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Distributions of Recently Recognized Species of Honey Bees (Hymenoptera: Apidae; *Apis*) in Asia

GARD W. OTIS¹

ABSTRACT: For most of this century scientists have generally accepted that the genus *Apis* is comprised of only four well recognized species: *A. mellifera* in Europe and Africa and *A. florea*, *A. dorsata*, and *A. cerana* in Asia. Recent biological studies indicate that the genus is more diverse than indicated by this traditional view, with evidence supporting at least an additional five species in Asia: *A. andreniformis*, *A. laboriosa*, *A. koschevnikovi*, *A. nigrocincta*, and a species from the highlands of Borneo.

Using morphological characters that are well defined and consistent for each of these species, museum specimens from numerous collections were examined and identified. Detailed collection localities from specimen labels and literature sources, distribution maps, and situations that deserve further study are presented for each of these newly recognized species.

The honey bees (*Apis* spp.) comprise a small, monophyletic genus. All together, dozens of “species” and at least 600 names of species, subspecies, races, nations, forms and varieties have been proposed to categorize the diversity found within the honey bees (Maa, 1953; Ruttner, 1988). Many of these names were proposed within the framework of species concepts that are no longer tenable. As bee systematists began to adopt the biological species concept, they reached a general consensus that there were only four species in *Apis*: *A. mellifera* in Europe and Africa and *A. florea*, *A. dorsata*, and *A. cerana* in Asia, with each of these exhibiting considerable geographic variability (Ruttner, 1988; Verma 1992; Damus, 1995). In part because of this extensive intraspecific variation and the general absence of males in collections, there has been no recent complete taxonomic treatment of the genus. Moreover, few bee researchers were actively working in the Asian region until recently, so other biological information that could have been used to differentiate species was lacking.

Heightened research on honey bees in Asia over the past 20 years has gradually produced evidence that there are several additional valid biological species. All of these differ in timing of mating flights from the traditional species that are sympatric with them; some have distinctive male genitalia as well. The first of these to be documented was the large honey bee of the Himalayas, *Apis laboriosa* (Sakagami et al., 1980), whose altitudinal range overlaps only slightly with that of the giant honey bee, *A. dorsata* (Roubik et al., 1985). All bees of the *laboriosa* form have a morphology that differs statistically in most characters from *dorsata* (Sakagami et al., 1980), and mating flights occur in early afternoon in contrast to flights at dusk by *dorsata* (Underwood, 1990b). In 1987, Wu and Kuang (1987) presented convincing evidence for a second dwarf honey bee species, *A. andreniformis*, that was morphologically distinct from the well known *A. florea*. It was subsequently shown that the genitalia of males of these two species differ substantially (Wongsiri et al., 1990) and mating flights are separated in time (Rinderer et al., 1993). Koeniger et al. (1988), Mathew and Mathew (1988), and Tingek et

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al. (1988) determined that *A. koschevnikovi* (= *A. vechti*) of Sabah is also a valid species based on timing of mating flights and male genitalia. In Sulawesi, S. Hadisoesilo and I discovered two partially sympatric morphs of cavity-nesting honey bees in 1989. Morphometric studies (Damus, 1995; Hadisoesilo et al., 1995) and DNA analyses (Damus, 1995; Smith and Hagen, 1996) indicate that the two populations are distinct, and data on timing of drone flights (Otis et al., in press; Hadisoesilo, in prep.) and the absence of hybrids indicate that the newly recognized morph will eventually be recognized as a separate species for which the oldest available name is *A. nigrocincta*. Finally S. Tingek, N. Koeniger, and G. Koeniger (pers. comm., 1995) recently found what appears to be yet another *Apis* species in the highlands of Sabah (Borneo).

Because the species of honey bees considered in this paper have only recently been confirmed, the range for each is confused with that of the most similar of the three traditionally recognized species. Consequently, there is no completely accurate range map for any species at present. In this work I have used data from museum specimens, published reports, and personal observations of qualified individuals to document the geographic distributions of *A. florea* and the five recently recognized species of honey bees.

I have chosen not to consider *A. dorsata* and *A. cerana*. Their ranges are quite accurately presented in Gould and Gould (1988: pp. 22–23), Sakagami et al. (1980: Fig. 63), and Ruttner (Ruttner, 1988: Figs. 9.1 and 8.3) with the following corrections. I have no evidence that *A. cerana* occurs on Hokkaido (Maa, 1953; Ruttner, 1988: Fig. 9.2), Mindanao, Halmahera, or Buru; it was probably transported by humans to Ambon (Maa, 1953) and Ceram (D. R. Smith, pers. comm.) where it now occurs; and on Sulawesi it has been collected only in the extreme south and in a small region southeast of Palu (pers. obs.; see discussion below concerning *A. nigrocincta*). *A. dorsata* is quite similar throughout its range except for distinctive populations in the Philippines (*A. d. breviligula*) and on Sulawesi and neighboring islands (*A. d. binghami*). These two populations may warrant species status in the future, but not until the Philippine islands are better collected and the *dorsata* group has been subjected to more thorough morphological and genetic study.

Materials and Methods

I examined all honey bee specimens in the Natural History Museum, London, U.K. (BMNH); the Rijksmuseum of Natural History, Leiden, the Netherlands (RNH); the Museum Zoologi in Bogor, Indonesia (MZB); the Snow Entomological Museum, the University of Kansas, Lawrence, KS (SEM); the Canadian National Collection of Insects, Ottawa, Canada (CNC); the Cornell University Entomology Museum Collection, Ithaca, NY (CU); the Royal Ontario Museum, Toronto, Ontario (ROM); and the University of Guelph Collection, Ontario, Canada (UGC). All specimens of the two dwarf honey bee species, *Apis florea* and *A. andreniformis*, were examined from: the B. P. Bishop Museum, Honolulu, Hawaii (BPBM); the U.S. National Museum of Natural History, Washington, D.C. (USNM); the American Museum of Natural History, New York City (AMNH); the Staatliches Museum für Naturkunde, Stuttgart, Germany (SMNS); the Naturhistoriska Riksmuseot, Stockholm, Sweden (NRS); the Zoological Museum, Copenhagen, Denmark (ZMC); the Peabody Museum of Yale University, New Ha-

ven, CT (PM); the Institut Royal des Sciences Naturelles de Belgique, Belgium (IRSN), the Zoological Institute, Academy of Sciences, Leningrad, Russia (ZIL); and personal collections of S. F. Sakagami and H. Nagase, Japan, and G. W. Otis, Ontario (GWO).

Localities obtained from publications concerning *A. florea* in the western part of its range (Central India and west) were included because they unambiguously referred to this species. Data for *A. andreniformis* presented in publications by Maa (1953) (for Sumatra, Java, and Borneo only), Salmah et al. (1990) for Sumatra, and de Guzman et al. (1992) for the Philippines were included for the same reason. I also incorporated the distributional data for both *florea* and *andreniformis* as presented by Kuang and Li (1985), the first researchers to provide key characters that can be used to discriminate between the two species.

Additional localities for *A. laboriosa* given by Kuang and Li (1985), Maa (1953), Sakagami et al. (1980), Roubik et al. (1985), and Underwood (1990a), were included because this species is easy to recognize once one is familiar with it (see below); I have confidence in their identifications.

For *A. koschevnikovi*, which could be confused with *A. cerana* or *A. nigrocincta*, I accepted only the locality data given by Maa (1953; presented under the species accounts for “*A. vechti*” and “*A. lieftincki*”). Collections of *A. koschevnikovi* on Sumatra by N. Koeniger (Institut für Bienenkunde, Oberursel, Germany; verified by morphometric analyses) and C. Darling (Royal Ontario Museum, Toronto, specimens personally checked), and on Borneo by S. Hadisoesilo (verified morphometrically) have been included, as well as my own personal collections.

Once species-specific characters were identified, the workers of the four species discussed here in detail could usually be easily distinguished from similar species. (In the absence of a dichotomous key for honey bees, this is the only approach possible at present). For the dwarf honey bees, *A. florea* usually has a distinct bicolored abdomen, with the reddish anterior contrasting sharply with the gray posterior, and the long hairs on the margin of the hind tibia are always whitish. In *A. andreniformis*, workers with black abdomens having white bands are distinctive (but some are completely reddish or bicolored, similar to *florea* but with the color transition usually gradual); marginal hairs on the hind tibia are always black. In rare instances with specimens of poor quality, it was necessary to check the cubital index, the ratio of the lengths of the distal two segments of the cubital vein (see Ruttner, 1988, Fig. 6.8) (CI = 1.9–5.3 in *florea*, 3.5–13.8 in *andreniformis*; Wongsiri et al., 1990). Specimens that could not be distinguished by these characters were not included in the data set.

Apis koschevnikovi was distinguished preliminarily from *A. cerana* by its larger size (a helpful characteristic, especially when there were specimens of both species to compare from the same locality) and by coloration. Specimens of *koschevnikovi* are always larger than sympatric *A. cerana* and have reddish-yellow clypeus and legs. Specimens from Borneo are distinctively more fulvous in dorsal coloration than any other honey bees. Those from Sumatra and peninsular Malaysia are similar to *A. cerana* in dorsal coloration but are still larger. The cubital index of *koschevnikovi* (5.6–9.6) is larger than that of *cerana* (3.1–4.2) (Rinderer et al., 1989) and is usually diagnostic; it was checked on all specimens to verify the identifications.

