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APIS LABORIOSA IN HIMALAYA, THE LITTLE KNOWN WORLD LARGEST HONEYBEE (HYMENOPTERA, APIDAE)

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and KENSUKE ITO

Abstract

SAKAGAMI, SH. F., MATSUMURA, T. and ITO, K. 1980. *Apis laboriosa* in Himalaya, the little known world largest honeybee (Hymenoptera, Apidae). *Ins. matsum. n. s.* 19: 47–77, 5 tabs., 63 text-figs., 2 pls.

The little known giant honeybee *Apis laboriosa* is morphologically compared with *A. dorsata* in worker characters and is considered the distinct world largest honeybee species. Its distribution range covers the mountainous areas of Nepal, Northern India and Yunnan, upward reaching 4,000 m. This species is regarded as specialized to the high altitude habitat without losing preparation of aerial single-combed nests.

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Contents

INTRODUCTION

In a systematic revision of the honeybees, Maa (1953) recognized three genera and 24 species, four of which were further subdivided in ten subspecies. This system has been ignored by most honeybee specialists who have admitted only four species in the genus *Apis*, or criticized for splitting of too many "species" (Goetze, 1964; Koeniger, 1976). Certainly the honeybees or the Apini are a minor group as for the number of species involved, sharply contrasting with the other three tribes of Apidae (Euglossini, Bombini, Meliponini), each of which contains nearly or more than 200 good species. This paucity of species should relate to the unusual ecological success of the recent honeybees. However, many if not all of Maa's species, at least those in S. Asia, seem to represent good taxa, irrespective of whether they are called species or subspecies. Instead of totally rejecting his system, it may be reasonable to critically examine his taxa and to incorporate the results into a more reliable system. As an attempt along this idea the present study deals with *Apis laboriosa*, one of the most remarkable taxa recognized by Maa.

Maa divided the giant honeybees or his genus *Megapis* Ashmead in four species, *dorsata* Fabricius 1793, *binghami* Cockerell 1906, *breviligula* Maa 1953, and *laboriosa* Smith 1871. He considered the last species as more remote than any of the other three. Recently we had an opportunity to examine a long series of *laboriosa* and to compare them with the specimens of *dorsata* taken from various districts. The results described below favor the opinion by Maa, i.e. this long ignored, magnificent form is specifically different from *dorsata*, regarded as the largest honeybee species in the world. In the following description, *breviligula* and *binghami* are also cited as if they were recognized as two distinct species.

MATERIALS AND METHODS

The material consists of workers captured on flowers, not sampled from colonies as practiced in microtaxonomy of *A. mellifera*.

Specimens examined and measured: *A. dorsata*, 71 from India, Nepal, Thailand, Cambodia, Laos, Vietnam, N. Borneo and Palawan Is.; *A. laboriosa*, 123 all from Nepal. Later, some additional specimens from Nepal (*A. laboriosa*), India and Malaya (*A. dorsata*) were examined. Further, specimens collected in Arunachal Pradesh, N.E. India, were studied at the Zoological Survey of India, Calcutta, by one of us (S.F.S.). Henceforth, the two species are abbreviated to D and L respectively. Comparatively, two specimens of *A. breviligula* collected by Mr. J. Kojima from Leyte Is., the Philippines, were also studied.

Two species were preliminarily sorted by size and hair color. Then various body parts were examined and measured. There was no specimen which invalidated the preliminary sorting. More than 100 charcters were measured but only those which significantly differed between D and L, as well as those of comparative importance, are cited below. The number of used specimens (n) varies for characters, being 10 or less for body parts requiring dissection. For each character the percentage difference between two species is expressed by $[(\bar{L}_i-\bar{D}_i)/\bar{L}_i]\times 100$, where $\bar{L}_i$ and $\bar{D}_i$ are the mean values in two species for character i. This is cited below simply as L-D. The significance of difference was checked by t-test applying, if necessary, Cochran and Cox's approximate method. The terminology mainly follows that by Michener (1944, 1965), but some terms

frequently used by honeybee specialists are parenthetically mentioned. Length, width (maximum) and distance (minimum) are abbreviated to L, W, D each.

<div align="center">MORPHOLOGY</div>

Gross body size

The size difference between L and D is obvious (Pl. 1). Table 1 gives some measurements which represent the differences in gross body size. In all listed characters L is significantly larger than D ($P<0.05$). The percentage difference, L-D, is larger in most characters than that between *A. mellifera ligustica* Spinola (an unpure strain reared in Japan) and *A. cerana cerana* Fabricius (of Japan, the largest subspecies) cited from Akahira and Sakagami (1959a).
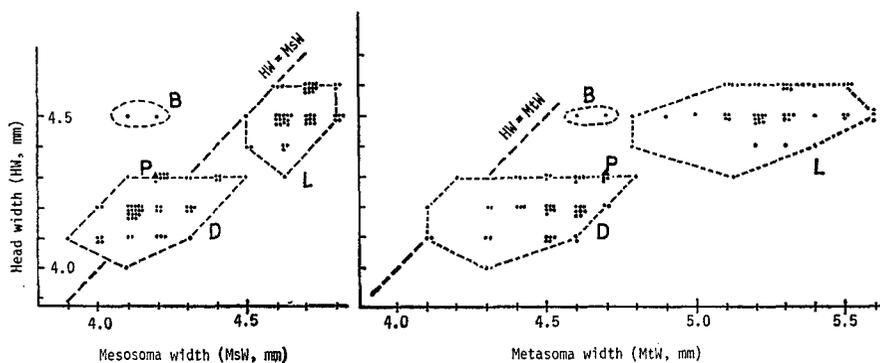

Fig. 1. Relations of head width to meso- and metasoma widths between *Apis laboriosa* (L) and *A. dorsata* (D). B=*A. breviligula*, P=One *A. dorsata* specimen from Palawan Is.

L-D varies among characters, e.g. larger in mesosoma W and particularly in metasoma W than in head W (Fig. 1), which give L a robuster appearance (Pl. 1). The measurements of 103 characters gave the following result*:

Degree of difference	$L>D$ ($P<0.05$)	$L \geq D$ ($P>0.05$)	$L \leq D$ ($P>0.05$)	$L<D$ ($P<0.05$)
No. characters	89	4	3	7

The frequency distribution of L-D values approximates the normal distribution, with the mean 10.08 and SD 11.88. This mean could be used as an index of average body size difference and the characters, L-D values of which conspicuously deviate from the mean, could be regarded as those representing specific differences independent of isometric size differences. Arbitrarily adopting $\bar{x} \pm$SD, such characters with L-D more than 22% or less than −1.8% are cited in Table 2. Table 3 lists the results on some other characters of comparative importance and those used for calculation of certain ratios. Table 4 gives such ratios obtained from Tables 2 and 3. The asterisked ratios show conspicuous specific differences while others behave rather isometrically as exemplified by Fig. 16.

Wing diagonal, head W, meso- and metasoma W of two *A. breviligula* workers

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* Measurements for combined characters are omitted, e.g., if character I=II+III+IV+ ...., the value for I is excluded.
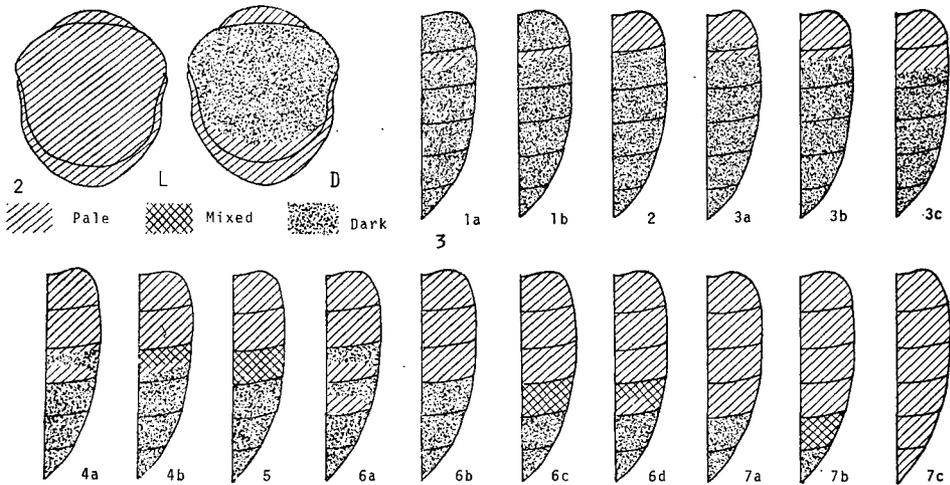
Figs. 2~3. Hair color of mesosomal dorsum in *Apis laboriosa* (L) and *A. dorsata* (D) (Fig. 2), and hair color variation of metasomal terga in two species (Fig. 3).

were respectively 7.9, 7.7; 4.5, 4.5; 4.2, 4.1; 4.6, 4.7 mm, suggesting proportions slightly different from *D* (Fig. 1).

