

***Pyrobombus lapponicus* auct., in Europe recognized as two species: *P. lapponicus* (Fabricius, 1793) and *P. monticola* (Smith, 1849) (Hymenoptera, Apoidea, Bombinae)**

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Pyrobombus (*Pyrobombus*) *lapponicus* (Fabricius, 1793) and *P. (P.) monticola* (Smith, 1849) are described from type material. The male and worker are described of the former; the lectotype and a paralectotype (worker) are designated and in addition the male of *P. monticola* is described. Type studies of *rondoui* Vogt, 1909 and *scandinavicus* Friese, 1911, previously regarded as subspecies of *P. lapponicus*, revealed conspecificity with *P. monticola*. Furthermore, the subspecies *hypsophilus* Skorikov, 1912 and *konradini* Reinig, 1965 are also regarded as forms of *P. monticola*. The status of *glacialis* Schneider, 1902 is uncertain.

P. lapponicus is distributed in northern Europe: Fennoscandia – eastwards in the northern parts of the USSR, while *P. monticola* exhibits a boreo-alpine distribution: Fennoscandia, eastwards on the Kola peninsula, the British Isles, Italy, the Pyrenees, the Alps and the Balkan mountains. In Fennoscandia *P. lapponicus* is found both in alpine/subalpine habitats and in adjacent coniferous forests, whereas *P. monticola* is restricted to alpine/subalpine areas.

A comparative diagnosis of the two species, reinforced by drawings, is given. Metric studies of male abdominal sternite 7, hind basitarsus and position of ocelli on the vertex of queens were made to establish their diagnostic value. Some remarks on the biology of both species are also provided. The status of the Nearctic forms allied to *P. lapponicus* are discussed.

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Chemical studies on the cephalic marking pheromones of *P. lapponicus* (Fabricius, 1793) males from northern Sweden showed that there exists a constant difference in the composition of components between males with numerous yellow hairs of the coat and those with few yellow hairs (Bergström & Svensson 1973). The two chemical forms of the males were also correlated to morphological characters of sternites 7–8 and in genitalia (Svensson 1973). The two male forms distinguished corresponded with the subspecies *P. l. lapponicus* (light colour of the coat) and *P. l. scandinavicus*, Friese, 1911 (dark colour of the coat). Queens identified to subspecies did not show differences in shape or form (Svensson 1973). However, records on separate nests of the two forms of *P. lapponicus* (Svensson & Lundberg 1977), identified by the males on both morphological and chemical grounds, enabled queens to be morphologically distinguished. These studies revealed that the variation of colour of the coat of *P. l. lapponicus* was much greater than previously considered. Thus, the division of subspecies in Fennoscandia had to some extent been incorrect.

Males chemically analyzed from the Austrian

Alps were also compared with the Fennoscandian forms (Svensson 1977) – *P. l. hypsophilus* Skorikov, 1912 coincided in every respect with *P. l. scandinavicus*. Further studies on the cephalic marking pheromones of the males of the N European *Pyrobombus* Dalla Torre species are summarized by Svensson & Bergström (1977).

Studies on the route flight behaviour of the males (Svensson, to be publ.) and on nests, together with morphological and chemical characteristics, lead to the conclusion that *P. lapponicus* should be divided into two separate species, *P. lapponicus* and *P. monticola* (Smith, 1849). In this paper *P. lapponicus* and *P. monticola* are redescribed. Comments on their ecology, behaviour and distribution and chemical characteristics are also provided.

