

The bumblebees of Sichuan (Hymenoptera: Apidae, Bombini)

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For the purposes of taxonomic nomenclature, the electronic version of this paper is deemed unpublished.

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Abstract Bumblebees are important pollinators in mountainous regions. The highland region of Sichuan and Chongqing (together, Sichuan in the former broad sense) includes part of the greatest hotspot of bumblebee diversity worldwide, with half of the species of China and more than a fifth of the world's species. In this paper we present the first review of this diverse but particularly poorly known fauna, drawing on 6705 bees from selective samples made by the authors during field work and from museum collections, together with 1123 literature records (an overlapping set). Among this material we recognise 56 species that have 847 names (including infrasubspecific names). One new species, *Bombus* (*Pyrobombus*) *wangae*, is described from Sichuan and Gansu. *B. laesus* is found to have a colour pattern in this part of its range that was previously undescribed. Six species are recorded from the Sichuan-Chongqing region for the first time (*B. avanus*, *B. branickii*, *B. difficillimus*, *B. humilis*, *B. norvegicus*, *B. tibetanus*), of which *B. avanus* is only the second published record worldwide. One species, *B. braccatus*, is endemic to Sichuan and is confirmed as extant in 2005. We provide diagnoses and keys to species for both sexes. Colour variation is described, distributions within the Sichuan-Chongqing region are mapped, altitudinal and seasonal activity are plotted, and the authors' records of food plants are listed.

Key words *Bombus*, China, Chongqing, bee taxonomy, bee systematics, pollination, hotspots, mountain biodiversity

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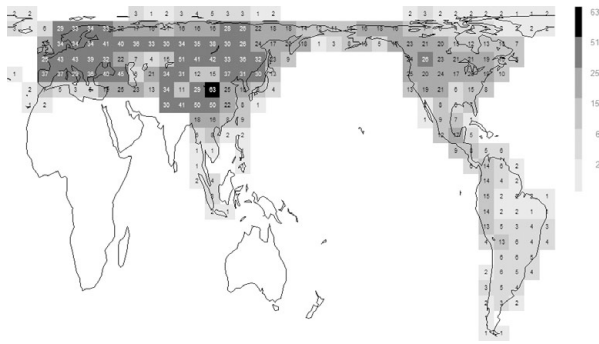


Figure 1 Map of the world (excluding Antarctica) showing species richness of bumblebees among equal-area grid cells (Williams, 1998). The grid is based on longitudinal intervals of 10° . These are used to calculate graduated latitudinal intervals that provide equal-area grid cells (each cell approximately $611\,000\text{ km}^2$). The portion of the grid shown covers the known, native distribution of bumblebees. A grey scale (right of map) is used to group counts of species richness (numbers on map) into six classes. The maximum species count is shown in black (covering northern Sichuan-Chongqing), otherwise counts are divided into five grey-scale classes of approximately equal size by numbers of grid cells. At higher latitudes, counts of bumblebee species are higher in grasslands, and at lower latitudes, in mountains. Cylindrical equal-area projection.

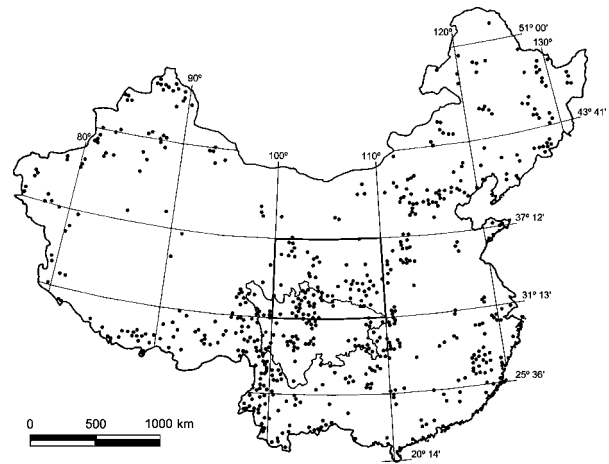


Figure 2 Map of mainland China showing approximate locations for all bumblebee samples held in the collection of the Institute of Zoology, Beijing. Data are combined from individual species' distribution maps, which are being confirmed and digitised by Yao J. (unpublished). The grid shows longitudinal intervals of 10° (top). These are used to calculate graduated latitudinal intervals (right) that provide equal-area grid cells of approximately $611\,000\text{ km}^2$ (Fig. 1). The grid cell with a thick border is the hotspot of greatest bumblebee diversity world-wide from Fig. 1. An outline shows the border of the Sichuan-Chongqing region. Bumblebee records are concentrated in the wetter highlands. Conic projection.

Introduction

Pollination biologists and applied ecologists concerned with land use and conservation have expressed a need to be able to identify bumblebees (tribe *Bombini*, genus *Bombus*) from the Sichuan (Szechwan) and Chongqing (Chungking) region of China. This paper aims to bring together the available information on their taxonomy, activity patterns, and food plants to help meet this need. At the same time it reviews one fifth, and perhaps the least well-known fifth, of the world's bumblebees.

Bumblebees provide a pollination service that is essential both for the sustainability and conservation of natural ecosystems and also for multi-billion-dollar industries for commercial crops, including tomatoes, fruit trees and berries (Dias *et al.*, 1999). They are particularly important to mountain ecosystems (Macior & Tang, 1997). Currently there are believed to be approximately 250 species worldwide (revised from Williams, 1998), occurring throughout most of Eurasia and the Americas, especially in the high mountains, but absent from most of Africa, from India (except in the Himalaya and north-eastern hills), and (as indigenous species) from all of Australia (Fig. 1). Accounts of their flower-visiting behaviour and of their general natural history are reviewed by Alford (1975), Heinrich (1979) and Goulson (2003).

In part because they are large, brightly coloured and furry, bumblebees have attracted attention and are particularly well sampled throughout the world. As a result, it is likely that the great majority of bumblebee species are already known (Williams, 1998). Approximately 44% of all bumblebee species occur in China (110 species: Williams, unpublished data), and about half of those occur in Sichuan (56 species). Even

though a relatively high species-discovery rate implies that the Oriental fauna is the least well known worldwide (Williams, 1998: his fig. 2), the distributions of the Chinese species are beginning to be clarified (from sample sites shown in Fig. 2). Consequently, in comparison with many other groups of insect pollinators in China, a relatively complete picture of bumblebee assemblages should now be possible. However, because bumblebees are morphologically relatively homogeneous compared to other bees (Michener, 2007), but often convergent in colour pattern among species (Williams, 2007) and frequently very variable in colour pattern within species, there has been much confusion in their taxonomy and nomenclature.

The Sichuan-Chongqing region forms part of one of the greatest hotspots of bumblebee diversity world-wide (Figs 1, 2). A complication of comparing diversity among areas is that the diversity of an area is in general related to its size. A way to reduce the effect of area on diversity comparisons that requires fewest assumptions is to start with grid cells of equal-area extent, as shown in Fig. 1. But to compare the more familiar bumblebee-rich countries of broadly similar area from Europe and North America (Table 1), Sichuan and Chongqing taken together are closest in area to France and are a third larger than California. Yet Sichuan and Chongqing have over a quarter more bumblebee species than France, and more than twice the number of species of California (Sichuan and Chongqing have more species than the whole of the USA and Canada). Latitude is not the principal effect on these comparisons, because in all three countries most of the bumblebee species occur in the mountains, where the broad range of altitudes in part offsets the latitudinal differences.

	Area in km ²	Number of species	Number of subgenera	Source
Sichuan + Chongqing	567 000	56	10	This study
France	544 000	44	13	Rasmont (1983)
California	424 000	25	8	Thorp <i>et al.</i> (1983)

Table 1 Geographical area (Anonymous, 2001) and number of bumblebee taxa for the Sichuan-Chongqing region, France, and California, with the simplified subgeneric classification of Williams *et al.* (2008).

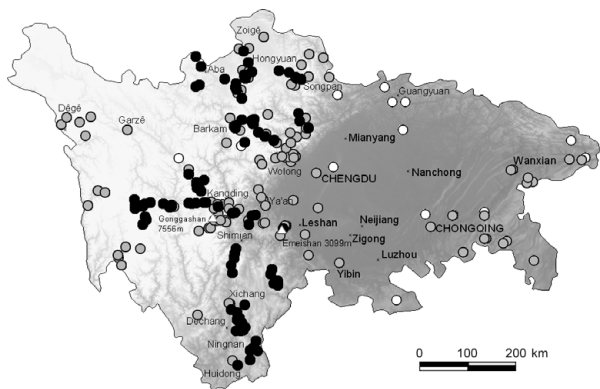


Figure 3 Map of the Sichuan-Chongqing region showing elevation (NESDIS Globe data) and the sites sampled for bumblebees. Black spots show sites sampled by the authors during 2002–2005. Grey spots show additional sites with museum collection records. White spots show additional sites with literature records. A grey scale shows elevations between low altitudes (in dark grey, the Red Basin and Yangtze Gorges, in parts below 500 m) and high altitudes (in light grey, e.g. Gonggashan, at over 7500 m) grouped into equal-interval classes. A selection of cities and larger towns is shown by crosses, and two mountains by triangles. Cartesian orthonormal projection.

For this study, we are interested in the province of Sichuan as recognised by the government of the People’s Republic of China (PRC) between 1955 and 1997. Prior to 1955, the western mountainous part of the region formed the separate province of Xikang (Sikong). After 1997, a part of the eastern basin centred on Chongqing was given separate provincial status. But the broader area encompassed by the combined Sichuan-Chongqing region is convenient for this study because it covers, in its western half, part of the highlands of the eastern Tibetan Plateau (lighter grey on the left of Fig. 3) and, in its eastern half, the lowlands of the entire Red Basin (Sichuan Pendi, darker grey on the right of Fig. 3). This natural division is reflected in strong contrasts within many factors, including topography, climate, vegetation, land use, human population density, culture and history (e.g. Anonymous, 2001). The Sichuan-Chongqing region, covering the entire Red Basin, is abbreviated here to ‘SCR’.

Some of the SCR species were first described from parts of their ranges outside the SCR (Fig. 4: upper histogram, prior to 1875). Some of these species are widespread within the Palearctic Region (e.g. *B. hypnorum*, *B. lucorum* *s.l.*, *B.*

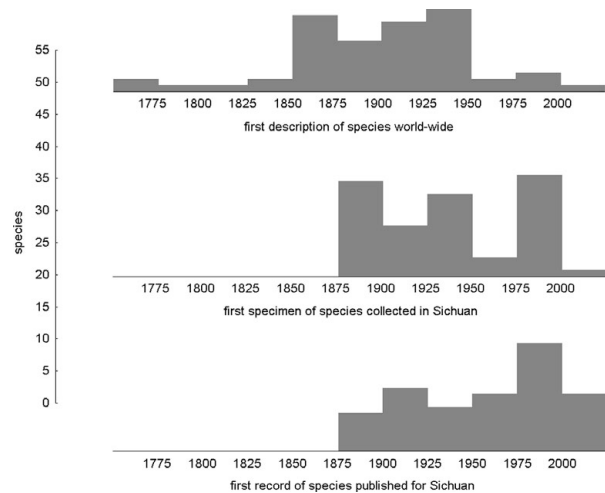


Figure 4 Histograms showing: (top) when the species recorded from the SCR were first described from somewhere in the world; (middle) when the first SCR specimen of each species was collected; and (bottom) when the first SCR record of each species was published. Summary of records compiled for the 56 species listed in this review.

rupestris, *B. humilis*) or were collected in parts of India and China neighbouring the SCR (e.g. *B. atripes*, *B. trifasciatus*, *B. funerarius*). Later, a great burst of exploration and collecting activity within the SCR occurred in the late nineteenth century and in the first half of the twentieth century (Fig. 4: middle histogram). Among the more famous expeditions that were especially productive for bumblebees were those by Nikolai Przewalski (see Morawitz, 1880, 1887; Rayfield, 1976), Grigori Potanin (Morawitz, 1890; Friese, 1905; Bretschneider, 1981), Sven Hedin (Bischoff, 1936), and David Graham (Frison, 1933, 1935). Bumblebees collected from the SCR were described or listed in contributions by bumblebee specialists including particularly Bischoff (1936), Friese (1905), Frison (1933, 1935), Morawitz (1890), Sakagami (1972), Skorikov ([1923], 1931, 1933a, 1933b), and Tkalci (1960, 1962, 1965, 1968a, 1968b, 1968c, 1987, 1989). Since 1975 (Fig. 4: middle and lower histograms), a series of faunal surveys, published by the Chinese entomologists Wang Shufang and Yao Jian (Wang, 1982b, 1985b, 1987b, 1988b, 1992b; Wang & Yao, 1992b, 1993b; Yao & Wang, 1993a; Yao, 1995; Wang & Yao, 1996b; Yao & Luo, 1997; Yao, 1998), have contributed to another major phase of improvement in our knowledge of the fauna. The rate at which new species are being collected (Fig. 4:

middle histogram) appears to be slowing down, so that few new species are expected to be discovered by morphological approaches (without a change in species concept). Therefore a regional total for the number of species is likely to be representative, at least over the period in which these data were collected. The expected total number of species in the fauna can then be estimated with the *Chao-2* statistic from the database of samples of species in museum collections compiled for this paper (using the *EstimateS* software, Colwell, 2005). This expected total number for the SCR is 56.24 species (95% confidence interval 56.01–60.75), only just above the observed number of 56 species. But this estimate is based on assumptions that both the species' individuals and the sampling effort are randomly distributed, neither of which are true. For comments on possible additions to the fauna, see the Discussion of Faunal elements.

Despite the substantial activity surveying bumblebees within China, at least three problems remain. First, because bumblebees are very variable in colour pattern, there are often many synonyms for each species (for the species in the SCR fauna, there are more than 15 times as many names as species). Second, although there are so many published descriptions, they are scattered in many small publications through the literature, and written in Chinese, English, French, German, Russian and Latin (see the References). Third, much of the type material came from the early European expeditions and is now housed in European and Russian museums (for the SCR fauna, 30% of the species have valid names for which some type material is in the BMNH collection in London, whereas prior to this paper, only one of the species (2%) has a valid name for which type material is in the IZB collection in Beijing, see Anonymous, 1991, and none are in Sichuan institutions). Consequently, it is difficult for any one person to bring together all of the available information. Fortunately, the present authors together have access to many of the type specimens, to descriptions, and to relatively large samples of specimens.

There have been no previous reviews of the bumblebee fauna of the SCR summarising what was known of the fauna. There is a checklist of Chinese bumblebees by Wu (1941), but it includes only 50% of the currently recognised species recorded from China. There is also a good overview of the distribution of the Chinese bumblebee fauna by Panfilov (1957). The northern part of the SCR fell within his Xinjiang-Tibetan bumblebee province, and the southern part fell within his Sichuan-east Himalayan bumblebee province. He described both of these provinces as poorly studied. Thus, a new review to include the results of the many more recent surveys is needed.

Here we review the information available to us on the bumblebees of SCR. Aside from re-examining material in collections, we have sampled the fauna directly (Fig. 3: black spots), particularly in Wanxian Prefecture in the east (YJ, 1993–1994), Aba Zang and Qiang Autonomous Prefecture in the north (PHW, SAC, TY, 2002–2003), Garzê Zang Autonomous Prefecture in the west (TY, 2003), and Liangshan Yi Autonomous Prefecture in the south (PHW, TY, 2003–2005). We are keenly aware that much remains to be done to describe the fauna of this large and diverse region.

Materials and methods

Diagnosis of Bombini

Bumblebees are a monophyletic group (Williams, 1995; Cameron *et al.*, 2007), constituting the tribe Bombini. They may be distinguished from other bees by the following diagnosis (see Characters studied below for terminology and description of the characters):

Bumblebees have a labrum at least twice as broad as long. The labrum lacks a longitudinal median ridge, although for the females it has a strong transverse anterior depression. The clypeus has a transverse anterior depression and the anterior lateral corners are curved back towards the occiput. A malar area separates the compound eye from the base of the mandible, often by a distance greater than the breadth of the mandible at its base. The hind wings lack a jugal lobe (anal lobe). The volsella (lacinia) of the male genitalia is greatly enlarged and is produced distally beyond the gonostylus (squama).

Bumblebees are large (body length 7–32 mm) robust insects. Their bodies have a dense covering of variously coloured long plumose hairs, although these are few or absent on some parts of the ventral surface of the metasoma, on the propodeum, on the anterior face of metasomal tergum 1, and on parts of the head. The sclerites are usually black, or lighter brown on the distal parts of the limbs, but are never marked with bright yellow, red or metallic (interference) colours. The wings may be transparent (hyaline) to strongly darkened (infuscated), but rarely show strongly metallic reflections.

Depositories of material examined

Large samples of material from Sichuan are available in the collections in Beijing (IZB), London (BMNH), Berlin (MNHU), St Petersburg (ZISP), Urbana (INHS) and New York (AMNH). More recent collections have been made by Lazarus (Walter) Macior (BMNH), J. van Asperen de Boer (ZMA), Michael Dillon (IZB) and the authors. Specimens examined are deposited in collections as shown using the abbreviations in Table 2.

Locality data

Latitude and longitude data were obtained using geographical positioning systems (GPS): model Garmin GPS Plus III (2002–2005), and Garmin eTrex Vista C (2005). These data, which appear as black spots on the maps (e.g. Fig. 3), are regarded as precise.

Many recent collection and literature records probably refer only to the nearest county towns as listed in Anonymous (1981). Latitude and longitude data for these towns are taken from The Times Atlas (Anonymous, 2001). Older records are often difficult to trace with certainty. Many towns and cities have changed their names, in part because of the change from the Wade-Giles to the Pinyin system of transliteration. Where possible, older names have been associated with current names using the maps and accounts provided by the collectors (e.g. Leech, 1892; Sjöstedt & Hummel, 1932; Fisher, 1948; Bretschneider, 1981). Where unavoidable, unrelated maps and gazetteers have been used (e.g. USBGN, 1944, 1963, 1979).

Abbreviation	Address
AMNH	American Museum of Natural History, New York, New York, USA
BMNH	Natural History Museum, London, UK (formerly the British Museum (Natural History))
BT	Dr Borek Tkalců, Praha, Czech Republic
CAS	California Academy of Sciences, San Francisco, California, USA
INHS	Illinois Natural History Survey, Urbana, Illinois, USA
IZB	Institute of Zoology, Chinese Academy of Sciences, Beijing, PRC
JAB	Prof. J. R. J. van Asperen de Boer, Amsterdam, The Netherlands
LSL	Linnean Society, London, UK
LWM	Prof. Lazarus Walter Macior, Akron, Ohio, USA
MCSN	Museo Civico di Storia Naturale, Genova, Italy
MNHU	Museum für Naturkunde an der Humboldt-Universität, Berlin, Germany
NMS	Naturmuseum Senckenberg, Frankfurt, Germany
PHW	Dr Paul Williams, London, UK
SAC	Dr Sydney Cameron, Urbana, Illinois, USA
TRM	Tromsø Museum, Tromsø, Norway
TY	Prof. Tang Ya, Chengdu, Sichuan, PRC
USNM	United States National Museum, Washington DC, USA
ZISP	Zoological Institute, Russian Academy of Sciences, St Petersburg, Russia
ZMA	Zoological Museum Amsterdam, Amsterdam, The Netherlands
ZMC	Zoological Museum, University of Copenhagen, Copenhagen, Denmark
ZMMU	Zoological Museum of the Moscow State University, Moscow, Russia
ZSM	Zoologische Staatssammlung, München, Germany

Table 2 Abbreviations for institutions and individuals.

Some of the most difficult cases were resolved by Catherine Cheetham of the Permanent Committee on Geographical Names (PCGN, c/o The Royal Geographical Society, London). These data from collections and from literature, which appear as grey or white spots on maps (Fig. 3), must be regarded as less precise. At best, the true collecting site has to be assumed to be close to the named town, while for the older records, a possibility of errors from misidentifying the many homonymous towns must remain. Specimen-sample database is available as ‘Supplementary data’ on Cambridge Journals Online: http://www.journals.cup.org/abstract_S1477200008002843.

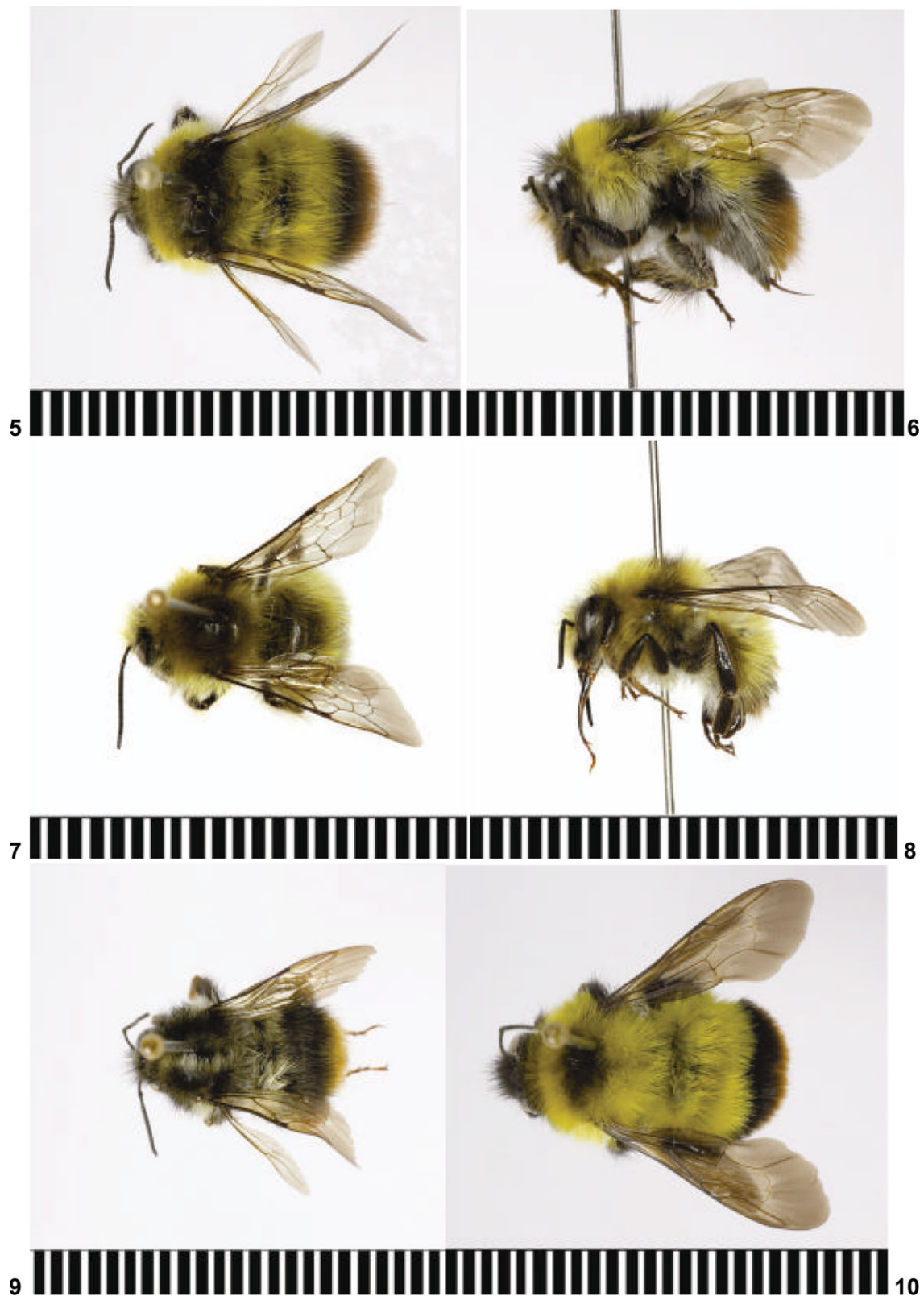
Characters studied

The most obvious characters of bumblebees are those of the colours of their pubescence (Williams, 2007). However, colour of the pubescence can be so variable that it may be misleading if used alone for the identification of species. Fortunately, once species have been recognised from the more reliable differences in shape and sculpturing of the sclerotised exoskeleton, then variation in some aspects of colour pattern within a region the size of Sichuan may in many cases be sufficiently low that colour can still be useful for identifying species (Figs 5–131). For more detailed descriptions of the external morphology of bumblebees see Gauld and Bolton (1988) and Michener (2007).

On the HEAD, the shape and details of the sculpturing of the LABRUM, CLYPEUS and MALAR AREA (the malar space of Richards, 1968) are frequently used as characters. The shape of the malar area can be measured as the ratio of the oculo-

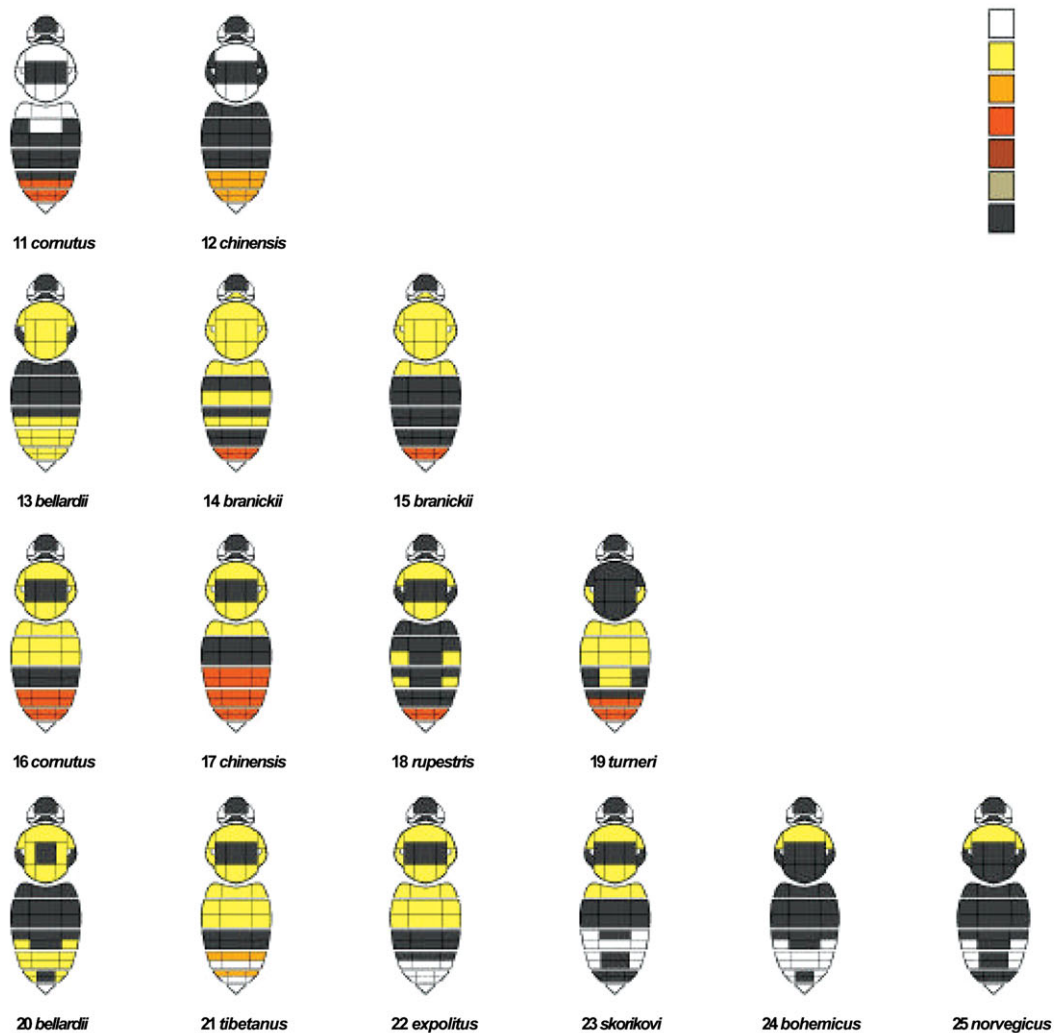
malar distance to the proximal breadth of the mandible, which is measured from its anterior corner of the acetabulum to the anterior edge of the condyle. This shape is related to variation in proboscis length (Medler, 1962), which is in turn related to variation in flower choice, both among and within species (see Measurements below). However, within at least some of the species with longer proboscides, the shape of the malar area may be subject to allometric effects among individuals of different sizes within a species (e.g. Sakagami, 1972). Furthermore, because the boundaries of the malar area require arbitrary definition, measurements by different authors are not always comparable. Therefore this character is used here only when the differences in shape are relatively large. The MANDIBLE provides many characters. There is an ANTERIOR TOOTH, variable numbers of SUBSIDIARY TEETH, and often a POSTERIOR TOOTH, which is defined at its base by an anterior notch also known as the INCISURA. These characters vary within species as well as among them and are subject to further apparent variation caused by wear. Nonetheless, they can still be useful in some species groups (e.g. for identifying the subgenus *Alpigenobombus*). The shape of the ANTENNAL ‘SEGMENTS’ (scape, pedicel and flagellomeres), measured as ratios of length to breadth, is also used here, but only when the differences in shape are large. The OCELLI vary in size and in position relative to the compound eyes. One of the most variable characters, both among and within species, is the sculpturing of the OCELLO-OCULAR AREAS of the VERTEX, on the dorsum of the head.

On the THORAX, the majority of characters are taken from the legs. The outer surface of the hind TIBIA has large areas

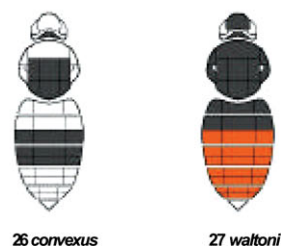


Figures 5–10 Photographs of habitus. Above, paratype queen of *B. wangae* nov. from Jintu (3186 m, 14.vii.2002, DB#220) shown from (5) the dorsal aspect and (6) the left lateral aspect. Middle, holotype male of *B. wangae* nov. from Zhegushan (3830 m, 2.viii.2002, DB#1013) shown from (7) the dorsal aspect and (8) the left lateral aspect. Below (9), worker of *B. avanus* from Luoqishan (2695 m, 14.viii.2005, DB#5571) shown from the dorsal aspect. Below (10), worker of *B. braccatus* from Xiaohechang (1015 m, 27.viii.2005, DB#5658) shown from the dorsal aspect. Scale units in mm. (Photos: NHM Photographic Unit.)

**I – Hindleg tibiae with the outer surface uniformly convex and densely hairy
(no workers)
(*Psithyrus*)**



**II – Hindleg tibiae with the outer surface coarsely granular, dull, and with only a few
long bristles medially
(*Mendacibombus*)**



Figures 11–27 Guide to species by simplified colour-pattern diagrams for females (queens and workers). The dorsum of the body is artificially divided into an arbitrary set of regions, which are classified into seven colour classes (shown at upper right).

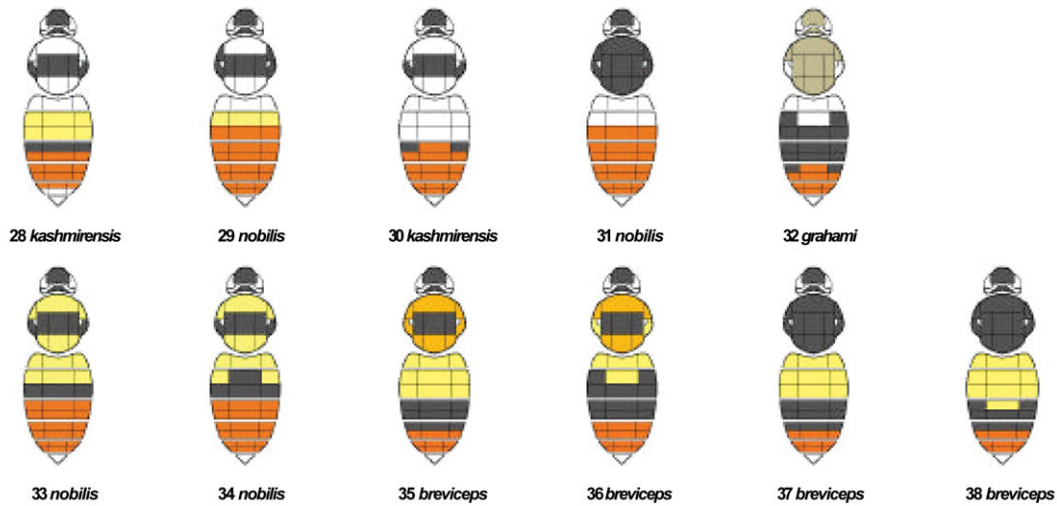
without long pubescence for females of most species, except for females of the subgenera *Psithyrus* and *Mendacibombus*, and for males of some species (Sakagami & Ito, 1981). For the females (except *Psithyrus*), the bare areas are surrounded by dense fringes of long, stout hairs that function as a CORBICULA, or ‘basket’ for carrying pollen. Within some species

groups there is a pronounced development of the distal posterior corner of the mid BASITARSUS (first tarsomere). This can form a spinose projection, but differences between closely related species are seldom pronounced.

On the ABDOMEN, the most obvious characters are found in the sculpturing of the posterior sclerites. Bumblebees, like

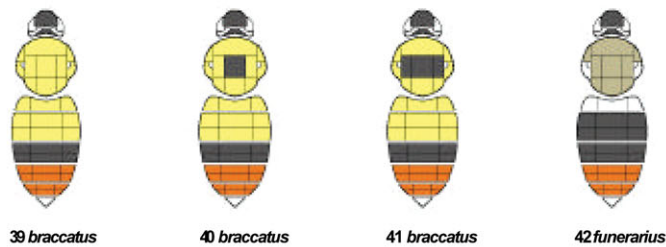
III - Mandibles with six large teeth

(*Alpigenobombus*)

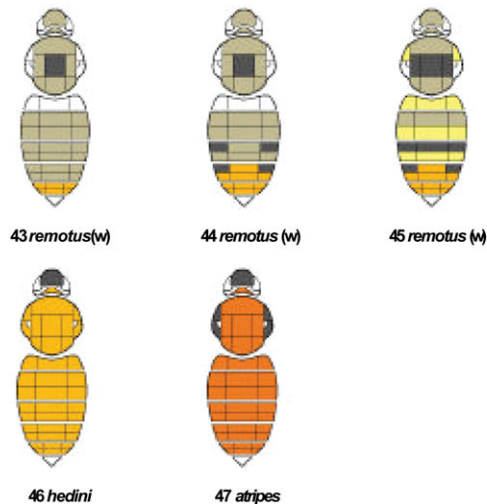


IV – Long-faced bees without a spine on the midleg basitarsi and with the dorsum of the head almost entirely smooth and shiny

(*Orientalibombus*)



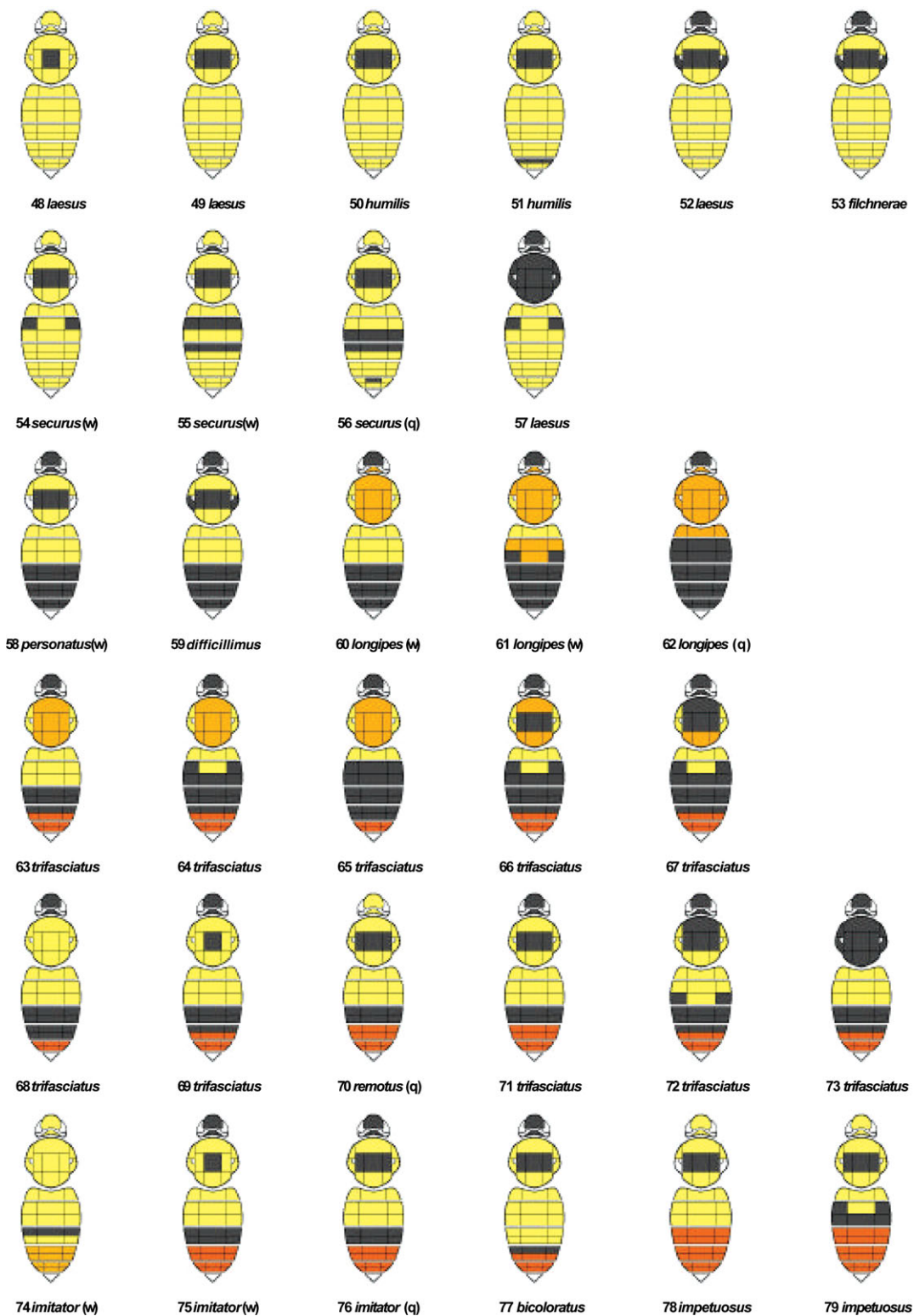
V – Medium- or long-faced bees with a spine on the midleg basitarsi



Figures 28–47 Guide to species by simplified colour-pattern diagrams for females (queens [q] and workers [w]). The dorsum of the body is artificially divided into an arbitrary set of regions, which are classified into seven colour classes.

other Apocrita, have a waist between the first two abdominal segments, so that the first abdominal segment (propodeum) is associated with the thorax, whereas the subsequent segments form a separate unit, the METASOMA (gaster). In this review, all references to segment numbers for the dorsal TERGA (tergites)

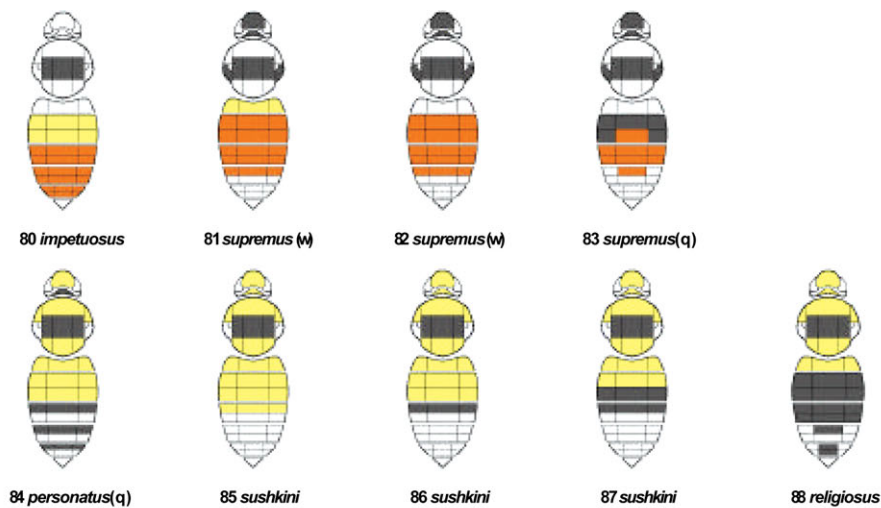
and ventral STERNA (sternites) refer to metasomal segments, so metasomal tergum 1 is the dorsal sclerite of the second abdominal segment. For the females, variation in sculpturing is often especially clear on metasomal tergum 6 (epipygium or pygidium) and sternum 6 (hypopygium), which may also



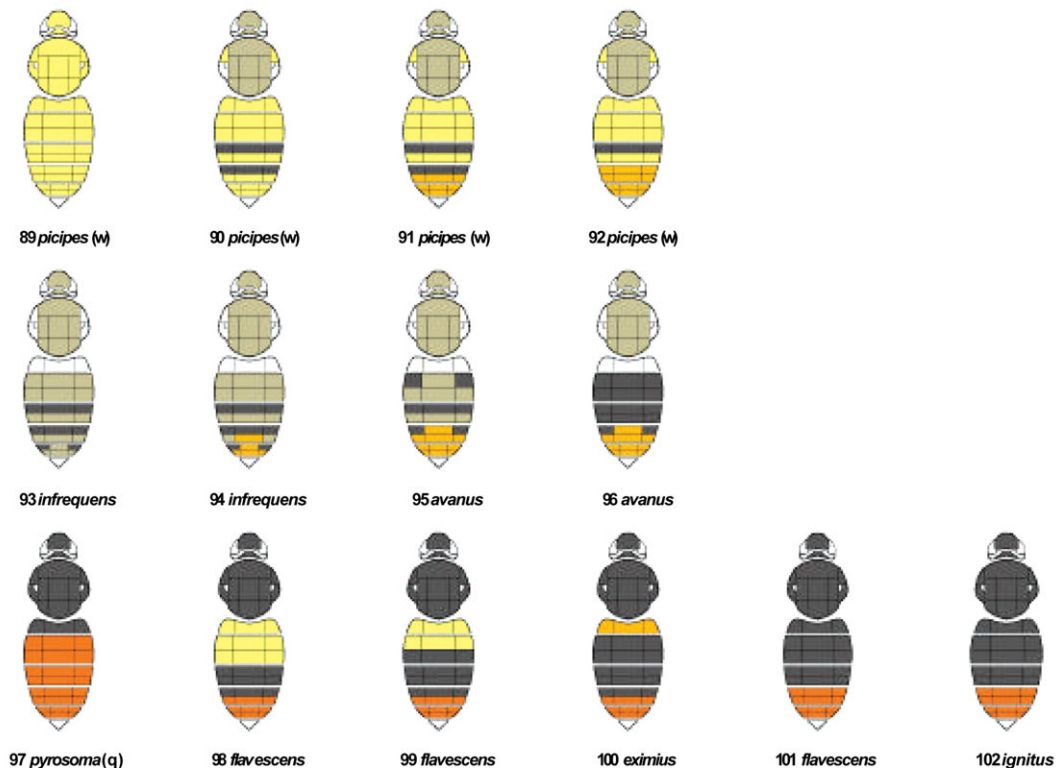
Figures 48–79 Guide to species by simplified colour-pattern diagrams for females (queens [q] and workers [w]). The dorsum of the body is artificially divided into an arbitrary set of regions, which are classified into seven colour classes.

show single or double KEELS (callosites or ridges), or a rounded boss, as well as variation in the shape of the apex. The female genitalia associated with the STING (modified ovipositor) do not always preserve well in dried specimens and may become distorted, so these characters are not used here. In contrast, the

MALE GENITALIA (genital capsule) do preserve well because they are strongly sclerotised. They require no treatment other than a straightforward extraction from the metasoma with a pin. The male genitalia consist of two pairs of claspers and an intromittant organ. We follow the homologies of the parts



VI – Medium- or round-faced bees with a rounded angle on the midleg basitarsi

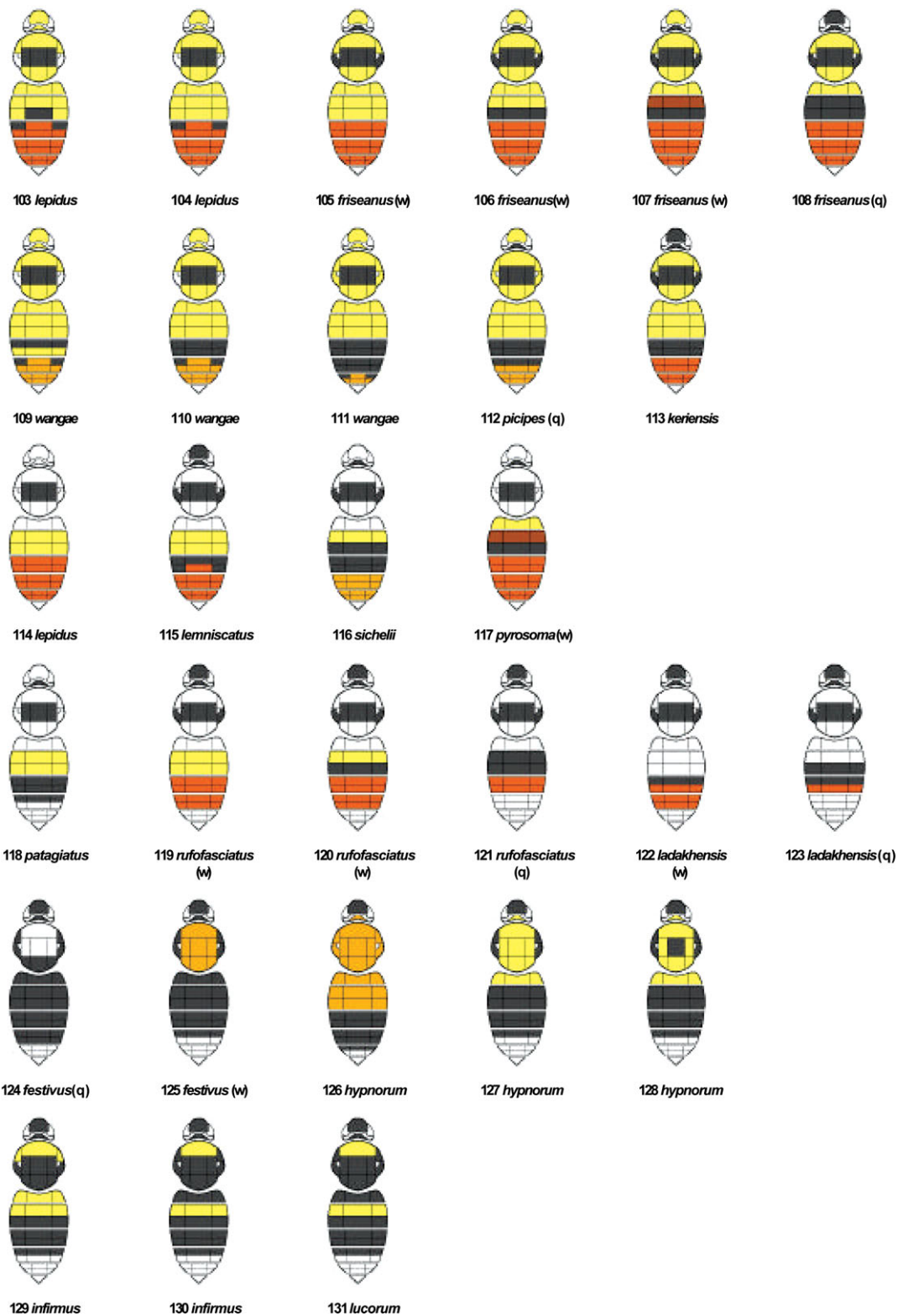


Figures 80–102 Guide to species by simplified colour-pattern diagrams for females (queens [q] and workers [w]). The dorsum of the body is artificially divided into an arbitrary set of regions, which are classified into seven colour classes.

elucidated by Williams (1985, 1991, 1995) and accepted by Michener (2007) (see Fig. 132). The larger outer claspers consist of a pair of anterior GONOCOXAЕ (gonocoxites, stipes), their posterior GONOSTYLI (squamae), and on their inner and ventral sides, the enlarged VOLSSELLAE (laciniae). Both the gonostylus and the volsella often have hook-like processes directed inwards towards the midline of the body. The smaller inner claspers consist of a pair of PENIS VALVES (sagittae). The inflatable intromittant organ (penis) has a median dorsal SPATHA at its base. Many of these male genital structures show

complex elaborations (for discussion of selection mechanisms see e.g. Eberhard, 1985; Hosken & Stockley, 2004) that are particularly valuable as taxonomic characters (Figs 132–187).

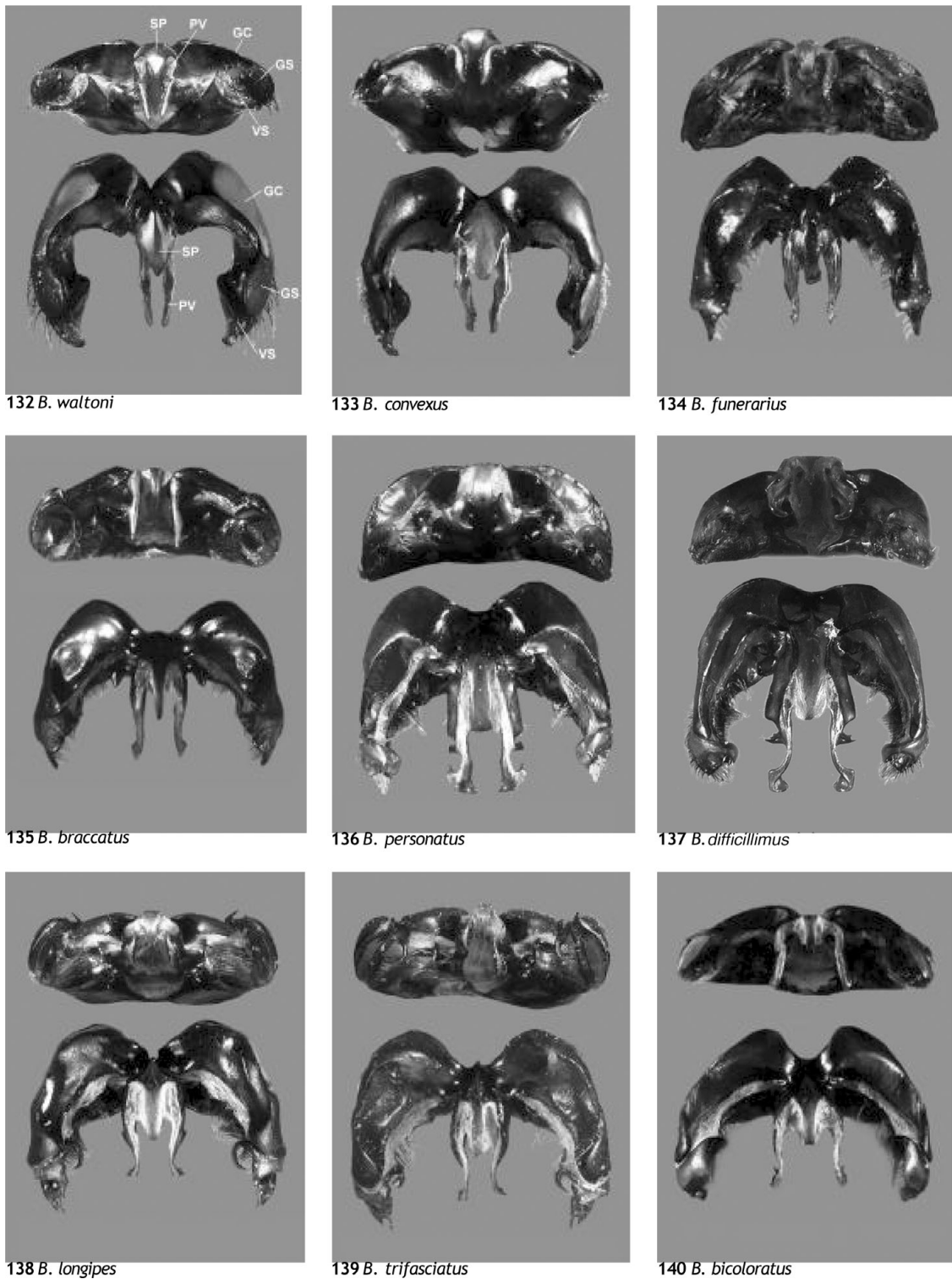
Several informal terms are used as shorthand, particularly for the key, when describing components of colour patterns of the pubescence (hair) that do not correspond precisely with particular sclerites. On the head, FACE is used for the large patch of hair around the antennal bases between the eyes and dorsal to the clypeus and anterior and ventral to the ocelli (frons + supraclypeal area + paraocular area). On the thorax,



Figures 103–131 Guide to species by simplified colour-pattern diagrams for females (queens [q] and workers [w]). The dorsum of the body is artificially divided into an arbitrary set of regions, which are classified into seven colour classes.

there is often an ANTERIOR BAND of pale hairs occupying most of the dorsum anterior to the wing bases (dorsal pronotum + anterior scutum), and a POSTERIOR BAND of pale hair occupying the dorsum posterior to the wing bases (posterior scutum + scutellum). The SIDES of the thorax refers to the long hair

covering the lateral parts of the thorax below the level of the wing bases, on the lateral pronotum + mesepisternum + metepisternum + lateral propodeum. On the abdomen, the term TAIL is used flexibly, referring to the palest long hair covering all or parts of metasomal terga 4–6.