Apis nigrocincta is rather similar to *A. koschevnikovi* in size and color, being

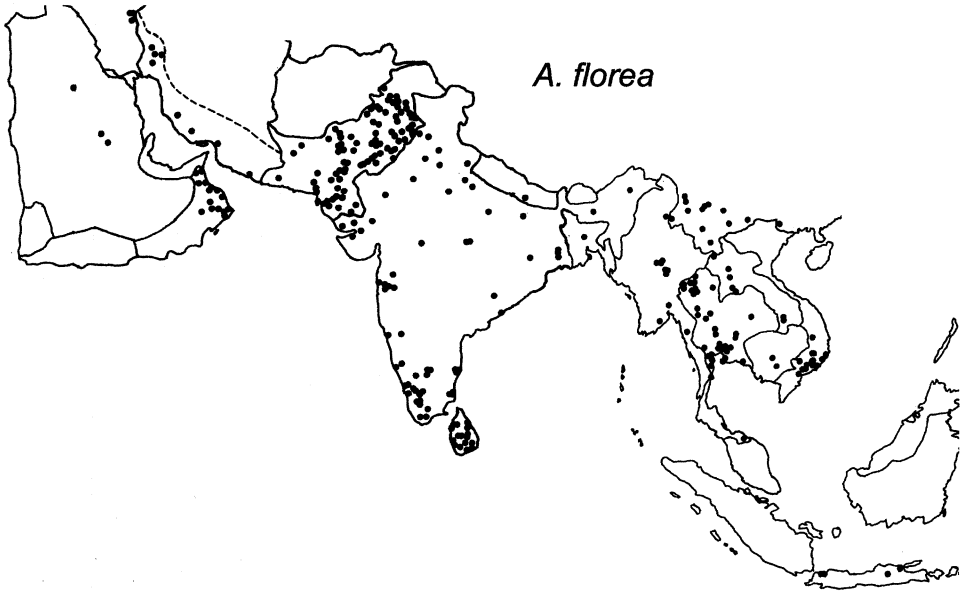


Fig. 1. Distribution of *Apis florea* in Asia (sites in Sudan are not shown).

yellowish to fulvous, but has the cubital index similar to *A. cerana*. Workers of *nigrocincta* are larger than *cerana* from Sulawesi. The hind femora are yellow and the clypeus yellowish in *nigrocincta*, characters which always allowed me to differentiate them from *cerana* in which clypeus and hind femora are blackish. Morphometric measurements analysed with multivariate statistics such as discriminant analysis (Damus, 1995; Hadisoesilo et al., 1995) enabled confirmation of the identities of some of the bees under study and allowed me to select the species-specific characters used for identification of other specimens.

Apis laboriosa is very easy to separate from *A. dorsata* by its larger size, all dark coloration (in contrast to the orange and black abdomen of *dorsata*), long body hairs, and the unraised ocelli on the head. Sakagami et al. (1980) reviewed other characters that differ between *laboriosa* and typical *dorsata*.

Specimen localities that could be located unambiguously on regional maps have been indicated by dots on range maps. Each dot indicates a known collection locality or reliable sight record for the species under consideration, although many of the specimens were old and subsequent habitat changes may have resulted in extirpation of the species from that site. Some localities on specimen labels could not be found on maps or in gazeteers and only the verbal description of the locality is given; these records are indicated by ● in the lists of localities. Collection month, year, and collector are given when available (not all names and collection months from labels were recorded). Information on type specimens is taken from Maa (1953).

Apis florea Fabricius 1787

HOLOTYPE: worker, "India"; *Type repository*: Kiel Museum; *Paratypes*: 1 worker, Kiel Museum.

COLLECTION/OBSERVATION LOCALITIES (See Fig. 1): BANGLADESH: Dacca, XII

1978, Dorothy C. Murrell (UGC). CAMBODIA: Ph. Chisau, 20 m, IV 1961, N. R. Spencer (BPBM); Kompong Chiang, 7 m, IV 1961, Bishop (BPBM). CHINA: Localities given in Kuang and Li (1985): Guanxi: Longzhou. Yunnan: Baoshan; Bijiang; Binchuan; Dali; Honghe (area to S); Jinghong (whole region); Lincang and vicinity; Lufeng (countryside); Lushui; Wenshan (area to S); Simao and vicinity; Weishan; Yingjiang. INDIA: Andhra Pradesh: Visakhapatnam (Reddi et al., 1983). Assam: Tinsukia, 10 mi. N (USNM). Bihar: Singbhoon (exact locality unknown), Mr. Rothney (BMNH 1938-614). Delhi: New Delhi, III-IV 1968, K. E. Gibson (USNM), XII 1964 (SEM). Goa: Marmagao, IX 1925, J.C. Bridwell (USNM). Gujarat: Deesa, II-III 1897, III 1899, XII 1901 (BMNH), Deesa, CGN Nurse (USNM); Bhuj, Dudhai, Kanthkot ●, Nawagam, Rapar, and Sumrasar ● (Chaudhary et al., 1994). Haryana: Hissar, II 1965, S. W. T. Batra (SEM); Karnal (Sinha and Chakrabarti, 1980). Karnataka: Bangalore (USNM), XII 1973 (Sakagami); Bangalore, Bannerghatta N.P., ca. 1100 m, X 1985, C. v. Achterberg (RNH); Dharwar, XII 1909, H. Swale (BMNH); Mangalore, J. C. Bridwell (USNM); Mudigere, 24 km W, IV 1980, Mathis & Freidburg (USNM); Mysore, Kakanakote Forest Stn., I 1965, S. W. T. Batra (SEM). Kerala: Anamalai Hills, Cinchona, 3500', V 1964, P. S. Nathan (SEM), 1959 & 1962, P. S. Nathan (RNH), 1050 m, IV 1956, P. S. Nathan (BPBM), 2500', 1964, P. S. Nathan (RNH); Malapuram, Calicut, Univ. Bot. Gardens, IX 1986, E. E. Grissel (USNM); Trivandrum Distr., Poonmudi Range, 3000', 1972, P. S. Nathan (SEM); Walayar Forests, 100', IX 1959, and 700', X 1959, P. S. Nathan (RNH ●), 700', 1965, P. S. Nathan (SEM ●). Madhya Pradesh: Danagar, 1966 (USNM ●); "Jubbelpore" (=Jabalpur), 1300', IV 1905, (USNM), "Panagar" (=Jabalpur), XII 1966, K. E. Gibson (USNM); Marble Rocks, F. Benton (USNM); Mhow, 1907 (BMNH 1927-184). Maharashtra: Bandra, Dr. Jayakar (BMNH 1905-152); Bombay Presidency, E. Comber (BMNH 1910-255); Lonavla, I 1959, F. L. Wain (UGC), Lonavla, 200', I 1959, F. L. Wain (SEM); Lonavla, 650m, W. Ghats, V 1963 (Sakagami); Madras, City Park, VIII 1973 (Sakagami); Matheran, III 1899, G. C. Nurse Coll. 1920-72 (BMNH); Nasik, VII 1911, N. B. Kinnear (BMNH); Poona, III 1945, D. Leston (BMNH), XI 1957, F. L. Wain (SEM). Meghalaya: N. Khasia Hills (BMNH 96-135). Orissa: Teypone (=Jeypore?), 1775', X 1958, P. S. Nathan (RNH). Pondicherry: Karikal, IV 1964, P. S. Nathan (SEM), Karikal (RNH); Karikal Territory, Kurum Bagaram, II, III 1947, II 1949, P. S. Nathan, (BMNH 1949-139), 1947, P. S. Nathan (USNM), 1950, P. S. Nathan (AMNH), 1949, S. W. Bromley (BMNH 1949-193); Negungadu, VI 1932, P. S. Nathan (BMNH 1933-16). Punjab: Amritsar Distr., Cholasahib Village, XI 1964, S. W. T. Batra (SEM); "Ludrianda" (Ludhiana?), II 1972, K. E. Gibson (USNM); Ludhiana Campus, Punjab Agric. Univ., IX 1964, S. W. T. Batra (SEM). Rajasthan: Jodhpur, Mandhur Park, X 1985, C. v. Achterberg (RNH); Sikar, Dunes, V 1959, W. Stower (BMNH). Tamil Nadu: Adyar, Madras, VII 1973 (Sakagami); Anamalai Hills, 3500', 1963, P. S. Nathan (RNH); Anamalai Hills, Kadamparai, VI 1962, P. S. Nathan (RNH); Chingleput, Madras (BMNH); Coimbatore, 1400', VI 1965, P. S. Nathan (SEM); Coonoor 86-94 (BMNH); Dohnavur, Tinnevely Dt., S. India, 350', IX, X 1938 (BMNH); Madras (BMNH), Madras, Airport, V 1962, P. S. Nathan (RNH); Nilgiri Hills, Naduvatam, 6000', V 1958, P. S. Nathan (RNH); Poonamalee, Madras State, V 1962, P. S. Nathan (RNH); Sivakasi (Parthiban et al., 1994). Uttar Pradesh: Agra, III 1960, B. Heineman (AMNH), Agra, nr. Taj Mahal, 1975, Ph. Pronk