Remarks on taxonomy and nomenclature

Pyrobombus lapponicus is a holarctic species according to Friese (1902), Pittioni (1942, 1943), Reinig (1965) and Milliron (1971). However, the

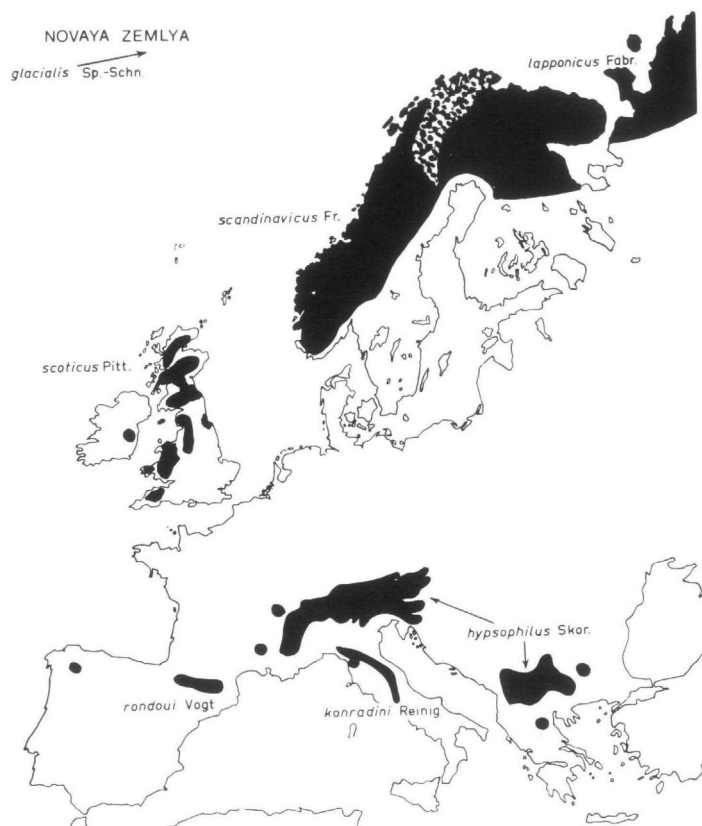


Fig. 1. Previously acknowledged distribution of *Pyrobombus lapponicus* in Europe with the division of subspecies according to Pittioni (1942) and Reinig (1965). Map modified from Reinig (1965) with records from Alford (1975), Løken (1973) and Reinig (1966 and in lit. 1977) added. The dotted area represents the sympatric distribution of *P. l. lapponicus* and *P. l. scandinavicus* according to Løken (1973).

Pittioni (1942)

subsp. <i>scandinavicus</i>	morfa <i>scandinavicus</i>
" "	" <i>scoticus</i>
" "	" <i>hypsophilus</i>
" "	" <i>rondoui</i>
" <i>glacialis</i>	" <i>glacialis</i>
" <i>lapponicus</i>	" <i>lapponicus</i>

Reinig (1965)

subsp. <i>scandinavicus</i>
" <i>scoticus</i>
" <i>hypsophilus</i>
" <i>rondoui</i>
" <i>glacialis</i>
" <i>lapponicus</i>
" <i>konradini</i>

subspecies *P. l. sylvicola* (Kirby, 1837), occurring in western North America, was treated as a separate species by Franklin (1912) and Stephen (1957).

P. lapponicus exhibits a large variation in the colour of the coat (Vogt 1909, 1911; Skorikov 1912; Körner & Zarapkin 1938; Reinig 1965; Løken 1973), and this has sometimes led to the naming of a vast number of infraspecific forms. Pittioni (1942: 186–192), for example, listed 82 nominal forms.

In Europe, Pittioni (1943) divided *P. lapponicus* into three subspecies, *lapponicus*, *glacialis* Schneider, 1902 and *scandinavicus*. These subspecies were also divided into morphs

and further into several forms. Reinig (1965) elevated Pittioni's morphs of *scandinavicus* to the rank of subspecies and in addition described the subspecies *konradini*. Thus, seven subspecies were recognized in Europe. The distribution of *P. lapponicus* and its division according to Pittioni (1942) and Reinig (1965) is shown in fig. 1.

