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Description of a new cavity nesting species of *Apis* (*Apis nuluensis* n. sp.) from Sabah, Borneo, with notes on its occurrence and reproductive biology

(Insecta: Hymenoptera: Apoidea: Apini)

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With 4 tables

Abstract

A new honeybee, *Apis nuluensis* n. sp., is described from mountain regions (above 1.700 m) of Sabah, Borneo. This species is closely related to *Apis cerana* Fabricius 1793 and *Apis koschevnikovi* Buttel-Reepen 1906 which occur at lower elevations. *Apis nuluensis* has a species specific daily mating period which does not coincide with any of the other known *Apis* species in Borneo. Further, a number of morphological characters of *Apis nuluensis* differ from *Apis koschevnikovi* and *Apis cerana*.

The genus *Apis* is a small monophyletic group native to the Old World (Europe, Africa and Asia). While the phylogeny within *Apis* is still under debate (Koeniger & Koeniger 1991), it is generally agreed that there are 3 different "closely related" taxonomic units.

I. The small free nesting honeybees with the species *Apis florea* Fabricius 1787 and *Apis andreniformis* Smith 1858 are characterised by building the comb around and not under a branch or other support.

II. The large free nesting bees with the giant honeybee *Apis dorsata* Fabricius 1793 and the Himalayan rock bee *Apis laboriosa* Smith 1857 which build their single comb below a rock or branch.

III. The cavity dwelling bees build multi-parallel combs fixed to the ceiling (upper portion) of the cavity. Earlier attempts to split this group into several species (Maa 1953) were not accepted and generally three species of cavity nesting honeybees are recognised.

1. The natural distribution of the western *Apis mellifera* Linnaeus 1758 extends from the steppes of western Asia through Europe as far north as southern Norway and into all of Africa. About 20 different subspecies of *Apis mellifera* are described (Ruttner 1988). Naturally, *Apis mellifera* occurs allopatric to all other species of *Apis*.

2. *Apis cerana* is found throughout Asia, including islands as Japan, Taiwan, the Philippines, Borneo, Sumatra and most of the Indonesian Archipelago. For a long time the question of whether or not *Apis cerana* should be classified as subspecies of *Apis mellifera* was discussed (Buttel-Reepen 1906, Butler 1954). Finally, a reproductive isolation was demonstrated by Ruttner & Maul (1983). They instrumentally inseminated *Apis cerana* queens with sperm of *Apis mellifera* and all hybrid embryos died in an early developmental stage. This experimental evidence of a post-mating barrier settled the discussion. Consequently, *Apis cerana* and *Apis mellifera* are recognised as separate species.

3. In 1988 the hive nesting species, *Apis koschevnikovi* from Sabah (north eastern Borneo) has been re-evaluated. Specific morphological characteristics like colour patterns, the structure of the endophallus, and wing venation were described (Tingek et al. 1988, Rinderer et. al. 1989).

Differences in mating time (compared to sympatric

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Table 1. *Apis nuluensis* n. sp. Measurements of worker; holotype (after RUTTNER 1988).

Character	mm	colour code	angle	number
1. Hair length (tergite5)	0.2196			
3. Tomentum	0.385			
4. Dark stripe	0.9635			
7. Length tibia	0.3100			
8. Length metatarsus, leg3	0.1900			
9. Width metatarsus, leg3	0.1040			
10. Pigment t2		6 (orange)		
11. Pigment t3		7 (yellow)		
12. Pigment t4		7 (yellow)		
13. Length t3	1.8300			
14. Length t4	1.8780			
22. Width forewing	2.9000			
23. Pigment scut1		7 (yellow)		
24. Pigment scut2		1 (black)		
25. Pigment labrum1		7 (yellow)		
26. Pigment labrum2		6 (orange)		
27. Cubital 1 (a)	0.4758			
28. Cubital 2 (b)	0.1220			
31. Angle A 4			33°	
32. Angle B 4			113°	
33. Angle D 7			97°	
34. Angle E 9			22°	
35. Angle G 18			86°	
36. Angle J 10			48°	
37. Angle J 16			05°	
38. Angle K 19			81°	
39. Angle L 13			13°	
40. Angle N 23			87°	
41. Angle O 26			34°	
42. Hooks (hamuli)				18

Apis cerana) function as a premating barrier and *Apis koschevnikovi* was recognised as a valid biological species (KOENIGER et al. 1988, RUTTNER et al. 1989). *Apis koschevnikovi*, the red hive bee, is found in Borneo and Sumatra. Very recently, it was recorded from the Malayan Peninsula. In most parts of its natural habitat *Apis koschevnikovi* coexists with *Apis cerana* (and other *Apis* species).