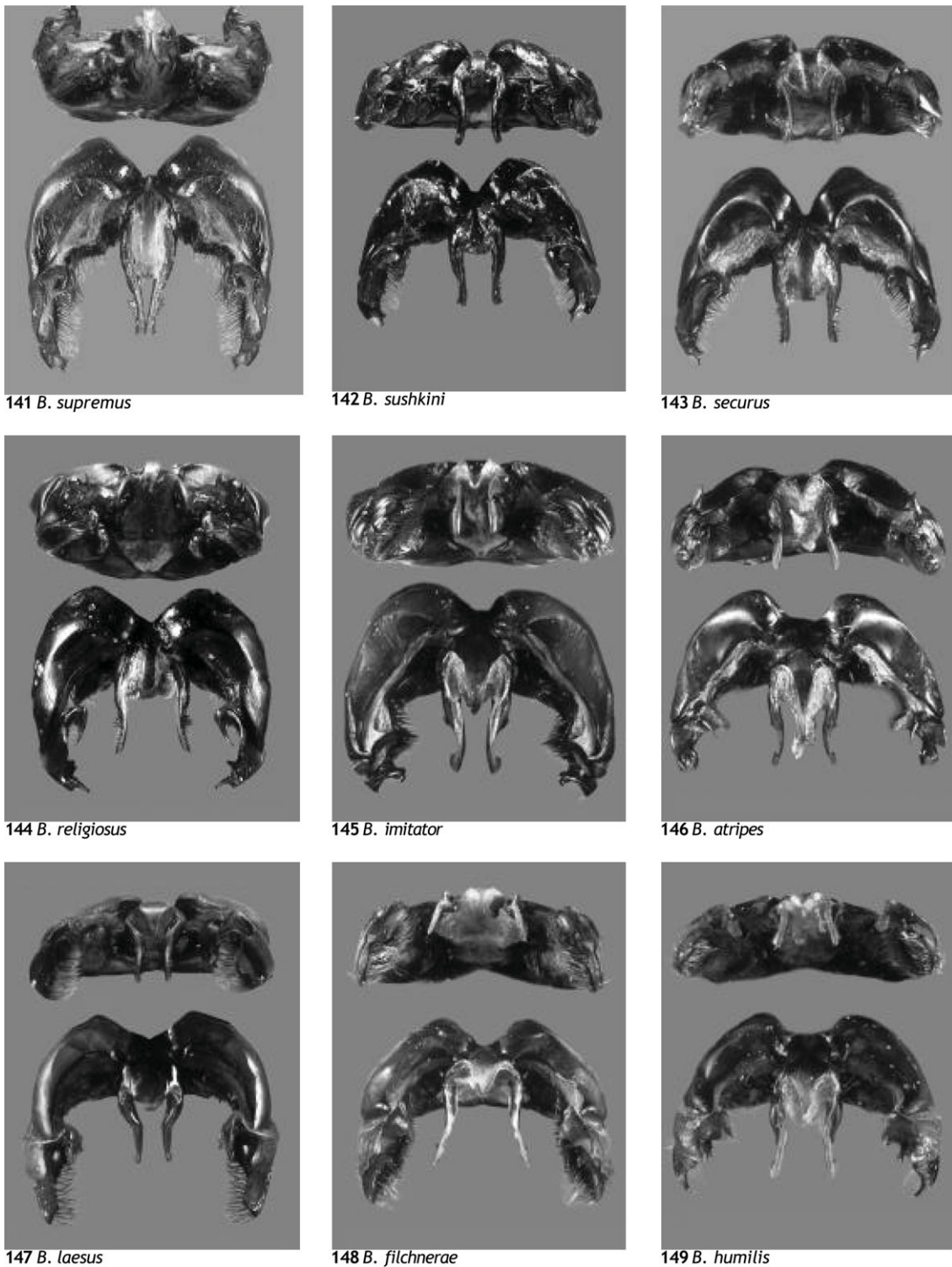


Figures 132–140 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. Labels on Fig. 132: GC gonocoxa, GS gonostylus, VS volsella, PV penis valve, SP spatha. (Photos: A. Polaszek.)

Discrimination of taxa

All bumblebees are placed here in a single genus *Bombus* Latreille (Williams, 1991). The subgeneric system has been simplified, following the recommendations of Williams *et al.* (2008). Subgeneric synonyms are listed here only where they

are necessary to interpret recent usage. For a discussion of bumblebee genera and subgenera, and for a complete synonymy of supraspecific taxa, see Williams (1998) and Williams *et al.* (2008). Species are listed in a numbered order that represents their phylogenetic relationships (after the sequencing

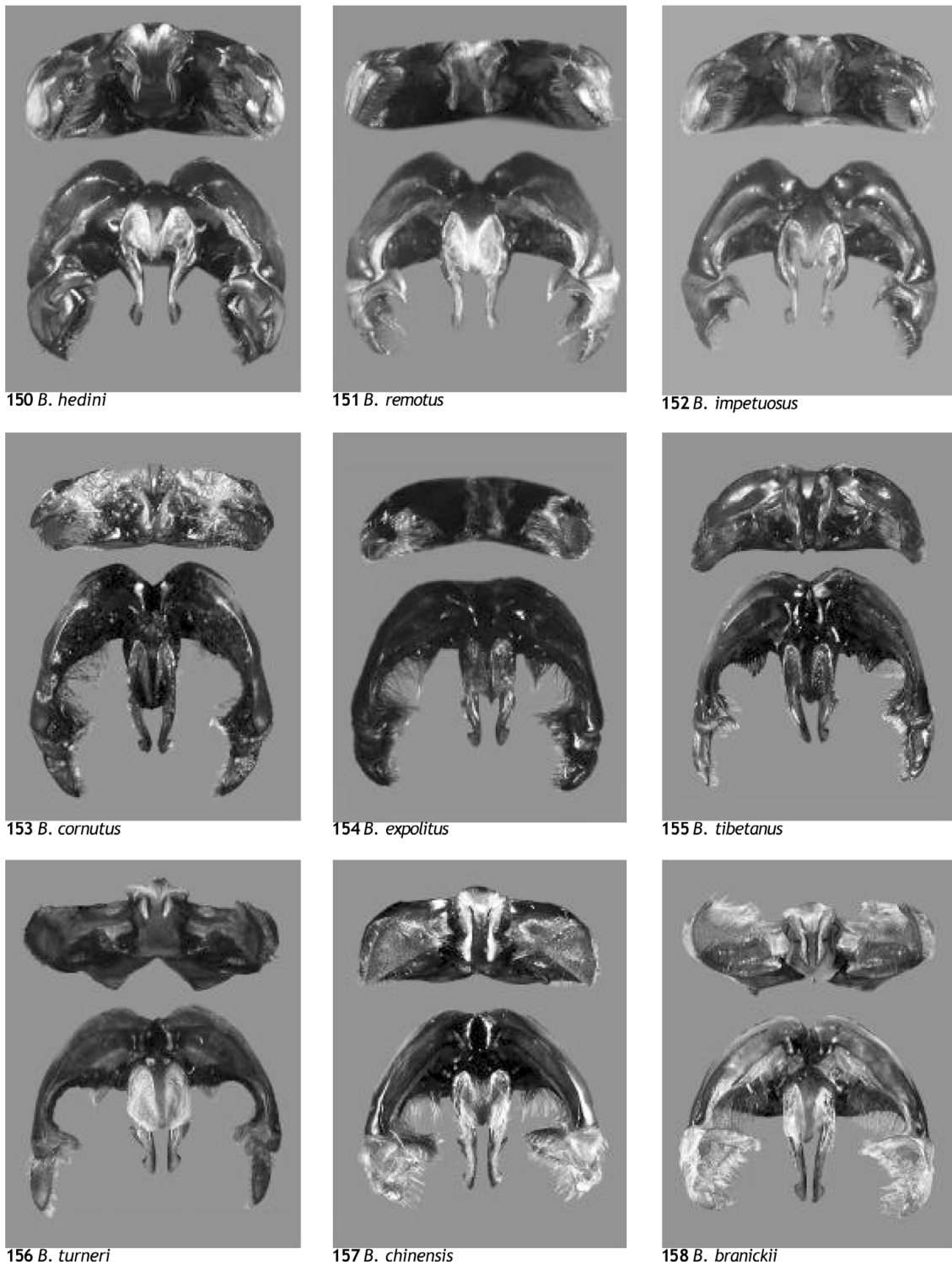


Figures 141–149 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

convention of Nelson, 1972) as these are currently understood from studies of DNA sequences from five genes (Cameron *et al.*, 2007). An alphabetic index is provided at the end of the paper as an aid to finding names.

The criteria used to discriminate species are those discussed for the preliminary world checklist of bumblebees (Williams, 1998). For this review, the interest is primarily in

problems of recognition and nomenclature for taxa at the rank of species. Subspecific names refer to parts of species, and so for present purposes these can be treated as synonyms of specific names (e.g. Schwarz *et al.*, 1996). This is not to say that subspecific taxa should not be recognised if they are considered useful, and of course other biologists may add subspecies names to this list. Treatment of names follows the fourth



Figures 150–158 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

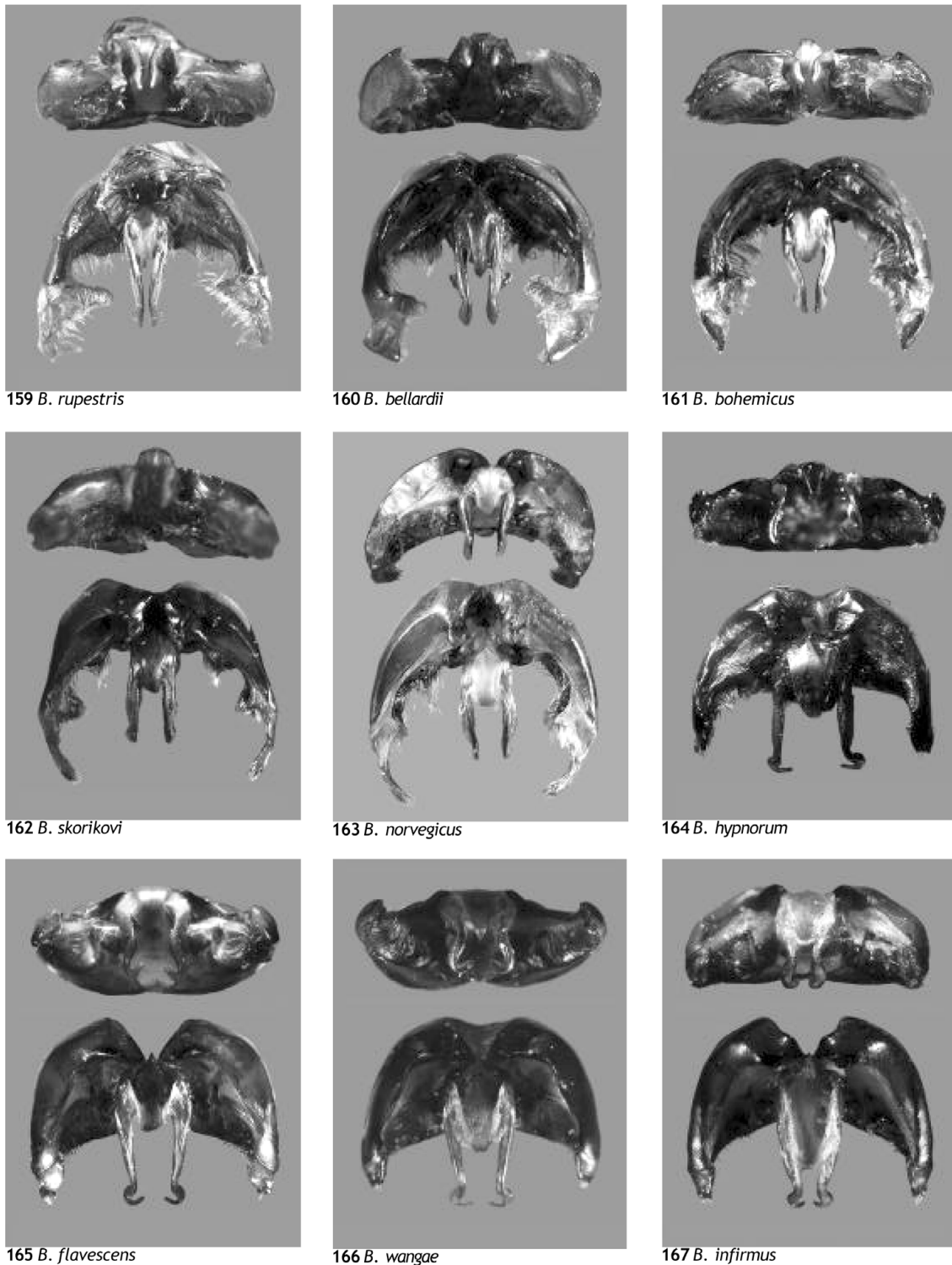
edition of the *International Code of Zoological Nomenclature* (ICZN, 1999).

Measurements

Body sizes are classified from measurements of dried pinned specimens taken from the lateral aspect with a ruler. Means for queens and males are used, because species of the subgenus

Psithyrus do not have workers for comparison. The highest quartile of size-ranked species is designated as ‘large’ bodied and the lowest quartile as ‘small’ bodied.

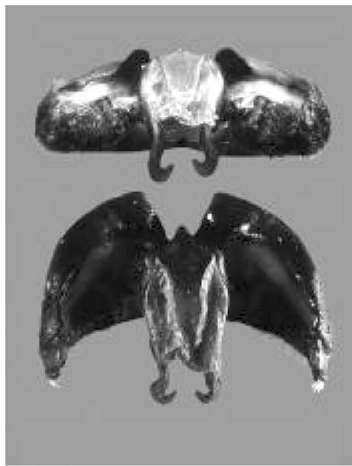
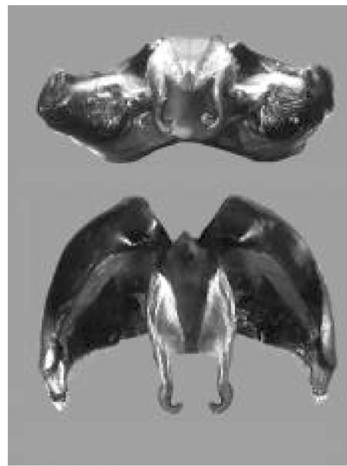
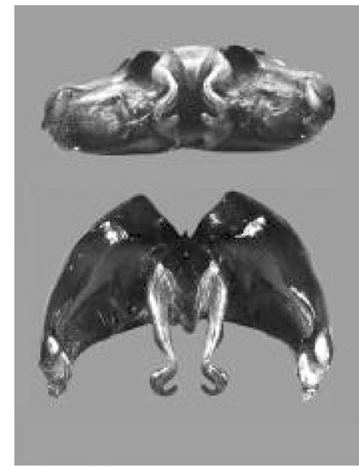
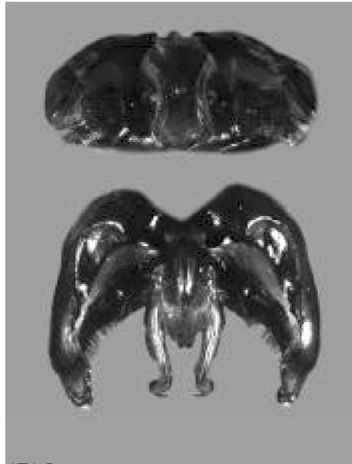
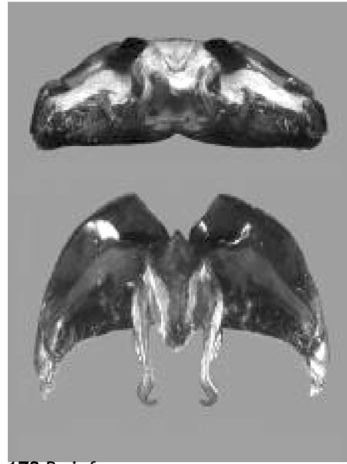
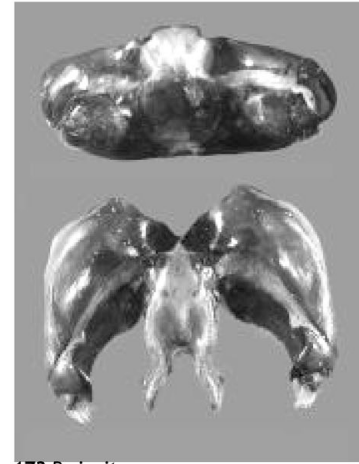
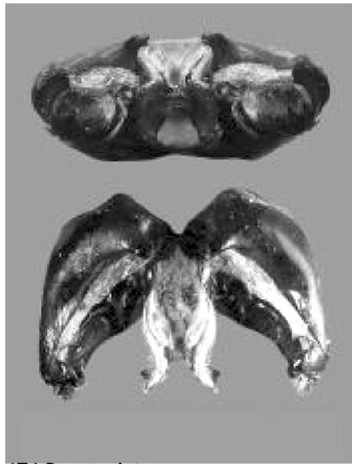
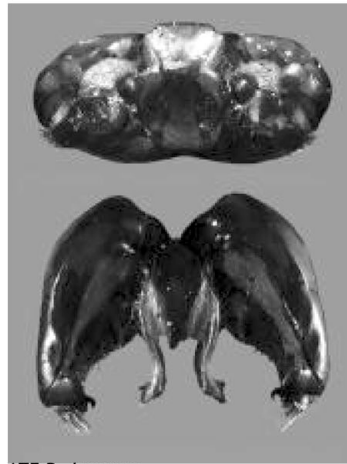
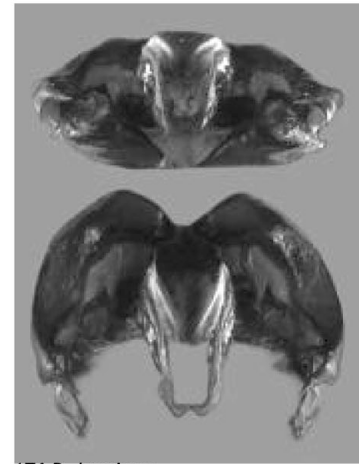
Lengths of bumblebees’ tongues (proboscides) are a good predictor of each species’ flower choice (e.g. Harder, 1983), diet, and ultimately pollination activity and resource partitioning (e.g. Hanski, 1982), at least among the social



Figures 159–167 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

(non-*Psithyrus*) species. The parasitic species have been excluded from most studies of bumblebee flower use for community ecology because their foraging behaviour has different constraints (Heinrich, 1979) and they are usually rare. Therefore they are also excluded from our comparisons, because these consider ranking among species with similar behaviour. Tongue length is difficult to measure with precision (Harder,

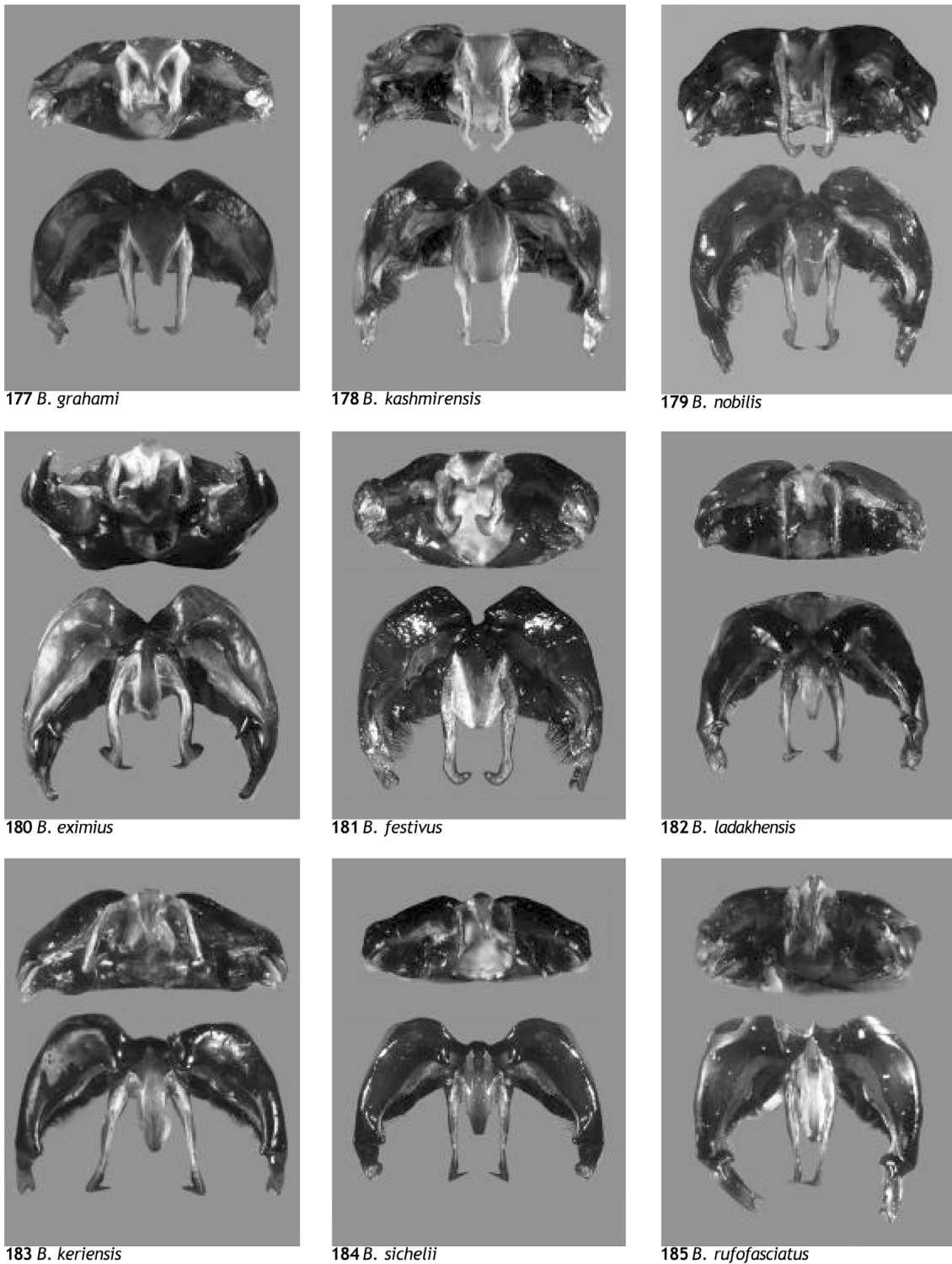
1982), particularly without damaging rare specimens. Fortunately, tongue length is correlated with the elongation of the head (Medler, 1962), which is more easily measured, especially for dried specimens. The relative elongation of the head can be represented by the shape of the malar area, which we measure as the ratio between the oculo-malar distance and the proximal breadth of the mandible (between its anterior corner

168 *B. lemniscatus*169 *B. lepidus*170 *B. picipes*171 *B. avanus*172 *B. infrequens*173 *B. ignitus*174 *B. patagiatus*175 *B. lucorum*176 *B. breviceps*

Figures 168–176 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

and the anterior edge of the posterior condyle). But body size also varies among species. Therefore, in order to convert our indicator for tongue length relative to body size (the malar area shape ratio) into an indicator of absolute tongue length, we multiply the malar shape ratio by the mean body length for workers. Workers are used because they are the majority of the foragers for each colony (although tongue lengths are

correlated between workers and queens: e.g. data in Medler, 1962). For example, *B. convexus* is a relatively long-headed species with a small body size, whereas *B. eximius* is a relatively short-headed species with a large body size. The social species are then ranked by this combined estimate and the highest quartile is designated as ‘long’ tongued and the lowest quartile as ‘short’ tongued.



Figures 177–185 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

Lengths of species' seasonal activity periods are classified from the relative lengths of the intervals between the lower (earlier) and upper (later) quartile dates of records for each species in the database. Parasitic species of the subgenus *Psithyrus* and species with fewer than four records are excluded. There is then no correlation between the number of records and the length of the recorded seasonal activity among

species (Spearman $r_s = 0.04$, $p > 0.05$). The highest quartile of species ranked by their inter-quartile season lengths is designated as having a 'long' season and the lowest quartile as having a 'short' season.

Altitudinal distributions of species are classified from the mean altitudes among all individuals of each species in the database. This variable is strongly skewed in favour of

186 *B. pyrosoma*187 *B. friseanus*

Figures 186–187 Photographs of male genitalia viewed from (above) posterior aspect and (below) dorsal aspect with the anterior towards the top of the page. (Photos: A. Polaszek.)

many high altitude species. Species with mean altitudes above 3500 m (tending to have Tibetan and Palearctic distributions, Table 3) are designated as ‘high’ altitude and those with means below 2000 m (tending to have southeastern Oriental distributions, Table 3) as ‘low’ altitude.

Abundances of species are classified using counts of individuals of each species in the database. These abundances are not adjusted in relation to the numbers of sites occupied because the untransformed counts are expected to be more representative of the relative probabilities of encountering each species across the SCR. As expected (Gaston, 1994), this variable is strongly skewed in favour of many rarer species. Quartiles of the log-transformed range of all species’ abundances are used to designate ‘abundant’, ‘common’, ‘uncommon’, and ‘rare’ species.

Results

List of the bumblebees of Sichuan and Chongqing

The bumblebees recorded from the SCR are listed in Table 4.

Key to females

Female bumblebees have 12 antennal ‘segments’ and six externally visible metasomal terga and sterna.

This key is not intended for use in the field, but for use with a low-power microscope. To make the key easier to use for people who are not bumblebee specialists, it is based primarily on the colour patterns of the pubescence (Figs 11–131). Note that with prolonged exposure to the sun, red, brown, orange and yellow colours will bleach to yellow and ultimately to grey, but this fading is usually correlated with wing wear and thereby easily recognised. Colour patterns often vary much more within species than does morphology, so this key will not work for colour patterns that have not been seen by the authors and will not be as reliable as more difficult keys based on morphology. Some morphological characters are used in the key when they are relatively easy to see and when they greatly reduce errors (in some cases supplementary morphological

characters are included as an additional check). The notes on each species include diagnoses that should be used to cross-check identifications.

All references to colour in the key are to the colours of the hairs on the body, not to the colour of the body surface. Hair is described as being either black or ‘pale’. The latter includes white, yellow, orange, red, brown, etc. The term ‘terga’ refers to metasomal terga.

- 1 Outer surface of the hind tibia broad, almost flat, and fringed with stout hairs as long as the greatest breadth of the tibia, forming a pollen basket (corbicula), the inner distal margin with a comb of stout spines (rastellum); metasomal sternum 6 without ventro-lateral keels 13
 - Outer surface of the hind tibia convex and without a pollen basket of long stout fringing hairs, the inner distal margin without a comb of stout spines (rastellum); metasomal sternum 6 with ventro-lateral keels (cuckoo bees without workers) 2
- 2(1) Dorsum of the thorax with black hair between the wing bases forming at least a black band extending between the wing bases (Figs 11–12, 16–19, 21–25) 4
 - Dorsum of the thorax *either* uniformly yellow, *or* with black hair forming a spot isolated from the wing bases by pale hair (Figs 13–15, 20) 3
- 3(2) ‘Tail’ red (Figs 14–15) ... *branickii* (Radoszkowski)
 - ‘Tail’ yellow (Figs 13, 20) *bellardii* (Gribodo)
- 4(2) Thorax with anterior and posterior pale bands (Figs 11–12, 16–18, 21–23) 7
 - Thorax *either* with only an anterior band of pale hairs and without a posterior pale band, *or* predominantly black (Figs 19, 24–25) 5
- 5(4) Thoracic dorsum with a broad anterior pale band (Figs 24–25) 6
 - Thoracic dorsum predominantly black haired with only a few pale hairs intermixed anteriorly and posteriorly (Fig. 19) *turneri* (Richards)

Species	Mean altitude SCR(m)									
		Alps	Armenia	Mongolia	Tien Shan	Xizang+ Qinghai	Himalaya	Shaanxi + Shanxi	Laos + Thailand	Fujian + Zhejiang
<i>branickii</i>	4277			•	•	•	•	•		
<i>skorikovi</i>	4075					•	•			
<i>rufofasciatus</i>	3916					•	•			
<i>personatus</i>	3864					•	•			
<i>ladakhensis</i>	3855					•	•			
<i>lemniscatus</i>	3832					•	•			
<i>chinensis</i>	3783					•		•		
<i>supremus</i>	3756					•				
<i>lucorum</i>	3744	•	•	•	•	•	•	•		
<i>patagiatus</i>	3739			•	•	•		•		•
<i>waltoni</i>	3703					•	•			
<i>kashmirensis</i>	3696					•	•			
<i>humilis</i>	3681	•	•	•	•			•		
<i>bohemicus</i>	3644	•	•	•	•	•	•	•		
<i>infirmus</i>	3600					•				
<i>sichelii</i>	3590	•	•	•	•	•		•		
<i>filchnerae</i>	3582			•		•				
<i>rupestris</i>	3576	•	•	•	•					
<i>sushkini</i>	3551			•	•	•				
<i>keriensis</i>	3527		•	•	•	•	•			
<i>laesus</i>	3504	•	•	•	•			•		
<i>difficillimus</i>	3468					•	•			
<i>expolitus</i>	3461					•				
<i>convexus</i>	3409					•				
<i>wangae</i>	3390									
<i>nobilis</i>	3342					•	•			
<i>lepidus</i>	3233					•	•			
<i>friseanus</i>	3166					•	•			
<i>tibetanus</i>	3166					•	•			
<i>impetuosus</i>	3143					•			•	
<i>securus</i>	2773					•				
<i>turneri</i>	2693					•	•			•
<i>religiosus</i>	2538							•		
<i>infrequens</i>	2501					•		•		
<i>norvegicus</i>	2500	•		•		•				
<i>avanus</i>	2485									
<i>funerarius</i>	2469						•			
<i>remotus</i>	2455							•		
<i>hypnorum</i>	2371	•	•	•		•	•	•		
<i>picipes</i>	2313							•		•
<i>festivus</i>	2245					•	•			
<i>pyrosoma</i>	2038					•		•		
<i>grahami</i>	2009					•				
<i>longipes</i>	2006							•		
<i>cornutus</i>	1947						•	•		•
<i>hedini</i>	1805							•		
<i>trifasciatus</i>	1469					•	•	•	•	•
<i>ignitus</i>	1425							•		•
<i>bicoloratus</i>	1250									•
<i>imitator</i>	1149									•
<i>breviceps</i>	1071						•		•	•
<i>bellardii</i>	909							•		•
<i>braccatus</i>	869									
<i>flavescens</i>	805						•		•	•
<i>eximius</i>	728					•	•		•	•
<i>atripes</i>	552									•

Table 3 Distribution of SCR bumblebee species beyond the SCR. Species are ranked by the mean altitude of specimen (excluding literature) records within the SCR.

<i>Bombus s. l.</i>	
(Mendacibombus)	
1. waltoni Cockerell, 1910	
2. convexus Wang, 1979	
(Orientalibombus)	
3. funerarius Smith, 1852	
4. braccatus Friese, 1905	
(Subterraneobombus)	
5. personatus Smith, 1879	
6. difficillimus Skorikov, 1912	
(Megabombus)	
7. longipes Friese, 1905	
8. trifasciatus Smith, 1852	
9. bicoloratus Smith, 1879	
10. supremus Morawitz, 1887	
11. sushkini (Skorikov, 1931)	
12. securus (Frison, 1935)	
13. religiosus (Frison, 1935)	
(Thoracobombus)	
14. imitator Pittioni, 1949	
15. atripes Smith, 1852	
16. laesus Morawitz, 1875	
17. filchnerae Vogt, 1908	
18. humilis Illiger, 1806	
19. hedini Bischoff, 1936	
20. remotus (Tkalcù, 1968)	
21. impetuosus Smith, 1871	
(Psithyrus)	
22. cornutus (Frison, 1933)	
23. expolitus (Tkalcù, 1989)	
24. tibetanus (Morawitz, 1887)	
25. turneri (Richards, 1929)	
26. chinensis (Morawitz, 1890)	
27. branickii (Radoszkowski, 1893)	
28. rupestris (Fabricius, 1793)	
29. bellardii (Gribodo, 1892)	
30. bohemicus Seidl, 1837	
31. skorikovi (Popov, 1927)	
32. norvegicus (Sparre-Schneider, 1918)	
(Pyrobombus)	
33. hypnorum (Linnaeus, 1758)	
34. flavescens Smith, 1852	
35. wangae sp. nov.	
36. infirmus (Tkalcù, 1968)	
37. lemniscatus Skorikov, 1912	
38. lepidus Skorikov, 1912	
39. picipes Richards, 1934	
40. avanus (Skorikov, 1937)	
41. infrequens (Tkalcù, 1989)	
(Bombus s. str.)	
42. ignitus Smith, 1869	
43. patagiatus Nylander, 1848	
44. lucorum (Linnaeus, 1761)	
(Alpigenobombus)	
45. breviceps Smith, 1852	
46. grahami (Frison, 1933)	
47. kashmirensis Friese, 1909	
48. nobilis Friese, 1905	
(Melanobombus)	
49. eximius Smith, 1852	
50. festivus Smith, 1861	
51. ladakhensis Richards, 1928	
52. keriensis Morawitz, 1887	
53. sichelii Radoszkowski, 1859	
54. rufofasciatus Smith, 1852	
55. pyrosoma Morawitz, 1890	
56. friseanus Skorikov, 1933	

Table 4 List of the bumblebees of Sichuan and Chongqing with the simplified subgeneric classification of Williams et al. (2008).

6(5) Anterior pale band of the thorax without black hairs intermixed; tergum 5 with lateral quarters white haired (Fig. 24); metasoma weakly curled so that the apex points ventrally bohemicus Seidl	6 with lateral keels strongly produced, in dorsal view projecting beyond tergum 6 laterally by more than the breadth of the hind tarsus
– Anterior pale band of the thorax with black hairs intermixed; tergum 5 with lateral quarters black haired (Fig. 25); metasoma strongly curled so that the apex points anteriorly norvegicus (Sparre-Schneider) chinensis (Morawitz) (part)
7(4) Tergum 1 with pale hair (Figs 11, 16–17, 21–23) 9	– Tergum 3 black haired, at most with a few isolated pale hairs intermixed, and tergum 1 pale haired (Figs 11, 16); sternum 6 with lateral keels weakly produced, in dorsal view projecting beyond tergum 6 laterally by less than the breadth of the hind tarsus
– Tergum 1 entirely black haired (Figs 12, 18) 8 cornutus (Frison)
8(7) Pale hair of thorax yellow (Fig. 18)	11(9) Tergum 2 with the hair predominantly yellow, tergum 3 black haired (Figs 21–22) 12
. rupestris (Fabricius)	– Tergum 2 with the hair predominantly black, tergum 3 whitish haired (Fig. 23) skorikovi (Popov)
– Pale hair of thorax white (Fig. 12)	12(11) Pale anterior band of the thorax about twice the breadth (measured longitudinally on the midline) of the posterior pale band, the pale ‘tail’ distinctly pinkish white haired on terga 4–5 (Fig. 21); labrum with the transverse median lamella produced into a strongly acutely pointed median projection, and with two strong
. chinensis (Morawitz) (part)	
9(7) Palest hair of terga 3–6 red (Figs 11, 16–17) 10	
– Palest hair of terga 3–6 yellowish white, pinkish white, or brownish (Figs 21–23) 11	
10(9) Tergum 3 either predominantly red haired, or if black then tergum 1 also with black hairs (Fig. 17); sternum	

- pointed projections (lateral tubercles) near the mid point at the base; sternum 6 with the lateral keels rounded, the ridges convex longitudinally in their posterior half *tibetanus* (Morawitz)
- Pale anterior and posterior bands of the thorax of equal breadth (measured longitudinally on the mid-line), the pale ‘tail’ indistinct and brownish white haired, tergum 4 predominantly black haired (Fig. 22); labrum with the transverse median lamella produced into a right-angled pointed median projection, without pointed projections near the mid point at the base; sternum 6 with lateral keels angled, the ridges strongly concave longitudinally in their posterior half *expositus* (Tkalci)
- 13(1) Outer surface of the hind tibia smooth and brightly shining, without long hairs in the middle of the proximal half 15
- Outer surface of the hind tibia very rough, matt and dull, not shining, with very long stout hairs in the middle of the proximal half that are spaced widely by more than the breadth of the last tarsal segment ... 14
- 14(13) Dorsum of the thorax with many black but grey-tipped hairs, without an anterior pale band (Fig. 27) *waltoni* Cockerell
- Dorsum of the thorax black haired with an anterior band of grey-white hairs (Fig. 26) ... *convexus* Wang
- 15(13) Mandible distally broadly rounded, with two or three teeth 22
- Mandible distally not broadly rounded, but with six evenly spaced large triangular teeth 16
- 16(15) Dorsum of the thorax with broad anterior and posterior pale bands (Figs 28–30, 33–36) 19
- Dorsum of the thorax predominantly black or olive-grey haired (Figs 31–32, 37–38) 17
- 17(16) Dorsum of the thorax dark olive-grey haired, with paler hairs along the midline (Fig. 32) ... *grahami* (Frison)
- Dorsum of the thorax black haired (Figs 31, 37–38) 18
- 18(17) Wings dark brown; at least part of terga 3–4 black haired (Figs 37–38) *breviceps* Smith (part)
- Wings clear; terga 3–4 red haired (Fig. 31) *nobilis* Friese (part)
- 19(16) Pale bands on the dorsum of the thorax grey-white (Figs 28–30) 20
- Pale bands on the dorsum of the thorax yellow or orange (Figs 33–36) 21
- 20(19) Posterior part of of tergum 2 yellow or white haired (Figs 28, 30); malar area shorter (0.7) than broad *kashmirensis* Friese
- Posterior part of tergum 2 red haired (Fig. 29); malar area as long as broad *nobilis* Friese (part)
- 21(17) Wings dark brown; pale thoracic bands often orange (Figs 35–36) *breviceps* Smith (part)
- Wings clear; pale thoracic bands yellow (Figs 33–34) *nobilis* Friese (part)
- 22(15) Dorsum of the thorax and metasoma (excluding tergum 6) entirely bright orange or reddish brown haired, with no black bands (Figs 46–47) 23
- Dorsum of the thorax and metasoma *either* yellow haired, *or* olive-grey haired, *or* with at least one black band (Figs 39–45, 48–131) 24
- 23(22) Sides of the thorax black haired (Fig. 47), pale hair red-brown *atripes* Smith
- Sides of the thorax orange haired (Fig. 46), pale hair orange-brown *hedini* Bischoff
- 24(22) Thorax with some hair that is not black (Figs 39–45, 48–56, 58–72, 74–96, 103–131) 30
- Thorax entirely black haired, or at most with a very few isolated pale hairs scattered in an anterior band (Figs 57, 73, 97–102) 25
- 25(24) Terga 1–5 with some orange-red hair (Figs 73, 97–102) 26
- Terga 1–5 without orange-red hair, but with yellow and some black hair (Fig. 57) *laesus* Morawitz (part)
- 26(25) Long hairs of the legs all black 27
- Long hairs of the mid and hind legs bright orange on the tibiae and basitarsi 29
- 27(25) Terga 2–3 black haired (Fig. 102) *ignitus* Smith
- Terga 2–3 with some yellow or red hair (Figs 73, 97) 28
- 28(27) Tergum 2 yellow, tergum 3 black haired (Fig. 73) *trifasciatus* Smith (part)
- Terga 2–3 red haired (Fig. 97) *pyrosoma* Morawitz (queen)
- 29(25) Tergum 1 black or yellow haired (Figs 98–99, 101); labral transverse lamella narrow and strongly curved *flavescens* Smith
- Tergum 1 black or dark brown haired (Fig. 100); labral transverse lamella broad and straight *eximius* Smith
- 30(24) Thorax black with a large round white patch between the wing bases; body length greater than 22 mm (Fig. 124) *festivus* Smith (queen, large worker)
- Thorax without a large round white patch between the wing bases; body length less or greater than 22 mm (Figs 39–45, 48–72, 74–96, 103–123, 125–131) ... 31
- 31(30) Dorsum of the thorax *either* predominantly black (not dark grey) haired, *or* with some yellow or brownish hairs very narrowly peripherally and particularly at the posterior of the thorax (Figs 57, 67, 72) 32
- Dorsum of the thorax *either* with one or two pale bands, *or* a small black spot, *or* greyish with pale (non-black) hairs intermixed throughout, *or* pale throughout (Figs 39–45, 48–56, 58–66, 68–71, 74–96, 103–123, 125–131) 33
- 32(31) ‘Tail’ red (Figs 67, 72) *trifasciatus* Smith (part)
- ‘Tail’ with black and yellow hair, often intermixed (Fig. 57) *laesus* Morawitz (part)
- 33(31) Dorsum of the thorax with a pale (transverse) band at least anteriorly, black hair strongly concentrated between the wing bases (Figs 40–41, 49–56, 58–59, 66, 69–71, 75–88, 103–123, 128–131) 47
- Dorsum of the thorax *either* with pale hair throughout, *or if* black hair is intermixed, *then* it is more

- evenly distributed and does not form a black band between the wing bases, *or if* dark grey, *then* with a prominent but narrow mid-longitudinal band of paler hairs (Figs 39, 42–45, 48, 60–65, 68, 74, 89–96, 125–127)..... 34
- 34(33) Dorsum of the thorax yellow or olive-grey haired (Figs 39, 42–45, 48, 68, 74, 89–96, 127) 38
- Dorsum of the thorax uniformly bright orange-brown haired (Figs 60–65, 125–126)..... 35
- 35(34) ‘Tail’ black or white haired (Figs 60–62, 125–126) 36
- ‘Tail’ red haired (Figs 63–65)..... *trifasciatus* Smith (part)
- 36(35) ‘Tail’ white haired, or with at least some white-tipped hairs (Figs 125–126); antennal segment 4 longer than broad..... 37
- ‘Tail’ black haired (Figs 60–62); antennal segment 4 shorter than broad..... *longipes* Friese
- 37(36) Dorsum of the head, tergum 2, and the sides of the thorax black haired; hair short (Fig. 125)..... *festivus* Smith (worker)
- Dorsum of the head, and often tergum 2 and the sides of the thorax orange-brown haired; hair long (Fig. 126)..... *hypnorum* (Linnaeus) (part)
- 38(34) Dorsum of the thorax with black hairs intermixed throughout (Figs 42–45, 89–96)..... 43
- Dorsum of the thorax with black hairs intermixed only between the wing bases (Figs 39, 48, 68, 74, 127)..... 39
- 39(38) ‘Tail’ *either* red, *or* yellow and black (Figs 39, 48, 68, 74)..... 40
- ‘Tail’ white (Fig. 127) .. *hypnorum* (Linnaeus) (part)
- 40(39) ‘Tail’ red (Figs 39, 68, 74)..... 41
- ‘Tail’ yellow and black (Fig. 48)..... *laesus* Morawitz (part)
- 41(40) Hair of the head black (Fig. 39, 68)..... 42
- Hair of the head yellow (Fig. 74)..... *imitator* Pittioni (small worker)
- 42(41) *Either* tergum 4 black haired anteriorly, *or* tergum 3 laterally red haired; femora black haired (Fig. 68); dorsum of the head with large punctured areas, only small shining areas without punctures around the ocelli..... *trifasciatus* Smith (part)
- Tergum 4 entirely red haired, tergum 3 entirely black haired; femora extensively yellow haired (Fig. 39); dorsum of the head with small punctured areas, almost all of the area around the ocelli smooth and shining without punctures..... *braccatus* Friese (part)
- 43(38) Tergum 2 black haired, at least in the anterior lateral corners; dorsum of the thorax dark olive grey haired, the hairs sometimes forming a narrow pale longitudinal line along the midline (Figs 42, 95–96) 44
- Tergum 2 with pale hair at least intermixed throughout; dorsum of the thorax yellow or olive-grey haired, without a narrow line of paler hair along the midline (Figs 43–45, 89–94)..... 45
- 44(43) Head black haired, terga 2 and 3 *either* usually without pale posterior fringes, *or if* pale fringes present *then* very narrow; upper sides of the thorax dark olive grey haired; surface and hair of mid and hind basitarsi nearly black (Fig. 42); distance between eye and the base of the mandible much greater than the basal breadth of the mandible..... *funerarius* Smith
- Head with many short pale hairs, terga 2 and 3 usually with pale hair at least as broad posterior fringes; upper sides of the thorax nearly white haired; surface and hair of mid and hind basitarsi bright orange-brown (Figs 95–96); distance between eye and the base of the mandible only just greater than the basal breadth of the mandible..... *avanus* (Skorikov)
- 45(43) Posterior distal corner of the mid basitarsus forming just less than a right angle..... 46
- Posterior distal corner of the mid basitarsus narrowly produced as a spine (Fig. 43–45)..... *remotus* (Tkalčú) (small worker)
- 46(45) Tergum 2 with black hair intermixed; the ‘tail’ often dominated by many black hairs; hair long (Figs 93–94)..... *infrequens* (Tkalčú)
- Tergum 2 without black hair intermixed; the ‘tail’ often orange or yellow without black hairs; hair short (Figs 89–92)..... *picipes* Richards (small worker)
- 47(33) Dorsum of the thorax with anterior and posterior pale bands (Figs 40–41, 49–56, 58–59, 66, 69–71, 75–88, 103–123, 128)..... 49
- Dorsum of the thorax black with only an anterior yellow band (Figs 129–131)..... 48
- 48(47) Tergum 1 black haired; the white ‘tail’ distinct with hairs of tergum 5 mostly white (Fig. 131); posterior margin of the hind basitarsus strongly arched..... *lucorum* (Linnaeus)
- Tergum 1 *either* yellow haired, *or if* black, *then* the white ‘tail’ obscure with hairs of tergum 5 either black or black with white tips (Figs 129–130); posterior margin of the hind basitarsus almost straight..... *infirmus* (Tkalčú)
- 49(47) Metasoma *either* with a black or red band on tergum 2 or 3, *or* at least with many black hairs intermixed laterally on tergum 2, *or* with a red tail (Figs 40–41, 54–56, 58–59, 66, 69–71, 75–84, 86–88, 103–123, 128)..... 53
- Metasoma mostly yellow haired and terga 2–3 without any black or red bands and without a red ‘tail’ (Figs 49–53, 85)..... 50
- 50(49) Tergum 3 without black hairs *unless* black hairs are also present anteriorly on tergum 2; terga 4–5 with yellow hairs, similar to those on tergum 2 (Figs 49–53)..... 51
- Tergum 3 with some black hairs anteriorly, tergum 2 yellow haired anteriorly; terga 4–5 predominantly whitish haired, paler than the yellow hairs of tergum 2 (Fig. 85)..... *sushkini* (Skorikov) (part)
- 51(50) Corbicular fringes *either* with longer hairs black, *or* at most with a few tips pale; black band between the wing bases often rectangular, broader (transversely) than long, the anterior and posterior margins parallel, with very little intermixing of black hairs within the pale bands just anteriorly and posteriorly to the black band (Fig. 53)..... *filchnerae* Vogt

- Corbicular fringes *either* yellow, *or* at least with some longer hairs mostly yellow; dorsum of the thorax varying from having a small rounded black spot to a very large rounded patch of black hair between the wing bases, often projecting posteriorly as a point, and with at least some black hairs intermixed with the yellow anteriorly and posteriorly to the spot (Figs 49–52) 52
- 52(51) Hairs of the face *either* black, *or* with a few yellow hairs intermixed; dorsum of the thorax yellow or brownish yellow haired, varying from having a small rounded spot of black hairs, to being almost entirely black, but the yellow bands with a few black hairs intermixed, and these black hairs only immediately anteriorly and posteriorly to the black patch (Figs 49, 52); the inner eye margin opposite the ocelli with only a few scattered punctures, which are restricted to the outer third of the area along the eye margin *laesus* Morawitz (part)
- Hairs of the face pale yellow with a few black hairs intermixed; dorsum of the thorax creamy yellow haired, with a large round patch of black hairs, but with some black and yellow hairs broadly intermixed almost throughout the dorsum (Figs 50–51); the inner eye margin opposite the ocelli with many large punctures, occupying the outer half of the area along the eye margin *humilis* Illiger
- 53(49) Metasoma with red, orange-red, or pinkish hair, often on the ‘tail’ (Figs 40–41, 66, 69–71, 75–83, 103–117, 119–123) 60
- Metasoma without red, orange-red, or pinkish hair (Figs 54–56, 58–59, 84, 86–88, 118, 128) 54
- 54(53) Thoracic pale bands yellow (Figs 54–56, 58–59, 84, 86–88, 128) 55
- Thoracic pale bands grey-white (Fig. 118) *patagiatus* Nylander
- 55(54) Tergum 2 with black hair at least intermixed laterally, tergum 4 anteriorly white or yellow haired (Figs 54–56, 86–88, 128) 57
- Tergum 2 entirely yellow haired, tergum 4 anteriorly either black haired, or hairs black with white tips (Figs 58–59, 84) 56
- 56(55) Terga 3–5 usually posteriorly with fringes of white hairs, which are narrower for the workers, white hairs are often also present on the lower sides of the thorax, leg bases and sterna (Figs 58, 84) *personatus* Smith
- Terga 3–5 always entirely black haired, as are the lower sides of the thorax, leg bases and sterna (Fig. 59) *difficillimus* Skorikov
- 57(55) ‘Tail’ white (Figs 86–88, 128) 58
- ‘Tail’ brownish yellow (Figs 54–56) *securus* (Frison)
- 58(57) Face and sides of the thorax with pale hair (Figs 86–88); malar area nearly twice (1.8–2.1) as long as broad 59
- Face and sides of the thorax with black hair (Fig. 128); malar area slightly shorter (0.9) than broad *hypnorum* (Linnaeus)
- 59(58) Terga 2–3 black haired, middle third of tergum 5 predominantly black haired (Fig. 88) *religiosus* (Frison)
- Terga 2–3 *either* extensively yellow haired, *or* at least yellow in the anterior half of tergum 2, and tergum 5 with few or no black hairs in the middle (Figs 86–87) *sushkini* (Skorikov) (part)
- 60(54) Pale thoracic bands yellow or orange (Figs 40–41, 66, 69–71, 75–79, 103–113) 68
- Pale thoracic bands grey-white (Figs 80–83, 114–117, 119–123) 61
- 61(60) Tergum 5 *either* red haired, *or* at least pale orange, *or* with some red hairs with white tips (Figs 80, 114–117) 64
- Tergum 5 *either* white haired, *or* at least white in the lateral thirds with pinkish hairs in the middle third (Figs 81–83, 119–123) 62
- 62(61) Tergum 2 *either* extensively yellow or white haired, *or if* black, *then* without any red hairs (Figs 119–123); distance between the eye and the mandible less than twice the proximal breadth of the mandible 63
- Tergum 2 extensively red haired, at least posteriorly (Figs 81–83); distance between the eye and the mandible more than twice the proximal breadth of the mandible *supremus* Morawitz
- 63(62) Tergum 2 black and/or bright yellow haired (Figs 119–121) *rufofasciatus* Smith
- Tergum 2 white or cream haired (Figs 122–123) *ladakhensis* Richards
- 64(61) Corbicular fringes predominantly orange or greyish 66
- Corbicular fringes black, at most some hairs with greyish tips 65
- 65(64) Head entirely black haired, the anterior thoracic grey band broader (measured longitudinally along the midline) than the posterior band, tergum 2 predominantly yellow haired; hair long (Fig. 115) *lemniscatus* Skorikov
- Head black with pale hair intermixed, the thoracic grey bands equally broad (measured longitudinally along the midline), tergum 2 predominantly brown haired; hair short (Fig. 117) *pyrosoma* Morawitz (worker)
- 66(64) Dorsum and posterior dorsal margin of the head with black and many pale hairs intermixed; tergum 2 yellow haired, tergum 3 extensively orange-red haired (Figs 80, 114) 67
- Dorsum and posterior dorsal margin of the head almost entirely black haired; tergum 2 white or cream haired, tergum 3 predominantly black haired (Fig. 116) *sichelii* Radoszkowski
- 67(66) Band of black hairs between the wing bases parallel sided (Fig. 114); posterior corner of the mid basitarsus broadly rounded *lepidus* Skorikov (part)
- Band of black hairs between the wing bases extending posteriorly in the middle as a point (Fig. 80); posterior corner of the mid basitarsus narrowly produced as a spine *impetuosus* Smith (part)
- 68(60) Hairs of the head all black 69

- Hairs of the head black and pale intermixed, at least on the face 73
- 69(68) Tergum 3 with black hair anteriorly (Figs 40–41, 66, 69, 71, 75–76, 113) 70
 - Tergum 3 with yellow hair anteriorly (Fig. 77) *bicoloratus* Smith
- 70(69) Yellow bands golden yellow or orange, the yellow anterior band of the thorax with some black hairs intermixed anteriorly, sides of thorax yellow haired (Figs 40–41, 66, 69, 71, 75–76) 71
 - Yellow bands cream yellow, the yellow anterior band of the thorax without black hairs intermixed anteriorly (if they are present, then the sides of the thorax and the posterior margin of tergum 2 are black haired) (Fig. 113) *keriensis* Morawitz
- 71(70) Tergum 4 entirely red haired (Figs 40–41, 75–76); antennal segment 4 longer than broad 72
 - Tergum 4 usually extensively black haired (Figs 66, 69, 71); antennal segment 4 shorter than broad *trifasciatus* Smith (part)
- 72(71) Dorsum of the head with large punctured areas, only small shining areas without punctures around the ocelli (Figs 75–76) *imitator* Pittioni (queen, large worker)
 - Dorsum of the head with small punctured areas, almost all of the area between the ocelli and the eyes smooth and shining without punctures (Figs 40–41) *braccatus* Friese (part)
- 73(68) Posterior corner of the mid basitarsus forming just less than a right angle 75
 - Posterior corner of the mid basitarsus narrowly produced as a spine 74
- 74(73) Terga 2–4 *either* without black hairs, *or if* they are present, *then* there are more black hairs on tergum 2 than on tergum 3 (Figs 78–79) *impetuosus* Smith (part)
 - Tergum 2 with few or no black hairs, tergum 3 and often tergum 4 extensively black haired (Fig. 70) *remotus* (Tkalci) (queen, large worker)
- 75(73) Dorsum and posterior dorsal fringe of the head predominantly pale with longer black hairs intermixed; tergum 2 yellow haired; tergum 3 usually with at least some black hair anteriorly; corbicular fringes *either* (usually) extensively pale, *or* at least some hairs pale at the tips (Figs 103–104, 109–112); tergum 6 posteriorly rounded, without a notch 76
 - Dorsum and posterior dorsal fringe of the head predominantly black with a few short pale hairs intermixed; tergum 2 *either* extensively yellow haired, *or* anteriorly brown, *or* black; tergum 3 entirely red haired; corbicular fringes (usually) predominantly black, with few or no pale tips (Figs 105–108); tergum 6 with a posterior notch *friseanus* Skorikov
- 76(75) Tergum 3 *either* entirely black haired, *or* black with a yellowish posterior fringe (Figs 109–112) 77
 - Tergum 3 extensively bright orange-red haired (Figs 103–104) *lepidus* Skorikov (part)
- 77(76) Short hairs on the dorsum of the head *either* entirely black, *or* between the ocelli sparsely yellow; the anterior yellow band of the thorax with black hairs intermixed throughout between the anterior and posterior margins of the band, the anterior and posterior pale bands of similar breadth (measured longitudinally on the midline); terga 3–4 at laterally extremes with black hair (Fig. 112); band of punctures along the inner eye margin opposite the ocelli sparse and shining with few fine punctures *picipes* Richards (queen, large worker)
 - Short hairs on the dorsum of the head usually densely yellow for the entire breadth of the head (except for the darkest workers); the anterior yellow band of the thorax with black hairs intermixed just behind the anterior margin and just ahead of the posterior margin, but at least for queens absent in between, the anterior pale band of the thorax usually broader than the posterior pale band (measured longitudinally on the midline); *either* tergum 3 *or* terga 3–4 usually with lateral fringes of yellow-white hairs (Figs 109–111); band of punctures along the inner eye margin opposite the ocelli dense with many fine punctures, which are only very narrowly reduced in density opposite the ocelli *wangae* sp. nov.