(RNH); Allahabad, X 1958, F. L. Wain (SEM); Faridpore 3057 (BMNH); Haldwani, Distr. of Naini Tal, 500', R. M. Muttoo (AMNH); Shahjahanpur, II 1967, K. E. Gibson (USNM). West Bengal: Barrachpore (BMNH); Calcutta, XI 1904, Brunetti, N. L. H. Krauss (USNM), Calcutta (CNC), Calcutta (CU), Calcutta, V 1908, Brunetti Coll. (BMNH), Calcutta, III, IV 1907, V, VI, VII, XII 1908 (BMNH); Howrah, Bot Gardens, I 1974 (Sakagami); Serampore, Mr. Woodbury, Smith Coll. (BMNH 99-303). Additional Indian localities: Ferczepore 11.97, 1.98, 2.98, G. C. Nurse Coll. 1920-72 (BMNH ●); N. India (BMNH ●); N. W. India 84.38 (BMNH ●). INDONESIA: Java: Jawa Barat: Antjol, Batavia, VI 1939, M. A. Lieftinck (RNH), I Antjol, 1931, J. v.d. Vecht (RNH), Batavia, I 1909 (USNM), Batavia, 1920, 1931, 1936, 1953 (MZB), Batavia, VII 1936, C. Franssen (RNH), Batavia, IV 1907, Dr. P. Buiterdijk (RNH), Djakarta, 20 m, I 1953, from swarm, A. M. R. Wegner (RNH); Moeara, Antjol, Batavia, II 1908 (RNH); Tandjong Priok, II 1937, Dr. C. Franssen (RNH), Tanjong Priok, Batavia, (BMNH 90-126), Tj. Priok, VI, X 1908, P. Buitendijk (RNH). Jawa Timur: Muneng, 1956, leg. Hamann (RNH); Surabaya, VIII 1950, on ship, J.v.d. Vecht (RNH). IRAN: Ahwaz, Balut ●, and Chahbahar (Ruttner et al., 1985); Dezful (Ruttner, 1988); Ghir and Karsin ●, summer 1983 (Ahmadi, 1988); Lar, 4 km N, Fars. Prov., VII 1965, John W. Neal (USNM); Masjed Soleiman (Ruttner, 1988); Minab, III 1955, leg. Sharif (SMNS); Shushtar (Ruttner, 1988); note approximate distribution limit in Fig. 1 (Mossadegh, 1993). IRAQ: Jalowla, Khanaqin, and Madeli, IX 1990 (Glaiim, 1992). LAOS: Muong Sing, NW of Luang Prabang, 650 m, VI 1960, S. Quate and L. Quate (BPBM); Paklung, I 1920, R. V. de Salvaza (BMNH); Sedone Prov., Pakse, V 1965, P. D. Ashlock (BPBM); Vientiane, V 1965 (Bunchgrass), P. D. Ashlock (BPBM); Vientiane Prov., Tha Ngone, I 1966, Native collector (BPBM). MYANMAR: Kachin: Myitkyina, 175 m, III 1934 (NRS). Mandalay: Mandalay, VII 1951, H. M. Smith (USNM). Pegu State: Rangoon, Birmania, XI 1887 (USNM), Rangoon, II 1906, Brunetti Coll. (BMNH 1927-184), Rangoon, XII year? (Cockerell) (BMNH). Shan: Maymyo, 1500 m, II 1934 (NRS, RNH); Taunggyi, 1500 m, IX 1934 (NRS, RNH). Taunggyi, 40 km E (NRS). Tenasserim: Ataran Valley, II 1894, Bingham coll. (BMNH); Shwegyin Distr., II 1895, C. T. Bingham (BMNH). NEPAL: Reported from Terai region, below 1000 m (Allen, 1995; no specimens for verification). OMAN: (RPW = Whitcombe, 1984); Adam (RPW); Al Khabura (RPW); Ba'ei Wadisarín, 400 m, year? (BMNH); Buraimi (RPW); Ibra (RPW); Khabura, 10 m (BMNH); Muscat, between Ajib and Veyah, 1926, J. Fernandez (BMNH 1926-215), Muscat, Ruwi, III 1976, K. Guichard (BMNH), Muscat, Dr. Jayakar 98-9 (BMNH), Muscat (RPW); Nizwa (RPW); Quryat (RPW); Sohar (RPW); Sur (RPW); numerous other localities in northern Oman, as given in Fig. 1.1 of Whitcombe (1984). PAKISTAN: (Note: All localities from Muzaffar and Ahmad, 1989 (=M&A), except where otherwise noted. Baluchistan: Bagh; Bela; Dadhai; Dalbandin; Harnai; Kechi Kalat; Kohlu; Lahri; Las Bela; Loralai; Mahri; Mastung; Pishin; Siarat Gali; Sibi; Temple Dera; Turbat; Uthal; Ziarat. Islamabad: Islamabad, 600 m, X 1969, leg. Krupka (SMNS), Islamabad (M&A); Rawalpindi; Jammu and Kashmir: Mirpur; Northwest Frontier: Bajaur; Bannu; Charsadda; Dera Ismail Khan; Kohat Mdi (?), 1906, Frank Benton (USNM); Miram Shah; Peshawar, VI 1971, M. Shadab (AMNH), Peshawar (Ruttner, 1988), Peshawar (M&A); Raripur (?) (nr. Mardan); Razmak, Wana; Punjab: Attock; Bahawalnagar; Bhakkar; Chakwal; Chistian; Cholistan; Dera Ghazi Khan;

Dera Mayab Sahib (?) (nr. Uch); Diralpur; Faisalabad; Fort Abbas; Gujranwala; Gujranwala; Gujrat; Jhang; Jhelum; Kashr; Khanewal; Khusbab; Kot Addu; Lahore; Leiah; Liagatpur (?) (nr. Allahabad); Lodhran; Mianwali; Multan, IX 1909 (BMNH), Multan (M&A); Pindi Gheb; Rahimyar Khan; Sadigabad; Sahiwal; Sargodha; Sheikupura; Sialkot; Toba Tek Singh; Vihari; Wazirabad; Sind: Badin; Chhad Bet (?); Dadu; Ghara, 38 mi. E. of Karachi, V 1984, Rozen, Lodhi, Stupakoff (AMNH); Jacobabad; Karachi, VIII 1972, M. Shadab (AMNH), Karachi (M&A); Khairpur; Khairpur Diathan Shah?; Lake Haleji, 50 mi. E. of Karachi, V 1984, Rozen, Lodhi, Stupakoff (AMNH); Larkana (F. Ruttner, pers. comm.); Pais Gasj (?); Shikarpur; Sukker; Thar Parkar; Thatta; Thul. SAUDI ARABIA: Al Gassem, Al Kharg, and Riyadh (Al Ghamdi, pers. comm.). SRI LANKA: Angunakolapelessa (Man. Distr.), VI 1978 (USNM ●); Anuradhapura, II 1974 (BMNH 1974-624); Bibile, III 1962, K. L. A. Perera (SEM); China Bay (Tri. Distr.), I 1977 (USNM); Chitihuara, XI 1956, Bolivia-Reyes (SEM ●); Colombo, XII 1907 (BMNH), Colombo, VI 1977, T. Wijesinhe (USNM), Colombo, V 1969, P. B. Karunaratne (AMNH), Colombo, I 1957 (SEM); Deduniova, Put. Distr., N. W. Prov., III 1958, R. L. A. Perera (SEM); Dobrn (NRS ●); Galikissa, 7 mi. S. of Colombo, IV 1959, R. L. A. Perera (SEM); Gampaha, Bot. Garden (Col. Distr.) (USNM ●); Gilimale, Induruwa Jungle (Rat. Distr.), IV 1981 (USNM ●); Habaruduwa (S. Ceylon), XII 1980, T. Osten, leg. (SMNS ●); Hambanloka, 1908 (BMNH ●); Hambantota (Ham. Distr.), X 1970, O. S. Flint, Jr. (USNM); Hasalaka (Kan. Distr.), 500', XI 1970, O. S. Flint, Jr. (USNM ●); Hiniduma (S. Prov.), II 1958, R. L. A. Perera (SEM); Hunuwilagama, Wilpattu (Anu. Distr.), III 1970 (USNM); Kala-Oya (Put. Distr.), VIII 1975 (USNM ●); Kalatuwawa, Kalatuwawa Res. (Col. Distr.), 1975 (USNM ●); Kalutara, VII 1957, N. L. H. Krauss (SEM); Kandy, 40 mi. N. of Dambulla, II 1908, C. B. Longstaff (BMNH), Kandy, 1899, W. Horn (USNM), Kandy, 1976 (USNM), Kandy Asgiriya (C.P.), VIII 1953, F. Keiser (RNH); Kegalla (W.P.), VIII 1953, F. Keiser (RNH); Kondachchi (Man. Distr.), I 1978 (USNM ●); Kuchchaveti (N.P.), VI 1953, F. Keiser (RNH ●); Kurunegala (Kur. Distr.), I 1975 (USNM ●); Laxapathiya, 13 mi. S. of Colombo, IV 1959, R. L. A. Perera (SEM); Maduru, Oya, Punani, 500', VI 1969, P. B. Karunaratne (AMNH); Mahiyangana (Kan. Distr.), 5 mi. NW, IV 1971, Spangler (USNM); Matale, 1899, W. Horn (USNM ●); Ma Villu (Man. Distr.), IX 1980 (USNM ●); Minipe, C. P., I 1961, K. L. A. Perera (SEM); Nawela, Welimada (Bad. Distr.), XI 1974 (USNM ●); Paradna (USNM ●); Peredeniya, VII 1887, E. E. Green (BMNH), Peredeniya Bot. Gardens (Kan. Distr.), I 1971, Piyadasa & Somapala (USNM); Podaviya (Anu. Distr.), 180', V 1976 (USNM ●); Ratmalana Airport (Col. Distr.), I 1975 (USNM ●); Tampalakaman (Tri. Distr.) (USNM ●); Trincomalee, X 1901 (BMNH 1901-311); Trinc., Felder (RNH ●); Trincomalee, China Bay (Tri. Distr.) (USNM); Uggalkaltota (Rat. Distr.), VI 1978 (USNM); Wilpattu, Maddikulam (Put. Distr.) (USNM ●), Wilpatto Nat. Park, Mullikulara, Modaragam Aru (Put. Distr.), VI 1975 (USNM ●); Yala, Palatupana (Ham. Distr.), IV 1972, Krombein & Karunaratne (USNM). SUDAN: Khartoum and vicinity, all months (Lord and Nagi, 1987; Mogga and Ruttner, 1988). THAILAND: Ahn Kang, in mountains W of Fang, I-II 1993, C. D. Michener (SEM); Ban Dan Lan Hoi, Sukhothai Prov., I-II 1993, C. D. Michener (SEM); Bang Khan, VI 1956 (Sakagami); Bangkok, IX 1934 (USNM), Bangkok, Morse (CU), Bangkok, II 1988 (Nagase), Bangkok, IX 1984 (ZMC), Bangkok, I-II 1993, C. D. Michener

