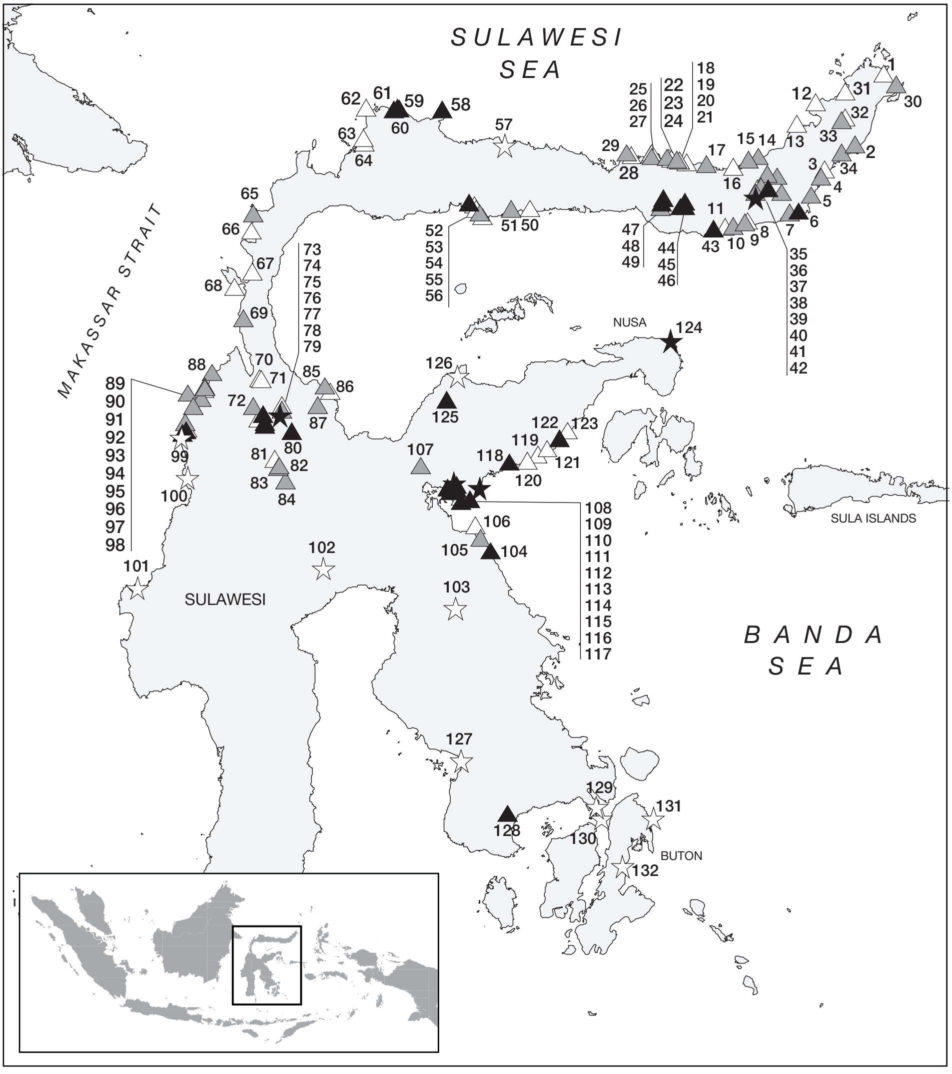
**DISTRIBUTION** The Maleo (see Remarks 1) has been recorded from the northern, eastern and south-eastern peninsulas and central Sulawesi, Indonesia, but not from the south-western peninsula, where it may or may not have formerly occurred and which is now mostly deforested and densely populated (Dekker 1990, Dekker and McGowan 1995, D. N. Jones *et al.* 1995). Wallace (1860) had observed that the species appeared to be confined to the northern peninsula of Sulawesi, "never being found in the mountain ranges or in the elevated district of Tondano". Although he was proved mistaken (see also Ecology), it is notable that a disproportionate concentration of nesting grounds are known from the Northern Peninsula (see the map in Argeloo 1994) and that virtually all known nesting grounds lie in the northern half of the island (see the map in Butchart and Baker 2000), but it remains the case that little work has been carried out in South-east Sulawesi. The exceptions are four nesting grounds on the island of Buton off South-east Sulawesi, and two on the mainland of South-east Sulawesi (Table 1). The number and size of suitable nesting grounds (see Ecology) are factors that determine the numbers and range of the species itself (MacKinnon 1978), so it must be assumed that the species is distributed almost entirely within the northern half of the island, although in general it has been considered "probably still quite widespread" within the remaining forested areas of Sulawesi (Holmes 1989).

In the past decade research has determined the current or former existence of 132 nesting grounds, and these are listed in Table 1. Twelve of these sites are of unknown status, and of the remaining 120, 42 have been abandoned, 42 are severely threatened, 31 are threatened and only five are not yet threatened (Butchart and Baker 2000; also Sinclair *et al.* 1996, Wardill *et al.* 1998, see Table 1 and Remarks 2).

**POPULATION** Around 1860 the species was very common on Gunung Klabat (Wallace 1860). In September 1883 the species was "very abundant on the lonely beach mentioned by Mr Wallace in his 'Malay Archipelago'", and the party shot "no less than 42 in two days" (Guillemard 1885).

In 1978 some extremely crude extrapolations were made as a means of generating a broad estimate of population size: observations at one nesting ground (see Ecology) suggested that the number of eggs laid daily was around 20, and that this rate was fairly constant throughout the year, so, assuming ("probably a fair guess") that each female lays 30 eggs a year, an adult population for the site would be c.500 individuals, and by making similar calculations for larger and smaller sites in North Sulawesi (13 known) a probable total of around 3,000 adult birds was estimated, yielding a probable total for the species of 5,000–10,000 birds (MacKinnon 1978). However, some of the assumptions behind these calculations proved to be mistaken, and a better approach to the question of total numbers is via the number of nesting grounds: of 85 known nesting grounds in the mid-1990s, at least 22 (19 coastal and three inland) had been abandoned, leaving 63 sites, 51 of which were known to be active, with 12 lacking data (D. N. Jones *et al.* 1995, superseding figures in Dekker and McGowan 1995). However, of the 51 active sites, only two were totally undisturbed and not yet threatened, while the remainder were at risk, some of them severe, and only being visited by a small number of birds; thus most were expected to be abandoned “in the near future”, the only factor offsetting this gloomy assessment being the possibility of another 17 potential sites, mainly beaches, whose existence needed to be verified by fieldwork (D. N. Jones *et al.* 1995, superseding figures in Dekker and McGowan 1995).

In 1990–1991 a 10-month study at Tambun revealed an average of 5.4 Maleo pairs per day at the nesting ground, and assuming that a female lays 10 eggs per year some 160 pairs




**The distribution of Maleo *Macrocephalon maleo* nesting grounds. Sites on this map are numbered according to the sites listed in Table 1.**

▲ Threatened ▲ Severely threatened △ Abandoned ★ Not yet threatened ☆ Unknown

**Table 1. Maleo nesting grounds.**

| | Nesting ground | Altitude[a] | Protected status[b] | Pairs | Access for Maleo[c] | Eggs[d] | Status[e] | References[f] |
|---|---|---|---|---|---|---|---|---|
| 1 | Batu Putih | C | | 0 | + | - | A | 1 (1), 2 (1), 11, 14, 15, 17, 20, 21, 22, 23, 24, 25, 30, 33, 38, 39 |
| 2 | Rumbia | C | | 1–10 | - | - | ST | 2 (2) |
| 3 | Kotabunan | C | | 0 | - | - | A | 2 (3) |
| 4 | Togid | C | | 5–20 | - | - | ST | 2 (4) |
| 5 | Molobog | C | PN | 15–30 | - | - | ST | 1 (11), 2 (5), 22, 30 |
| 6 | Onggunoi | C | | ? | - | - | T | 1 (12), 2 (6), 22 |
| 7 | Torosik | C | PN | 30–75 | ± | - | ST | 1 (10), 2 (7), 22 |
| 8 | Lungkap | C | | 0 | - | - | A | 2 (8) |
| 9 | Dami | C | | 5–20 | - | - | ST | 2 (9) |
| 10 | Pinolosian | C | | 5–20 | - | - | ST | 1 (13), 2 (10) |
| 11 | Dodepo | C | | 0 | - | - | A | 2 (11) |
| 12 | Kumu | C | NR | 0 | - | ? | A | 1 (6), 2 (12), 20, 22 |
| 13 | Laim Pangi | C | | 0 | - | - | A | 1 (7), 2 (13), 10 |
| 14 | Labuan Uki | C | | 1–10 | - | - | ST | 1 (8), 2 (14) |
| 15 | Buntalo | C | MN | 15–30 | ± | - | ST | 1 (9), 2 (15) |
| 16 | Babo/Ayong | C | | 0 | - | - | A | 2 (16) |
| 17 | Sangkup | C | PN | 20–40 | - | - | ST | 2 (17) |
| 18 | Muara Bintauna | C | | 0 | - | - | A | 1 (27), 2 (18) |
| 19 | Bohobok | C | | 0 | - | - | A | 2 (19) |
| 20 | Binjeita | C | | 0 | - | - | A | 2 (20) |
| 21 | Saleo | C | | 1–10 | - | - | ST | 2 (21) |
| 22 | Wakat | C | | 0 | - | - | A | 1 (28), 2 (22) |
| 23 | Iyok | C | | 0 | - | - | A | 2 (23) |
| 24 | Kuala | C | | 5–21 | - | - | ST | 2 (24) |
| 25 | Komus I | C | | 0 | - | - | A | 2 (25) |
| 26 | Komus II | C | | 0 | - | - | A | 2 (26) |
| 27 | Tuntung | C | | 1–10 | - | - | ST | 2 (27) |
| 28 | Gentuma | C | | 0 | - | - | A | 2 (28) |
| 29 | Molonggota | C | PN | 15–30 | - | - | ST | 2 (29) |
| 30 | Tiwo/Remesun | I | TD | | + | - | ST | 1 (2), 2 (30), 11, 20, 21, 22, 33, 47 |
| 31 | Empung | I | | 0 | - | ? | A | 1 (3), 2 (31), 25, 30 |
| 32 | Kiawa | I | | 0 | - | ? | A | 1 (4), 2 (32), 30 |
| 33 | Tombatu | I | | ? | ± | - | ST | 1 (5), 2 (33), 22, 47 |
| 34 | Belang | I | | ? | - | - | ST | 2 (34) |
| 35 | Inuai | I | | ? | - | - | ST | 2(35) |
| 36 | Lobong | I | | ? | - | - | ST | 2 (36) |
| 37 | Bakan | I | DB | ? | ± | - | ST | 1 (14), 2 (37), 45 |

