out the lower mesepisternum. About 9 mm of the pin should project above the specimen. It is good to pin them on a foam board so that the legs do not hang down which results in them being easily broken. Sometimes small bees are pinned sideways with minute pins, *i.e.* by placing a minute pin laterally though the mesosoma and into a small polyporpous square on the pin. It is best to pin specimens in the field to avoid relaxing, which often leads to specimens getting wet and/or excessively handled. Boxes with newly pinned specimens should be opened periodically to allow them to dry. When not observed place the insect box into a securely sealed plastic bag or place the box on an inverted dish in a larger dish of water to avoid ants from eating the specimens.

The first (upper) label should have the country, province/state, city/town, precise locality (*i.e.*, farm name or number of kilometres from the nearest town), grid co-ordinates (indicate whether in degrees and minutes or decimal), altitude, date, collector and accession number, if available. Subsequent labels have biological, collecting and/or other data if available.


**Fig. 4.** Correctly pinned and labelled specimen.

Permanent storage should be in insect cabinet drawers. All material should be frozen for about a week before going into a drawer. Cabinets must be inspected periodically (*e.g.*, every 3 months) for museum pests. In the drawers they should be placed in neat rows behind the species name.

Bees can be carried or posted. For this they should be pinned into some foam glued to the base of a small, secure box. If the specimen looks like it will move on the pin and damage other insects bracing pins should be placed on each side of it, and the box covered with thin plastic. For posting it should be placed in a bigger box with at least 40 mm of lightweight packaging all around it, the outer

box sealed, with “fragile and handle with care” stickers on it and posted via registered or insured mail.

**Fig. 5.** Permanent storage in well-designed cabinets


**Fig. 6.** Carrying or sending specimens requires carefull packing.

## 5. How to conduct a pollination study

Pollination biology and ecology is a science of its own with a number of sub-disciplines. It is beyond the scope of this book to give an introduction to the field or detailed instructions for conducting a field study. Depending on the focus of a research project different methods need to be applied to get the required data. A large set of different methods covering the entire field of pollination biology and ecology are presented in two books by Kearns & Inouye (1993) and Dafni *et al.* (2005). They provide detailed methodological information on how to perform a study on all relevant fields of pollination biology.

Before starting a pollination study be aware: not every flower visitor is a pollinator and the most abundant ones are not necessarily the most efficient / important. To demonstrate that a certain flower visitor is a pollinator it needs to be shown that pollen is successfully transferred from the anthers of one flower to the stigma of a conspecific one. This can be tricky at times and, thus, careful planning and design of the fieldwork is required.

## 6. Terminology

Several excellent publications discuss bee morphology and terminology in detail (Michener, 1944; 2007). It thus suffices to provide explanation of the terms used in the keys and descriptions of the taxa treated here. It is assumed that the reader has a basic knowledge of insect morphology, and the focus is on terminology peculiar to bees.

| | |
|---|---|
| *Aerolium* | Small pad at apex of leg between pretarsal claws (Fig. 8B). |
| *Antenna* | Feeler in middle of face, made up of scape, pedicel and flagellum (Fig. 7A). |
| *Antennal socket* | Hole in face where antenna is inserted, either near middle of face (Fig. 7A) or distinctly below middle of face. |
| *Axilla* | Small sclerite lateral to scutellum adjacent to scutum (Fig. 8A). |
| *Basal vein* | Diagonal vein in middle of forewing, between radial and first medial cells (Fig. 8D), either straight or curved. |
| *Basitarsus* | First, enlarged, segment of tarsus (Fig. 8B). |
| *Basitibial plate* | Plate near base of outer surface of hind tibia (Fig. 8B). |
| *Chalicodomiform* | In leaf-cutter bees, metasoma about as wide as high (as in *Chalicodoma*). |

