A rearing of *Antheraea (Antheraea)* sp. (probably *jana* (Stoll, 1782)) from Bali, Indonesia (Lepidoptera: Saturniidae)

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Abstract: The preimginal morphology of *Antheraea (Antheraea)* sp. (probably *jana* (Stoll, 1782)) from Bali, Indonesia, is described and illustrated in colour, based on the offspring of one yellow female collected in the wild. It is a typical member of the *mylitta/frithi*-group of the subgenus. A second generation was achieved. Larval variability appears to be quite high, when seeing many caterpillars reared under quite different conditions by different rearers; even silvery air-filled spots were observed in some larvae.

Eine Zucht von *Antheraea (Antheraea)* sp. (wahrscheinlich *jana* (Stoll, 1782)) von Bali (Indonesien) (Lepidoptera: Saturniidae)

Zusammenfassung: Die Präimaginalmorphologie einer Art von *Antheraea (Antheraea)* sp. (wahrscheinlich *jana* (Stoll, 1782)) von Bali (Indonesien) wird beschrieben und farbig abgebildet. Von dem im Freiland gefangenen gelben Muttertier konnten zwei Zuchtgenerationen erzielt werden. Die Präimaginalstadien sind typisch für die *mylitta/frithi*-Gruppe der Untergattung. Wenn man die größeren Stückzahlen von Raupen, die unter teilweise unterschiedlichen Bedingungen von verschiedenen Züchtern aufgezogen wurden, vergleicht, stellt man eine beträchtliche Variabilität fest. Sogar silberglänzende luftgefüllte Flecke konnten bei wenigen Raupen beobachtet werden.

Introduction

Antheraea is evidently the most species-rich genus of Saturniidae in the Indo-Australian fauna. However, preimaginal morphology and life-histories are still known for some of these species only. Nässig et al. (1996) and Nässig & Treadaway (1998) provided some overview about the present knowledge; a further description was published by, e.g., L. H. & U. Paukstadt (1999).

When returning from a travel to Bali in late January 1999, Dr. Karel Černý (Zirl, Austria) managed to pass on two papered females of *Antheraea (Antheraea)* to the junior author of the present publication via the Frankfurt Airport staff while in transit in Frankfurt. The two ♀♀ were collected at light on January 16, 1999, in Indonesia, N-Bali, [Buleleng District], 1 km N Lake Buyan, 1340 m. One ♀ was yellow ("no. 1", Fig. 2), the other one dark brownish ("no. 2", Fig. 1). While there were relatively many eggs from (the then still alive) ♀ no. 1 (not counted, ca. 80–120), ♀ no. 2 layed only a few in its envelope; the eggs were kept separate. So the junior author sent L_1 larvae from ♀ no. 1 to Berlin, while he kept the few caterpillars of ♀ no. 2.

In their envelopes, the yellow one of the two ♀♀ was still moving on arrival, the other one was dead, but still soft. Both were injected with killing fluid and set. Hatching of the first larvae commenced upon arrival on January 28th (i.e., ca. 12 days after the first oviposition), and further larvae eclosed over more than a week.

Of the few eggs of ♀ no. 2, only a very few larvae hatched, but seemed to be weak and not fully viable from the very begin and died within a few days without feeding. The larvae of ♀ no. 1 hatched at about 90 %, so there were plenty of them. However, it took some time (at least one day) until they commenced feeding on evergreen oak, and about a third of the larvae kept in Frankfurt did not start feeding at all.

Abbreviations and conventions follow Nässig & Treadaway (1998: 229 f.).

Identity of the species

As shown by U. Paukstadt et al. (2000), the status of Javanese and Balinese saturniid species still remains to be studied in more detail. Also, the type specimen of Stoll's taxon *jana* is most likely lost, and the illustration in his book is not unambiguous (see Nässig 1992, depicting a b/w photograph of the copy of Stoll 1782 in the library of Claude Lemaire). Therefore the identity of the taxon reared remains slightly dubious.

However, it is at least quite likely that the yellow ♀♀ no. 1 (Fig. 2) (and its offspring, Figs. 3–6) and the corresponding orangy-brown ♂♂ (Figs. 7 & 8, specimens collected in the wild) with yellow highlights from Java and Bali belong to *Antheraea (Antheraea) jana* (Stoll, 1782).