Recently, we collected honey bees from flowers in mountain regions of Sabah which showed distinct morphological characters different from *Apis cerana* and *Apis koschevnikovi*. These specimens are considered to represent a new species described in this paper.

The type material has been deposited in the collection of the Senckenberg-Museum, Frankfurt a.M. (SMF).

Apis nuluensis n. sp.

Holotype: Worker (SMF H 2366), Borneo, Malaysia, Sabah, Crocker Range, Gunung Emas (elevation of 2,040 m a. s. l.) 23.2.1995, leg. N. KOENIGER.

Paratypes: 6 workers (SMF H 2367) same data as holotype; 1 drone (SMF H 2368) same data as holotype; (200 workers Sample No [Oberursel] 2011).

Etymology: "Nulu" is the word for mountain in the language of the Kadazans, the native people of Sabah who live in the regions where these bees were found; "-ensis" means belonging to.

Diagnosis: Worker: *Apis nuluensis* appears as a "dark" honeybee of medium size with conspicuous 4 whitish tomenta on the abdomen. Tibia II and III are

Table 2. *Apis nuluensis* n. sp. Measurements of drone; paratype (after RUTTNER 1988).

Character	mm	colour code	angle	number
7. Length tibia	3.50			
8. Length mtarsus, leg3	2.12			
9. Width mtarsus, leg3	1.22			
10. Pigment t2		1 (black)		
11. Pigment t3		1 (black)		
12. Pigment t4		1 (black)		
22. Width forewing	3.48			
23. Pigment scut1		1		
24. Pigment scut2		1 (black)		
25. Pigment labrum1		1 (black)		
26. Pigment labrum2		1 (black)		
27. Cubital 1 (a)	0.55			
28. Cubital 2 (b)	0.16			
31. Angle A 4			31°	
32. Angle B 4			116°	
33. Angle D 7			106°	
34. Angle E 9			22°	
35. Angle G 18			82°	
36. Angle J 10			49°	
37. Angle J 16			92°	
38. Angle K 19			70°	
39. Angle L 13			14°	
40. Angle N 23			80°	
41. Angle O 26			25°	

black, Femur II and III are light brown. Very long abdominal hairs; the hair length on the posterior part of 5th tergite is 0.22 mm to 0.24 mm.

Drone: *Apis nuluensis* appears as an entirely black honeybee drone without any yellow or rufous marks. It is of medium size and the length of fore wing is between 9.3 mm and 9.8 mm.

Queen still unknown.

Description: Worker: Mandibles black; clypeus black, towards the lower margin brown, labrum yellow, face (genae + frons) black with thick whitish hairs in the lower parts; vertex (around the ocelli) black with very long hairs. Scapus and base of pedicellus brown, upper portion of pedicellus and flagellum black. Scutum black, scutellum dark brown. Tergite III, light yellow in the anterior portion, posterior black. Four white tomenta (tergite 3, t4, t5, t6) long hairs. Trochanter II; trochanter III yellow to light brown. Femur II; femur III light brown. Tibia II; tibia III black.

Drone entirely black with no other marks, medium size.

Measurements: In general we followed the biometric standard procedure of RUTTNER (1988). Because we did not dissect the holotype, not all measurements were carried out, but we kept the numbers as indicated by RUTTNER (1988). The colours are given in RUTTNER's number code, in which "0 = black" and "9 = light yellow" (Tabs. 1–2).

Type locality: Opposite the Gunung Emas rest house which is situated at the road which connects Kota Kinabalu and Tambunan (54 km from KK and 28 km from Tambunan). The hollow tree with the colony of *Apis nuluensis* was found about 150 m above the rest house at a steep slope in 2040 m elevation. The vegetation was dense mountain forest.

Distribution: So far only known from Mount Kinabalu and Crocker Range in elevations above 1700 m in Sabah, Borneo.

Table 3. Morphological comparison of workers of cavity dwelling *Apis* species of Sabah.

Character	*A. nuluensis*	*A. koschevnikovi*	*A. cerana*
Hair length (tergite 5)	0.23 ± 0.016 mm	0.15 ± 0.02 mm	0.15 ± 0.09 mm
Pigment. integument	black	rufous	black
leg II; leg III	femur light brown tibia black	femur light brown tibia light brown	femur black tibia black
Length fore wing	8.08 ± 0.09 mm	8.46 ± 0.11 mm	7.42 ± 0.09 mm
Width fore wing	2.78 ± 0.07 mm	2.98 ± 0.05 mm	2.60 ± 0.05 mm
Cubital index	3.77 ± 0.12	7.64 ± 1.40	3.74 ± 0.23

Table 4. Morphological comparison of drones of cavity dwelling *Apis* species of Sabah.