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| *Cleptoparasitic* | Form of parasitism where bees lay their eggs in other bee's nests and then leave the host's nest. |
| *Clypeus* | Sclerite in middle of lower half of face (Fig. 7A). |
| *Corbicula* | Scopa modified to form a pollen basket. |
| *Coxa* | Basal segment of each leg (Fig. 8A, 8B). |
| *Epistomal suture* | Suture surrounding clypeus (Fig. 7A). |
| *Femur* | Third segment of leg (first long segment) (Fig. 8B). |
| *Flagellum* | Third to tenth (females) or eleventh (males) segments of antenna (Fig. 7A). |
| *Galea* | Tongue cover (Fig. 7C-D). |
| *Glossa* | Tongue (Fig. 7C-D), pointed or bifid. |
| *Gonocoxa* | Sclerotized part of male genitalia between basal area (gonobase) and gonostylus (Fig. 9B). |
| *Gonoforceps* | Fused gonocoxa and gonostylus. |
| *Gonostylus* | In male, distal end of gonocoxa (Fig. 9B) |
| *Gradulus* | Ridge across metasomal terga (Fig. 9A). |
| *Hypostomal area* | Back of head around chamber for mouthparts (Fig. 7B). |
| *Integument* | Hard outer covering of bee body. |
| *Jugal lobe* | Basoposterior lobe of hind wing (Fig. 8C). |
| *Juxta-antennal carina* | Vertical carina mesad to antennal socket. |
| *Labrum* | Hinged sclerite below clypeus (Fig. 7A). |
| *Labial palp* | Palp arising from base of glossa (Fig. 7C-D). |
| *Long-tongued* | Labial palp with basal two segments long, apical two segments short (Fig. 7C). |
| *Malar area* | Area between eye and mandible (Fig. 7A). |
| *Mandible* | Jaws, below clypeus (Fig. 7A). |
| *Mandibular teeth* | Teeth at distal end of jaw (Fig. 7A). |
| *Marginal cell* | Anterior distal cell in forewing (Fig. 8C). |
| *Megachiliform* | Metasoma flattish, wider than high (as in *Megachile*). |

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| *Mesepisternum* | Large sclerite on side of mesosoma, below wing, and comprising most of posterior region of mesopleuron. |
| *Mesopleuron* | Side of mesosoma, largely area below wings (Fig. 8A). |
| *Mesosoma* | Thorax together with first abdominal segments (propodeum) (Fig. 8A). |
| *Metalic* | A shiny gloss to integument, usually blue or green, sometimes red or copery. |
| *Metanotum* | Mesosomal sclerite between scutellum and propodeum (Fig. 8A). |
| *Metasoma* | Abdomen excluding first abdominal segment (propodeum), which is fused to thorax (Fig. 9A). |
| *Metatibia* | Middle tibia (Fig. 8B). |
| *Occiput* | Area just before posterior surface of head (Fig. 7B). |
| *Ocellus (pleural ocelli)* | Three small round ‘eyes’ near top of face (Fig. 7A). |
| *Ocellocular* | Area between lateral ocelli and eye. |
| *Omaulus* | Curved, carina or lamella separating anterior (foreward facing) region of mesepisternum from lateral, posterior, region (Fig. 8A). |
| *Pedunculate* | Club-shaped, refers to thickened distal end of antennal flagellum. |
| *Preoccipital area* | Where dorsal and lateral regions of head curve into posterior region (Fig. 7B). |
| *Prepygidial fimbriae* | Subapical hairs on metasoma tergum V (Fig. 9A). |
| *Prestigma* | Sclerotized (darker area) before pterostigma (Fig. 8D). |
| *Proboscidial fossa* | Cavity under head where mouthparts are concealed at rest (Fig. 7B). |
| *Pronotal lobe* | Posterolaterally lobe of pronotum, jutting into mesepisternum anteroventral to base of forewing (Fig. 8A). |
| *Pronotum* | First segment of mesosomal dorsum (Fig. 8A). |
| *Propodeal triangle* | Dorsomedial area on propodeum, posterior view. |