Key to males

Male bumblebees have 13 antennal ‘segments’ and seven externally visible metasomal terga and sterna.

Unfortunately at this stage it is not possible to make a reliable key to males based on colour patterns, because males tend to be more uniformly yellow and are relatively poorly known (they are only 16% of the total sample here). Therefore, this key is based largely on morphological characters of the male genitalia (Figs 132–187), because these are more reliable and more clearly distinctive. Consequently, male specimens should be prepared for examination by extracting their genital capsules. The notes on each species include diagnoses that should be used to cross-check identifications.

- 1 Volsella with the inner margin bearing *either* two inwardly-directed hooks or a single combined inwardly-directed process, *or if* this process is strongly reduced and small, *then* the penis valve head is always inwardly turned and sickle-shaped (volsella always strongly sclerotised; gonostylus often with an inner proximal process or shelf, but not associated with many long hairs; head of the penis valve often much modified, *either* curved in strongly towards the midline of the body as a sickle-shaped hook, *or* curved slightly outwards) (Figs 134–152, 164–187) 14
- Volsella with the inner margin without any inwardly-directed hooks or processes (volsella weakly or strongly sclerotised; gonostylus *either* without an inner proximal process, *or if* it is present, *then* it is associated with many long branched hairs; head of the penis valve nearly straight from the dorsal aspect) (Figs 132–133, 153–163) 2

- 2(1) Volsella usually weakly sclerotised, yellowish or light brown in colour; gonostylus with a pronounced inner proximal process, which is associated with long branched hairs; head of the penis valve, as defined by an outer lateral ridge, not strongly curved from the lateral aspect, shaped like a slender arrowhead (Figs 153–163) 4
- Volsella strongly sclerotised, dark brown in colour; gonostylus without an inner proximal process or hairs; head of the penis valve, as defined by an outer lateral toothed ridge, ventrally curved from the lateral aspect and sabre-shaped (Figs 132–133) 3
- 3(2) Dorsum of thorax *either* black haired *or* hairs black with greyish tips, without grey-white bands, tergum 1 black haired, hairs of terga 3–6 orange-red with greyish tips, or black with greyish tips (Fig. 132) *waltoni* Cockerell
- Dorsum of thorax black with a grey-white band anteriorly, behind the wing bases with small lateral patches of grey-white hairs, hairs of tergum 1 grey-white, terga 4–6 white or black with greyish tips (Fig. 133) *convexus* Wang
- 4(2) Volsella in its distal part, beyond the inner corner, greatly narrowed, almost parallel sided and finger-shaped; gonostylus with only a few long hairs (Figs 162–163) 5
- Volsella distally *either* broader in the form of a broad nearly triangular plate, *or if* the distal part is narrowed, *then* the inner corner is strongly produced; gonostylus usually with many long hairs around the inner proximal process (Figs 153–161) 6
- 5(4) Thorax with yellow bands anteriorly and posteriorly; penis valve with the ventro-basal angle strongly projecting and narrow, distally pointed (Fig. 162) *skorikovi* (Popov)
- Thorax with only an anterior yellow band; penis valve with the ventro-basal angle strongly projecting and broad, distally rounded (Fig. 163) *norvegicus* (Sparre-Schneider)
- 6(4) Ventro-basal angle of the penis valve strongly and broadly produced ventrally and outwardly, so as to be visible from the dorsal or at least the dorso-lateral aspect (Figs 153–160) 7
- Ventro-basal angle of the penis valve much reduced and not visible from the dorso-lateral aspect (terga 3–6 with some white hair) (Fig. 161) *bohemicus* Seidl
- 7(6) Volsella in its distal half forming an elongate paddle with the inner margin broadly incurved, the narrowest point halfway along this distal part scarcely broader than the gonocoxa distally (Figs 153–159) 8
- Volsella in its distal half broadly triangular with the inner margin almost straight, the narrowest point halfway along this distal part more than twice the breadth of the gonocoxa distally from the dorsal aspect (terga 4–6 yellow haired) (Fig. 160) *bellardii* (Gribodo)
- 8(7) Volsella in its distal half very pale yellow, with the inner corner strongly produced towards the mid-line to almost twice the breadth halfway along the distal part (Figs 157–159) 9
- Volsella in its distal part brownish, with the inner corner scarcely produced towards the mid-line (Figs 153–156) 11
- 9(8) Volsella in its distal part beyond the inner corner forming a broad, almost equilateral triangle with the inner margin only weakly curved or almost straight when viewed perpendicularly to the dorsal surface; thoracic pale hair yellow or white (Fig. 157) *chinensis* (Morawitz)
- Volsella in its distal part beyond the inner corner distinctly longer than broad, with the inner margins strongly incurved when viewed perpendicularly to the dorsal surface; thoracic pale hair yellow (Figs 158–159) 10
- 10(9) Thoracic dorsum with yellow bands anteriorly and posteriorly, tergum 4 orange-red haired (Fig. 159) *rupestris* (Fabricius)
- Thoracic dorsum yellow haired with just a few black hairs between the wing bases, tergum 4 black haired (Fig. 158) *branickii* (Radoszkowski)
- 11(8) Terga 5–6 red haired 12
- Terga 5–6 *either* white haired, *or* these hairs black with white tips 13
- 12(11) Gonostylus narrowing gradually from near the inner end (nearer to the body midline) towards the outer end; penis valve with the ventro-basal angle strongly projecting and broad, forming almost a right angle distally; volsella with the proximal inner margin at its base with only a weak, curved, inwardly-projecting swelling (Fig. 153) *cornutus* (Frison)
- Gonostylus narrowing gradually from near the outer end (further from the body midline) towards the inner end; penis valve with the ventro-basal angle strongly projecting and narrowed and acute, shaped like a shark's fin; volsella with the proximal inner margin at its base with a large inwardly projecting swelling that is irregular but broadly rectangular (Fig. 156) *turneri* (Richards)
- 13(11) Thorax black haired posteriorly and on the underside; gonostylus and volsella weakly sclerotised (pale); penis valve with the ventro-basal angle strongly projecting and distally narrowed so that it is almost spinose; volsella with the proximal inner margin at its base with a large inwardly projecting swelling that is broadly triangular (Fig. 155) *tibetanus* (Morawitz)
- Thorax sometimes with a yellow band posteriorly, otherwise posteriorly and on the underside with black pale-tipped hairs; gonostylus and volsella strongly sclerotised, the volsella thickened (dark); penis valve with the ventro-basal angle strongly projecting and distally broad, forming a right angle distally; volsella with the proximal inner margin at its base with a large inwardly

- projecting swelling that is broadly rectangular (Fig. 154) *expolitus* (Tkalcū)
- 14(1) Penis valve from the dorsal aspect turned inwards distally as a hook, often either dorso-ventrally flattened in the form of a sickle, or as an incurved spoon (Figs 136–137, 164–172, 176–187) 15
- Penis valve from the dorsal aspect distally *either* nearly straight *or* turned slightly outwards (Figs 134–135, 138–152, 173–175) 37
- 15(14) Penis valve *either* strongly turned in near the apex in a flattened sickle shape, *or if* it is only slightly turned in, *then* it is not spoon-shaped but tubular and pointed, the ventro-basal angle of the penis valve *either* produced ventrally but hardly laterally as a single tooth, *or* very much reduced (Figs 164–172, 176–187) 16
- Penis valve slightly turned in near the apex, but spoon-shaped rather than sickle shaped, the ventro-basal angle of the penis valve strongly produced ventro-laterally, forming a flattened paddle shape with 2–3 teeth or prominences, which is transverse to the main axis of the penis valve (Figs 136–137) 20
- 16(15) Gonostylus often triangular, without a distinct inner proximal process that would be directed inwardly as a finger or shelf, but with a narrow submarginal groove along the inner margin (Figs 164–172) 24
- Gonostylus *either* rounded, *or* quadrate, *or* triangular, *or* reduced, but with a strong inner proximal process directed inwardly as a finger or shelf, and without a narrow submarginal groove along the inner margin (Figs 176–187) 17
- 17(16) Penis valve in lateral view with the ventro-basal angle very much reduced, *either* shown only as a weak curve, *or* absent (Figs 180–187); mandible distally pointed and with one additional anterior tooth 18
- Penis valve in lateral view with the ventro-basal angle produced as a basally directed hook (Figs 176–179); mandible distally pointed and with two additional anterior teeth 21
- 18(17) Thoracic dorsum with some pale hair; penis-valve head scarcely expanded on the outer lateral side by less than the breadth of the rest of the penis-valve head; distal part of the gonostylus *either* large and rounded, *or if* reduced, *then* at least as long as the dorso-ventral breadth of the penis valve at the base of the head; volsella nearly parallel sided, the inner distal process present at least as a broad square stump and often as an elongate hook (Figs 181–187) 19
- Thoracic dorsum entirely brownish black haired; penis-valve head greatly expanded on the outer lateral side into an almost equilateral triangular wing, broader than the rest of the penis-valve head; distal part of the gonostylus reduced to a narrow strip that is shorter than the dorso-ventral breadth of the penis valve at the base of the head; volsella constricted at its mid point to form a slightly clubbed finger shape, the inner distal process hardly marked (Fig. 180) *eximius* Smith
- 19(18) Thoracic dorsum with at least yellow or white anterior and posterior bands; penis valve with the recurved head narrow and sharply pointed (Figs 182–187) . . . 32
- Thoracic dorsum uniformly brown haired; penis valve with the recurved head broad, as an almost equilateral triangle, and broadly rounded (Fig. 181) *festivus* Smith
- 20(15) Hair around the antennal bases, ventral parts of the thorax, and posterior fringes of terga 3–7 predominantly pale; curved head of the penis valve from the dorsal aspect as long as broad; paddle-like ventro-basal angle of the penis valve almost rounded, with a weak dorso-lateral tooth, which is shorter than the spinose tooth of the outer proximal corner of the penis-valve head (Fig. 136) *personatus* Smith
- Hair around the antennal bases, ventral parts of the thorax, and terga 3–7 predominantly black; curved head of the penis valve from the dorsal aspect longer than broad; paddle-like ventro-basal angle of the penis valve tridentate, with a spinosely-produced dorso-lateral tooth, the outer proximal corner of the penis-valve head without a tooth (Fig. 137) *difficillimus* Skorikov
- 21(17) Gonostylus shortened with a spinose inner distal projection (Fig. 176) *breviceps* Smith
- Gonostylus broadly triangular or rounded distally (Figs 177–179) 22
- 22(21) Thoracic dorsum *either* with anterior and posterior pale bands and a well-defined black band between the wing bases, *or* sometimes the pale bands are narrowed so that the dorsum is predominantly black haired; gonostylus distally rounded or quadrate (Figs 178–179) 23
- Thoracic dorsum yellow or grey-yellow haired with black hairs intermixed, but not forming a black band between the wing bases; gonostylus distally acutely triangular (Fig. 177) *grahami* (Frison)
- 23(22) Malar area shorter than broad; penis valve with the recurved part reaching back about half way to the proximal end of the penis-valve head; volsella reaching beyond the gonostylus by a distance equal to half of its own breadth (Fig. 178) . . . *kashmirensis* Friese
- Malar area longer than broad; penis valve with the recurved part reaching back about a quarter of the way to the proximal end of the penis-valve head; volsella reaching beyond the gonostylus by a distance equal to its own breadth (Fig. 179) *nobilis* Friese
- 24(16) Penis valve in lateral view with the ventro-basal angle closer to the distal penis-valve head than to the proximal end of the penis valve, the distal part short and ventro-laterally strongly and evenly curved in towards the proximal end of the penis-valve head, the recurved part of the penis-valve head *either* no longer than broad, *or if* it is longer, *then* the penis-valve head strongly ‘S’-shaped (Figs 167–172) 25
- Penis valve in lateral view with the ventro-basal angle

- just further from the distal penis-valve head than from the proximal end of the penis valve, the distal part long and ventro-laterally nearly straight below the proximal end of the penis-valve head, the recurved part of the penis-valve head longer than broad (Figs 164–166).....30
- 25(24) Recurved part of the penis-valve head scarcely or no longer than broad, the penis-valve head weakly hooked (Figs 167–169, 171–172).....26
- Recurved part of the penis-valve head more than twice as long as broad, the penis-valve head strongly ‘S’-shaped (Fig. 170).....*picipes* Richards
- 26(25) Thoracic dorsum posteriorly extensively pale haired, terga 4–5 yellow, orange, or red haired; penis-valve head with the recurved crook longer than broad (Figs 168–169, 171–172).....27
- Thoracic dorsum posteriorly black haired, occasionally with a yellow fringe that is only a quarter of the breadth of the anterior yellow band (measured longitudinally on the midline), hair of terga 4–5 black with white tips, except occasionally for extreme lateral yellow fringes; penis-valve head with the recurved crook shorter than broad (Fig. 167).....*infirmus* (Tkalčū)
- 27(26) Thoracic dorsum with a black band between the wing bases; penis-valve head with the recurved distal bend not narrowed, the recurved crook of the penis-valve head triangular (Figs 168–169).....28
- Thoracic dorsum yellow or grey-yellow haired with black hairs intermixed, but without a black band between the wing bases; penis-valve head with the recurved distal bend narrowed, the recurved crook of the penis-valve head parallel-sided and finger-like (Figs 171–172).....29
- 28(27) Short hair on the dorsum of the head yellow, thoracic dorsum with the pale bands yellow; recurved crook of the penis-valve head distally broad and rounded (Fig. 169).....*lepidus* Skorikov
- Short hair on the dorsum of the head black, at most with a few grey-white hairs intermixed, thoracic dorsum with the pale bands grey-white; recurved crook of the penis-valve head narrowed and pointed (Fig. 168).....*lemniscatus* Skorikov
- 29(27) Gonostylus about half as long as broad, the inner submarginal longitudinal groove separated from the gonocoxa by a distance less than half of the greatest breadth of the penis-valve head (Fig. 172).....
-*infrequens* (Tkalčū)
 - Gonostylus about as long as broad, the inner submarginal longitudinal groove separated from the gonocoxa by a distance nearly as great as the greatest breadth of the penis-valve head (Fig. 171).....*avanus* (Skorikov)
- 30(24) Terga 5–6 *either* white haired, *or* hairs black with white tips; gonostylus with the proximal end of the submarginal groove separated from the gonocoxa by a concavity as deep as the distal breadth of the spatha (Fig. 164).....*hypnorum* (Linnaeus)
- Terga 5–6 with some orange or yellow hair; gonostylus with the proximal end of the submarginal groove separated from the gonocoxa by a concavity less than a quarter as deep as the distal breadth of the spatha (Figs 165–166).....31
- 31(30) Hind tibiae with the outer surface only narrowly hairless in the centre, with orange hairs almost throughout; gonostylus with the inner margin above the submarginal groove almost straight; hair short (Fig. 165).....*flavescens* Smith
- Hind tibiae with the outer surface largely shining and hairless, the yellow hairs confined to the margins; gonostylus with the inner margin above the submarginal groove weakly ‘S’-shaped; hair long (Fig. 166).....*wangae* sp. nov.
- 32(19) Gonostylus with the distal margin concave, leaving an outer distal corner and an inner distal process, the latter often bidentate; volsella extending beyond the gonostylus distally by nearly twice its own breadth at the point where it emerges from beneath the gonostylus from the dorsal aspect (Figs 185–187).....33
- Gonostylus with the distal margin broadly convex; volsella extending beyond the gonostylus distally by only about its own breadth at the point where it emerges from beneath the gonostylus from the dorsal aspect (Figs 182–184).....35
- 33(32) Compound eyes strongly enlarged relative to female bumblebees; thoracic dorsum with the pale bands grey-white (Fig. 185).....*rufofasciatus* Smith
- Compound eyes not obviously enlarged relative to female bumblebees; thoracic dorsum with the pale hair yellow.....34
- 34(33) Thoracic dorsum yellow haired with a completely black band between the wing bases, and with some black hairs intermixed immediately anterior to the band (Fig. 187).....*friseanus* Skorikov
- Thoracic dorsum yellow haired with black hairs intermixed between the wing bases, but not forming an exclusively black band (Fig. 186).....
 -*pyrosoma* Morawitz
- 35(32) Orange hairs of terga 6–7 white-tipped; penis valve with the crook of the head turned back almost parallel to the head and fused to it for more than two thirds of its length (Fig. 182).....*ladakhensis* Richards
- Orange hairs of terga 6–7 without white tips; penis valve with the crook of the head free of the head for more than half of its length (Figs 183–184).....36
- 36(35) Volsella with the inner distal process forming a narrow curved hook (Fig. 183).....*keriensis* Morawitz
- Volsella with the inner distal process forming a broad short stump (Fig. 184).....*sichelii* Radoszkowski
- 37(14) Antennae long, reaching back beyond wing bases; penis valve dorso-ventrally narrow, at least in its distal third, which is slightly ventrally curved (Figs 134–135, 138–152).....40
- Antennae short, reaching back only as far as the wing bases; each penis valve dorso-ventrally greatly broadened so as to form half of a tube, the distal end flared outwards as half of a broad funnel (Figs 173–175).....38

- 38(37) Tergum 5 white or brownish-white haired 39
 – Tergum 5 orange-red haired (Fig. 173)
 *ignitus* Smith
- 39(38) Thoracic dorsum with a lemon-yellow band anteriorly,
 at most with a few obscure grey-yellow hairs posteriorly
 (Fig. 175) *lucorum* (Linnaeus)
 – Thoracic dorsum with lemon-yellow bands anteriorly
 and posteriorly (Fig. 174)
 *patagiatus* Nylander
- 40(37) Gonostylus with both an inner distal lobe and an inner
 proximal process directed inwardly as a shelf or spine
 (Figs 138–152) 41
 – Gonostylus with an inner distal lobe but without an
 inner proximal process directed inwardly as a shelf or
 spine (Figs 134–135) 46
- 41(40) Volsella with the inner hooks arising closer to its
 broadest point near the mid point of its length; gonostylus
 with the inner proximal process forming an inwardly directed
 shelf, either rounded or broadly triangular and narrowing to
 a distal point, at most with two small distal teeth (Figs
 147–152) 42
 – Volsella with the inner hooks arising closer to its distal
 end; gonostylus with the inner proximal process forming
 an inwardly directed shelf, with *either* at least a large dorsal
 tooth and a ventral lobe with many small teeth, *or* the shelf
 with one or two very long narrow spinose processes (Figs
 138–146) 43
- 42(41) Volsella projecting beyond the gonostylus by less than
 the length of the gonostylus; gonostylus with the inner
 proximal process narrowed distally to a sharp point
 (Figs 148–152) 52
 – Volsella projecting beyond the gonostylus by slightly
 more than the length of the gonostylus; gonostylus with
 the inner proximal process rounded without a sharp point
 (Fig. 147) *laesus* Morawitz
- 43(41) Gonostylus at least as long as broad from the dorsal
 aspect, distally convex; penis-valve head at least four times
 as long as broad, slightly curved ventrally, with distinct
 teeth along most of its outer margin (Figs 140–144) 44
 – Gonostylus shorter than broad from the dorsal aspect,
 distally concave; penis-valve head less than four times
 as long as broad, *either* straight *or* very short, the teeth
either very small *or* restricted to the proximal half
 (Figs 138–139, 145–146) 45
- 44(43) Tergum 5 *either* white *or* yellow haired, at least laterally;
 penis-valve head with many strong nearly equal-sized
 outer lateral teeth; gonostylus with the distal lobe
 irregular but nearly triangular, with a longitudinal
 depression causing the distal margin to be slightly
 depressed and concave; volsella with the inner hooks
either strongly produced, *or if* reduced to a squarish
 stump, *then* at least the distal hook straight and
 strongly produced (Figs 141–144) 48
 – Tergum 5 orange-red haired; penis-valve head with
 small outer lateral teeth, except proximally where there
 is one large curved spinose tooth; gonostylus with the
 distal lobe rectangular and evenly convex, without a
 longitudinal depression, the distal margin weakly convex;
 volsella with the inner hooks reduced to a squarish
 toothed stump, the distal hook short and curled back
 on itself (Fig. 140) *bicoloratus* Smith
- 45(43) Volsella with the inner distal process divided into
 a long distally projecting ‘S’-shaped spine and an
 equally long proximally-projecting curled flattened
 process with many small radiating marginal teeth
 (Figs 138–139) 47
 – Volsella with only a single large inner distal process,
 which is turned distally at almost a right angle, on the
 proximal side of its base only a small tooth (Figs 145–
 146) 51
- 46(40) Thoracic dorsum grey-yellow haired with many black
 hairs intermixed throughout; gonostylus very short and
 broad, forming a nearly rectangular transverse band,
 the weak inner distal projection convex, without a cleft
 in the middle; distal end of volsella narrowed, straight
 and finger-like (Fig. 134) *funerarius* Smith
 – Thoracic dorsum bright lemon-yellow haired with
 black hairs only between the wing bases; gonostylus
 short and broad, nearly rectangular, with two weak inner
 distal projections that are broadly rounded with a
 cleft between them; distal end of the volsella twisted
 and curled over (Fig. 135) *braccatus* Friese
- 47(45) Terga 5–6 orange-red haired; gonostylus with two
 long recurved spine-like inner proximal processes, one
 dorsal and one ventral (Fig. 139) . . . *trifasciatus* Smith
 – Terga 5–6 black haired; gonostylus with a single
 long dorsal recurved spine-like inner proximal process
 (Fig. 138) *longipes* Friese
- 48(44) Thoracic dorsum with pale bands yellow; gonostylus
 with the inner proximal process at most dorsally with
 one large spine and sometimes ventrally with several
 very small triangular teeth (Figs 142–144) 49
 – Thoracic dorsum with pale bands grey-white; gonostylus
 with the inner proximal process with one long narrow
 spine dorsally and another ventrally (Fig. 141)
 *supremus* Morawitz
- 49(48) Gonostylus with the inner proximal process dorsally
 with one large narrow spine, the ventral process smaller
 than the dorsal spine and not strongly toothed; hair
 short (Figs 143–144) 50
 – Gonostylus with the inner proximal process dorsally
 with one strong triangular tooth, the ventral process
 larger than the dorsal tooth and forming a rounded
 lobe with small marginal teeth; hair long (Fig. 142)
 *sushkini* (Skorikov)
- 50(49) Tergum 4 white or yellowish-white haired, hairs of
 tergum 5 entirely black medially; volsella with the
 distally-directed hook nearly straight, except near its
 distal end, where it is ‘S’-shaped, and nearly twice
 the length of the proximally directed hook, which
 is widely separated at its base as an acute tooth
 (Fig. 144) *religiosus* (Frison)
 – Terga 4 and 5 lemon-yellow haired with only a few
 black hairs intermixed anteriorly; volsella with the

- distally directed hook nearly straight, and just longer than the proximally directed hook, which is not separated at its base as an acute tooth (Fig. 143)
- 51(45) Thoracic dorsum with the pale hair yellow; gonostylus reduced to very narrow transverse band, projecting inwards as a single long spinose process (Fig. 145) *imitator* Pittioni
- Thoracic dorsum orange-red haired; gonostylus distally reduced to a small square, the inner proximal process divided into two long nearly straight spines at right angles to each other (Fig. 146) . . . *atripes* Smith
- 52(42) Thoracic dorsum *either* yellow *or* grey-white haired, *either* with many black hairs intermixed *or* with a complete black band between the wing bases 53
- Thoracic dorsum uniformly orange-red haired, without black hairs between the wing bases (Fig. 150) *hedini* Bischoff
- 53(52) Pale hairs of terga 5–6 at least in part orange-red, although sometimes partly replaced by black 54
- Pale hairs of terga 5–6 yellow with no orange-red 55
- 54(53) Thoracic dorsum *either* yellow *or* grey-white haired, often with black hairs intermixed, and with an exclusively black band between the wing bases, terga 4–6 orange-red haired without posterior yellow fringes; gonostylus with the inner distal corner obtuse or right-angled (Fig. 152) *impetuosus* Smith
- Thoracic dorsum yellow haired with many black hairs more or less evenly intermixed, but without an exclusively black band between the wing bases, terga 4–6 orange haired with posterior yellow fringes, the anterior orange hair sometimes largely replaced by black; gonostylus with the inner distal corner acute by an angle of approximately 60° (Fig. 151)
- 55(53) Thoracic dorsum with the black band between the wing bases narrow and sharply defined; volsella densely hairy distally and with the distal corner broadly rounded, the inner hooks forming a short stump, each hook reduced to a triangular tooth at one corner of the stump (Fig. 148) *filchnerae* Vogt
- Thoracic dorsum with the black band between the wing bases very broad and weakly defined; volsella with only a few long hairs distally and with the distal corner spinosely produced inwards, the inner hooks forming a short stump, the distal hook forming a long spine and the proximal hook forming a square tooth (Fig. 149) *humilis* Illiger

Species notes

The list of synonyms for each species is not exhaustive because for some species there are very many (e.g. more than 180 for *B. lucorum* in the broad sense: Williams, 1998). Instead, names are included primarily where they have been applied in the literature to the species when recorded from the SCR, or where names apply to colour forms that are known to occur within the SCR. Food-plant records are from the authors' observations

(with some identifications by Mike Gilbert, BMNH) and plant families follow Heywood *et al.* (2007).

Genus **BOMBUS** Latreille

Subgenus **MENDACIBOMBUS** Skorikov

1. **Bombus (Mendacibombus) waltoni** Cockerell (Figs 27, 132, 188, 192)

[*Bombus mendax* Gerstaecker, 1869: 323; Morawitz, 1890: 352, misidentification. China: 'Sse-tschuan', but probably Qinghai.]

Bombus mendax ssp. *chinensis* Skorikov, 1910a: 330 (not of Morawitz, 1890: 352 = *B. chinensis* (Morawitz)), holotype queen ZISP examined. China: Qinghai.

Bombus waltoni Cockerell, 1910: 239, holotype queen BMNH examined. Synonymised with *Bombus mendax* ssp. *chinensis* Skorikov by Skorikov in Cockerell (1911). India.

[*Bombus waltoni* var. *kozloviellus* Skorikov, 1912: 608, infrasubspecific.]

Bombus rufitarsus Friese, 1913: 85, type not seen. Synonymised with *Bombus waltoni* Cockerell by Skorikov (1914). 'Zentralasien', believed incorrect.

Bombus asellus Friese, 1924: 438, type not seen. Regarded as conspecific with *Bombus waltoni* Cockerell by Bischoff (1936). 'Mongolei bei Tippet', believed incorrect.

Bombus (Mendacibombus) waltoni Cockerell; Wang, 1982a: 430, 1992a: 1424; Williams, 1991: 42; Wang & Yao, 1996a: 303. China: Sichuan.

This species together with *B. convexus* constitute the *waltoni*-group of species, which is endemic to the eastern Tibetan Plateau and fringing mountains.

Diagnosis. Small species. *Female* (length of queens 14–16 mm, workers 10–12 mm) with the outer (corbicular) surface of the hind tibia coarsely sculptured (imbricate), appearing very rough and not shining, with a few widely spaced long stout hairs arising from the centre in the upper (proximal) half (cf. non-*Mendacibombus* species); labrum without a longitudinal median furrow or anterior lamella; oculo-malar distance approximately 1.6 times the proximal breadth of the mandible; hair (Fig. 27) predominantly black, or black with greyish tips, metasomal tergum 2 black or black with a posterior orange-red fringe, terga 3–6 orange-red with greyish tips (cf. *B. convexus*); wings light brown.

Male (length 13–16 mm) similarly coloured (cf. *B. convexus*), though sometimes with the orange-red replaced by black on tergum 3, or on all of terga 3–6; compound eye enlarged relative to the female and the antenna short, like the female; genitalia (Fig. 132) with the penis valve straight (cf. *B. convexus*), without a strong distal hook or flared head; gonostylus and volsella without medially-directed processes or hooks (cf. non-*Mendacibombus* species).

Global distribution. Oriental species: Tibetan plateau (Yunnan, Sichuan, Gansu, Qinghai, Xizang).

SCR material examined. Common at high altitudes of the northwestern and western plateau and mountains (Fig. 192)

with a medium-length seasonal activity period (Fig. 188): 10 queens, 85 workers, 40 males, 2500–4700 m (BMNH, INHS, IZB, PHW, SAC, TY, ZMA). Literature records: Morawitz (1890), Wang (1982a, 1992a), Williams (1991), Wang and Yao (1996a).

SCR food plants. Long-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Ligularia* sp., *Saussurea* sp.; (Leguminosae) *Hedysarum* sp., *Oxytropis* sp.; (Scrophulariaceae) *Pedicularis cranolopha* Maxim., *P. spicata* Pall., *P. roylei* Maxim., *P. szetschuanica* Maxim., *P. verticillata* L.

2. *Bombus (Mendacibombus) convexus* Wang (Figs 26, 133, 189, 193)

Bombus lugubris Morawitz, 1880: 339 (not of Kriechbaumer, 1870: 159 = *B. maxillosus* Klug), holotype worker ZISP examined. China: ‘Gan-su’, but probably Qinghai.

Bombus lugubris Morawitz; Morawitz, 1890: 352. China: ‘Sse-tschuan’, but probably Qinghai.

Mendacibombus lugubris (Morawitz); Skorikov, [1923]: 149. China: Sichuan.

Bombus (Mendacibombus) convexus Wang, 1979: 190, holotype queen IZB examined. Synonymised with *Bombus lugubris* Morawitz by Williams (1991). China: Xizang.

Bombus (Mendacibombus) convexus Wang; Williams, 1991:42; Wang, 1992a: 1424. China: Sichuan.

This species together with *B. waltoni* constitute the *waltoni*-group of species, which is endemic to the eastern Tibetan Plateau and fringing mountains.

Diagnosis. Small species. *Female* (length of queens 12–16 mm, workers 10–12 mm) with the outer (corbicular) surface of hind tibia coarsely sculptured (imbricate), appearing very rough and not shining, with a few widely spaced long stout hairs arising from the centre in the upper (proximal) half (cf. non-*Mendacibombus* species); labrum without a longitudinal median furrow or anterior lamella; oculo-malar distance approximately 1.7 times the proximal breadth of the mandible; hair (Fig. 26) predominantly black with a white band at the anterior of the thorax, posterior of the thorax behind the wing base with only a small lateral patch of white, metasomal tergum 1 white, tergum 2 white anteriorly (cf. *B. patagiatus*) and black posteriorly, terga 4–5 white (cf. *B. waltoni*); wings light brown.

Male (length 13 mm) similarly coloured, although hair of terga 4–6 with varying white tips so that the ‘tail’ appears either black or white (cf. *B. waltoni*); compound eye enlarged relative to the female and the antenna short, like the female; genitalia (Fig. 133) with the penis valve nearly straight but with a slight elbow near its mid point from the dorsal aspect (cf. *B. waltoni*), without a strong distal hook or flared head; gonostylus and volsella without medially directed processes or hooks (cf. non-*Mendacibombus* species).

Global distribution. Oriental species: eastern Tibetan plateau (Yunnan, Sichuan, Gansu, Qinghai, Xizang).

SCR material examined. Common at medium altitudes of the northwestern and western plateau and mountains (Fig. 193)

with a long seasonal activity period (Fig. 189): 1 queen 119 workers, 8 males, 2370–4500 m (IZB, PHW, SAC, TY, USNM). Literature records: Morawitz (1890), Skorikov ([1923]), Williams (1991), Wang (1992a).

SCR food plants. Long-tongued species: (Asteraceae) *Cirsium* sp.; (Caprifoliaceae) *Lonicera* sp.; (Gentianaceae) *Halenia elliptica* D. Don; (Lamiaceae) *Salvia* sp.; (Scrophulariaceae) *Pedicularis melampyriflora* Franch. ex Maxim., *P. rex* C.B. Clarke ex Maxim., *P. szetschuanica*.

Subgenus *ORIENTALIBOMBUS* Richards

3. *Bombus (Orientalibombus) funerarius* Smith (Figs 42, 134, 190, 194)

Bombus funerarius Smith, 1852b:47, holotype queen BMNH examined. India.

Bombus funerarius var. *lateritius* Friese, 1916: 108, type not seen. India.

Bremus (Agrobombus) priscus Frison, 1935: 349, type not seen. Synonymised with *Bombus funerarius* Smith by Richards (1968). India.

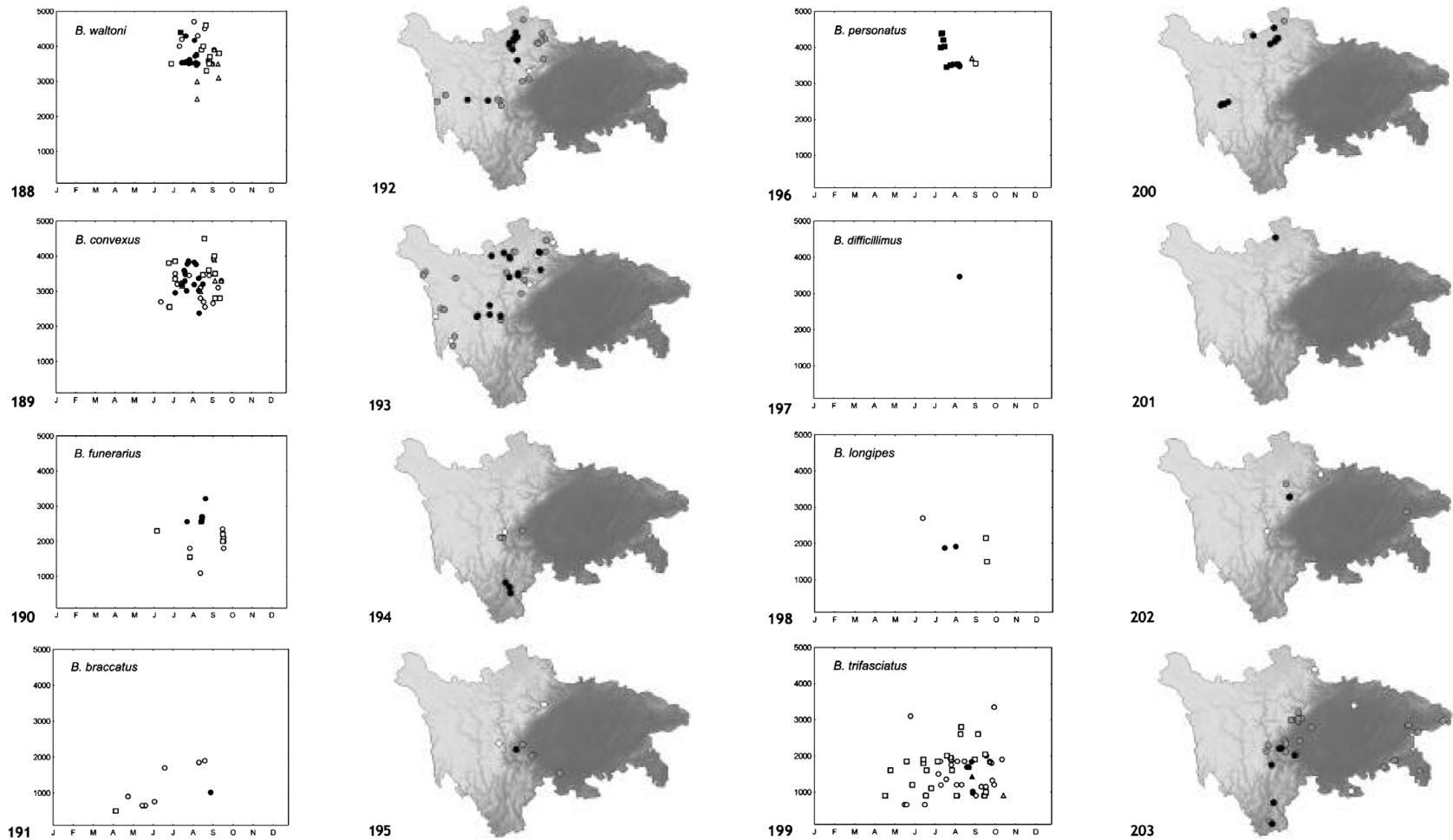
Bombus (Orientalibombus) funerarius Smith; Panfilov, 1957: 235; Williams, 1991: 60. China: Sichuan.

Bombus (Orientalibombus) funerarius [ssp.] *lateritius* Friese; Wang, 1992a: 1423. China: Sichuan.

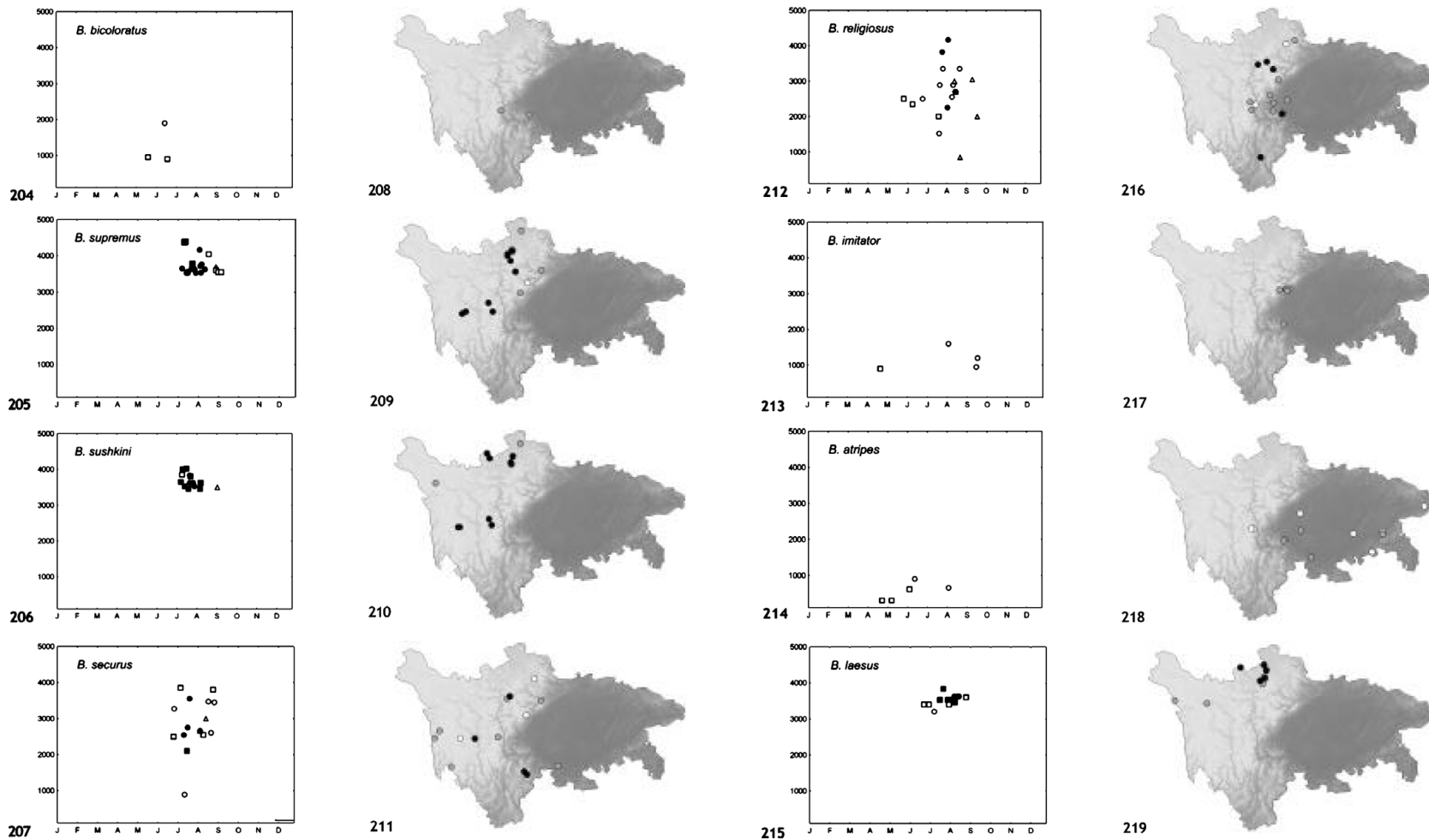
Diagnosis. Medium-sized species. *Female* (length of queens 19 mm, workers 11–14 mm) with the mid basitarsus with the distal posterior corner just acute but narrowly rounded, without a spine; oculo-malar distance approximately 1.6 times the proximal breadth of the mandible; centre of the clypeus with evenly scattered very fine punctures; dorsum of the head with the ocello-ocular area and the pre-ocellar area with only a very few large punctures and largely smooth and shining (cf. non-*Orientalibombus* species e.g. *B. grahami*); hair (Fig. 42) of the head nearly black (cf. *B. avanus*, *B. grahami*), thorax grey densely intermixed with black giving a dark grey or olive colour in combination (cf. *B. braccatus*), the thoracic midline, lower sides of the thorax and metasomal tergum 1 paler whitish grey, terga 2–3 black, sometimes with just a few paler hairs very narrowly along the anterior, lateral, and occasionally posterior margins of tergum 2 (cf. *B. picipes*, *B. avanus*, *B. infrequens*), terga 4–5 orange-red; wings dark brown.

Male (length 13–14 mm) hair of the head and thorax yellow with some black intermixed, metasomal terga 1–2 yellow, tergum 3 black with a posterior yellow fringe, terga 4–7 orange; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 134) with the penis valve with a short distal weakly flared and almost toothless head; gonostylus very short and broad, forming a nearly rectangular transverse band, the weak inner distal projection square-ended without a cleft, the inner proximal projection very much reduced (cf. *B. braccatus*); distal apex of the volsella narrowed, straight and finger-like.

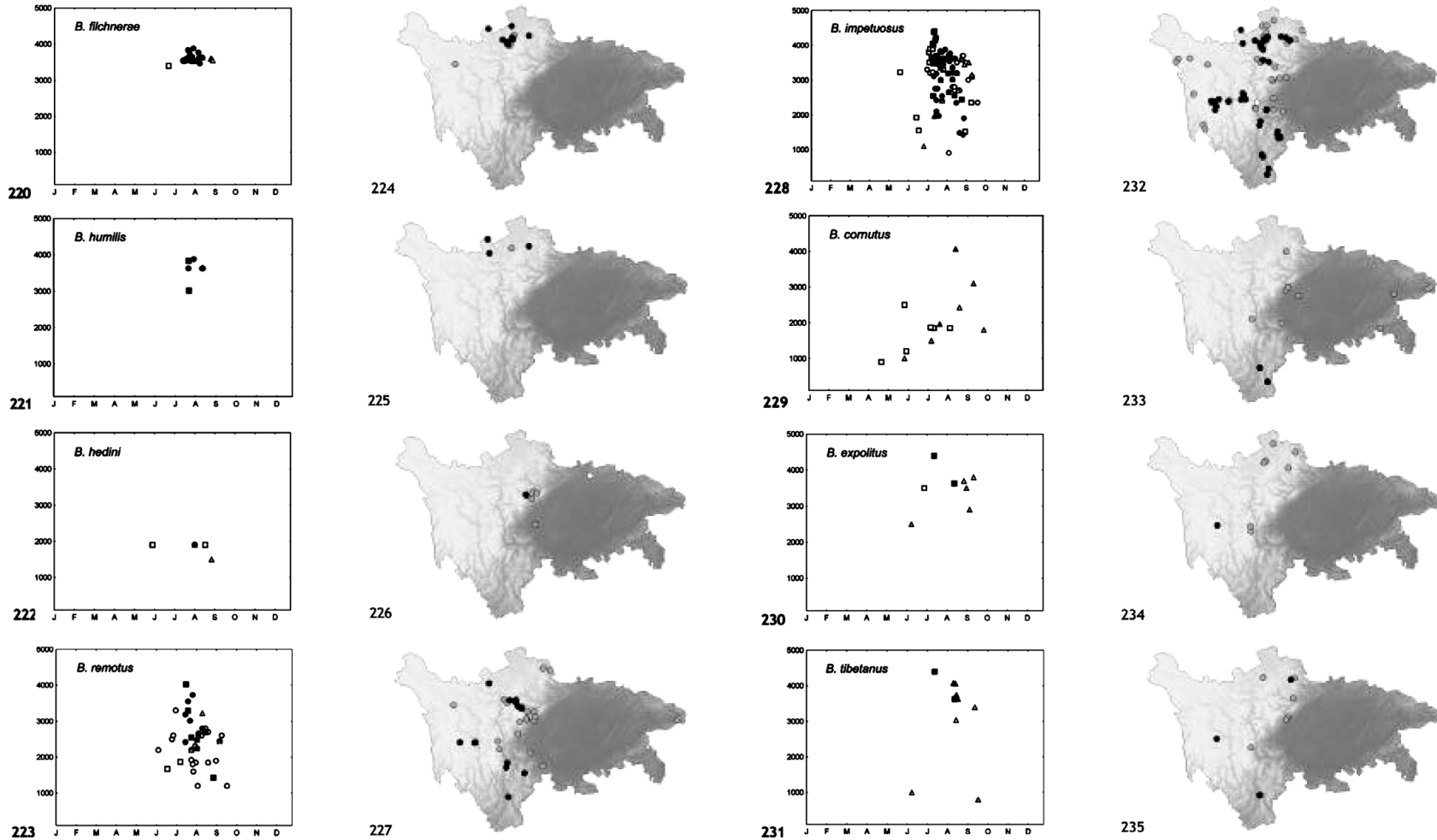
Global distribution. Oriental species: Himalaya, Myanmar, and southwestern China (Yunnan, Xizang, Sichuan).