**Table 1 continued. Maleo nesting grounds.**

| | Nesting ground | Altitude[a] | Protected status[b] | Pairs | Access for Maleo[c] | Eggs[d] | Status[e] | References[f] |
|---|---|---|---|---|---|---|---|---|
| 38 | Muara Pusian | I | DB | ? | ± | - | T | 1 (15), 2 (38), 20, 22, 45, 46 |
| 39 | Tambun | I | DB | ? | ± | - | ST | 1 (16), 2 (39), 11, 13, 20, 29, 45, 46, 48, 50 |
| 40 | Uuwan | I | | 0 | ± | - | A | 1 (17), 2 (40) |
| 41 | Tumokang | I | DB | ? | + | - | ST | 1 (18), 2 (41), 13, 20, 22, 29, 45, 46, 48, 50 |
| 42 | Tapokolintang | I | | ? | + | + | NYT | 1 (19), 2 (42) |
| 43 | Negeri Lama I | I | | ? | + | - | T | 1 (20), 2 (43), 30 |
| 44 | Pilomanu | I | DB | ? | + | - | T | 1 (21), 2 (44), 45 |
| 45 | Sinondu | I | DB | ? | + | - | T | 1 (22), 2 (45), 45 |
| 46 | Leda-Leda | I | DB | ? | + | - | T | 1 (23), 2 (46), 45 |
| 47 | Pahulongo | I | DB | ? | ± | - | T | 1 (24), 2 (47), 45 |
| 48 | Hungayono | I | DB | ? | ± | - | T | 1 (25), 2 (48), 20, 22, 45 |
| 49 | PKMT/Tulabolo | I | DB | ? | ± | - | ST | 1 (26), 2 (49), 45 |
| 50 | Bulo Oliyo | C | | 0 | - | - | A | 1 (29), 2 (50), 22, 36 |
| 51 | Panua | C | P | 125–200 | ± | - | ST | 1 (30), 2 (51), 20, 22, 36, 47, 49 |
| 52 | Tanjung Panjang | C | | 0 | - | - | A | 1 (31), 2 (52), 20, 22, 36 |
| 53 | Malopuulo | C | | 15–30 | - | - | ST | 2 (53) |
| 54 | Tanggarasi | C | | 0 | - | - | A | 2 (54) |
| 55 | Bunto | C | | 0 | - | - | A | 2 (55) |
| 56 | Dehua | C | PN | 76–125 | ± | - | T | 2 (56) |
| 57 | Paleleh | C | | ? | ? | - | ? | 1 (32), 2 (57), 16, 34 |
| 58 | Tanjung Dako | 0 | HL | 100–200 | + | - | T | 3 (1) |
| 59 | Tanjung Bambalatung | 0 | TM | 50–100 | + | - | T | 3 (2) |
| 60 | Tanjung Matop | 0 | TM | 100–200 | + | - | T | 1 (IV), 2 (L), 3 (3) |
| 61 | Tanjung Labuanunuk | 0 | None | 50–100 | - | - | T | 3 (4) |
| 62 | Tanjung Bone | 0 | None | 0 | - | - | A | 3 (5) |
| 63 | Tanjung Doiyan | 0 | None | 0 | - | - | A | 3 (6) |
| 64 | Nalu | 0 | None | 0 | - | - | A | 1 (33), 2 (58), 3 (7), 34 |
| 65 | Siraro | 0 | None | 10–50 | - | - | ST | 3 (8) |
| 66 | Rerang | 0 | None | 0 | - | - | A | 3 (9) |
| 67 | Silambea | 0 | None | 0 | - | - | A | 3 (10) |
| 68 | Tanjung Parimpi | 0 | None | 0 | - | - | A | 3 (11) |
| 69 | Tamarenja | 120 | None | 10–50 | - | - | ST | 3 (12) |
| 70 | Ngatabaru | c.200 | None | 0 | - | - | A | 3 (13) |
| 71 | Loru | c.300 | None | 0 | - | - | A | 3 (14) |
| 72 | Pulu | 90 | None | 10–50 | - | - | ST | 3 (15) |
| 73 | Bangga | c.100 | None | 0 | - | - | A | 3 (16) |

**Table 1 continued. Maleo nesting grounds.**

| | Nesting ground | Altitude[a] | Protected status[b] | Pairs | Access for Maleo[c] | Eggs[d] | Status[e] | References[f] |
|---|---|---|---|---|---|---|---|---|
| 74 | Pakuli | 155–220 | LL | 50–100 | + | - | T | 1 (34), 2 (59), 3 (17), 44 |
| 75 | Air Panas | 555 | None | 0 | - | - | A | 3 (18) |
| 76 | Kamarora | 605 | LL | 1–10 | ± | - | ST | 1 (39), 2 (64), 3 (19), 44 |
| 77 | Hulurawa | 695–760 | LL | 10–50 | + | + | NYT | 3 (20) |
| 78 | Saluki | 235–305 | LL | 10–50 | + | - | T | 1 (35), 2 (60), 3 (21), 44 |
| 79 | Mapane | 360–390 | LL | 10–50 | + | - | T | 1 (35), 2 (60), 3 (22), 44 |
| 80 | Taveki | 1,045–1,065 | LL | 1–10 | + | - | T | 1 (40), 2 (65), 3 (23), 44 |
| 81 | Haluapu | 415 | None | 0 | - | - | A | 3 (24) |
| 82 | Mangku | 665 | LL | 1–10 | + | - | ST | 3 (25) |
| 83 | Kaya | 695 | LL | 1–10 | + | - | ST | 1 (37), 2 (62), 3 (26), 44 |
| 84 | Kare Tambe | 730 | LL | 1–10 | + | - | ST | 1 (38), 2 (63), 3 (27), 44 |
| 85 | Taba | 0 | None | 10–50 | - | - | ST | 1 (VI), 2 (N), 3 (28), 10 |
| 86 | Tambu | 0 | None | 0 | - | - | A | 3 (29) |
| 87 | Salubanga | 230 | None | 10–50 | + | - | ST | 3 (30) |
| 88 | Pambua | 0 | None | 1–10 | - | - | ST | 3 (31) |
| 89 | Bambamata | 0 | None | 1–10 | - | - | ST | 3 (32) |
| 90 | Kasoloang | 0 | None | 1–10 | - | - | ST | 3 (33) |
| 91 | Terbao | 0 | None | 0 | - | - | A | 3 (34) |
| 92 | Randomoyang | 0 | None | 1–10 | - | - | ST | 3 (35) |
| 93 | Kayumoloa | 0 | None | 1–10 | - | - | ST | 3 (36) |
| 94 | Tanjung Tambue | 0 | None | 1–10 | - | - | ST | 2 (76), 3 (37), 7 |
| 95 | Padongga | 0 | None | 1–10 | ± | - | ST | 3 (38) |
| 96 | Tikke | 0 | None | 0 | - | - | A | 3 (39) |
| 97 | Koloe | 0 | None | 1–10 | + | - | T | 3 (40) |
| 98 | Lema | 0 | None | 1–10 | + | - | T | 3 (41) |
| 99 | Lariang | 0 | ? | ? | ? | - | ? | 1 (VII), 2 (77), 3 (42), 5 |
| 100 | Tanjung Dapuran | 0 | ? | ? | ? | - | ? | 2 (78), 3 (43), 7 |
| 101 | Mamuju | 0 | ? | ? | ? | ? | ? | 1 (VIII), 2 (79), 3 (44) |
| 102 | Danau Matano | I | ? | ? | + | - | ? | 2 (80), 3 (45), 7 |
| 103 | Danau Towuti | I | ? | ? | + | - | ? | 2 (81), 3 (46), 7 |
| 104 | Sungai Bosu | 0 | None | 100–200 | ± | - | T | 2 (75), 3 (47), 5, 12 |
| 105 | Ambunu | 0 | None | 10–50 | - | - | ST | 2 (74), 3 (48), 12 |
| 106 | Sungai Karaopa | 0 | None | 0 | - | - | A | 2 (73), 3 (49), 5 |
| 107 | Tambayoli | I | None | 1–10 | - | - | ST | 3 (50) |
| 108 | Kilo Dua | I | M | 200–500 | + | - | T | 1 (46), 2 (72), 3 (51), 32 |
| 109 | Kilo Tujuh | I | M | 10–50 | + | - | T | 1 (45), 2 (68), 3 (52), 32 |
| 110 | Kilo Sembilan | I | M | 10–50 | + | - | T | 1 (42), 2 (69), 3 (53), 32 |

**Table 1 continued. Maleo nesting grounds.**

| | Nesting ground | Altitude[a] | Protected status[b] | Pairs | Access for Maleo[c] | Eggs[d] | Status[e] | References[f] |
|---|---|---|---|---|---|---|---|---|
| 111 | Kayu Poli | I | M | 50–100 | + | - | T | 1 (43), 2 (70), 3 (54), 32 |
| 112 | Batu Katunda | I | M | 200–500 | + | - | NYT | 1 (44), 2 (71), 3 (55), 32 |
| 113 | Kekeya | 0 | M | 10–50 | + | - | T | 3 (56) |
| 114 | Matube | 0 | ? | 0 | - | - | A | 3 (57) |
| 115 | Bunto | 0 | M | 10–50 | + | - | T | 3 (58) |
| 116 | Tobu | 0 | M | 50–100 | + | - | T | 3 (59) |
| 117 | Peo | 0 | M | 200–500 | + | - | NYT | 3 (60) |
| 118 | Ondolia | 0 | None | 50–100 | ± | - | T | 3 (61) |
| 119 | Nipa Nipa | 0 | ? | 0 | - | - | A | 3 (62) |
| 120 | Dongin | 0 | ? | 0 | - | - | A | 3 (63) |
| 121 | Topo | 0 | ? | 0 | - | - | A | 3 (64) |
| 122 | Bakiriang | 0 | HL | 100–200 | ± | - | T | 1 (41), 2 (67), 3 (65), 6, 12, 18, 42, 43 |
| 123 | Nonong | 0 | ? | 0 | - | - | A | 3 (66) |
| 124 | Libun | 0 | HL | 100–200 | + | - | NYT | 2 (66), 3 (67), 12, 19 |
| 125 | Pintu Kubur | I | None | 200–500 | + | - | T | 3 (68) |
| 126 | Tanjung Api | ? | ? | ? | - | - | ? | 3 (69) |
| 127 | Konoweha | 0 | ? | ? | ? | ? | ? | 1 (47), 2 (82), 3 (70), 34 |
| 128 | Sungai Pampea | 30 | RA | ? | + | - | T | 1 (IX), 2 (O), 3 (H), 31, 40, 41 |
| 129 | Tanjung Batikolo | 0 | TB | ? | ? | ? | ? | 1 (48), 2 (83), 3 (71), 28 |
| 130 | Lebo | I | NB | ? | ? | - | ? | 2 (R), 3 (72), 4, 8, 9, 12, 26, 27, 35, 37 |
| 131 | Lagito | I | NB | ? | ? | ? | ? | 4, 27 |
| 132 | Bubu | 0 | None | ? | + | - | ? | 3 (74), 8 |

[a] Altitude is given in metres where known; for those sites where altitude is unknown, C = coastal, I = inland.