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| *Propodeum* | Posterior region of mesosoma, first abdominal segment fused to thorax (Fig. 8A). |
| *Pseudopygidium* | Area on tergum V that resembles a pygidium (Fig. 9A). |
| *Pterostigma* | Scerotized (dark) area on anterior edge of forewing (sometimes called stigma), preceeded by prestigma (Fig. 8D). |
| *Punctate* | Indentations in integument. |
| *Pygidial plate* | Posteromedian plate on tergum VI (Fig. 9A). |
| *Scopa* | Pollen carrying structure, in female pollen collecting bees only, mostly on hind leg or under metasoma. |
| *Sculpture* | Pattern in integument. |
| *Scutellum* | Third sclerite of mesosomal dorsum (Fig. 8A). |
| *Scutum* | Second sclerite of mesosomal dorsum (Fig. 8A), largest sclerite. |
| *Scutoscutellar suture* | Join between scutum and scutellum (Fig. 8A). |
| *Sternum (plural sterna)* | Ventral segments of metasoma, abbreviated 'S', third sternum being S3 (Fig. 9A). |
| *Short tongued* | Labial palp with four similar segments (Fig. 8B). |
| *Subantennal sutures* | Line between antennal socket and clypeus, either one or two (Fig. 7A). |
| *Submarginal cells* | Cells in forewing, posterior to marginal cell and pterostigma (Fig. 8C), there may be one, two or three cells. |
| *Pretarsal claws* | Two pointed teeth at distal end of tarsus (Fig. 8B). |
| *Tarsus* | Distal five segments of all legs (Fig. 8B). |
| *Taxon* | A taxonomic group, family, tribe, genus or subgenus. |
| *Tegula* | Cap over wing base (Fig. 8A). |
| *Tentorial pits* | Small pit on lateral margin of clypeus, usually in epistomal suture (Fig. 7A). |
| *Tergum (plural terga)* | Dorsal segments of metasoma (Fig. 9A), abbreviated 'T', third tergum being T3. |
| *Tibia* | Forth segment of legs (second long segment) (Fig. 8B). |

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| *Tibial spur* | Spine on distal end of tibia (Fig. 8B). |
| *Tomentum* | Mat of fine hairs on basal or distal regions of metasomal terga. |
| *Vannal lobe* | Second posterobasal lobe of hind wing (Fig. 8C). |
| *Vein cu-a* | Vein bisecting vein a, in hind wing (Fig. 8D). |
| *Vein M+Cu* | Posterior vein in hind wing, divided into two parts (abcissas) (Fig. 8D). |
| *Veins 1rs-m and 2rs-m* | First and second veins distal to second and third submarginal cells (Fig. 8D). |
| *Veins 1m-cu and 2m-cu* | First and second veins distal to first and second medial cells (Fig. 8D). |
| *Vein a* | Distal vein in hind wing (Fig. 8D). |
| *Vertex* | Region of head above ocelli and eyes (Fig. 7A). |