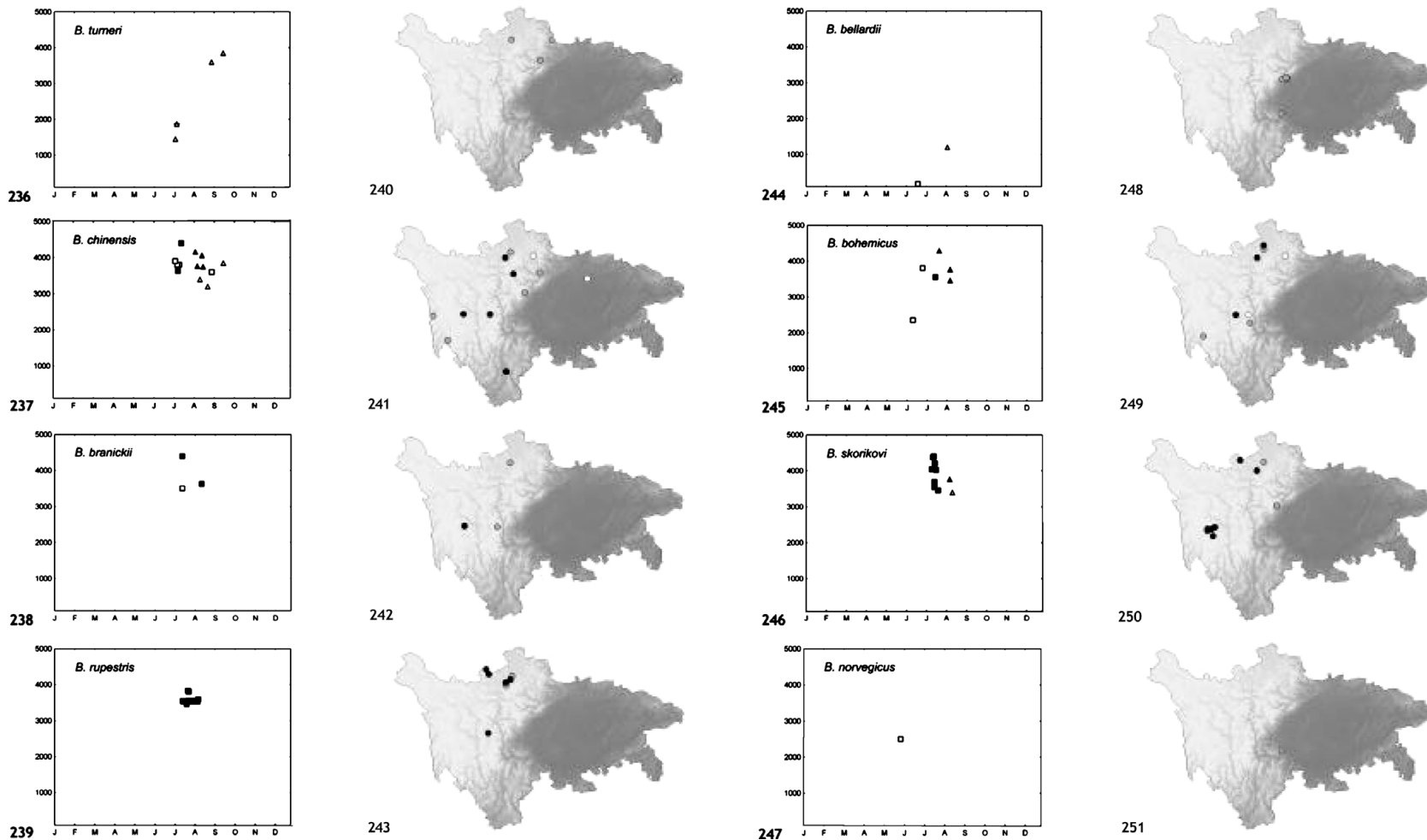
Figures 188–203 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (188–191, 196–199) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (192–195, 200–203) by geographical location. Symbols in the first and third columns (188–191, 196–199) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (192–195, 200–203) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



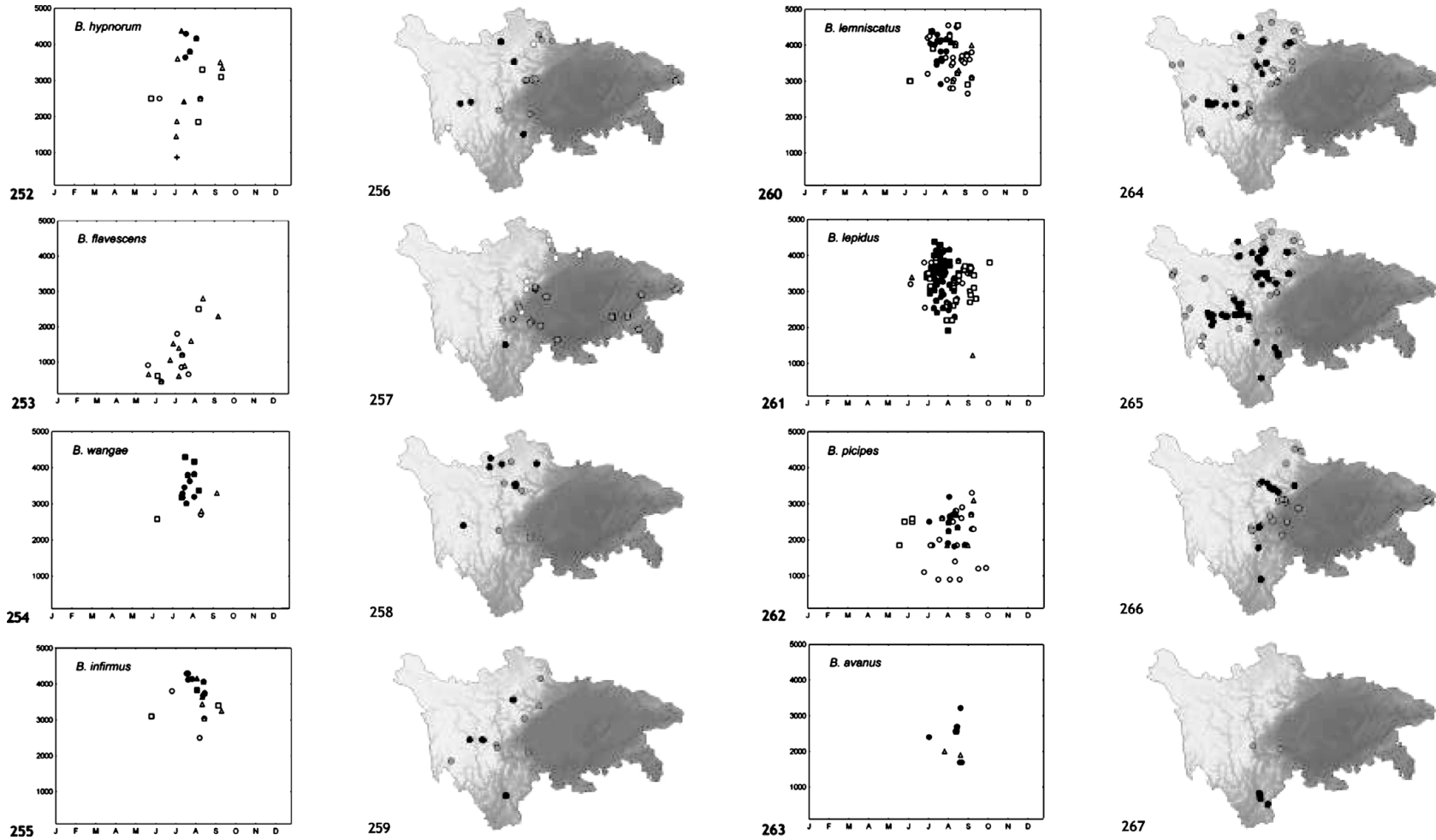
Figures 204–219 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (204–207, 212–215) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (208–211, 216–219) by geographical location. Symbols in the first and third columns (204–207, 212–215) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (208–211, 216–219) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



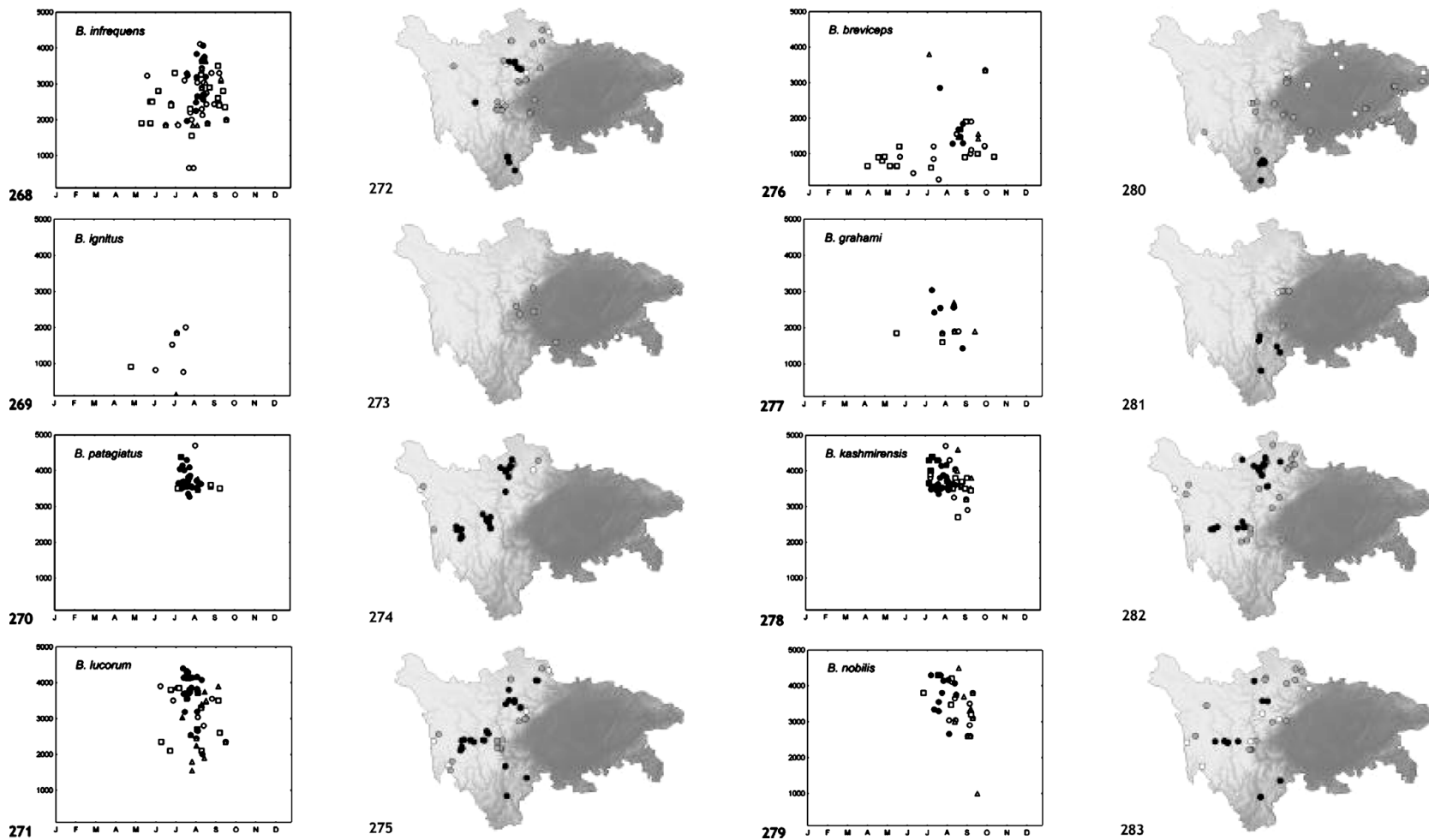
Figures 220–235 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (220–223, 228–231) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (224–227, 232–235) by geographical location. Symbols in the first and third columns (220–223, 228–231) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (224–227, 232–235) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



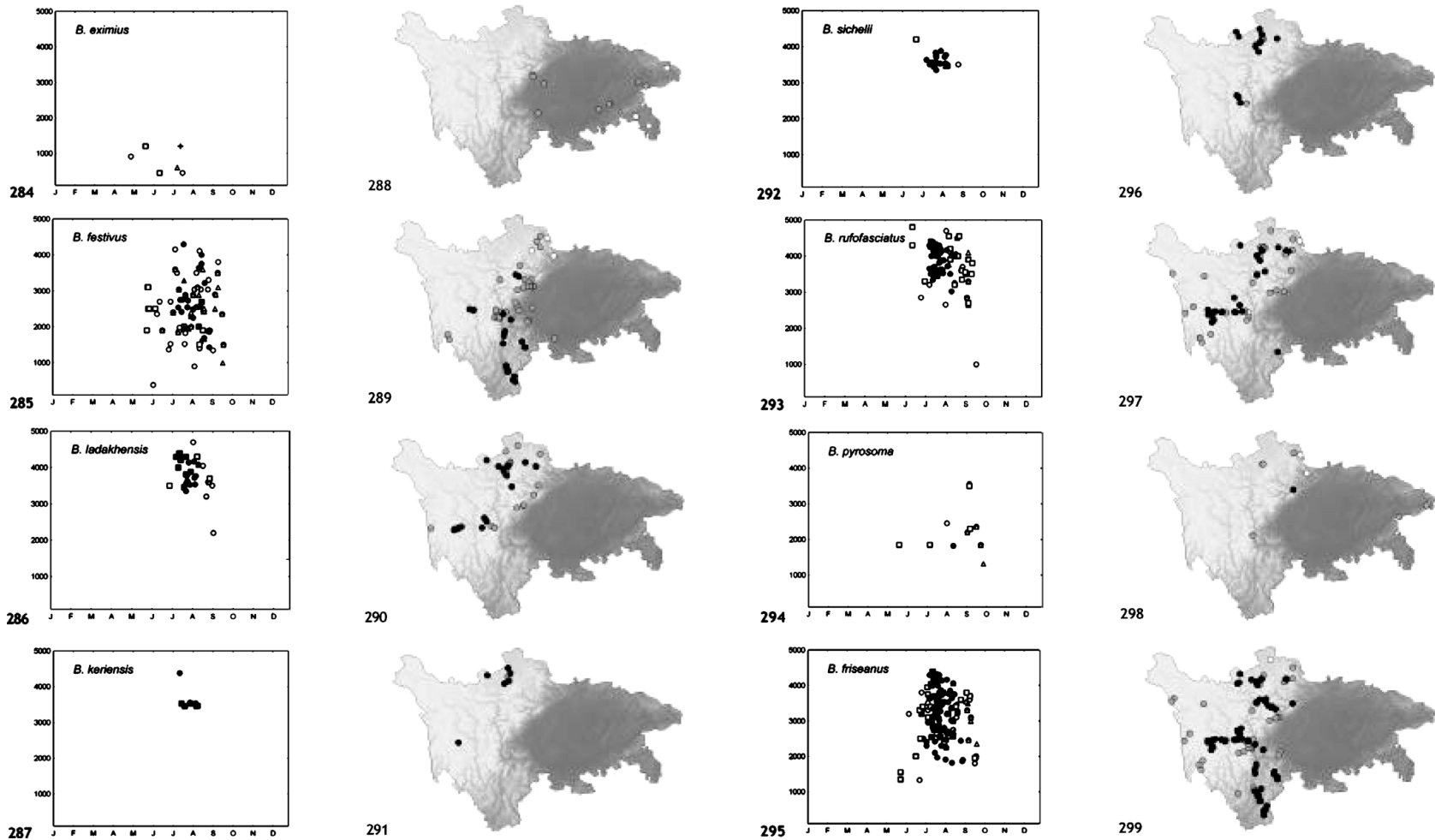
Figures 236–251 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (236–239, 244–247) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (240–243, 248–251) by geographical location. Symbols in the first and third columns (236–239, 244–247) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (240–243, 248–251) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



Figures 252–267 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (252–255, 260–263) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (256–259, 264–267) by geographical location. Symbols in the first and third columns (252–255, 260–263) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (256–259, 264–267) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



Figures 268–283 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (268–271, 276–279) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (272–275, 280–283) by geographical location. Symbols in the first and third columns (268–271, 276–279) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (272–275, 280–283) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).



Figures 284–299 Distribution of species' activity records in the Sichuan-Chongqing region, in the first and third columns (284–287, 292–295) by (x axis) phenology (day of the year, letters refer to months) and (y axis) altitude (m), and in the second and fourth columns (288–291, 296–299) by geographical location. Symbols in the first and third columns (284–287, 292–295) show records for (squares) queens, (circles) workers, (triangles) males, and (crosses) literature records of unknown sex and caste (black symbols show higher precision data, e.g. from GPS; white symbols show lower precision data, which in some cases may refer to the nearest town). Symbols in the second and fourth columns (288–291, 296–299) show (black spots) sites sampled by the authors during 2002–2005, (grey spots) additional sites with museum collection records, and (white spots) additional sites with literature records (the grey scale shows elevations between low altitudes from 500 m, in dark grey, to high altitudes up to 7556 m, in light grey, grouped into equal-interval classes, see Fig. 3).

SCR material examined. Uncommon at medium altitudes of the southwestern mountains (Fig. 194) with a medium-length seasonal activity period (Fig. 190): 1 queen, 33 workers, 6 males, 1090–3213 m (INHS, IZB, PHW, SAC, TY). Literature records: Frison (1935), Panfilov (1957), Williams (1991), Wang (1992a).

SCR food plants. Long-tongued species: (Asteraceae) short herb with yellow inflorescences; (Balsaminaceae) *Impatiens* sp.; (Dipsacaceae) *Dipsacus inermis* Wallich; (Lamiaceae) *Phlomis* sp., *Salvia* sp., *Siphocranion macranthum* (Hook. f.) C.Y. Wu; (Polygalaceae) *Polygala arillata* Buch.-Ham. ex D. Don; (Scrophulariaceae) *Pedicularis rex*.

4. *Bombus (Orientalibombus) braccatus* Friese (Figs 10, 39–41, 135, 191, 195)

Bombus braccatus Friese, 1905: 512, lectotype queen (Tkalci, 1987: 60) MNHU examined. China: Sichuan.

Bombus braccatus Friese; Skorikov, [1923]: 159. China: Sichuan.

Bremus (Orientalibombus) metcalfi Frison, 1935: 357, holotype male USNM examined. Synonymised with *Orientalibombus braccatus* (Friese) by Tkalci (1987). China: Sichuan.

Bombus (Orientalibombus) braccatus Friese; Panfilov, 1957: 235; Williams, 1991: 60. China: Sichuan.

Diagnosis. Large species (Fig. 10). *Female* (length of queens 23 mm, workers 14–19 mm) with the mid basitarsus with the distal posterior corner just acute but narrowly rounded, without a spine (cf. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*); oculo-malar distance approximately 1.5 times the proximal breadth of the mandible; centre of the clypeus with evenly scattered very fine punctures; dorsum of the head with the ocello-ocular area and the pre-ocellar area with only a very few large punctures and largely shining (cf. non-*Orientalibombus* species, e.g. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. breviceps*); antennal segment 4 longer than broad, scarcely shorter than segment 3 (cf. *B. trifasciatus*); hair (Figs 39–41) of the thorax and metasomal terga 1–2 yellow, often with at least some black hairs intermixed in a band or spot between the wing bases (cf. *B. funerarius*), tergum 3 black, terga 4–5 orange-red; wings dark brown.

Male (length 12–18 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 135) with the penis valve with a distal weakly flared toothless head, like a spear head; gonostylus short and broad, nearly rectangular, the weak inner projection rounded with a cleft, the inner proximal projection pronounced and broad (cf. *B. funerarius*); distal apex of the volsella twisted and curled over.

Global distribution. Oriental species: endemic to Sichuan. This species has one of the narrowest global distributions recorded among all bumblebees, from a region including literature records of approximately 325 km from north to south and

250 km from east to west, or excluding literature records of approximately 150 km from north to south and 190 km from east to west.

SCR material examined. Uncommon at low altitudes of the western foothills (Fig. 195) with a long seasonal activity period (Fig. 191): 3 queens, 71 workers, 2 males, 500–1900 m (AMNH, INHS, IZB, PHW, USNM, ZMMU). Literature records: Friese (1905), Skorikov ([1923]), Frison (1935), Panfilov (1957), Williams (1991). Most records are from the vicinity of Emeishan. The species was still extant in 2005.

SCR food plants. Long-tongued species: (Leguminosae) shrub with pendulous yellow inflorescences.

Subgenus *SUBTERRANEOBOMBUS* Vogt

5. *Bombus (Subterraneobombus) personatus* Smith (Figs 58, 84, 136, 196, 200)

Bombus personatus Smith, 1879: 132, lectotype queen (Richards, 1930: 656) BMNH examined. India.

Bombus Roborowskyi Morawitz, 1887: 197, syntype queen ZISP examined. Synonymised with *Bombus personatus* Smith by Williams (1991). China: Qinghai.

[*Subterraneobombus roborowskii* (Morawitz); Skorikov, [1923]: 154, incorrect subsequent spelling.]

Bombus (Subterraneobombus) personatus Smith; Wang, 1992a: 1430. China: Sichuan.

Diagnosis. Large species. *Female* (length of queens 19–20 mm, workers 14–16 mm) with the mid basitarsus with the distal posterior corner acute and sharply pointed; oculo-malar distance approximately 1.9 times the proximal breadth of the mandible; clypeus flattened and without large punctures in the central area, but with many widely spaced very fine punctures, appearing smooth and shiny (cf. non-*Subterraneobombus* species); hair (Figs 58, 84) of the thorax with cream-coloured bands anteriorly and posteriorly (cf. *B. longipes*), lower sides and underside white (or for some workers, black with a few white hairs intermixed), metasomal terga 1–2 cream (or for queens, more lemon yellow), terga 3–5 black with white posterior fringes (or for some workers, Fig. 58, black with only a few posterior white hairs); wings mid brown.

Male (length 16 mm) similarly coloured to the worker with pale hair on the face; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 136) with the penis valve with a spoon-shaped distal head, with a strong spine laterally at the proximal end of the head, the laterally projecting paddle-like ventro-lateral angle of the penis valve (cf. non-*Subterraneobombus* species) almost rounded with only a weak dorso-lateral tooth (cf. *B. difficillimus*); gonostylus shorter than broad, with a broad inner proximal process without spines; volsella with the inner hooks reduced to a small weakly toothed stump.

Global distribution. Oriental species: Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Fig. 200) with a medium-length seasonal activity period (Fig. 196): 23 queens, 6 workers, 1 male, (?2600–) 3456–4396 m (IZB, PHW, SAC, TY). Literature records: Wang (1992a). A literature record for a worker labelled ‘Nanping’ (Jiuzhaigou) with unusually low altitude data (2600 m) is not supported by a specimen of *B. personatus* in the IZB collection and may be based on only an approximate location, which needs to be confirmed, and is not shown in the activity plot and map.

SCR food plants. Long-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Delphinium* sp.; (Scrophulariaceae) *Pedicularis chenocephala* Diels, *P. muscoides*, *P. szetschuanica*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

6. *Bombus (Subterraneobombus) difficillimus* Skorikov

(Figs 59, 137, 197, 201)

Bombus difficillimus Skorikov, 1912: 609, syntype queen ZISP examined. Tajikistan.

Taxonomic status. *Bombus difficillimus* (light wings, long pale yellow hair) and *B. tschitscherini* Behr (dark wings, short dark yellow hair), which both have a black band between the wing bases, have been treated both as separate species from the banded or unbanded *B. melanurus* Lepeletier (dark or light wings, dark or light yellow hair) (e.g. Richards, 1930; Skorikov, 1931; Tkalcú, 1974a) and as vicariant conspecific colour forms (Williams, 1991). However, with more material available, both the Mongolian *B. tschitscherini* and the Tibetan *B. difficillimus* differ from the Himalayan *B. melanurus* in having a distinctly broader band of punctures in the ocello-ocular area, a narrower and ‘V’-shaped (in transverse section, seen from above) longitudinal median furrow of the labrum, and a longer penis valve head. *Bombus tschitscherini* and *B. difficillimus* are also considered here to be separate species, because of the differences in colour, hair length, and male genitalia. For *B. difficillimus*, the male gonostylus has a more broadly rounded and right-angled distal inner corner, whereas for *B. tschitscherini*, the corner is acute and pointed.

Diagnosis. Large species. *Female* [queen based on specimens from Ladakh] (length of queens 19–21 mm, workers 19 mm) with the mid basitarsus with the distal posterior corner acute and sharply pointed; oculo-malar distance approximately 2.0 times the proximal breadth of the mandible; clypeus flattened and with at most only a very few widely scattered very fine punctures in the central area, appearing smooth and shiny (cf. non-*Subterraneobombus* species); hair (Fig. 59) of the thorax with cream-coloured bands anteriorly and posteriorly (cf. *B. longipes*), lower sides and underside entirely black (cf. *B. per-*

sonatus), metasomal terga 1–2 cream, terga 3–5 entirely black (cf. *B. personatus*); wings light brown.

Male [based on specimens from Xizang] (length 18–20 mm) similarly coloured with the hair of the face black; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 137) with the penis valve with a distal spoon-shaped head, with no tooth or small spine laterally at the proximal end of the head, the laterally projecting paddle-like ventro-lateral angle of the penis valve clearly tridentate (cf. non-*Subterraneobombus* species) with a strong dorso-lateral tooth (cf. *B. personatus*); gonostylus shorter than broad, with a broad inner proximal process without spines; volsella with the inner hooks reduced to a small weakly toothed stump.

Global distribution. Species of the Oriental region: Himalaya and Tibetan plateau (Xizang, Qinghai, Sichuan, Gansu).

SCR material examined. Rare at high altitude in the northwestern plateau (Figs 197, 201): 1 worker, 3468 m (PHW). New record for the SCR.

SCR variation. Single worker with very pale, cream-yellow hair.

SCR food plants. Long-tongued species: (Scrophulariaceae) *Pedicularis verticillata*.

Subgenus MEGABOMBUS Dalla Torre

Diversobombus Skorikov, 1915.

Senexibombus Frison, 1930.

7. *Bombus (Megabombus) longipes* Friese subgn. comb. nov.

(Figs 60–62, 138, 198, 202)

Bombus longipes Friese, 1905: 511, type not seen. China: Sichuan.

Bombus longipes Friese; Skorikov, [1923]: 159. China: Sichuan.

Bombus (Diversobombus) hummeli Bischoff, 1936: 18, paratype male (Tkalcú, 1987: 63) MNHU examined. Synonymised with *Megabombus longipes* (Friese) by Tkalcú (1987). China: Gansu.

Bombus (Diversobombus) longipes Friese; Panfilov, 1957: 235. China: Sichuan.

Bombus (Diversobombus) hummeli Bischoff; Wang, 1992a: 1429. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Megabombus*, within which it belongs to the *trifasciatus*-group of species.

Nomenclature. Although it has not been possible to examine the syntype queen of *Bombus longipes*, said to be in the MNHU by Tkalcú (1987), the identity of this

taxon appears clear from the original description and from Tkalců (1987).

Diagnosis. Large species (queen only, workers examined small). *Female* (length of queens 21 mm, workers 11–12 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine; oculo-malar distance approximately 1.3 times the proximal breadth of the mandible; dorsum of the head with punctures scattered almost throughout except in the ocellar depressions; antennal segment 4 just shorter than broad, half of the length of segment 3; hair (Figs 60–62) of the thorax orange-brown, metasomal tergum 1 yellow-brown (sometimes black for queens), tergum 2 black for queens (Fig. 62) or often yellow-brown for workers (Figs 60–61), terga 3–5 black or sometimes with slightly greyish fringes (cf. *B. trifasciatus*); wings mid brown.

Male [based on specimens from Beijing Municipality] (length 15 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 138) with the penis valve with a short distal weakly flared and toothed head; gonostylus short and broad, nearly rectangular, with a single long recurved spine-like inner proximal process (cf. *B. trifasciatus*); volsella with the inner hooks very close to the distal corner, with the distally directed hook spinose, the proximally directed hook tightly recurved, shorter than the distal hook, and broadly flattened with many radiating teeth (*trifasciatus*-group of the subgenus *Megabombus*).

Global distribution. Oriental species: northeastern and central China (Liaoning, Hebei, Beijing, Shandong, Anhui, Shanxi, Shaanxi, Gansu, Sichuan).

SCR material examined. Rare at low altitudes of the western, northern and eastern foothills (Fig. 202) with a long seasonal activity period (Fig. 198): 1 queen, 8 workers, 1500–2700 m (AMNH, PHW, SAC, TY, USNM). Literature records: Friese (1905), Skorikov ([1923]), Panfilov (1957), Wang (1992a).

SCR variation. The sample size is small, but this species appears to show size-dependent variation in the colour of metasomal terga 1–2 among females, which is expressed most obviously as a difference between queens and workers (see above).

SCR food plants. Medium tongue-length species: (Lamiaceae) *Salvia* sp.

8. *Bombus (Megabombus) trifasciatus* Smith subgn. comb. nov.

(Figs 63–69, 71–73, 139, 199, 203)

Bombus trifasciatus Smith, 1852a: 43, lectotype queen (Williams, 1991: 52) BMNH examined. China: Zhejiang.

Bombus ningpoënsis Friese, 1909: 676, type not seen. Synonymised with *Bombus trifasciatus* Smith by Tkalců (1961). China: Zhejiang.

Bombus haemorrhoidalis var. *albopleuralis* Friese, 1916: 108, lectotype queen (Tkalců, 1974a: 344) MNHU examined. Synonymised with *Bombus trifasciatus* Smith by Williams (1991). India.

Bombus (Hortobombus) mimeticus var. *gantokiensis* Richards, 1931: 530, holotype queen BMNH examined. Synonymised with *Bombus trifasciatus* Smith by Williams (1991). India.

Diversibombus malaisei Skorikov, 1937: 2, syntype queens ZISP not found (Y. Pesenko, *in litt.*). Synonymised provisionally with *Bombus trifasciatus* Smith by Williams (1998), confirmed here. Myanmar.

Bombus (Diversobombus) ningpoënsis ssp. *minshanicus* Bischoff, 1936: 19, lectotype worker (Williams, 1991: 52) MNHU examined. Synonymised with *Bombus trifasciatus* Smith by Williams (1991). China: Gansu.

Bombus (Diversobombus) trifasciatus Smith; Panfilov, 1957: 235; Sakagami, 1972: 158; Williams, 1991: 52; Yao & Wang, 1993b: 768; Yao, 1995: 579, 1998: 403; Yao & Luo, 1997: 1686; Yin *et al.*, 2001: 753. China: Sichuan.

Bombus (Diversobombus) ningpoënsis Friese; Tkalců, 1960: 70; Wang, 1992a: 1429; Wang & Yao, 1992a: 689. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Megabombus*, within which it belongs to the *trifasciatus*-group of species.

Taxonomic status. This complex of taxa has been regarded both as including several species (Tkalců, 1968b, 1989) and as a single very variable species (Williams, 1991, 1998). Within the SCR, two morphological taxa have been identified in this study (see comments on variation below) which, although only subtly different, might represent two species: (1) *B. trifasciatus* Smith in the strict sense, which is widespread in the north and east; and (2) *B. montivagus* Smith (including the taxa *albopleuralis* Friese and *gantokiensis* Richards from the Himalaya), confined to the far south-west. These Sichuan morphotaxa appear to be consistent with morphotaxa from beyond Sichuan, in that queens of *trifasciatus* s. str. tend to have the punctures of the middle and anterior ocello-ocular areas more dense and reaching closer to the edges of the ocellar depressions, and males of *trifasciatus* s. str. tend to have the proximally directed hook of the volsella longer. However, because there appear to be some specimens with intermediate character states of both colour pattern and morphology (PHW, IZB), these taxa are treated here as a single species while further evidence is awaited.

Diagnosis. Large species. *Female* (length of queens 18–20 mm, workers 12–17 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine (cf. *B. breviceps*); oculo-malar distance approximately 1.7 times the proximal breadth of the mandible; dorsum of the head with punctures scattered almost throughout except in the ocellar depressions (cf. *B. braccatus*); antennal segment 4 just shorter than broad, half of the length of segment 3 (cf. e.g. *B. bicoloratus*, *B. imitator*); hair colour very variable (Figs 63–69, 71–73), usually with the head and hind tibia (corbicular fringes) black (cf. *B. breviceps*), metasomal tergum 1 yellow, tergum 3 black, and tergum 5 orange-red (cf. *B. longipes*); wings dark brown.

Male (length 15–18 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long,

reaching posteriorly to the wing bases; genitalia (Fig. 139) with the penis valve with a short distal weakly flared and toothed head; gonostylus short and broad, nearly rectangular, with two long recurved spine-like inner proximal processes (cf. *B. longipes*); volsella with the inner hooks very close to the distal corner, with the distally directed hook spinose and nearly straight or weakly 'S'-shaped, the proximally directed hook strongly recurved, as long or longer than the distal hook, and broadly flattened with many radiating teeth (*trifasciatus*-group of the subgenus *Megabombus*).

Global distribution. Widespread Oriental species: Himalaya, Myanmar, Peninsular Malaysia, Thailand, Vietnam, Laos, China (Yunnan, Xizang, Gansu, Sichuan, Shanxi, Shaanxi, Hubei, Fujian, Jiangxi, Guangdong, Hunan, Guangxi, Guizhou, Anhui, Zhejiang), Taiwan.

SCR material examined. Formerly common at low altitudes of the southwestern mountains and the foothills surrounding the Sichuan basin, but with fewer recent records (Fig. 203), with a long seasonal activity period (Fig. 199): 27 queens, 149 workers, 15 males, 500–3350 (–?3500) m (AMNH, BMNH, CAS, IZB, PHW, SAC, TY, USNM, ZMMU). Literature records: Panfilov (1957), Tkalcū (1960), Sakagami (1972), Williams (1991), Wang (1992a) [records from Dêgê, Garzê, Hongyuan and Barkam (atypical habitats for this species which have been surveyed intensively) are not supported by specimens of *B. trifasciatus* in the IZB collection and need to be confirmed (they are likely to be misidentifications of *B. keriensis*), so they are not shown in the activity plot and map], Wang and Yao (1992a), Yao and Wang (1993b), Yao (1995, 1998), Yao and Luo (1997), Yin *et al.* (2001).

SCR variation. This species is very variable in colour pattern. Individuals from around the Sichuan basin generally show the colour pattern common for mainland China, with broad yellow bands anteriorly and posteriorly on the dorsum of the thorax (the 'ningpoensis' pattern, Fig. 71; '*trifasciatus*' s. str. has no black on the thoracic dorsum, Fig. 68). Individuals from the southeast of Sichuan, around Emeishan and to the east of Luoqishan, have the dorsum of the thorax uniformly orange-brown, similar to individuals from the southeast on the Yunnan-Myanmar border (the '*malaisei*' pattern, Figs 63–65). Intermediate queens with orange on the thorax with many black hairs intermixed have been collected at Emeishan and Luding. In contrast, individuals from the southwest of Sichuan, to the south and west of Luoqishan, have the thorax entirely black, similar to individuals from further west in southern Xizang (the Himalayan '*gantokiensis*' pattern, similar to the Himalayan '*albopleuralis*' pattern, but with the sides of the thorax black, Fig. 73). These workers with a black thorax from the far south west have the punctures on the head anterior to the ocello-ocular areas more widely spaced than the other workers (banded or unbanded) from further to the north and east in Sichuan. However, very few of these dark individuals are available and they vary in how distinct this difference is. What appear to be individuals with colour patterns intermediate between the black-thorax and the pale-thorax patterns, with much darkened and narrowed thoracic bands (the '*minshan-*

icus' pattern) or with the dorsum of the thorax black with a narrow pale band only posteriorly (Fig. 72), have been collected at Luding, Wenchuan, and in Yunnan. See also the comments on *B. breviceps*.

SCR food plants. Long-tongued species: (Asteraceae) *Saussurea* sp.; (Balsaminaceae) *Impatiens* sp.; (Bignoniaceae) *Incarvillea* sp.; (Convolvulaceae) *Convolvulus* sp.; (Cucurbitaceae) *Cucurbita pepo* DC.; (Lamiaceae) *Salvia* sp.

9. *Bombus (Megabombus) bicoloratus* Smith subgn. comb. nov. (Figs 77, 140, 204, 208)

Bombus bicoloratus Smith, 1879: 132, holotype queen BMNH examined. Taiwan.

Bombus kulingensis Cockerell, 1917: 266, holotype worker USNM examined. **New synonym.** China: Jiangxi.

Bombus (Senexibombus) tajushanensis Pittioni, 1949: 244, type not seen. Synonymised with *Bombus kulingensis* Cockerell by Sakagami (1972); new provisional synonym. China: Fujian.

Megabombus (Senexibombus) kulingensis ssp. *pullus* Tkalcū, 1977: 227, type not seen. New provisional synonym. China: 'Tibet', believed incorrect.

Bombus (Senexibombus) kulingensis Cockerell; Yao & Wang, 1993b: 767; Yao & Luo, 1997: 1686; Yao, 1998: 403; Yin *et al.*, 2001: 753. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Megabombus*, within which it belongs to the *senex*-group of species.

Taxonomic status. Within the *senex*-group of the subgenus *Megabombus*, *B. senex* Vollenhoven (from Sumatera) and *B. irisanensis* Cockerell (from the Philippines), have the male volsella narrow distally, with only a single small tooth on the inner margin before the recurved inner distal hook, and the gonostylus has the inner proximal process with a relatively short ventral spine (females of *B. irisanensis* can be distinguished from all other species of the subgenus by the sparse large punctures interspersed with shining smooth areas posterior to the ocello-ocular area of the head, rather than having these areas very closely punctured). The remaining taxa of the *senex*-group (*B. kulingensis* with yellow bands, from mainland China; and *B. bicoloratus* s. str. without yellow bands, from the adjacent large islands of Hainan and Taiwan) have a broad, inner, toothed process just before the recurved inner distal hook of the volsella, and the gonostylus has the inner proximal process produced ventrally with a long, straight, narrow, bifid spine. These Chinese bumblebees have previously been considered to be two separate species. They show variation in the pattern of teeth on the inner proximal process of the gonostylus and on the outer margin of the penis valve head, and they vary especially in how pronounced is the outer lateral shoulder on the penis valve just anterior to the ventro-lateral process. However, this morphological variation is considered to fall within the range shown within other single species. Some specimens

from mainland China have the yellow thoracic bands very much narrowed and intermixed with black, while some island specimens have small patches of yellow on the upper sides of the thorax. Consequently *B. bicoloratus* and *B. kulingensis* are regarded here as likely to be parts of one species.

Diagnosis. Large species. *Female* (length of queens 22 mm, workers 18 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine (cf. *B. breviceps*); oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible; dorsum of the head with punctures scattered almost throughout except in the ocellar depressions (cf. *B. braccatus*); antennal segment 4 longer than broad (cf. *B. trifasciatus*); hair (Fig. 77) of the thorax with yellow bands anteriorly and posteriorly (cf. *B. breviceps*), although these may be obscured by having many black hairs intermixed, metasomal terga 1–2 and often most of tergum 3 yellow (cf. *B. imitator*, *B. braccatus*, *B. trifasciatus*), tergum 5 orange-red; wings dark brown.

Male [based on a specimen from Guizhou] (length 20 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 140) with the penis valve with a distal weakly flared and toothed head, which has a strong spine proximally; gonostylus broadly rounded (cf. *B. imitator*, *B. braccatus*, *B. trifasciatus*, *B. breviceps*), with a broad inner proximal process that gives rise to a long narrow straight spine ventrally; volsella with the inner hooks very close to the distal corner, but reduced to a squarish toothed stump.

Global distribution. Oriental species: central and southern China (Sichuan, Hubei, Anhui, Guizhou, Guangxi, Hunan, Guangdong, Jiangxi, Fujian, Zhejiang, Hainan), Taiwan.

SCR material examined. Rare at low altitudes of the western and southern foothills (Figs 204, 208): 3 queens, 1 worker, 900–1900 m (IZB, PHW). Literature records: Yao & Wang (1993b), Yao & Luo (1997), Yao (1998), Yin *et al.* (2001).

SCR food plants. Long-tongued species, no records.

10. *Bombus (Megabombus) supremus* Morawitz (Figs 81–83, 141, 205, 209)

Bombus supremus Morawitz, 1887: 196, holotype queen ZISP not found (Y. Pesenko, *in litt.*). China: Qinghai.

Bombus linguarius Morawitz, 1890: 351, holotype worker ZISP examined. Synonymised provisionally with *Bombus supremus* Morawitz by Williams (1998), confirmed here. China: ‘Kan-ssu’, but probably Qinghai.

Hortobombus (Hortobombus) supremus (Morawitz); Skorikov, [1923]: 156. China: Sichuan.

Bombus (Hortobombus) supremus ssp. *beicki* Bischoff, 1936: 20, type not seen. [China: Qinghai]

Bombus (Megabombus) supremus Morawitz; Wang, 1982a: 442, 1992a: 1428. China: Sichuan.

Bombus supremus Morawitz; Macior & Tang, 1997: 3. China: Sichuan.

This species belongs to the *hortorum*-group of species.

Nomenclature. Although it has not been possible to find the single type specimen of *Bombus supremus* specified in the original description, the identity of this taxon appears clear from the original description, so the designation of a neotype is unjustified (ICZN, 1999: Article 75.1).

Diagnosis. Large species. *Female* (length of queens 20–21 mm, workers 13–19 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine; oculo-malar distance approximately 2.5 times the proximal breadth of the mandible (cf. all other SCR species e.g. similarly coloured *B. kashmirensis*, *B. rufofasciatus*); hair (Figs 81–83) of the thorax with grey-white bands anteriorly and posteriorly, metasomal terga 2–3 with orange-red (cf. *B. sushkini*, *B. securus*, *B. religiosus*), tergum 5 white (cf. *B. impetuus*); wings light brown.

Male (length 21 mm) similarly coloured, metasomal tergum 1 white, terga 2–4 orange-red, tergum 5 white, tergum 6 white with some orange at the base of the hairs, tergum 7 predominantly orange-red; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 141) with the penis valve with a long distal unflared head with many strong teeth (cf. *B. longipes*, *B. trifasciatus*, *B. bicoloratus*, and non-*Megabombus* species); gonostylus longer than broad, with a broad inner proximal process with two prominent long narrow spines (cf. *B. sushkini*, *B. securus*, *B. religiosus*); volsella with the inner hooks very close to the distal corner, but reduced to a squarish stump with a short distal spine.

Global distribution. Oriental species: eastern Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau and mountains (Fig. 209) with a long seasonal activity period (Fig. 205): 8 queens, 51 workers, 1 male, (?3500–) 3529–4464 m (BMNH, IZB, LWM, PHW, SAC, TY, ZMA). Literature records: Skorikov ([1923]), Wang (1982a, 1992a) [records from Dêgê and Xichang (atypical habitats) are not supported by specimens of *B. supremus* in the IZB collection, need to be confirmed, and are not shown in the activity plot and map], Macior and Tang (1997).

SCR food plants. Long-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp.; (Caryophyllaceae) *Dianthus* sp.; (Lamiaceae) *Ajuga* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Aconitum gymnantrum* Maxim., *Delphinium* sp.; (Scrophulariaceae) *Pedicularis polyodonta* H.L. Li, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis* Batalin. This species is closely related to the southern European montane bumblebee *B. gerstaeckeri* Morawitz, but unlike that species, which is well known for its oligolecty (e.g. Ponchau *et al.*, 2006), *B. supremus* appears to visit many plant species.

11. *Bombus (Megabombus) sushkini* (Skorikov) (Figs 85–87, 142, 206, 210)

Hortobombus sushkini Skorikov, 1931: 235, paralectotype queen (Podbolotskaya, 1988: 117) ZISP examined. Kazakhstan.

Bombus (Hortobombus) sushkini (Skorikov); Bischoff, 1936: 21. Change in generic combination.

Bombus (Hortobombus) hortorum ssp. *morawitzianus* Pittoni, 1939: 244 (not of Popov, 1931: 183 = *B. morawitzianus* (Popov)), lectotype queen (Tkalčú, 1974b: 52) BMNH examined. Synonymised with *Megabombus sushkini* (Skorikov) by Tkalčú (1974b). Mongolia.

This species belongs to the *hortorum*-group of species.

Taxonomic status. Skorikov (1931) described *B. sushkini* from syntypes from several localities in Kazakhstan. *B. sushkini* and the northern tundra *B. saltuarius* were mentioned as two separate species under the title ‘*Hortobombus sushkini* sp. n.’ (page 235), although elsewhere in the same paper (page 204) Skorikov refers to ‘*saltuarius sushkini*’ as though he regarded them as parts of one species. This was the first publication to give characters by which *B. sushkini* and *B. saltuarius* might be distinguished from other species and from one another (the name *Hortobombus saltuarius* was published earlier by Skorikov, [1923]:156, but without description) and so this is the first publication to make these names available (ICZN, 1999: Article 13.1). Queens of both *B. sushkini* and *B. saltuarius*, labelled as paralectotypes by Podbolotskaya (designation published for *B. sushkini* but not for *B. saltuarius*; specimens labelled as lectotypes could not be located, Y. Pesenko, *in litt.*), have been examined from the ZISP collection, together with a queen and a worker labelled ‘*Hortobombus saltuarius*’ in Skorikov’s handwriting from northern Russia (from the Pechora River, Arkhangel’skaya Oblast’/Komi ASSR) in the BMNH collection. Both taxa (along with *B. portchinsky* Radoszkowski from the Caucasus) were described by Skorikov (1931) as being light coloured, with yellow extending onto part of tergum 3. But contrary to the detail of Skorikov’s description, neither the queens of *B. portchinsky* (queens examined from the BMNH collection) nor any of the specimens mentioned above have a distinct patch or intermixture of yellow hair on tergum 3, although there is a posterior whitish fringe. Furthermore, *B. portchinsky* and the unpublished ‘paralectotype’ queen of *B. saltuarius* have the hair of the head black and have of the lower sides and underside of the thorax black or predominantly black. In contrast, the BMNH queen labelled *B. saltuarius* and the paralectotype queen of *B. sushkini* are distinctive in being light coloured, with the short hair on the face and on the dorsum of the head with cream-yellow hairs intermixed, and the lower sides and underside of the thorax so pale as to be almost white haired. All of these specimens have the central area of the clypeus with few or no fine punctures (characteristic of the group), apart from Podbolotskaya’s unpublished ‘paralectotype’ queen of *B. saltuarius* (from Shchel’yayur on the Pechora River, Komi ASSR). This latter queen has distinct fine punctures on the central area of the clypeus, like the widespread Palaearctic *B. hortorum* (Linnaeus). Therefore one possibility is that the unpublished ‘paralectotype’ queen of *B. saltuarius* that does not match the original description is a misidentified specimen, whereas the specimen labelled *B. saltuarius* by Skorikov in the BMNH collection which matches the original description more closely is accepted here as representative of this taxon.

The queens of *B. sushkini* were said by Skorikov to be a little more shaggy haired than those of *B. saltuarius*, although this is not strongly obvious from the material available. Assuming that Skorikov’s Russian queen of *B. saltuarius* in the BMNH is correctly identified, then the queens of *B. sushkini* differ from those of *B. saltuarius* in having the labral furrow narrower and more ‘V’-shaped rather than ‘U’-shaped when viewed from the anterior and dorsally (*B. portchinsky* also has the labral furrow more rounded and the labral tubercles less pointed than *B. sushkini*). The males of *B. sushkini* were described by Skorikov as approaching *B. portchinsky* in the breadth of the ‘lacinia’ (volsella) (Skorikov, 1931: his fig. 40), which was said to be less broad than for *B. saltuarius* (Skorikov, 1931: his fig. 39). *Bombus saltuarius* was also described by Skorikov as differing from both of the other taxa in having a tendency for a tooth on the ventral part of the inner proximal projection of the ‘squama’ (gonostylus) (from the very few specimens available, *B. sushkini* seems to have the ventral part of the inner proximal process of the gonostylus larger and extending more posteriorly than *B. portchinsky*, the volsella is broader, and the distal apex of the volsella is acute rather than forming a right angle as in *B. portchinsky*). Subsequently *B. sushkini* and *B. saltuarius* have been treated as conspecific by Bischoff (1936) and Tkalčú (1961) and as separate species by Tkalčú (1974b), Podbolotskaya (1988) and P. Rasmont (*in litt.*).

Within *B. sushkini*, 16 males from Mongolia and the three males from Sichuan for which the genitalia have been examined do all have the volsella very broad (as described by Skorikov, 1931), and lack the ventral tooth on the gonostylus described for *B. saltuarius*. However, *B. sushkini* differs slightly between Sichuan and northern Mongolia, on the other side of the Gobi Desert. The 16 males examined from Mongolia have the penis valve with 12–14 lateral teeth, whereas the three males from Sichuan have the penis valve with 18 lateral teeth. In addition, females from Sichuan often have the pubescence more extensively yellow, which may replace most of the black on terga 2–3 and which is unknown from Mongolia. This pale pubescence is always cream yellow rather than the sometimes more lemon yellow to the north, in Mongolia.

On the basis of Skorikov’s character of the male gonostylus for *B. saltuarius*, which it has not been possible to examine and confirm, we tentatively regard *B. sushkini* as a single variable species, separate from the northern tundra species, *B. saltuarius*.

Diagnosis. Medium-sized species. *Female* (length of queens 17–19 mm, workers 11–16 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine; oculo-malar distance approximately 1.8 times the proximal breadth of the mandible (cf. *B. bicoloratus* and non-*Megabombus* species); hair (Figs 85–87) of the thorax with cream-yellow bands anteriorly and posteriorly (cf. *B. supremus*), metasomal tergum 1 cream yellow, tergum 2 cream yellow at least anteriorly (cf. *B. religiosus*), terga 4–5 white (cf. *B. securus*, *B. personatus*); wings light brown.

Male (length 16 mm) similarly coloured, sometimes predominantly yellow, with a black band between the wing bases,

with black intermixed on metasomal tergum 2 posteriorly and on tergum 3 anteriorly (apex white), terga 4–5 white with black weakly intermixed anteriorly, terga 6–7 predominantly black with white at sides, or the apex of tergum 2 and most of tergum 3 black, tergum 4 with just a few black hairs intermixed anteriorly; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 142) with the penis valve with a long distal unflared head with many regular strong teeth (cf. *B. longipes*, *B. trifasciatus*, *B. bicoloratus* and non-*Megabombus* species); gonostylus longer than broad, with a broad inner proximal process with one large and several small triangular teeth; volsella broad with the inner hooks very close to the distal corner, with the distally directed hook spinose, the proximally directed hook reduced to a right angle.

Global distribution. Species of the southeastern Palaearctic mountains, and within the Oriental region: eastern Tibetan plateau and northeastern China (Sichuan, Gansu, Qinghai, Xizang, Yunnan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Fig. 210) with a short seasonal activity period (Fig. 206): 13 queens, 44 workers, 4 males, 3456–4021 m (BMNH, IZB, PHW, SAC, TY, ZMA). Literature records: Skorikov (1931: 204).

SCR variation. Females from Sichuan often have the pubescence more extensively yellow, which may replace most of the black on terga 2–3 (Figs 85–86). This more extensive pale hair does occur in queens, but is more frequent among the smaller workers. Workers may be extensively pale yellow and appear similar to e.g. *B. laesus* (Fig. 49) at the same sites.

SCR food plants. Long-tongued species: (Lamiaceae) *Ajuga* sp., *Scutellaria* sp.; (Ranunculaceae) *Aconitum gymmandrum*; (Scrophulariaceae) *Pedicularis ingens* Maxim., *P. muscoides* H.L. Li, *P. szetschuanica*, *P. verticillata*.

12. *Bombus (Megabombus) securus* (Frison) (Figs 54–56, 143, 207, 211)

Bremus (Hortobombus) securus Frison, 1935: 346, holotype male USNM examined. China: Sichuan.

Bombus (Hortobombus) yuennanicus Bischoff, 1936: 23, holotype queen MNHU examined. Synonymised with *Megabombus securus* (Frison) by Tkalců (1987). China: Yunnan.

Megabombus (Megabombus) securus (Frison); Tkalců, 1987: 63. China: Sichuan.

Bombus (Megabombus) yuennanicus Bischoff; Wang, 1992a: 1428. China: Sichuan.

Bombus (Megabombus) securus (Frison); Williams, 1998: 118. Change in generic combination.

This species belongs to the *hortorum*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 17–18 mm, workers 11–15 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine; oculo-malar distance approximately 2.0 times the proximal breadth of the mandible (cf. *B. bicoloratus* and non-

Megabombus species); hair (Figs 54–56) of the thorax with golden yellow bands anteriorly and posteriorly (cf. *B. supremus*), the sides of the thorax paler yellow or white, metasomal tergum 1 golden yellow, tergum 3 (queens, Fig. 56) or terga 2–3 (workers, Figs 54–55) with posterior yellow fringes, terga 4–5 extensively dull yellow (cf. *B. sushkini*, *B. religiosus*); wings mid brown.

Male (length 14 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 143) with the penis valve with a long distal unflared head with many irregular strong teeth distally (cf. *B. longipes*, *B. trifasciatus*, *B. bicoloratus* and non-*Megabombus* species), proximally also with irregular but distinctly protruding large teeth (cf. *B. religiosus*); gonostylus longer than broad, with a broad inner proximal process with one large tooth or short spine, shorter than the proximal breadth of the process, and several small triangular teeth; volsella with the inner hooks very close to the distal corner, with the distally directed hook spinose and nearly straight, the proximally directed hook reduced to an acute tooth (cf. *B. religiosus*).

Global distribution. Oriental species: eastern fringes of the Tibetan plateau (Yunnan, Xizang, Sichuan, Gansu, Shaanxi).

SCR material examined. Uncommon at medium altitudes of the northwestern, western and southwestern plateau and mountains (Fig. 211) with a medium-length seasonal activity period (Fig. 207): 2 queens, 17 workers, 1 male, (?890–) 2100–3850 m (INHS, IZB, PHW, SAC, TY). A worker (INHS) labelled ‘Suifu’ (Yibin) and two workers (INHS) labelled Maoxian with unusually low altitude data (890 m) may be based on only approximate locations and need to be confirmed, but are shown in the activity plot and map. Literature records: Frison (1935), Tkalců (1987), Wang (1992a). This species is particularly associated with deep flowers in open areas along forest streams.

SCR food plants. Long-tongued species: (Lamiaceae) *Salvia* sp.; (Scrophulariaceae) *Pedicularis densispica* Franch. ex Maxim., *P. melampyriflora*, *P. rex*.

13. *Bombus (Megabombus) religiosus* (Frison) (Figs 88, 144, 212, 216)

Bremus (Hortobombus) religiosus Frison, 1935:344, holotype male USNM examined. China: Sichuan.

[*Bombus (Hortobombus) hortorum* ssp. ? Bischoff, 1936: 19, misidentification. China: Gansu.]

Bombus (Megabombus) religiosus (Frison); Wang, 1992a: 1429. Change in generic combination. China: Sichuan.

This species belongs to the *hortorum*-group of species.

Diagnosis. Large species. *Female* (length of queens 21 mm, workers 13–16 mm) with the mid basitarsus with the distal posterior corner produced as a narrow sharp spine; oculo-malar distance approximately 2.1 times the proximal breadth of the mandible (cf. *B. bicoloratus* and non-*Megabombus* species); hair (Fig. 88) of the thorax with lemon-yellow bands anteriorly

and posteriorly (cf. *B. supremus*), white on the lower sides, metasomal tergum 1 lemon yellow, tergum 2 black, tergum 3 black (cf. *B. sushkini*, *B. securus*), and terga 4–5 with some white at least laterally; wings mid brown.

Male (length 15–17 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 144) with the penis valve with a long distal unflared head with many regular strong teeth distally (cf. *B. longipes*, *B. trifasciatus*, *B. bicoloratus*, and non-*Megabombus* species), proximally with 3–4 regular and distinctly protruding large teeth (cf. *B. securus*); gonostylus longer than broad, with an inner proximal process with one large spine, longer than the proximal breadth of the process; volsella with the inner hooks very close to the distal corner, with the distally directed hook spinose and nearly straight, except near its distal end, where it is 'S'-shaped, the proximally directed hook widely separated as a broadly triangular but acute tooth (cf. *B. securus*).

Global distribution. Oriental species: eastern fringes of the Tibetan plateau (Yunnan, Sichuan).

SCR material examined. Uncommon at medium altitudes of the northwestern, western and southwestern mountains (Fig. 216) with a medium-length seasonal activity period (Fig. 212): 5 queens, 25 workers, 10 males, (?850–) 1520–4164 m (BMNH, INHS, IZB, JAB, PHW, SAC, TY, USNM). Three males (INHS, PHW) labelled Ya'an with unusually low altitude data (850 m) may be based on only an approximate location and need to be confirmed, but are shown in the activity plot and map. Literature records: Frison (1935), Wang (1992a) [records from Batang and Xiangcheng are not supported by specimens of *B. religiosus* (but cf. *B. securus*) in the IZB collection, need to be confirmed, and are not shown in the activity plot and map]. This species is particularly associated with deep flowers in open areas along forest streams.

SCR food plants. Long-tongued species: (Lamiaceae) *Salvia* sp., *Siphocranion macranthum*; (Ranunculaceae) *Aconitum gymnandrum*, *Delphinium* sp.

Subgenus *THORACOBOMBUS* Dalla Torre

Laesobombus Krüger, 1920.

Tricornibombus Skorikov [1923].

14. *Bombus (Thoracobombus) imitator* Pittioni subgn. comb. nov.

(Figs 74–76, 145, 213, 217)

Bombus (Tricornibombus) imitator Pittioni, 1949: 251, lectotype queen (Tkalčú, 1968a: 90) BMNH examined. China: Fujian.

Megabombus (Tricornibombus) imitator (Pittioni); Tkalčú, 1968a: 90. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Thoracobombus*, within which it constitutes the *imitator*-group of species.