Pilosity and coloration

The hairs on mesosomal dorsum are uniformly tawny yellow in *L* (Fig. 2, L) while mostly dark except anterior and posterior parts in *D* (Fig. 2, D). No variation was found on this character among all specimens examined. This difference is one of the most distinct and stable cues to distinguish *L* from *D*, *A. breviligula* (Pl. 1, cf. also Morse and Laigo, 1969), and, according to Maa (op. cit.), from *A. binghami*.

Hair color of metasomal dorsum is homogeneously black except long tawny yellow hairs on tergum 1 in *L* while basal terga are more extensively pale in *D*. Extension of pale hairs to the apical terga is slightly variable among specimens, but with little overlap between *L* and *D*:

Degree (Fig. 3)	1	2	3	4	5	6	7
L	2	2	89	1			
D				7	12	27	11

Some *D* workers which exhibit degree 7 seem still in a callow stage, at least with respect to the pilosity. By a distinct metasomal bicolorism *D* is distinguished from all other three taxa. No *L* specimens possessed whitish bands on the base of T_2 and T_3 as in *A. breviligula*. The basic hair coat pattern of *L* (mesosoma+ tergum 1=pale, other terga=dark) is replicated by *A. cerana vechti* Maa (comb. nov.) in Borneo (Pl. 1).

Another peculiarity of *L* to *D* (and probably to *breviligula* and *binghami*) is its unusually long hairs (Table 2–26~31, Fig. 4) with *L-D* sometimes exceeding 50%.

Integumental color of metasomal dorsum is uniformly blackish in *L* but the basal terga are pale orange brown in *D*. These pale parts approximately but not strictly correspond to the parts covered with pale hairs. At the boundary, the integument covered with pale hairs is often darker, though less than on the

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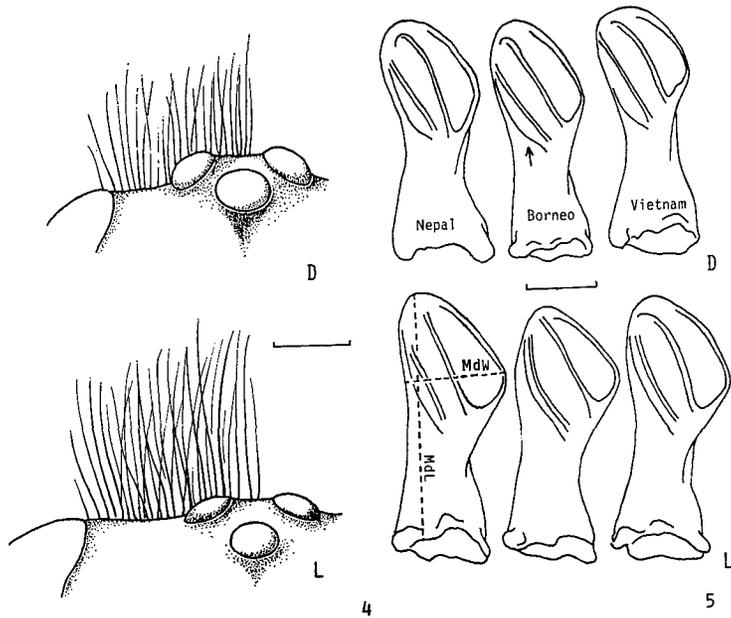
Figs. 4~5. Vertex of *Apis laboriosa* (L) and *A. dorsata* (D) (Fig. 4) and left mandible of two species (Fig. 5). Scale=0.5 mm.

posterior terga. Mouth parts and legs are also generally paler in D than in L but coloration is more variable there.

Head

The most conspicuous structural difference of L from D is, as mentioned by Maa (op. cit.), its flat ocellar area (Fig. 4). Some metric characters showing clear differences are given in Tables 2 (11~16) and 4 (I~II). Among these, the ocellocular and malar ratios are most useful for separation of L and D (Figs. 6, 7). The malar length of *A. breviligula* falls within the range of D while IOD/OOD is quite different. According to the illustrations by Maa (op. cit.), the mandible of L is apically more pointed, medially more constricted and the posterior keel parallel-margined. The last two conditions were, though subtly, recognized in our specimens, too (Fig. 5).

The mouth parts were examined in a limited number of specimens (Table 2–35 ~40, Table 4–IV~VI). The difference in tongue length (L_2=mentum+prementum +glossa=submentum+mentum+glossa by Snodgrass, L_1=prementum+glossa) is relatively small. This is caused by the glossa of L rather short in relation to prementum (Fig. 8). On the other hand, the labial palpi of L are isometrically longer than in D with D-L 10.7%. Measurements of the mouth parts of a single *A. breviligula* worker gave the following figures (mm): Tongue L_1 5.24, L_2 4.8, prementum L 1.96, W 0.68, glossa L 2.84. The unusually short tongue of this taxon (Maa, op. cit.) was reconfirmed (Fig. 8).

Wings and legs

The metric characters of wings exhibiting conspicuous L-D differences are given in Table 2 (17~21). Some reference characters are listed in Table 3 (41~
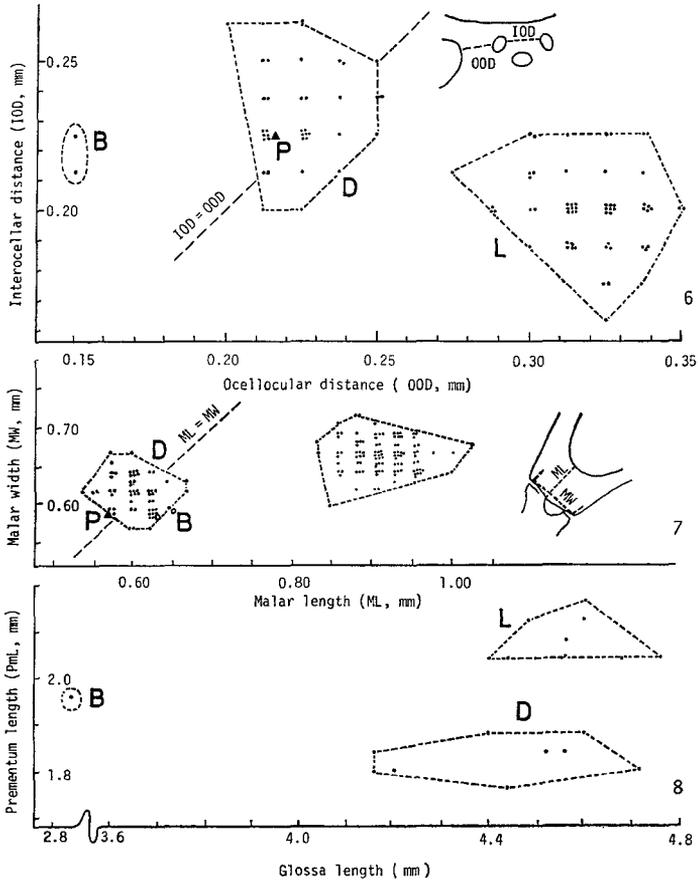
Figs. 6~8. Differences between *Apis laboriosa* (L) and *A. dorsata* in ocellocular (Fig. 6), malar (Fig. 7, polygon in center for L) and glossopremental ratios (Fig. 8), (B, P, cf. Fig. 1).