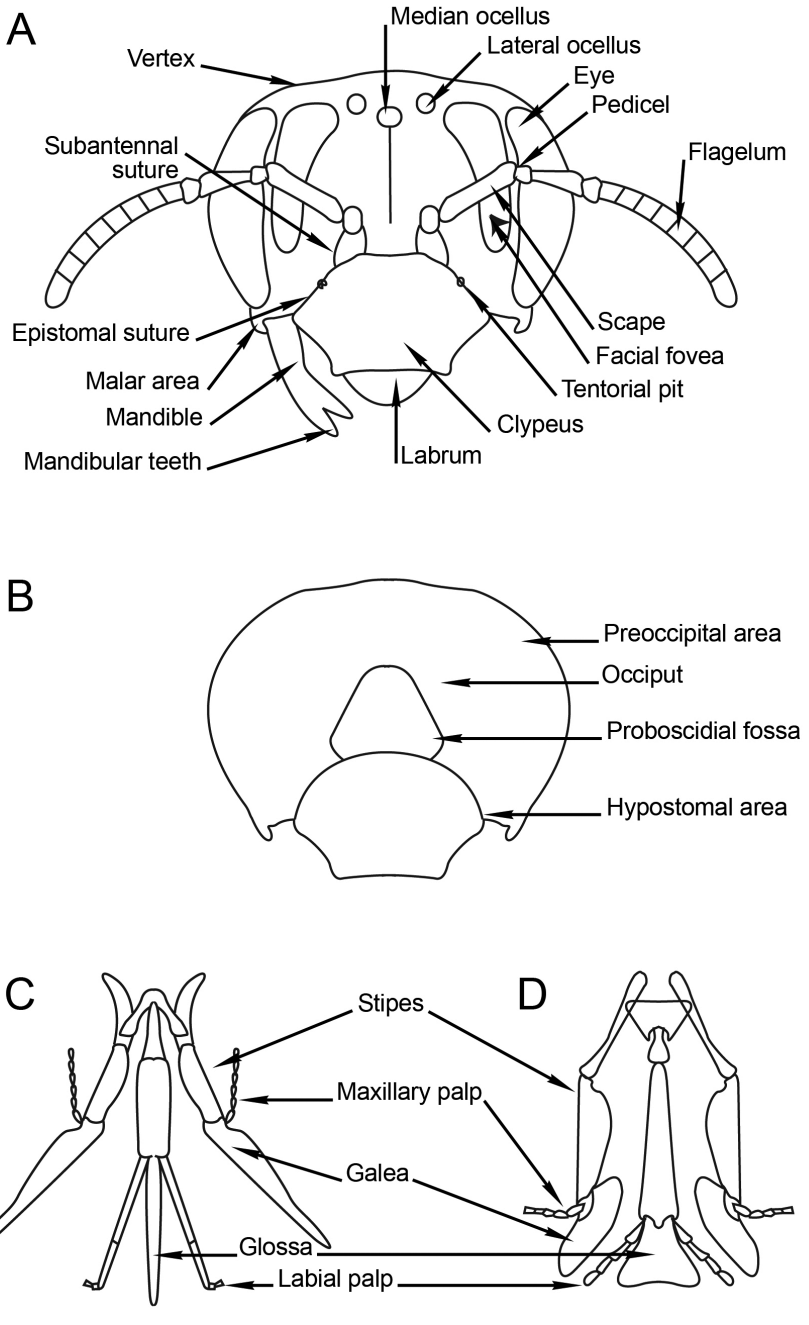


**Fig. 7.** Bee morphology and taxonomic characters. A. Face; B. Back of head; C. Mouthparts of long-tongued bee; D. Mouthparts of short-tongued bee.