Although it appears feasible that the two different ♀♀ (see Figs. 1 & 2) were colour forms of the same species (the hatching L_1 larvae were indistinguishable), this cannot be proven presently, because no offspring was achieved from female no. 2.

To remain on the safe side, we prefer to identify the yellow ♀ no. 1 and its offspring as "probably *jana*" for the time being. U. & L. H. Paukstadt and U. Brosch are presently preparing a revision of the genus *Antheraea,* and we expect that in the course of this revision eventually the identity will be assessed.

Rearing report

Newly hatched L_1 larvae of female no. 1 were sent to the senior author. Some of these were passed on to U.

[1] 53rd contribution to the knowledge of the Saturniidae.

Weritz, Braunschweig, because no evergreen oak was available in Berlin. Rearing data for the first generation (F_1) see in Table 1.

Table 1: Rearing data of the F_1 generation (offspring of female no. 1) by different rearers.

All dates in 1999	W. A. Nässig	S. Naumann	U. Weritz
L_1 hatching (♀ collected 16. i.)	28. i.–ca. 8. ii.	–	–
moult to L_2	not recorded	15. ii.	8. ii.
moult to L_3	due to	24. ii.	14. ii.
moult to L_4	lack of time	7. iii.	20. ii.
moult to L_5	and traveling	21. iii.	25. ii.
moult to L_6	– (no L_6)	– (no L_6)	2. iii.
cocoon	dates not recorded (April)	4.–9. iv. (4 cocoons)	8. iii. (♂)/ 11. iii. (♀)
hatching of specimens	26. v.–23. vi. (6 ♂♂, 6 ♀♀)	16. v. (1 ♂, 1 ♀)	29. iii. (1 ♂)/ 1. iv. (1 ♀)
F_2 pairing	–	17. v. (see below)	–

Rearing of the F_1 generation took place with different evergreen *Quercus* species (Fagaceae); the material in Berlin and Braunschweig was reared with *Quercus × turneri "pseudoturneri"*, while the Palmengarten in Frankfurt provided a variety of different evergreen oak species; the changes in food, sometimes from day to day, were usually accepted by the larvae without problems. Only the leaf texture and the corresponding speed of the desiccation of the plant material made relevant differences in the suitability of the different oak species as larval food.

Rearing conditions were diverse: Room temperature (ca. 19°–23° C in Berlin, ca. 20°–25° in Frankfurt in January–April, ca. 18°–22° C in May/June) with larvae kept in closed containers (early instars, later partly covered with cloth to allow drier conditions or freely in the room on watered twigs without any cover) versus nearly tropical conditions (12 h-day) in a warm and wet greenhouse in Braunschweig. The "tropical" greenhouse rearing by U. Weritz resulted in an additional 6th instar, but the rearing from L_1 larva to imago took less than 9 weeks, while the more unnatural rearing conditions in Berlin and Frankfurt resulted in only 5 instars, but a development time from eggs to imagines of between 15 weeks (in Berlin) and 16 to nearly 21 weeks (in Frankfurt).

The junior author did not manage to get a copulation of the specimens hatching, because they hatched in great intervals. However, the senior author achieved a pairing with the pair hatching from his cocoons, and eggs of the F_2 generation were dispersed to different rearers (U. Weritz again, U. Brosch, Hille, M. Beeke, Hille, U. & L. H. Paukstadt, Wilhelmshaven, and U. Nardelli, Vela, Trento, Italy). The rearing was only in part successful (total losses in early instars by Beeke, Nardelli & Weritz); some imagines of the F_2 generation are in the collections CUBH, CUPW, and CSNB. In all cases, the larvae of the F_2 did not accept the European oak species (*Q. robur*) and were, therefore, in most cases reared with ornamental apple (*Malus hilleri*, Rosaceae) for the early instars, later with European birch (*Betula pendula*, Betulaceae), else again with evergreen oak ("*pseudoturneri*").