53) and ratios in Table 4 (VII~X). Discoidal displacement (Bährmann, 1964, 1967) gives deviation of junction C from the line connecting A and B (Fig. 9). In both L and D, C lies notably outward of line AB in comparison with *A. mellifera* and *A. cerana*. The difference between L and D is conspicuous, but the variability is also high (cf. Table 2, CV). The ratio S_3L_1/S_3L_2 (Fig. 12) or so called cubital index has been used extensively for *A. mellifera* and *A. cerana* (Götze, 1964, Bährmann, 1964, 1967; Ruttner et al., 1978, etc.), but its high variability has also been mentioned (Maa and Shao, 1947; Maa, 1953; Akahira and Sakagami, 1959a, b). The results obtained in L and D confirm both these findings, i.e. its usefulness within a limit. In both L and D, S_3L_2 is so short that cubital index is very high compared with *A mellifera* and *A. cerana* (Fig. 12 vs 13, 14; Table 4-IX). The difference between L and D in S_3L_2 is significant (Table 2-17) but the variability is quite large (Fig. 15, Table 2-17, CV). The same is true to the so called *indica*-vein (Figs. 9~11). This is one of the most important characters to distinguish *A. mellifera* (*indica*-vein reduced in workers) from *A. cerana*, but its length in the latter species is fairly variable (Akahira and Sakagami, 1959a, b). The *indica*-vein
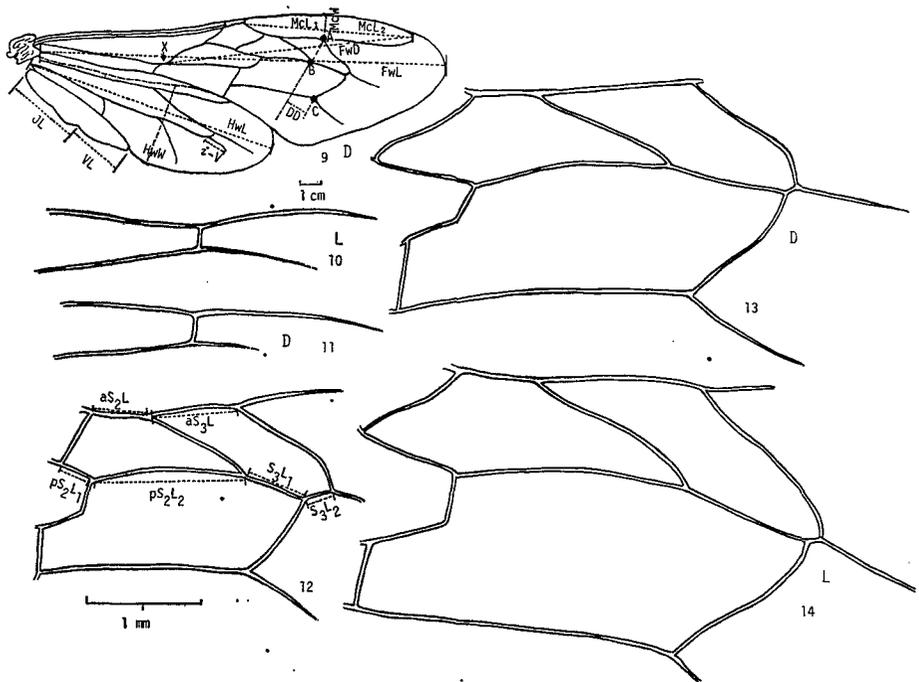
Figs. 9~14.   Wing venation of *Apis dorsata* (D, Figs. 9, 11, 13), *A. laboriosa* (L, Figs. 10, 14)
and *A. mellifera* (Fig. 12).   Fig. 9: entire wings (scale=1 cm); Figs. 10, 11; *indica*-vein
(*i-v*) in hind wing (scale=1 mm); Figs. 12~14: submarginal cells 2 and 3 (scale=1 mm).

of L is distinctly longer than in D but the variability is fairly large as seen in Table
2 (21) and the following frequency distribution:

L (0.1 mm)	~2	~3	~4	~5	~6	~7	~8	~9	~10	~11
No. specimens										
D	1		4	6	11	2				
L					1	3	7	9	5	1

S_3L_1, S_3L_2, S_3L_1/S_3L_2 of two *A. breviligula* workers were respectively 1.20, 1.12
mm; 0.15, 0.20 mm; 8.0, 5.6; suggesting a high variability.   The *indica*-vein was
0.25 and 0.38 mm, being closer to D than L.   Many other wing characters and ratios
among them behaved isometrically between L and D (cf. Fig. 16).

No conspicuous differences between L and D were found in legs, except for the
length of bristles of the posterior margin of hind tibia (Table 2–22).   This might
reflect the aforementioned difference in hair length.   The arrangement of bristle
rows on the underside of hind tibia was illustrated by Maa (op. cit.) as though
differing between L and D.   Comparison of ten specimens each of two species
showed overlap of variation ranges.

Metasoma

The metric characters exhibiting conspicuous *L-D* are given in Table 2 (23~25),
some reference characters in Table 3 (56~67) and ratios in Table 4 (XII~XIV).
Figs. 17~60 illustrate some of these characters together with several non-metric
characters which show significant differences between L and D.   All these characters
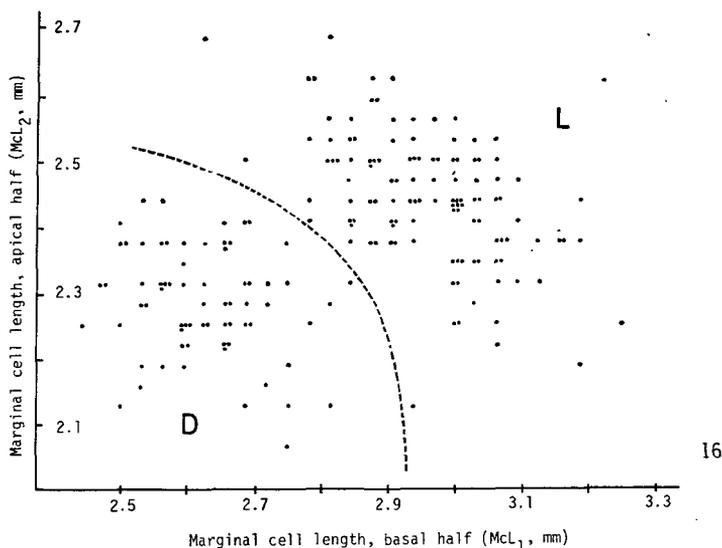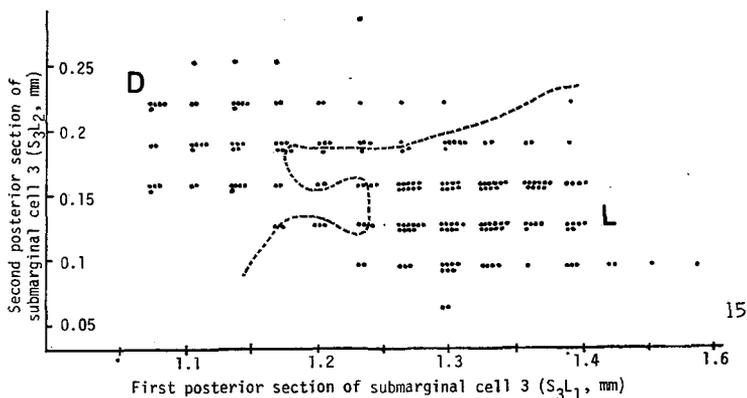
Figs. 15~16. Differences between *Apis laboriosa* (L) and *A. dorsata* (D) in ratio of second to first posterior section of submarginal cell 3 (=cubital index, Fig. 15, cf. Fig. 12) and ratio of apical to basal length of marginal cell (Fig. 16, cf. Fig. 9).

cannot be examined unless dissecting the specimens. The sample size is thus limited but the differences are clear and reconfirm the results by Maa. Namely, *L* is characterized by (1) antegradular areas of sterna laterally very wide (Figs. 22 and 31, S_2AW, S_3AW), (2) gradulus of sternum 2 medially mildly arcuate, not sharply angulate (Figs. 17 and 23, G), (3) wax mirrors of sterna 2 and 3 latero-posteriorly not projecting caudally (Figs. 29 and 33, W), (4) gradulus of sternum 3 medially gently convex foreward, not postward (Figs. 28 and 32, G).

Additional information was obtained by examining sting apparatus. Quadrate plate (=hemitergite 9 in Michener, 1944) of *L* has the apodemal corner much projecting than in *D* (Figs. 35 and 40, A). Spiracular plate (=hemitergite 8) of *L* is much wider than in *D* (Figs. 45~54, 58, 59). Finally, a notable difference was found in the relative length of sting lancet. The barbed portion of *L* was

Figs. 17~26. Metasomal sternum 2 of *Apis laboriosa* (L) and *A. dorsata* (D). Figs. 27~ 34. Metasomal sternum 3 of *Apis laboriosa* (L) and *A. dorsata* (D).

conspicuously long relative to the total length (Fig. 60). Weiss (1978) reported the number of barbs as 11 pairs in *A. mellifera, A. cerana* and *A. dorsata*, while 10 in *A. florea*. Nine workers of *D* examined by us possessed 11 pairs of barbs (11/10 in one specimen), while nine *L* specimens 13/13 (6 specimens), 14/13 (1), and 14/14 (2), exhibiting a marked deviation from other species (Figs. 56, 57).