(SEM); Bankhun Si, Amphur Kabinburi, Parjinburi Prov., XII 1965, Kol Mongkolpanya (AMNH); Ban Mai, nr. Muang Chiang Rai, 19.56 N, 99.51 E, XI 1976, Ph. Pronk (RNH); Ban Phiang, Nakhon Sawan Prov., I–II 1993, C. D. Michener (SEM); Cha-Am, Petchaburi Prov., I–II 1993, C. D. Michener (SEM); Chachoenngsao (Sakagami); Chantaburi, Hort. Res. Centre, II 1992 (Rinderer et al, 1993), Chiang Dao, 80 km N of Chiang Mai, IV 1989 (Nagase); Chiangmai, 1961 (Sakagami), Chiang Mai, XI 1976 (RNH); Doi Saket, Chieng Mai Prov., 950 m (ZMC); Fang, Chiangmai, 500 m, IV 1958, T. C. Maa (BPBM), Fang (Agr. Exp. Stn.), 600 m, VI 1965, P. D. Ashlock (BPBM), Fang Hort. Exp. Station, 550–600 m, X 1981 (ZMC), Fang, Chiang Mai Prov., I–II 1993, C. D. Michener (SEM); Hua Hin, W. coast of Siam Gulf, VIII 1979 (ZMC); Huai Nam Dang, Chieng Mai Prov., 1500–1700 m, X 1984 (ZMC ●); Kamphaeng Phet, XII 1957 (Sakagami); Kamphaeng Saen, T. D. Seeley (PM); Khao Yai Nat. Park, 800 m, T. D. Seeley (PM); Khlong Sip Si, Pathum Thani Prov., I–II 1993, C. D. Michener (SEM ●); Lampang, I–II 1993, C. D. Michener (SEM); Lang Sang N. P., 19 km W. of Tak, 13.28 N 99.48 E, 600 m, VII 1986, leg. R. Hensen (RNH); Nakhon Nayok, I–II 1993, C. D. Michener (SEM); Nakhon Ratchasima, 60 km. S., III 1971 (USNM), Nakonrat chasima, 1958 (Sakagami), Nakhorn Ratchasima, VII 1988 (Nagase); Nan, I 1914, Cockerell (USNM); Narathiwat, 1958 (Sakagami); Pak Chong, 100 mi. NE of Bangkok, 1957, J. L. Gressitt (BPBM), Pak Chong, 1979–80, T. D. Seeley (CU, PM), Pak Chong, Ratchasima Prov., I–II 1993, C. D. Michener (SEM); Paknomphoh (=Nakhon Sawan), XI 1933, W. R. S. Ladell (J. 690) (BMNH); Pak Thawarn Prachuap Khirikhan, 1956 (Sakagami ●); Pathaya, E. Coast Siam Gulf, XI 1979 (ZMC); Peng Tam, Chiang Mai Prov., I–II 1993, C. D. Michener (SEM ●); Phetburi, 1963 (Sakagami); River Kwai Lodge, S. of Sai Yok, VIII 1979 (ZMC); Sam Ngao at Bhumipol Dam, XI 1979 (ZMC); Sam Ngow Tak, V 1959 (Sakagami); Samut Songkhram, II 1992 (Oldroyd et al., 1994); Saraburi, XII 1964 (Sakagami); Sarakam, III 1929 (USNM); Sattahip, Chan Buri Prov., I–II 1993, C. D. Michener (SEM); Tak, 50 km N., Tak Prov., I–II 1993, C. D. Michener (SEM); Ta Salva, Kamburi, VII 1930 (AMNH ●), Tha Chang, Ratchasima Prov., I–II 1993, C. D. Michener (SEM ●); Thagad Dam, 60 km SE of Chiang Mai, IV 1989 (Nagase). VIETNAM: Ban Me Thnot, 500 m, V 1960, S. Quate (BPBM); Blao Agr. Sta., Prov. Haut Donai, Annam, Cochinchina, 800 m, V 1933 (USNM ●); Dalat, 15 km NW., 1850 m, V 1960, C. M. Yoshimoto (BPBM), Dalat, 6 km S, 1400–1500 m, VI–VIII 1961, N. R. Spencer (BPBM); Dilinh, 7 km SE, 920 m, IV 1960, L. W. Quate (BPBM), Dilinh, 7 km SE, 990 m, V 1960, R. E. Leech (BPBM), Dilinh (Djiring), IV 1960, C. M. Yoshimoto (BPBM), Di Linh (Djring), 1200 m, 1960, S. Quate (BPBM), Dilinh, 9 km S, ex. human excrement, IV 1960, Bishop (BPBM); Fyan, 900–1000 m and 1200 m, VII–VIII 1961, N. R. Spencer (BPBM); Karyu Danar, 200 m, II 1961, N. R. Spencer (BPBM ●); M'Drak, E. of Ban Me Thout, 400–600 m, XII 1960, C. M. Yoshimoto (BPBM); Mt. Lang Bian, 1500–2000 m, V–VI 1961, N. R. Spencer (BPBM); Nha Trang, XI 1960, C. M. Yoshimoto (BPBM); Ninh Hoa, N. of Nha Trang, XI 1960, C. M. Yoshimoto (BPBM); Phan Rang, 15–35 km NW, XI 1960, C. M. Yoshimoto (BPBM); Phan Thiet, XI 1960, C. M. Yoshimoto (BPBM); Pleiku, 700 m, 1960 (BPBM), Pleiku, 25 km SW, 400 m, V 1960, L. W. Quate (BPBM); Saigon, R. V. N., Giadinh Prov., V 1970, W. H. Tyson (USNM); Van Gia, N. of Nha Trang, Light trap, XI–XII 1960, C. M. Yoshimoto (BPBM). Ad-

ditional localities: China, locality illegible, col. Dr. Wu (SEM ●); Indes Orientales, 1867, coll. D.J. Tosquinet (IRSN ●); Kenya, Diani Beach, V 1957, N. L. H. Krauss (SEM ●); Kinb., Manilla (NRS ●).

DISCUSSION: *Apis florea* is an extremely widespread species, occurring from Vietnam west to Iraq and Oman, with outlier populations in Indonesia and Sudan. It has not reached the Andaman Islands (G. Otis, pers. obs.; the report by Dutta et al. (1983) of its presence there was probably a result of the misidentification of a meliponine bee), suggesting its dispersal ability is more restricted than that of *A. cerana* or *A. dorsata*, both of which have colonized those oceanic islands. This limited dispersal ability suggests that the disjunct populations on Java and in Sudan were established through human-assisted movement. The specimens from Surabaya, Java, were collected from a ship, which confirms the potential for human transport. The rapid range expansion in Sudan after its discovery suggests that it only recently became established there (Lord and Nagi, 1987; Mogga and Ruttner, 1988). The most likely source of the Sudanese colonies is Pakistan (Mogga and Ruttner, 1988).

Of interest is a specimen labelled "Kenya, Diani Beach, May 1957, N. L. H. Krauss." Normally such a record would be discarded as erroneous; N. Krauss did collect in Sri Lanka in July of 1957 and the specimen may have been mislabelled. However, the recent discovery of *A. florea* in Africa suggests it would be worthwhile to survey coastal Kenya to clarify this situation.

A. florea is generally reported to be found up to elevations of 500 m (Ruttner, 1988), with summer records up to 900 m in Iran (Ruttner et al., 1985) and 1900 m in Oman (Whitcombe, 1984). A number of museum specimens were collected at relatively high elevation (e.g. 3500'–6000' = 1065–1830 m) in S. India, and several sites between 1400–2000 m in Vietnam. These specimens were noticeably larger than those at lower elevations, making it unlikely that they represent seasonal migrations to higher elevations. However, it is known that *florea* does migrate in response both to microclimatic conditions and to seasonal conditions. Wongsiri et al. (submitted) report that in northern Thailand, *A. florea* is present for two months in the dry season and from July to November in the rainy season. They suggest the colonies migrate, but there is no evidence of where they go.

In Thailand, *A. florea* is common below 1000 m in urban and agricultural areas with little of the original vegetation remaining; in the dry season it can be found up to 1600 m (Wongsiri et al., submitted). *A. andreniformis* is more commonly (but not always) found at higher, cooler elevations (Wongsiri et al., submitted). However, in Yunnan Province, China, at the northern limit of distribution of the two species, *A. florea* has a slightly more northern distribution. That it is slightly larger than *A. andreniformis* (Wu and Kuang, 1987) may be important in this regard. Surprisingly, the locality data from Vietnam indicate that the two species are collected in many of the same localities over a range of elevations from 400–1200 m; *A. florea* is the only dwarf honey bee in collections from higher elevations there. There are presently no suitable explanations for these patterns in distribution.

Apis andreniformis F. Smith 1858

HOLOTYPE: Worker, Sarawak, coll. by A. R. Wallace, probably near Kuching.
Type repository: Oxford University Museum, Oxford, U.K.

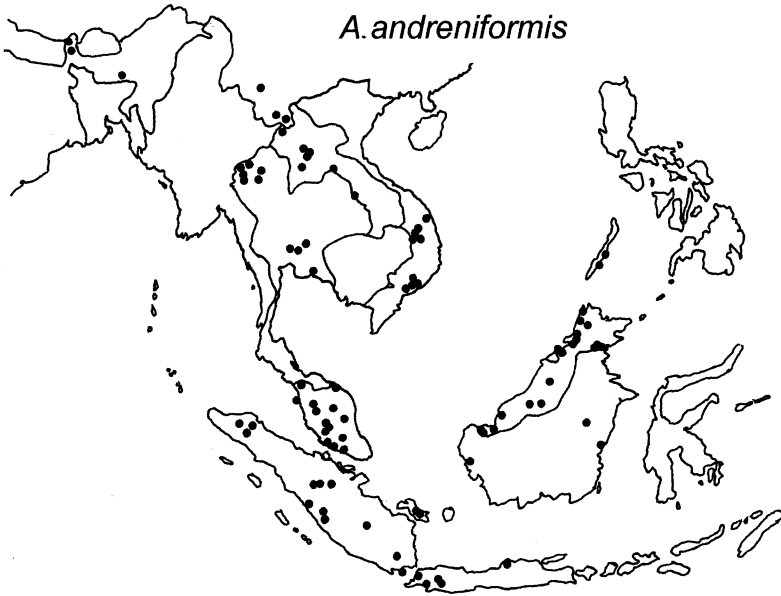


Fig. 2. Distribution of *Apis andreniformis* in Southeast Asia.

COLLECTION/OBSERVATION LOCALITIES (See Fig. 2): BRUNEI DARUSSALAM: Belalong Field Sta., S. of Bangar Seri Begawan (D. W. Roubik, pers. comm.); Bukit Sih, nr. Bandar Seri Begawan (D. W. Roubik, pers. comm.). CHINA: All data from Kuang and Li (1985): Yunnan: Jinghong; Lincang; Mengla; China, location unknown, Wu (SEM ●). INDIA: Meghalaya: Khasia Hills, IV 1895, F. W. Sladen coll. (CNC). Sikkim: Sikkim (ZMC). West Bengal: Teesta Bridge, I 1897, F. W. Sladen coll. (CNC). INDONESIA: Borneo: Kalimantan Barat: Pontianak, F. Muir (BPBM); Kalimantan Timur: Balikpapan, Mentawir River, 50 m, X 1950, A. M. R. Wegner (RNH); Tabang, Bengen River, 125 m, VIII, X 1956, A. M. R. Wegner (RNH). Java: Jawa Barat: Djampang Tengah, Tjitalahal, 700 m, M. A. Lieftinck (RNH); Palabuanratu, 1935, Mrs. M. E. Walsh (Maa, 1953); Tjibarangbang Djasinga, 150 m, XI 1936, J. v. d. Vecht (RNH); Wynkoopsbaai, III 1935, Mrs. M. Walsh (RNH); Jawa Tengah: Moeria Mtns, Tjolo, X 1939, M. A. Lieftinck (RNH). Sumatra: Aceh: Alas Valley, Balelutu, 3.43 N, 97.38 E, 320 m, VIII 1972, J. Krikken (RNH); Pending, 400 m, II, III 1937, A. Hoogerwerf (RNH, MZB); Takengon, NGS-S1 Exp., 1937 (USNM); Lampung: Air Njurus Dempu, 1400 m, VIII 1916 (RNH); P. Legundi, VI 1956, A. M. R. Wegner (RNH); Riau: Kampar, Batu Basurek, Bukit Kincung, 155 m, III 1985 (Salmah et al., 1990); Moeara Mahat, NGS-S1 Exp., 1937 (USNM); Sum. Barat: Lubuk-gadang, 750 m, XII 1984 (Salmah et al., 1990); Padang, Padang Sarai, 2 m, X, XI 1984, III 1985 (Salmah et al., 1990); Tapan, Bukit Tapan Watas, 470 m, XII m, 1984 (Salmah et al., 1990); Sum. Selatan: Rawas - Sum. Exp., V 1878 (RNH); Bangka, Aer Mesoe, XI 1929 (RNH); Djelaetaeng (Bangka), XII 1935, J. v. d. Vecht (RNH); Troe (Bangka), XII 1935 J. v. d. Vecht (RNH ●); Additional Sumatra localities: Alpig., Sum., X 1877 (RNH ●); Lampongs, Karny & Siebers, 1921 (MZB ●); Serapai: Kur: Sum., VII 1915; Edw. Jacobson (RNH ●); Suban