The ♂ of the pair hatched on 16. v. (1:00 h), the ♀ on 15. v. (18:00 h). Pairing in a cage in the room in front of an opened window took place around 1:30 h on 17. v.; the pair remained in copula until the following evening and parted at ca. 22:00 h on 17. v. The number of eggs deposited see in Table 2. The ♀ was later kept alive in an envelope, where it deposited its eggs. The envelope was changed every day, and the eggs were counted; altogether 355 ova were layed by the ♀ over its live.

In the F_2-rearing of the senior author, only 1 ♂ hatched on 15. vii. 1999. Due to a travel, this single specimen was brought up by Bernd Kalipke, Berlin.

Table 2: Eggs deposited by the ♀ of the F_1-pairing, giving rise to the F_2 generation.

Dates (1999)	no. of eggs deposited	comment
17./18. v.	134	in small groups up to 6
18./19. v.	72	
19./20. v.	83	material partly sent to Paukstadt & Brosch
20./21. v.	37	material partly sent to Nardelli & Weritz
21./22. v.	0	
22./23. v.	2	
23./24. v.	8	
24./25. v.	17	
25./26. v.	2	
26.–29. v.	0	♀ killed on 29. v.
Total	355	

Description

Eggs (Fig. 9): flattened, round (nearly circular), of the lying type with the micropyle on the side. Ground colour an opaque light brownish or cream colour (darkened by the adhesive secretion), with two dark brown (hyaline?) "equatorial rings" below and above the micropyle. — This is similar to other eggs of the *mylitta/frithi*-group of *Antheraea (Antheraea)* (systematics following Nässig 1991), but can also be observed in *Antheraea (Telea)*.

(In earlier publications starting with Nässig 1991 we used the term "*paphia/frithi*-group" for this aggregate; however, as the taxon *paphia* Linnaeus, 1758 is of somewhat dubious identity and probably may not correctly be associated with the genus *Antheraea*, we prefer to use the clearly identified name *mylitta* Drury, 1773 now; see also Nässig & Treadaway 1998: 286.)

There were different numbers of moults in the different rearings; the two authors observed only 5 instars, while

U. Weritz and U. Brosch found 6 instars. Evidently this number of moults indeed is variable, just as the observed morphology. We describe here our own rearings, supplemented with some observations provided by U. Brosch where indicated.

L_1: ground colour, when newly emerged, orangy yellow, later turning yellow and finally yellowish green just before the first moult. Abdominal segments A1–A7 (less so on A8) laterally with two black dots on each side, one in front and one behind the spiracle and the ring of scoli. Prothoracic shield (with dorsal and subdorsal scoli in contrasting yellowish ground colour – the two dorsal ones are widely separated from each other middorsally, but nearly fused to the subdorsal ones), anal plate, and disto-lateral shields on the anal prolegs totally velvety black. Head blackish brown. – This is very similar to most other species of the *frithi*-subgroup, see for comparison, e.g., *A. (A.) gschwandneri* (sensu Nässig et al. 1996, Appendix I: fig. 25, p. 144/145), those two indeterminate *A. (A.)* larvae from the Philippines (Nässig & Treadaway 1998: figs. 136–138, 151–153) or *A. (A.) platessa* (L. H. & U. Paukstadt 1999: fig. 1). But even the larvae of some of the Nearctic *A. (Telea)* show a similar pattern on greenish ground (Nässig et al. 1996).

L_2: The caterpillar changes drastically from L_1 to L_2. It shows now the typical *Antheraea (Antheraea)* pattern with yellowish green ground colour, a yellowish supraspiracular lateral stripe merging into the triangular lateral anal pattern, etc. Head: deep dark brown, with a brighter brown colour at the rear end; frons contrasting bright brownish, often even red (Fig. 14); antennal sockets and clypeus yellowish or whitish. The articulate legs are dark brown, the prolegs have nearly black lateral shields, except the anal prolegs. Ground colour yellowish green. The whole body is covered with small whitish spatulate hairs with enlarged bases; dorsally some of these hairs are elongate and not spatulate, much longer. Scoli still of the "Sternwarzen" type ("asterisk-like warts"; compare Nässig 1989); colour of them very variable, from yellow (Fig. 17) over orange (Fig. 15) and red (Fig. 16) to nearly blackish (Figs. 14, 16); often base brighter than top of the scolus.