DISTRIBUTION AND OTHER NOTES

Distribution in Nepal

The specimens from Nepal were collected by the following persons, T. Kawamichi (KA, xii, 1967~ii, 1968), I. Kudo (IK, x, 1973), T. Kumata (TK, iv~vii, 1968), T. Matsumura (TM–1, iv-vii, 1968; TM–2, iii-v, 1972), S. Takagi (ST, ix, 1975), I. Yoneta (IY, ix-x, 1965) from the localities given below (altitude, collector, and number of specimens in parentheses):

    A. laboriosa: 1. Tukucha (2,600 m, TM–1,6), 2. Lete (2,400 m, TM–1, 1), 3. Tatopani (1,300 m, TK, 1). 4. Ghara (1,800 m, TM–1, 1), 5. Sikha (2,000 m,

Figs. 35∼57. Sting apparatus of *Apis laboriosa* (L) and *A. dorsata* (D). Figs. 35∼44: quadrate plate; Figs. 45∼54: spiracular plate; Figs. 55∼57: sting lancet and its barbed portion.

TK, 1), 6. Ulleri (2,000 m, TM–1), 7. Heele (1,400 m, TM–1, 1), 8. Biratanti (1,150 m, TK, 2), 9. Trubuking Kharka (4,100 m, TM–2, 6, Pl. 2, Top), 10. Madi Khola (1,400 m, TM–2, 3, Pl. 2, Bottom), 11. Gosainkund (3,300 m, TK, 1; 2,600 m, KA, 9), 12. Thare Pati (3,300 m, TM–1, 7), 13. Bangel Kharka (3,000 m, TM–1, 1), 14. Punguchaga (3,500 m, TM–1, 1), 15. Namche Bazar (3,300 m, TM–1, 13, Pl. 2, Middle), 16. Kali La (3,000 m, TM–1, 4). 22. Khorza (1,500 m, IY, 15), 23. Darandi Khola (1,200 m, KA, 2), 24. Dunche∼Chandanbari (2,500 m, IK, 6), 25. Thare Pati∼ Melamchi (3,000 m, IK, 24), 26. Syabru (2,000∼2,400 m, ST, 1), 27. Ghora Tobela (3,000∼3,300 m, ST, 14), 28. Ghora Tobela ∼ Kyangjin Gompa (3,300 ∼3,800 m, ST, 3).

A. dorsata: 17. Tansing (1,020 m, IY, 4), 18. Tamaspur (200 m, KA, 1), 19. Adhabar (300 m, TK, 3; ST, 1), 20. Birganji (100 m, KA, 4), 21. Kathmandu (1,340 m, TM–1, 1; TM–2, 2).
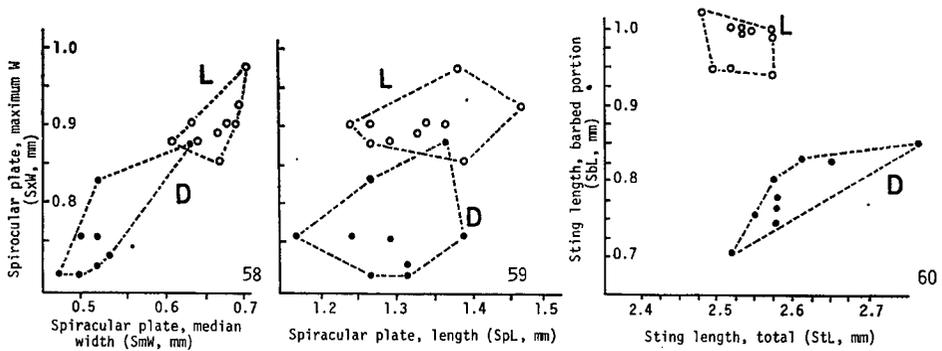
Figs. 58~60. Differences between . *Apis laboriosa* (L) and *A. dorsata* (D) in ratios of spiracular plate, maximum/median width (Fig. 58), ditto, maximum width/length (Fig. 59), and sting lancet length, barbed portion/total (Fig. 60).

Using the annexed numerical codes, these localities are shown in Fig. 61 with approximate altitudes. Table 5 gives altitudinal distribution of the localities corresponding to climatic and vegetational zones (cf. also Matsumura, 1971). The records are still insufficient but the altitudinal segregation of *L* and *D* is obvious, *L* ranging from 1,200 to 4,000 m on the southern slope of the Great Himalaya. The highest record is Trubuking Kharka (4,100 m, Pl. 2; Top), the height rarely attained by bees except some bumblebee species. *D* is mainly confined to the southern subtropical zone, though it attains Kathmandu Basin.

This segregation suggests the differential influence of climate, particularly thermal conditions, upon the distribution of the two species. The meteorological conditions of Nepal are not well surveyed yet. From the records compiled by Yamada (1970), monthly fluctuations of air temperatures and rainfall in five localities were chosen and cited in Fig. 62 (location of observatories in Fig. 61). All localities where *L* and *D* were collected seem to be governed by the typical monsoon climate, with concentration of rainfall during June to September. Possible exceptions are Tukucha and Lete (Loc. 1, 2, Fig. 61), where the climate might be arid as in Jomsom (Fig. 62). Concerning thermal conditions, the range of *D* may roughly be represented by Butwal and Kathmandu, and that of *L* by other three places. In Fig. 62 the thermal range 12~14°C at which *A. mellifera* starts to fly in early spring (April on clear days; 16~18°C in May, Lundie, 1925) is shown by dotted bars. If *L* behaves similarly, the flight period should be limited approximately to March~November at 2,100 m alt., May~October at 2,800 m, only to June~September at 3,000 m and much shortened above 3,000 m. The following collection records do not support this assumption: Trubuking Kharka, 4,100 m, April 2~5; Gosainkund, 2,600 m, December 31; Thare Pati~Melamchi, 3,000 m, October 24. The discrepancy may be explained by one of the two following reasons or probably by their combination.

First *L* may start the flight at temperatures lower than in case of *A. mellifera* due to its adaptation to the habitat climate. The stronger mountainous insolation may also help its flight. Second, the strong flight ability of honeybees should be considered. In *A. mellifera* the flight radius exceeds 2 km and often attains 4 km or more. Its flight speed is approximately 15~20 km/h or 1 km/

Kangchenjunga
8585

Cho Oyu
8158

Everest
8840

Makalu
8470

Wallungachung Gola

29°

85°

86°

Ganesh Himal
7406

Gauri Sankar
7144

Manaslu
8125

28

Jomsom

Dhaulagiri
8172

1

2

8070

Anna Purna

26

27

12

9

25

24

11

13

3

4

5

10

laboriosa

6

8

23

dorsata

Okhaldhunga

22

17

Kathmandu

21

14

15

16

Butwal

18

19

83°

27°

20

84°

Altitude (m)

3900 <

2900 ~ 3900

2500 ~ 2900

1900 ~ 2500

1200 ~ 1900

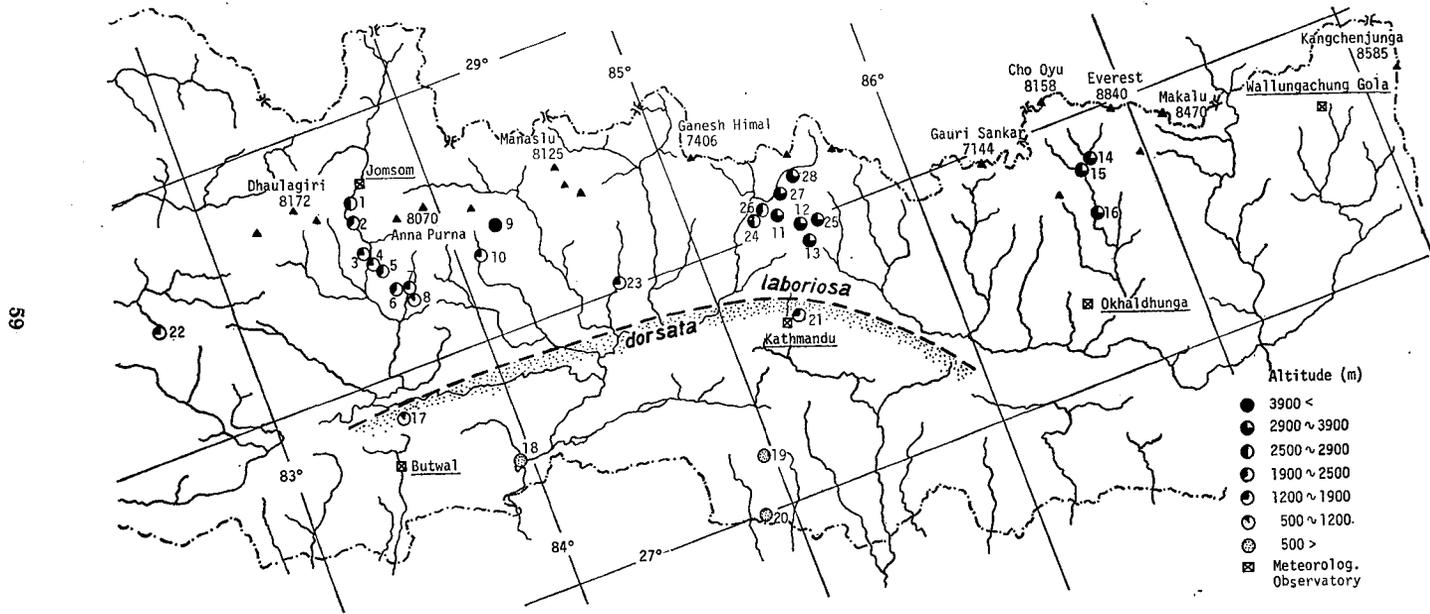500 ~ 1200.