[b] Protected status: MN = Manembo-nembo Reserve; TD = Tangkoko-DuaSudara Nature Reserve (=Tangkoko-Batuangus Nature Reserve); DB = Dumoga-Bone National Park (=Bogani Nani Wartabone National Park); P = Panua Nature Reserve; TM = Tanjung Matop Wildlife Reserve; LL = Lore Lindu National Park; M = Morowali Nature Reserve; RA = Rawa Aopa Watumohai National Park; TB = Tanjung Batikolo Nature Reserve; NB = North Buton Wildlife Reserve, PN = proposed nature reserve ; HL = hutan lindung ("protected forest"); for sites 1–57, those with no protected status indicated are presumed to be unprotected, but this is not explicitly stated in Dekker (1990) or Argeloo (1994).

[c] Access (for Maleos to nesting ground): "+" = free, "±" = limited, "-" = disrupted, ? = unknown. For definitions see Dekker (1990), Argeloo (1994) or Butchart and Baker (2000).

[d] Eggs: "+" = safe from collectors, "-" not safe from collectors, ? = unknown. For sites 1–57 information is taken from Argeloo (1994), for sites 58–132 information is taken mainly from Butchart and Baker (2000), Butchart *et al.* (1998) and Baker (1998).

[e] Status information is taken from the most recent source, generally Argeloo (1994), and Butchart and Baker (2000). A = Abandoned, T = Threatened, ST = Severely Threatened, NYT = Not Yet Threatened, ? = unknown.

[f] References: For the three main publications listing Maleo nesting grounds, *viz* 1, Dekker (1990), 2, Argeloo (1994), and 3, Butchart and Baker (2000), numbers/letters in parentheses indicate the site number/letter used in that reference. Additional references are: 4, Addin (1992 in Prawiradilaga 1997); 5, Andrew and Holmes (1990); 6, Argeloo and Dekker (1996); 7, Baltzer (1990); 8, Baltzer (undated); 9, Catterall (undated); 10, Coomans de Ruiter (1930); 11, Dekker (1988); 12, Dekker and Argeloo (1992); 13, Dekker and Wattel (1987); 14, Guillemard (1885); 15, Guillemard (1886); 16, Heinrich (1932); 17, Hose (1903); 18, Indrawan (1992b); 19, Kobayashi and Gurmaya (1993); 20, MacKinnon (1978); 21, MacKinnon (1980); 22, MacKinnon (1981); 23, Meyer (1879); 24, Meyer and Wiglesworth (1895a); 25, Meyer and Wiglesworth (1898); 26, Pramono (1991); 27, Prawiradilaga (1997); 28, Rifai and Suhyar (1976 in Dekker 1990); 29, Rozendaal and Dekker (1989); 30, Sarasin and Sarasin (1905 in Dekker 1990); 31, Silvius *et al.* (1987 in Wardill 1995); 32, Simonson (1987 in Dekker 1990); 33, Sinclair *et al.* (1996); 34, Stresemann and Heinrich (1941); 35, Sykes (1996); 36, Uno (1949); 37, Viney (1995); 38, Wallace (1860); 39, Wallace (1869); 40, Wardill (1995); 41, Wardill *et al.* (1998); 42, Watling (1983a); 43, Watling (1983b); 44, Watling and Mulyana (1981); 45, Wind (1984); 46, Wiriosoeparto (1979 in Dekker 1990); 47, Wiriosoeparto (1980 in Dekker 1990); 48, Zieran (1985 in Dekker 1990); 49, J. Riley *in litt.* (2000); 50, M. Argeloo *in litt.* (2000).

must have used the site in that time (Argeloo 1994). The total number of pairs using the 35 coastal sites in North Sulawesi, 19 of which were abandoned, was estimated at 335–740 in 1991 (340–670 in Argeloo and Dekker [1996], who indicated this as a 90% decline since the 1950s), and the total number of pairs using inland sites, where "huge areas of primary forest have not been surveyed", seemed likely to be in excess of 2,000 (Argeloo 1994); thus a safe generalisation from this assessment is that there were probably 2,000–3,000 pairs of Maleos in existence in North Sulawesi (which was then considered to be comprise virtually all the range of the species).

At the start of the 1980s, however, the species had been considered still common in lowland areas of Central Sulawesi (Watling 1983b), and in 1998 studies in Central and South Sulawesi, involving site visits and semi-structured interviews, significantly extended the number of nesting grounds known, even though the great majority were abandoned or used by small and declining numbers of birds; the total population for these two provinces was crudely estimated at 1,700–4,300 pairs (Butchart and Baker 2000). The addition of the figures proposed by Argeloo (1994) for North Sulawesi furnishes a total of roughly 4,000–7,000 pairs (Butchart and Baker 2000). In places the species is declining rapidly, with for example 21 (70%) out of 30 sites (at which population trends were reported by local people) having fewer Maleos and smaller egg harvests than 10 years ago; and 50% of populations have declined severely, with less than 10% of the egg harvests found 19 years ago (Butchart and Baker 2000).

By the end of the 1970s, fewer than 20 pairs a day were visiting nesting grounds in Tangkoko-DuaSudara Nature Reserve (MacKinnon 1981). Sinclair *et al.* (1996) carried out survey transects seeking to replicate those of MacKinnon (1978). The results implied a 77-fold decrease in Maleos in Tangkoko in around 15 years, and just seven pairs were estimated to remain. The species was judged to be "on the verge of extinction" in the reserve (O'Brien and Kinnaird 1996a), a situation which remained so at the end of the 1990s (J. C. Wardill *in litt*. 1999).

In the early 1980s the nesting ground at Bakiriang was regarded as the Maleo's single largest (Watling 1983a) with as many as 175 birds present at one time, but by the mid-1990s this had declined to 50 birds a day (Argeloo and Dekker 1996), and by 1998 Butchart and Baker (2000) estimated the total population using the nesting ground to be 100–200 pairs. In 1985, two important nesting grounds within Bogani Nani Wartabone (Dumoga-Bone) National Park, Tambun and Tumokang, were estimated each to hold 150–200 pairs, and together these sites were estimated to have received 3,500 eggs in the eight-month laying season from September 1985 to June 1986 (Dekker and Wattel 1987, Rozendaal and Dekker 1989), but only a handful of birds were seen on visits in December 1998 and August 1999, and park guards reported that "very few eggs" were now laid (K. D. Bishop *in litt.* 2000). In Buton at the Lebo nesting ground 26 birds (maximum) were counted in October 1996 (Catterall undated).

**ECOLOGY** ***Habitat*** Wallace's (1860) assumption that the Maleo is a lowland bird, absent from mountainous areas, almost certainly reflected his sense of the influence that available nesting substrate exerts on the species. The Maleo requires undisturbed areas of warm sand or soil found in the form of beaches, where the sun supplies the heat; or in the form of volcanically warmed sands near hot springs. The latter sites have been reported at altitudes up to 1,200 m (Watling 1983b, D. N. Jones *et al.* 1995), but a more recent study suggests that a particular site in question must have been Taveki, in Lore Lindu National Park, whose elevation is 1,045–1,065 m (Butchart and Baker 2000). The sites at Dunau Matano and Dunau Towuti are the only Maleo nesting grounds found on lake shores (Baltzer 1990). Although largely terrestrial, the species flies well and perches readily in trees, sometimes high up (e.g. Meyer 1879, Meyer and Wiglesworth 1895a). Birds pass through secondary vegetation, coconut plantations and other man-modified habitats when travelling from forest to beach nesting grounds (D. N. Jones *et al.* 1995), but nesting grounds may be abandoned if the distance to forest becomes excessive (Butchart *et al.* 1998, Baker and Butchart 2000, Dekker and McGowan 1995). Nesting grounds to date have been found on exposed beaches, lake shores, riverbanks and even adjacent to and on dirt roads or roads made of ground-up coral (see, e.g., Coomans de Ruiter 1930); of the 132 nesting grounds known to date, 82 are coastal and heated by the sun, and 50 are inland and heated by geothermal sources (Baker and Butchart 2000, Wardill *et al.* 1998; see Remarks 2 for comments on the sites on Buton island). Roosting takes place on large horizontal branches of forest trees (D. N. Jones *et al.* 1995).

***Food*** Wallace (1860) noted that the species feeds “entirely on fallen fruits, which in the crop resemble the cotyledons of leguminous seeds”, but von Rosenberg (1878) found from stomach-content analysis the remains of snails and insects as well as the fruit of *Pangium edule* (a high tree belonging to the Bixinae [Flacourtiaceae], cultivated everywhere in the Eastern Archipelago [Meyer and Wiglesworth 1898], but note that D. N. Jones *et al.* [1995] comment that the seeds of this tree are poisonous). Indeed, the species has proved omnivorous, the diet consisting of fruits, seeds and invertebrates such as beetles, ants, termites and snails; one stomach held a whip-scorpion, 8–9 land snails and 10 freshwater snails, indicating that birds feed not only on the forest floor but along riverbeds or stream margins (D. N. Jones *et al.* 1995). Stomachs of three other birds held “zaden en zand” (ZMA label data).