L_3: About in this or the following instar the pattern, structure and colours reach more or less the mature conditions. The scoli become reduced to flattened "warts", with usually only one soft black hair left. The scolus is now usually blue; such blue scoli were also observed in *A. (A.) rumphii* (C. Felder, 1861) (L. H. Paukstadt et al. 1996). In later instars the scoli just get further reduced. Secondary hairs now yellow; sparse short spatulate hairs and, mainly dorsally, fewer long bristles, bend towards the head. – L_3 in the authors' rearing ca. 20 mm long before moult.

L_4: Similar to former instar. In some of the rearings (e.g., in UBH's) there were a few caterpillars which, at least in penultimate and ultimate instar, showed some silvery pattern (tracheal chambers filled with air just below the cuticle) above the spiracle on a few segments (usually on A2 only), see Fig. 20. The two authors, however, did not observe this pattern. – L_4 in the authors' rearing ca. 25 mm long soon after moult.

L_5 (last instar): Similar to former instar. Head deep brown, laterally brighter, with darker pattern (Fig. 22). Prothoracic shield brownish, towards the rear end green; prothoracic scoli nearly totally reduced now. Scoli further reduced, but still present; blue, the two dorsal rows on the abdominal segments more dark brownish. Prolegs brown distally, proximally green, with black dots (hair-bases with one hair each). Articulate legs brown. – L_5 in the authors' rearing starting with ca. 30 mm length soon after moult; reaching ca. 65–70 mm length at maturity. Diameter (when elongate) ca. 7 mm. The larva is, just like the resulting moth, a smaller and elongate one, compared with other species.

L_6 (last instar UBH): Practically identical to our last instar. The differences are mainly found in the size development. The instars from L_3 to ultimate instar (irrespective of the number of moults) do not differ very much except in size and individual variability.

The mediodorsal larval scoli on segment A8 have a fused base, but the tips remain separate in **all** instars.

Cocoon: Usually spun between leaves or between a twig and leaves, with some strong silken attachments to the surrounding (the nearest twig usually), but not a well-developed stiff, free-hanging "peduncle". Cocoon wall thin, but strong and hard. Silk silvery whitish, with some brownish strands externally. This colour is probably caused by some secretion filling the silk matrix. Shape very elongate ovoid. The texture on the top of the cocoon, where the moth emerges, is different from the rest, and there appears to be some type of a preformed valve-like exit, but with the silk totally glued together.

Pupa: Dark blackish brown. A hyaline "window" above the eyes.