Ajam Sum., VII 1916, Edw. Jacobson (RNH ●); Sungai Kumbang, Sum., IX 1915 (RNH ●); Wai Lima Z. Sum. (MZB ●). LAOS: Borikhane Prov., Pakkading, VII 1965, J. L. Gressitt (BPBM); Luang Prabang, 300 m, VI 1960, L. W. Quate (BPBM), Luang Prabang (Sakagami), Luang Prabang, 40 km NW (Sakagami); Muong Sing, NW of Luang Prabang, 650 m, VI 1960, S. Quate & L. Quate (BPBM); Sayaboury, Sayaboury Prov., I 1966 (BPBM); Savannakhet Prov., Savannakhet, IV 1967 (BPBM). MALAYSIA: Borneo: Sabah: Bettotan, Nr. Sandakan, North Borneo, VII, VIII 1927, C.B.K. & H.M.P, F.M.S. Museum (BMNH 1955-354); Kalabakan, Tawau Distr., N. Borneo, primary forest, fish bait trap, XI 1958, T. C. Maa (BPBM), Kalabakan R., Tawau, 48 km W., Br. N. Borneo, XI 1958, T. C. Maa (BPBM); Kota Belud, III 1973, K. M. Guichard (BMNH 1974-444); Kudat, North Borneo IX 1927, C.B.K. & H.M.P, F.M.S. Museum (BMNH 1955-354); Luasong Forestry Center, 100 km W of Tawau, 1989 (G. W. Otis, pers. obs.); Ranau, North Borneo, IX 1958, on *Crotalaria*, L. W. Quate (BPBM), Ranau, British N. Borneo, 500 m, X 1958, T. C. Maa (BPBM), Ranau, 8 mi. N. Poring Hot Springs, Br. N. Borneo, 500 m, X 1958, L. W. Quate & T. C. Maa (BPBM); Tawau, Quoin Hill, Cocoa Res. Sta., Br. N. Borneo, some on *Leucaena glauca*, VII 1962, Y. Hirashima (BPBM); Tawau, Quoing Hill, 1962, light trap, H. Holtmann (BPBM); Tenom, 180 m, XII 1962, Y. Hirashima (BPBM), Tenom, Sapong Estate, 180 m, XII 1962, Y. Hirashima (BPBM), Tenom Agr. Res. Sta., 5.10 N, 115.57 E, V, VI 1989, G. W. Otis (SEM, CU, GWO), Tenom, 9.8 km SW, forest camp, XII 1962, Y. Hirashima (BPBM); Sarawak: Gunong Matang, 120 m, IX 1958, T. C. Maa (BPBM); Merirai V., Kapit Distr., 30–300 m, VIII 1958, T. Maa (BPBM); Mt. Dulit, 4000', moss forest, at waterfall, X 1932, B. M. Hobby & A. W. Moore, Oxford Univ. Exped. (BMNH 1933-254); Mt. Dulit foot, jct. of Rivers Tinjar & Lejok, VIII 1932 (BMNH); Nanga Pelagus, nr. Kapit, 180–585 m, VIII 1958, T. C. Maa (BPBM); Pangkalan Tebang, Bau Distr., 300–450 m, IX 1958, T. C. Maa (BPBM); Rejang Delta, Sarikei Distr., VII 1958, T. C. Maa (BPBM). Malaya: Johor: Air Panas, Sungai Grisek, 1.55 N, 102.46 E, 1989, G. W. Otis (SEM, CU, GWO); Sungai Palong, V 1930, D. S. Inglis (BMNH). Kedah: Nr. Jitra Catchment Area, IV 1928, H. M. Pendlebury (BMNH). Kelantan: Pasir Puteh, 1994 (G. W. Otis, pers. obs.). Kuala Lumpur: V, VI, VII 1922, VII 1923, IV, V, VIII 1926, IV 1928, V 1933, (BMNH); 1985, R. Jander (SEM); Ampang, VIII 1932 (BMNH); Sungai Buloh, 1973, Phang Ong Wah (SEM); Weld Hills Res., X 1922 (BMNH). Melaka: Melaka, VIII 1994 & III 1995 (G. W. Otis, pers. obs.). Negri Sembilan: Port Dickson, XI 1932 (BMNH). Pahang: Cameron Highlands: Lubok Tamang, 3600', V 1931, H. T. Pagden (BMNH), Rhododendron Hill, 5200', VI 1923, H. M. Pendlebury (BMNH), Tanah Bota, 4800–5000', VII 1938, H. M. Pendlebury (BMNH), No. 9 Camp, 4800', X 1923, H. M. Pendlebury (BMNH); 19.3 mile, V 1931, H. T. Pagden (BMNH); Jerantut-Kuantan Rd., 75 miles, VI 1926, H. M. Pendlebury, and 1957, Pagden (BMNH); Kuala Tahan, 300', XI 1921, H. M. Pendlebury, FMS Museum, B. M. 1955-354 (BMNH); Lubok Temang, 3500', VI 1923, Pendlebury (BMNH). Penang: Batu Feringgi Catchment Area, IV 1957 and VI 1961, H. T. Pagden (BMNH ●); Penang, X 1913, G. E. Bryant (BMNH), XII 1958, L. W. Quate (BPBM), Sungei Penang Hills, nest on citrus, 1957, H. T. Pagden (BMNH). Perak: Batang Padang, Jor. Camp, 1800', V, VI 1923, and 2000', VIII 1922, H. M. Pendlebury (BMNH ●); Gopeng Pipeline, VIII 1963, H. T. Pagden (BMNH); Fraser's Hill, Sungei Hijan,

3250', IV 1966, H. T. Pagden (BMNH); Ulu Sungai Triang, VI 1930 (BMNH ●). Selangor: Ampang, Water Works Reserve, VIII 1926 (BMNH); Bukit Kutu, 3500', IX 1929 (BMNH), Bukit Kutu, 3300', IX 1932 (BMNH); Gonilak Valley, 1900–2200', IV 1924 (BMNH), Serdang, Universiti Pertanian Malaysia, M. Mardan (pers. comm.); Ulu Langa (Langat?), Sungai Chongkok, VII 1961 (BMNH ●). Additional Malaysian locality: Malakka Up.-Perak, XII 1902 (ZIL ●). PHILIPPINES: Palawan: Arborlan, Palawan Nat. Agric. College campus (de Guzman et al., 1992); Brooke's Point, Uring Uring, VIII 1961 (ZMC); Tarumpitao Pt., VI 1958, H. E. Milliron (BPBM). THAILAND: Ban Mae Sai Kao, 30 km N. of Mae Hong Son, IV 1989 (Nagase); Chanthaburi (Sakagami), Chanthaburi, Hort Res. Centre, II 1992 (Rinderer et al., 1993); Chiangdao, Chiangmai Prov., 450 m, IV 1958 (BPBM), Chiang Dao, IV 1989 (Nagase), Chieng Dao (Sakagami); Chum Het Trang (SEM ●); Doi Inthanon, Chiang Mai (Sakagami); Doi Nya Chang, IV 1941, A. M. Hemmingsen (ZMC ●); Doi Suthep, nr. Chiang Mai, IV 1989 (Nagase); Fang, Chiang Mai Prov., 500 m, IV 1958, T. C. Maa (BPBM), Fang (Sakagami); Khao Yai Nat. Park, S. of Nakhon Ratchasima, XII 1984 & I, II, III 1985, Fred Dyer (PM); Nakhon-nayok (Sakagami); Nakhon Ratchasima, 60 km S., Sak-aerat Expt. Sta., 14.30 N, 101.55 E, 300–600 m, malaise trap, III 1971, P. & P. Spangler (USNM); Nam Buh, III 1941, N. F. Prae (ZMC ●); Pha Mon, Chiangmai Prov. (Sakagami ●); Saraburi (Sakagami); Uthaithani (Sakagami ●: possibly misidentified; in this site only *A. florea* should occur). Additional Thailand locality: Thailand, F. A. Moller (ZMC ●). VIETNAM: Chute de Bobla, 7 km W. of Dilinh, ex human excrement, 1960, R. E. Leech (BPBM); "Djiring" (Dilinh), 920 m, V 1960, and 1200 m, (one at light), V 1960, L. W. Quate (BPBM), Dilinh, 30 km N, 870 m, IV 1960, R. E. Leech (BPBM), Dilinh, 40 km N, 540 m, IV 1960, R. E. Leech (BPBM), DiLinh (Djiring), 1960, C. M. Yoshimoto (BPBM); Fyan, 1200 m, VII–VIII 1961, N. R. Spencer (BPBM); Haut Donai, Annam Prov., 900 m, IX 1932, M. Poilane (USNM); Kontum, N. of Pleiku, 550 m, V 1960, S. Quate (BPBM); Pleiku, 20 km N, 650 m, V 1960, L. W. Quate (BPBM), Pleiku, 25 km SW, 400 m, V 1960, L. W. Quate (BPBM); Trang Bom, 30 mi NW of Saigon, VIII 1932, M. Poilane (USNM). Additional locality: Rungtong (N. India?), F. W. Sladen coll., I 1897 (CNC ●).