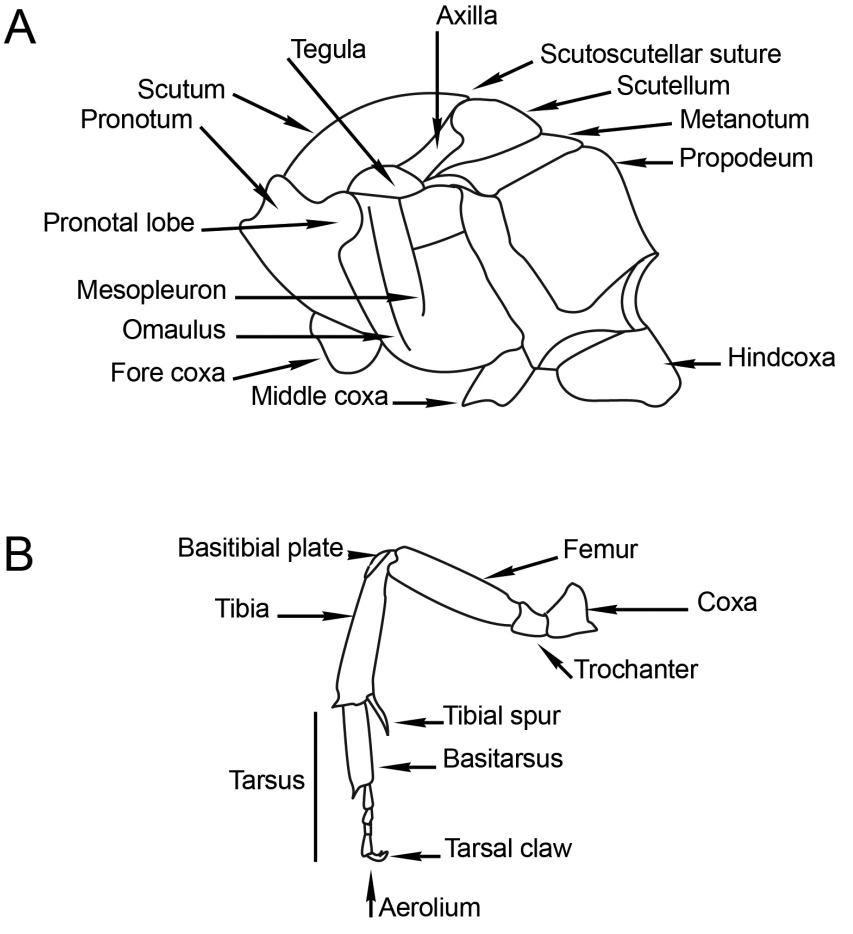


**Fig. 8.** Bee morphology and taxonomic characters. A. Mesosoma, side view; B. Leg.

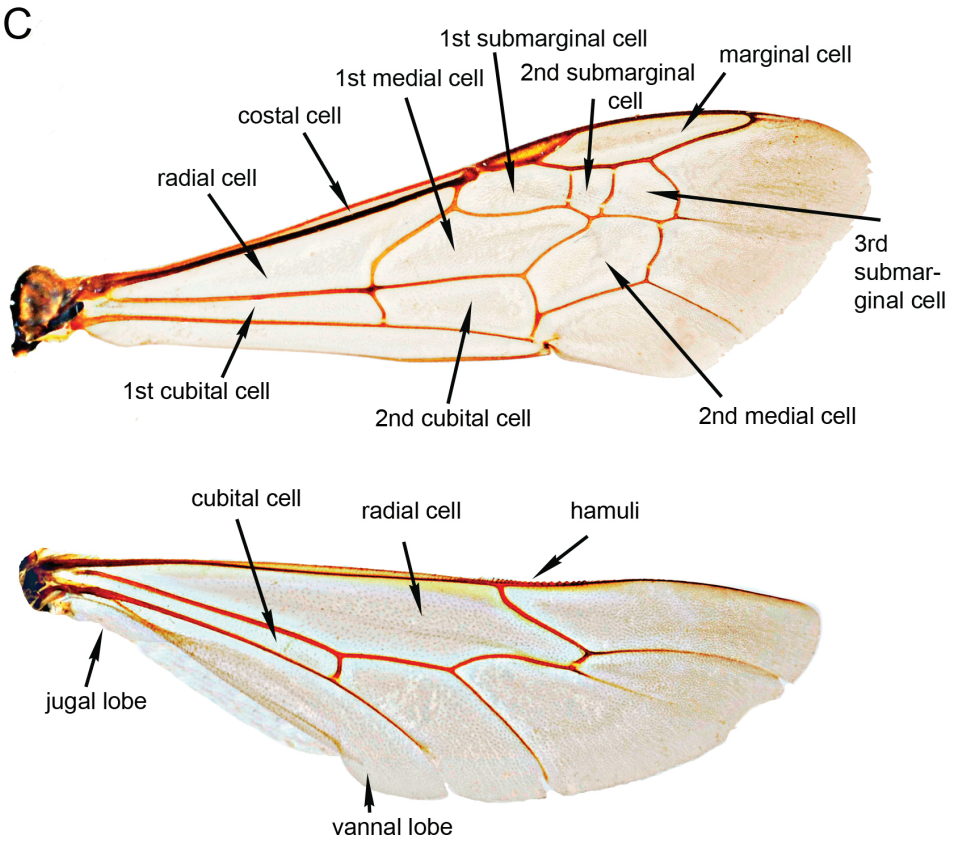


**Fig. 8.** Bee morphology and taxonomic characters. C. Wing with membranous cells and gross anatomical structures labeled. Upper picture is a forewing; lower picture is a hind wing.