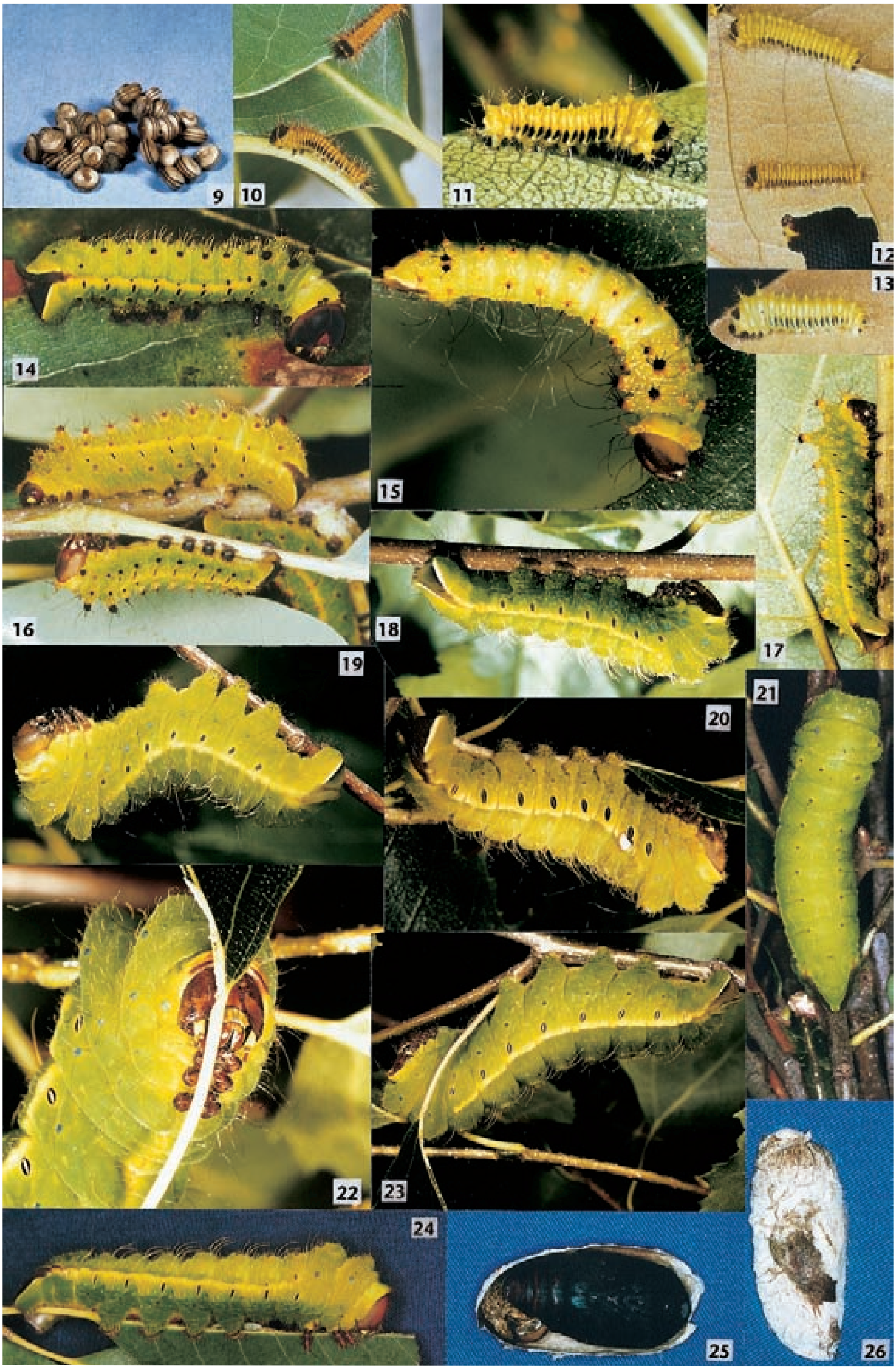
Imagines: All ♀♀ from the rearing were yellow, a dark brown form was not found. However, it is well known that the ground colour of imaginal saturniidae may exhibit a lot of genetically determined or climate-dependant variability. So this result does not rule out that the second ♀ collected in Bali might be the same species as the one with yellow ♀♀. In other species (e.g., in *A. (A.) semperi* C. & R. Felder, 1861 from the Philippines) the variability range is much larger than a simple dimorphism.

Discussion

This was the first time that a SE Asian *Antheraea* species was reared synchronously by different rearers under different conditions and with different foodplants over two generations. So we have, for the first time, the chance to learn about the natural variability of the offspring of one single ♀ collected in the wild. In most other rearing attempts, only a few larvae (if any!) reached maturity

Colour plate A, Fig. 1: Brown female, "no. 2", collected by K. Černý in Bali. **Fig. 2:** Yellow female, "no. 1", collected by K. Černý in Bali, the mother of the rearings described here. Fig. 3: Male offspring of female no. 1, F_1 generation (dwarfed form due to suboptimal rearing conditions; reared by the junior author, hatched 1. vi. 1999). (All three specimens in CWAN in SMFL.) **Figs. 4–6:** Male and female offspring of female no. 1, F_1 generation (reared by the senior author, live specimens, the ♂ [**Fig. 4**] sitting on a twig, the ♀ [**Figs. 5**, upperside, **& 6**, underside] sitting on its cocoon). **Figs. 7–8:** Male specimens collected in the wild at other occasions, but most likely conspecific with female no. 1 (deposited in CWAN in SMFL): **Fig. 7:** same locality as the 1999 ♀♀, collected by K. Černý on 8.–10. ii. 1997. **Fig. 8:** Bali, Candi Kuning, 1200 m, 13./14. i. 1989, leg. D. Kovač & S. Steghaus-Kovač. — Scales (where provided) in cm. — Photographs 1–3 and 7–8 by W. A. Nässig; 4–6 by S. Naumann. — **Note:** The photographs printed on the colour plates A and B were taken by different photographers with different equipment and film material at different times; therefore the colour accuracy is not optimal, and there may be different colour tones in the pictures.