Diagnosis. Large species. *Female* (length of queens 19 mm, workers 12–17 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine (cf. *B. braccatus*, *B. picipes*, *B. breviceps*); oculo-malar distance approximately 1.2 times the proximal breadth of the mandible; dorsum of the head with a broad band of punctures in the outer third along the inner eye margin (cf. *B. braccatus*); antennal segment 4 longer than broad (cf. *B. trifasciatus*) but shorter than segment 5; hairs on the lateral parts of the metasomal terga arising from unusually large and close punctures, especially on terga 4–5 (cf. e.g. *B. bicoloratus*, *B. impetuosus*); for larger females only, metasomal tergum 6 with a strong subapical boss and a longitudinal keel; for larger females (Fig. 76), the hair of the thorax with yellow bands anteriorly and posteriorly (cf. *B. atripes*), sides of the thorax yellow (cf. *B. impetuosus*), metasomal terga 1–2 yellow, tergum 3 black (cf. *B. bicoloratus*), terga 4–5 orange-red; smaller workers (Fig. 75) without a black band between the wing bases; the smallest workers (Fig. 74, not seen from Sichuan, see below) tending to have all of the black on the thorax and metasoma replaced by yellow; wings dark brown.

Male [based on specimens from Guizhou] (length 16–18 mm) similarly coloured; compound eye unenlarged relative to female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 145) with the penis valve with a distal strongly flared head; gonostylus reduced to a very narrow transverse band, projecting inwards as a single long spinose process (cf. all other *Bombus* species).

Global distribution. Oriental species: central and southern China (Gansu, Sichuan, Hubei, Guizhou, Hunan, Guangxi, Fujian, Zhejiang).

SCR material examined. Uncommon at low altitudes of the western foothills of the Sichuan basin (Fig. 217) with a long seasonal activity period (Fig. 213): 3 queens, 11 workers, 858–1600 m (IZB, PHW, ZMMU). Literature records: Tkalčú (1968a).

SCR variation. Although not seen in the small sample from Sichuan, specimens from Fujian show strong colour variation among the females (see above), with black being replaced by yellow in some workers (Pittioni, 1949; Tkalčú, 1968a). From material in the BMNH collection, this variation appears to be size dependent, with the two smallest workers being the most extensively yellow.

SCR food plants. Long-tongued species, no records.

15. *Bombus (Thoracobombus) atripes* Smith subgn. comb. nov. (Figs 47, 146, 214, 218)

Bombus atripes Smith, 1852a: 44, lectotype worker (Tkalčú, 1968a: 87) BMNH examined. China: Zhejiang.

Megabombus (Tricornibombus) atripes (Smith); Tkalčú, 1968a: 87. China: Sichuan.

Bombus (Tricornibombus) atripes Smith; Wang, 1987a: 1381; Wang & Yao, 1992a: 689; Yao & Luo, 1997: 1688; Yin *et al.*, 2001: 752. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Thoracobombus*, within which it belongs to the *atripes*-group of species.

Diagnosis. Large species. *Female* (length of queens 22–23 mm, workers 16–18 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine; oculo-malar distance approximately 1.1 times the proximal breadth of the mandible; the hairs on the lateral parts of the metasomal terga arising from unusually large and close punctures (cf. e.g. *B. hedini*); for larger females only, metasomal tergum 6 with a strong subapical boss with a longitudinal keel; hair (Fig. 47) of the thoracic dorsum and metasomal terga 1–5 orange-red (cf. all other SCR *Bombus* species), sides of the thorax and tergum 6 black (cf. *B. hedini*); wings dark brown.

Male [based on a specimen from Zhejiang] (length 19 mm) similarly coloured, but metasomal terga 1–7 orange-red; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 146) with the penis valve with a distal weakly flared head; gonostylus distally reduced to a small square, the inner proximal process divided into two long nearly straight spines at right angles to each other (cf. all other *Bombus* species).

Global distribution. Oriental species: central and southern China (Sichuan, Hubei, Anhui, Jiangsu, Yunnan, Guizhou, Guangxi, Hunan, Jiangxi, Fujian, Zhejiang, ?Hainan [Tkalčú, 1968a: 80]).

SCR material examined. Rare at low altitudes of the Sichuan basin and surrounding foothills (Fig. 218) with a medium-length seasonal activity period (Fig. 214): 4 queens, 2 workers, 300–900 m (BMNH, IZB, USNM). Literature records: Tkalčú (1968c), Wang (1987a), Wang and Yao (1992a), Yao and Luo (1997), Yin *et al.*, 2001.

SCR food plants. Long-tongued species, no records.

16. *Bombus (Thoracobombus) laesus* Morawitz (Figs 48–49, 52, 57, 147, 215, 219)

Bombus laesus Morawitz, 1875: 3, syntype queen (lectotype by designation of P. Rasmont, in prep.) ZMMU examined. Kazakhstan.

Bombus Mocsáryi Kriechbaumer, 1877: 253, type not seen. Regarded as conspecific with *Bombus laesus* Morawitz by Dalla Torre (1896). Hungary.

[*Agrobombus (Laesobombus) laesus* subsp. *mocsáryi* var. *maculidorsis* Skorikov, 1922: 23, infrasubspecific] *Bombus (Laesobombus) maculidorsis* Panfilov, 1956: 1328, syntype queen (lectotype by designation of Podbolotskaya, unpublished) ZISP examined. Synonymised provisionally with *Bombus laesus* Morawitz by Williams (1998), confirmed here. Russia.

Bombus (Laesobombus) tianschanicus Panfilov, 1956: 1327, type not seen. Synonymised provisionally with *Bombus laesus* Morawitz by Williams (1998). Kyrgyzstan.

Megabombus (Thoracobombus) laesus (Morawitz); Reinig, 1981: 161, new subgeneric combination.

[*Bombus (Laesobombus) tianshanicus* Panfilov; Wang, 1992a: 1429, incorrect subsequent spelling. China: Sichuan.]

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Thoracobombus*, within which it belongs to the *mucidus*-group of species.

Nomenclature. Skorikov (1922) in his paper on bumblebees of the St Petersburg region described variation across northern, middle and southern European Russia. As part of this he described ‘var. *maculidorsis*’ as being associated particularly with the southern part of this range (figure p. 22), although no specific type locality was given. In the ZISP collection a queen from Ryazan Province has a red label ‘Lectotypus A. (LaesoB.)/laesus ssp. mocsaryi/var. maculidorsis Sk./design. [female] Podbolot’. No lectotype designation has been published. This specimen is regarded as a possible syntype.

A male in the ZISP collection has a red unsigned paralectotype label in what appears to be Podbolotskaya’s handwriting for *B. tianschanicus* Panfilov. The specimen was collected by Ryukbeil in 1910 and therefore cannot be the syntype male described by Panfilov (1956: 1328) as having been collected by him in 1953.

Taxonomic status. Bumblebees of this species or species complex show variation in morphology and colour (especially in the extent of black hairs). For example, the distal inner corner of the male gonostylus can be variable in shape, from approximately a right angle to a narrow finger, but that this can vary between the two sides of the same specimen. However, until more evidence to the contrary is available, *B. laesus* is interpreted here as a single, broadly distributed and variable species.

Diagnosis. Medium-sized species. *Female* (length of queens 16–17 mm, workers 9–14 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine; oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible (cf. *B. securus*); ocello-ocular area with only a few scattered punctures restricted to the outer third along the eye margin (cf. *B. filchnerae*, *B. humilis*); hair (Figs 48–49, 52, 57) of the face black with long yellow hairs intermixed, thorax yellow with a black spot between the wing bases (especially queens, Fig. 48), or with yellow bands anteriorly and posteriorly with only a few black hairs intermixed (Figs 49, 52), sometimes the thoracic dorsum almost entirely black with a few yellow hairs intermixed at the anterior and posterior (Fig. 57), corbicular fringes yellow or with the longer hairs mostly yellow, metasomal terga 1–5 yellow, or with a few or more black hairs at the base of each tergum, tergum 6 black (cf. *B. filchnerae*, *B. humilis*); wings light brown.

Male (length 13 mm) similarly coloured, the pale anterior thoracic band nearly twice as broad (measured longitudinally) as the pale posterior band, terga 3–5 with a few black hairs anteriorly, hairs of tergum 6 mostly black and of tergum 7 all black with a few pale tips; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 147) with the penis valve with a small distal unflared toothless head (cf. *B. securus*); gonostylus with a broad inner proximal process without teeth (cf. *B. filchnerae*, *B. humilis*); volsella densely hairy and projecting

beyond the gonostylus by more than the length of the gonostylus, the distal corner of the volsella just acute, the inner hooks forming a short stump far from the distal corner, the hooks reduced to acute teeth at the inner corners of the stump (cf. *B. filchnerae*, *B. humilis*).

Global distribution. Palaearctic species with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Xinjiang, Neimenggu, Heilongjiang, Liaoning, Hebei, Shanxi, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Fig. 219) with a short seasonal activity period (Fig. 215): 25 queens, 50 workers, 1 male, 3200–3836 m (BMNH, IZB, PHW, SAC, TY). Literature records: Wang (1992a).

SCR variation. This species lacks a black spot on the thoracic dorsum in the central southern part of its distribution (around Turkey and the Tien Shan), but has the black pubescence in the west, north, and east (Reinig, 1939: abb. 17), including Sichuan. Three workers from near Hongyuan (PHW) show a stronger melanic tendency, with the thoracic dorsum predominantly black (Fig. 57). This melanic tendency in the colour form from Sichuan has not been described previously and is described briefly here:

Queens head with black and straw-yellow hairs intermixed, the darker specimens with few yellow hairs. Thorax predominantly straw yellow with a patch of black hairs between the wing bases, which varies from a spot occupying a third of the length of the thorax and completely surrounded by yellow, to covering three quarters of the dorsum leaving only yellow anterior and posterior bands; underside of the thorax and leg bases varying from yellow to dark brownish; corbicular fringes yellow with black hairs intermixed. Metasomal terga 1–5 straw yellow, with black hairs intermixed anteriorly on terga 3–5; tergum 6 black; sternal fringes brownish yellow.

Workers similar to queen, but often with more black hair on the thoracic dorsum. The darkest specimen has the head and thorax almost completely black, a few brownish yellow hairs intermixed, particularly at the posterior margin of the thorax; the metasoma with black hair in the anterior half of all terga, the posterior pale hair a dull brownish yellow; sternal fringes brownish.

Males pubescence of the head black with pale yellow on the clypeus and on the dorsum of the head. Thorax predominantly pale yellow, with a transverse black band between the wing bases and black on the underside and leg bases. Metasomal terga 1–6 pale yellow, with varying numbers of black hairs intermixed anteriorly on terga 4–6; tergum 7 black; sternal fringes yellowish.

SCR food plants. Medium tongue-length species: (Asteraceae) *Saussurea* sp., *Taraxacum* sp.; (Ranunculaceae) *Aconitum gymnandrum*, *Delphinium* sp.; (Scrophulariaceae) *Pedicularis alaschanica* Maxim., *P. kansuensis* Maxim., *P. longiflora* Rudolph, *P. plicata* Maxim., *P. polyodonta*, *P. spicata*, *P. szetschuanica*, *P. verticillata*.

17. *Bombus (Thoracobombus) filchnerae* Vogt (Figs 53, 148, 220, 224)

Bombus Filchnerae Vogt, 1908:100, lectotype worker (Tkalčú, 1974b: 39) MNHU examined. China: Gansu.

Agrabombus adventor Skorikov, 1914: 119, type not seen. Synonymised with *Megabombus filchnerae* (Vogt) by Tkalčú (1974b). Mongolia.

Bombus (Agrobombus) lii Tkalčú, 1961: 355, type not seen. Synonymised with *Megabombus filchnerae* (Vogt) by Tkalčú (1974b). China: Qinghai.

Bombus filchnerae Vogt; Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *muscorum*-group of species.

Diagnosis. Small species. *Female* (length of queens 15–16 mm, workers 11–15 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine; oculo-malar distance approximately 1.4 times the proximal breadth of the mandible (cf. *B. securus*); ocello-ocular area with many small punctures in the outer half along the eye margin (cf. *B. laesus*, *B. humilis*); hair (Fig. 53) of the face black with some very short yellow hairs intermixed, thorax with yellow bands anteriorly and posteriorly with very few black hairs intermixed, the black band between the wing bases with distinct and parallel sides, corbicular fringes black or with a few pale tips, metasomal terga 1–5 yellow without black, tergum 6 black (cf. *B. laesus*, *B. humilis*); wings light brown.

Male (length 10–15 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 148) with the penis valve with a small distal weakly flared head, with a proximal tooth (cf. *B. securus*); gonostylus with a broad inner proximal process that narrows distally to an acute spine (cf. *B. laesus*, *B. humilis*); volsella densely hairy and projecting beyond gonostylus by less than the length of the gonostylus, the distal corner of the volsella broadly rounded, the inner hooks forming a short stump, each hook reduced to an acute tooth at one corner of the stump (cf. *B. laesus*, *B. humilis*).

Global distribution. Species of the eastern Palaearctic region with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Neimenggu, Qinghai, Gansu, Sichuan, Shanxi).

SCR material examined. Common at high altitudes of the northwestern and western plateau (Fig. 224) with a short seasonal activity period (Fig. 220): 4 queens, 99 workers, 16 males, 3400–3880 m (BMNH, INHS, IZB, PHW, SAC, TY). Literature records: Macior and Tang (1997).

SCR food plants. Medium tongue-length species: (Asteraceae) *Cirsium* sp., *Saussurea* sp.; (Gentianaceae) *Gentiana* sp., *Halenia elliptica*; (Leguminosae) *Oxytropis* sp.; (Ranunculaceae) *Aconitum gymnandrum*, *Delphinium* sp.; (Scrophulariaceae) *Pedicularis alaschanica* Maxim., *P. kansuensis* Maxim., *P. longiflora* Rudolph, *P. plicata* Maxim., *P. polyodonta*, *P. spicata*, *P. szetschuanica*, *P. verticillata*.

18. *Bombus (Thoracobombus) humilis* Illiger (Figs 50–51, 149, 221, 225)

Apis fulvescens Schrank, 1802: 367. *Nomen oblitum*. Germany.

Bombus humilis Illiger, 1806: 171, holotype worker MNHU examined. Synonymised provisionally with *Apis fulvescens* Schrank by Warncke (1986). *Nomen protectum*. Germany.

Bombus (Agrobombus) helperanus var. *subbaicalensis* Vogt, 1911: 42, 54, 10 queen and 1 worker syntypes ZMA examined. Regarded as conspecific with *Megabombus humilis* (Illiger) by Tkalců (1974b). Russia: ?Primorskiy Krai.

This species belongs to the *muscorum*-group of species.

Nomenclature. Warncke (1986) recognised *Bombus fulvescens* (Schrank) as questionably conspecific with *Bombus humilis*, and although we have seen no type material, Schrank's description is consistent with this interpretation. *Bombus fulvescens* is therefore likely to be the oldest available name for this species. Warncke (1986: 98) followed the listing of the name with 'Art. 23b', which is a reference to purpose of the Principle of Priority (ICZN, 1985). Following this lead, Williams (1998) suggested an application be made to the Commission to use its plenary power to suppress the unused senior synonym (ICZN, 1985: Article 79). However, the fourth edition of the Code (ICZN, 1999) requires that prevailing usage must be maintained if the conditions for reversal of precedence are met (Article 23.9.1). In accordance with these conditions, we are unaware of any publications that have used the name *Bombus fulvescens* (Schrank) for this species since 1899 (Article 23.9.1.1), and we believe that the name *Bombus humilis* has been in common use for the species since 1899 (e.g. case and references in Løken *et al.*, 1994) (Article 23.9.1.2). Therefore we consider *Bombus humilis* to be the valid name for this species.

Diagnosis. Small species. *Female* (length of queens 14–15 mm, workers 9–11 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine; oculo-malar distance approximately 1.2 times the proximal breadth of the mandible (cf. *B. securus*); ocello-ocular area with many large punctures in the outer half along the eye margin (cf. *B. laesus*, *B. filchnerae*); hair (Figs 50–51) of the face yellow with a few black hairs intermixed, thorax with indistinct yellow bands anteriorly and posteriorly, with many black hairs intermixed, the black band between the wing bases broad, corbicular fringes mostly yellow, metasomal terga 1–4 yellow, tergum 5 black anteriorly with a posterior yellow fringe, tergum 6 black (cf. *B. laesus*, *B. filchnerae*); wings light brown.

Male [from specimens from Austria] (length 12–13 mm) expected to be similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 149) with the penis valve with a small distal weakly flared head, with a proximal tooth (cf. *B. securus*); gonostylus with a broad almost rectangular inner proximal process forming an inner right angle with only a small pointed corner (cf. *B. laesus*, *B. filchnerae*); volsella projecting beyond the gonostylus by less than the length of the gonostylus,

the distal corner of the volsella spinosely produced inwards (cf. other SCR *Thoracobombus* species), the inner hooks forming a short stump, the distal hook forming a spine and the proximal hook forming a blunt tooth (cf. *B. laesus*, *B. filchnerae*).

Global distribution. Widespread Palaearctic species with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Xinjiang, Neimenggu, Heilongjiang, Jilin, Hebei, Beijing, Shanxi, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern plateau (Fig. 225) with a short seasonal activity period (Fig. 221): 2 queens, 17 workers, 3010–3880 m (BMNH, LWM, PHW, SAC, TY). New record for the SCR.

SCR food plants. Medium tongue-length species: (Asteraceae) *Saussurea* sp.; (Ranunculaceae) *Delphinium* sp.; (Scrophulariaceae) *Pedicularis szetschuanica*.

SCR variation. Individuals from Sichuan have the pale hair of the head and thorax distinctly yellow, in contrast to the grey hair (the '*subbaicalensis*' pattern) of individuals from north of the Gobi Desert in Mongolia and in the Russian far east. The yellow individuals from Sichuan are more similar to the colour form from Iran, to the west.

19. *Bombus (Thoracobombus) hedini* Bischoff (Figs 46, 150, 222, 226)

Bombus silvarum ssp. *unicolor* Friese, 1905: 514 (not of Kriechbaumer, 1870: 159 = *B. maxillosus* Klug), lectotype worker (Tkalců, 1968c: 49) MNHU examined. China: 'Sz'-tschwan', but probably Neimenggu (see Note below).

Bombus (Agrobombus) hedini Bischoff, 1936: 15 (not of Bischoff, 1936: 25 = *B. bohemicus* Seidl), type not seen. Synonymised with *Megabombus unicolor* (Friese) by Tkalců (1968c). China: Gansu.

This species belongs to the *muscorum*-group of species.

Nomenclature. Tkalců (1968c) designated as lectotype of *Bombus silvarum* ssp. *unicolor* (p. 49) one of the workers described by Friese (1905: 514) as having been collected by Potanin from 'vall. Kussör, Tschüti-[to]-Kuerrkou', supposedly from 'Sz'-tschwan'. The closest match I can find for any of these place names given by Friese from the account of Potanin's itinerary by Beresovskii and Bianchi (1891) is a reference to Khe-kou (cf. 'Kuerrkou'), which is described as a village near the Yellow River (Huang He) at the edge of the Ordos plateau. In addition, Rayfield's (1976) itinerary account mentions a 'Kuku Khoto (Hu-ho-hao-t'e)' near Ordos and shows it (page *x*) in the location of modern Hohhot, in Neimenggu.

The name *Bombus unicolor* Friese is a junior secondary homonym in *Bombus* of *Psithyrus maxillosus* var. *unicolor* Kriechbaumer. Following the Principle of First Reviser (ICZN, 1985: Article 24), and as the first author to regard *Psithyrus distinctus* ssp. *hedini* Bischoff (1936: 25) and *Bombus hedini* Bischoff (1936: 15) as congeneric, Williams (1998: 109) selected the name *Bombus hedini* as the valid name for this

species. While the name *Bombus unicolor* had been used by Panfilov (1957), Tkalčú (1968a, 1968c), and Sakagami (1972), the name *Bombus hedini* has been used for this species by Bischoff (1936), Yasumatsu (1951) and Tkalčú (1961).

Diagnosis. Small species. *Female* (length of queens 17 mm, workers 10–11 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine or acutely and sharply pointed; oculo-malar distance approximately 1.2 times the proximal breadth of the mandible; hair (Fig. 46) of the thoracic dorsum and of metasomal terga 1–6 orange-brown (cf. other SCR *Thoracobombus* species, except *B. atripes*), lower sides of the thorax paler (cf. *B. atripes*, and *B. hedini* from northern China); wings mid brown.

Male (length 12 mm) similarly coloured; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 150) with the penis valve with a small distal flared head; gonostylus with the distal margin curved strongly inwards, the inner distal corner a right angle or strongly acute, the triangular inner proximal process narrowed to a sharp point (cf. *B. impetuus*, *B. remotus*, *B. atripes*); volsella projecting beyond the gonostylus by less than the length of the gonostylus, the distal corner of the volsella acutely produced inwards but the apex narrowly rounded, the inner hooks forming a short toothed stump.

Global distribution. Oriental species: northeastern China (Neimenggu, Jilin, Beijing, Hebei, Shanxi, Gansu, Sichuan).

SCR material examined. Uncommon at low altitudes of the northern and northwestern foothills of the Sichuan basin (Figs 222, 226); 2 queens, 19 workers, 6 males, 1360–1912 m (IZB, PHW, SAC, USNM). Literature records: Friese (1905).

SCR food plants. Medium tongue-length species: (Asteraceae) *Arctium* sp.

20. *Bombus (Thoracobombus) remotus* (Tkalčú) (Figs 43–45, 70, 151, 223, 227)

Megabombus (Agrobombus) remotus Tkalčú, 1968c: 45, holotype queen BMNH examined. China: Sichuan.

Bombus (Thoracobombus) remotus (Tkalčú); Yao, 1995: 579. Change in generic combination. China: Sichuan.

Bombus (Thoracobombus) remotus (Tkalčú); Yao & Luo, 1997: 1687; Yin *et al.*, 2001: 753. China: Sichuan.

This species belongs to the *muscorum*-group of species.

Diagnosis. Small species. *Female* (length of queens 14–17 mm, workers 9–14 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine (cf. *B. picipes*, *B. infrequens*); oculo-malar distance approximately 1.3 times the proximal breadth of the mandible; for larger females (Fig. 70), the hair of the thoracic dorsum is yellow with black hairs intermixed but concentrated between the wing bases in a more or less distinct band (cf. other SCR *Thoracobombus* species), metasomal terga 1–2 yellow (cf. *B. funerarius*, *B. grahami*), tergum 3 black anteriorly, often with a posterior yellow fringe, tergum 4 black anteriorly and with a posterior

orange fringe, tergum 5 orange; smaller workers (Figs 44–45) have the thorax greyish, with yellow and black hairs intermixed throughout; the smallest workers (Fig. 43) tending to appear only indistinctly banded and generally greyish, or greyish yellow, intermixed with black; wings mid brown.

Male (length 10–12 mm) similar to the smaller workers, with black intermixed on the thoracic dorsum and on terga 3–5, terga 5–7 orange; compound eye unenlarged relative to the female and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 151) with the penis valve with a small distal flared head (cf. *B. picipes*, *B. infrequens*, *B. grahami*); gonostylus with the distal margin nearly straight, the inner distal corner acute (by an angle of approximately 60°), the triangular inner proximal process narrowed to a sharp point (cf. *B. impetuus*, *B. hedini*); volsella projecting beyond the gonostylus by less than the length of the gonostylus (cf. *B. funerarius*), the distal corner of the volsella acutely produced inwards but the apex narrowly rounded, the inner hooks forming a short toothed stump.

Global distribution. Oriental species: eastern fringes of the Tibetan plateau and central China (Shanxi, Shaanxi, Hubei, Gansu, Sichuan, Yunnan).

SCR material examined. Common at medium altitudes of the northwestern, western, southwestern, and eastern mountains (Fig. 227) with a medium-length seasonal activity period (Fig. 223): 8 queens, 92 workers, 39 males, 1200–4021 m (AMNH, BMNH, IZB, PHW, SAC, TY). Literature records: Tkalčú (1968c), Yao (1995), Yao and Luo (1997), Yin *et al.* (2001).

SCR variation. This species shows size-dependent variation in the colour of the thorax and of metasomal tergum 3 among females, which is expressed most obviously as a difference between queens and workers (see above).

SCR food plants. Medium tongue-length species: (Asteraceae) *Saussurea* sp.; (Dipsacaceae) *Dipsacus inermis*; (Lamiaceae) *Leonurus japonicus* Houtt., *Phlomis* sp., *Salvia* sp.; (Lythraceae) *Lagerstroemia* sp.; (Scrophulariaceae) *Pedicularis melampyriflora*, *P. verticillata*.

21. *Bombus (Thoracobombus) impetuus* Smith (Figs 78–80, 152, 228, 232)

BOMBUS IMPETUOSUS Smith, 1871: 249, lectotype queen (Tkalčú, 1987: 61) BMNH examined. China: Yunnan.

Bombus Potanini Morawitz, 1890: 350, type ZISP not found (Y. Pesenko, *in litt.*). Synonymised provisionally with *Bombus impetuus* Smith by Williams (1998). China: ‘Kanssu’, but probably Qinghai.

[*Bombus potaninii* Morawitz; Dalla Torre, 1896: 541, incorrect subsequent spelling.]

[*Bombus potanini* var. *grumiellus* Skorikov, 1912: 607, infrasubspecific.]

Bombus silvarum var. *subrufescens* Friese, 1913: 87, holotype male MNHU examined. Synonymised with *Megabombus potanini* (Morawitz) by Tkalčú (1987). China: ‘Tibet’, ?Xizang.

Bombus (Agrobombus) yunnanensis Bischoff, 1936: 14, lectotype queen (Tkalců, 1987: 61) MNHU examined. Synonymised with *Megabombus impetuosus* (Smith) by Tkalců (1987). China: Yunnan.

Bombus (Diversobombus) impetuosus Smith; Panfilov, 1957: 235. China: Sichuan.

Bombus (Agrobombus) combai Tkalců, 1961: 357, type not seen. Synonymised with *Megabombus potanini* (Morawitz) by Tkalců (1987). China: Qinghai.

Bombus (Thoracobombus) yunnanensis Wang, 1982a: 442, unjustified emendation. China: Xizang.

Bombus (Thoracobombus) yunnanensis Wang; Wang, 1992a: 1429. China: Sichuan.

Bombus potanini Morawitz; Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *muscorum*-group of species.

Taxonomic status. The white-banded *B. potanini* is morphologically indistinguishable from the yellow-banded *B. impetuosus*. Many individuals from northwestern Sichuan are intermediate in colour pattern in that they have the pale bands of the thorax and of metasomal tergum 1 more yellowish-white. The yellow form is more common among males, which is consistent with simple dominance between yellow and white alleles at a single locus. There is considerable variation in the male gonostylus, but this variation appears to overlap between the colour forms. They are treated here as parts of a single variable species.

Diagnosis. Small species. *Female* (length of queens 13–14 mm, workers 9–13 mm) with the mid basitarsus with the distal posterior corner produced as a sharp spine (cf. *B. lepidus*, *B. kashmirensis*); oculo-malar distance approximately 1.2 times the proximal breadth of the mandible; hair (Figs 78–80) of the head grey-white or yellow with long black hairs intermixed at least on the dorsum, thorax with distinct grey-white or yellow bands anteriorly (with black hairs intermixed) and posteriorly, particularly if the bands are white then the posterior band often pinched in the middle with a narrow posteriorly-directed black ‘V’, the sides of the thorax white (cf. *B. braccatus*, *B. trifasciatus*, *B. bicoloratus*, *B. imitator*) or yellow, without black hairs below and behind the wing bases (cf. *B. lepidus*, *B. friseanus*), corbicular fringes white, yellow or black, metasomal tergum 1 grey-white or yellow, tergum 2 yellow at least anteriorly in the middle (Fig. 79) and often almost throughout (Figs 78, 80), the posterior fringe usually orange, with black hairs varying from intermixed in two posterior lateral patches to occupying all of the posterior and lateral areas, terga 3–5 orange (cf. *B. supremus*, *B. rufofasciatus*); wings light brown.

Male (length 10–13 mm) similarly coloured, but relatively more frequently yellow-banded than white-banded; compound eye unenlarged relative to the female (cf. *B. rufofasciatus*) and the antenna long, reaching posteriorly to the wing bases; genitalia (Fig. 152) with the penis valve with a small distal flared head (cf. *B. supremus*, *B. lepidus*, *B. kashmirensis*); gonostylus with the distal margin nearly straight, the inner distal corner obtuse or right-angled, the broad triangular inner

proximal process narrowed to a sharp point (cf. *B. remotus*, *B. hedinii*); volsella projecting beyond the gonostylus by less than the length of the gonostylus, the distal corner of the volsella acutely produced inwards but the apex narrowly rounded, the inner hooks forming a short-toothed stump.

Global distribution. Oriental species: eastern Tibetan plateau and southern China (Ningxia, Gansu, Sichuan, Qinghai, Xizang, Yunnan, Guizhou).

SCR material examined. Common at medium altitudes of the northwestern, western and southwestern plateau and mountains (Fig. 232) with a medium-length seasonal activity period (Fig. 228): 54 queens, 233 workers, 47 males, 900–4396 m (BMNH, INHS, IZB, LWM, PHW, SAC, TY, USNM). Literature records: Panfilov (1957), Wang (1992a), Macior and Tang (1997).

SCR variation. Both the white-banded form (the ‘*potanini*’ pattern, Fig. 80) and the yellow-banded form (the ‘*impetuosus*’ pattern, Figs 78, 79) occur together in the northwest of Sichuan around Zhegushan, and together with some intermediate, cream-banded individuals. The higher frequency of yellow bands in (haploid) males than in (diploid) females is consistent with simple dominance of a white allele over a yellow (recessive) allele at a single locus controlling the pale band colour. In the south of Sichuan around Luoishan, the yellow-banded form with metasomal tergum 2 mostly black (Fig. 79, the ‘*impetuosus*’ s. str. pattern) occurs alone. Individuals from intermediate areas (e.g. around Kangding) show intermediate amounts of black hair on metasomal tergum 2.

SCR food plants. Medium tongue-length species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp., *Saussurea* sp.; (Bignoniaceae) *Incarvillea* sp.; (Dipsacaceae) *Dipsacus inermis*; (Gentianaceae) *Halenia elliptica*; (Lamiaceae) *Ajuga* sp., *Salvia* sp., *Scutellaria* sp., *Stachys* sp.; (Leguminosae) *Astragalus* sp., *Oxytropis* sp., *Parochetus communis* Buch.-Ham. ex D. Don; (Lythraceae) *Lagerstroemia* sp.; (Ranunculaceae) *Aconitum gymnandrum*, *Delphinium* sp.; (Scrophulariaceae) *Pedicularis alopecuroides* Franch. ex Maxim., *P. anas* Maxim., *P. bidentata* Maxim., *P. chenocephala*, *P. cranolopha*, *P. densispica*, *P. floribunda* Franch., *P. kansuensis*, *P. lachnoglossa* Hook. f., *P. melampyridiflora*, *P. oxycarpa* Franch. ex Maxim., *P. rex*, *P. rhinanthoides* Schrenk, *P. roylei*, *P. szetschuanica*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*; (Verbenaceae) *Verbena* sp.

Subgenus *PSITHYRUS* Lepeletier

Species of the subgenus *Psithyrus* are social parasites in colonies of other species of the genus *Bombus* and lack workers.

22. *Bombus (Psithyrus) cornutus* (Frison) (Figs 11, 16, 153, 229, 233)

Psithyrus (Psithyrus) cornutus Frison, 1933: 338, type not seen. India.

Psithyrus (Psithyrus) pyramideus Maa, 1948: 19, paratype male IZB examined. Regarded as conspecific with *Psithyrus cornutus* Frison by Tkalců (1989). China: Fujian.

Psithyrus (Psithyrus) acutisquameus Maa, 1948: 21, holotype male IZB examined. Synonymised with *Psithyrus cornutus* ssp. *pyramideus* Maa by Tkalců (1989). China: Anhui.

Psithyrus (Ceratopsithyrus) klapperichi Pittioni, 1949: 273 (not of Pittioni, 1949: 266 = *B. picipes* Richards), paratype female BMNH examined. Synonymised with *Psithyrus cornutus* ssp. *pyramideus* Maa by Tkalců (1989). China: Fujian.

Psithyrus (Eopsithyrus) cornutus ssp. *canus* Tkalců, 1989: 42 (not of Schmiedeknecht, 1883: 359 = *B. pomorum* (Panzer)), paratype female MNHU examined. China: Yunnan.

Bombus (Psithyrus) cornutus (Frison); Williams, 1991: 45. Change in generic combination.

Psithyrus cornutus Frison; Yao, 1995: 580, 1998: 404; Yao and Luo, 1997: 1694. China: Sichuan.

This species belongs to the *rupestris*-group of species.

Nomenclature. Although it has not been possible to examine the holotype female of *Psithyrus cornutus*, said to be in the 'Indian Museum, Calcutta', the identity of this taxon appears clear from the original description.

Diagnosis. Medium-sized species. *Female* (length 14–19 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting very strongly above the apex of the labrum as a broad triangle with a sharply pointed right angle at the apex between its converging lateral margins, the lateral tubercles at its base forming pointed pyramidal projections, the labral furrow occupying at least one third of the breadth of the labrum (Frison, 1933: Fig. 4a; Tkalců, 1989: Abb. 3–4) (cf. all other *Psithyrus* species e.g. *B. turneri*, *B. expolitus*); metasomal sternum 6 with lateral keels that are strongly swollen, each of which is 'V'-shaped in profile and with a 'V'-shaped angle between them posteriorly, but not visible from the dorsal aspect (Frison, 1933: Fig. 4e; Tkalců, 1989: Abb. 11); hair (Figs 11, 16) of the thorax with yellow or grey-white bands anteriorly and posteriorly (cf. *B. bohemicus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), in the palest individuals with yellow hairs intermixed throughout the thoracic dorsum, in the darkest individuals with black hairs intermixed throughout the anterior band, metasomal terga 1–2 yellow or grey-white (matching the thorax), but if grey-white then tergum 2 has black hairs at least laterally and often throughout at least the posterior half (Fig. 11), tergum 3 black at least in part, terga 4–5 bright orange-red; wings mid brown.

Male (length 13–14 mm) similarly coloured, but with tergum 3 yellow and/or black, tergum 4 black often with an orange posterior fringe; genitalia (Fig. 153) with the gonostylus and volsella (to a lesser extent) moderately sclerotised, pale, and not thickened (cf. *B. expolitus*), and the gonostylus densely hairy (cf. non-*Psithyrus* species), narrowing gradually from near its inner projection towards its outer margin (cf. *B. turneri*); penis valve with the ventro-lateral angle strongly projecting and broad, forming almost a right angle distally (cf. *B. turneri*, *B. tibetanus*); volsella proximally with only weak, curved, inwardly projecting swelling (cf. *B. turneri*, *B. tibetanus*), volsella near its mid point marked only by a broad

curve, not strongly produced inwards as an inner projection (cf. *B. chinensis*, *B. branickii*, *B. rupestris*).

Global distribution. Oriental species: Himalaya and central China (Yunnan, Sichuan, Gansu, Shaanxi, Shanxi, Hunan, Guizhou, Fujian, Zhejiang, Anhui).

SCR material examined. Uncommon at low altitudes of the southwestern mountains and of the foothills surrounding the Sichuan basin (Figs 229, 233): 15 females, 22 males, 858–4067 m (IZB, JAB, PHW, SAC, TY, USNM, ZMMU, ZMA). Literature records: Yao (1995, 1998), Yao and Luo (1997).

SCR variation. Most females (IZB) have the pale bands at the anterior and posterior of the thorax and on metasomal terga 1–2 dull yellow with an orange-red tail (the 'pyramideus' pattern, Fig. 16). Four females from Emeishan (JAB, PHW, ZMMU) have the pale bands at the anterior and posterior of the thorax and on tergum 1 grey-white (the 'canus' pattern, Fig. 11). There is also variation in the distal breadth of the male gonocoxa, the significance of which needs to be assessed.

SCR food plants. No records.

SCR host species. No records, but suggested to include *B. trifasciatus* (Maa, 1948).

23. *Bombus (Psithyrus) expolitus* (Tkalců) (Figs 22, 154, 230, 234)

Psithyrus (Eopsithyrus) expolitus Tkalců, 1989: 44, holotype female MNHU examined. 'Turkestan Kashgar', believed incorrect.

Bombus (Psithyrus) expolitus (Tkalců); Williams, 1998: 104. Change in generic combination.

This species belongs to the *rupestris*-group of species.

Diagnosis. Medium-sized species. *Female* (length 17–18 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting very strongly above the apex of the labrum as a broad triangle with a slightly rounded apex, the lateral tubercles at its base reduced to small rounded traces, the labral furrow indistinct (Tkalců, 1989: Abb. 9) (cf. all other *Psithyrus* species e.g. *B. cornutus*, *B. turneri*); metasomal sternum 6 with lateral keels that are strongly swollen, each of which is 'V'-shaped in profile, but not visible from the dorsal aspect (Tkalců, 1989: Abb. 11); hair (Fig. 22) of the thorax with nearly equally broad (measured longitudinally) yellow bands anteriorly and posteriorly (cf. *B. bohemicus*, *B. turneri*, *B. tibetanus*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal terga 1–2 yellow, tergum 3 black, tergum 4 anteriorly black and posteriorly hairs brownish with pale whitish tips, tergum 5 hairs brownish with pale whitish tips; wings light brown.

Male (length 15 mm) with the hair of the thorax with a yellow band anteriorly and sometimes posteriorly, otherwise posteriorly and on the underside with pale-tipped hairs (cf. *B. tibetanus*), metasomal terga 1–2 yellow, terga 3–7 black with white tips; genitalia (Fig. 154) with the gonostylus and

volsella strongly sclerotised, the volsella thickened (dark, cf. *B. tibetanus*), the gonostylus densely hairy (cf. non-*Psithyrus* species) and reduced to a very short transverse band; penis valve with the ventro-lateral angle strongly projecting and distally broad, forming a right angle distally (cf. *B. turneri*, *B. tibetanus*); volsella proximally with a large inwardly projecting swelling that is broad and rectangular (cf. *B. tibetanus*), volsella near its mid point marked only by a broad curve, not strongly produced inwards as an inner projection (cf. *B. chinensis*, *B. branickii*, *B. rupestris*).

Global distribution. Oriental species: eastern Tibetan plateau (Sichuan, Xizang).

SCR material examined. Uncommon at medium altitudes of the northwestern and western plateau (Figs 230, 234): 4 females, 11 males, 2500–4396 m (IZB, PHW). Literature records: Tkalců (1989).

SCR food plants. (Asteraceae) *Saussurea* sp.; (Ranunculaceae) *Delphinium* sp.

SCR host species. No records.

24. *Bombus (Psithyrus) tibetanus* (Morawitz) (Figs 21, 155, 231, 235)

Apathus tibetanus Morawitz, 1887: 202, lectotype female (Pesenko, 2000: 20) ZISP examined. China: ‘Bassin des gelben Flusses,’ probably Qinghai.

Bombus (Psithyrus) tibetanus (Morawitz); Williams, 1991: 45. Change in generic combination.

This species belongs to the *rupestris*-group of species.

Diagnosis. Medium-sized species. *Female* (length 15–16 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting distinctly above the apex of the labrum as a small acute triangle, almost as a narrow median tooth, the lateral tubercles at its base raised as pointed pyramidal projections (cf. *B. cornutus*), the labral furrow occupying slightly less than one third of the breadth of the labrum; metasomal sternum 6 with lateral keels, which are swollen and form one continuous U-shape, but which are not visible from the dorsal aspect (cf. all other *Psithyrus* species e.g. *B. cornutus*); hair (Fig. 21) of the thorax with a broad yellow band anteriorly and a narrow yellow band posteriorly (cf. *B. bohemicus*, *B. exopolitus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal terga 1–2 yellow, tergum 3 black, terga 4–5 hairs predominantly dull orange-brown with pale whitish tips; wings light brown.

Male (length 12–14 mm) with the hair of the thorax with a yellow band anteriorly, black posteriorly and on the underside (cf. *B. exopolitus*), metasomal terga 1–2 yellow, terga 3–7 black, often with white tips on terga 5–7; genitalia (Fig. 155) with the gonostylus and volsella weakly sclerotised (pale, cf. *B. exopolitus*), the gonostylus densely hairy (cf. non-*Psithyrus* species) and reduced to a very short transverse band; penis valve with the ventro-lateral angle strongly projecting and distally narrowed so that it is almost spinose (cf. *B. cornu-*

tus, *B. exopolitus*); volsella proximally with a large inwardly projecting swelling that is broadly triangular (cf. *B. cornutus*, *B. exopolitus*, *B. turneri*), volsella near its mid point marked only by a broad curve, not strongly produced inwards as an inner projection (cf. *B. chinensis*, *B. branickii*, *B. rupestris*).

Global distribution. Oriental species: eastern Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan, Yunnan).

SCR material examined. Uncommon at medium altitudes of the northwestern, western and southwestern mountains (Figs 231, 235): 3 females, 18 males, (?800–) 3040–4396 m (IZB, PHW, SAC, TY). Three males (IZB) labelled Dujiangyan and Qingchengshan with unusually low altitude data (800 m, 1000 m) may be based on only approximate locations and need to be confirmed, but are shown in the activity plot and map. New record for the SCR.

SCR food plants. (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Saussurea* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Delphinium* sp.

SCR host species. No records.

25. *Bombus (Psithyrus) turneri* (Richards) (Figs 19, 156, 236, 240)

Psithyrus turneri Richards, 1929: 141, holotype male BMNH examined. India.

Psithyrus (Eopsithyrus) decoomani Maa, 1948: 26, holotype male IZB examined. Synonymised with *Psithyrus turneri* Richards by Tkalců (1974a). China: Zhejiang.

Psithyrus (Eopsithyrus) martensi Tkalců, 1974a: 314, holotype female NMS examined. Synonymised provisionally with *Bombus turneri* (Richards) by Williams (1998) confirmed here. Nepal.

Bombus (Psithyrus) turneri (Richards); Williams, 1991: 52. Change in generic combination.

Psithyrus turneri Richards; Yao and Luo, 1997: 1695. China: Sichuan.

This species belongs to the *rupestris*-group of species.

Diagnosis. Small species. *Female* [based on a specimen from Anhui] (length 16 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting strongly above the apex of the labrum as a broad, rounded triangle, the lateral tubercles at its base forming pointed pyramidal projections, the labral furrow occupying between one third and one half of the breadth of the labrum (Tkalců, 1974b: Abb. 3–4); metasomal sternum 6 with lateral keels that are strongly swollen and each of which is broadly ‘V’-shaped in profile, but not visible from the dorsal aspect (Tkalců, 1974b: Abb. 8); hair (Fig. 19) of the thorax black with yellow hairs sparsely intermixed anteriorly, posteriorly and on the sides (cf. *B. bohemicus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal terga 1–2 yellow, tergum 3 yellow but with black laterally, tergum 4 black anteriorly and red posteriorly, tergum 5 red; wings mid brown.

Male (length 12–14 mm) with the hair of the thorax and tergum 3 black, sometimes with greyish bands anteriorly,

posteriorly, and on the sides of the thorax, terga 1–2 yellow, terga 4–7 orange-red; genitalia (Fig. 156) with the gonostylus and volsella weakly sclerotised and pale (cf. *B. expolitus*), the gonostylus densely hairy (cf. non-*Psithyrus* species), narrowing gradually from near its outer margin towards its inner projection (cf. *B. cornutus*); penis valve with the ventro-lateral angle strongly projecting and narrowed and pointed, like a shark's fin (cf. *B. cornutus*, *B. expolitus*, *B. tibetanus*); volsella proximally with a large inwardly projecting swelling that is irregular but nearly rectangular (cf. *B. cornutus*, *B. tibetanus*), volsella near its mid point marked only by a broad curve, not strongly produced inwards as an inner projection (cf. *B. chinensis*, *B. branickii*, *B. rupestris*).

Global distribution. Oriental species: Himalaya, eastern Tibetan plateau, and central China (Qinghai, Sichuan, Guangxi, Guizhou, Anhui, Zhejiang).

SCR material examined. Rare at medium altitudes of the northwestern, western, and eastern mountains (Figs 236, 240): 4 males, 1450–1870 (–?3850) m (IZB, PHW). Two males (IZB, PHW) with unusually high altitude data (3600 m, 3850 m) from Hongyuan and Zhegushan need to be confirmed, but are shown in the activity plot and map. Literature records: Yao and Luo (1997).

SCR food plants. No records.

SCR host species. No records.

26. *Bombus (Psithyrus) chinensis* (Morawitz) (Figs 12, 17, 157, 237, 241)

Apathus rupestris var. *chinensis* Morawitz, 1890[April 30]: 352 (not of Dalla Torre, 1890[June 25]: 139 = *B. rufofasciatus* Smith), holotype female ZISP examined. China: 'Kanssu', but probably Qinghai.

Psithyrus morawitzi Friese, 1905: 516 (not of Radoszkowski, 1876: 101 = *B. morawitzi* Radoszkowski), paralectotype female (Pesenko, 2000: 14; see also Tkalců, 1987: 59) MNHU examined. Regarded as conspecific with *Psithyrus chinensis* (Morawitz) by Tkalců (1987). China: Sichuan.

Psithyrus (Psithyrus) chinensis (Morawitz); Bischoff, 1936: 26. China: Sichuan.

Psithyrus (Psithyrus) chinensis ssp. *hōnei* Bischoff, 1936: 26 (not of Bischoff, 1936: 10 = *B. friseanus* Skorikov), lectotype female (Tkalců, 1987: 59) MNHU examined. China: Yunnan.

Bombus (Psithyrus) chinensis (Morawitz); Williams, 1991: 47. Change in generic combination.

This species belongs to the *rupestris*-group of species.

Diagnosis. Medium-sized species. *Female* (length 17–18 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting only indistinctly above the apex of the labrum, broadly rounded, the lateral tubercles at its base strongly raised as rounded pyramidal projections, the labral furrow occupying approximately one third of the breadth of

the labrum; metasomal sternum 6 with lateral keels that are strongly swollen, each of which is 'V'-shaped in profile and clearly visible from the dorsal aspect (cf. all *Psithyrus* species except *B. branickii*, *B. rupestris*); hair (Figs 12, 17) of the thorax with pale bands anteriorly and posteriorly that are usually yellow (Fig. 17), or sometimes white (Fig. 12) intermixed with black (cf. *B. bohemicus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal tergum 1 yellow, or black if the thoracic bands are white, tergum 2 mostly black (cf. *B. cornutus*, *B. tibetanus*, *B. expolitus*), terga 3–5 usually mostly orange-red; wings light brown.

Male (length 13–15 mm) with the hair of the thorax with yellow or white bands anteriorly and posteriorly, metasomal tergum 1 yellow or white, tergum 2 yellow or black, tergum 3 black or orange-red or both, terga 4–7 orange-red; genitalia (Fig. 157) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle strongly projecting and distally narrowed so that it is almost spinose (cf. *B. cornutus*, *B. expolitus*); volsella in the distal part beyond the inner corner forming a broad, almost equilateral triangle with the distal inner margin almost straight when viewed perpendicularly to the dorsal surface (cf. *B. branickii*, *B. rupestris*, *B. cornutus*, *B. tibetanus*, *B. expolitus*, *B. turneri*).

Global distribution. Oriental species: eastern fringes of the Tibetan plateau and central China (Xizang, Qinghai, Yunnan, Sichuan, Shaanxi).

SCR material examined. Uncommon at high altitudes of the northwestern and western mountains (Figs 237, 241): 8 females, 21 males, 2890–4396 m (IZB, PHW, SAC, TY). Literature records: Friese (1905), Bischoff (1936) [a female with unusually low altitude data from Langzhong ('Pao-Ning-Fu') needs to be confirmed, and is not shown in the activity plot, but is shown on the map].

SCR variation. Some females and males (IZB, PHW) have the pale bands at the anterior and posterior of the thorax and on metasomal tergum 1 yellow (the '*morawitzi*' and '*hōnei*' [mandatory correction of an umlaut: ICZN, 1999: Article 32.5.2.1] patterns, Fig. 17). Other females and males (IZB, PHW) have the pale bands at the anterior and posterior of the thorax grey-white (Fig. 12).

SCR food plants. (Amaryllidaceae) *Allium* sp.; (Leguminosae) *Hedysarum* sp.

SCR host species. No records, but suggested by Reinig (1935) to include *B. pyrosoma* and presumed here to include *B. friseanus*.

27. *Bombus (Psithyrus) branickii* (Radoszkowski) (Figs 14–15, 158, 238, 242)

Psithyrus Branickii Radoszkowski, 1893: 241, lectotype female (Tkalců, 1969b: 204) MNHU examined. Uzbekistan.

Apathus chloronotus Morawitz, 1893:6, holotype female (designated as lectotype by Pesenko, 2000: 8) ZISP examined. Synonymised with *Psithyrus branickii* Radoszkowski by Popov (1931). Uzbekistan.

Psithyrus rupestris var. *eriphoroides* Reinig, 1930a: 110, not infrasubspecific after Reinig, 1935: 329, type not seen. Synonymised with *Psithyrus branickii* Radoszkowski by Tkalcū (1969b). Tajikistan.

Psithyrus (Psithyrus) rupestris ssp. *elisabethae* Reinig, 1940: 231, holotype female ZSM examined. Synonymised with *Psithyrus branickii* Radoszkowski by Tkalcū (1969b). Afghanistan.

Bombus (Psithyrus) branickii (Radoszkowski); Williams, 1991: 48. Change in generic combination.

This species belongs to the *rupestris*-group of species.

Nomenclature. According to Pesenko and Astafurova (2003), the papers by Radoszkowski (1893) and Morawitz (1893) must both be considered to have been published on the last day of November 1893. Popov (1931, citing O. Vogt *in litt.*), in synonymising *Apathus chloronotus* Morawitz with *Psithyrus branickii* Radoszkowski, is deemed to be acting as First Reviser in the meaning of the ICZN (1999: Article 24). Consequently, the name *Psithyrus branickii* Radoszkowski is accepted as taking precedence, which serves the stability of nomenclature.

Diagnosis. Medium-sized species. *Female* (length 18–20 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella projecting only indistinctly above the apex of the labrum, broadly rounded, the lateral tubercles at its base reduced to rounded traces, the indistinct labral furrow occupying slightly less than one third of the breadth of the labrum; metasomal sternum 6 with lateral keels that are strongly swollen, each of which is ‘V’-shaped in profile and clearly visible from the dorsal aspect (cf. all *Psithyrus* species except *B. chinensis*, *B. rupestris*); hair (Figs 14–15) of the thoracic dorsum yellow with some black hairs between the wing bases (cf. all SCR *Psithyrus* species except *B. bellardii*), metasomal tergum 1 yellow, terga 2–4 black but often with traces of yellow posterior fringes, tergum 5 orange-red (cf. *B. bellardii*); wings light brown.

Male [based on specimens from Ladakh] (length 13–14 mm) with the hair of the thoracic dorsum yellow with some black hairs between the wing bases, metasomal terga 1–3 yellow, tergum 4 black, terga 5–7 orange-red (cf. *B. bellardii*); genitalia (Fig. 158) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle strongly projecting and distally narrowed so that it is almost spinose (cf. *B. bellardii*); volsella in the distal part extending inwards broadly towards the inner corner (cf. *B. cornutus*, *B. tibetanus*, *B. expolitus*, *B. turneri*), in the distal half with the inner margin strongly inwardly curved (cf. *B. chinensis*).

Global distribution. Species of the Palaearctic region and within the Oriental region: Tibetan plateau and northeastern China (Xinjiang, Xizang, Qinghai, Sichuan, Shanxi).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Figs 238, 242): 14 females, 3500–4396 m (IZB, PHW, TY). New record for the SCR.

SCR food plants. (Amaryllidaceae) *Allium* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Aconitum gymnanthrum*.

SCR host species. No records, but presumed from its co-occurrence in both Kashmir (Williams, 1991) and Sichuan to include *B. keriensis*.

28. *Bombus (Psithyrus) rupestris* (Fabricius) (Figs 18, 159, 239, 243)

APIS rupestris Fabricius, 1793: 320, lectotype female (Løken, 1966: 203) ZMC examined. Germany.

Psithyrus rupestris f. *buyssoni* Vogt, 1911: 64, 2 syntype females ZMA examined. China: Xinjiang.

Psithyrus rupestris ssp. *orientalis* Reinig, 1930b: 276, 66 syntype females ZMA examined. Russia: Respublika Buryatiya.

Bombus (Psithyrus) rupestris (Fabricius); Williams, 1991: 44. Change in generic combination.

Psithyrus rupestris (Fabricius); Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *rupestris*-group of species.

Diagnosis. Medium-sized species. *Female* (length 14–20 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella weakly pointed and projecting only indistinctly above the apex of the labrum, the lateral tubercles at its base pointed but not strongly raised, the labral furrow occupying slightly less than one third of the breadth of the labrum; metasomal sternum 6 with lateral keels strongly swollen, each of which is ‘V’-shaped in profile and clearly visible from the dorsal aspect (cf. all *Psithyrus* species except *B. chinensis*, *B. branickii*); hair (Fig. 18) of the thorax with yellow bands anteriorly and posteriorly (cf. *B. bohemicus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal terga 1–4 black, with pale posterior lateral fringes of varying extent on terga 1–3, tergum 5 orange-red; wings dark brown.