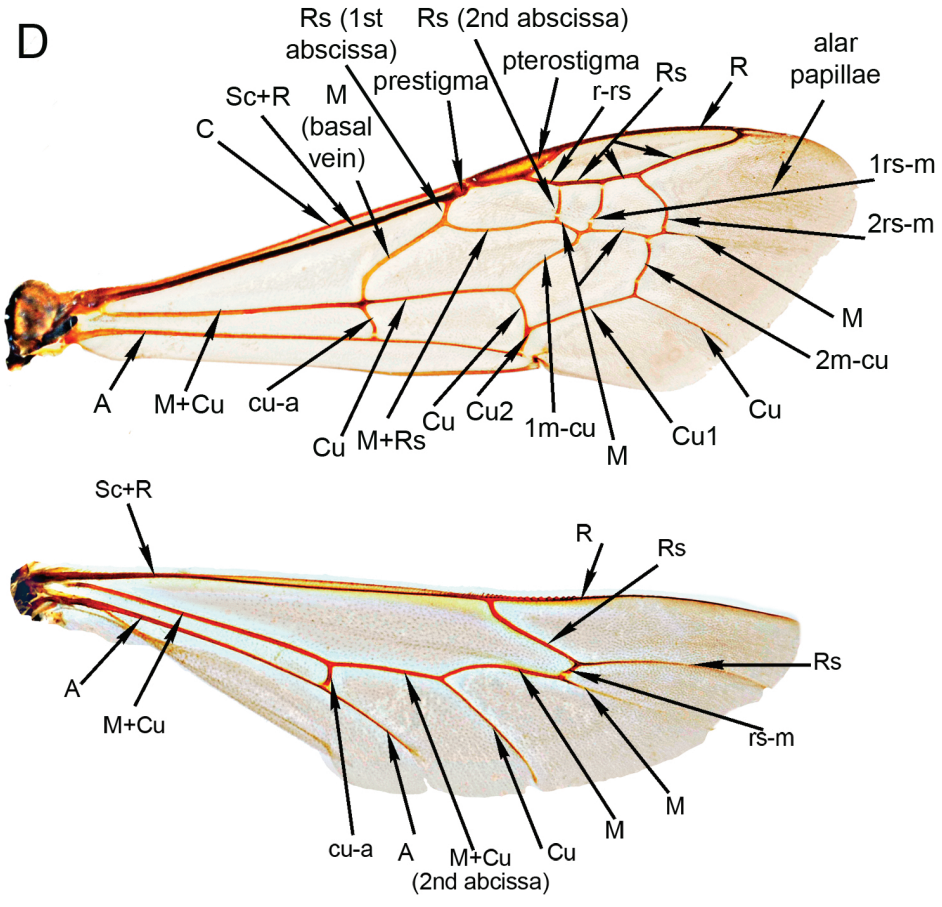


**Fig. 8.** Bee morphology and taxonomic characters. D. Wing with longitudinal and cross veins labeled together with single membrane feature (*i.e.* alar papillae). Upper picture is a forewing; lower picture is a hind wing.