***Breeding*** *Nest site and nest preparation* The Maleo forms an apparently monogamous pair-bond, probably for life, and the members of the pair remain close to each other (within a few metres) at all times, when foraging, roosting or egg-laying (D. N. Jones *et al.* 1995). The species breeds in traditional communal nesting grounds at which, as with nearly all megapodes, eggs are laid and left to develop and hatch with no further parental support. The nesting grounds experience sufficient natural heat, being either sand beaches well above the high-tide line, where solar radiation incubates the egg, or inland sites in sandy soil heated by solar radiation or geothermal activity or both (MacKinnon 1978, Dekker 1990). Sand beaches are of two types, black beaches (of volcanic origin) in which birds concentrate their egg-laying in a constrained area, and white beaches, in which eggs are laid over a length of many kilometres (Dekker 1990). Wallace (1960) described Maleos nesting in coarse black volcanic sand at Batu Putih which was probably derived from an ancient lava-flow from Gunung Klabat. At most inland sites in Central and South Sulawesi, at least, burrows were located 2–40 m from hot water springs, and most of these sites were close to large rivers (S. H. M. Butchart *in litt.* 2000). It may be significant that birds have been found to lay nests in roads made of ground-up coral (Coomans de Ruiter 1930), since this implies that the species may be opportunistic in its use of appropriate areas to serve as nesting grounds, and can therefore establish new nesting grounds with relative ease (something which might have implications for future management).

Pairs of Maleos gather near nesting grounds in the evening (roosting in trees nearby), and early in the morning they investigate holes and make trial burrows before selecting a site and digging in earnest, one bird at a time excavating with powerful flicks of the legs, the other bird acting as sentinel and to ward off the approaches of conspecifics (MacKinnon 1978, D. N. Jones *et al.* 1995). Short-distance territorialism while digging may be a mechanism to prevent the overall loosening of substrates by too many birds operating at one spot: incubating eggs might otherwise be exposed or overturned to the detriment of their embryos (MacKinnon 1981). Wallace’s (1860) report (probably based on local information rather than direct observation) that as many as eight females may lay communally in a single hole is likely to be a misinterpretation of the presence of several eggs in close proximity deriving from multiple females laying in the same spot over several days (S. H. M. Butchart *in litt.* 2000). Holes may take 30–180 minutes to excavate depending on substrate (if the birds meet problems, such as stones, or collapsing sides, or too cold a substrate, they abandon the work and start afresh elsewhere), and the egg is laid at a depth of 40–100 cm depending on local conditions; in volcanically heated soils the holes are c.30 cm deep, with another 30–60 cm of loose earth before hard substrate begins (MacKinnon 1978); on some occasions a pair will use the same hole as before (D. N. Jones *et al.* 1995). In another study, egg depth varied from 10 to 100 cm, but the most frequent depth was 30–50 cm; of 556 eggs, 82% were buried in the vertical position, 14% horizontal, and 4% diagonal (D. N. Jones *et al.* 1995). Filling in the hole may take as long as its excavation, causing considerable stress to the birds, which then proceed to dig one or more false burrows, piling the excess sand over the true site as further protection from pigs and monitors (MacKinnon 1978).

Temperatures in volcanically heated soils, which are damp but well drained and well aerated, vary from 32 to 39°C, but remain constant within each hole (MacKinnon 1978). In coral sand, day-surface temperatures are commonly intense, and on black volcanic sand they can become blisteringly high, but in both cases a few centimetres below the surface a fairly constant 36°C prevails (MacKinnon 1978). In separate measurements the temperature at egg depths never fluctuated beyond a 5°C width of extremes, although soil moisture content varied from dry dusty sand through to clayish soil (Dekker 1988). At one site (evidently Tiwo-Remesun) it appears that warm subterranean water was the original source of heat, but over time the Maleos have turned over so much soil that only ephemeral secondary forest shrubs survive, allowing sufficient sunlight penetration for solar heat also to operate (MacKinnon 1978). The egg is extremely large relative to the body size of the female (16% of her body weight *vs.* 3% in domestic chickens), this being the consequence of its needing to contain sufficient yolk resources to allow the embryo to develop into a fully fledged chick at hatching. A secondary consequence of this is an extremely long incubation period of around three months (62–85 days, depending on prevailing temperature conditions: Dekker 1988), a period exceeded only by the largest albatrosses, penguins and kiwis (Wilcove 1997). Tunnelling to the surface after hatching takes probably around two days, and by the time the chick emerges it is ready to fly (MacKinnon 1981). The young apparently emerge at night since they are so rarely observed (MacKinnon 1978, Dekker and Brom 1990; see also Guillemard 1886).

MacKinnon (1978, 1981) described an egg-translocation experiment designed to test the practicability of semi-artificial incubation: over the course of a year 1,500 eggs were collected from Panua and the nearby beach of Tanjung Panjang, and buried in sand in a cage at Panua; c.500 eggs hatched and the chicks were released at Panua. MacKinnon (1978) concluded that (1) since the eggs hatched on an area of beach not used by Maleos, they can be successfully transported and hatched; (2) since they were buried at a depth of only 30 cm, and those buried more shallowly or deeply appeared to show no differences in hatching success, depth is of minor importance to the *mechanics* of incubation (other work showed that depth of laying is not correlated with temperature and appears to be merely an anti-predation factor); (3) since the cage was covered in palm leaves, giving greater shade to the sand than normal (the site being 4°C cooler than elsewhere even when exposed), eggs must have a considerable tolerance of cold. However, hatching success does drop in long cold spells of wet weather (MacKinnon 1978). In 1979 a repeat experiment, using best practices, determined that eggs can be translocated successfully to artificial hatcheries where the customary pressures from human and animal predators can be eliminated, and the release at Panua of hatched birds from this experiment apparently resulted in a considerable increase in numbers coming to the nesting ground there the following year (MacKinnon 1981); however, these are unlikely to have been the chicks released the previous year, as Maleos probably take 2–3 years to reach maturity (see below; see also comments questioning the effectiveness of hatcheries under Measures Proposed).

*Seasonality and individual yearly egg output* Breeding is more-or-less year-round, but the timing of the peak varies in different areas. At the inland nesting grounds in North Sulawesi egg-laying peaks during October to May or June, and only a few pairs lay in the period July–September (D. N. Jones *et al.* 1995). Similarly at inland sites in Central Sulawesi, egg-laying peaks in September–December or even as late as March (Butchart *et al.* 1998, D. N. Jones *et al.* 1995). At the coastal nesting grounds egg-laying occurs only or mainly during the dry season, thus on the south coast of North Sulawesi from September to March, but on the north coast from March to September (D. N. Jones *et al.* 1995). Similarly on the west coast of South Sulawesi the peak was in November to January, but on the north coast of Central Sulawesi breeding peaked in April to September (Butchart *et al.* 1998). Eggs are laid throughout the year in Bogani Nani Wartabone (Dumoga-Bone) National Park in North Sulawesi, but peaking in October–April (Rozendaal and Dekker 1989). At one of the sites in the park, Tambun, birds visited throughout a nine-month period of study, but with a distinct peak in the period February–May and a notable low in July–August (Argeloo 1994). At Panua on the south coast of North Sulawesi, egg-laying was found to be year-round, albeit with a peak in January–May, the period after the monsoon season, although in 1947 there was an apparently anomalous resurgence of laying in August–September (Uno 1949, D. N. Jones *et al.* 1995). Seasons of May–July and November–January have been reported for South-east Sulawesi (White and Bruce 1986), but at sites on Buton island in this province the breeding season was stated to be August–November (Baltzer undated) or July-September (Addin 1992). There is no evidence to support the assertion made by villagers that Maleos lay by preference when the moon is full (MacKinnon 1978), although lunar synchronicity exists in the laying regimes of the Moluccan Megapode *Eulipoa wallacei* (see relevant account).

Wallace (1860) ascertained from locals that the same pair returned to lay subsequent eggs every 13 days, a supposition which internal examination of birds tended to support, since each female appeared to produce around eight eggs over a three-month period (Wallace 1860). Guillemard (1886) thought the period was much more extended, and judged on the basis of dissections that the number was likely to be 16–18 "during the season", and recorded a maximum of 20 ova in some females (Guillemard 1885). Coomans de Ruiter (1930) estimated a period of 14 days between eggs, and a total of 6–8 eggs per season, based on local information. MacKinnon (1978) made a "fair guess" that a female lays 20–30 eggs a year. However, fieldwork in the 1980s suggested one egg laid every 7–9 days over a laying season of 2–3 months, hence 8–12 eggs per female (Dekker 1990). Birds probably reach breeding age after 2–3 years (R. W. R. J. Dekker *in litt.* 2000); captive birds may live to over 30 years old (Baker and Butchart 2000), and they can still produce eggs at 20 years of age (Dekker and Wattel 1987).

**THREATS** The Maleo is one of (at least) five threatened members of the suite of 42 bird species that are entirely restricted to the "Sulawesi Endemic Bird Area", threats and conservation measures in which are profiled by Sujatnika *et al.* (1995) and Stattersfield *et al.* (1998).

***Egg collection*** The value of the Maleo egg as a food resource may be gauged by the fact that its average weight is 232 g, and it possesses one-half to two-thirds yolk, compared to a chicken egg, which weighs 55 g and possesses one-third yolk (thus a Maleo egg is four times the weight and perhaps six times the nutritional value of a chicken egg); indeed the market price of a Maleo egg in the mid-1980s—when trade in eggs was (as it remains) illegal—was five times that of a chicken egg (Dekker and Wattel 1987) and this price ratio is still current (R. F. A. Grimmett *in litt.* 2001). Unsurprisingly, such was the attraction of such resources that people in the past travelled from as far as 80 km from a nesting ground in order to harvest eggs (Wallace 1869). In former times, collecting Maleo eggs was supervised by local kings or other authorities, involving the leasing of nesting grounds to a few harvesters (von Rosenberg 1878, Stresemann and Heinrich 1939-1941, Watling 1983a).