Character	*A. nuluensis*	*A. koschevnikovi*	*A. cerana*
Pigmentation integument	entirely black, no lighter marks	black; yellow and rufous marks	black, yellow marks (abdomen)
Length fore wing	9.63 ± 0.32 mm	10.12 ± 0.21 mm	8.28 ± 0.53 mm
Width fore wing	3.23 ± 0.16 mm	3.57 ± 0.21 mm	2.85 ± 0.10 mm
Cubital index	3.50 ± 0.37	3.54 ± 0.44	2.40 ± 0.14

Notes on occurrence and habitat: Collection tours were performed 1994 and 1995 at two mountain regions of Sabah, the Mount Kinabalu (6°34'N, 116°33'E) and the Crocker Range (Gunung Emas 5°42'N; 116°5'E). The classification of vegetation zones was done according to Takashi Sato (1991). The foraging worker bees of *Apis nuluensis* were collected from flowers.

Sample No 1856: 15 workers, Headquarters, Kinabalu Park altitude, 1,524 m, collected from garden flowers (*Begonia* sp.).

Sample No 1857: 2 workers, Power Station: Kinabalu Park altitude 1,829 m, 17.2.1993 Lower Mountain Forest, collected from *Solidago* sp.

Sample No 1858: 9 workers, Radio Station, Kinabalu Park, altitude 2,591 m, 17.2.1993, Upper Mountain Forest, collected from garden flowers.

Sample No 1859: 8 workers, fifth trail shelter, Kinabalu Park, altitude 2,900 m, 17.2.1993, Ultrabasic Rock Forest, *Leptosperma* sp.

Sample No 1860: 15 workers, Laban Rata, Kinabalu Park, altitude 3,400 m, 17.2.1993, Granitic Boulder Vegetation, collected from *Hieracium* sp., Ericaceae and *Rubus* sp.

At the Crocker Range we collected bees along the road Tambunan – Gunung Emas at the following places:

Sample No 1925: 24 workers, Rafflesia centre, altitude 1,500 m, 3.2.1994, transition zone of Upper Dipterocarp Forest and Lower Mountain Forest, *Mimosa* sp.

Sample No 1928: 7 workers, Mountain Garden, altitude 1,950 m, 3.2.1994, Mountain Forest, *Rubus* sp.

Sample No 1868: 15 workers, Gunung Emas, altitude 2,040 m, Mountain Forest, 2.1993, collected from *Rubus* sp., *Begonia* sp.

Sample No 1929: 18 workers, Gunung Emas, altitude 2,040 m, Mountain Forest, 3.2.1994, collected from *Rubus* sp.

At the locations of sample No 1856 and sample No 1925 we caught also several foragers of *Apis cerana* and *Apis koschevnikovi.* Further, we collected at 3 locations (Sample No 1853, 1854, 1855) at the foot hills of Mount Kinabalu (altitude 900 m to 1100 m) where we caught only *Apis cerana* and *Apis koschevnikovi.* Also at the Crocker Range several bee samples (Sample No 1922–1924) were collected in the Tambunan area (altitude 900–1200 m) and we did not find *Apis nuluensis.*

The natural distribution of *Apis nuluensis* in our research areas can be summarised as follows:

In zones higher than 1700 m until 3400 m *Apis nuluensis* was the only honeybee species which was caught, below 1500 m, from lowland (10 m) up to the upper dipterocarp forest, we captured *Apis koschevnikovi, Apis cerana* and not *Apis nuluensis.* In the transition zone of the upper dipterocarp forest and lower mountain forest (between 1,500 m to 1,700 m) all 3 bee species were caught foraging at flowers of the same plant species. We did not find hybrid bees.

Remarks: *Apis nuluensis* is closely related to *Apis cerana* and *Apis koschevnikovi,* but readily distinguished by the characters indicated in Tabs. 3–4.

Notes on reproductive behaviour: The sympatric *Apis* species of Sabah are reproductively isolated by different times of the daily mating flight. Therefore we observed the drone flight at the colony of *Apis nuluensis* (Sample No 2011) for 3 days (23.2., 1.3., 2.3.1995) from 8.00 to 18.00. The drones were flying from 10.45 till 13.15 each day. Altogether we observed 221 drone flights. The drones of *Apis cerana* in Sabah fly from 14.00 until 15.30 and the drones of *Apis koschevnikovi* from 17.00 to 18.15 (Koeniger et al. 1994).

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