Male [based on specimens from Spain] (length 14 mm) with the hair of the thorax with yellow bands anteriorly and posteriorly (cf. *B. branickii*), terga 1–3 yellow, terga 4–7 orange-red; genitalia (Fig. 159) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle strongly projecting and distally very strongly narrowed so that it is spinose (cf. *B. cornutus*, *B. expolitus*); volsella in the distal part extending inwards broadly towards the inner corner (cf. *B. cornutus*, *B. tibetanus*, *B. expolitus*, *B. turneri*), in the distal half with the inner margins strongly inwardly curved (cf. *B. chinensis*).

Global distribution. Palaearctic species with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Heilongjiang, Neimenggu, Xinjiang, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Figs 239, 243): 15 females, 3456–3836 m (BMNH, IZB, PHW, SAC, TY). Literature records: Macior and Tang (1997).

SCR food plants. (Asteraceae) *Saussurea* sp.; (Geraniaceae) *Geranium* sp.; (Ranunculaceae) *Aconitum gymnanthum*, *Delphinium* sp.; (Scrophulariaceae) *Pedicularis cranolopha*, *P. polyodonta*, *P. rhinanthoides*, *P. szetschuanica*, *P. verticillata*; (Valerianaceae) *Valeriana* sp.

SCR host species. No records, but presumed by comparison with its European population to include *B. sichelii* (see table II in Løken, 1984).

29. *Bombus (Psithyrus) bellardii* (Gribodo) (Figs 13, 20, 160, 244, 248)

Psithyrus Bellardii Gribodo, 1892: 108, syntype female MCSN examined. Myanmar.

Psithyrus (Metapsithyrus) pieli Maa, 1948: 29, type not seen. Synonymised provisionally with *Bombus bellardii* (Gribodo) by Williams (1998). China: Fujian.

Psithyrus (Metapsithyrus) tajushanensis Pittioni, 1949: 277 (not of Pittioni, 1949: 244 = *B. bicoloratus* Smith), paratype female BMNH examined. Synonymised with *Psithyrus pieli* Maa by Tkalců (1987). Synonymised provisionally with *Bombus bellardii* (Gribodo) by Williams (1998). China: Fujian.

Psithyrus (Metapsithyrus) pieli Maa; Tkalců, 1987: 59. China: Sichuan.

Bombus (Psithyrus) bellardii (Gribodo); Williams, 1998: 105. Change in generic combination.

Psithyrus pieli Maa; Yao, 1995: 580. China: Sichuan.

This species belongs to the *campestris*-group of species.

Nomenclature. The oldest available name for this species is *Bombus bellardii* (Gribodo) (see Williams, 1998). The only publications using the name *Bombus pieli* were by Maa (1948), Sakagami (1972), Tkalců (1987) and Williams (1991), so this change of valid name was not a serious disruption of common usage. Therefore *Bombus bellardii* is considered to be the valid name.

Diagnosis. Medium-sized species. *Female* (length 14–16 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); labral lamella pointed and projecting only indistinctly above the apex of the labrum, the lateral tubercles at its base pointed and raised, the labral furrow broad, occupying nearly one half of the breadth of the labrum; metasomal sternum 6 with lateral keels that are strongly swollen, broad and weakly 'S'-shaped in profile, and not visible from the dorsal aspect; hair (Fig. 13) of the thoracic dorsum and the upper sides of the thorax yellow, occasionally with a few black hairs intermixed in a mid-dorsal spot (Fig. 20, cf. all SCR *Psithyrus* species except *B. branickii*), metasomal terga 1–2 black, tergum 3 with a posterior yellow fringe, terga 4–5 yellow (cf. *B. branickii*); wings dark brown.

Male (length 15 mm) similarly coloured, sometimes with yellow also on metasomal tergum 1; genitalia (Fig. 160) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis

valve with the ventro-lateral angle strongly projecting, broad, and distally rounded (cf. *B. branickii*); volsella in the distal half broadly triangular with the inner margin almost straight (cf. all other SCR *Psithyrus* species).

Global distribution. Oriental species: Myanmar and central and southern China (Liaoning, Neimenggu, Shanxi, Shaanxi, Sichuan, Guangxi, Hubei, Anhui, Jiangxi, Fujian, Zhejiang).

SCR material examined. Rare at low altitudes of the western and southwestern foothills of the Sichuan basin (Figs 244, 248): 5 females, 4 males, 180–1600 m (BMNH, IZB, ZMMU). Literature records: Tkalců (1987), Yao (1995).

SCR food plants. No records.

SCR host species. No records, but presumed by comparison with its European relative *B. campestris* (Panzer) (see table II in Løken, 1984) to include species of the subgenus *Thoracobombus*.

30. *Bombus (Psithyrus) bohemicus* Seidl (Figs 24, 161, 245, 249)

Bombus bohemicus Seidl, 1837: 73, type not found (Tkalců, 1969a). Czech Republic.

Psithyrus distinctus Pérez, 1884: 268, type not seen. Synonymised with *Psithyrus bohemicus* (Seidl) by Blüthgen (1918). France.

Psithyrus distinctus Pérez; Popov, 1927b: 130. China: Sichuan. *Psithyrus (Ashtonipsithyrus) chinganicus* Reinig, 1936: 8, type not seen. Synonymised provisionally with *Bombus bohemicus* Seidl by Williams (1998). China: Neimenggu.

Psithyrus (Ashtonipsithyrus) distinctus ssp. *hedini* Bischoff, 1936: 26 (not of Bischoff, 1936: 15, see nomenclatural note on *B. (Thoracobombus) hedini* Bischoff), paratype female MNHU examined. Synonymised provisionally with *Bombus bohemicus* Seidl by Williams (1998). China: Gansu.

Bombus (Psithyrus) bohemicus Seidl; Williams, 1991: 45. Change in generic combination. China: Sichuan.

Psithyrus bohemicus (Seidl); Wang and Yao, 1996a: 306. China: Sichuan.

This species belongs to the *bohemicus*-group of species.

Nomenclature. Although the type of *Bombus bohemicus* is presumed lost (Tkalců, 1969a) and the original description is insufficient, the accepted identity of this taxon appears clear from Popov (1931) and Løken (1984), so the designation of a neotype is unjustified (ICZN, 1999: Article 75.1).

Diagnosis. Medium-sized species. *Female* (length 17 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); metasomal sternum 6 with lateral keels that are strongly swollen and 'S'-shaped in profile, but not visible from the dorsal aspect (cf. *B. norvegicus*); hair (Fig. 24) of the thorax with a pale yellow band anteriorly but not posteriorly (cf. all SCR *Psithyrus* species except *B. norvegicus*), metasomal terga 3–5 with some white, remainder black; wings light brown.

Male (length 14 mm) similarly coloured; genitalia (Fig. 161) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle much reduced and not visible from the dorsal aspect (cf. all other SCR *Psithyrus* species).

Global distribution. Widespread species of the Palaearctic region, and within the Oriental region: Himalaya and northern China (Xinjiang, Neimenggu, Heilongjiang, Jilin, Hebei, Shanxi, Gansu, Sichuan, Xizang, Yunnan).

SCR material examined. Rare at high altitudes of the northwestern and western plateau (Figs 245, 249): 3 females, 4 males, 2350–4294 m (IZB, PHW, SAC, TY). Literature records: Popov (1927b), Williams (1991), Wang and Yao (1996a).

SCR food plants. (Asteraceae) *Ligularia* sp., *Taraxacum* sp.

SCR host species. No records, but presumed by comparison with its European population to include *B. lucorum* (see table II in Løken, 1984).

31. *Bombus (Psithyrus) skorikovi* (Popov) (Figs 23, 162, 246, 250)

Psithyrus skorikovi Popov, 1927a: 267, holotype female ZISP examined. China: Qinghai.

Psithyrus (Fernaldaepsithyrus) gansuensis Popov, 1931: 202, holotype male ZISP examined. Synonymy with *Psithyrus skorikovi* Popov suggested by Popov (1931), confirmed here. China: Qinghai.

Psithyrus (Fernaldaepsithyrus) kuani Tkalců, 1961: 362, holotype female BT examined. Synonymised provisionally with *Bombus skorikovi* (Popov) by Williams (1998), confirmed here. China: Qinghai.

Bombus (Psithyrus) skorikovi (Popov); Williams, 1991: 50. Change in generic combination.

Psithyrus skorikovi Popov; Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *sylvestris*-group of species.

Diagnosis. Medium-sized species. *Female* (length 16–18 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); metasomal tergum 2 ventro-laterally and near the anterior margin below the spiracle with many close large punctures, the raised ridges between them strongly shining with almost no small deep punctures (cf. *B. norvegicus*); sternum 6 with lateral keels that are small and weakly swollen, but not visible from the dorsal aspect; apex of sternum 6 strongly down-curved and with a spinose projection beyond the apex of tergum 6 (cf. all *Psithyrus* species except *B. norvegicus*); hair (Fig. 23) of the thorax with pale yellow bands anteriorly and posteriorly (cf. *B. bohemicus*, *B. turneri*, *B. branickii*, *B. bellardii*, *B. norvegicus*), metasomal tergum 1 yellow, tergum 2 black, or black with a pale posterior fringe, terga 3–4 with yellow or white at least laterally, tergum 5 black; wings light brown.

Male (length 14–15 mm) with the hair of the thorax black with yellow bands anteriorly, posteriorly, and on the upper sides, metasomal tergum 1 yellow, tergum 2 black, tergum 3 yellow, tergum 4 yellow or black, terga 5–7 black but often with some reddish hairs; genitalia (Fig. 162) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle strongly projecting and narrow, distally pointed (cf. *B. norvegicus*); volsella in the distal half narrowed into an elongate finger (cf. all *Psithyrus* species except *B. norvegicus*).

Global distribution. Oriental species: Himalaya and Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Figs 246, 250): 30 females, 5 males, 3400–4396 m (IZB, PHW, SAC, TY). Literature records: Macior and Tang (1997).

SCR food plants. (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp., *Saussurea* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Aconitum gymnandrum*; (Scrophulariaceae) *Pedicularis lachnoglossa*, *P. roylei*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

SCR host species. No records, but presumed by comparison with its European relatives to include species of the subgenus *Pyrobombus* (see table II in Løken, 1984).

32. *Bombus (Psithyrus) norvegicus* (Sparre-Schneider) (Figs 25, 163, 247, 251)

Psithyrus norvegicus Sparre-Schneider, 1918:40 (not of Friese, 1911: 571 = *B. monticola* Smith), lectotype female (Løken, 1984:36) TRM examined. Norway.

Psithyrus norvegicus var. *transbaicalicus* Popov, 1927a: 269, type not seen. Russia: Chitinskaya Oblast'.

Bombus (Psithyrus) norvegicus (Sparre-Schneider); Williams, 1998: 105. Change in generic combination.

This species belongs to the *sylvestris*-group of species.

Nomenclature. With *Psithyrus* regarded as being a subgenus of the genus *Bombus* (Williams, 1991; Williams *et al.*, 2008), *Bombus norvegicus* (Sparre-Schneider, 1918) became a junior secondary homonym in *Bombus* of *Bombus lapponicus* var. *norvegicus* Friese (1911) (deemed subspecific, ICZN, 1985: Article 45g(ii)). Therefore Williams (1998) considered the name *Bombus norvegicus* (Sparre-Schneider) to be invalid for this species of the subgenus *Psithyrus* (ICZN, 1985: Article 57c). He identified *Psithyrus norvegicus* var. *transbaicalicus* Popov, 1927a (deemed to be subspecific, ICZN, 1985: Article 45g(ii)) as one of the oldest available names and went on to suggest that an application be made to the Commission to use its plenary power to suppress the unused senior synonym (ICZN, 1985: Article 79) to maintain the usage of *Bombus norvegicus* (Sparre-Schneider). The fourth edition of the Code (ICZN, 1999) also provides for this (Articles 23.9.3, 81) and requires that prevailing usage be maintained while the case is under consideration (Article 82). Therefore because we

expect the matter to be referred to the Commission, we consider *Bombus norvegicus* (Sparre-Schneider) to be the valid name for this species.

Diagnosis. Medium-sized species. *Female* (length 18 mm) with the outer surface of the hind tibia convex with dense moderately long hairs throughout (cf. non-*Psithyrus* species); metasomal tergum 2 ventro-laterally and near the anterior margin below the spiracle with many close large punctures, the raised ridges between them dull with many small deep punctures (cf. *B. skorikovi*); sternum 6 with lateral keels that are small and weakly swollen, but not visible from the dorsal aspect; apex of sternum 6 strongly down-curved and with a spinose projection beyond the apex of tergum 6 (cf. all *Psithyrus* species except *B. skorikovi*); hair (Fig. 25) of the thorax with an anterior dull yellow band and no posterior band (cf. *B. skorikovi*), metasomal terga 1–2 black, terga 3–5 with white laterally; wings mid brown.

Male [based on specimens from Yunnan] (length 14–15 mm) with the hair of the thorax with an anterior yellow band, metasomal tergum 1 yellow, tergum 2 black, tergum 3 black anteriorly and yellow posteriorly, tergum 4 yellow, terga 5–7 black but often with some reddish hairs; genitalia (Fig. 163) with the gonostylus and volsella weakly sclerotised and pale, the gonostylus densely hairy (cf. non-*Psithyrus* species); penis valve with the ventro-lateral angle strongly projecting and broad, distally rounded (cf. *B. skorikovi*); volsella in the distal half narrowed into an elongate finger (cf. all *Psithyrus* species except *B. skorikovi*).

Global distribution. Palaearctic species with a disjunct distribution within the Oriental region: between the eastern fringes of the Tibetan plateau and north-eastern China (Jilin, Liaoning, Sichuan, Xizang, Yunnan).

SCR material examined. Rare at medium altitude of the western foothills of the Sichuan basin (Figs 247, 251): 5 females, 2500 m (JAB, PHW, ZMA). New record for the SCR.

SCR food plants. No records.

SCR host species. No records, but presumed by comparison with its European population to include *B. hypnorum* (see table II in Løken, 1984).

Subgenus *PYROBOMBUS* Dalla Torre

33. *Bombus (Pyrobombus) hypnorum* (Linnaeus) (Figs 126–128, 164, 252, 256)

APIS Hypnorum Linnaeus, 1758: 579, lectotype queen (Day, 1979: 64) LSL examined. Sweden.

Bombus hypnorum (Linnaeus); Walckenaer, 1802: 148. Change in generic combination.

Bombus calidus Erichson, 1851: 65, type not seen. Regarded as conspecific with *Bombus hypnorum* (Linnaeus) by Schmiedeknecht (1883). Russia: Khabarovskiy Krai.

Bombus hypnorum var. *calidus* Erichson; Morawitz, 1890: 349. China: ‘Sse-tschan’, but probably Qinghai.

Bombus hypnorum var. *bryorum* Richards, 1930: 650, not infrasubspecific after Tkalců, 1974a: 328, holotype queen BMNH examined. Synonymised with *Bombus hypnorum* (Linnaeus) by Williams (1991). India.

Bombus (Pyrobombus) hypnorum (Linnaeus); Williams, 1991: 70; Yao and Luo, 1997: 1691. China: Sichuan.

Bombus (Pyrobombus) hypnorum [ssp.] *bryorum* Richards; Wang, 1992a: 1426. China: Sichuan.

This species belongs to the *hypnorum*-group of species.

Taxonomic status. *Bombus hypnorum* is a broadly distributed species with a fairly easily recognised brown-black-white colour pattern in most of its range (e.g. Reinig, 1939). The form from the Himalaya, described under the name *B. bryorum*, has been regarded both as a separate species (Tkalců, 1974a) and as conspecific (Williams, 1991).

Diagnosis. Medium-sized species. *Female* (length of queens 17–18 mm, workers 11–13 mm) with the mid basitarsus with the distal posterior corner acute but rounded (cf. *B. longipes*); hind tibia with the distal posterior corner forming almost a right angle (cf. *B. festivus*), hind basitarsus with the posterior margin nearly straight; oculo-malar distance approximately 0.9 times the proximal breadth of the mandible; ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species); hair (Figs 126–128) on the dorsum of the head, the thoracic dorsum (cf. other SCR *Pyrobombus* species), the upper half of the sides of the thorax (cf. *B. festivus*), and metasomal terga 1–2 orange-brown (Fig. 126), terga 3–4 black, tergum 5 white, or else yellow (Figs 127–128) on the dorsum of the head, on the thoracic dorsum except for a black spot in the middle (cf. *B. festivus*), often with black hairs intermixed on either side between the wing bases, metasomal tergum 1 yellow, terga 2–3 black, tergum 4 black with a white posterior fringe, tergum 5 white; wings mid brown.

Male (length 12–13 mm) of the brown form similarly coloured to the females, but metasomal terga 5–7 black with white tips, males of the yellow form with the head, thorax, and metasomal terga 1–2 yellow, tergum 3 yellow or with black intermixed anteriorly, tergum 4 yellow with black intermixed anteriorly, terga 5–7 white or yellowish white; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 164) with the penis valve distally with an incurved sickle-shaped head, the triangular recurved sickle or crook with the sides converging gradually towards the distal end, the ventro-lateral angle of the penis valve closer to the proximal end of the penis valve than to the distal head; gonostylus triangular, without an inner proximal process (cf. non-*Pyrobombus* species e.g. *B. festivus*), but with an inner submarginal longitudinal groove, the proximal end of this groove separated from the gonocoxa by a concavity as deep as the distal breadth of the spatha (cf. other SCR *Pyrobombus* species).

Global distribution. Widespread species of the Palaearctic region, and within the Oriental region: Himalaya and fringes of the Tibetan plateau, Myanmar, northeastern and central China (Xinjiang, Neimenggu, Jilin, Liaoning, Gansu, Ningxia,

Shanxi, Hubei, Guizhou, Sichuan, Qinghai, Xizang, Yunnan), Taiwan.

SCR material examined. Uncommon at medium altitudes of the northwestern, western, and southwestern mountains (Fig. 256) with a medium-length seasonal activity period (Fig. 252): 5 queens, 50 workers, 25 males, 858–4382 m (IZB, JAB, PHW, SAC, TY). Literature records: Morawitz (1890), Williams (1991), Wang (1992a), Yao and Luo (1997).

SCR variation. Individuals from around Zhegushan have the pale pubescence deep orange-brown (Fig. 126), whereas individuals from around Wolong have the pale pubescence yellow (Figs 127, 128).

SCR food plants. Short-tongued species: (Asteraceae) *Cirsium* sp., *Saussurea* sp.; (Gentianaceae) *Halenia elliptica*; (Leguminosae) *Hedysarum* sp.; (Scrophulariaceae) *Pedicularis longiflora*.

34. *Bombus (Pyrobombus) flavescens* Smith (Figs 98–99, 101, 165, 253, 257)

Bombus flavescens Smith, 1852a: 45, holotype male BMNH examined. China: Zhejiang.

Bombus rufocaudatus Friese, 1905: 510, type not seen. Synonymised with *Pyrobombus flavescens* (Smith) by Tkalců (1974a). China: Sichuan.

BOMBUS MEARNSI Ashmead, 1905: 959, type not seen. Regarded as conspecific with *Bombus flavescens* Smith by Pittioni (1949). Philippines.

Bombus geei Cockerell, 1917: 265, type not seen. Regarded as conspecific with *Bremus mearnsi* (Ashmead) by Frison (1934). Regarded as conspecific with *Bombus flavescens* Smith by Pittioni (1949). China: Jiangxi.

Bombus rufocaudatus Friese; Skorikov, [1923]: 160. China: Sichuan.

Bremus (Pratobombus) mearnsi var. *dilutus* Frison, 1934: 174, holotype worker INHS examined. Regarded as conspecific with *Bombus flavescens* Smith by Pittioni (1949). China: Zhejiang.

Bombus (Pratobombus) mearnsi ssp. *chekiangensis* Bischoff, 1936: 5, type not seen. Regarded as conspecific with *Bombus flavescens* Smith by Pittioni (1949). China: Zhejiang.

Bombus (Pratobombus) flavescens f. *dilutior* Pittioni, 1949: 264, holotype male BMNH examined. China: Fujian.

Bombus (Pratobombus) mearnsi Ashmead; Panfilov, 1957: 235. China: Sichuan.

Bombus (Pratobombus) flavescens Smith; Panfilov, 1957: 2353. China: Sichuan.

Bombus (Pyrobombus) flavescens Smith; Wang, 1982a: 433, 1988a: 556, 1992a: 1426; Wang and Yao, 1992a: 688; Yao and Wang, 1993b: 767; Yao and Luo, 1997: 1691; Yao, 1998: 40; Yin *et al.*, 2001: 752. China: Sichuan.

Bombus (Pyrobombus) dilutior Pittioni; Wang, 1992: 1426. China: Sichuan.

This species belongs to the *pratorum*-group of species.

Taxonomic status. The species or species complex of *B. flavescens* includes widespread and variable taxa from the Himalaya, southeast Asia, southern China and neighbouring islands. While it is not yet clear whether or which of these nominal taxa should be regarded as separate species, this is unlikely to affect the name of the species in Sichuan.

Diagnosis. Medium-sized species. *Female* (length of queens 17–18 mm, workers 11–15 mm) with the mid basitarsus with the distal posterior corner acute but broadly rounded; hind basitarsus with the posterior margin nearly straight; oculo-malar distance approximately 0.9 times the proximal breadth of the mandible; labrum with the lamella strongly curved and less than one third of the breadth of the labrum (cf. *B. eximius*); ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species); hair (Figs 98–99, 101) of the thorax black, hair of the mid and hind tibiae and basitarsi orange, metasomal terga 1–2 black (Fig. 101), or more often tergum 1 yellow and tergum 2 black or partly or entirely yellow (Figs 98–99), tergum 3 black, terga 4–5 orange; wings light orange brown.

Male (length 12–15 mm) very variable, from having the hair most often uniformly yellow (cf. *B. eximius*), to yellow on the head, thorax and metasomal terga 1–2, with tergum 3 black and terga 4–7 orange, to occasionally black with some short grey hair on the head and hair of the mid and hind tibia and basitarsus orange, metasomal terga 1–3 black, terga 4–7 orange; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 165) with the penis valve distally with an incurved sickle-shaped head, the ventro-lateral angle of the penis valve closer to the proximal end of the penis valve than to the distal head (cf. *B. infirmus*, *B. lemniscatus*, *B. lepidus*, *B. picipes*, *B. infrequens*); gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species), the inner margin above the submarginal groove almost straight (cf. *B. wangae*), the proximal end of the groove separated from the gonocoxa by a concavity less than one quarter as deep as the distal breadth of the spatha (cf. *B. hypnorum*).

Global distribution. Widespread species (complex) within the Oriental region: Himalaya, Myanmar, Thailand, Vietnam, Peninsular Malaysia, Philippines, China (Yunnan, Sichuan, Shanxi, Hubei, Hunan, Jiangxi, Fujian, Guangdong, Hainan, Guangxi, Guizhou, Zhejiang), Taiwan.

SCR material examined. Formerly common at low altitudes of the foothills surrounding the Sichuan basin but with few recent records (Fig. 257), with a medium-length seasonal activity period (Fig. 253): 6 queens, 42 workers, 56 males, 450–2800 (–?3800) m (BMNH, INHS, IZB, PHW, USNM, ZMMU). Literature records: Friese (1905), Skorikov ([1923]), Frison (1935), Bischoff (1936) [queens and workers labelled Long'an with unusually high altitude data (3650 m) may be based on only an approximate location, need to be confirmed, and are not shown in the activity plot and map], Panfilov (1957), Wang (1982a, 1988a, 1992a) [queens and males labelled Barkam,

Songpan, Kangding and Xiangcheng (atypical habitat that has been intensively surveyed) are not supported by specimens of *B. flavescens* in the IZB collection, need to be confirmed, and are not shown in the activity plot and map], Wang and Yao (1992a), Yao and Wang (1993b), Yao and Luo (1997), Yao (1998), Yin *et al.* (2001).

SCR variation. Two workers (BMNH) have pale yellow hair on tergum 1 and on the anterior half of tergum 2 (Fig. 99). Other workers (IZB, ZMMU) from around Wolong and Emeishan have terga 1–2 yellow (Fig. 98). These are similar to the ‘*geei*’ pattern (tergum 1 yellow) and to the ‘*chekiangensis*’ pattern (terga 1–2 yellow) (see Frison, 1934; Pittioni, 1949; and comments on *B. eximius*, *B. trifasciatus*, *B. breviceps*).

SCR food plants. Short-tongued species, no records.

35. *Bombus (Pyrobombus) wangae* sp. nov. (Figs 5–8, 109–111, 166, 254, 258)

[*Bombus modestus* Eversmann, 1852: 134; Morawitz, 1890: 349, not found, presumed misidentification. China: ‘Sse-tschuan’, but probably Qinghai.]

This species belongs to the *pratorum*-group of species.

Nomenclature. *Holotype*: male (Figs 7–8) deposited at the IZB. Labels: (1) printed ‘CHINA Sichuan 3830 m/(5) south of Zhegushan/N 31°51′51.8″/E 102°43′01.2″/2.viii.2002 PH Williams’; (2) red-edged printed ‘Holo-/type’; (3) printed ‘Bumble bees of Sichuan / DB# 1013 det. PHW/HOLOTYPIC male/*Bombus wangae*’. *Paratypes*: all remaining specimens included below under the list of SCR material examined, excluding the literature records, are regarded as the type series and therefore are considered to be paratypes. This species is named after Professor Wang Shu-fang, formerly of the IZB.

Taxonomic status. This Sichuanese species is most similar to *B. modestus*, a species with a broad distribution in Kazakhstan, Asian Russia, Mongolia, Korea and China (Jilin, Liaoning, Hebei, Beijing, Shanxi). Both sexes of *B. modestus* have the pubescence extensively yellow, with black hairs intermixed between the wing bases and anteriorly on metasomal terga 3–4. Queens often have white hair posteriorly on tergum 4 and throughout tergum 5. Males may have black intermixed anteriorly on terga 3–7. Small workers, some males and, at least in Korea, some queens (PHW), are predominantly yellow. A queen from Yakutsk, described under the name *eversmanni* (Skorikov, 1910c: 581, not infrasubspecific after Skorikov [1923]: 149), has a black band between the wing bases and terga 3–4 have black hairs, at least anteriorly. A queen from the Altai, described under the name *dorsodecolor* (Skorikov, 1910c: 582, infrasubspecific), also has black bands, but in addition, has terga 5–6 light brownish rose-red (‘hellbräunlich-rosenrot’). This is closer to the more brightly orange-red tailed species from Sichuan.

Description. Small species. *Queen* (length 12–14 mm) with the mandible distally broadly rounded with two pronounced anterior teeth and a weak posterior tooth, which is separated from the rounded anterior margin by a broad shallow rounded

excision or ‘*incisura*’, which is less than half as deep as wide; labrum with the lateral tubercles low with many coarse punctures on their proximal side, the median labral furrow narrow; clypeus with small punctures scattered irregularly throughout, large punctures widely scattered laterally but absent near the midline; oculo-malar distance approximately equal (0.9–1.0) to the proximal breadth of the mandible; ocello-ocular area along inner eye margin with scattered large punctures and with many small punctures, which are only very narrowly reduced in density opposite the ocelli, the area of dense small punctures reaching the eye margin just behind the eye dorsally; mid basitarsus with the distal posterior corner acute but broadly rounded; hind tibia with the outer surface smooth and brightly shining, without long hairs in the middle of the upper half; hind basitarsus with the proximal posterior process produced by more than its proximal breadth, the posterior margin nearly straight; metasomal sternum 6 with a weak central keel. Colour pattern (Figs 5–6): the head with the short hair creamy yellow, the long hairs below the antennal bases and medially orange, or above the antennal bases, black. Short hairs of the entire breadth of the head dorsally yellow, the long hairs black. Thorax dorsally with a black band between the wing bases, a well-defined broad anterior band and a narrower posterior band lemon yellow, the anterior band with many black hairs intermixed behind the anterior margin and ahead of the posterior margin but not in between, hairs of the dorsal half of the side of the thorax yellow, of the ventral half nearly white, of the side of the thorax posterior to the wing bases black, pale yellow, or intermixed; hairs of the leg bases and hind femur nearly white, hairs of the corbicular fringes black, or black with orange tips, or orange; wings light brown. Hairs of metasomal terga 1 and 2 lemon yellow, sometimes tergum 2 with scattered black hairs intermixed near the posterior margin, especially laterally; tergum 3 predominantly black with lateral white fringes, often with a few orange hairs posteriorly; tergum 4 anteriorly black, or terga 4–6 predominantly orange-red often with narrow whitish fringes on the lateral margins; sternal posterior fringes whitish.

Worker (length 8–12 mm) similar to the queen, with a broad black band between the wing bases, which may have many yellow hairs intermixed, although it remains darker than the band at the anterior of the thorax, which has a less distinct (or no) area free of black hairs than the queen, hairs of the corbicular fringes black with orange tips, often more extensive yellow and orange hair on metasomal tergum 3, sometimes with terga 3–5 predominantly black, the orange hairs restricted to the posterior margins of tergum 4 and more especially tergum 5.

Male (length 9–12 mm) with the mandible distally acute with one additional large anterior tooth, the posterior mandibular beard long and dense; compound eye unenlarged relative to the female; antenna reaching posteriorly only just to the wing bases; hind tibia with the outer surface smooth, shining and hairless in its central half; genitalia (Fig. 166) with the penis valve distally with incurved sickle-shaped head, the head with the recurved crook only very slightly broader at the posterior recurved angle as near the distal end, which is broadly rounded, the ventro-lateral angle of the penis valve just closer to the

proximal end of the penis valve than to the distal head; volsella projecting scarcely beyond the gonostylus, distally narrow, the blunt inner distal process about as broad as long; gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove, the inner margin above the submarginal groove distinctly 'S'-shaped, the proximal end of the groove separated from the gonocoxa by a concavity that is less than one quarter as deep as the distal breadth of the spatha; gonocoxa with the inner distal corner not produced but reduced to a sharply-angled right angle. Colour pattern (Figs 7–8): the pubescence of the entire body is predominantly yellow, including the ventral surface; a few long black hairs are intermixed around the eye and between the wing bases, forming at most only a very indistinct band; the darkest specimens have metasomal terga 3–7 anteriorly with many black hairs intermixed, but the posterior fringes are yellow, and orange hairs may replace much of the black on terga 5–7.

Diagnosis. *Female* labrum with the lateral tubercles low with many coarse punctures on their proximal side, the median labral furrow narrow (cf. *B. picipes*), oculo-malar distance approximately equal (0.9–1.0) to the proximal breadth of the mandible (cf. *B. picipes*), the largest punctures of the clypeus nearly confined to the lateral parts of the ventral transverse impressions rather than being broadly scattered on the clypeus (cf. *B. modestus*), ocello-ocular area along inner eye margin with scattered large punctures and with many small punctures, which are only very narrowly reduced in density opposite the ocelli (cf. non-*Pyrobombus* species), the area of dense small punctures reaching the eye margin just behind the eye dorsally (cf. *B. lepidus*); hair (Figs 109–111) of queens with the short hair of the head creamy yellow, the long hairs below the antennal bases and medially orange (cf. *B. picipes*), thorax dorsally black between the wing bases, a well-defined broad anterior band and a narrower posterior band lemon yellow (cf. *B. modestus* which has the bands weakly defined, or the black band absent), the anterior band with many black hairs intermixed behind the anterior margin and ahead of the posterior margin but not in between (cf. *B. picipes*), lower sides of the thorax, leg bases and hind femur nearly white (cf. *B. keriensis*, *B. friseanus*), hairs of metasomal tergum 3 predominantly black with lateral white fringes, often with a few orange hairs posteriorly (cf. *B. modestus* with a yellow posterior fringe, *B. lepidus* with the posterior half orange-red), tergum 4 anteriorly black, or terga 4–6 predominantly orange-red (usually much less bright than *B. lepidus*, *B. friseanus*) often with narrow whitish fringes on the lateral margins (cf. *B. modestus* with terga 4–6 usually whitish), workers similar with a broad black band between the wing bases, which may have many yellow hairs intermixed, although it remains darker than the band at the anterior of the thorax (cf. *B. picipes*), hairs of the corbicular fringes black with orange tips (cf. *B. picipes*).

Male dorsum of the head anterior to the ocelli usually with uniformly widely scattered moderately large punctures between the eyes anterior to the ocelli (cf. *B. modestus*, which has an unpunctured area the size of the lateral ocellus anterior to the ocelli near the inner eye margin); genitalia (Fig. 166) with the penis valve distally with an incurved sickle-shaped

head, with the recurved crook only very slightly broader at the posterior recurved angle as near the distal end, which is broadly rounded (cf. *B. hypnorum*, *B. flavescens*, which have the recurved angle of the sickle-shaped head distinctly broader than just below the rounded distal end of the sickle), the ventro-lateral angle of the penis valve just closer to the proximal end of the penis valve than to the distal head (cf. the *lepidus*-group, e.g. in the SCR: *B. infirmus*, *B. lemniscatus*, *B. lepidus*, *B. picipes*, *B. infrequens*, which have the ventro-lateral angle closer to the head), gonostylus with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species), the inner margin above the submarginal groove distinctly 'S'-shaped (cf. *B. modestus*, *B. flavescens*, *B. hypnorum*, which usually have the inner margin nearly straight or weakly convex), the proximal end of the groove separated from the gonocoxa by a concavity less than one quarter as deep as the distal breadth of the spatha (cf. *B. hypnorum*), the gonostylus narrower proximally than the distal end of the gonocoxa so that the gonostylus does not apparently reach to the inner distal corner of the gonocoxa (cf. *B. modestus*, which has the gonostylus as broad or broader proximally than the distal end of the gonocoxa so that the gonostylus reaches to and sometimes slightly beyond the inner distal corner of the gonocoxa).

Global distribution. Oriental species: eastern fringes of the Tibetan plateau (Sichuan, Gansu), this species is apparently narrowly distributed with much of its distribution range within Sichuan.

SCR material examined. Uncommon at medium altitudes of the northwestern, western, and southwestern mountains (Fig. 258) with a short seasonal activity period (Fig. 254): 5 queens, 31 workers, 50 males, 2600–4294 m (IZB, LWM, PHW, SAC, TY, ZMMU).

SCR variation. Workers in the north have varying degrees of replacement of black by yellowish hairs on tergum 3 (Fig. 109), and in the south have varying degrees of replacement of orange by black hairs on terga 4–5 (Fig. 111). The darkest males have terga 3–7 anteriorly with many black hairs, while the lightest males have orange hairs replacing most of the black on terga 3–7.

SCR food plants. Short-tongued species: (Asteraceae) *Cirsium* sp.; (Caprifoliaceae) *Lonicera* sp.; (Gentianaceae) *Halenia elliptica*; (Onagraceae) *Chamerion angustifolium* (L.) Holub; (Scrophulariaceae) *Pedicularis longiflora*, *P. rex*.

36. *Bombus (Pyrobombus) infirmus* (Tkalčú) (Figs 129–130, 167, 255, 259)

[*Bombus (Pratobombus) leucurus* Bischoff and Hedicke, 1931: 391; Bischoff, 1936: 8, misidentification. China: Gansu.]

Pyrobombus (Pyrobombus) infirmus Tkalčú, 1968c: 24, holotype male BMNH examined. Myanmar.

Bombus (Pyrobombus) infirmus (Tkalčú); Williams, 1991: 75. Change in generic combination. China: Sichuan.

This species belongs to the *lepidus*-group of species.

Diagnosis. Small species. *Female* (length of queens 16 mm, workers 8–13 mm) with the mid basitarsus with the distal posterior corner just acute but rounded; hind basitarsus with the posterior margin nearly straight (cf. *B. lucorum*); oculo-malar distance approximately 1.1 times the proximal breadth of the mandible; ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species); hair (Figs 129–130) of the thorax with a yellow band anteriorly, metasomal terga 1–2 (cf. *B. lucorum*) or sometimes just tergum 2 mostly yellow, tergum 3 black, terga 4–5 black with white tips (cf. *B. lucorum*); wings mid brown.

Male (length 10–14 mm) similarly coloured, but more extensively yellow on the head, the sides of the thorax, the sides of metasomal terga 3–4, the underside, and often without white on terga 4–7; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 167) with the penis valve with an incurved sickle-shaped head (cf. *B. lucorum*), the recurved crook of the head shorter than broad and triangular (cf. other SCR *Pyrobombus* species), the ventro-lateral angle of the penis valve closer to the head than to the proximal end of the penis valve; gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species).

Global distribution. Oriental species: Myanmar and the eastern fringes of the Tibetan plateau (Yunnan, Xizang, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern, western, and southwestern mountains (Fig. 259) with a short seasonal activity period (Fig. 255): 7 queens, 18 workers, 21 males, 2500–4294 m (BMNH, IZB, JAB, PHW, SAC, TY, USNM, ZMMU). Literature records: Tkalčú (1968c), Williams (1991).

SCR food plants. Short-tongued species: (Asteraceae) *Ligularia* sp.; (Ericaceae) *Rhododendron decorum* Franch.; (Loganiaceae) *Buddleja* sp.; (Onagraceae) *Chamerion angustifolium*.

37. *Bombus (Pyrobombus) lemniscatus* Skorikov (Figs 115, 168, 260, 264)

Bombus lemniscatus Skorikov, 1912: 607, holotype queen ZISP examined. China: Qinghai.

Bombus nursei var. *flavopilosus* Friese, 1918: 84, lectotype queen (Williams, 1991: 73) MNHU examined. Synonymised with *Bombus lemniscatus* Skorikov by Williams (1991). Probably India.

Bombus (Lapidariobombus) peralpinus Richards, 1930: 646, holotype queen BMNH examined. Synonymised with *Pyrobombus lemniscatus* (Skorikov) by Tkalčú (1974a). China: Xizang.

Bombus (Pyrobombus) lemniscatus Skorikov; Williams, 1991: 73; Williams and Cameron, 1993: 126. China: Sichuan.

[*Bombus (Pyrobombus) mirus* (Tkalčú, 1968c: 37); Wang, 1992a: 1427, misidentification. China: Sichuan.]

This species belongs to the *lepidus*-group of species.

Diagnosis. Small species. *Female* (length of queens 16–18 mm, workers 10–12 mm) with the mid basitarsus with the distal posterior corner acute but broadly rounded (cf. *B. supremus*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight; oculo-malar distance approximately 1.1 times the proximal breadth of the mandible (cf. *B. kashmirensis*); ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species e.g. *B. rufofasciatus*, *B. pyrosoma*); hair (Fig. 115) of the head black (cf. *B. lepidus*, *B. sichelii*), the thorax with grey-white bands anteriorly and more narrowly posteriorly, metasomal tergum 1 white, tergum 2 mostly yellow with white laterally and sometimes posteriorly, tergum 3 black anteriorly, posteriorly orange-red and laterally white, terga 4–5 orange-red (cf. *B. supremus*, *B. rufofasciatus*); wings light brown.

Male (length 10–12 mm) similarly coloured; compound eye unenlarged relative to the female (cf. *B. rufofasciatus*) and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 168) with the penis valve distally with an incurved sickle-shaped head (cf. *B. supremus*, *B. impetuosus*), the recurved crook of the head longer than broad but narrowed and pointed, almost spine-like (cf. other SCR *Pyrobombus* species e.g. *B. lepidus*), the ventro-lateral angle of the penis valve closer to the distal head than to the proximal end of the penis valve; gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species).

Global distribution. Oriental species: Himalaya, Tibetan plateau and central China (Gansu, Sichuan, Qinghai, Xizang, Yunnan).

SCR material examined. Common at high altitudes of the northwestern and western plateau and mountains (Fig. 264) with a medium-length seasonal activity period (Fig. 260): 9 queens, 133 workers, 10 males, 1874–4550 m (BMNH, IZB, PHW, SAC, TY). Literature records: Williams (1991), Wang (1992a), Williams and Cameron (1993).

SCR food plants. Medium tongue-length species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Ligularia* sp., *Saussurea* sp.; (Caprifoliaceae) *Lonicera* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Aconitum gymmandrum*, *Ranunculus* sp.; (Scrophulariaceae) *Pedicularis chenocephala*, *P. cranalopha*, *P. integerrima* Pennell & H.L. Li, *P. lachnoglossa*, *P. rex*, *P. roylei*, *P. siphonantha* D. Don, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

38. *Bombus (Pyrobombus) lepidus* Skorikov (Figs 103–104, 114, 169, 261, 265)

Bombus lepidus Skorikov, 1912: 606, syntype queen ZISP examined. China: Qinghai.

[*Bombus lepidus* var. *grumi* Skorikov, 1912: 607, infrasubspecific.]

Bombus genitalis Friese, 1913: 85, holotype male MNHU examined. Synonymised with *Bombus lepidus* Skorikov by Williams (1991). China: 'Tibet', ?Xizang.

Bombus nursei var. *tetrachromus* Friese, 1918: 85 (not of Cockerell, 1909: 397 = *B. kashmirensis* Friese), lectotype queen (Williams, 1991: 75) MNHU examined. Synonymised with *Bombus lepidus* Skorikov by Williams (1991). India.

Bombus (*Pratobombus*) *yuennanicola* Bischoff, 1936: 7, holotype queen MNHU examined. Regarded as conspecific with *Pyrobombus lepidus* (Skorikov) by Tkalců (1989). China: Yunnan.

Bombus (*Pyrobombus*) *yunnanicola* Wang, 1982a: 435, unjustified emendation. China: Xizang.

Bombus (*Pyrobombus*) *yunnanicola* Wang; Wang, 1992a: 1425. China: Sichuan.

Bombus (*Pyrobombus*) *lepidus* Skorikov; Wang, 1992a: 1426. China: Sichuan.

This species belongs to the *lepidus*-group of species.

Diagnosis. Small species. *Female* (length of queens 13–15 mm, workers 8–11 mm) with the mid basitarsus with the distal posterior corner acute but broadly rounded (cf. *B. impetuosus*, *B. friseanus*); hind basitarsus with posterior margin nearly straight; oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible; clypeus centrally rather bulbous with deep impressions adjacent to the labrum (cf. *B. friseanus*); ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species), the area of dense small punctures not reaching the eye margin just behind the eye dorsally (cf. *B. wangae*); hair (Figs 103–104, 114) of the face and dorsum of the head usually grey-white (or yellow) intermixed with black (cf. *B. lemniscatus*, *B. kashmirensis*, *B. friseanus*), the thorax with grey-white (Fig. 113) or yellow (Figs 103–104) bands anteriorly and posteriorly, sides of the thorax grey-white (or yellow above, cf. *B. braccatus*, *B. nobilis*, *B. keriensis*, *B. friseanus*), with black hairs below and behind the wing bases (cf. *B. impetuosus*), corbicular fringes varying from black with some orange tips to almost entirely orange, metasomal tergum 1 white (or yellow), tergum 2 mostly yellow with white laterally (cf. *B. pyrosoma*) and black posteriorly, often with some orange-red, tergum 3 black anteriorly or at least laterally (often forming a slightly anteriorly curved or crescent shape with the lateral points directed posteriorly, cf. *B. friseanus*), posteriorly orange-red (cf. *B. wangae*, *B. sichelii*) and laterally white (cf. *B. friseanus*), terga 4–5 orange-red (cf. *B. ladakhensis*, *B. rufofasciatus*); wings light brown.

Male (length 9–12 mm) similarly coloured with a black band between the wing bases (cf. *B. wangae*, *B. picipes*, *B. avanus*, *B. infrequens*), but always yellow-banded rather than grey-white banded; compound eye unenlarged relative to the female (cf. *B. rufofasciatus*) and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 169) with the penis valve distally with an incurved sickle-shaped head (cf. *B. impetuosus*), the recurved crook of the head just longer than broad and distally broad (cf. *B. lemniscatus*), the ventro-lateral angle of the penis valve closer to the distal head than to the proximal end of the penis valve; gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species).

Global distribution. Oriental species: Himalaya and Tibetan plateau (Yunnan, Xizang, Qinghai, Gansu, Ningxia, Sichuan). A record from Shanxi (Yasumatsu, 1951) is probably a misidentification of *B. picipes*.

SCR material examined. Abundant at medium altitudes of the northwestern, western and southwestern plateau and mountains (Fig. 265) with a medium-length seasonal activity period (Fig. 261): 15 queens, 664 workers, 189 males, (?1230–) 1912–4382 m (BMNH, IZB, LWM, PHW, SAC, TY). A male (IZB) labelled Dawei with unusually low altitude data (1230 m) may be based on only an approximate location and needs to be confirmed, but is shown in the activity plot and map. Literature records: Wang (1992a).

SCR variation. Both the white-banded form (the '*lepidus*' s.str. pattern, Fig. 114) and the yellow-banded form (the '*yuennanicola*' pattern, Figs 103, 104) occur in Sichuan, often together at the same sites in the north around Zhegushan. Further south, only the yellow-banded form occurs (see the comments on *B. impetuosus*).

SCR food plants. Short-tongued species: (Asteraceae) *Cirsium* sp., *Ligularia* sp., *Saussurea* sp.; (Boraginaceae) *Microula* sp.; (Caprifoliaceae) *Lonicera* sp.; (Crassulaceae) *Sedum* sp.; (Ericaceae) *Rhododendron* sp.; (Lamiaceae) *Ajuga* sp., *Salvia* sp.; (Leguminosae) *Oxytropis* sp.; (Onagraceae) *Chamerion angustifolium*; (Ranunculaceae) *Aconitum gymnanthum*, *Clematis* sp.; (Scrophulariaceae) *Pedicularis alopecuros*, *P. anas*, *P. bidentata*, *P. cranolopha*, *P. cyathophylla* Franch., *P. davidii* Franch., *P. densispica*, *P. floribunda*, *P. integerrima*, *P. lachnoglossa*, *P. longiflora*, *P. melampyriflora*, *P. oxycarpa*, *P. polyodonta*, *P. pseudomuscicola* Bonati, *P. racemosa* Douglas ex Hook., *P. rex*, *P. rhinanthoides*, *P. roylei*, *P. semitorta* Maxim., *P. siphonantha*, *P. szetschuanica*, *P. torta* Maxim., *P. verticillata*.

39. *Bombus* (*Pyrobombus*) *picipes* Richards (Figs 89–92, 112, 170, 262, 266)

Bombus pratorum ssp. *flavus* Friese, 1905: 517 (not of Pérez, 1884:265 = *B. campestris* (Panzer)), holotype male MNHU examined. 'Turkestan Kashgar', believed incorrect.

Bombus (*Pratobombus*) *parthenius* var. *picipes* Richards, 1934: 90, holotype worker BMNH examined. Synonymised with *Bombus flavus* Friese by Tkalců in Sakagami (1972). China: Shaanxi.

Bombus (*Pratobombus*) *klapperichi* Pittioni, 1949: 266, holotype queen BMNH examined. Synonymised with *Bombus flavus* Friese by Sakagami (1972). China: Fujian.

Bombus (*Pyrobombus*) *flavus* Friese; Sakagami, 1972: 165; Yao, 1995: 579; Yao and Luo, 1997: 1691; Yin et al., 2001: 753. China: Sichuan.

Bombus (*Pyrobombus*) *picipes* Richards; Williams, 1998: 125.

This species belongs to the *lepidus*-group of species.

Nomenclature. Williams (1998) noted that, with *Psithyrus* being regarded as a subgenus of the genus *Bombus*, *Bombus pratorum* subsp. *flavus* Friese (1905) became a junior

secondary homonym in *Bombus* of *Psithyrus campestris* var. *flavus* Pérez (1884) (deemed to be subspecific, with reference to the then current third edition of the code, ICZN, 1985: Article 45g(ii)), and therefore *Bombus flavus* Friese is invalid (ICZN, 1985: Article 57c) as the name for this species. The oldest available name is then *Bombus parthenius* var. *picipes* Richards, 1934 (deemed to be subspecific, ICZN, 1985: Article 45g(ii)), so the valid name of the species became *Bombus picipes*. The only publications using the name *Bombus flavus* Friese since 1947 are by Sakagami (1972), Ito (1993) and Yao (1995), so this change of valid name was not a serious disruption of common usage.

Diagnosis. Small species. *Female* (length of queens 15–17 mm, workers 9–12 mm) with the mid basitarsus with the distal posterior corner acute but broadly rounded (cf. *B. imitator*, *B. remotus*); hind basitarsus with the posterior margin nearly straight; labrum with the lateral tubercles with few coarse punctures on their proximal side, the median labral furrow is broad (cf. *B. wangae*, *B. avanus*); oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible (cf. *B. wangae*, *B. avanus*); ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures (cf. non-*Pyrobombus* species); for queens (Fig. 112), the hair of the thoracic dorsum is yellow with black hairs intermixed, especially throughout the anterior pale band, but concentrated between the wing bases, usually as a narrow black band but sometimes as a black spot, corbicular fringes black or with a few orange hairs, metasomal terga 1–2 yellow (cf. *B. funerarius*, *B. infrequens*, *B. grahami*), tergum 2 with a few black hairs intermixed posteriorly and laterally, tergum 3 black, tergum 4 black with a posterior orange fringe, tergum 5 orange; larger workers (Figs 90–92) with the thorax with yellow and black hairs intermixed evenly throughout or with the black hairs only slightly more dense in a narrow band between the wing bases, tergum 3 black with a broad posterior yellow fringe; the smallest workers (Fig. 89) tending to appear generally bright lemon yellow or greyish yellow with only a few black hairs intermixed usually on the head, the thorax, and on tergum 3; wings mid brown.

Male (length 9–12 mm) predominantly bright lemon yellow, with black intermixed on the thoracic dorsum, sometimes with black intermixed on metasomal terga 3–7 and orange intermixed on terga 5–7; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 170) with the penis valve distally with a very strongly outwardly curved and then inwardly recurved sickle-shaped head, forming a pronounced ‘S’ shape (cf. *B. funerarius*, *B. imitator*, *B. remotus*), the outwardly curved head broadened, the recurved crook of the head much longer than broad and strongly narrowed and curved (cf. *B. infrequens*), the ventro-lateral angle of the penis valve closer to the distal head than to the proximal end of the penis valve; gonostylus triangular, without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species e.g. *B. grahami*).

Global distribution. Oriental species: northeastern and central China (Hebei, Beijing, Shanxi, Shaanxi, Gansu, Sichuan,

Hubei, Anhui, Zhejiang, Fujian, Jiangxi, Hunan, Guizhou, Yunnan).

SCR material examined. Common at medium altitudes of northwestern, western, southwestern and eastern mountains (Fig. 266) with a medium-length seasonal activity period (Fig. 262): 9 queens, 100 workers, 38 males, 900–3300 m (AMNH, BMNH, CAS, IZB, JAB, PHW, SAC, TY, USNM, ZMA). Literature records: Sakagami (1972), Yao (1995), Yao and Luo (1997), Yin *et al.* (2001).

SCR variation. This species shows strong size-dependent variation in the colour of the thorax and of metasomal tergum 3 among females, which is expressed most obviously as a difference between queens and workers (see Sakagami, 1972: his fig. 10).

SCR food plants. Short-tongued species: (Asteraceae) *Arctium* sp., *Cirsium* sp.; (Dipsacaceae) *Dipsacus inermis*; (Lamiaceae) *Leonurus japonicus*; (Malvaceae) *Urena lobata* L.; (Rosaceae) *Rubus* sp.

40. *Bombus (Pyrobombus) avanus* (Skorikov) (Figs 9, 95–96, 171, 263, 267)

Pratibombus avanus Skorikov, 1937: 2, syntype queens, workers, and males ZISP not found (Y. Pesenko, *in litt.*). Myanmar.

Bombus (Pyrobombus) avanus (Skorikov); Williams, 1998: 124. Change in generic combination.

This species belongs to the *lepidus*-group of species.

Nomenclature. Although it has not been possible to find any of the unspecified number of syntypes of *Bombus avanus* used to make the original description, the identity of this taxon appears clear from that description, so that the designation of a neotype is unjustified (ICZN, 1999: Article 75.1).

Taxonomic status. No records of this species have been published since the original description, in part perhaps because of its narrow distribution in an infrequently visited part of the Myanmar-China border. It is recognisable from the original description, both amongst material in the IZB collection and amongst our field collections made in southern Sichuan during 2005, by its striking convergence in colour pattern with *B. funerarius*, which is referred to in the original description. However, in contrast to the original description, for these specimens the hair of metasomal tergum 1 is greyish yellow rather than red (‘fuchsroten’; red hair is uncommon in this position on bumblebees). Paler queens of *B. avanus* from Yunnan (IZB, ZMMU) can be very similar in colour pattern to the Himalayan *B. parthenius* (BMNH), but *B. parthenius* has scattered large punctures throughout the ocello-ocular area outside the ocellar depressions. The males of *B. avanus* from Sichuan agree with the original description in having a particularly short recurved head and pronounced ventro-lateral angle of the penis valve (‘Sagitta’), which place this species in the *lepidus*-group, and in having an unusually long gonostylus (‘Squama’).