By the beginning of the twentieth century there was, however, clear evidence of decline at one site (Panua) in response to over-exploitation (Uno 1949), and this decline continued: whereas in 1947 Panua yielded 9,705 eggs, i.e. visited on average by over 30 pairs per day

(Uno 1949), 30 years later it was only attracting 2–3 pairs per day (i.e. maximum of 1,000 eggs per year), a decline of 90% (MacKinnon 1981). By 2000 the forest behind the nesting grounds had become an illegal gold-mining area, the nesting grounds were isolated from the forest by plantations and the Trans-Sulawesi Highway, any eggs continued to be exploited by villagers and fishermen, the area was disturbed by livestock, dogs and monitor lizards, most forest had been destroyed and the rest continued to be extracted, and no birds could be found in two visits totalling six days (J. Riley *in litt*. 2000). The magnificent population at Batu Putih described by Wallace and Guillemard had vanished within six years of a permanent settlement (involving people from Sangihe) in 1913 owing to human over-exploitation (MacKinnon 1978, 1981). At least in recent years the eggs of Maleo have become sought-after Christmas gifts, and are used as tokens of esteem; they have even been exported to Jakarta restaurants (Dekker and Wattel 1987). At Makiriang, where a guard-post had been established and a one-time egg-collector employed as a warden to help with the local hatchery, a request was received in 1991 from local traditional leaders for a contribution of 400 eggs for an annual ritual, which the conservation authorities were bargaining down to 150 (Indrawan 1992b). In 1998–1999 at the Tambun nesting ground in Bogani Nani Wartabone (Dumoga-Bone) National Park, illicit egg-collectors (mainly transmigrants) had destroyed protective fences erected by the forest department to protect the nesting ground, and they had even cut through chain-link fencing to steal eggs from a hatchery cage (K. D. Bishop *in litt.* 2000).

Government-sponsored transmigration programmes (transporting people largely from Java to the outer provinces of Indonesia) have led to the breakdown of traditionally controlled egg-collecting systems in North Sulawesi (Argeloo and Dekker 1996). Egg-harvesting was also found to be a particular problem at nesting grounds located near transmigration areas in Central Sulawesi, with all nesting grounds within 5 km of transmigrant settlements abandoned or severely threatened (Baker and Butchart 2000). The nesting ground at Sungai Karaopa in Central Sulawesi was one such victim, being considerably reduced by loss of habitat to a transmigration settlement (Andrew and Holmes 1990). The introduction of transmigrants into the Dumoga valley has been predicted to result in “the total despoliation of all lowland forest areas and many important montane areas within the Dumoga-Bone National Park” (K. D. Bishop *in litt.* 2000).

The Maleo’s chronic loss of reproductive output to human appetite has mistakenly been taken to indicate that it can tolerate such exploitation, whereas in reality its populations can quickly disappear (MacKinnon 1978). Of the 120 Maleo nesting grounds whose present conservation status is known, 42 (35%) have already been abandoned largely owing to over-collection of eggs and habitat destruction (Butchart and Baker 2000, Baker and Butchart 2000, Wardill *et al.* 1998). This has particularly been the pattern with the “uprooting” of local traditions associated with the large-scale environmental and social changes on the island in post-colonial times (Dekker and Wattel 1987); the human populations in coastal Sulawesi are higher and more volatile than ever before, making sustainable harvesting regimes very difficult to devise and implement (Dekker and McGowan 1995). Even in the 1970s at nesting grounds in Bogani Nani Wartabone (Dumoga-Bone) National Park, MacKinnon (1978) judged that although cropping could work under strict management, current levels of exploitation were so unsustainable that “total protection has become necessary”. Watling (1983a) reported that in Central Sulawesi most nesting colonies were despoiled by local people, including the largest site at Bakiriang. In South Sulawesi both new coastal sites discovered in 1989 in the Lariang-Lumu area were well known to local villagers who exploited the eggs (Baltzer 1990).

Opportunistic egg-taking by rattan-collectors is a significant threat at inland sites in North Sulawesi (Argeloo 1994) and in Central and South Sulawesi (Baker and Butchart 2000). In the past, rattan was collected from forest close to villages, but dwindling supplies are forcing collectors further afield: recent studies in Lore Lindu National Park suggest that it may not be economically viable to collect even more distant cane supplies, and as a result rattan-collection may decline over the next decade (Baker and Butchart 2000). However, trails made by rattan-collectors make Maleo grounds in forest more accessible to hunters and other villagers; these indirect consequences of rattan exploitation are more significant than the direct effects of habitat modification (Baker and Butchart 2000).

Egg-collecting by local people is effectively controlled at only 12% of sites in Central and South Sulawesi, with nominal but ineffective control systems at another 5% of sites (Butchart and Baker 2000). Egg-harvesting systems operated by local people probably do not benefit Maleos *per se*, because in most cases nearly all the eggs are taken, perhaps more efficiently than at sites with intensive but opportunistic egg-collection; however, the existence of effective systems for restricting the number of people collecting eggs facilitates the implementation of conservation measures aimed at reducing the intensity of harvesting (Butchart and Baker 2000).

***Habitat destruction*** Evidence of the rate of forest loss in lowland Sulawesi, to which most nesting grounds are confined, is presented in Threats under Blue-faced Rail *Gymnocrex rosenbergii*. Forest clearance on Sulawesi must play, and have played, a significant but little understood role in the decline of the Maleo, since it is essentially a forest bird, and the fact that it is peculiarly vulnerable owing to its nesting habits should not dominate conservation planning to the exclusion of considerations of its broader habitat requirements; Watling (1983a) emphatically declared that the Maleo "is seriously threatened by habitat loss, especially in its principal habitat, the lowland rain forest", and initially Dekker (1988) identified destruction of rainforest and nesting grounds for agricultural and urban development ahead of egg collection as a threat to the species. Forest destruction in the past has led to the discovery and exploitation of hitherto unknown nesting grounds (Dekker and Wattel 1987). In the case of the Dumoga valley in North Sulawesi, pressure on two nesting grounds, Tambun and Tumokang, increased as the valley was opened up for agriculture, letting in a flood of settlers who continued to cut forest fringing the Bogani Nani Wartabone (Dumoga-Bone) National Park, established in 1980, and to enter it to remove food resources (Dekker and Wattel 1987). At Tambun the entire area of the nesting ground was radically degraded between the mid-1980s and the late 1990s; many trees were cut down, and the subsequent growth of *Lantana* scrub now hinders access to burrows by Maleos (K. D. Bishop *in litt.* 2000); the guardpost at this nesting ground had been destroyed by July 2000 (M. Argeloo *in litt.* 2000). At the Tumokang nesting ground, the situation in July 2000 was said to be "shocking": the guardpost had been destroyed, timber and rattan-collection was intense, and trees were being felled as close as 200 m from the nesting ground (M. Argeloo *in litt*. 2000). The entire southern boundary of the Dumoga-Bone National Park is almost entirely degraded now by coconut plantations and other cultivation, and several logging operations with already established dirt roads are presumed to penetrate the national park (K. D. Bishop *in litt.* 2000). On Buton logging is pervasive and a transmigration programme is compounding the danger (see Threats under Snoring Rail *Aramidopsis plateni* and Yellow-crested Cockatoo *Cacatua sulphurea*). The mature secondary forest adjacent to the Lebo nesting ground on Buton was being selectively logged in 1996, and loggers were also known to collect eggs (Catterall undated).

Coastal nesting grounds have been more severely affected by habitat degradation than inland nesting grounds (Baker and Butchart 2000). Of 48 known coastal sites in the early 1990s, 19 (40%) were abandoned, 14 (29%) were severely threatened, five (10%) were threatened, 10 (21%) were unknown and thus none was not threatened, whereas of the 35 known inland sites, three (9%) were abandoned, seven (20%) were severely threatened, 13 (37%) were threatened, eight (23%) were unknown and four (11%) were not threatened (see Argeloo 1994). Baker and Butchart (2000) incorporated up-to-date data from Central and South Sulawesi and estimated that 45% of coastal nesting grounds (34 out of 75) had been abandoned (mainly in the last 20 years), compared to 18% of inland nesting grounds (8 out of 45). This phenomenon is related to the much heavier human settlement of the coasts (Dekker and Wattel 1987), leading to the destruction of adjacent forest habitat for coconut and oil palm plantations, habitations, roads, and fish farms, (Dekker 1990, Argeloo 1994, Baker and Butchart 2000). Consequently a higher proportion of coastal (56%) than inland (19%) nesting grounds are now completely isolated from primary forest (Baker and Butchart 2000). This isolation of nesting grounds from foraging habitat is likely to have a detrimental impact on Maleo populations (Dekker and McGowan 1995) because the survival of chicks depends on reaching forest cover as soon after hatching as possible. In many cases they now have to endure a journey of over 10 km through modified habitat in which they are probably exposed to significantly elevated predation pressures. In the Tanjung Panjang area apparently very few young survive to the week-old stage, and irrigation and transmigration projects in the beach hinterland are likely to reduce survival rates still further (MacKinnon 1981). At Bakiriang (once the single largest nesting ground: see above) a "massive migration settlement" was being established less than 3 km away in the early 1980s, and all the lowland forest hinterland was then being felled (Watling 1983a); the site was apparently still just extant in the late 1980s (Dekker 1990) and in 1991, when a hatchery and guard-post then existed to protect it (Indrawan 1992b). In 1998 the site was heavily disturbed, particularly by fishermen using explosives, and the nearest primary forest was 10 km away; consequently the Maleo population had declined considerably (Butchart and Baker 2000).

Dekker (1990) noted that habitat destruction combined with the scattered distribution of nesting grounds means that "some populations are fully isolated" and thus "highly vulnerable", so he predicted that without intervention all coastal nesting grounds would be abandoned by the year 2000. In the five years between the assessments by Dekker (1990) in 1985–1986 and Argeloo (1994) in 1990–1991 the situation deteriorated: of 21 sites controlled in the 1990–1991, the number of severely threatened sites rose from four to six, and the number of not threatened sites decreased from three to one (Argeloo 1994). Butchart and Baker (2000) combined these data from North Sulawesi with data collected in 1998 in Central and South Sulawesi and estimated that 32% of sites had been abandoned, 42% were severely threatened, 49% were threatened, and only 9% (four sites) were not yet threatened.

***Hunting*** Adult Maleos appear to have few natural enemies and grow to be fairly old, but they are hunted for their flesh (Dekker and Wattel 1987). Baker and Butchart (2000) reported shooting, trapping and snaring of Maleos at or adjacent to nesting grounds at 28% of active sites in Central and South Sulawesi. They judged that "although habitat degradation and over-collection of eggs are probably having the greatest detrimental impact on maleo populations, hunting in combination with these threats may have serious consequences for dwindling populations at the remaining active sites".