DISCUSSION: The distribution of *A. andreniformis* is largely restricted to Indochina and Sundaland (Malaysia and part of Indonesia). In Sundaland, it is often encountered at low elevations (0–500 m), where it can sometimes be abundant (e.g., Tenom Agr. Res. Station, Sabah, and Muar, Johor, Malaysia; pers. obs.). In their extensive study in Central Sumatra, Salmah et al. (1990) found this to be one of the most common apid species, particularly at elevations of 200–500 m; they did not collect it above 1000 m. However, it does occasionally occur at higher elevations, including Lampung Province, Sumatra (1400 m), Mt. Dulit, Sarawak (1220 m), Vietnam (1200 m), and several locations in the Cameron Highlands, Malaysia (1100–1590 m). Local abundance is probably influenced by climate, local plant communities, human activities, and other factors because the species is rare in some parts of its range and abundant in others.

Bees from high elevation are notably larger than those collected at lower elevations; this is a common trend seen in several honey bee species (Ruttner, 1988), and was noted for *A. florea* above. In addition, bees of some regions seem to be larger than those of others. For example, specimens from 500 m in Borneo are

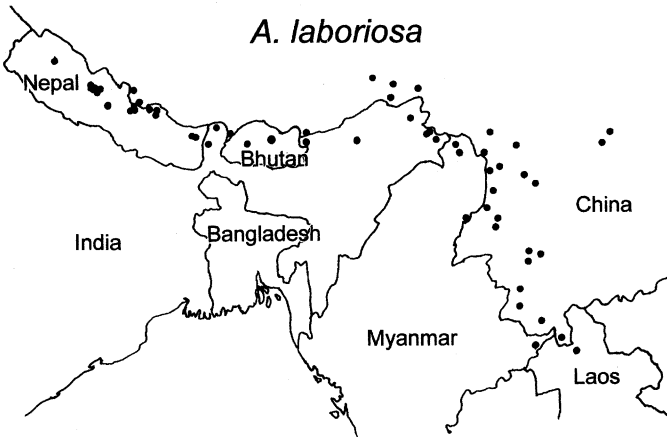


Fig. 3. Distribution of *Apis laboriosa* (site in Uttar Pradesh, India, not shown).

more robust than those from Vietnam at similar elevations. Factors influencing size are unknown at present.

A. andreniformis was recently reported from Palawan (Otis, 1991; de Guzman et al., 1992), an island that was connected to Borneo in the Pleistocene. It has not crossed into the rest of the Philippine Archipelago, even though the water gaps were quite narrow. It is also unknown from Sulawesi which was separated from Borneo by only 50–100 km during the height of the glaciations (Whitmore, 1987). The absence of records from these regions suggests that, like *A. florea*, this species has limited dispersal abilities. Somewhat contrasting to this, there is indirect evidence that *andreniformis* may follow a seasonal migration pattern (Wongsiri et al., submitted). In Thailand, nests are present in Chantaburi (south-east) from January to June and are difficult or impossible to find in other months. In Chiang Mai (north), they are first noted in March and April; between June and October (rainy season) they abscond.

A few *andreniformis* were collected in northeastern India many years ago. The species may still occur in this region as well as in neighboring Nepal and Bhutan. It is most likely to be encountered in the foothills of the mountains. It almost certainly occurs in Myanmar and Cambodia given the nearby collection sites in Thailand and Vietnam.

Apis laboriosa F. Smith 1871

HOLOTYPE: Worker, Yunan; coll. by Dr. Anderson. *Type repository*: The Natural History Museum, London, U.K.

COLLECTION/OBSERVATION LOCALITIES (see Fig. 3): (Note: DWR = Roubik et al., 1985; SFS = Sakagami et al., 1980; and BAU = Underwood, 1990a; complete data in those publications). BHUTAN: Lake Tang Memba Tso, N. of Bumthang, 2600 m (SFS); Thimphu, IX 1985 (BMNH); CHINA: All data from Kuang and Li, 1985, except where otherwise noted. Sichuan: Jinyang. Tibet: Bomi (Bowo); Chumbi Valley (BMNH); Cona; Gyirong; Medog; Nyalam; Rongshar Valley, 9500' and 10,000' (BMNH ●); RongTo Valley, 6000' (BMNH); Yadong (Chongma); Zayu; Zhangmu ●. Yunnan: Baoshan; Bijiang; Deqen; Fugong; Gongshan;

Jingdong; Jinghong; Lancang; Lijiang; Lincang; Luku; Mengla; Wayao; Weixi; Yongshan; Yongshen; Yunxian; Zhongdian. Additional Chinese localities: "Moller, Thibet" (SFS ●); Tse-Kou (Maa, 1953 ●); Yunan (Smith, 1871 ●). INDIA: Arunachal Pradesh: Chhagion, 5350', III 1935 (BMNH ●); Delai Valley, Taphlogam, XI 1936 (BMNH); Denling Forest, Kameng Div. (SFS ●); Deng Zi, Kameng Div. (SFS ●); Dingliang, Mishmi Hills, 2450 m, III 1935 (BMNH ●); Gidakom, X 1985 (BMNH ●); Lohit River (BMNH); Minutang, 3900', II 1935 (BMNH); Pamir, Subansi Div. (SFS); Tawang, Kameng Div, 200 m (SFS). Sikkim: Lachen, 8000' (BMNH); Jukvar, 4000' (BMNH ●); Uttar Pradesh: Harsil, gorge of the Bhagirathi Ganga, 2660 m, and Uttarkashi, 1300 m, (S. Batra, 1996; localities not shown on map). West Bengal: Darjeeling, Tiger Hill, 2450 m, 1938, T. Maa (Maa, 1953). LAOS: Kiou Theu, Luang Prabang Prov., III 1920 (BMNH). MYANMAR: Adung Valley, 6000', III 1931 (BMNH); Kambaiti, N. E. Burma, 2000 m and 7000', V 1934 (RNH); Nam Tamai Valley, Upper Burma, 3000', VII 1938 (BMNH). NEPAL: Bagar (BAU); Bamboo (BAU); Bangel Kharka (SFS); Beding, Rolwaling Valley, Janakpur (DWR); Changa, 27.29 N, 87.34 E, 6900' (BMNH), Changa, 27.28 N, 87.42 E, 8400' (BMNH); Chomrong (BAU); Biratanti (SFS); Darandi Khola (SFS); Dhunche, Gosainkund Lekh, Bagmati (DWR), Dunde-Chandanbari (SFS); Donga Kharka, Rolwaling Valley, Janakpur (DWR ●); Dovan (BAU); Dudh Kosi Valley, Thyangboche (SFS), Ghachak (BAU); Ghara (SFS); Ghora Tobela (SFS); Ghora Tobela-Kyangjin Gompa (SFS); Gosainkund (SFS); Heele (SFS); Jillimarang (BAU); Jumla Distr., W. Nepal, 12–14,000', V–VI 1961 (BMNH); Kali La (SFS); Khorza (SFS); Kimrung Khola (BAU); Kuldi Ghar (BAU); Kuli (BAU); Landrung (BAU); Lantang, Bagmati (DWR); Lete (SFS); Machhapuchhare Base Camp (BAU); Madi Khola (SFS); Namche Bazar (SFS); Obio (BAU); Peyu (BAU); Phewa Tal, nr. Pokhara (Gandaki), 28.14 N, 83.59 E, XI 1975, Ph. Pronk (RNH); Punguchaga (SFS); Rowinami (BAU); Sing Gomba, Gosainkund Lekh, Bagmati (DWR); Sikha (SFS); Siklis, 7000' (BMNH ●); Simigaon, Rolwaling Valley, Janakpur (DWR ●); Supbu Kharka, Rolwaling Valley, Janakpur (DWR ●); Syabru (SFS); Tamejung (BAU); Tatopani (SFS); Thare Pati (SFS); Thare Pati-Melanchi (SFS); Tikhedhunga (BAU); Trubuking Kharka (SFS); Tukucha (SFS); Ulleri, 6000–7000' (BMNH), Ulleri (SFS). Additional localities: Nam Mia, Haut Mekong (BMNH; estimated in Fig. 4 in extreme eastern Myanmar); "Tabu" (Maa, 1953 ●).

Discussion. *Apis laboriosa* is a very distinctive bee with a range that barely overlaps that of *A. dorsata*, and then at different seasons (Underwood, 1990a).

This study includes a number of specimens from the British Museum of Natural History as well as those published previously by Sakagami et al. (1980), Kuang and Li (1985), Roubik et al. (1985), and Underwood (1990a), and Batra (1996). Collectively, these records demonstrate that *A. laboriosa* has a nearly continuous distribution in the mountains from Uttar Pradesh in India to extreme northern Laos, with some specimens known from Sichuan Province as well. It is unlikely that additional sampling will change this distribution to any substantial extent, although this species is undoubtedly more common in Myanmar and Bhutan than existing records indicate, and it may occur in the highlands of northern Vietnam.

Sakagami et al. (1980) presented a detailed summary of the many distinctive features of *A. laboriosa*. Of 103 different measurements, *laboriosa* and *dorsata* were statistically different for 96 of them. This extensive differentiation between

two forms of honey bees not physically separated by any substantial barriers almost certainly indicates that they are reproductively isolated and consequently different species. The only data available to address this question other than morphological differences are for timing of mating flights of drones. Underwood (1990b) observed *laboriosa* drones leaving and returning to colonies in early afternoon. In contrast, in all studies of typical *dorsata*, males fly at dusk just prior to nightfall (Koeniger and Wijayagunasekera, 1976; Koeniger et al., 1988; Rinderer et al., 1993; M. Mardan, pers. comm., G. W. Otis, pers. obs.). A characteristic of *dorsata* males is the raised ocelli, an adaptation also found in other crepuscular and nocturnal bees, that probably functions in gathering light (R. Menzel, pers. comm.) and allows them to fly at very low lux. Because males of *A. laboriosa* lack this feature, it is unlikely they can fly at the same time as *dorsata* drones. Unfortunately, Underwood (1990b) obtained complete flight data from only one *laboriosa* colony on one afternoon, and no comparative data from *dorsata* on the same date. Genitalic structures of males have been less informative. McEvoy and Underwood (1988) stated that they did not find differences in the male endophalli of the two forms; however, because their diagram of *laboriosa* disagrees in several substantial features from that of *dorsata* by Koeniger et al. (1990), this requires further analysis. To conclude, although the evidence favors species status for *A. laboriosa*, additional studies should be conducted to verify this status.