500 >

Meteorolog.
Observatory

Fig. 61.   Altitudinal distribution of *Apis laboriosa* and *A. dorsata* in Nepal.
Locality codes given in pp. 56~57.

3~4 min. (Park, 1928). If the flight ability of L is equally effective, which is highly probable as in bees the larger forms are generally excellent fliers, the workers in a nest situated on a slope of 30° could reach the point 1,000 m higher within 10 min., provided they took the shortest course. Obviously such ideal condition would rarely be realized. The strong mountainous winds may also obstruct the linear flight. Nevertheless, it is possible that many capture records taken at the localities higher than 3,000 m actually reflect the excellent flight ability of this species.
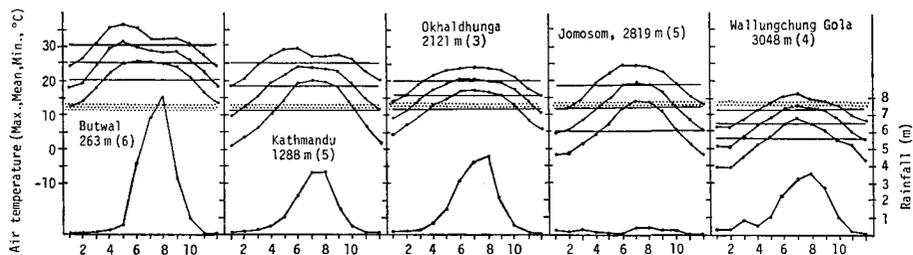

Fig. 62. Seasonal change of meteorological conditions at four localities in Nepal. Abscissa, month; ordinate, air temperature (left) and rain fall (right). Dotted bar means the air temperature range at which *Apis mellifera* starts flight activity.

Distribution out of Nepal

Distribution records of L out of Nepal is scarce. The species was originally described from Yunnan but ignored until and even after Maa (op. cit.). Maa recorded two workers from Tiger Hill, Darjeeling (2,450 m), India, one from Tse-Kou, China, one from "China" and gave the distributional range as India (Sikkim, Assam), China (W. Yunnan) and probably N. Burma.

In 1978 one of us (S.F.S.) had an opportunity to find some additional specimens of L in the collection of Hymenoptera Section, the Zoological Survey of India (all labelled *Magapis dorsata*, nw=no. workers): 1w, Dudh Kosi Valley below Thyangboche (Nepal), ca 12,000 ft, iv 19, 1954, Daily Mail 1954 Himalaya Expedition, B. Bisswas collection, 1w labelled "Moller, Thibet" and 9w from Arunachal Pradesh, mostly by ZSI & DRDO joint NEFA survey by O.B. Chotani-C.O. Ray and collected by R.N. Joseph: Pamir, Subansi Division, 564 m, v 17, 4w; Denling Forest, Kameng Div., 229 m, v 5, 1w; Tawang, Kameng Div., 3, 200 m, iv 27, 3w; Deng Zi, Kameng Div., 4,050 m, v 29 (1961), 1w.

By the same survey 29ww of D were collected: Sonai Rupi Forest, Kameng Division, 79 m, 2w; Tipi, Kameng Div., 213 m, v 3, 2w; Denling Forest, Kameng Div., 229 m, v 5, 11w; Pinjuli, Kameng Div., 244 m, v 4, 2w; Reyring Vill, Siang Div., 200 m, x 15, 3w; Tashidoni, Siang Div., 400 m, x 24, 7w; Tamen, Subansiri Div., 457 m, v 20, 2w.

Again the altitudinal segregation is suggested but here L is collected from quite low altitudes, too. This may be caused in part by a characteristic of Assam Himalaya, which is, unlike Central Nepal Himalaya, not separated from lowlands by lower mountainous ridges, but rather abruptly raises from Brahmaputra plain. In such condition, vertical shift by flight would be much easier than in Nepal Himalaya.

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Thus, the distributional range of L covers the mountainous parts (mainly 1,000 ~3,000 m alt.) of the areas separating the Palaearctic and Oriental regions. Its westward limit is unknown. Two voluminous books by Mani (1962, 1968) mainly dealing with high altitude entomology of the western Himalaya do not cite this species, though his main aim is focussed to the insect life in nival zone. The increasing aridity and vegetational impoverishment in the western areas might be unfavorable for L.

The geographical distribution of *A. dorsata* group or *Megapis* (Fig. 63) reveals its typically Oriental pattern, the northern limit of which is occupied by L. The eastern boundary is just text-book fashioned. All the areas connected by the Pleistocene shore line are occupied by D, which is fairly homogeneous throughout the range in color, structures (Figs. 5, 17~21, 27~30, 35~39, 45~49) and size (e. g. head width: 4.25 mm, SD 0.671, $n=10$ in Malaya; 4.22 mm SD 0.853, $n=18$ in Nepal), not exhibiting regional differentiation as in *A. cerana*. East of these areas, i.e. east of Wallace-Merrill line, there exist two other forms, *A. breviligula* in the Philippines excluding Palawan and *A. binghami* in Celebes. This paradigm pattern is, however, broken at the heart of the original Wallace line, the Lesser Sunda Is., where D penetrates deeply eastward across the Bali-Lombok channel to the islands south of western New Guinea (the easternmost record from Kei Is., Maa, 1953). Evidently the chain of small islands gave a good opportunity for transinsular dispersal to this strong flier. This tongue-like extension at the southeastern part of its range is thus regarded as a relatively recent addition to its domain.
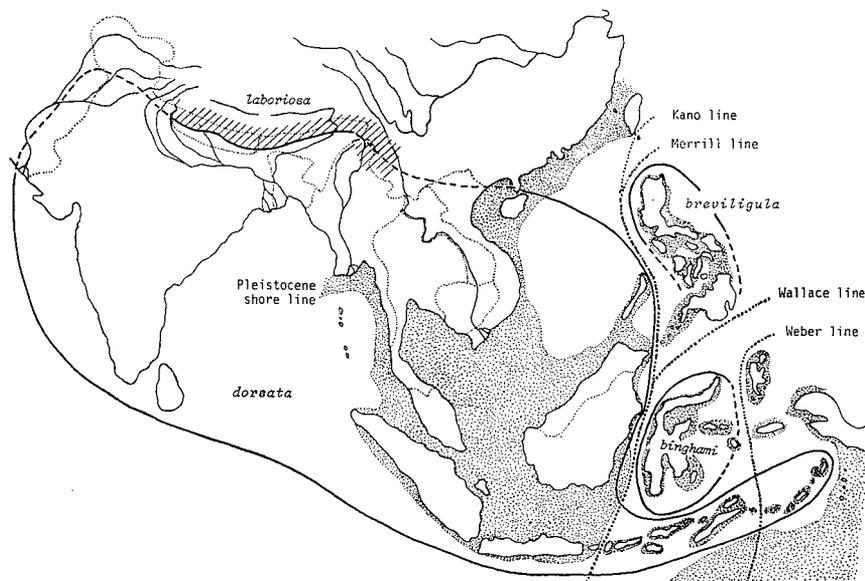

Fig. 63. Geographical distribution of four forms of *A. dorsata*-group or *Megapis*. Pleistocene shore line mainly from Darlington, 1957.

Biological notes

Virtually nothing is known on the biology of L except three casual observations cited below:

I. Melamchi, Nepal (Loc. No. 25, Fig. 61), 2,500 m evergreen oak zone, x 25 1973 (Mr. I. Kudo). Two single-combed nests, each about 1 m long were contiguously built under a cliff about 10 m high. Foraging traffic was active near the nests. Very dangerous according to native people.