***Natural predators*** Meyer (1879) shot a young crocodile "which was busy digging for eggs in a Moleo-hole [*sic*]". Dogs, wild pigs *Sus celebensis* and monitor lizards *Varanus salvator* are significant predators on eggs and chicks (MacKinnon 1981, Dekker and Wattel 1987, Butchart *et al.* 1998), and dogs kill adult birds (Argeloo 1991). Monitors in particular appear to take a heavy toll, with as many as 2–3 eggs being taken daily at the Tangkoko Batuangus reserve, representing 10–20% of all eggs laid, and they occasionally also catch digging adults and emerging hatchlings (MacKinnon 1981). Brahminy Kites *Haliastur indicus* and other birds of prey frequent Maleo nesting grounds and presumably catch hatchlings, which also probably fall prey to the giant civet *Macrogalidia musschenbroekii*, large rats (MacKinnon 1981) and pythons *Python reticulatus* and *P. molurus* (Butchart *et al.* 1998). At Tanjung Panjang wild pigs scout the beach every day, consuming half of all eggs laid, and although they are natural predators their numbers appear to have been boosted by widespread human settlement of Sulawesi, since the animals exploit cultivated foods and are particularly numerous in coastal coconut plantations (MacKinnon 1981).

***Introduced predators*** The introduction to Sulawesi of dogs and cats has probably caused additional pressure on Maleos, which previously faced only one native [mammalian] carnivore [*Macrogalidia musschenbroeckii*] (Wilcove 1997).

***Myth and ignorance*** Maleos have almost the status of myth on Sulawesi, where stories about eggs are passed down through generations, although these days the disappearance of the species means that the majority of people on the island have no direct contact with the bird (Dekker and Wattel 1987). Nevertheless, there was still in the 1980s and 1990s a prevalent view that the species was common and widespread and that egg-collecting has no impact on it—thus ignorance was regarded as a major problem and obstacle to long-term conservation (Dekker and Wattel 1987, Baker and Butchart 2000).

**MEASURES TAKEN** Legal protection certainly exists, but there is confusion about the timing and type of protection involved. It already had protected status in the 1940s (Uno 1949), but it was bestowed again in 1970 (MacKinnon 1978), although at neither time were the authorities in Sulawesi able to enforce the law (Uno 1949, MacKinnon 1978). It has also been protected under Indonesian law since 1972 (Inskipp 1986). It is listed on Appendix I of CITES.

***Protected areas*** Only 37 of the total of 132 nesting grounds have formal protected status. Six protected areas cover 32 inland nesting grounds: the Bogani Nani Wartabone (Dumoga-Bone) National Park includes ten nesting grounds; Lore Lindu National Park contains nine, but four of these are likely to be abandoned in the near future (Butchart and Baker 2000), Morowali Nature Reserve also contains nine nesting grounds, the Tangkoko-DuaSudara Nature Reserve (=Tangkoko-Batuangus Nature Reserve) includes the Tiwo/Remesun nesting ground; two sites on Buton are protected by the North Buton Wildlife Reserve, and Sungai Pampea is protected in the Rawa Aopa Watumohai National Park (see Table 1, Prawiradilaga 1997, Wardill *et al.* 1998, Butchart and Baker 2000). Five coastal nesting grounds are formally protected, but two are now abandoned or virtually abandoned: Tanjung Matop and Tanjung Bambalatang are protected in a 1,692 ha wildlife reserve (Butchart and Baker 2000); Tanjung Batikolo Nature Reserve protects a nesting ground (Dekker 1990); Kumu lies within the "Manembo-nembo Reserve" (MacKinnon 1981), but this site was listed as abandoned by Dekker (1990); and the Panua Nature Reserve was created in 1938 explicitly to protect a large nesting area (Panua being a local word for Maleo: MacKinnon 1981), but this site is now virtually abandoned (see Threats). At least three additional nesting grounds are located in *hutan lindung* ="protected forest" (see Table 1) but this confers little meaningful protection (S. H. M. Butchart *in litt.* 2000). In around 1980 the Indonesian Department of Conservation (PHPA) was in the process of acquiring the shoreline at Tanjung Panjang to establish a reserve there (MacKinnon 1981), but it was not listed as a reserve in Dekker (1990), and its current status is unknown.

Within Central and South Sulawesi (which include the significant reserves of Morowali and Lore Lindu), four nesting grounds are not yet threatened, and 68% of threatened sites lie in protected areas, whereas 95% of abandoned and 77% of severely threatened sites are unprotected; however, whilst protected status can reduce the threat of habitat degradation, even within protected areas forest is being cleared by local communities for agriculture, firewood and construction (Baker and Butchart 2000). Furthermore, reserve status fails to deter exploitation of eggs (Dekker 1990). Worse, changes in land rights can have negative consequences for nesting grounds previously exploited under traditional systems: Maleo population declines at Saluki in Lore Lindu were exacerbated when the area was gazetted as a national park in 1982, and the traditional system of management broke down and uncontrolled egg-collecting increased (Baker and Butchart 2000, Butchart and Baker 2000).

***Hatcheries*** Following the experiments reported in MacKinnon (1978, 1981), protected hatcheries were built at Tambun and Tumokang for the reburial of eggs gathered by park staff at Bogani Nani Wartabone (Dumoga-Bone) National Park, with average hatching rates of 55% at Tambun and 75% at Tumokang; this management, plus increased patrolling of both nesting grounds, led to the successful hatching of 700 Maleo chicks in the year 1985–1986 (Dekker and Wattel 1987). Baker and Butchart (2000) found two hatcheries operating in Central Sulawesi in 1998, at Tanjung Matop and Bakiriang, and additional abandoned hatchery programmes at Saluki and Taba (but see comments under Measures Proposed).

***Megapode Specialist Group*** From 1985 to the early 1990s fieldwork building on the work of MacKinnon (1978, 1981) was initiated under the title of "Maleo Project", involving the above hatchery experiments and evaluating the status and distribution of the Maleo in Sulawesi and the potential the species has for fulfilling a sustainable niche in the island's economy (Dekker and Wattel 1987, Dekker 1990, Argeloo 1994), and during this period the Megapode Specialist Group was formed (see Dekker and McGowan 1995). Most field studies relating to Maleo conservation, and most plans related to future initiatives for the species, are initiated, advised or coordinated through this group. The Maleo Project had as its targets, 1995–1999, the expansion of management activities like clearance of scrub at nesting sites, the monitoring of nesting grounds in North Sulawesi, the promotion of sustainable egg-harvesting, and searches for nesting grounds elsewhere in Sulawesi (Dekker and McGowan 1995). Work by Wardill *et al.* (1998), Baltzer (undated), Baker (1998), Butchart *et al.* (1998), Butchart and Baker (2000), Baker and Butchart (2000) and others (M. Argeloo *in litt.* 2000) described above has gone some way to meeting these targets.

**MEASURES PROPOSED** The following general programme has been outlined for practical management of nesting grounds: (1) Maleo populations can be built up again by policing nesting grounds both inside protected areas (by park staff) and outside them (by local authorities), enforcing a ban on egg-collecting for a number of years (with incentives to do so that represent a higher return than any exploitation could achieve, albeit with frequent independent monitoring of progress: R. F. A. Grimmett *in litt.* 2001), along with the removal of egg predators such as dogs and monitors from the areas in question, perhaps by shooting or using barriers, although Baker and Butchart (2000) warned that fencing runs the risk of negative consequences; (2) once the populations have reached an acceptable size, eggs can be exploited under strict supervision, with a certain percentage always being transferred to hatcheries, so that the harvest is sustainable and provides a continuous income to the harvesters and the protecting authorities; (3) tourist interest in viewing Maleo grounds can be encouraged through these practices, adding to the economic incentives to implement them (Dekker and Wattel 1987); (4) at many sites nesting ground suitability could be improved by clearing, burning or trimming vegetation (particularly the vigorous invasive *Lantana camara*) to increase insolation (MacKinnon 1981, Sinclair *et al.* 1996, Baker and Butchart 2000), and by raking sand over burrows to make detection of eggs by unauthorised collectors more difficult (Baker and Butchart 2000).

The translocation of eggs to "virgin" sites is a poor alternative to protecting known sites, but carefully constructed programmes to re-establish the species at former nesting grounds would be very welcome, if human exploitation could be eliminated (MacKinnon 1978). However, before such work can be contemplated, a major body of biological information must first be gathered on a variety of factors such as those that determine nesting ground choice by first-time and repeat breeders (MacKinnon 1978). The possibility that nesting grounds in "safe" areas might be created through soil preparation and the use of sand deserves consideration, at least at some stage, although again the prior need remains for more robust biological data on the species's life-history.

MacKinnon (1981) recommended that outside reserves the best strategy for Maleo conservation would be to require villages to establish hatcheries and stock them with predetermined numbers of eggs *before* harvesting for consumption occurs, the harvest being dictated by the state of the population, with the aim of reaching the situation in which the number of harvested eggs would be as high as the proportion normally lost to natural mortality factors. This recommendation was reiterated by Dekker and McGowan (1995). However, following fieldwork in 1998, it was argued that inadequate management, insufficient funding, unmotivated guards, the lack of monitoring and an absence of local political support and sustained commitment of resources had all significantly reduced the effectiveness of hatcheries, that hatchery programmes should only be continued if these problems can be addressed and that no new hatcheries should be initiated (Baker and Butchart 2000).

Protection of nesting grounds within designated reserves should be strengthened as a matter of urgency (Baker and Butchart 2000). This must involve more intensive patrolling, effective prevention of illicit egg-collecting, habitat degradation and hunting, and strict enforcement of punishment for offenders. Close collaboration between conservation NGOs and the forest department, and effective management of forest officers, are required in order to achieve these results (Baker and Butchart 2000). New laws on the protected status of the Maleo need to be advertised and enforced, including the prevention of the illegal trade in eggs (MacKinnon 1978).