Colour plate B, Fig. 9: Eggs, deposited by the F_1 pairing achieved by the senior author, rearing UBH. **Fig. 10:** newly hatched L_1, orangy yellow colour. **Fig. 11:** L_1 in moult to L_2, now deep yellow. **Figs. 12/13:** L_1 larvae of different ages in different colours. **Fig. 14:** L_2 larva with dark scoli and a very prominent and contrasting (reddish) frons within the blackish head capsule; clypeus and antennal sockets are yellowish. **Fig. 15:** L_2 larva with more



orangy scoli. Clearly visible: the separated dorsal scoli on A8. **Fig. 16:** L_2 larvae in different sizes and different colours; prolegs with black base. **Fig. 17:** L_2 larva with yellow scoli. **Fig. 18:** L_3 larva; most scoli are now reduced in size and bluish. **Fig. 19:** Larva approximately in L_4 just before a moult. **Fig. 20:** L_5 larva (penultimate instar, UBH rearing) with a very prominent silvery spot (a tracheal chamber filled with air underlying the cuticle) on A2 just above the spiracle within the supraspiracular lateral stripe. This silvery spot was found in only a very few larvae, and this character evidently is part of the variability in many species. **Fig. 21:** L_5 (ultimate instar, SNB rearing), dorsal view. In last instar the dorsal rows of scoli are often no more brilliant blue, but somehow brownish or greenish. The dorsal scoli on A8 are still separated. **Fig. 22:** L_6 (ultimate instar, UBH), ventral view and "portrait". **Fig. 23:** L_6 (ultimate instar, UBH), lateral view. **Fig. 24:** L_5 (ultimate instar, WAN). **Figs. 25/26:** Cocoon, cut open, with pupa. — Photographs 10, 12, 13, 16, 24 by W. A. Nässig (F_1 generation on different evergreen oaks); 14, 21, 25, 26 by S. Naumann (F_1 generation on evergreen *Quercus* × *turneri "pseudoturneri"*); 9, 11, 15, 17–20, 22, 23 by U. Brosch, Hille (F_2 generation, late instars on *Betula pendula*).

and eventually developed into imagines. Many earlier descriptions were, therefore, based on extremely small numbers (often the "famous n=1-rearings") and did not tell us anything about individual variability.

Nothing can be said about the behaviour of the species (courtship behaviour, required mating conditions, diurnal flight times, preferred ambient conditions like humidity, light, temperature, etc.) in its original habitat. The area where the species was collected is a remnant of a primary montane rainforest with temperatures around 30° C and high humidity during daytimes, but during the nights the temperatures in mountains on Bali may fall below 10° C. Specimens of this *Antheraea* species from Bali in the senior authors' collection derive from altitudes between 1200 and 1650 m, so it seems to prefer the described climate. It still is unclear, whether in the natural habitat the species normally has only 5 (or even less?) or 6 or more instars, and which factors have ruled the alteration of the number of moults, the size or the colour of the resulting imagos unter artificial conditions during rearing in Europe. Generally, higher temperatures and more humidity speeded up the development time, but in this case also resulted in the increase of the number of instars which normally is a strong hint for suboptimal conditions. Further research, especially in the field, may be necessary.

Acknowledgements

Thanks are due to Dr. Karel Černý (Zirl, Austria) for obtaining the females. The Palmengarten of the City of Frankfurt am Main (C. Barthelmes, M. Breimhorst, by kind support of D. Breimhorst) regularly provided evergreen oak leaves as food for the caterpillars in Frankfurt. Ulrich Weritz, Braunschweig, provided food for the rearing in Berlin. Thanks to Ulrich Brosch, Hille, for his fine photographs of the F_2 rearing in Hille and his permission to reproduce some of them here.

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 ISSN 0723-9912