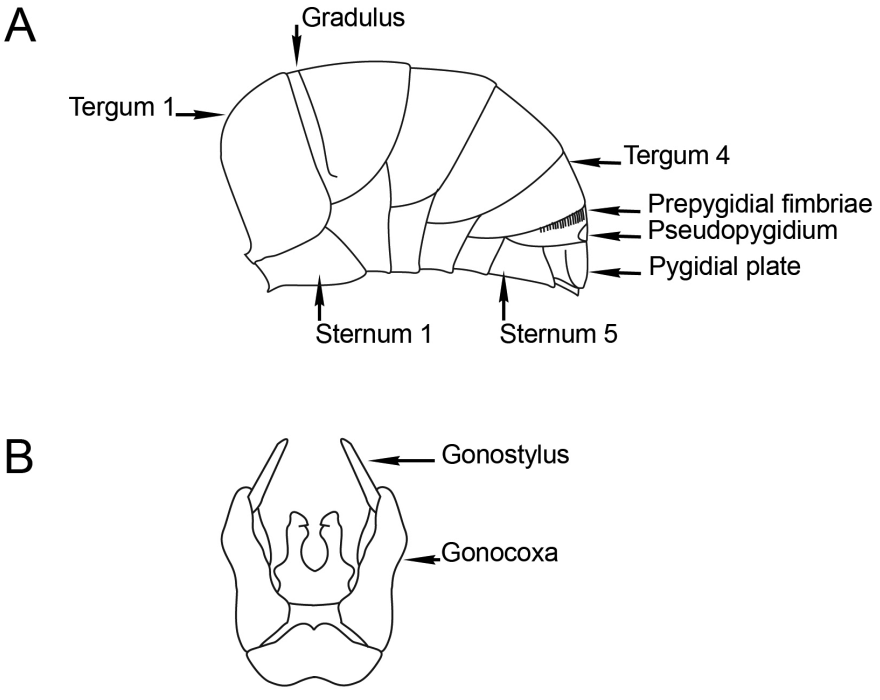


**Fig. 9.** Bee morphology and taxonomic characters. A. Metasoma, side view; B. Males genitalia, dorsal view.

## 7. The taxonomy and identification of bees

Bees all belong to the Class Insecta, Order Hymenoptera, Superfamily Apoidea. The Apoidea comprises two groups, the Anthophila (bees) and the Spheciformes (sphecid wasps). This book treats only the bees or Anthophila. The Anthophila has six families in the Afrotropical Region: Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae and Apidae. These families can in turn be separated into several subfamilies (scientific names ending with –inae), which can be further divided into tribes (scientific name ending with –ini). There may be several subfamilies or tribes in the World, but only one in Africa. In the text below these will be indicated by only one taxon in the higher category.

All species' names are binomial. That is they have a generic name followed by a specific epithet, such as *Apis mellifera*, the honey bee. The specific epithet is never used in isolation. The genus name may be abbreviated to its first letter, like *A. mellifera,* after it has been used in full earlier in the text. Bee genera are sometimes divided into subgenera. Subgeneric names may be incorporated into the name, but then they are placed in parenthesis between the genus and species names, for example *Xylocopa* (*Mesotrichia*) *flavorufa*, a large carpenter bee. The name of the author who originally described the species, and the date of publication is placed behind the species name - e.g. *Apis mellifera* Linnaeus,

1758 - the first time it is used in a document. The author name is placed in parenthesis if the species has been moved to another genus - e.g. *Xylocopa flavorufa* (DeGeer, 1778), which was described as *Apis flavorufa* De Geer, 1778.

This book is designed for the identification of the bee genera and subgenera that occur in sub-Saharan Africa. Taxonomic revisions should be used to identify up to species level. Table 1, in annex to this work provides a list of references to various taxonomic revisions.

Bees are divided into two broad, informal groups, short-tongued bees and long-tongued bees. Although these structures are often difficult to see, it still appears to be the best starting point. Most families of bees have an additional unique feature that does not occur in any other bee family, so they can mostly be identified without studying the mouth parts, which are often hard to see. Unfortunately female, cleptoparasitic, long-tongued bees do not have such unique features, which makes some of them more difficult to identify. A key for these genera is included near the end of this publication.

The following section is to enable the identification of the bee families, genera and subgenera. Most of the diagnostic characters are given in the keys. The short discussion on each taxon might give additional characters but those given in the keys are not repeated unless they need to be emphasized. Distribution data is given because it might facilitate identification but care must be taken as the distribution of many bees is incompletely known.

## 8. Systematic account

Students beginning with bee identification often find separating short and long-tongued bees difficult. However, keys avoiding the use of these characters tend to be more cumbersome and have many exceptions. It is not always necessary to dissect the mouthparts to separate short and long -tongued bees.

When the mouthparts are contracted, and when viewed from below, short-tongued bees have the stipes visible, the distal end of the galea only visible near the mandibles, and the stipes tightly concealed in the proboscidial fossa. In long-tongued bees the galea are clearly visible, concealing the stipes, and the hypostomal carina is not visible. The stipes is longitudinally fused, while in the galea the two sides are separate.

Only short-tongue bees have: two subantennal sutures (Andrenidae), a forked glossa (Colletidae), strongly curved basal vein in the forewing (Halictidae), scopa laterally on metasoma (*Systropha*, Halictidae), laterally directed hair on T4-T5 (*Thrinchostoma*, Halictidae) or mediolongitudinally directed fasciae on T5 (Halictini, Halictidae), weakly developed veins distally in forewing (*Lasioglossum*, Halictidae), greatly expanded hind femur (Halictidae and Melittidae) or pale coloured integument distally on T2-T5 (*Patellapis* and *Nomia*, Halictidae). Only long-tongued bees have the scopa under the abdomen (Megachilidae), basally greatly expanded hind tibial spur (*Ctenoplectra*, Apidae), pale stripes on paraocular area adjacent to lower eye edges (*Allodape*, Apidae), long antennal flagellum (*Tetraloniella* males, Apidae) or a corbicula (Apidae). Some of these features do not occur in all species and many other taxa have unique features;