The following eight-point programme of recommendations was made by Dekker (1990), here greatly abbreviated: (1) protect all nesting grounds inside protected areas; (2) gather data on nesting ground status and numbers of pairs; (3) keep nesting grounds clear of invasive vegetation; (4) create additional pits at sites where birds compete intensively for existing pits; (5) extend the number of hatchery projects (but see comments above); (6) extend protected area status to certain nesting grounds, and encourage nature tourism with Maleos as the target; (7) plan and experiment for the repopulation of certain former sites; (8) ensure that future development takes the existence of Maleo nesting grounds into consideration.

In respect of recommendation (6) above, protected status should be extended to six severely threatened coastal nesting grounds in North Sulawesi, namely Molobog, Torosik, Buntalo, Sangkup, Molonggota and Dehua, as (in the early 1990s) they still retained adjacent forest and still offered the chance to be maintained free of vegetation (Argeloo 1994). A comment on the need to establish one or more major tracts of low-lying forest on Sulawesi as reserves is made in the equivalent section under Blue-faced Rail. Moreover, a suggestion for the preservation of a further area of montane forest on Sulawesi, fulfilling a proposal in Indonesia's original national conservation plan, is made again in the equivalent section under Blue-faced Rail. In respect of recommendation (7) above, the discovery of a female at Tambun which had been wing-tagged five years earlier 25 km away at Tumokang indicates that birds are not necessarily faithful to the nesting ground at which they hatched (Argeloo 1994); this should at least be recalled when planning repopulation programmes.

In Central and South Sulawesi, conservation efforts should be prioritised in eight areas which at present have the most favourable conservation status, and hence the best chance of successfully protecting Maleos: these comprise two areas on the north coast (Tanjung Dako and Tanjung Matop, this latter being particularly important and viable), the provinces' two major protected areas (Lore Lindu National Park and Morowali Nature Reserve), and four sites on the eastern peninsula (Sungai Bosu, Libun, Bakiriang and Pintu Kubur) (Butchart and Baker 2000). Tanjung Matop is the highest priority coastal site in the northern or western part of Central Sulawesi, with a large and apparently stable Maleo population, some form of control over egg-collecting, and a conservation programme already in place; however, problems with the hatchery scheme need to be addressed urgently, and a coordinated conservation programme should be developed for this site and the two neighbouring sites (Butchart and Baker 2000). In Lore Lindu National Park, Maleo conservation efforts should be prioritised at Hulurawa, Saluki and Pakuli, where control of access by people requires significant improvements, forest guards need to be motivated, offenders punished, and intensive education programmes in the surrounding villages introduced (Butchart and

Baker 2000). In Morowali Nature Reserve egg-collecting by non-indigenous people at coastal nesting grounds and at Kilo Dua needs to be effectively controlled by empowering park guards and increasing the frequency of patrols (Butchart and Baker 2000). At Sungai Bosu, where development of land for an oil palm plantation adjacent to the nesting ground is proposed, a corridor of forest should be retained along the river to connect mid-altitude forest to the nesting ground, and guards should be appointed to control human disturbance (Butchart and Baker 2000). At Bakiriang an arrangement should be made with the royal family of Banggai and the local authorities to restore and implement the traditional harvesting system, which would generate its own policing controls (Argeloo and Dekker 1996), and the hatchery scheme at this site needs significant improvements (Butchart and Baker 2000). At Pintu Kibur the nesting ground should be given formal protected status and egg-collecting controlled through restricting access upriver from Watu Songo (Butchart and Baker 2000).

In the mid-1980s, there was a general emphasis on the importance of public information and education involving or planning film-making, television programmes, newspaper articles and poster campaigns (Dekker 1987). Indeed, the Maleo is an "extraordinarily suitable flagship species" because the species is so well known, being the official symbol of Central Sulawesi, with "Maleo monuments and namesakes throughout the island" (Baker and Butchart 2000). Community education needs to focus on the Maleo's uniqueness and endemism to Sulawesi, its conservation status, the extent of population declines, the degree to which it is threatened by habitat degradation and egg-collecting, and the urgency of protecting this species, because there is widespread ignorance regarding these facts (Baker and Butchart 2000).

Holmes (1989) called for renewed initiatives in community-based protection, and this has been reiterated more recently: within protected areas, agreements between forest department officials and local community leaders are needed, preferably with the involvement of local conservation NGOs (J. C. Wardill *in litt.* 1999). Community management of resources may be the most successful strategy in the long term, but such programmes "need to be developed with a deep regard for local politics if they are to be successful" (Baker and Butchart 2000). A network of local conservationists, researchers , government departments and international NGOs should be formed to cooperate on long-term, island-wide conservation programmes for the Maleo, with a view to distributing an Indonesian-language document detailing a realistic agenda for its protection (Baker and Butchart 2000).

***Further surveys*** Further fieldwork should concentrate on long-term monitoring of Maleo populations at nesting grounds to gain better data on population trends; detailed information from individual sites on the number of burrows used daily over the whole season are required to validate and refine population estimates (Butchart and Baker 2000). Confirmation of the annual egg output by individual females and the hatching success of eggs is required (K. D. Bishop *in litt.* 2000). Radio-tracking of adult hens would clearly yield a great deal of valuable data for management purposes (Dekker 1987). Future searches for nesting grounds should be focused on the coast south of Wosu, inland areas in the northern part of the eastern peninsula and in South-east Sulawesi, but "it is unlikely that there are many nesting grounds yet to be discovered by local people", because rattan-collectors and hunters visit even very remote forested regions (Baker and Butchart 2000, Butchart and Baker 2000). Searches should also be made in the extensive tracts of hill and montane forest south of Lore Lindu National Park which extend into South-west Sulawesi, and in the Paleleh and Ogoamas mountains (K. D. Bishop *in litt.* 2000). The use of infra-red satellite images has been proposed in order to detect hot springs inside forest where undiscovered nesting grounds might be found (Dekker 1987).

***Captive breeding*** In the mid-1990s there were some birds in captivity (Winn 1992, Dekker and McGowan 1995) but there is no direct or significant relevance of *ex situ* captive breeding (in contradistinction to hatchery programmes) to the conservation of this species.

**REMARKS** (1) This is a highly distinctive megapode fully justifying its monotypic genus. Perhaps its most striking feature is the enlargement of the rear skull to produce a casque in both sexes, and it has been suggested that this is an adaptation for heat loss (the birds being exposed to violent temperatures on open beaches while excavating nest holes) and/or for shock absorption when hammering open hard seeds (D. N. Jones *et al.* 1995). Wallace (1869) also noted its departure from typical megapodes (=big feet) in *not* having particularly big feet, since of course it is not a mound-builder, but adapted over aeons to excavate nest-holes in soft volcanic sand.

(2) *Site classification* (This entire section is based on a review of evidence by S. H. M. Butchart.) Torosik (site 7 in Argeloo 1994) is synonymous with Terosik (site 10 in Dekker 1990). Pinolosian (site 10 in Argeloo 1994) is synonymous with Pinolosean (site 13 in Dekker 1990). Wakat (site 22 in Argeloo 1994) is synonymous with Mokodite-Wakat (site 28 in Dekker 1990). Tiwo/Remesun (site 2 in Dekker 1990, site 30 in Argeloo 1994) was treated as a single site by these authors, but Sinclair *et al.* (1996) discussed them separately, noting that Tiwo was abandoned and Remesun retained only four areas of active burrows, c.7% of the area previously used, but eggs were still being collected and hence the site was severely threatened. For consistency they are treated as a single site (30) here following Dekker (1990) and Argeloo (1994). Hornskov (1992) reported sightings at Doloduo and Toraut in Bogani Nani Wartabone (Dumoga-Bone) National Park; these presumably refer to individuals from the well known nesting grounds listed above, e.g. Tambun (K. D. Bishop *in litt.* 2000). Tapokolintang (site 42 in Argeloo 1994) is synonymous with Molibagu (site 19 in Dekker 1990). Negeri Lama I (site 43 in Argeloo 1994) is synonymous with Negeri Lama (site 20 in Dekker 1990). Bulo Oliyo (site 50 in Argeloo 1994) is synonymous with Tanjung Bulo Olio (site 29 in Dekker 1990). Nalu (site 7 in Butchart and Baker 2000) is synonymous with Toli-toli (site 33 in Dekker 1990, site 58 in Argeloo 1994), but is more accurately known by the former name (see Butchart *et al.* 1998). Saluki and Mapane were treated as a single site by Dekker (1990, site 35) and Argeloo (1994, site 60), but Butchart *et al.* (1998) thought them better treated as separate sites, and they were listed as sites 21 and 22 respectively in Butchart and Baker (2000). Sidaonta was listed erroneously as a confirmed nesting ground by Dekker (1990, site 36) and Argeloo (1994, site 61); see Butchart *et al.* (1998). Tanjung Tambue (site 37 in Butchart and Baker 2000) is synonymous with Pasangkayu (Baltzer 1990; listed as site 76 in Argeloo 1994); see Butchart *et al.* (1998). Tanjung Dapuran (site 43 in Butchart and Baker 2000) is synonymous with Tanjung Dapurang (site 78 in Argeloo 1994; referred to as Majene in Baltzer 1990). Sungai Bosu (site 47 in Butchart and Baker 2000) is synonymous with Wosu (site 75 in Argeloo 1994, see also Andrew and Holmes 1990, Dekker and Argeloo 1992); see Baker (1998). Andrew and Holmes (1990) reported a pair seen along a gravel road through forest near Salonsa (02°12′S 121°34′E) on 12 May 1981. These birds may have derived from the Sungai Bosu nesting ground (approximately 20 km ESE from Salonsa), or alternatively an undiscovered nesting ground may lie on the coast north-west of Sungai Bosu, or in the forest inland around Salonsa. Ambunu (site 48 in Butchart and Baker 2000) is synonymous with Ambuno (site 74 in Argeloo 1994; see also Dekker and Argeloo 1992). Sungai Karaopa (Andrew and Holmes 1990, site 73 in Argeloo 1994) is synonymous with Sungai Karoapa [*sic*] (site 49 in Butchart and Baker (2000). Within Morowali Nature Reserve, Kilo Dua (site 51 in Butchart and Baker 2000) is synonymous with Morowali Kecil (site 46 in Dekker 1990, site 72 in Argeloo 1994), and Kilo Tujuh, Kilo Sembilan, Kayu Poli, and Batu Katunda (sites 52–55 in Butchart and Baker 2000) are presumed to correspond to Morowali Besar and Morowali 1–3 (sites 42–44 in Dekker 1990, sites 68–71 in Argeloo 1994). Taima was reported to be a nesting ground by Dekker and Argeloo (1992), who noted observations by Priyono of five pairs egg-laying in September 1990, but this site was regarded as synonymous with Libun by Argeloo (1994; M. Argeloo *in litt.* 2000). The same site was incorrectly described as being located at 1°36′30″S 123°21′36″E by Butchart and Baker (2000,

site 67); the correct coordinates are 0°36′30″S 123°21′36″E (S. H. M. Butchart *in litt.* 2000; see also Kobayashi and Gurmaya 1993).