Schneider (in Friese 1902) described the subspecies *glacialis*, distributed only on the islands of Novaya Zemlya and from the Pyrenees *rondoui* was recognized by Vogt (1909). The subspecies *hypsophilus* is distributed in the Alps and the Balkan mountains while *konradini* Reinig, 1965 is recognized in Italy. In the British

Isles Pittioni (1942), Reinig (1965) and Alford (1975) distinguished *scoticus* Pittioni, 1942, although Smith (1844) had already described the species *montanus* (non *Bombus montanus* Lepelletier, 1836), correcting it in 1849 to *monticola*. Later (1855: 218), he synonymized *monticola* with *lapponicus*, as Pittioni did in 1942. Reinig (in lit. 1977) however, pointed out that *monticola* is still available and therefore has priority over *scandinavicus* and the European forms further south.

In Fennoscandia the form of *P. lapponicus* without yellow hairs was originally often confused with *Alpinobombus alpinus* (L.) (cf. Schneider 1909) until Schneider (in Friese 1902) regarded the form as var. *lugubris* of *P. lapponicus*. Friese (1911) corrected *lugubris* (non F. Morawitz 1880) to var. *scandinavicus*. According to Løken (1973) this subspecies is distributed from southern Norway, northwards in the Swedish and Norwegian mountains while *B. l. lapponicus* is found southwards to about 65°N. The two subspecies also appear sympatrically (cf. fig. 1).

There has been much confusion about several species within the genus *Pyrobombus* – one of the largest genera of the *Bombini* – e.g. the Eurasian *hypnorum* group and the American *praticola* group (Tkalčů 1969; Stephen 1957). Several authors, especially Pittioni, have discussed the status of *P. lapponicus*. He regarded (1938: 34) *P. lugubris hypsophilus* (*P. lapponicus hypsophilus*, sensu Pittioni, 1942) as a species distinguished from *P. lapponicus*. Although, in the same paper (p. 61) he writes "Es gelang mir trotz grösserer Serienuntersuchungen an ♂♂ und ♀♀ nicht, trotz in die Augen springender Färbungsunterschiede, irgendwelche durchgreifende strukturelle Unterschiede festzustellen ... Da es, wenn auch sehr selten, Übergänge auch in der Färbung gibt, sehe ich mich ausserstande, die Trennung in zwei verschiedene Arten aufrecht zu erhalten, wenn ich auch persönlich vollständig von der artlichen Verschiedenheit von *lugubris* und *lapponicus* überzeugt bin. Bis zur Auffindung eines geeigneten trennenden Merkmales sind wir also gezwungen, *lugubris* als eine Morphe von *lapponicus* aufzufassen; *hypsophilus*, der in mancher Beziehung Ähnlichkeit mit *lugubris* aufweist, bleibt solange als Subspecies von *lapponicus* bestehen." He also expressed similar doubts in 1942: 192–193. Furthermore, Körner & Zarapkin (1938), in their study of the coat

colour of *P. lapponicus*, came to the conclusion that two colour forms existed, one circumpolar the other in the South European mountains, but in Fennoscandia both forms were found and there "teilweise verbastardiert" (p. 752).

As a result of the present study, the seven subspecies recognized by Reinig (1965), except *lapponicus* and *glacialis*, are shown to belong to the species *P. monticola* (cf. figs 51, 52). However, *lapponicus* and *glacialis* may also be conspecific. Since only a single queen of *glacialis* was studied its status remains uncertain.

Methods

The morphological terminology follows Michener (1944) but Richards (1968) is followed as regards some specific generic characteristics. The generic classification of bumble bees proposed by Tkalčů (1969, 1974) is followed.

Some characteristics are highly variable and studied in order to establish their diagnostic value. Measurements were made with a micrometer eyepiece. Metric studies of male sternite 7 follow Svensson (1973:141) while measurements of parts not described in the text were carried out according to Løken (1973). Some of the parts measured and given in the redescrptions and in Tab. I were not transformed into mm; in these cases the figure 10 corresponds to 1/8 mm. The density of puncturation is estimated in relation to the diameter of the punctures.