Seasonal movements are better understood for *A. laboriosa* than for any other *Apis* species (Underwood, 1990a). Nests are constructed on cliffs at altitudes between 1200–3600 m. Those at lower elevations may be active for as many as 10 months of the year (Feb.–Dec.), although some of these colonies, in part in response to honey harvesting activities of humans, migrate in up-valley directions in April–June. Colonies at higher elevations (e.g., 2680–3360 m) are colonized in July and abandoned in October. The highest sites (>3500 m) are not occupied every year, and when they are it is only for a few months in mid-summer. Toward the end of the active season at a particular elevation, colonies prepare for absconding by ceasing brood rearing and reducing foraging. Bees perform migration dances, and eventually abandon their nests and fly in a down-valley direction. They seek protected locations under rocks and tree trunks near ground level below 2000 m where they remain as combless swarms. Body temperatures are maintained just above lethal levels. After existing like this for about two months, the swarms move back to cliff sites in early February to reinitiate the annual cycle.

Apis koschevnikovi Buttel-Reepen 1906

HOLOTYPE: Worker, “Kamerun (Karstensen leg.).” *Type repository*: Berlin Museum, Berlin, Germany. *Paratypes*: 6 workers, “Kamerun” (Karstensen leg.), 1 worker “North Borneo (J. Waterstradt leg.),” Berlin Museum, Berlin, Germany.

COLLECTION/OBSERVATION LOCALITIES (see Fig. 4): BRUNEI DARUSSALAM: Belalong Field Sta., S. of Bangar (D. W. Roubik, pers. comm.); Bukit Sih, nr. Bandar Seri Begawan (D. W. Roubik, pers. comm.). INDONESIA: Borneo: Kalimantan Barat: Gunung Palung Nat. Park, Cabang Pant. Res. Sta., 1.15 S, 110.05 E, VI–VII 1991, Darling, Rosichon, Sutrisno (ROM); Ketapang, 150' (BMNH). Kalimantan Selatan: Barabai, Banjarbaru, IV 1990 (S. Hadisoelilo, pers. comm.). Kalimantan Timur: Babi Islet, 1937, K. M. Walsh (BMNH 1938-99 ●); Balik-

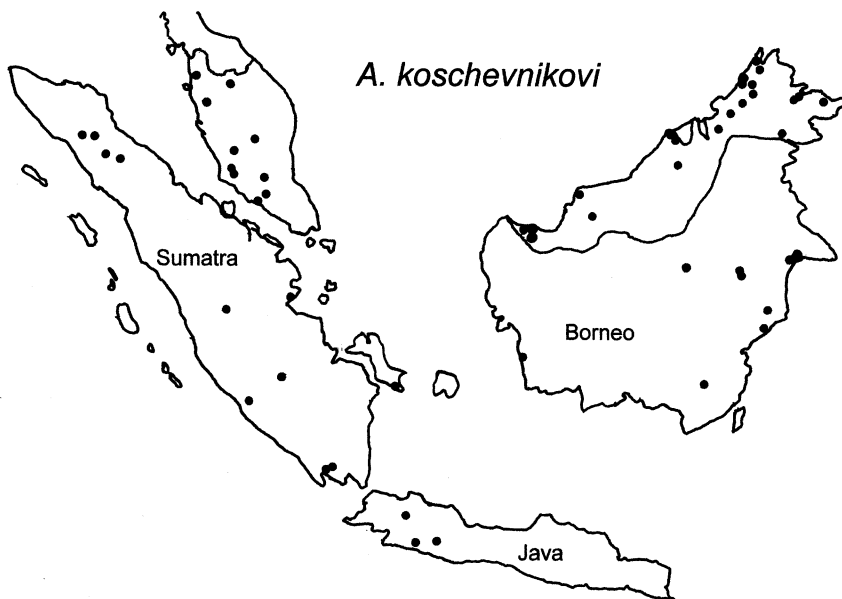


Fig. 4. Distribution of *Apis koschevnikovi* in Malaysia and Indonesia.

papan, Mentawir River, 50 m, XII 1950, A. M. R. Wegner (RNH); Kariorang River, IV 1937, K. M. Walsh (BMNH 1938-99, RNH); Long-“Bloe-oe,” Mahalkam, 1898, Dr. Niuwenhuis (RNH); Maluwi River, V 1937, K. M. Walsh (BMNH 1938-99, RNH); Pelawanbesar, V 1937, M. E. Walsh (RNH); Pelewan Mt., 1937, K. M. Walsh (BMNH 1938-99); Sungai Inasan, 1963 (RNH); Tabang, Bengen R., 125 m, X 1956, A. M. R. Wegner (RNH); Tanah Merah, Lampahe, Samarinda, 50 m, XI 1976, S. Adis & Woro (RNH); SE Borneo, VI 1937, Miss Walsh (very large and pale; RNH ●). Additional Borneo localities: Borneo expedition, Dr. J. Buttik (very large and pale specimen) (RNH ●); Borneo’s Ld. Kust (RNH ●). Java: Jawa Barat: Pan Kalan Kasai, 500± m (MZB ●); Tjibunar, Bospad. Tjidaon, VII 1955, A. M. Wegner (RNH); Tjimandala, Gunung Pantjar, 550–600 m (MZB); Udjong Kulon, Tjidaon, VII 1958, A. M. R. Wegner (RNH). Sumatra: Aceh: Gumpang, Alas Valley, 640–670 m, 1972, J. Krikken (RNH); Gunung Leuser N. P., Ketamba Res. Sta., IX–XII 1989, I–III 1990, pr. C. D. Darling (ROM). Bengkulu: Benkoelen, 1938 (BMNH). Lampung: Mt. Tanggamoos, Gisting, 550–600 m, XII 1939, M. A. Lieftinck (MZB, RNH). Riau: Indiragiri, 1939 (MZB). Sum. Barat: Muara, nr. Solok (Ruttner et al., 1989); Sum. Selatan: Rawas, 5/78 (V 1878) (RNH); Taboali, Bangka, II 1929, J.v.d. Vecht (RNH). Sum. Utara: Bukit Kacang, Bohorok, 1980 (MZB); “Sibolangi” (=Sibaulangit), 450 m, XI 1950, Lieftinck (RNH). MALAYSIA: Borneo: Sabah: Bettotan, nr. Sandakan (BMNH); Bukit Kretam (BMNH); Long Pa Sia, nearby, c. 1050 m, XI–XII 1987, C. v. Achterberg (RNH); Luasong Forestry Center, 100 km W. of Tawau, 1989 (G. W. Otis, pers. obs.); Mt. Kinabalu, Kerokok, 3300’ (BMNH); Mt. Kinabalu, Kamborang, 7000’ (BMNH ●; specimen should be checked because of possible confusion with *Apis* sp. indet.; see account below); Kudat (BMNH); Spitang River (=Spitoh R.?) (BMNH); Tenom, Agr. Res. Sta.,

500 m, G. W. Otis (CU, SEM, GWO); Additional Sabah locality: N. Borneo, 1912 (Maa's paratype for *A. vechti linda*) (RNH ●); Sarawak: Batu Kawa, X–XI 1950, M. A. Lieftinck (RNH); Lambir Hills (D. W. Roubik, pers. comm.); Mt. Dulit, 4000', Moss Forest (BMNH); Mt. Dulit (foot), jct. of Tinjar & Lejok Rivers, nest, IX 1932, Oxford Exped. (RNH); Mt. Matang, 1000', (BMNH); Santubong, X 1950, M. A. Lieftinck (RNH); Shelford (BMNH ●); Sio Matu, Baram River (BMNH); Tebakan (nearby) (D. W. Roubik, pers. comm.). Malaya: Kedah: Kedah Peak, 1000–3950', 1928, 1930, 1932 (BMNH). Kuala Lumpur: College of Agr., 1955 (BMNH); Dusun Tua, 1930 (BMNH); Kuala Lumpur, III 1962, G. F. Mees (RNH). Melaka: Malakka, v.d. Does de Bayo (RNH). Pahang: Jerantut, Balin Balai, 1927 (BMNH); Pasoh Forest Reserve, XI 1995, G. W. Otis (SEM, GWO). Perak: Gompeng Pipeline, 1963 (BMNH); Gunong Kledang, 2646', 1916, 1925 (BMNH); Larut Hills, 3700', 4500', 1932 (H. M. Pendlebury ●). Selangor: Ayer Itam, 100–600', 1920 (BMNH); Bukit Kutu, 3300–3500', 1915, 1932 (BMNH).

DISCUSSION: When rediscovered in 1988, *Apis koschevnikovi* was described as the Sabah honey bee (Mathew and Mathew, 1988; Tingek et al. 1988), and to date nearly all research on this species has been conducted at one site (Tenom) where it is common. Elsewhere on Borneo it is encountered frequently in lower mixed dipterocarp forest sites in East Malaysia and Brunei (S. Tingek, pers. comm., D. W. Roubik, pers. comm.). This contrasts with its apparent scarcity in Malaya, Sumatra, and Java. For example, Salmah et al. (1990) failed to report it in their extensive survey of social bees in Central Sumatra, although it does still occur on that island (as recently as 1990 in Gunung Leuser National Park). Despite intensive collecting activity on the Malay Peninsula for over a century, it is known from only a few sites and is undoubtedly less common than in the past due to loss of rain forest habitat. However, on a recent trip to the Pasoh Forest Reserve, I attracted numerous individuals to diluted honey baits, indicating it is still common in some localities. On Java, there are only four known collection sites; its habitat there must be very restricted.

There is another interesting difference in the distribution of *A. koschevnikovi* between Borneo and the rest of its range. In Borneo, it is occasionally abundant at sea level and can be found up to 1000 m in elevation, although it may be more common at mid-elevations. In contrast, on Java, Sumatra, and the Malay Peninsula it is almost always collected at mid-elevations, from 400–1000 m. With the extensive deforestation that has occurred in the area, the true patterns of distribution and their causative factors may never be determined. This species may even be extirpated from some parts of its range, such as Bangka Island where habitat conversion must be extensive, and West Java where the collection sites coincide with the optimal elevations for tea plantations. At Gunung Jerai (Kedah Peak) in northern Malaysia in March 1995, I did not attract it to honey baits at elevations where it was collected 65 years ago.

A. koschevnikovi is apparently sympatric with *A. cerana* throughout its range. However, it seems to be restricted to wet primary forests, whereas *A. cerana* is common in many secondary growth, agricultural, and urban settings.

Apis nigrocincta F. Smith 1861

HOLOTYPE: Worker, "Makassar, Celeb. A. R. Wallace." *Type Repository*: Oxford University Museum, Oxford, U.K.