The information regarding sites on Buton island is somewhat confusing. Pramono (1991) described a nesting ground on a sandy area around the headwaters of the Lebo river, north of the coastal village of Maligano. This is also presumed to be the site described by Viney (1995) on a riverbank inland from Maligano. Baltzer (undated) presumably referred to the same site when he described an area "near to Maligano [that] stretches along a river for up to 1.5 km amongst primary and secondary forest". Catterall (undated) provided more details and stated that "five breeding sites have been found along a 1.5 km stretch of river north of Maligano". Following Butchart and Baker (2000), this area is best regarded as a single site termed Lebo; in Argeloo (1994, site R) and Butchart and Baker (2000, site 72) it was incorrectly mapped as being located further east. Addin (1992, quoted by Prawiradilaga 1997) "reported the presence of Maleos along the Lebo and Lagito rivers (North Buton Wildlife Reserve between 122°47′ and 123°13′E)". Lagito should therefore be regarded as an additional site which was not recognised by Butchart and Baker (2000), and which is located to the east of Lebo. Sykes (1996, cited by Prawiradilaga 1997) reported Maleos "on the Maligano coast (between 4°20′ and 5°38′S)". This is presumed to refer to Lebo; it is unlikely to refer to an additional nesting ground because Viney (1995), Sykes (1996), Catterall (undated), and Baltzer (undated) were all associated with the same organisation (Operation Wallacea) and the two latter reports failed to mention any additional site in the area. Hence Butchart and Baker's (2000) site 73 "Maligano" should be regarded as redundant and synonymous with Lebo. A fourth site, Bubu, on the east coast, is described by Baltzer (undated) and listed as site 74 in Butchart and Baker (2000). The overall number of sites on Buton remains four as stated by Butchart and Baker (2000), but Maligano should be deleted and Lagito added (S. H. M. Butchart *in litt.* 2000). All four sites are probably still active, but their conservation status is best treated as unknown given the paucity of information.

Dekker (1990), Argeloo (1994), and Butchart and Baker (2000) additionally listed unconfirmed nesting grounds, based largely on reports from local people. Bakadia (potential site II in Dekker 1990) was confirmed and renamed Dodepo by Argeloo (1994, site 11). Mokodite-Wakat (potential site III in Dekker 1990) was confirmed and renamed Wakat by Argeloo (1994, site 22). Matop (potential site IV in Dekker 1994, potential site L in Argeloo 1994) was confirmed and renamed Tanjung Matop by Butchart and Baker (2000, site 3). Pulau Dolongan (potential site V in Dekker 1990, potential site M in Argeloo 1994) was found to be erroneous by Butchart *et al.* (1998). Taba (site 28 in Butchart and Baker 2000) was considered by these authors to be synonymous with Teluk Tomini (Coomans de Ruiter 1930; potential site VI in Dekker 1990; potential site N in Argeloo 1994), as "Teluk" means "gulf" and hence could refer any site along the coastline of the Gulf of Tomini. Lariang (potential site VII in Dekker 1990) was confirmed by Andrew and Holmes (1990) and treated as such by Argeloo (1994, site 77) and Butchart and Baker (2000, site 42). Mamuju (potential site VIII in Dekker 1990) was confirmed by Argeloo (1994, site 79) based on local reports, and was treated as such by Butchart and Baker (2000, site 44). Lebo (potential site R in Argeloo 1994) was confirmed by Prawiradilaga (1997) and treated as such by Butchart and Baker (2000, site 72). Watumohai (potential site IX in Dekker 1990, potential site O in Argeloo 1994, potential site H in Butchart and Baker 2000) was confirmed by Wardill *et al.* (1998) but this was overlooked by Butchart and Baker (2000). The site is renamed Sungai Pampea because Wardill *et al.* (1998) described burrows along and around a 2 km stretch of a river of this name, located near to Gunung (=mountain) Watumohai. Wardill *et al.* (1998) regarded the maleo to be threatened by egg-collection at this nesting ground.

Meyer (1979, 1890) reported Maleos on Tagulandang, Siau and Sangihe in the Sangihe group of islands, e.g. the species was found to be common in or around 1871 on Siau, with birds and eggs often being shipped to Menado (Meyer 1879). However Meyer and Wiglesworth

(1898) determined through inquiry that "birds were introduced there by a Rajah years ago and multiplied rapidly in consequence of its being unlawful to shoot them. But since this is no longer the case, the number has gradually decreased and now hardly any are found there." This source was cited as indicating that the species had entirely died out from the islands by White and Bruce (1986). Riley (1996) discussed local reports of Maleos on Tagulandang in the Sangihe islands (potential site A in Argeloo 1994), where he considered that a nesting ground may exist, and he also suggested that there may have been additional nesting grounds on the islands of Para, Siau and Sangihe. However, subsequently Riley (1998a) stated that "it seems highly unlikely that Maleo populations still exist on the Sangihe islands", and that "all recent reports of Maleo on the islands are now thought to refer to the Philippine Megapode [*Megapodius cumingii*] and arise from confusion with the latter species' local name of 'Maleo Gosong'". Butchart *et al.* (1998) also noted this confusion over local reports of Maleos. In the absence of any convincing data that Maleos have ever occurred naturally on the Sangihe islands, these sites are now considered to be erroneous. Similarly, Meyer and Wiglesworth (1898) reported the species on Lembeh island in March 1895 (specimen in AMNH), and stated that it was "said to occur on Bangka [island]". D. N. Jones *et al.* (1995) stated that the species possibly still exists on Lembeh and Bangka "but no records exist for the past few decades". Dekker (1990) implied that Maleos may have been introduced to these islands, as on the Sangihe islands. Hence these are also not regarded as genuine sites, given the lack of data suggesting that wild populations ever occurred.

Seventeen sites have not been confirmed by subsequent surveys and remain putative: (*North Sulawesi*): Pulau Bangka, Picuan, Raanan Lama, Tobajangan, Pulau Pondan, Mokima/Pangkasu, Tapa Togop, Negeria Lama 2, Bolontio, Molosipat (Dekker 1990, Argeloo 1994); (*Central Sulawesi*) Tamid, Pangkalan, Siboang, Tanjung Kramet, Tanamorambu (Butchart and Baker 2000); (*South-east Sulawesi*) Tanjung Peropa, Tanjung Amulenggo (Dekker 1990, Argeloo 1994, Butchart and Baker 2000). Wardill (1995) also suggested that further nesting grounds in addition to Sungai Pampea may be present in the Rawa Aopa Watumohai National Park in South-east Sulawesi.

Historical records and specimens from sites which mostly cannot be matched to specific nesting grounds include: Duluduo or Duluduk, 150 m, December 1893 (Meyer and Wiglesworth 1895a); Kumarsot, Tonsea, Minahassa, 200–250 m, February 1931 (three males in AMNH), March–April 1939 (five specimens in RMNH, ZMA); Boujat, before 1840 (two specimens in RMNH); Saousou, June 1863 (female in RMNH); Pagouat, August 1863 (two specimens in RMNH); Kema, August 1864 (male in RMNH), August and November 1893 (Meyer and Wiglesworth 1895a); Bolaang, March 1917 (male in RMNH) possibly = Belang, site 34; Poopo, January 1940 (male in RMNH); Prigor, Amurang, July 1925 (egg in RMNH); Burukan, July and October 1884 (two males in SNMB); Kap Flesko, 1894 (Meyer and Wiglesworth 1895a), = Cape Flesko (Sarasins in Meyer and Wiglesworth 1898); Bolontio (Meyer and Wiglesworth 1898); Kalinaong, May 1871 (Meyer 1879); Soputan ("sand-volcano"), June 1871 (Meyer 1879); Djiko, Minahassa, April 1930 (hatchling in AMNH); a specimen probably from Minahassa (Blasius 1896); Bumbaraedjaba, November 1916 (Riley 1924); Labua Sore, November 1916 (Riley 1924); Kuala Prang, May 1916 (Riley 1924); Rumusum, June 1916 (Riley 1924) possibly = Tiwo/Remesun, site 30; reports almost certainly referring to Batu Putih (site 1) including: 11 specimens (in BMNH, RMNH, SNMS) from Menado before 1840 to February 1895 (Meyer and Wiglesworth 1895a); another specimen from Menado in 1895 (Hose 1903; but see Remarks 3); near Menado, evidently September 1883 (Guillemard 1885); Wallace Bay = Batu Putih (i.e. the bay between the island of Limbe and Banca: Wallace 1860), September 1883 (Guillemard 1885; seven specimens in AMNH); Gunung Klabat, 1860 (Wallace 1860); a report of nesting in the Bone valley in January 1894 (Meyer and Wiglesworth 1895a) which presumably corresponds to one or more of the nesting grounds known from the Bogani Nani Wartabone (Dumoga-Bone) National Park (sites 37–

39, 41, 44–49); near Gorontalo (Hose 1903; this may refer to any of a number of nesting grounds in Gorontalo district, e.g. site 51, or sites 37–39, 41, 44–49 in Dumoga-Bone National Park), Paleleh, October 1930 (male in ZMB) = site 57; Central Sulawesi: Loko mountain, between Eurekang and the Mandar Gulf, September 1895 (Meyer and Wiglesworth 1896) = Lokon volcano, (Sarasins in Meyer and Wiglesworth 1898); Wawo, January 1932 (Stresemann 1932); Konoweha near Kolaka, February 1932 (female in ZMB) = site 127.

(3) Hose (1903) began his narrative by saying he arrived in Sulawesi in October 1895 and proceeded to spend two months there. However, the date he gave for the specimen from Menado is 11 February, and he stated he took it himself. Hose also gave records of other species, including Blue-faced Rail *Gymnocrex rosenbergi* (see relevant account), from September, without explanation. Bafflingly, however, his only *Gymnocrex* specimen in BMNH is dated January 1889!