II. Khorza, Nepal (Loc. No. 22, Fig. 61), 1,500 m, xi 2 1965 (Mr. I. Yoneta). A large bee cluster, 50 cm long and 30 cm in diameter, hanging from a branch 1.5 m above the ground of a broad leaved tree, was found at 13:00. Very quiet without counter attack against probing by a stick and capturing some specimens from the cluster.

III. Near Lake Tang Memba Tso, N of Bumthang, Buthan, 2,600 m, ix 1958 (Prof. S. Nakao). Nakao (1959) recorded a violent mass attack by huge honeybees during his botanical survey in Buthan. In reply to the letter by one of us (S.F. S.) he kindly sent him two photos of nests and the following notes: "No memory on the appearance of the bees but were very huge. Several elongate nests hanging under overhanged cliffs were found before the mass attack. Such nests were seen in several occasions in Buthan. According to native people, extraction of honey is very difficult". The photos clearly show the *dorsata* type single-combed nests. Judging from the altitude the bees are in all probability *L*.

The records I and III inform the habits similar to *D* such as strong aggressiveness with mass attack, preparation of large single-combed nests under some substrates and building of several nests closely nearby. The record II suggests the docility at swarming, either reproductive or absconding, common to all honeybees even in this aggressive species.

Some flower visit records were taken by one of us (T. M.) as follows:

L: *Rhododendron lepidotum* Wall. (Namche Bazar, vii), *Rh.* sp. (Namche Bazar, vii), *Rosa sericea* Lindley (Thare Pati, vi, Namche Bazar, vii), *Anemone obtusiloba* D. Don, *Berberis angulosa* Wall. (Thare Pati, vi), *B.* sp. (Tukucha, v; Lete, v).

D: *Callistemon lanceolatus* D.C. (Kathmandu, iv), *Cajanus cajan* (L.) Mill., *Lathyrus sativus* L. (Birganji, ii).

DISCUSSION

Taxonomic status

The morphological comparison of *L* and *D* reveals a number of distinct and stable differences between them. The main differences of *L* from *D* are (asterisked are those pointed out by Maa, 1953, at least qualitatively): (1)* Size on the average of various parts about 10% larger. (2)* Hairs on mesosomal dorsum concolorously twany yellow, without admixture of dark hairs (Plate 1, Fig. 2), (3)* Integument and hairs on metasomal terga black, not bicolorous (Plate 1, Fig. 3). (4) Hairs 30% or more longer. (5)* Ocellar area flat, not raised (Fig. 4). (6)* Ratio IOD/OOD 0.3 against 1.0 in *D* (Table 2, Fig. 6). (7)* Malar area 34% longer (Table 2, Fig. 7). (8) Second posterior section of submarginal cell 35% shorter (Table 2, Figs. 13, 14). (9) Discoidal displacement 35% smaller (Table 2). (10) *Indica*-vein 40% longer. (11)* Antegradular areas of metasomal sterna laterally 30~50% wider (Table 2, Figs. 17~34). (12)* Gradulus of sternum 2 medially mildly, not sharply pointed, and of 3 medially convex forward, not postward (Table 2, Figs. 17~34). (13) Sting with 13~14 pairs of barbs instead of 11 (Fig. 56, 57).

Considering these differences altogether, it is safe to conclude that differences between the two taxa are as large as, probably larger than, those between the European and the Asian honeybee, *A. mellifera* and *A. cerana*. Even by differences in the ocellocular area alone, the two forms would be regarded as specifically distinct by most specialists of the family Apidae. Criticisms to Maa (1958) for his splitting of many species thus cannot be applied to this case, even though probably valid for *A. mellifera* and *A. cerana*.

Consequently the following system is proposed for the classification of the genus *Apis*:

Subgenus *Apis* Linné 1758. *A. mellifera* Linné 1758, *A. cerana* Fabricius 1793.

Subgenus *Megapis* Ashmead 1904. *A. dorsata* Fabricius 1793, *A. laboriosa* Smith 1871. [*A. breviligula* (Maa 1953), *A. binghami* Cockerell 1906].

Subgenus *Micrapis* Ashmead 1904. *A. florea* Fabricius 1787 (*A. andreniformis* Smith 1858).

As mentioned previously, *A. breviligula* is quite different from *A. dorsata* by its ocellocular distance (Fig. 6), unusually short glossa (Fig. 8), and concolorously black metasoma (Plate 1). It may be either an independent species or a very conspicuous subspecies of *A. dorsata*. The same should be applied to *A. binghami*, provided its characteristics enumerated by Maa are stable, though both are evidently closer to D than L. The relation between *A. florea* and *A. andreniformis* will be given in a separate paper. Three subgenera are retained for conspicuous ethological differences between these groups.

Evolutionary comments

The distribution records confirm that *A. labriosa* is a typical high mountain honeybee form probably only rivalled by *A. mellifera monticola* Smith in the Tanzanian Mountains (2,400~3,100 m) (Ruttner 1976)*. This implies its adaptation to high altitude habitats. Morphologically the large size and long hair coat can be regarded as such adaptive features. Application of Bergman's rule to poikilo-thermal animals should be cautious. But the honeybees have an excellent ability in heat production and regulation. In this case, the larger size and longer hairs must be more efficient to prevent heat loss. Since Alpatov (1929), it is well known that body size of *A. mellifera* decreases from north to south (cf. also Götze, 1964). A similar tendency is also recognized in *A. cerana* and even in some Oriental stingless bees (Sakagami, 1978). In bumblebees the significance of larger size and longer and denser hair coat in high arctic species is suggested (Richards, 1973) and the inferior thermoregulatory ability in smaller individuals is experimentally confirmed (Heinrich, 1975).

The intensified melanism is also characteristic of many high altitude insects (Mani, 1962, 1968). The black body color of L against bicolorism of D might signify such adaptive change. But two marginal forms of *Megapis*, *A. breviligula* and *A. binghami*, are also melanic so that the secondary acquisition of bicolorism by D is not precluded.

Recently Königer (1976) presented a new interpretation of the honeybee phylogeny. He assumed hollow nesters as the ancestral type, from which two different life strategies have derived: Forms building aerial single-combed nest adapted to tropical climate (*A. dorsata* and *A. florea*) versus forms retaining

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* *A. cerana* ssp. is collected up to 3,000 m in Nepal (Matsumura, 1971).

the hollow dwelling habit with multiple-combed nest and more adapted to cooler climate (*A. mellifera* and *A. cerana*). This hypothesis seems to explain various aspects of honeybee life better than the previous opinion, which postulates a gradual evolutionary elaboration in the order of *florea*→*dorsata*→*cerana*→*mellifera*. But it must not be ignored that the two basic strategies can be complicated by additional "sub-strategies" in either direction. For instance, the distributional range of *A. cerana* in S.E. Asia nearly completely overlaps with that of *A. dorsata*. Under this humid tropical climate *A. cerana* had to adopt some habits comparable to those exhibited by *A. dorsata*. Frequent absconding is one of such traits actually displayed by *A. cerana* there. *A. laboriosa* may represent an opposite case. It had adapted to cool mountainous climate without changing its aerial single-combed nest. Probably some modifications of the basic strategy are involved in its mode of life. One ethological feature characteristic of *Megapis*, frequent absconding at flower dearth, might be effective in mountainous habitats, where the season and flower blooming vary within a short horizontal distance. The absconding swarms might find favorable habitats by a relatively short flight. It is even guessed that *L* seasonally practices altitudinal migration just as having undertaken by certain Himalayan people.

The adaptation of *L* to high altitude habitats should be a specialization against the lowland life mode of *D*. The relative antiquity of two species is a different problem. Without mentioning the reasons, Maa (op. cit.) enumerated primitive and specialized alternatives of some taxonomic characters in honeybees. But some of his opinions must be examined critically. For example, he considered the longer malar space the primitive alternative. Although a secondary reduction is not precluded, the long malar space should be a specialized state throughout the bees. Morphologically *L* is specialized in large size and long hairs as mentioned above. Its long malar space and supernumerary sting barbs may also be specialized features. On the other hand, its longer *indica*-vein should be primitive, as this vein occurs in some fossil species from the Oligocene, *A.* (*Synapis*) *cuenoti* Theobald and *A.* (*S*) *h. henshawi* Cockerell* (Götze, 1964), but reduced in *A. mellifera*, at least in the workers. As referred to above, the bicolorism of *D* might be a secondary condition. Therefore, it is assumed that both *D* and *L* are the offshoots of the common ancestor which had dwelled in lowlands and built aerial single-combed nests.