Diagnosis. Small species (Fig. 9). *Female* (length of queens 15–16 mm, workers 9–12 mm) with the mid basitarsus with the distal posterior corner acute but rounded (cf. *B. remotus*), hind basitarsus with the posterior margin nearly straight, basitarsus usually orange-brown; oculo-malar distance approximately 1.2 times the proximal breadth of the mandible (cf. *B. funerarius*); ocello-ocular area along inner eye margin with scattered large punctures in the outer half but with few small punctures (cf. non-*Pyrobombus* species); hair (Figs 9, 95–96) of the head yellowish grey intermixed with black (cf. *B. funerarius*), dorsum of the thorax with yellowish grey densely intermixed with black giving an olive colour in combination, sides of the thorax whitish or yellowish grey with a few black hairs only in the dorsal third, metasomal tergum 1 whitish or yellowish grey, tergum 2 variable but usually with at least many black hairs antero-laterally, sometimes with grey intermixed with black posteriorly, medially, and at the lateral extremes (cf. *B. funerarius*, *B. picipes*, *B. infrequens*, *B. grahmi*), tergum 3 variable but usually predominantly black with a pale posterior fringe, tergum 4 orange at least posteriorly, and terga 5–6 orange without black (cf. *B. infrequens*); wings mid brown.

Male (length 11–12 mm) variable from predominantly bright yellow mixed with black, to grey-yellow intermixed with black and with metasomal terga 4–7 predominantly orange; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; hind tibia with sparse short pale decumbent hairs often nearly throughout the central outer area, hind basitarsus with the longest hairs of the hind margin shorter than the greatest breadth of the basitarsus; genitalia (Fig. 171) with the penis valve with an incurved sickle-shaped head (cf. *B. funerarius*, *B. remotus*), the recurved crook of the head longer than broad but still relatively short and narrow (cf. *B. picipes*), the apex narrow but rounded (cf. *B. infrequens*), the ventro-lateral angle of the penis valve closer to the head than to the base of the penis valve; gonostylus triangular, about as long as broad (cf. *B. infrequens*), without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species e.g. *B. grahmi*), which is separated from the gonocoxa by a distance nearly as great as the greatest breadth of the penis valve head (cf. *B. infrequens*).

Global distribution. Oriental species: Myanmar and southwestern China (Yunnan, Sichuan).

SCR material examined. Uncommon at medium altitudes of the southwestern mountains (Fig. 267) with a short (recorded) seasonal activity period (Fig. 263): 35 workers, 7 males, 1688–3213 m (IZB, PHW, SAC, TY). New record for the SCR.

SCR variation. Males from the far north of the range in Sichuan are predominantly bright yellow, whereas males from further south around Luojishan show the grey-yellow orange-tailed pattern.

SCR food plants. Medium tongue-length species: (Asteraceae) *Saussurea* sp.; (Balsaminaceae) *Impatiens* sp.; (Dipsacaceae) *Dipsacus inermis*; (Loganiaceae) *Buddleja* sp.; (Ranunculaceae) *Thalictrum delavayi* Franch.; (Rosaceae) *Spiraea* sp.

41. *Bombus (Pyrobombus) infrequens* (Tkalčú) (Figs 93–94, 172, 268, 272)

Pyrobombus (Pyrobombus) infrequens Tkalčú, 1989: 56, holotype worker BMNH examined. Myanmar.

[*Bombus (Pratobombus) sonani* Frison, 1934: 175; Panfilov, 1957: 235, misidentification. China: Sichuan.]

[*Bombus (Pyrobombus) sonani* Frison; Wang, 1982a: 434, 1987a: 1380, 1988a: 556, 1992a: 1425; Wang and Yao, 1992a: 688, misidentification. China: Sichuan.]

Bombus (Pyrobombus) infrequens (Tkalčú); Williams, 1991: 75. Change in generic combination. China: Sichuan.

[*Bombus (Pyrobombus) parthenius* Richards, 1934: 89; Williams and Cameron, 1993: 126, misidentification. China: Sichuan.]

This species belongs to the *lepidus*-group of species.

Taxonomic status. Tkalčú (1989) distinguished this species from the closely similar *B. parthenius* Richards of the Himalaya on the basis of four workers: three from northern Burma (Myanmar), and one from Sichuan. Williams (1991, 1998) examined a series of variable workers of the *lepidus*-group from the Himalaya, Myanmar, Yunnan and Sichuan and agreed that *B. infrequens* might prove to be a separate species, but with little material available, treated them provisionally as parts of the same variable species. Now, from examining much new material from Sichuan of queens, workers, and particularly a series of males, *B. infrequens* appears to be consistently distinct in morphology. Most clearly, males of *B. infrequens* have the inner proximal processes of the gonostylus projecting inwards beyond the gonocoxa (more like *B. infirmus*). This is unlike *B. parthenius*, in which this process does not reach to the inner distal angle of the gonocoxa, leaving a distinct emargination. The spatha is also slightly broader distally for *B. infrequens*.

From examining a series of males from Sichuan, *B. infrequens* also appears to be consistently distinct from *B. sonani* in its male genitalia. For *B. sonani* (cf. *B. infrequens*) the inner proximal process of the gonostylus reaches almost exactly to the inner margin of the gonocoxa, leaving no emargination and no projection. The recurved head of the penis valve is also slightly shortened for *B. sonani*. See also the comments above on *B. avanus*. Therefore, we tentatively recognise *B. infrequens* and *B. sonani* as separate species, at least until more material can be examined from eastern mainland China.

Diagnosis. Medium-sized species. *Female* (length of queens 15–18 mm, workers 9–13 mm) with the mid basitarsus with the distal posterior corner acute but broadly rounded (cf. *B. remotus*), hind basitarsus with the posterior margin nearly straight, the basitarsus usually dark brown or sometimes orange brown; oculo-malar distance approximately 1.1 times the proximal breadth of the mandible; ocello-ocular area along inner eye margin with scattered large punctures up to the edge of the ocellar depressions but with few small punctures (cf. non-*Pyrobombus* species e.g. *B. funerarius*); hair (Figs 93–94) of the body grey intermixed with black giving an olive colour in combination, sides of the thorax and metasomal tergum 1 whitish or yellowish grey without black hairs, tergum 2 grey

intermixed with black (cf. *B. funerarius*, *B. picipes*, *B. avanus*, *B. grahami*), terga 3–5 with more black intermixed anteriorly, and terga 5–6 often with some pale orange medially, black laterally (cf. *B. avanus*); wings mid brown.

Male (length 12–14 mm) similarly coloured, but lemon yellow rather than grey or olive and with fewer black hairs on the head, the thorax (although sometimes with black patches laterally on the scutellum), and metasomal terga 1–2; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; hind tibia with sparse short pale decumbent hairs absent from most of the central outer area, hind basitarsus with the longest hairs of the hind margin variable but often longer than the greatest breadth of the basitarsus; genitalia (Fig. 172) with the penis valve with an incurved sickle-shaped head (cf. *B. funerarius*, *B. remotus*), the recurved crook of the head longer than broad but still short and narrow (cf. *B. picipes*), the apex broad and rounded (cf. *B. avanus*), the ventro-lateral angle of the penis valve closer to the head than to the bases of the penis valve; gonostylus triangular, about half as long as broad (cf. *B. avanus*), without an inner proximal process, but with an inner submarginal longitudinal groove (cf. non-*Pyrobombus* species e.g. *B. grahami*), which is separated from the gonocoxa by a distance less than half of the greatest breadth of the penis valve head (cf. *B. avanus*).

Global distribution. Oriental species: Myanmar, the eastern fringes of the Tibetan plateau, and central China (Yunnan, Xizang, Gansu, Sichuan, Shaanxi, Hubei, Hunan, Guizhou).

SCR material examined. Common at medium altitudes of the northwestern, western, southwestern, and eastern mountains (Fig. 272) with a medium-length seasonal activity period (Fig. 268): 21 queens, 253 workers, 42 males, 650–4110 m (BMNH, IZB, JAB, PHW, SAC, TY, USNM, ZMMU, ZMA). Literature records: Panfilov (1957), Wang (1982a, 1987a, 1988a, 1992a), Tkalců (1989), Williams (1991), Wang and Yao (1992a), Williams and Cameron (1993).

SCR variation. These bees appear to be particularly variable in morphology and colour. Some queens from Gonggashan have long shaggy hair and are dark greyish with many black hairs anteriorly on metasomal terga 3–5, the mid and hind tibiae are dark brown, the corbicular fringes are black or brown, and most or all of the ocello-ocular area is punctured up to the edge of the ocellar depressions. Males from the same area are also long haired with many black hairs anteriorly on terga 3–5, terga 6–7 are orange, and the hind tibiae have the outer surface largely shining and without short hairs. Some queens from Emeishan are similar to those from Gonggashan, but others from Emei have shorter hair and are lighter and more yellowish with fewer black hairs on terga 3–5 (especially 5), the mid and hind tibiae are orange brown, the corbicular fringes are orange, and the punctures are confined to the outer half of the ocello-ocular area. Some males from Emeishan resemble those from Gonggashan, but others have shorter hair that is mostly yellow, terga 3–5 have only a few black hairs intermixed anteriorly, there is no orange hair, and the hind tibiae have the outer surface covered almost throughout with short yellow

hairs. The pattern of variation among individuals appears to be continuous, so from this evidence we believe that a single species is involved, but further sampling and analysis would be desirable. A similar very light yellow form (metasoma with few black hairs) occurs further to the south east, in Guizhou.

SCR food plants. Medium tongue-length species: (Balsaminaceae) *Impatiens* sp.; (Dipsacaceae) *Dipsacus inermis*; (Lamiaceae) *Salvia* sp.; (Loganiaceae) *Buddleja* sp.; (Onagraceae) *Chamerion angustifolium*; (Scrophulariaceae) *Pedicularis cranulopha*, *P. rex*.

Subgenus *BOMBUS* in the strict sense

42. *Bombus (Bombus) ignitus* Smith (Figs 102, 173, 269, 273)

Bombus ignitus Smith, 1869: 207, holotype queen BMNH examined. Japan.

Bremus (Bremus) ignitus (Smith); Frison, 1935: 351. China: Sichuan.

[*Bremus (Bremus) ignitus* var. *cancellatus* Frison, 1935: 351, infrasubspecific.]

Bombus ignitus Smith; Tkalců, 1962: 84, 1965: 10. China: Sichuan.

Bombus (Bombus) ignitus Smith; Yao and Luo, 1997: 1693; Yao, 1998: 403; Yin *et al.*, 2001: 753. China: Sichuan.

Diagnosis. Large species. *Female* (length of queens 19 mm, workers 15–17 mm) with the mid basitarsus with the distal posterior corner forming a rounded right angle; hind basitarsus with the posterior margin strongly arched (cf. non-*Bombus* s.str. species e.g. *B. eximius*, *B. flavescens*); oculo-malar distance approximately 0.8 times the proximal breadth of the mandible; hair (Fig. 102) of the thoracic dorsum and of the tibiae black (cf. *B. eximius*, *B. flavescens*), metasomal terga 1–3 black, terga 4–5 orange-red; wings light brown.

Male (length 17 mm) with the hair of the thorax with golden yellow bands anteriorly and posteriorly, metasomal terga 1–2 golden yellow, tergum 3 black, terga 4–5 orange-red; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 173) with the penis valve greatly broadened and flared outwards to form half of a funnel (cf. *B. eximius*, *B. flavescens*), the dorsal extremity extending beyond the ventral lobe as a narrow finger, which is longer than broad (cf. *B. patagiatus*, *B. lucorum*).

Global distribution. Species of the eastern Palearctic region, and within the Oriental region: eastern and southern China (Heilongjiang, Jilin, Liaoning, Hebei, Shandong, Shanxi, Shaanxi, Gansu, Sichuan, Hubei, Anhui, Jiangsu, Zhejiang, Jiangxi, Guangdong, Guizhou, Yunnan).

SCR material examined. Uncommon at low altitudes of the western, southern, and eastern foothills of the Sichuan basin (Fig. 273) with a short (recorded) seasonal activity period (Fig. 269): 1 queen, 14 workers, 3 males (?140–) 760–2000 m (BMNH, INHS, IZB, USNM). A male (IZB, not found) labelled Jiangdongcun with unusually low altitude data (140 m)

may be based on only an approximate location and needs to be confirmed, but is shown in the activity plot and map. Literature records: Frison (1935), Tkalčú (1962, 1965), Yao and Luo (1997), Yao (1998), Yin *et al.* (2001).

SCR food plants. Medium tongue-length species, no records.

43. *Bombus (Bombus) patagiatus* Nylander (Figs 118, 174, 270, 274)

Bombus patagiatus Nylander, 1848: 234, holotype queen (Helsinki Museum) not found (Tkalčú, 1967). Russia: 'E Sibiria'.

Bombus terrestris var. *patagiatus* Nylander; Morawitz, 1890: 349. China: 'Sse-tschuan', but probably Qinghai.

Bombus lucorum var. *lan-tschóuensis* Vogt, 1908: 101, syntype queen ZMA examined. Regarded as conspecific with *Bombus patagiatus* Nylander by Tkalčú (1967). China: Gansu.

Bombus vasilievi Skorikov, 1913: 172, type not seen. Regarded as conspecific with *Bombus patagiatus* Nylander by Tkalčú (1967). China: Gansu and Heilongjiang.

Terrestribombus patagiatus (Nylander); Skorikov [1923]: 155. China: Sichuan.

Bombus lucorum ssp. *beickianus* Bischoff, 1936: 2, type not seen. Regarded as conspecific with *Bombus patagiatus* Nylander by Tkalčú (1967). China: Gansu.

Bombus lucorum ssp. *pseudosporadicus* Bischoff, 1936: 2, type not seen. Regarded as conspecific with *Bombus patagiatus* Nylander by Tkalčú (1967). China: Gansu.

Bombus (Bombus) patagiatus ssp. *minshanensis* Bischoff, 1936: 3, type not seen. China: Gansu.

Bombus (Bombus) patagiatus [ssp.] *minshanensis* Bischoff; Wang, 1992: 1424. China: Sichuan.

Nomenclature. Although it has not been possible to find the single type specimen of *Bombus patagiatus* specified in the original description, the identity of this taxon appears clear from the original description and from Tkalčú (1967), so the designation of a neotype is unjustified (ICZN, 1999: Article 75.1).

Diagnosis. Medium-sized species. *Female* (length of queens 18 mm, workers 10–15 mm) with the mid basitarsus with the distal posterior corner forming a rounded right angle; hind basitarsus with the posterior margin strongly arched (cf. non-*Bombus* s.str. species); oculo-malar distance approximately 0.8 times the proximal breadth of the mandible; hair (Fig. 118) of the thorax with grey-white bands anteriorly and posteriorly (cf. *B. ignitus*, *B. lucorum*), metasomal tergum 1 white, tergum 2 pale yellow (cf. *B. convexus*), tergum 3 black (cf. *B. ladakhensis*, *B. rufofasciatus*), terga 4–5 mostly white (cf. *B. sichelii*); wings light brown.

Male (length 14–15 mm) with the hair of the thorax with lemon-yellow bands anteriorly and posteriorly, metasomal terga 1–2 lemon yellow, tergum 3 black or with a posterior yellowish-white fringe, tergum 4 anteriorly black and posteriorly white, terga 5–7 white; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 174) with the penis valve

greatly broadened and flared outwards to form half of a funnel (cf. non-*Bombus* s.str. species), the dorsal extremity extending beyond the ventral lobe as a short projection, which is as broad as long (cf. *B. ignitus*).

Global distribution. Species of the Palaearctic region, and within the Oriental region: eastern Tibetan plateau and northern and central China (Xinjiang, Ningxia, Neimenggu, Heilongjiang, Jilin, Liaoning, Hebei, Beijing, Shanxi, Shaanxi, Gansu, Sichuan, Qinghai, Xizang, Hubei, Guizhou, Hunan, Guangxi, Fujian, Zhejiang).

SCR material examined. Common at high altitudes of the northwestern and western plateau (Fig. 274) with a medium-length seasonal activity period (Fig. 270): 1 queen, 135 workers, 15 males, 3268–4700 m (BMNH, IZB, PHW, SAC, TY). Literature records: Morawitz (1890), Skorikov ([1923]), Wang (1992a).

SCR food plants. Short-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Saussurea* sp.; (Caprifoliaceae) *Lonicera* sp.; (Lamiaceae) *Ajuga* sp.; (Leguminosae) *Astragalus* sp., *Oxytropis* sp.; (Ranunculaceae) *Aconitum gymnanthum*; (Scrophulariaceae) *Pedicularis cranolopha*, *P. floribunda*, *P. integerrima*, *P. kansuensis*, *P. lachnoglossa*, *P. longiflora*, *P. rhinanthoides*, *P. spicata*, *P. verticillata*.

44. *Bombus (Bombus) lucorum* (Linnaeus) in the broad sense (Figs 131, 175, 271, 275)

APIS lucorum Linnaeus, 1761: 425, lectotype male (Day, 1979: 66) LSL examined. Sweden.

Bombus lucorum (Linnaeus); Fabricius, 1804: 350. Change in generic combination.

Bombus (Bombus) terrestris ssp. *minshanicola* Bischoff, 1936: 2, type not seen. Regarded as conspecific with *Bombus lucorum* (Linnaeus) by Krüger (1951). China: Gansu.

Bombus (Bombus) lucorum (Linnaeus); Wang, 1982: 429, 1985: 160, 1987: 1380, 1988: 555, 1992: 1423; Williams, 1991: 81; Wang and Yao, 1996a: 305. China: Sichuan.

Taxonomic status. The subgenus *Bombus*, and particularly the *lucorum*-complex, has received particularly close attention by European authors who have described the minutiae of colour variation (e.g. Krüger, 1951, 1954, 1956, 1958). At least some of the very many nominal taxa are regarded as separate species by some authors (e.g. Scholl & Obrecht, 1983; Rasmont, 1984; Pamilo *et al.*, 1987; Bertsch *et al.*, 2004, 2005). Nonetheless, there are conflicting patterns of variation among some characters of these nominal taxa, which are not fully understood (Pekkarinen, 1979; Pamilo *et al.*, 1984; Amiet, 1996; Pamilo *et al.*, 1997; Davydova, 2001; Davydova & Pesenko, 2002). From DNA sequence data for five genes, specimens from Sichuan are likely to belong to species separate from the typical European *B. lucorum* in the strict sense (Hines *et al.*, 2006; Cameron *et al.*, 2007). Unfortunately, so far only a small subset of Asian taxa in this group have been studied for DNA sequences, and these patterns of variation have yet to be associated with thoroughly revised species. From morphological

evidence, there appears to be a broad range of variation in Asia with some recombination between morphological character combinations (e.g. Williams, 1991). Consequently, from the evidence available at present, the separation of taxa, the recognition of species, and the nomenclature of those species, are all still unreliable, so there remains an urgent need for this species group to be revised throughout its range. Thus for the Asian taxa, as a conservative temporary measure the name *B. lucorum* is applied here in its broadest sense, to include the entire complex of similar nominal taxa.

Diagnosis. Medium-sized species. *Female* (length of queens 18 mm, workers 13–15 mm) with the mid basitarsus with the distal posterior corner forming rounded right angle; hind basitarsus with the posterior margin strongly arched (cf. non-*Bombus* s.str. species e.g. *B. infirmus*); oculo-malar distance approximately 0.9 times the proximal breadth of the mandible; hair (Fig. 131) of the head black, queen with long orange hairs around the clypeus and short grey feathered hairs on the face around the antennal base, the thorax with a yellow band anteriorly (cf. *B. ignitus*, *B. patagiatus*) extending half way down the sides of the thorax and without a transverse black 'S'-shape (cf. *B. cryptarum*), metasomal tergum 1 black, tergum 2 lemon yellow in the anterior half to two thirds and posteriorly black, tergum 3 black, tergum 4 anteriorly black and posteriorly white, tergum 5 white; wings light brown.

Male (length 12–15 mm) with the hair of the thorax with a lemon-yellow band anteriorly, posteriorly at most with some obscure grey-yellow hairs (cf. *B. patagiatus*), metasomal tergum 1 often with many black hairs, tergum 2 anteriorly lemon yellow and posteriorly black, tergum 3 black, tergum 4 anteriorly black and posteriorly white, terga 5–7 mostly white; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 175) with the penis valve greatly broadened and flared outwards to form half of a funnel (cf. non-*Bombus* s.str. species, e.g. *B. infirmus*), the dorsal extremity extending beyond the ventral lobe as a short projection, which is as broad as long (cf. *B. ignitus*).

Global distribution. Widespread species (complex) of the Palearctic and Nearctic regions, and within the Oriental region: Himalaya and the fringes of the Tibetan plateau, Myanmar, and northeastern China (Xinjiang, Ningxia, Neimenggu, Heilongjiang, Jilin, Liaoning, Hebei, Shanxi, Shaanxi, Gansu, Sichuan, Qinghai, Xizang, Yunnan).

SCR material examined. Common at high altitudes of the northwestern, western and southwestern plateau and mountains (Fig. 275) with a medium-length seasonal activity period (Fig. 271): 2 queens, 231 workers, 63 males, 1550–4396 m (IZB, PHW, SAC, TY). Literature records: Wang (1982a, 1985a, 1987a, 1988a, 1992a), Williams (1991), Wang and Yao (1996a).

SCR food plants. Medium tongue-length species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium falconeri* (Hook. f.) Petrak, *Ligularia* sp.; (Boraginaceae) *Microula* sp.; (Caprifoliaceae) *Lonicera* sp.; (Crassulaceae) *Sedum* sp.; (Legumino-

sae) *Hedysarum* sp.; (Onagraceae) *Chamerion angustifolium*; (Ranunculaceae) *Aconitum gymnantrum*, *Anemone* sp.; (Scrophulariaceae) *Pedicularis cranolopha*, *P. floribunda*, *P. roylei*, *P. siphonantha*.

Subgenus *ALPIGENOBOMBUS* Skorikov

45. *Bombus (Alpigenobombus) breviceps* Smith (Figs 35–38, 176, 276, 280)

Bombus nasutus Smith, 1852a: 44, LECTOTYPE queen by present designation (note below) BMNH examined. Synonymised provisionally with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). China: Zhejiang.

Bombus breviceps Smith, 1852a: 44, holotype worker (note below) BMNH examined. China: Zhejiang.

Bombus dentatus Handlirsch, 1888: 227, type not seen. Synonymised provisionally with *Bombus breviceps* Smith by Williams (1991). Probably India.

Bombus simulus Gribodo, 1892: 114, holotype worker MCSN examined. Synonymised with *Bombus breviceps* Smith by Williams (1998). India.

Bombus Channicus Gribodo, 1892: 116, type not seen. Regarded as conspecific with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). Myanmar.

Bombus laticeps Friese, 1905: 513, type not seen. Regarded as conspecific with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). China: Sichuan

Bombus orichalceus Friese, 1916: 107, holotype queen MNHU examined. Synonymised provisionally with *Bombus breviceps* Smith by Williams (1991), confirmed here. India.

BOMBUS RUFOCOGNITUS Cockerell, 1922: 4, holotype queen USNM examined. Regarded as conspecific with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). China: Sichuan.

Bombus laticeps Friese; Skorikov [1923]: 159. China: Sichuan. [*Bremus (Alpigenobombus) dentatus* var. *surdus* Frison, 1935: 353, infrasubspecific.]

Bombus (Alpigenobombus) dentatus ssp. *pretiosus* Bischoff, 1936: 11 (not of Friese, 1911: 571 = *B. polaris* Curtis), lectotype queen (Tkalcü, 1968b: 20) MNHU examined. Regarded as conspecific with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). China: Yunnan.

Bombus (Alpigenobombus) channicus ssp. *cantonensis* Bischoff, 1936: 14, type not seen. Regarded as conspecific with *Alpigenobombus breviceps* (Smith) by Tkalcü (1968b). China: Guangdong.

Bombus rufocognitus Cockerell; Wu, 1941: 283. China: Sichuan.

Bombus (Alpigenobombus) laticeps Friese; Panfilov, 1957: 235. China: Sichuan.

Bombus (Alpigenobombus) channicus [ssp.] *laticeps* Friese; Tkalcü, 1960: 67. China: Sichuan.

Alpigenobombus breviceps (Smith); Tkalcü, 1968b: 12. China: Sichuan.

Bombus (Alpigenobombus) breviceps [ssp.] *channicus* Gribodo; Sakagami, 1972: 163. China: Sichuan.

Alpigenobombus breviceps [ssp.] *bischoffiellus* Tkalcü, 1977: 224, replacement name for *pretiosus* Bischoff, 1936: 11.

Bombus (Alpigenobombus) breviceps Smith; Wang, 1987a: 1379; Wang and Yao, 1993a: 416; Yao and Luo, 1997: 1688; Yin *et al.*, 2001: 752. China: Sichuan.

Bombus (Alpigenobombus) channicus Gribodo; Wang, 1992a: 1422; Wang and Yao, 1993a: 417. China: Sichuan.

Bombus (Alpigenobombus) rufocognitus Cockerell; Wang, 1992a: 1422; Wang and Yao, 1992a: 688, 1993a: 418. China: Sichuan.

Bombus (Alpigenobombus) dentatus Handlirsch; Wang and Yao, 1993a: 418. China: Sichuan.

This species belongs to the *breviceps*-group of species.

Nomenclature. Smith's description of *B. breviceps* is of a worker from 'Chusan' [= Zhoushan, Zhejiang]. A worker in the BMNH collection agrees with the original description and bears the labels: (1) round red-edged printed 'Type'; (2) 'B.M. TYPE/HYM./17B.997.'; (3) hand-written 'Bombus/breviceps/TYPE. Smith.'; (4) hand-written in Smith's hand 'China'; (5) hand-written in Smith's hand on blue paper 'breviceps/Smith mss'; (6) 'type F. Sm. Coll./79.22'; (7) round red-edged printed 'Holo-/type'. From the original publication and from the collection, there is no evidence for the existence of other workers seen by Smith. Therefore this worker, which lacks only part of the tarsus of the right hind leg, is regarded as the holotype.

Smith's description of *B. nasutus* is of another worker from 'Chusan', although it goes on to give a range of sizes, implying more than one specimen. A small, slightly faded, queen in the BMNH collection agrees with the original description apart from the length of the head. However, as pointed out by Tkalčú (1968b: 13), the impression of a long head could be explained by the extended position of the mandibles of this specimen (in contrast, they are folded for the holotype of *B. breviceps*). This queen bears the labels: (1) round red-edged printed 'Type'; (2) 'B.M. TYPE / HYM. / 17B.996.'; (3) hand-written '*Bombus/nasutus*/TYPE. Smith.'; (4) hand-written in Smith's hand on blue paper 'nasutus/Smith. mss.'; (5) round hand-written in Smith's hand on blue card 'n/China' reverse side '54/42'; (6) round red-edged printed 'Holo-/type'. The label for 'n China' appears to match the title of Smith's paper. From the original publication, other Smith syntypes appear to have existed and may have become dispersed to other collections. Therefore this queen, which lacks the left and right anterior leg, the right mid leg, and the right hind leg, is designated here as lectotype (ICZN, 1999: Article 74.1).

Smith described *Bombus nasutus* and *Bombus breviceps* together in the same paper (Smith, 1852a) and noted the 'considerable general resemblance' between them. Tkalčú (1968b: 13), in making *Bombus nasutus* a provisional synonym of *Bombus breviceps*, is deemed to be acting as First Reviser in the meaning of the ICZN (1999: Article 24). Consequently the name *Bombus breviceps* is accepted as taking precedence, which serves the stability of nomenclature.

Diagnosis. Medium-sized species. *Female* (length of queens 18–21 mm, workers 10–16 mm) with the mid basitarsus with the distal posterior corner acutely and sharply pointed; hind

basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface only just over half as long as the greatest breadth of the basitarsus (these may break or abrade) (cf. *B. kashmirensis*, *B. nobilis*, *B. grahami*); mandible distally with six teeth (these may be subject to wear) (cf. all non-*Alpigenobombus* species e.g. *B. braccatus*, *B. trifasciatus*, *B. longipes*, *B. bicoloratus*, *B. imitator*); oculo-malar distance approximately 0.7 times the proximal breadth of the mandible (cf. *B. funerarius*, *B. nobilis*); dorsum of the head with the punctures scattered almost throughout, some even in the ocellar depressions (cf. *B. braccatus*); hair (Figs 35–38) of the thorax variable from entirely black (Figs 37–38) to having orange bands (Figs 35–26) of variable breadth anteriorly and posteriorly (cf. *B. longipes*), lighter orange on the sides, corbicular fringes orange (cf. *B. trifasciatus*), metasomal tergum 1 and sometimes at least parts of terga 2–3 golden or lemon yellow, posterior corners of tergum 3 and usually the anterior half of tergum 4 black, the posterior half of tergum 4 and tergum 5 orange-red; wings dark brown.

Male (length 14–15 mm) similarly coloured, the head usually with at least some yellow intermixed; compound eye slightly enlarged relative to the female and the antenna reaching posteriorly to the wing bases; mandible distally pointed, with two additional teeth (cf. all non-*Alpigenobombus* species e.g. *B. braccatus*, *B. trifasciatus*, *B. longipes*, *B. bicoloratus*, *B. imitator*); genitalia (Fig. 176) with the penis valve distally with an incurved sickle-shaped head, the recurved crook of the head as long as its proximal breadth (cf. *B. kashmirensis*); gonostylus shortened and spinose (cf. *B. kashmirensis*, *B. nobilis*, *B. grahami*), without an inner submarginal longitudinal groove, the inner proximal process pointed (cf. *Pyrobombus* species).

Global distribution. Widespread Oriental species: Himalaya, Myanmar, Thailand, Vietnam, China (Yunnan, Xizang, Sichuan, Hubei, Hunan, Jiangxi, Zhejiang, Fujian, Guangdong, Guangxi, Guizhou).

SCR material examined. Formerly common at low altitudes of the Sichuan basin, surrounding foothills, and the southwestern mountains, but with few recent records (Fig. 280), with a long seasonal activity period (Fig. 276): 57 queens, 75 workers, 10 males, 270–3350 (–?3800) m (AMNH, BMNH, CAS, INHS, IZB, PHW, SAC, TY, USNM, ZMMU). A male (IZB) labelled Zhongrewu with unusually high altitude data (3800 m) may be based on only an approximate location and needs to be confirmed, but is shown in the activity plot and map. Literature records: Friese (1905), Skorikov ([1923]), Frison (1935), Bischoff (1936), Wu (1941), Panfilov (1957), Tkalčú (1960, 1968c), Sakagami (1972), Wang (1987a, 1992a), Wang and Yao (1992a, 1993a), Yao and Luo (1997), Yin *et al.* (2001).

SCR variation. This species is very variable in colour pattern. Individuals from around the Sichuan basin show the common colour pattern for the Changjiang (Yangtze) valley of central China, with two broad orange bands on the dorsum of the thorax and orange-yellow on the sides of the thorax (the '*channicus*' [metasomal tergum 2 mostly black, Fig. 36] and

'*laticeps*' [tergum 2 mostly yellow, Fig. 35] patterns). Individuals from further south around Luojishan have the thorax entirely black and tergum 2 lemon yellow (the '*pretiosus*' pattern, Figs 37, 38), similar to individuals from further west in southern Xizang and the Himalaya. Intermediate individuals with the thorax black with only very narrow orange bands anteriorly and posteriorly (and on the sides) have been collected at Emeishan, Luding, Zhongrewu, and in Yunnan. See the comments on *B. trifasciatus*.

SCR food plants. Short-tongued species: (Amaranthaceae) *Bougainvillea glabra* Choisy; (Asteraceae) *Saussurea* sp.; (Balsaminaceae) *Impatiens* sp.; (Bignoniaceae) *Incarvillea* sp.; (Lamiaceae) *Salvia* sp.; (Malvaceae) *Urena lobata*; (Scrophulariaceae) *Pedicularis racemosa*; (Verbenaceae) *Verbena* sp.

46. *Bombus (Alpigenobombus) grahami* (Frison) (Figs 32, 177, 277, 281)

Bremus (Alpigenobombus) grahami Frison, 1933: 334, holotype queen USNM examined. China: Sichuan.

Bombus (Alpigenobombus) grahami (Frison); Wang, 1982a: 427. Change in generic combination. China: Sichuan.

Bombus (Alpigenobombus) grahami (Frison); Wang, 1992a: 1422; Wang and Yao, 1993a: 421; Yao and Luo, 1997: 1689. China: Sichuan.

This species belongs to the *breviceps*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 22 mm, workers 12–14 mm) with the mid basitarsus with the distal posterior corner acutely and sharply pointed; hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface about as long as the greatest breadth of the basitarsus (these may break or abrade); mandible distally with six teeth (these may be subject to wear) (cf. all non-*Alpigenobombus* species e.g. *B. funerarius*, *B. remotus*, *B. picipes*, *B. avanus*, *B. infrequens*); oculo-malar distance approximately 0.7 times the proximal breadth of the mandible (cf. *B. nobilis*); dorsum of the head with the punctures scattered almost throughout except in the ocellar depressions (cf. *B. funerarius*); hair (Fig. 32) of the head and the thoracic dorsum grey densely intermixed with black giving a dark grey or olive colour in combination (cf. *B. remotus*, *B. kashmirensis*, *B. nobilis*, *B. breviceps*), thoracic midline, lower sides of thorax, metasomal tergum 1, and anterior quarter to three-quarters of tergum 2 paler grey to almost white, posterior part of tergum 2 and all of tergum 3 black, terga 4–5 orange-red; wings mid brown.

Male (length 13 mm) hair of the head, thorax, and metasomal terga 1–2 grey-yellow with some black intermixed, tergum 3 black, terga 4–7 orange; compound eye slightly enlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with two additional teeth (cf. all non-*Alpigenobombus* species e.g. *B. funerarius*, *B. remotus*, *B. picipes*, *B. infrequens*); genitalia (Fig. 177) with the penis valve distally with an incurved sickle-shaped head (cf. *B. funerarius*, *B. remotus*), the recurved crook

of the head as long as its proximal breadth (cf. *B. kashmirensis*); gonostylus triangular (cf. *B. kashmirensis*, *B. nobilis*, *B. breviceps*), without an inner submarginal longitudinal groove, the inner proximal process pointed (cf. *Pyrobombus* species e.g. *B. picipes*, *B. avanus*, *B. infrequens*).

Global distribution. Oriental species: central China (Henan, Hubei, Hunan, Sichuan, Xizang, Yunnan).

SCR material examined. Uncommon at medium altitudes of the western, southwestern, and eastern mountains (Fig. 281) with a medium-length seasonal activity period (Fig. 277): 1 queen, 25 workers, 5 males, 858–3040 m (INHS, IZB, PHW, SAC, TY). Literature records: Wang (1982a, 1992a), Wang and Yao (1993a), Yao and Luo (1997).

SCR food plants. Short-tongued species: (Balsaminaceae) *Impatiens* sp.; (Leguminosae) *Phaseolus* sp.; (Scrophulariaceae) *Pedicularis densispica*, *P. roylei*.

47. *Bombus (Alpigenobombus) kashmirensis* Friese (Figs 28, 30, 178, 278, 282)

[*Bombus mastrucatus* Gerstaecker, 1869: 326; Morawitz, 1880: 344, misidentification. China: 'Gan-su.']

[*Bombus mastrucatus* Gerstaecker; Morawitz, 1890: 349, misidentification. China: 'Sse-tschuan', but probably Qinghai.]

Bombus mastrucatus var. *kashmirensis* Friese, 1909 [September, Tkalčú, 1974a]: 673, lectotype queen (Tkalčú, 1974a: 327) MNHU examined. India.

Bombus mastrucatus var. *stramineus* Friese, 1909 [September, Tkalčú, 1974a]: 673, type not found (Tkalčú, 1974a: 327). Synonymised with *Alpigenobombus kashmirensis* (Friese) by Tkalčú (1974a). India.

Bombus tetrachromus Cockerell, 1909 [November, Tkalčú, 1974a]: 397, holotype queen BMNH examined. Synonymised with *Alpigenobombus kashmirensis* (Friese) by Tkalčú (1974a). Pakistan.

Alpigenobombus pulcherrimus Skorikov, 1914: 128, type not seen. Synonymised with *Bombus tetrachromus* Cockerell by Richards (1930). Synonymised with *Alpigenobombus kashmirensis* (Friese) by Tkalčú (1974a). India.

[*Alpigenobombus (Alpigenobombus) beresovskii* Skorikov [1923]: 156, published without description. China: Sichuan.]

[*Alpigenobombus beresovskii* Skorikov, 1931: 204, published without description.]

Alpigenobombus beresovskii Skorikov, 1933a: 248, syntype queen ZISP examined. Synonymised with *Bombus kashmirensis* Friese by Williams (1991). China: Sichuan.

[*Bombus (Alpigenobombus) beresowskii* (Skorikov); Panfilov, 1957: 235, incorrect subsequent spelling. China: Sichuan.]

Bombus (Alpigenobombus) tetrachromus Cockerell; Wang, 1982a: 428, 1992a: 1422; Wang and Yao, 1993a: 423. China: Sichuan.

Bombus (Alpigenobombus) kashmirensis Friese; Williams, 1991: 66; Williams and Cameron, 1993: 126. China: Sichuan.

Bombus kashmirensis Friese; Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *wurflenii*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 17 mm, workers 10–15 mm) with the mid basitarsus with the distal posterior corner acutely and sharply pointed; hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface longer than the greatest breadth of the basitarsus (these may break or abrade); mandible distally with six teeth (these may be subject to wear) (cf. all non-*Alpigenobombus* species e.g. *B. supremus*, *B. impetuosus*, *B. lemniscatus*, *B. lepidus*, *B. rufofasciatus*, *B. pyrosoma*); oculo-malar distance approximately 0.7 times the proximal breadth of the mandible (cf. *B. nobilis*, *B. lemniscatus*); ocello-ocular area along the inner eye margin with scattered large and small punctures; hair (Figs 28, 30) of the head black (cf. *B. impetuosus*, *B. lepidus*), the thorax with grey-white bands anteriorly and posteriorly, metasomal tergum 1 grey-white, tergum 2 grey-white (Fig. 30) or yellow (Fig. 28), tergum 3 anteriorly black, posteriorly orange-red, terga 4–5 orange-red, although the hairs are sometimes white-tipped; wings light brown.

Male (length 15–16 mm) similarly coloured; compound eye only slightly enlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with two additional teeth (cf. all non-*Alpigenobombus* species e.g. *B. supremus*, *B. impetuosus*, *B. lemniscatus*, *B. lepidus*, *B. rufofasciatus*, *B. pyrosoma*); genitalia (Fig. 178) with the penis valve with an incurved sickle-shaped head, the recurved crook of the head longer than its proximal breadth (cf. *B. nobilis*); gonostylus rounded (cf. *B. grahami*, *B. breviceps*), without an inner submarginal longitudinal groove, the inner proximal process pointed (cf. *Pyrobombus* species e.g. *B. lemniscatus*, *B. lepidus*).

Global distribution. Oriental species: Himalaya and Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan, ?Guangxi: Wang, 1982: 429).

SCR material examined. Common at high altitudes of the northwestern and western plateau and mountains (Fig. 282) with a medium-length seasonal activity period (Fig. 278): 14 queens, 164 workers, 33 males, 2700–4700 m (BMNH, IZB, LWM, PHW, SAC, TY, ZMA). Literature records: Morawitz (1890), Skorikov (1933a, [1923]), Panfilov (1957), Wang (1982a, 1992a), Williams (1991), Wang and Yao (1993a), Williams and Cameron (1993), Macior and Tang (1997).

SCR variation. Both the white-banded form (the '*kashmirensis*' pattern, Fig. 30) and the white-and-yellow-banded form (the '*stramineus*' pattern, Fig. 28) occur in Sichuan, often together at the same site.

SCR food plants. Short-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Ligularia* sp.; (Crassulaceae) *Sedum* sp.; (Leguminosae) *Hedysarum* sp., *Oxytropis* sp.; (Onagraceae) *Chamerion angustifolium*; (Ranunculaceae) *Aconitum gymnantrum*, *Delphinium* sp.; (Scrophulariaceae) *Pedicularis cranolopha*, *P. davidii*, *P. longiflora*, *P. muscoides*,

P. polyodonta, *P. rhinanthoides*, *P. roylei*, *P. siphonantha*, *P. spicata*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

48. *Bombus (Alpigenobombus) nobilis* Friese (Figs 29, 31, 33–34, 179, 279, 283)

[*Bombus haemorrhoidalis* Smith, 1852a: 43; Morawitz, 1880: 344, misidentification. China: 'Gan-su.']

Bombus validus Friese, 1905: 510, syntype queen (Tkalčú, 1987: 60) MNHU examined. Synonymised provisionally with *Bombus nobilis* Friese by Williams (1998). 'Turkestan Kashgar', believed incorrect.

Bombus nobilis Friese, 1905: 513, type not found (see below). China: Sichuan.

Bombus sikkimi Friese, 1918: 82, syntype queen MNHU examined. Synonymised provisionally with *Bombus nobilis* Friese by Williams (1998). [India]

[*Bombus morawitziides* Skorikov [1923]: 159, published without description.]

Bombus nobilis Friese; Skorikov [1923]: 160. China: Sichuan.

Bombus validus Friese; Skorikov [1923]: 160. China: Sichuan.

[*Bombus moravitziiides* Skorikov 1931: 203, published without description.]

Nobilibombus morawitziides Skorikov, 1933b: 62, holotype worker ZISP examined. Synonymised with *Alpigenobombus validus* (Friese) by Tkalčú (1987). Synonymised provisionally with *Bombus nobilis* Friese by Williams (1998). China: 'Gan-su', but probably Qinghai.

Bombus (Nobilibombus) xizangensis Wang, 1979: 188, holotype worker IZB examined. Synonymised provisionally with *Bombus nobilis* Friese by Williams (1998). China: Xizang.

Bombus (Nobilibombus) chayaensis Wang, 1979: 189, holotype queen IZB examined. Synonymised provisionally with *Bombus nobilis* Friese by Williams (1998). China: Xizang.

Bombus (Alpigenobombus) nobilis Friese; Williams, 1991: 67. China: Sichuan.

Bombus (Nobilibombus) chayaensis Wang; Wang, 1992a: 1423. China: Sichuan.

This species belongs to the *wurflenii*-group of species.

Nomenclature. Following the Principle of First Reviser (ICZN, 1985: Article 24), and as the first author to regard these taxa as conspecific, Williams (1998) selected the name *Bombus nobilis* as the valid name in preference to *Bombus validus* from the available names for this species from Friese (1905).

The type specimens of *Bombus nobilis* have also been in some doubt (Richards, 1968). Friese (1905) described the female of *Bombus nobilis* as having a 'quadratis' oculo-malar area and 4–5 distal teeth on the mandible (even though he placed this species [p. 519] in a group with *Bombus lapidarius*). The original description lists several females (from Sichuan), but the only putative type female that I have been able to examine (although it carries no Friese 'type' label) is in the MNHU collection and is a specimen of *Bombus friseanus* labelled 'Kashgar' (this locality is outside the known range

of either *Bombus nobilis* or *Bombus friseanus*). The specimen does not match the original description regarding the mandibles of *Bombus nobilis* and so cannot be considered as a valid syntype. Nonetheless, the identity of *Bombus nobilis* appears clear from the original description, so the designation of a neotype is unjustified (ICZN, 1999: Article 75.1).

Taxonomic status. Several of these nominal taxa have been treated as separate species. *Bombus nobilis* is interpreted here in the broadest sense, to include a complex of morphologically closely similar taxa (Williams, 1991). At least some of the taxa included may prove to be separate species from *B. nobilis*. However, aside from these differences in colour pattern, they are similar in morphology and have been treated as parts of a single variable species (Williams, 1998).

Diagnosis. Large species. *Female* (length of queens 22 mm, workers 11–18 mm) with the mid basitarsus with the distal posterior corner acutely and sharply pointed; hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface longer than the greatest breadth of the basitarsus (these may break or abrade); mandible distally with six teeth (these may be subject to wear) (cf. all non-*Alpigenobombus* species e.g. *B. braccatus*, *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*, *B. wangae*, *B. lepidus*, *B. keriensis*, *B. friseanus*); oculo-malar distance approximately 0.9–1.0 times the proximal breadth of the mandible (cf. *B. kashmirensis*, *B. grahami*, *B. breviceps*); ocello-ocular area along the inner eye margin with scattered large and fewer small punctures; hair (Figs 29, 31, 33–34) of the face black (cf. *B. impetuosus*, *B. lepidus*, *B. friseanus*), the thorax variable from entirely black (Fig. 31) to having yellow (Figs 33–34) or grey-white (Fig. 29) bands anteriorly and posteriorly, corbicular fringes black, metasomal tergum 1 yellow or grey-white, the anterior half of tergum 2 yellow often interrupted in the middle by black (cf. *B. friseanus*), the posterior half of tergum 2 black or red, terga 3–5 red; wings mid brown.

Male (length 16–17 mm) similarly coloured but with yellow on the head; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with two additional teeth (cf. all non-*Alpigenobombus* species e.g. *B. braccatus*, *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*, *B. wangae*, *B. lepidus*, *B. keriensis*, *B. friseanus*); genitalia (Fig. 179) with the penis valve distally with an incurved sickle-shaped head, the recurved crook of the head as long as its proximal breadth (cf. *B. kashmirensis*); gonostylus rounded (cf. *B. grahami*, *B. breviceps*), without an inner submarginal longitudinal groove, the inner proximal process pointed (cf. *Pyrobombus* species e.g. *B. wangae*, *B. lepidus*).

Global distribution. Oriental species: Himalaya and fringes of the Tibetan plateau (Yunnan, Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Uncommon at medium altitudes of the northwestern, western, and southwestern plateau and mountains (Fig. 283) with a medium-length seasonal activity

period (Fig. 279): 2 queens, 55 workers, 26 males, (?1000–) 2600–4500 m (BMNH, IZB, PHW, SAC, TY, USNM). Two males (IZB) labelled Qingchengshan with unusually low altitude data (1000 m) may be based on only an approximate location and need to be confirmed, but are shown in the activity plot and map. Literature records: Friese (1905), Skorikov ([1923]), Williams (1991), Wang (1992a).

SCR variation. This species has all of the pale bands yellow in most of southern Sichuan, as in Yunnan (the '*nobilis*' s.str. pattern, Figs 33–34). Individuals from further west in Xizang have the pale thoracic bands and metasomal tergum 1 grey-white rather than yellow (tergum 2 remains yellow, the '*morawitzii*' pattern, Fig. 29). Individuals from around Songpan and Jiuzhaigou, in the northeast of the species' range, also have these bands grey-white, but in addition the grey thoracic bands are often strongly narrowed or even absent and the black on tergum 2 is replaced by orange-red except near the midline (the '*validus*' pattern, Fig. 31).

SCR food plants. Medium tongue-length species: (Asteraceae) *Ligularia* sp.; (Crassulaceae) *Sedum* sp.; (Lamiaceae) *Salvia* sp.; (Leguminosae) *Hedysarum* sp.; (Ranunculaceae) *Delphinium* sp.; (Scrophulariaceae) *Pedicularis cranolopha*, *P. longiflora*, *P. oxycarpa*, *P. rex*, *P. roylei*, *P. siphonantha*.

Subgenus *MELANOBOMBUS* Dalla Torre

Rufipedibombus Skorikov [1923].

Festivobombus Tkalcü, 1972.

49. *Bombus (Melanobombus) eximius* Smith subgn. comb. nov. (Figs 100, 180, 284, 288)

Bombus eximius Smith, 1852b: 47, holotype queen (note below) BMNH examined. India.

Bombus latissimus var. *tricoloratus* Friese, 1916: 109, type not seen. Regarded as conspecific with *Bremus eximius* (Smith) by Frison (1934). Taiwan.

Bombus (Rufipedibombus) eximius Smith; Tkalcü, 1960: 70; Wang, 1987: 1379, 1988: 556, 1992: 1428; Wang and Yao, 1992: 688; Yao and Wang, 1993b: 766; Yao and Luo, 1997: 1692; Yin *et al.*, 2001: 752. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Melanobombus*, within which it belongs to the *rufipes*-group of species.

Nomenclature. Smith's description of *B. eximius* is of a large female (queen) from 'Silhet', although it goes on to say that there are 'specimens' in the BMNH collection. There is only one queen in the BMNH collection with a Silhet label and this specimen agrees with the original description. It bears the labels: (1) round red-edged printed 'Type/H.T.'; (2) 'B.M. TYPE/HYM./17B.1002.'; (3) round hand-written 'Silhet'; (4) hand-written 'Bombus/eximius/TYPE. Smith.'; (5) hand-written in Smith's hand 'eximius/Type Sm.'; (6) round red-edged printed 'Holo-/type-'. From the original publication and from the collection, there is no evidence for the

existence of other queens seen by Smith from Silhet. Therefore this queen, which lacks the left foreleg and parts of the tarsi on the right anterior leg, right hind leg, and left mid leg, is regarded as the holotype.

Diagnosis. Very large species (especially queens). *Female* (length of queens 28–29 mm, workers 14–19 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed; hind basitarsus with the posterior margin nearly straight (cf. *B. ignitus*); oculo-malar distance approximately equal (0.9–1.0) to the proximal breadth of the mandible; labrum with the lamella irregular but nearly straight and about half of the breadth of the labrum (cf. *B. flavescens*); ocello-ocular area along the inner eye margin with scattered large punctures but with few small punctures; hair (Fig. 100) of the thorax black, hair of the mid and hind tibiae and of the basitarsi orange (cf. *B. ignitus*), metasomal tergum 2 mostly black (cf. *B. flavescens*), terga 4–5 orange; wings light orange brown.

Male (length 18–19 mm) similarly coloured, hair of the fore tibia and basitarsus orange, terga 3–7 orange; compound eye unenlarged relative to the female and the antenna reaching posteriorly to the wing bases; genitalia (Fig. 180) with the penis valve distally with an incurved sickle-shaped head (cf. *B. ignitus*); gonostylus reduced to a transverse ‘S’-shaped band; volsella produced beyond the gonostylus by more than three times its breadth at its mid point, without an obvious inner distal process or hook (cf. *B. flavescens*).

Global distribution. Southern Oriental species: Himalaya, Myanmar, Thailand, Vietnam, China (Yunnan, Xizang, Sichuan, Fujian, Jiangxi, Guangdong, Guangxi, Guizhou; Taiwan).

SCR material examined. Uncommon at low altitudes of the Sichuan basin and surrounding foothills (Fig. 288) with a long seasonal activity period (Fig. 284): 2 queens, 8 workers, 9 males, 450–1200 m (BMNH, IZB, USNM). Literature records: Tkalčú (1960), Wang (1987a, 1988a, 1992a), Wang and Yao (1992a), Yao and Wang (1993b), Yao and Luo (1997), Yin *et al.* (2001).

SCR variation. The two workers in the BMNH collection both have pale brown hair predominating on tergum 1. This colour form is close to the ‘*tricoloratus*’ pattern (metasomal tergum 1 yellowish red [‘gelblichrot’]) (see the comments on *B. flavescens*, and Frison, 1934).

SCR food plants. Medium tongue-length species, no records.

50. *Bombus (Melanobombus) festivus* Smith subgn. comb. nov. (Figs 124–125, 181, 285, 289)

Bombus festivus Smith, 1861: 152, lectotype queen (Tkalčú, 1974a: 342) BMNH examined. India.

BOMBUS ATROCINCTUS Smith, 1870: 193, holotype male BMNH examined. Synonymised with *Bombus festivus* Smith by Richards (1968). India.

BOMBUS TERMINALIS Smith, 1870: 193, LECTOTYPE worker by present designation (below) BMNH examined. Synonymised with *Bombus atrocinctus* Smith by Richards (1930). Synonymised with *Pyrobombus festivus* (Smith) by Tkalčú (1974a). India.

[*Bombus melaleucus* Handlirsch, 1888: 228; Skorikov [1923]: 159, misidentification. China: Sichuan.]

Bremus (Rufipedibombus) festivus (Smith); Frison, 1935: 356. China: Sichuan.

Bremus (Pratobombus) atrocinctus (Smith); Frison, 1935: 360. China: Sichuan.

Bombus (Alpigenobombus) handel-mazettii Pittioni, 1939: 260, lectotype male (Tkalčú, 1974a: 342) BMNH examined. Synonymised with *Pyrobombus festivus* (Smith) by Tkalčú (1974a). China: Yunnan.

Bombus (Pratobombus) handel-mazettii Pittioni; Panfilov, 1957: 235. China: Sichuan.

Bombus (Rufipedibombus) festivus Smith; Panfilov, 1957: 235. China: Sichuan.

Bombus (Pyrobombus) atrocinctus Smith; Wang, 1982: 433, 1987: 1380, 1988: 555, 1992: 1425; Wang and Yao, 1992: 688. China: Sichuan.

Bombus (Pyrobombus) festivus Smith; Wang, 1982: 433, 1988: 556, 1992: 1424. China: Sichuan.

Bombus (Festivobombus) festivus Smith; Yao and Luo, 1997: 1691. China: Sichuan.

In the simplified subgeneric classification (Williams *et al.*, 2008) this species is part of the enlarged subgenus *Melanobombus*, within which it constitutes the *festivus*-group of species.

Nomenclature. Smith’s description of *B. terminalis* is of a single male (from Simla) and at least one worker, said by Smith (p. 186) to be in the BMNH collection. Two workers in the BMNH collection agree with the original description and bear identical labels: (1) round red-edged printed ‘Type’; (2) ‘B.M. TYPE/HYM./17.B.968.’; (3) hand-written in Smith’s hand ‘*Bombus/terminalis/(Type) Smith*’; (4) round red-edged printed ‘Holo-/type’. Therefore one of these workers, which lacks the right hind leg, is designated here as lectotype (ICZN, 1999: Article 74.1).