Fig. 5. Distribution of *Apis nigrocincta* in Sulawesi and Mindanao.

COLLECTION/OBSERVATION LOCALITIES (see Fig. 5): INDONESIA: Sulawesi Selatan: Bantimurung, VIII 1949, A. Dinkouoff & Manis (RNH); Bontobulaeng, 15 km NNW of Bulukumba, 100–150 m, VI 1989, and VIII 1994, G. W. Otis (GWO); G. Hsuelaloeng, 1936, L. J. Toxopeus (RNH ●); Bulo Bulo, 13 km NNW of Bulukumba, 100–150 m, VI 1989, G. W. Otis (GWO); Kompang, C. Sinjai Distr., 625 m, VI 1989, G. W. Otis (GWO); Manipi, W. Sinjai Distr., 725 m, VI 1989 and V 1993, G. W. Otis (GWO); Penannang, nr. Mamasa, 1850 m, IV 1991, C. v. Achterberg (RNH); Sanging, 1500 m, V 1949, C. Franssen (RNH ●); Sinjai, 10 km SE, 5.09 S, 120.16 E, 3m, VI 1989, G. W. Otis, (GWO); Tabo Tabo For. Centre, 10 km NE of Pangkajene, 70 m, VI 1989, V 1993, G. W. Otis (GWO); Tabing Jai, W. Sinjai Distr., 725 m, VI 1989, G. W. Otis (GWO); Todjambo, 400 m, XII year?, L. J. Toxopeus (RNH). Sulawesi Tengah: Bobo, 50 km SE of Palu, VIII 1994, XI 1995, G. W. Otis (GWO); Kamarora, 70 km SE of Palu, VIII 1994, XI 1995, G. W. Otis (GWO); Palu Valley, V 1955, leg. HHF Hamann (RNH); Sedoa, 8 km N, 1500 m, XI 1995, G. W. Otis (GWO); Watutau, 1100 m, XI 1995, G. W. Otis (GWO). Sulawesi Utara: Kinali, Nr. Sonder, c. 300 m, V 1993, G. W. Otis; Lenganeng, 6 km E. of Tahuna, Sangihe, 150 m, VI 1993, G. W. Otis (GWO); Manado, VI 1937, Dr. J. S. Phillips (RNH), Manado, 0 m, VIII 1941, F. Dupont (RNH); Mapanget, Minahasa, 85 m, VI–VII 1941, ded. F. Dupont (RNH), Mapanget, V 1949, C. Franssen (RNH); Modinding, 1100 m, X 1941, F. Dupont (RNH); Sungai Mosungkam, Dumoga-Bone, 600 m, F. G. Rozendaal (RNH); Teeb, Capito, Amurang, 0 m, V 1993, G. W. Otis (GWO); Toelabollo, Rosenberg (RNH); Tondano, Forsten (RNH). PHILIPPINES: Mindanao: Kauswagan, Lanao del Norte, 0–20 m, 1994, A. Lao (GWO).

DISCUSSION: *Apis nigrocincta* is superficially similar to *A. koschevnikovi* (color, larger than *cerana*), but they are apparently completely allopatric. Morphometric

analyses always separate specimens of this species from throughout its range from both *koschevnikovi* and *cerana* (Damus, 1995; Hadisoesito et al., 1995). Recent data indicate that *nigrocincta* drones take their mating flights considerably later in the day than the drones of sympatric *cerana* colonies (Otis et al., in press; S. Hadisoesito, in prep.), indicating that they are reproductively isolated despite no major genitalic differences between the species (pers. obs.). Additional research is underway by S. Hadisoesito and me to clarify the species status of *A. nigrocincta*. At present, all evidence points toward this being a valid species, and consequently it has been included here for future reference. There is no evidence to indicate it migrates seasonally.

Although specimens are lacking from many parts of Sulawesi, this species is probably found over most of the island and some adjacent islands (e.g., Selayar, Butung (Buton), Taliabu, Mangole, and possibly islands further to the east). An exception is the southwest tip of the island where a unique subspecies of *A. cerana* occurs exclusively (Damus, 1995). A zone of sympatry approximately 35 km wide has been found between *cerana* and *nigrocincta* near Bontobulaeng (Hadisoesito, in prep.). This limited range of *cerana* could be a direct result of the arid climate in this region that favors *A. cerana*, an indirect effect of climate acting on the vegetation, strong habitat preferences, competition between the two species, or the result of a recent colonization by *A. cerana* that is now expanding its range to the detriment of the *A. nigrocincta* population. This last explanation is not supported by observations to date.

A second zone of sympatry has been located in the Palolo Valley of Central Sulawesi. In the village of Kamarora and surrounding fields, detailed searching yielded 38 colonies of bees, of which only 6 were of *A. nigrocincta* (Hadisoesito, in prep). In contrast, of the more than one thousand bees that were recruited to diluted honey baits in the nearby (0.5–1.5 km away) forests of Lore Lindu National Park, all were *nigrocincta* except for a single *A. cerana* worker (G. W. Otis, pers. obs.). This striking localized difference in distribution is unusual for *Apis* species and deserves detailed study.

It was surprising to find that bees from the north coast of Mindanao also belong to this species. There is presently little information on the honey bees of the Philippines other than for Luzon. Further analyses of the cavity-nesting honey bees of this region should prove very interesting biogeographically.

A. nigrocincta is phenetically (wing and leg measurements; Damus, 1995) and genetically (non-coding mtDNA sequences; Damus, 1995; Smith and Hagen, 1996) more similar to *A. cerana* of Luzon (Philippines) than to populations of *cerana* in Borneo or the Lesser Sunda Islands (Nusa Tenggara). The best working hypothesis is that *nigrocincta* was derived from bees that moved south from China through Taiwan into the Philippines and Sulawesi, possibly with some intraspecific mixing with bees derived from Borneo as well. More recently, *cerana* from Nusa Tenggara and Java have become established in Sulawesi, resulting in the three distinct morphs of bees now found there (Damus, 1995; Otis et al., in press).

Apis sp. indet.

S. Tingek, N. Koeniger, and G. Koeniger (pers. comm., 1995) recently reported on what appears to be an undescribed species of honey bee from Sabah. In 1994, they observed *A. cerana*, *A. koschevnikovi*, and another *cerana*-like bee foraging

together in the mountain forests of Sabah to the WNW of Tambunan, at the transition between the lower dipterocarp and higher oak forests. In 1995, they searched the area, found a nest, and recorded mating flight times of drones. Unlike *koschevnikovi*, whose drones fly in the 1.5 hours before sunset, drones of this new form took their mating flights before noon. There is a possibility that this is a disjunct population of *A. nigrocincta* (see above), but it seems unlikely because of the differences in drone flight times between the two populations and the apparent restriction of this new species to high elevation forests. This issue should be clarified by morphometric analyses being conducted by N. Koeniger and his associates. Because this form of bee had not yet been recognized when several major collections were visited for this study, some records of this new species may have been confused with *A. koschevnikovi* or *A. cerana*. In preparing this summary of distributions, I omitted one locality initially assigned to *koschevnikovi* that may belong to this poorly known morph.

The data for specimens of the "mountain bee" are: MALAYSIA: Sabah: Crocker Range, nr. Tambunan, 2100 m, 1 III 1995, N. & G. Koeniger (Institut für Bienenkunde, Oberursel, Germany); Mt. Kinabalu, Marei Parei, 5000', 29 IV 1929, H. M. Pendlebury, ex F. M. S. Museum, BM1955-354 (BMNH); Mt. Kinabalu, Lumu Lumu, 5500', 10 IV 1929, H. M. Pendlebury, ex F. M. S. Museum, BM1955-354 (BMNH); Mt. Kinabalu, Kamborangah, 7000', 29 III 1929, H. M. Pendlebury, ex F. M. S. Museum, BM1955-354 (BMNH); Mt. Kinabalu, Pakka, 10,000', 25 III 1929, H. M. Pendlebury, ex F. M. S. Museum, BM1955-354 (BMNH).

General Discussion

Distributional analyses provide baseline data necessary for ecological and evolutionary studies (Andrewartha and Birch, 1954). For example, from this analysis it is now evident that the richness of honey bee species varies considerably between different areas of Southeast Asia. Several peripheral areas of Southeast Asia, such as much of the Philippines, Sulawesi, the high elevation Himalayan region, and the Persian Gulf region, have two sympatric species of *Apis*. In contrast, some central areas have four sympatric species, such as Thailand/Indochina with two dwarf honey bee species, *andreniformis* and *florea*, in addition to *cerana* and *dorsata*, and Borneo with two cavity-nesting species in addition to *andreniformis* and *dorsata*. Moreover, the relative abundances of these species can vary tremendously with elevation and vegetation (Salmah et al., 1990). Seeley (1985) initiated discussion of the ecology of communities of *Apis* in Asia, but he considered only the three traditional species. Clearly there is much to be done in this field before we can discuss the community ecology of bees and plants in tropical Asia with the same confidence as in the New World tropics (Roubik, 1990).

Analyses such as these have another important function: they highlight not only where species are found, but also where they are absent. Unfortunately, gaps in distributions often indicate a lack of collecting effort rather than the true absence of the species. Some areas with a notable dearth of information on bee diversity are the lower regions (up to 1000 m) of the Himalayan region, Myanmar, Cambodia, n. Vietnam, Tenasserim and the northern portion of the Malay Peninsula, Java, Kalimantan, Bali, and most of the Philippines. Detailed surveys of bee faunas over many parts of Southeast Asia would provide information that would

help us to understand the dynamic nature of bee communities, such as has been admirably compiled for parts of Sumatra by Inoue et al. (1990) and Salmah et al. (1990).

At present few of the people conducting research on the honey bees of Asia are qualified to conduct detailed taxonomic studies. Morphometric and genetic analyses provide interesting information on the relative similarities between bees of different geographic regions but do not allow discrimination of new species (unless a different species concept is used). A modern systematic treatment of the genus *Apis* would allow for confirmation of the species discussed here while providing more objective criteria for their identification. Such a study is likely to support the suggestion that *Apis* should be split into three genera (e.g., Ashmead, 1904; Maa, 1953; S. F. Sakagami, pers. comm.): *Apis*, the cavity-nesting honey bees (Linnaeus, 1758), *Micrapis*, the dwarf honey bees (Ashmead, 1904, already in use by some authors, e.g., Wu and Kuang, 1987), and *Megapis*, the giant honey bees (Ashmead, 1904).

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¹ Note: This article has three authors, but species descriptions are by F. Smith alone.