It is difficult to clarify the origin of *L* in space and time. Only some tentative conjectures are given here. The fossils of the genus *Apis* are known since the Oligocene but only from Europe, except *A. mellifera* from the Pleistocene in E. Africa. All these forms rather resemble nowaday *A. mellifera* (and/or *A. cerana*) than *Megapis* and *Micrapis* (Zeuner and Manning, 1976). This makes inferences on the origin of the latter groups difficult. The confluence of basal vein (M) with cu-v in *A. cuenoti* and *A. h. henshawi*, not displaced as in *A. h. kaschkei* (Staz) from the Oligocene, in other fossil forms from the Miocene and in all recent froms (Fig. 9, X), favors, though not conclusively, the appearance of *Megapis* at least as late as the Miocene. Adoption of aerial single-combed nests must have also occurred under warm Tertiary climate either in the southern Asia in that time (=nowaday S. Central Asia) or in S.E. Asia, but certainly not in India, which have

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* *A. h. henshawi* from the lower Miocene after Götze; but from the Oligocene after Zeuner and Manning (1976).

firmly fused with Asia only after the Miocene. Then *A. laboriosa* should have appeared either before or after the Ice Age, because the adaptation of this "homoiothermal" insect to high altitude habitat during the Ice Age is hardly conceivable. Its preglacial origin with high altitude adaptation postulates a lasting permanence at such habitat followed by repetition of altitudinal up-and-down dispersals, which must have considerably affected its morphophysiological makeup. The basic resemblance of four "forms" of *Megapis* favors the postglacial, or more probably interglacial origin of nowaday *L*. Its deviation from other *Megapis* forms may have been caused by adaptation to severe habitat. On the other hand, two peripheral forms, *A. breviligula* and *A. binghami*, have less deviated from *A. dorsata* despite a longer isolation, probably because of the habitat conditions similar to those of the main stock.

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TABLES

Table 1. Differences of gross body size between *Apis laboriosa* (L) and *A. dorsata* (D) (in mm).

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
1	Body L[a]	L	17.50	0.753	58	4.34	5.9
		D	16.47	0.736	28	4.55	
2	Fore wing L (FwL, Fig. 9)	L	14.51	0.336	50	2.34	10.3 (8.5)[d]
		D	13.02	0.335	32	2.61	
3	Fore wing diagonal (FwD, Fig. 9)	L	8.13	0.160	116	1.98	7.1
		D	7.53	0.177	66	2.36	
4	Hing wing L (HwL, Fig. 9)	L	9.20	0.204	29	2.26	8.0 (8.9)
		D	8.47	0.165	26	1.98	
5	Head W	L	4.52	0.068	50	1.51	6.9 (3.7)
		D	4.20	0.077	50	1.84	
6	Total flagella L	L	3.16	0.068	63	2.19	4.6 (3.2)
		D	3.02	0.083	38	2.79	
7	Mesosoma (=thorax and propodeum)[b]	L	4.66	0.082	50	1.75	10.7
		D	4.12	0.121	50	2.90	
8	Mesoscutum L	L	4.01	0.019	67	2.28	13.3 (3.9)
		D	3.48	0.104	39	3.01	
9	Hind tibia L[c]	L	4.66	0.080	27	1.77	10.6 (2.7)
		D	4.17	0.082	22	2.01	
10	Metasoma (=abdomen excl. propodeum)	L	5.26	0.184	50	3.50	13.8
		D	4.53	0.132	50	2.90	

a. Measured in the specimens with metasoma neither telescoped nor hung down; b. Distance between outer rims of tegulae, measured in the specimens with wings not expanded laterally; c. From base to posterior apex; d. % size difference between *A. mellifera* and *A. cerana cerana*.

Table 2. Some characters exhibiting conspicuous differences between *A. laboriosa* (L) and *A. dorsata* (D) independent of body size difference (in mm).

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
11	Interocellar D (IOD, Fig. 6)	L	0.197	0.0132	59	6.70	−16.7
		D	0.230	0.0154	37	6.71	
12	Ocellocular D (OOD, Fig. 6)	L	0.315	0.0139	59	5.02	29.6
		D	0.226	0.0125	37	5.63	
13	Anterior ocellus diameter	L	0.365	0.0167	27	4.74	−10.4
		D	0.403	0.0137	22	3.57	
14	Interalveolar D	L	0.366	0.0176	26	4.82	−9.6
		D	0.401	0.0254	23	6.60	
15	Malar L (ML, Fig. 7)	L	0.912	0.0358	114	3.97	34.2
		D	0.600	0.0258	66	4.32	
16	Flagellomere 2 L	L	0.188	0.0129	81	6.79	−0.2
		D	0.190	0.0138	49	7.74	

Table 2. Continued

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
17	Second posterior section of submarginal cell 3 L(S₃L₂, Fig. 12)	L	0.141	0.319	123	22.47	−35.3
		D	0.191	0.308	64	15.77	
18	Marginal cell W (McW, Fig. 9)	L	0.649	0.229	122	3.59	−2.6
		D	0.666	0.258	64	3.83	
19	Discoidal displacement (DD, Fig. 9)	L	0.532	0.151	119	28.60	−35.3
		D	0.720	0.595	63	13.70	
20	Anterior section of submarginal cell 2 L (a S₂L₂, Fig. 12)	L	0.671	0.664	60	10.00	−6.6
		D	0.715	0.511	35	8.34	
21	*Indica*-vein (*i*-V, Fig. 9)	L	0.938	0.143	27	15.54	42.2
		D	0.542	0.106	24	19.21	
22	Hind tibia, posterior bristle L	L	0.925	0.505	55	5.56	23.1
		D	0.717	0.613	46	8.78	
23	Antegradular area of sternum 2, lateral W (S₂AW, Fig. 22)	L	1.087	0.569	10	5.71	34.7
		D	0.710	0.999	9	14.97	
24	Antegradular area of sternum 3, lateral W (S₃AW, Fig. 31)	L	0.746	0.465	10	6.52	49.2
		D	0.374	0.512	10	14.34	
25	Spiracular plate median W (SmW, Fig. 45)	L	0.667	0.275	10	4.31	22.2
		D	0.519	0.424	9	8.72	
26	Eye hair L	L	0.464	0.017	20	6.33	32.3
		D	0.314	0.034	20	10.80	
27	Vertex hair L	L	1.180	0.065	20	5.51	29.3
		D	0.834	0.052	20	6.30	
28	Mesoscutum medially hair L	L	1.126	0.068	20	6.08	34.4
		D	0.738	0.041	20	5.54	
29	Mesoscutellum hair L	L	1.254	0.041	20	3.23	31.6
		D	0.858	0.059	20	6.83	
30	Tergum 5 hair L	L	0.377	0.059	56	15.88	62.6
		D	0.141	0.026	39	18.22	
31	Tergum 6 hair L	L	0.667	0.054	56	8.22	53.7
		D	0.309	0.031	40	10.62	

Table 3. Differences between *A. laboriosa* (L) and *A. dorsata* (D) in some characters of comparative importance and those used to calculate the indices in Table 4 (in mm. except character 52).

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
32	Malar W (MW, Fig. 7)	L	0.682	0.022	107	3.18	10.7
		D	0.609	0.022	59	3.56	
33	Mandible L (MdL, Fig. 5)	L	1.648	0.052	9	3.13	8.9
		D	1.512	0.053	9	3.50	
34	Mandible, apical W (MdW, Fig. 5)	L	0.690	0.035	9	5.14	1.7
		D	0.572	0.036	9	6.29	