Diagnosis. Large species (especially queens). *Female* (length of queens 22–25 mm, workers 12–17 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. longipes*); hind tibia with the distal posterior corner forming a spine (cf. *B. hypnorum*), hind basitarsus with the posterior margin nearly straight; oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible; ocello-ocular area along the inner eye margin with scattered large and small punctures; for large females (queens and a few of the largest workers, Fig. 124), hair entirely black except for a posteriorly-directed triangle between the wing bases white (or more yellowish for the largest workers), metasomal tergum 5 white; smaller females (workers, Fig. 125) with the dorsum of the head black, thorax with a narrow anterior band and the upper half of the sides black (cf. *B. hypnorum*), otherwise the thoracic dorsum orange-brown, metasomal terga 1–4 black (cf. *B. hypnorum*),

tergum 4 with a few white hairs posteriorly, tergum 5 white (cf. *B. longipes*); wings dark brown.

Male (length 14–16 mm) may be similarly coloured to workers except for short grey hairs on the face, or may be lighter, with the head, sides of the thorax, and metasomal terga 1–2 orange-brown, terga 5–7 white; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; genitalia (Fig. 181) with the penis valve distally with an incurved sickle-shaped head (cf. *B. longipes*); gonostylus rounded, with a pronounced inner proximal processes and without an inner submarginal longitudinal groove (cf. *B. hypnorum*); volsella produced beyond the gonostylus by a distance about equal to its own breadth, with a strongly curved inner distal hook.

Global distribution. Oriental species: Himalaya and fringes of the Tibetan plateau (Yunnan, Xizang, Sichuan, Hubei, Guizhou).

SCR material examined. Common at medium altitudes of the northwestern, western and southwestern mountains (Fig. 289) with a medium-length seasonal activity period (Fig. 285): 35 queens, 255 workers, 114 males, (?380–) 858–4292 m (AMNH, BMNH, INHS, IZB, JAB, PHW, SAC, TY, USNM, ZMMU). Two workers (INHS) labelled ‘Suifu’ (Yibin) with unusually low altitude data (380 m) may be based on only an approximate location and need to be confirmed, but are shown in the activity plot and map. Literature records: Skorikov ([1923]), Frison (1935), Panfilov (1957), Wang (1982a, 1987a, 1988a, 1992a), Wang and Yao (1992a), Yao and Luo (1997). This species is particularly associated with open areas within forests.

SCR variation. This species shows unusually strong size-dependent variation in the colour of the thorax among females (see above), which is expressed most obviously as a difference between queens and workers. This has been confirmed from a study of one colony in the Himalaya (Ito *et al.*, 1984).

SCR food plants. Medium tongue-length species: (Asteraceae) *Cirsium* sp.; (Bignoniaceae) *Incarvillea* sp.; (Caprifoliaceae) *Lonicera* sp.; (Dipsacaceae) *Dipsacus inermis*; (Ericaceae) *Rhododendron decorum*; (Loganiaceae) *Buddleja* sp.; (Lythraceae) *Lagerstroemia* sp.; (Onagraceae) *Chamerion angustifolium*; (Ranunculaceae) *Anemone* sp.; (Scrophulariaceae) *Pedicularis densispica*, *P. roylei*.

51. *Bombus (Melanobombus) ladakhensis*

Richards

(Figs 122–123, 182, 286, 290)

Bombus (Lapidariobombus) rufofasciatus var. *ladakhensis* Richards, 1928: 336, not infrasubspecific after Tkalčú, 1974a: 335, holotype queen BMNH examined. India.

Bombus (Lapidariobombus) rufofasciatus var. *phariensis* Richards, 1930: 642, not infrasubspecific after Tkalčú, 1974a: 336, holotype queen BMNH examined. Regarded as conspecific with *Pyrobombus ladakhensis* (Richards) by Tkalčú (1974a). China: Xizang.

Bombus variopictus Skorikov, 1933b: 248, syntype queen ZISP examined. Regarded as conspecific with *Pyrobombus ladakhensis* (Richards) by Tkalčú (1974a). China: Qinghai.

Bombus (Pratobombus) reticulatus Bischoff, 1936: 7, paralectotype workers (Tkalčú, 1974a: 336) MNHU examined. Regarded as conspecific with *Pyrobombus ladakhensis* (Richards) by Tkalčú (1974a). China: Gansu.

Bombus (Melanobombus) phariensis Richards; Wang, 1992: 1428. China: Sichuan.

This species belongs to the *lapidarius*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 16–19 mm, workers 9–12 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. supremus*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface about equal to the greatest breadth of the basitarsus; mandible distally broadly rounded with three teeth (cf. *B. kashmirensis*); oculo-malar distance approximately 0.9 times the proximal breadth of the mandible; dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. lemniscatus*, *B. lepidus*); hair of the head black (cf. *B. lepidus*, *B. sichelii*), queens (Fig. 123) with the thorax with white bands anteriorly and posteriorly (cf. *B. keriensis*), although the posterior band may be very much narrowed, the femora predominantly black, metasomal tergum 1 white, tergum 2 white, cream, or rarely yellow, with a posterior black fringe (occasionally all black except for anterior lateral patches of grey-white), tergum 3 orange, tergum 4 hairs white with orange bases, tergum 5 white, or for workers (Fig. 122) the posterior thoracic band is often very weak, metasomal tergum 1 white, tergum 2 white with a narrow posterior black fringe (cf. *B. rufofasciatus*, *B. pyrosoma*, *B. friseanus*), tergum 3 orange-red except black narrowly anteriorly and at the sides, tergum 4 orange-red, tergum 5 white (cf. *B. lemniscatus*, *B. lepidus*); wings light brown.

Male (length 12 mm) with the thorax with yellow bands anteriorly and posteriorly, metasomal tergum 1 yellow, tergum 2 yellow with a posterior black fringe, tergum 3 black, terga 4–7 orange-red with some black hairs laterally; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*, *B. nobilis*); genitalia (Fig. 182) with the penis valve distally with an incurved sickle-shaped head (cf. *B. supremus*, *B. impetuosus*), the recurved crook of the head turned back almost parallel to the head and fused to the head for more than two thirds of its length (cf. *B. keriensis*, *B. sichelii*), the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus distally rounded (cf. *B. rufofasciatus*, *B. pyrosoma*, *B. friseanus*), without an inner submarginal longitudinal groove, the inner proximal processes short and rounded (cf. *Pyrobombus* species e.g. *B. lemniscatus*, *B. lepidus*); volsella with the inner distal process forming a broad short stump (cf. *B. keriensis*).

Global distribution. Oriental species: Tibetan plateau (Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Common at high altitudes of the northwestern and western plateau and mountains (Fig. 290) with a short seasonal activity period (Fig. 286): 40 queens, 80 workers, 4 males, (?1360–) 3200–4700 m (BMNH, INHS, IZB, PHW, SAC, TY, USNM). Two queens and a worker (IZB) labelled Wenchuan, Wolong (unsuitable habitats?), and Jiuzhaigou with unusually low altitude data (1360 m, 1874 m, 2200 m) may be based on only approximate locations and need to be confirmed, but only the Jiuzhaigou record is shown in the activity plot and map. Literature records: Wang (1992a).

SCR food plants. Short-tongued species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Saussurea* sp., *Taraxacum* sp.; (Ericaceae) *Rhododendron* sp.; (Gentianaceae) *Halenia elliptica*; (Leguminosae) *Hedysarum* sp.; (Scrophulariaceae) *Pedicularis chenocephala*, *P. lachnoglossa*, *P. longiflora*, *P. rhinanthoides*, *P. roylei*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

52. *Bombus (Melanobombus) keriensis* Morawitz (Figs 113, 183, 287, 291)

Bombus keriensis Morawitz, 1887: 199, syntype queen ZISP examined. China: Xinjiang.

Bombus separandus Vogt, 1909: 61, lectotype queen (Williams, 1991: 96) ZMA examined. Regarded as conspecific with *Bombus keriensis* Morawitz by Reinig (1935). China: Xinjiang.

Bombus kohli Vogt, 1909: 61 (not of Cockerell, 1906: 75 = *B. morio* (Swederus)), 3 syntype workers ZMA examined. Synonymised with *Bombus keriensis* Morawitz by Williams (1991). Mongolia.

Bombus kozlovi Skorikov, 1910b: 413, replacement name for *kohli* Vogt, 1909: 61.

Bombus lapidarius var. *tenellus* Friese, 1913: 86, type not seen. Synonymised provisionally with *Bombus keriensis* Morawitz by Williams (1991). Russia: Zapadnyy Sayan.

Bombus (Lapidariobombus) keriensis f. *richardsi* Reinig, 1935: 341 (not of Frison, 1930: 6 = *B. rufipes* Lepeletier), holotype queen ZMA examined. Pakistan.

Bombus (Melanobombus) tenellus ssp. *tibetensis* Wang, 1982: 439, replacement name for *richardsi* Reinig, 1935: 341.

Bombus (Melanobombus) trilineatus Wang, 1982a: 441, holotype queen IZB examined. Synonymised with *Bombus keriensis* Morawitz by Williams (1998). China: Xizang.

This species belongs to the *lapidarius*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 19–22 mm, workers 11–14 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface shorter than the greatest breadth of

the basitarsus; mandible distally broadly rounded with three teeth (cf. *Alpigenobombus* species e.g. *B. nobilis*); oculo-malar distance approximately 0.9–1.0 times the proximal breadth of the mandible; dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. braccatus*, *B. wangae*, *B. lepidus*); hair (Fig. 113) of the head usually black (cf. *B. wangae*, *B. lepidus*, *B. sichelii*), the thorax with yellow bands anteriorly and posteriorly (cf. *B. ladakhensis*, *B. sichelii*, *B. rufofasciatus*, *B. pyrosoma*), femora predominantly black, metasomal terga 1–2 yellow right up to the posterior margin of tergum 2, tergum 3 black with only a few scattered pale hairs at the sides (cf. *B. friseanus*), terga 4–5 orange-red; wings light brown.

Male [based on males from Kashmir] (length 12–13 mm) more extensively yellow, with a black band between the wing bases, metasomal tergum 3 black with yellow hairs at the sides, terga 4–7 orange-red with some black hairs laterally; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. nobilis*); genitalia (Fig. 183) with the penis valve distally with an incurved sickle-shaped head (cf. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*), the recurved crook of the head longer than its proximal breadth, narrowed and straight (cf. *B. ladakhensis*), the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus distally rounded (cf. *B. rufofasciatus*, *B. pyrosoma*, *B. friseanus*), without an inner submarginal longitudinal groove, the inner proximal process short and rounded (cf. *Pyrobombus* species e.g. *B. wangae*, *B. lepidus*); volsella with the inner distal process forming a narrow curved hook (cf. *B. ladakhensis*, *B. sichelii*).

Global distribution. Species of the southeastern Palaearctic region, with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Xinjiang, Xizang, Qinghai, Sichuan, Gansu).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Fig. 291) with a short seasonal activity period (Fig. 287): 26 queens, 12 workers, 3450–4382 m (BMNH, IZB, PHW, SAC, TY). Literature records: Wang (1982a) [records under the name *B. richardsi* by Wang (1982: 437, 1987: 1380, 1988: 556, 1992: 1427) are misidentifications of *B. friseanus*].

SCR variation. One worker has the posterior margin of tergum 2 and the sides of the thorax black.

SCR food plants. Medium tongue-length species: (Scrophulariaceae) *Pedicularis alaschanica*, *P. chenocephala*, *P. cranalopha*, *P. polyodonta*, *P. verticillata*.

53. *Bombus (Melanobombus) sichelii* Radoszkowski (Figs 116, 184, 292, 296)

BOMBUS SICHELII Radoszkowski, 1860: 481, lectotype queen (Tkalčů, 1974b: 34) MNHU examined. Russia: Kamchatka Oblast'.

[*Bombus Sichelii* Radoszkowski; Radoszkowski, 1877: 213, incorrect subsequent spelling.]

Bombus sicheli f. *uniens* Vogt, 1909: 62, 26 queen 94 worker syntypes ZMA examined. 'Zentralasien', probably Mongolia.

Bombus sicheli ssp. *chinganicus* Reinig, 1936: 6 (not of Reinig, 1936: 8 = *B. bohemicus* Seidl), type not seen. China: Neimenggu.

Bombus sichelii Radoszkowski; Macior and Tang, 1997: 3. China: Sichuan.

This species belongs to the *lapidarius*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 17–19 mm, workers 9–13 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. supremus*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight (cf. *B. patagiatus*), the longest of the erect hairs near the anterior margin of the outer surface shorter than the greatest breadth of the basitarsus; mandible distally broadly rounded with three teeth (cf. *B. kashmirensis*); oculo-malar distance approximately 0.9–1.0 times the proximal breadth of the mandible (cf. *B. supremus*); dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. lemniscatus*, *B. lepidus*); hair (Fig. 116) of the face with many whitish hairs (cf. *B. ladakhensis*, *B. keriensis*), dorsum of the head black, the thorax with white bands anteriorly and posteriorly (cf. *B. keriensis*) and femora predominantly whitish, metasomal tergum 1 white, tergum 2 white, cream or brownish-white, with black hairs intermixed along the posterior margin, tergum 3 black with many pale hairs at the sides, terga 4–5 pale orange; wings light brown.

Male [based on males from Mongolia] (length 13–14 mm) extensively yellow, the thorax with a black band between the wing bases, metasomal tergum 3 black with yellow hairs at the sides, tergum 4 orange with some black hairs laterally, terga 5–7 orange; compound eye unenlarged relative to the female and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*); genitalia (Fig. 184) with the penis valve distally with an incurved sickle-shaped head (cf. *B. supremus*, *B. impetuosus*, *B. patagiatus*), the recurved crook of the head longer than its proximal breadth, narrowed and straight (cf. *B. ladakhensis*), the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus distally rounded (cf. *B. rufofasciatus*, *B. pyrosoma*, *B. friseanus*), without an inner submarginal longitudinal groove, the inner proximal process short and rounded (cf. *Pyrobombus* species e.g. *lemniscatus*, *B. lepidus*); volsella with the inner distal process forming a broad short stump (cf. *B. keriensis*).

Global distribution. Palaearctic species with a disjunct distribution within the Oriental region: between the eastern Tibetan plateau and northern China (Neimenggu, Heilongjiang, Jilin, Liaoning, Hebei, Shanxi, Gansu, Qinghai, Sichuan).

SCR material examined. Uncommon at high altitudes of the northwestern and western plateau (Fig. 296) with a medium-length seasonal activity period (Fig. 292): 10 queens, 42 workers, 3350–4200 m (BMNH, IZB, PHW, SAC, TY). Literature records: Macior and Tang (1997).

SCR food plants. Short-tongued species: (Asteraceae) *Saussurea* sp.; (Gentianaceae) *Halenia elliptica*; (Ranunculaceae) *Aconitum gymnanthum*; (Scrophulariaceae) *Pedicularis craniolepta*, *P. davidii*, *P. plicata*, *P. rhinanthoides*, *P. roylei*, *P. spicata*, *P. verticillata*.

54. *Bombus (Melanobombus) rufofasciatus* Smith (Figs 119–121, 185, 293, 297)

Bombus rufo-fasciatus Smith, 1852b: 48, lectotype queen (Tkalcu, 1974a: 340) BMNH examined. India.

Bombus Prshewalskyi Morawitz, 1880: 342, type not seen. Regarded as conspecific with *Bombus rufofasciatus* Smith by Richards (1930). China: 'Gan-su', but probably Qinghai.

Bombus rufocinctus Morawitz, 1880: 343 (not of Cresson, 1863: 106 = *B. rufocinctus* Cresson), syntype queen ZISP examined. Synonymised with *Bombus rufofasciatus* Smith by Handlirsch (1888). China: 'Gan-su', but probably Qinghai.

[*Bombus Przewalskyi* Morawitz; Morawitz, 1890: 349, incorrect subsequent spelling. China: 'Sse-tschuan', but probably Qinghai.]

Bombus chinensis Dalla Torre, 1890 [June 25]: 139, replacement name for *rufocinctus* Morawitz, 1880:343 (not of Morawitz, 1890 [April 30]: 352 = *B. chinensis* (Morawitz)). Synonymised with *Bombus rufofasciatus* Smith by Richards (1930).

[*Bombus prshewalskii* Morawitz; Dalla Torre, 1896: 544, incorrect subsequent spelling.]

[*Kozlovibombus przewalskii* (Morawitz); Skorikov [1923]: 152, incorrect subsequent spelling. China: Sichuan.]

Bombus rufofasciatus Smith; Skorikov, [1923]: 160. China: Sichuan.

Bombus (Melanobombus) rufofasciatus Smith; Wang, 1982: 438, 1988: 556, 1992: 1427; Williams, 1991: 105; Williams and Cameron, 1993: 127. China: Sichuan.

This species belongs to the *rufofasciatus*-group of species.

Diagnosis. Medium-sized species. *Female* (length of queens 19–20 mm, workers 12–16 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. supremus*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight (cf. *B. patagiatus*), the longest of the erect hairs near the anterior margin of the outer surface as long as the greatest breadth of the basitarsus (these may break or abrade); mandible distally broadly rounded with three teeth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*); oculo-malar distance approximately 1.1 times the proximal breadth of the mandible (cf. *B. supremus*, *B. kashmirensis*); dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. lemniscatus*, *B. lepidus*); hair (Figs 119–121) of the head black (cf. *B. lepidus*, *B. sichelii*), the thorax with grey-white

bands anteriorly and posteriorly (cf. *B. friseanus*), metasomal tergum 1 white, queens (Fig. 121) with tergum 2 black (cf. *B. ladakhensis*), tergum 3 red, terga 4–5 white, or workers (Figs 119–120) with tergum 2 anteriorly yellow (cf. *B. ladakhensis*), posteriorly black (sometimes reduced to a posterior fringe), terga 3–4 red, tergum 5 white (cf. *B. pyrosoma*); wings light brown.

Male (length 15 mm) similarly coloured, but with metasomal tergum 2 almost entirely yellow; compound eye strongly enlarged relative to the female (cf. *B. pyrosoma*, *B. friseanus*) and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*); genitalia (Fig. 185) with the penis valve distally with an incurved sickle-shaped head (cf. *B. supremus*, *B. impetuosus*), the recurved crook of the head longer than its proximal breadth, narrowed and straight, the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus distally reduced to an inner bifid process (cf. *B. ladakhensis*, *B. keriensis*, *B. sichelii*), without an inner submarginal longitudinal groove, the inner proximal process broad and pointed (cf. *Pyrobombus* species e.g. *B. lemniscatus*, *B. lepidus*).

Global distribution. Oriental species: Himalaya, Myanmar, and Tibetan plateau (Yunnan, Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Common at high altitudes of the northwestern and western plateau and mountains (Fig. 297) with a long seasonal activity period (Fig. 293): 13 queens, 307 workers, 53 males, (?800–) 2650–4800 m (AMNH, BMNH, IZB, PHW, SAC, TY). A worker (IZB) labelled Qingchenshan with unusually low altitude data (800–1200 m) may be based on only an approximate location and needs to be confirmed, but is shown in the activity plot and map. Literature records: Morawitz (1890), Skorikov ([1923]), Wang (1982a, 1988a, 1992a), Williams (1991), Williams and Cameron (1993).

SCR variation. This species shows strong size-dependent variation in the colour of metasomal terga 2 and 4 of the females, which is expressed most obviously as a difference between queens and workers (see above).

SCR food plants. Medium tongue-length species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp., *Ligularia* sp., *Saussurea* sp., *Taraxacum* sp.; (Caprifoliaceae) *Lonicera* sp.; (Crassulaceae) *Sedum* sp.; (Lamiaceae) *Ajuga* sp., *Salvia* sp.; (Leguminosae) *Hedysarum* sp., *Oxytropis* sp.; (Scrophulariaceae) *Pedicularis alaschanica*, *P. anas*, *P. bidentata*, *P. chenocephala*, *P. cranolopha*, *P. cyathophylla*, *P. davidii*, *P. floribunda*, *P. integerrima*, *P. lachnoglossa*, *P. longiflora*, *P. rhinanthoides*, *P. roylei*, *P. siphonantha*, *P. spicata*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

55. *Bombus (Melanobombus) pyrosoma* Morawitz (Figs 97, 117, 186, 294, 298)

Bombus pyrosoma Morawitz, 1890: 349, syntype queen ZISP examined. China: ‘Kan-ssu’, but probably Qinghai.

Bombus pyrrhosoma Dalla Torre, 1896: 544, unjustified emendation.

Bombus rufus Friese, 1905: 511 (not of Villers, 1789: 328 = *B. pascuorum*), type not seen. Synonymised with *Bombus pyrrhosoma* Morawitz [sic] by Skorikov ([1923]). China: Sichuan.

[*Bombus pyrrhosoma* var. *canosocollaris* Skorikov, 1912: 608, infrasubspecific.]

Bombus pyrrhosoma Dalla Torre; Skorikov [1923]: 160. China: Sichuan.

Pyrobombus (Lapidariobombus) wutaishanensis Tkalci, 1968c: 39, holotype queen MNHU examined. Synonymised with *Bombus pyrosoma* Morawitz by Williams (1991). China: Shanxi.

Bombus (Melanobombus) pyrosoma Morawitz; Sakagami, 1972: 164; Williams, 1991: 101; Williams and Cameron, 1993: 126; Yao and Luo, 1997: 1694. China: Sichuan.

Bombus (Melanobombus) pyrrhosoma Dalla Torre; Wang, 1992: 1428. China: Sichuan.

This species belongs to the *rufofasciatus*-group of species.

Taxonomic status. *Bombus pyrosoma* has been considered conspecific with *B. friseanus* (Bischoff, 1936; Tkalci, 1961; Sakagami, 1972) and has also been considered conspecific with *B. formosellus* (Frison) and *B. flavothoracicus* Bingham (= *B. miniatus* Bingham) (Williams, 1991). However, from the material in the IZB collection, these taxa appear to remain discrete, particularly in the colour patterns of the queens, and are interpreted here as separate species until further information is available.

Bombus pyrosoma appears to vary substantially across its range. Workers from near Beijing often have the large punctures of the ocello-ocular area rather shallow and sparse, with few intervening small punctures, and the hair of the head and thorax is almost entirely black, usually with only small numbers of black hairs laterally on tergum 2. Workers examined from Shaanxi have denser and deeper ocello-ocular punctures, with short white hair intermixed particularly on the face, broad white bands on the thorax, and only small numbers of black hairs on tergum 2. A worker from Sichuan (Maoxian) has denser and deeper ocello-ocular punctures, white hair intermixed on the face and to a lesser extent on the dorsum and posterior dorsal margin of the head, very broad white bands on the thorax, and much black hair intermixed in a band anteriorly to the posterior margin of tergum 2, leaving a red posterior fringe. This specimen is unusual in having white hair intermixed with the black on the sides of the thorax posterior to the wing bases, where this hair is usually black in workers and queens of both *B. pyrosoma* and *B. friseanus*. Otherwise this specimen is similar to *B. friseanus*, except in the colour of the pale hair of the head, thorax, and tergum 1. More work on variation within this species and *B. friseanus* is needed.

Diagnosis. Medium-sized species. *Female* (length of queens 20–23 mm, workers 12–15 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. supremus*, *B. impetuosus*); hind basitarsus with the posterior margin nearly straight, longest

of the erect hairs near the anterior margin of the outer surface less than the greatest breadth of the basitarsus; mandibles distally broadly rounded with three teeth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*); oculo-malar distance approximately 1.0–1.1 times the proximal breadth of the mandible (cf. *B. kashmirensis*); dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. lemniscatus*, *B. lepidus*); hair of the head and thorax for queens (Fig. 97) usually black with a few grey-white hairs intermixed anteriorly and posteriorly on the thoracic dorsum (cf. *B. rufofasciatus*, *B. friseanus*), metasomal tergum 1 black, sometimes with white hairs, terga 2–5 orange-red, or for workers (Fig. 117), the head and thorax are predominantly black, sometimes with short white hairs intermixed especially on the face, and usually with narrow (or sometimes broad) grey-white bands anteriorly and posteriorly on the thorax (cf. *B. friseanus*), metasomal tergum 1 is cream-white, tergum 2 anteriorly orange-brown, posteriorly black with a fringe of red hairs (cf. *B. ladakhensis*, *B. sichelii*, *B. rufofasciatus*), terga 3–5 red; wings light brown.

Male (length 13–15 mm) extensively yellow, at most with only an indistinct black band between the wing bases (cf. *B. friseanus*), and with metasomal terga 3–7 orange-red; compound eye unenlarged relative to the female (cf. *B. rufofasciatus*) and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. kashmirensis*); genitalia (Fig. 186) with the penis valve distally with an incurved sickle-shaped head (cf. *B. supremus*, *B. impetuosus*), the recurved crook of the head longer than its proximal breadth, narrowed and straight, the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus variable but distally reduced to an inner bifid process (cf. *B. ladakhensis*, *B. keriensis*, *B. sichelii*), without an inner submarginal longitudinal groove, the inner proximal processes broad and pointed (cf. *Pyrobombus* species e.g. *B. lemniscatus*, *B. lepidus*).

Global distribution. Oriental species: northeastern and central China (Neimenggu, Hebei, Beijing, Shandong, Shanxi, Shaanxi, Gansu, Qinghai, Sichuan, Hubei, Ningxia, Guizhou, Xizang).

SCR material examined. Uncommon at medium altitudes of the northwestern, western, and eastern mountains (Fig. 298) with a long seasonal activity period (Fig. 294): 7 queens, 66 workers, 9 males, 1320–3650 m (CAS, IZB, PHW). Literature records: Skorikov (1933b, [1923]), Sakagami (1972), Wang (1992a) Williams and Cameron (1993), Yao and Luo (1997).

SCR variation. This species shows strong size-dependent variation in the colour of the thorax and of metasomal tergum 2 of the females, which is expressed most obviously as a difference between queens and workers (see above).

SCR food plants. Medium tongue-length species: (Lamiaceae) *Salvia* sp.

56. *Bombus (Melanobombus) friseanus* Skorikov (Figs 105–108, 187, 295, 299)

Bombus friseanus Skorikov, 1933b: 62, holotype queen ZISP examined. China: Sichuan.

Bombus (Lapidariobombus) pyrrhosoma ssp. *hönei* Bischoff, 1936:10, lectotype queen (Williams, 1991: 102) MNHU examined. Synonymised with *Bombus friseanus* Skorikov by Williams (1998). China: Yunnan.

[*Bombus (Kozlovibombus) friseanus* Skorikov; Panfilov, 1957: 235, incorrect subsequent spelling. China: Sichuan.]

[*Bombus (Melanobombus) richardsi* Reinig; Wang, 1982: 437, 1987: 1380, 1988: 556, 1992: 1427, misidentification. China: Sichuan.]

[*Bombus (Melanobombus) pyrosoma* Morawitz; Williams, 1991: 101, misidentification, see below. China: Sichuan.]

This species belongs to the *rufofasciatus*-group of species.

Taxonomic status. *Bombus friseanus* has been considered conspecific with *B. pyrosoma* (Bischoff, 1936; Tkalců, 1961; Sakagami, 1972; Williams, 1991) and has also been considered conspecific with *B. formosellus* (Frison) and *B. flavothoracicus* Bingham (= *B. miniatus* Bingham) (Williams, 1991). However, from the material in the IZB collection, these taxa appear to remain discrete, particularly in the colour patterns of the queens, and are interpreted as separate species until more information is available.

Diagnosis. Medium-sized species. *Female* (length of queens 19–22 mm, workers 10–16 mm) with the mid basitarsus with the distal posterior corner forming nearly a right angle and not sharply pointed (cf. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*) but not rounded (cf. *B. lepidus*); hind basitarsus with the posterior margin nearly straight, the longest of the erect hairs near the anterior margin of the outer surface less than the greatest breadth of the basitarsus; mandible distally broadly rounded with three teeth (cf. *Alpigenobombus* species e.g. *B. nobilis*); oculo-malar distance approximately 1.3 times the proximal breadth of the mandible; clypeus centrally nearly flat with shallow impressions adjacent to the labrum (cf. *B. lepidus*); dorsum of the head with large and small punctures scattered almost throughout, except in the ocellar depressions (cf. *B. braccatus*, *B. wangae*, *B. lepidus*); hair (Figs 105–108) of the head black with some short yellow hairs on the face, dorsum of the head predominantly black with rarely at most only a small anterior median patch of short yellow hairs (cf. *B. lepidus*), thorax with golden yellow bands anteriorly, posteriorly and on the sides (cf. *B. ladakhensis*, *B. sichelii*, *B. rufofasciatus*, *B. pyrosoma*), with black hairs below and behind the wing bases (cf. *B. impetuosus*), corbicular fringes entirely black (cf. *B. lepidus*), for queens (Fig. 108) metasomal tergum 1 yellow, tergum 2 black or occasionally with a narrow anterior yellow band, terga 3–5 red (cf. *B. keriensis*), or for workers (Figs 105–107) tergum 1 yellow, tergum 2 varying from mostly yellow with a black posterior fringe, to brown in the anterior half and black posteriorly (the black band is straight and not curved, cf. *B. lepidus*), to mostly black, terga 3–5 red (cf. *B. keriensis*) so that the anterior margin of

the red hair is nearly straight (cf. *B. lepidus*); wings light brown.

Male (length 13–15 mm) extensively yellow, but with a black band between the wing bases (cf. *B. pyrosoma*), metasomal terga 3–6 red, with some black hairs laterally on tergum 6; compound eye unenlarged relative to the female (cf. *B. rufofasciatus*) and the antenna reaching posteriorly only just to the wing bases; mandible distally pointed, with one additional tooth (cf. *Alpigenobombus* species e.g. *B. nobilis*); genitalia (Fig. 187) with the penis valve distally with an incurved sickle-shaped head (cf. *B. trifasciatus*, *B. bicoloratus*, *B. imitator*, *B. impetuosus*), the recurved crook of each head longer than its proximal breadth, narrowed and straight, the ventro-lateral angle of the penis valve reduced and almost absent (cf. non-*Melanobombus* species of the SCR); gonostylus variable but distally reduced to an inner bifid process (cf. *B. ladakhensis*, *B. keriensis*, *B. sichelii*), without an inner submarginal longitudinal groove, the inner proximal process broad and pointed (cf. *Pyrobombus* species e.g. *B. wangae*, *B. lepidus*).

Global distribution. Oriental species: eastern fringes of the Tibetan plateau (Yunnan, Xizang, Qinghai, Gansu, Sichuan).

SCR material examined. Abundant at medium altitudes of the northwestern, western, and southwestern plateau and mountains (Fig. 299) with a medium-length seasonal activity period (Fig. 295): 169 queens, 907 workers, 44 males, 1000–4396 m (AMNH, BMNH, IZB, PHW, SAC, TY, USNM, ZMMU). Literature records: Panfilov (1957), Wang (1982a, 1987a, 1988a, 1992a), Williams (1991).

SCR variation. This species shows strong size-dependent variation in the colour of metasomal tergum 2 of the females, which is expressed most obviously as a difference between queens and workers (see above).

SCR food plants. Medium tongue-length species: (Amaryllidaceae) *Allium* sp.; (Asteraceae) *Cirsium* sp., *Helianthus* sp., *Ligularia* sp., *Saussurea* sp.; (Bignoniaceae) *Incarvillea* sp.; (Boraginaceae) *Microula* sp.; (Caprifoliaceae) *Lonicera* sp.; (Crassulaceae) *Sedum* sp.; (Dipsacaceae) *Dipsacus inermis*; (Fagaceae) *Quercus aquifolioides* Rehder & E.H. Wilson; (Gentianaceae) *Halenia elliptica*; (Iridaceae) *Iris* sp.; (Lamiaceae) *Ajuga* sp., *Leonurus japonicus*, *Salvia* sp., *Stachys* sp.; (Leguminosae) *Hedysarum* sp., *Oxytropis* sp., *Parochetus communis*; (Loganiaceae) *Buddleja* sp.; (Lythraceae) *Lagerstroemia* sp.; (Onagraceae) *Chamerion angustifolium*; (Ranunculaceae) *Aconitum gymnantrum*; (Rosaceae) *Rubus* sp.; (Scrophulariaceae) *Pedicularis alopecuros*, *P. chenocephala*,

P. cranolopha, *P. cyathophylla*, *P. densispica*, *P. floribunda*, *P. integerrima*, *P. lachnoglossa*, *P. longiflora*, *P. melampyriiflora*, *P. muscoides*, *P. oxycarpa*, *P. polyodonta*, *P. racemosa*, *P. rex*, *P. rhinanthoides*, *P. roylei*, *P. siphonantha*, *P. szetschuanica*, *P. torta*, *P. verticillata*; (Valerianaceae) *Nardostachys chinensis*.

Discussion

Diversity

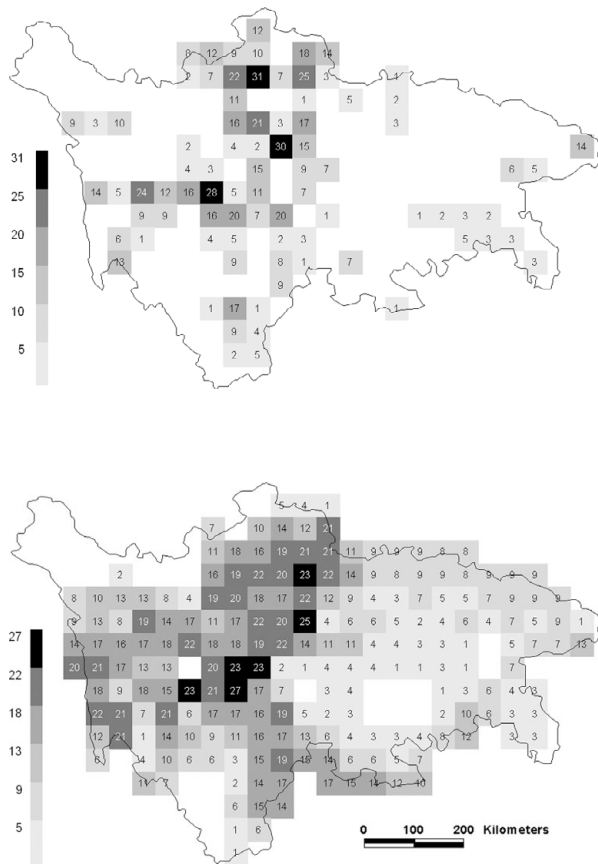
SCR is part of the greatest hotspot of bumblebee diversity worldwide (Fig. 1), with half of China's species and more than a fifth (22%) of the world's species. This diversity is far from being uniformly distributed. Figs 300–301 show the distribution of bumblebee diversity within the SCR, measured as species richness. The map for the raw data (Fig. 300) is necessarily constrained by the distribution of sampling effort (Fig. 3) and clearly shows higher recorded richness following the pattern of roads that run from Chengdu towards the northwest, west and south. To some extent, the effect of sampling biases can be reduced by modelling the expected distributions of the species, based upon their climatic associations. In Fig. 301 this has been done using the BIOCLIM software (Nix, 1986) and variables representing temperature and precipitation (from the University of East Anglia Climate Research Unit CL 1.0 dataset). However, modelling is especially difficult in high relief terrain such as Sichuan, because of (1) lack of precision in specimen and climate data; (2) complications from local effects such as rain shadows; and (3) departures from the equilibrium assumption of the models caused by the many barriers to dispersal.

Figure 301 shows that the highest diversity occurs in a band running from north to south through the middle of the map. This corresponds to the mountains at the eastern edge of the Tibetan Plateau (cf. Fig. 3), where there are wet mountain meadows and warm wet forests. The richest cells at this scale of grid are in these mountains, and to the south of the global hotspot identified at the coarser scale of Figs 1–2. This non-nesting of hotspots at different spatial scales is not unusual (e.g. Stoms, 1994).

In Sichuan, the largest numbers of bumblebee individuals and species are recorded at altitudes between 3000–4000 m (Table 5). These figures have not been adjusted for the differing land area in the different altitudinal zones, which would be expected to affect them through the species-area relationship (adjusting for equal areas would make the excess species richness at higher altitudes even more exaggerated). Similarly,

	Altitude (m)					
	<999	1000–1999	2000–2999	3000–3999	>4000	
Individuals	323	625	1515	2932	838	
Species	20	29	30	45	31	

Table 5 Distribution of numbers of individuals and species from specimen (excluding literature) records by altitudinal zones within the SCR.

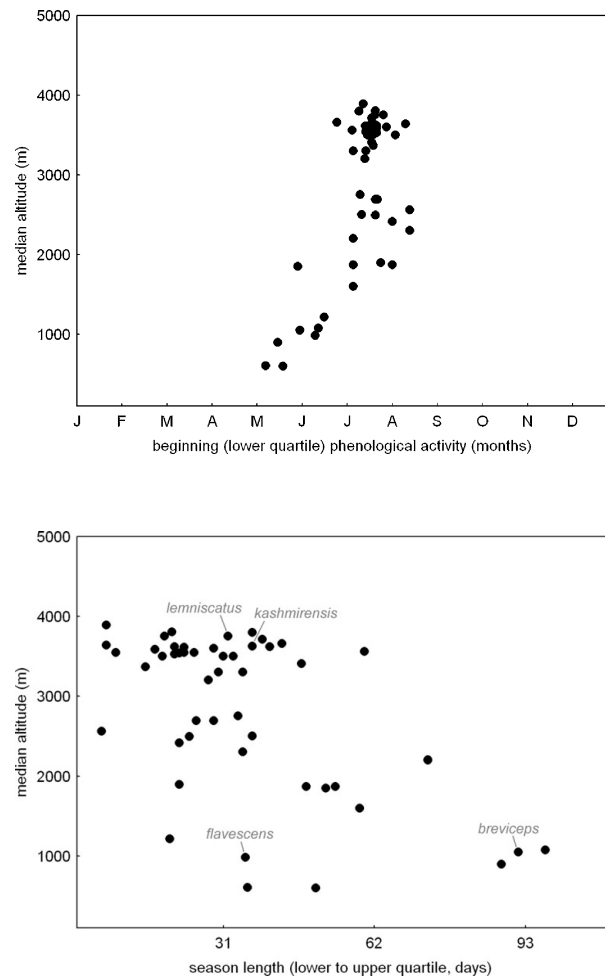


Figures 300–301 Maps of counts of bumblebee species richness for the SCR for 0.5×0.5 degree grid cells: (300) observed from the raw data from the localities in Fig. 3; and (301) expected with species distributions modelled from these data using climatic suitability with BIOCLIM (S. Bhagwat, unpublished). A grey scale shows richness grouped into equal-interval classes (scale bars left). Cartesian orthonormal projection.

the figures have not been adjusted for the differing sampling effort deployed in the different altitudinal zones. Nonetheless, the pattern agrees broadly with perceptions in the field that the highest abundance and species richness of bumblebees occur in the higher mountains.

Faunal elements

Only one bumblebee species is known to be endemic to Sichuan: *B. braccatus*. This species has been confirmed by us as extant in 2005. It is part of a low altitude fauna that is not easy to find, because the vegetation at these altitudes is often highly disturbed by agriculture and there are few suitable flowers. Most records of *B. braccatus* (70/81) come from the slopes of Emeishan (Mount Omei). The vegetation around the temples is particularly well conserved because of the significance of these sites to Buddhists. Emeishan is one of the four most famous ‘Buddhism Mountains’ in China, so this mountain has been, in effect, a protected area and refuge for the flora and fauna for more than a millennium, even during the Cultural Revolution. Unsurprisingly, it has also attracted



Figures 302–303 Comparison of activity among SCR bumblebee species between (x axis) phenology (by day of the year, letters refer to months) and (y axis) altitude (m) for: (302) timing of the beginning of the annual season of activity, measured as the lower (earlier) quartile day of records; and (303) length of the annual season of activity, measured as the difference between the lower (earlier) and upper (later) quartile day of records.

plant hunters (see Lancaster, 1989) and bumblebee collectors since the nineteenth century. Emeishan is now a World Natural Heritage site, but not a reserve. Nonetheless, it has been under strict protection for the last two decades. Unfortunately, the mountain is under growing pressure from its popularity as a tourist destination. This is a particular problem during two of the three ‘golden-week’ holiday seasons each year (in May and October), when it attracts large crowds of visitors.

Most SCR species are broadly distributed outside the region, either to the north and west, or to the south and east. Table 3 relates the SCR bumblebee species’ broader distributions to their altitudinal distributions, by ranking species by the mean altitude of their records within the SCR. The higher altitude (alpine) elements tend to have western associations beyond Sichuan: (1) the very highest species are associated with the Tibetan Plateau (Xizang-Qinghai as well as

Sichuan) and the fringing Himalaya; otherwise high species (2) extend further west from the Tibetan Plateau into the mountains of Central Asia (e.g. Tien Shan + Mongolia) and beyond; or have (3) disjunct distributions with the north (see below). Lower altitude (forest) elements tend to have more eastern associations beyond Sichuan: with (4) Southeast Asia (e.g. Laos + Thailand), or with (5) the southeast Chinese mountains (e.g. Fujian + Zhejiang). So as knowledge of the bumblebee fauna of Sichuan has improved, we now see that, contrary to Skorikov (1931), the fauna of Sichuan does contain species in common with the Himalaya and even with Central Asia, as described subsequently by Panfilov (1957).

A peculiar feature of the SCR fauna is that some species show narrow distributions that are disjunct across the northern Chinese deserts with much broader distributions in the grasslands and forests to the north, within the Palaearctic Region. Panfilov (1957) noted that several species that are widespread in northern Mongolia and in southern Siberia also have a separate, isolated, and narrow area of distribution in part of the east of his Qinghai and Tibetan bumblebee province, which includes part of Sichuan. This disjunction can also be seen to include an area around Xining and Lanzhou in the maps plotted by Skorikov ([1923], 1931) and by Reinig (1939) for their subgenera *Hortobombus* (= *Megabombus* in part) and *Pratobombus* (= *Pyrobombus* in part), and for *Agrobombus laesus* (= *B. laesus*). Among the species said by Panfilov to show the disjunct pattern, *B. agrorum* (F.) (= *B. pascuorum* (Scopoli)) and *B. distinguendus* Morawitz have not been found by us in collections from Sichuan, while in contrast, *B. lucorum* (Linnaeus) [in the broad sense] and *B. patagiatus* are now known to be much more widespread in China. But this leaves Panfilov's *B. subbaicalensis* (= *B. humilis*), *B. advertor* (= *B. filchnerae*), *B. maculidorsis* (= *B. laesus*) and *B. sushkini*, as otherwise Palaearctic species with narrow disjunct distributions south of the Gobi Desert, near where Gansu, Qinghai, and Sichuan meet. To this list we may add: *B. rpestris* and *B. sichelii*, bringing the sum to six species, a substantial element of the total SCR fauna (10.9%).

It is tempting to seek an explanation for this disjunction in the relatively recent uplift and aridification events, because the disjunct species' populations have not obviously diverged very strongly (even in colour pattern). This part of the Gansu-Qinghai-Sichuan fauna might have been cut off from a formerly continuous distribution with a northern Mongolian fauna as aridification and desertification spread (and is still spreading) in central Asia (Zhou, 1985; Yu *et al.*, 1998). We have found all of these species in open, flat, flower-rich, tall grass habitats around Hongyuan. These are similar to some of the steppe habitats that persist in parts of Mongolia today (Anonymous, 2001).

Further species might be expected to be added to the SCR fauna in the future (see the Introduction). The most likely candidates from neighbouring regions include: (1) high Tibetan species, e.g. *B. oberti* Morawitz and *B. asiaticus* Morawitz, in the high mountains of the far west; (2) Himalayan species, e.g. *B. haemorrhoidalis*, *B. rotundiceps* Friese, and possibly *B. luteipes*, and *B. genalis* Friese, in the mountains of the

south; and (3) northern Chinese species, e.g. *B. consobrinus* Dahlbom, *B. koreanus* (Skorikov), *B. coreanus* (Yasumatsu), *B. deuteronymus* Schulz, and *B. schrencki* Morawitz, in the mountains of the north east.

Activity patterns

Species' activity plots are included here as an aid for studies of pollination ecology. They also provide evidence of relationships between patterns of seasonal activity (phenology) and patterns of altitudinal distribution. For example, well recorded species within the subgenus *Alpigenobombus* illustrate some of the simpler patterns. A higher altitude species, *B. kashmirensis* (Fig. 278), is recorded over a period of only three months of the year, as compared with more than twice that long for a lower altitude species, *B. breviceps* (Fig. 276). The first record of the higher species is also three months later in the year, so at higher altitudes the season starts later but ends at the same time. We assume that these differences represent differences in the activities of the bees, rather than just differences in the activities of collectors. If so, then this pattern may reflect the constraints imposed by the more severe climate at higher altitudes (Inouye & Wielgolaski, 2003) on the shorter annual period available for colony development and the production of a new generation of queens and males. The longer period of activity at lower altitude for *B. breviceps* probably represents only one colony cycle per season (in contrast to species such as European *B. jonellus* (Kirby), see Meidell, 1968; Prys-Jones & Corbet, 1987), because almost all records for males are from August and September.

The generality of an association among species between a later start to annual activity and a higher altitude distribution was assessed by comparing the dates of the early quartile of activity with the median altitudes (Fig. 302). This relationship shows a significant positive correlation (Spearman $r_s = 0.38$, $p < 0.05$). The generality of an association among species between a shorter period of annual activity and a higher altitude distribution was assessed by comparing the numbers of days between the early and late quartile activity dates with the median altitudes (Fig. 303). This relationship shows a significant negative correlation ($r_s = -0.42$, $p < 0.05$).

Unsurprisingly, there are exceptions. For example, some well recorded high (*B. lemniscatus*, Fig. 260) and low (*B. flavescens*, Fig. 253) altitude species of the subgenus *Pyrobombus* show activity periods that are more similar in length. The higher altitude species is recorded over a period of four months, as compared with only five months for the low altitude species. The short activity pattern for the high altitude *B. lemniscatus* is very similar to that of *B. kashmirensis*. However, the low altitude *B. flavescens* differs from *B. breviceps* in at least two ways. First, below 2000 m, *B. flavescens* is active for just over half of the annual activity period of *B. breviceps*. Short cycles are characteristic of *Pyrobombus* species at low altitudes in Europe (Prys-Jones & Corbet, 1987). Second, a higher proportion of *B. flavescens* records extend above 2000 m than for *B. breviceps*, but only later in the year, where progressively higher records may be delayed by the later flowering season. Species with a few higher altitude records may or may not

be nesting throughout their altitudinal range, because high records for queens do not always indicate that colonies succeed in producing reproductives locally (Bowers, 1985). Alternatively, some workers could simply be commuting to higher foraging areas within deep narrow valleys later in the season (Williams, 1991). *Bombus flavescens* may be able to persist at higher altitudes than *B. breviceps* at least in part because *B. flavescens* may require a shorter flowering season for its colonies to produce new queens and males. *Bombus flavescens* is closely similar to *B. breviceps* in colour pattern and *B. lemniscatus* is closely similar to *B. kashmirensis*.

One of the characters that is believed to have some of the broadest effects on bumblebee ecology is tongue (proboscis) length (e.g. Harder, 1983). We find no significant correlation among species between our estimated tongue lengths and activity patterns when measured as: (1) the mean altitude of a species' records; (2) the start of the annual activity; or (3) the duration of annual activity. On the other hand, all three of these parameters are significantly correlated with queen body size (1: Spearman $r_s = -0.50$, 2: $r_s = -0.49$, 3: $r_s = 0.39$, Bonferroni adjusted $p < 0.0167$; or if the two largest species, *B. eximius* and *B. festivus*, are removed, 1: $r_s = -0.42$, 2: $r_s = -0.38$, 3: $r_s = 0.40$, Bonferroni adjusted $p < 0.0167$). Among the possible explanations, one of the simplest is that large bumblebees may take more resources to rear. Therefore their development may take more time and colony cycles of these larger species may tend to be longer. Consequently, young queens and males would be more likely to be reared successfully if they were to start earlier in the year. This would be more likely at lower altitudes where the flowering season is longer.

Environmental change

There is serious concern about bumblebee conservation worldwide, because it is widely agreed that in many parts of the world some bumblebee species have declined, both in local abundance and in geographical range extent, and that this has often been driven in large part by land-use changes (e.g. Williams, 1986; Rasmont & Mersch, 1988; Berezin *et al.*, 1996; Yang, 1999; Hines & Hendrix, 2005; Benton, 2006; Carvell *et al.*, 2006; Fitzpatrick *et al.*, 2007; Kosior *et al.*, 2007). These changes do not seem to be driven by climate change (Williams, 1986; Williams *et al.*, 2007). Unfortunately, because bumblebees are social and because their haplo-diploid sex-determination mechanism can be disrupted by low heterozygosity within small populations, bumblebees may be at increased extinction risk compared to many organisms (Packer & Owen, 2001; Zayed & Packer, 2005) and may therefore be especially sensitive indicators of environmental change.

Grazing patterns. The high grasslands of the Tibetan Plateau region in the west and northwest of Sichuan are an important habitat for many bumblebee species. It was apparent from recent field work by the authors around Hongyuan and Litang that there is substantial variation in the abundance and diversity of the bumblebees of these grasslands. This appears to be related to the frequency and intensity of grazing, particularly by yak (Xie *et al.*, 2008).

Tibetan peoples in Sichuan are shifting from a nomadic to a more sedentary way of life, in particular as they become more

concentrated around towns. The grazing pressure increases in these areas because people's wealth is expressed traditionally in numbers of yak, sheep and horses, so people are unwilling to part with them even after they settle. Some forms, intensities and frequencies of grazing may be beneficial to the flora and to the bees. But highly intensive and continuous grazing around towns can reduce bumblebee abundances and diversity (Xie *et al.*, 2008). Support is being sought to study this environmental change in more detail.

Deforestation and reforestation. Bumblebees generally are not abundant in closed canopy forest, but are more abundant around forest edges and in more open areas within the forests that support more of their food plants (e.g. Bowers, 1985; Williams, 1988, 1991). In Sichuan, meadows and forest edges in the upper forest zone of the mountainous areas support a large proportion of the species found in the recent surveys (59% of the SCR bumblebee species are recorded reliably between 2000–3000 m). Recent field work (Tang Ya *et al.*, unpublished data) in the southwest of Sichuan (Ningnan County) shows that decreases in the area of forest and increases in the area used for agriculture are associated with decreases in counts of bees. It is unknown as yet which bumblebee species are most affected.

A large national reforestation programme has been implemented in China, particularly in the western areas. The aim is to convert agricultural land on steeper slopes back to forested land. This programme is expected to affect bumblebee populations, particularly if it were accompanied by a decrease in pesticide use, but data are unavailable as yet.

Agriculture. A particular feature of our distribution maps for the SCR is that several bumblebee species, formerly widespread at lower altitudes around and within the Sichuan Basin (e.g. *B. atripes*, *B. trifasciatus*, *B. breviceps*, *B. flavescens*, *B. ignitus*) and apparently still common elsewhere in China, have not been recaptured during the authors' recent surveys. Although there may be several possible explanations for this, one factor that deserves consideration is that it may be the result of changes in agricultural land use. Agricultural changes are believed to be important factors in the declines of many European bumblebees (e.g. Kosior *et al.*, 2007) and this has also been suggested for China (Yang, 1999).

Changes in agricultural land use within the SCR have been rapid in recent years, with a particular increase in cultivation of economic trees and cash crops. This could have a negative impact on bumblebees. Based on recent field work (Tang Ya *et al.*, unpublished data), bumblebees are less abundant in areas with cash crops such as tobacco, apple and pear, compared with areas with crops such as maize or potato. The effect could also be related to an increased intensity in the use of insecticides and herbicides with some crops.

Urbanisation. Urbanisation has become rapid in China but is concentrated mainly in the lowland areas and is much less pronounced in mountainous areas. Because bumblebees are associated primarily with the mountainous areas of the SCR, urbanisation is unlikely to have had a strong effect on them. Even in the Basin, urbanisation is still very patchy.

The Three Gorges Dam and other dams. The Three Gorges Reservoir Area has records of many rare and endemic

insects (Yang *et al.*, 1997). The Three Gorges Dam will submerge an area extending 600 km upstream along the Changjiang (Yangtze) river. This is widely expected to have negative impacts on the flora and fauna of the valley and the surrounding region. No studies of these changes are available yet, but many plants distributed here are expected to disappear, which could have impacts on the bumblebees. It is expected that some areas will be flooded for part of the year but be without water for the rest of the year. In addition, human populations are being relocated to areas higher up the valleys, which will lead to a higher proportion of the remaining land being cultivated more intensively. This is of particular concern for its potential effects on bumblebees if it involves unfavourable cash crops (see above). A survey of the bumblebee fauna was made before the dam was built (Yao & Luo, 1997) and it would be interesting to re-survey the region after the dam fills. Other dams are being constructed or are planned in almost all of the tributaries of the Changjiang. Along the Jialingjiang, Upper Minjiang, Daduhe and Yalongjiang alone, over 70 dams have been constructed or are planned. The effects of these dams remain to be seen.

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