Table 3. Continued

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
35	Prementum L (PmL)	L	2.068	0.037	10	1.94	11.7
		D	1.824	0.040	10	2.00	
36	Prementum W (PmW)	L	0.876	0.038	10	4.30	9.1
		D	0.756	0.045	10	6.01	
37	Glossa L (GL)	L	4.556	0.105	10	2.30	3.2
		D	4.408	0.186	10	4.27	
38	Tongue L 1 (PmL+GL)	L	6.624	0.117	10	1.77	5.9
		D	6.232	0.192	10	3.15	
39	Tongue L 2 (Mentum L+PmL+GL)	L	7.052	0.129	10	1.83	4.6
		D	6.728	0.329	10	4.88	
40	Labial palpi 1~4 L (LpL)	L	3.141	0.080	10	2.56	10.7
		D	2.808	0.138	10	4.93	
41	Fore wing W	L	4.425	0.137	96	3.13	6.0
		D	4.159	0.118	57	2.86	
42	Marginal cell, basal half L (McL$_1$, Fig. 9)	L	2.446	0.106	121	4.32	6.6
		D	2.284	0.082	69	3.64	
43	Marginal cell, apical half L (McL$_2$, Fig. 9)	L	2.958	0.108	121	3.70	11.3
		D	2.624	0.093	69	3.45	
44	Marginal cell (=radial cell) L (McL=McL$_1$+McL$_2$)	L	5.400	0.097	119	1.84	9.2
		D	4.404	0.117	58	2.39	
45	First posterior section of submarginal cell 2 (pS$_2$L$_1$, Fig. 12)	L	0.864	0.065	123	7.50	3.4
		D	0.835	0.074	64	8.96	
46	Second posterior section of submarginal cell 2 (pS$_2$L$_2$, Fig. 12)	L	1.962	0.070	123	3.55	8.2
		D	1.802	0.054	64	3.06	
47	Anterior section of submarginal cell 3 L (aS$_3$L, Fig. 12)	L	1.526	0.094	121	6.17	10.5
		D	1.326	0.074	63	5.46	
48	First posterior section of submarginal cell 3 L (S$_3$L$_1$, Fig. 12)	L	1.305	0.059	123	4.50	12.3
		D	1.145	0.058	64	5.05	
49	Hind wing W (HwW, Fig. 9)	L	2.539	0.084	106	3.35	-0.1
		D	2.542	0.142	50	5.36	
50	Jugal lobe L (JL, Fig. 9)	L	2.974	0.105	26	3.59	10.8
		D	2.654	0.102	23	3.90	
51	Vannal lobe L (VL, Fig. 9)	L	2.026	0.066	27	3.31	7.6
		D	1.873	0.077	27	4.20	
52	No. hamuli (=wing hooks)	L	2.614	2.121	118	8.15	2.5
		D	2.549	2.034	65	8.04	
53	Section occupied by hamuli, L	L	1.681	0.070	118	4.16	2.3
		D	1.642	0.066	63	4.09	
54	Hind basitarsus L (HbL)	L	3.189	0.078	54	2.49	8.7
		D	2.911	0.061	46	2.14	
55	Hind basitarsus W (HbW)	L	1.453	0.046	53	3.19	5.4
		D	1.374	0.034	47	2.50	

Table 3. Continued

Code	Character (abbreviation)	Species	Mean	SD	n	CV (%)	L-D (%)
56	Wax mirror of sternum 3 L (WS$_3$L, Fig. 27)	L	1.929	0.070	10	3.84	9.5
		D	1.745	0.055	9	3.31	
57	Wax mirror of sternum 3 W (WS$_3$W, Fig. 31)	L	2.914	0.088	10	3.20	14.4
		D	2.494	0.058	9	3.47	
58	Sternum 3 L (S$_3$L, Fig. 34)	L	3.269	0.084	10	2.72	10.5
		D	2.926	0.107	9	3.91	
59	Sternum 3, half W (S$_3$W, Fig. 30)	L	2.813	0.067	10	2.51	14.6
		D	2.403	0.088	9	3.89	
60	Sternum 6 L	L	3.097	0.061	10	2.08	8.0
		D	2.848	0.112	9	4.19	
61	Sternum 6, half W	L	2.006	0.061	10	3.20	18.7
		D	1.631	0.063	8	4.12	
62	Wax mirror of sternum 6 W	L	1.853	0.061	10	3.43	18.7
		D	1.510	0.050	8	3.58	
63	Wax mirror of sternum 6 L	L	2.143	0.106	10	5.21	14.3
		D	1.837	0.142	7	8.34	
64	Spiracular plate maximum W (SxW, Fig. 47)	L	0.901	0.031	10	3.63	15.3
		D	0.763	0.054	9	7.49	
65	Spiracular plate maximum L (SpL, Fig. 46)	L	1.355	0.064	10	5.08	3.1
		D	1.293	0.062	9	5.08	
66	Sting, total L (StL, Fig. 55)	L	2.526	0.049	9	2.05	−2.5
		D	2.588	0.078	9	3.22	
67	Sting, barbed portion L (SbL, Fig. 55)	L	0.997	0.040	9	4.27	21.2
		D	0.786	0.044	9	6.01	

Table 4. Differences between *A. laboriosa* (L) and *A. dorsata* (D) in some indices (=ratios between two body parts). Codes and abbreviations of characters given in Tables 2, 3.

Code	Index	Characters x/y in abbreviations (in codes)	Species	$\bar{x}$	SD	n	CV (%)	L/D (%)
I*	Ocellocular	IOD/OOD (11/12)	L	0.628	0.058	59	9.14	0.60
			D	1.043	0.092	37	8.85	
II*	Malar	ML/MW (15/32)	L	1.375	0.075	102	5.48	1.36
			D	1.011	0.062	54	6.13	
III	Mandibular	MdL/MdW (33/34)	L	0.418	0.014	20	3.48	1.11
			D	0.376	0.019	20	4.96	
IV	Premental	PmL/PmW (35/36)	L	0.423	0.013	10	3.03	1.02
			D	0.414	0.028	10	6.74	
V	Labiopremental	LpL/PmL (40/35)	L	1.520	0.036	10	2.35	0.99
			D	1.540	0.089	10	5.78	
VI	Glossopremental	GL/PmL (37/35)	L	2.204	0.062	10	2.80	0.90
			D	2.446	0.104	10	4.26	

Table 4. Continued

Code	Index	Characters x/y in abbreviations (in codes)	Species	$\bar{x}$	SD	n	CV (%)	L/D (%)
VII	Marginal cell (=radial cell) A	McL₁/McL₂ (42/43)	L	0.829	0.058	121	7.06	0.95
			D	0.871	0.047	69	5.43	
VIII	Marginal cell (=radial cell) B	McL/McW (44/18)	L	8.351	0.320	117	3.83	1.14
			D	7.352	0.318	67	4.33	
IX*	Cubital	S_3L_1/S_3L_2 (48/17)	L	9.820	2.499	123	25.4	1.59
			D	6.160	1.082	67	17.6	
X	Jugo-vannal	JL/VL (50/51)	L	1.467	0.051	25	3.50	1.03
			D	1.423	0.056	23	3.93	
XI	Basitarsal	HbW/HbL (55/54)	L	0.455	0.011	52	2.51	0.96
			D	0.472	0.013	46	2.72	
XII	Spiracular, A	SxW/SmW (64/25)	L	1.352	0.044	10	3.22	0.92
			D	1.473	0.074	9	5.06	
XIII*	Spiracular, B	SpL/SxW (65/64)	L	1.483	0.074	10	4.98	0.87
			D	1.701	0.128	9	7.53	
XIV*	Sting	SbL/StL (67/65)	L	0.623	0.032	9	5.18	1.30
			D	0.479	0.018	9	3.68	

* Indices showing conspicuous interspecific differences.

Table 5. Altitudinal distribution of *A. laboriosa* (*L*) and *A. dorsata* (*D*) in Nepal (climatic and vegetational zones from Kawakita, 1956).

Altitude (Upper limit, m)	Climatic zone	Vegetation (dominants)	Localities in codes L	Localities in codes D	No. localities L	No. localities D
5,200	Nival	Alpine barrens				
4,600	Alpine	Alpine vegetation	9		1	
3,900	Subalpine	*Abies* type (*A. spectabilis, Betula utilis, Rhododendron* spp.)	11, 12, 13, 14, 15, 16, 25, 27, 28		9	
2,900	Cool-temperate	*Picea* type and deciduous oak type (*P. smithiana, Quercus semecarpifolia, Tsuga dumosa, Rhododendron arboreum*)	1, 24		2	
2,500	Temperate	Evergreen oak type (*Quercus* spp., *R. arboreum*)	2, 5, 6, 26		4	
1,900	Warm-temperate	*Schima-Castanopsis* type (*S. wallichii, C. indica*)	3, 4, 7, 10, 22, 23	21	6	1
1,200 500	Subtropical	*Shorea* type (*S. robusta, Ficus religiosa*)	8	17 18, 19, 20	1	1 3

PLATES

Plate I

Apis laboriosa and other honeybee forms.
    Top.   *A. dorsata* (left), *A. laboriosa* (middle), *A. breviligula* (right).
    Bottom.   *A. mellifera* (left, from Czechoslovakia), *A. cerana vechti* (right).

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Plate II

Three localities where *A. laboriosa* was collected.
Top. Trubuking Kharka 4,100 m (Lamjung Himal at the back).
Middle.   Namche Bazar 3,300 m.
Bottom.   Madi Khola 1,400 m (Anna Purna II at the back).