Abbreviations of the collections studied

BML	Brit. Mus. (Nat. Hist.), London.
HDZ	Hope Dept Zool. (Ent.), Oxford.
MNH	Swedish Mus. nat. Hist., Stockholm.
TMT	Tromsø Mus., Tromsø, Norway.
ZMA	Zool. Mus., Amsterdam.
ZMB	Zool. Mus., Bergen, Norway.
ZMC	Zool. Mus., Copenhagen.
ZMH	Zool. Mus., Helsinki.
ZML	Zool. Mus., Lund, Sweden.
ZMU	Zool. Mus., Dept of Ent., Uppsala, Sweden.
AP	A. Pekkarinen, Helsinki.
BC	B. Cederberg, Uppsala.
BS	The author's collection, Uppsala.
HB	H.-E. Bergwall, Uppsala.
HL	H. Lundberg, Stockholm.
LE	L. Eldefors, Uppsala.

Pyrobombus (P.) lapponicus (Fabricius, 1793)

Figs 1, 2–9, 18–21, 26–28, 32–38, 47 A–F, 48–51, 53.

The redescription of the queen is based on the lectotype designated by Løken (1966) from the "Copenhagen collection", ZMC (Zimsen 1964). The description of the worker is based on one of the two workers in the "Kiel collection" of Fabricius, ZMC (which is labelled "morphotype"). No type label of Milliron's was attached to either of the workers (cf. Milliron 1960, Løken 1966). The male is described from a nest found at Välijaure, 22.VII.1977, Torne Lappmark, Sweden. Leg. B. G. Svensson. Further material from that nest, 6 ♂♂, 11 ♀♀, 8 ♀♀ were used for the figures when parts of the fragile old specimens did not allow study.

Type area: Sweden, Lapland.

Type material: Lectotype ♀, labelled: 1) "B. lapponica D:de Paykull"; 2) "B. lapponicus Fabr. ♀ lectotype, A. Løken design. 1965"; 3) "Pyrobombus lapponicus (Fabr.) ♀, B. G. Svensson 1977". Condition of the lectotype: all joints of the left hind tarsus are lost, dorsal part of thorax around the pin is broken with some parts missing, 6th joint of flagellum of right antenna is slightly damaged, wings moderately worn. In coll. ZMC.

Additional material studied

The total number of specimens is given for each country together with the number of specimens from the different collections studied. Workers are omitted on account of the occasional identification difficulties. "Provinces" from which material was studied are shown in fig. 51, together with a rough distribution of the species in W Europe.

The description of the male is based on a specimen labelled 1) Sweden, Torne Lappmark, Välijaure 22/7 1973, B. G. Svensson leg. (from excavated nest, No 3) 2) *Pyrobombus lapponicus* (Fabr.) ♂ allotype, B. G. Svensson design. 1977. In ZMU. Condition good genitalia and sternites 7–8 on card.

Finland: 34 ♂♂, 4 ♀♀. (19 ♂♂ AP; 6 ♂♂ 1 ♀ BS; 3 ♂♂ 3 ♀♀ MNH; 6 ♂♂ ZMNH). – *Norway:* 8 ♂♂, 37 ♀♀. (7 ♂♂ 37 ♀♀ ZMB; 1 ♂ ZMU). – *Sweden:* 254 ♂♂, 172 ♀♀. (13 ♂♂ AP; 2 ♂♂ 1 ♀ BC; 71 ♂♂ 80 ♀♀ BS; 4 ♀♀ HB; 6 ♂♂ 22 ♀♀ HL; 1 ♀ LE; 93 ♂♂ 63 ♀♀ MNH; 3 ♂♂ 68 ♀♀ ZML; 1 ♂ 1 ♀ ZMU). –

USSR: 7 ♂♂, 1 ♀. (2 ♂♂ BS; 1 ♀ MNH; 5 ♂♂ ZMH).

Nests examined: Sweden, Torne Lappmark: Abisko (one nest), Kärketjärro (two nests), Njulla (nine nests), Välijaure (one nest). Total number of specimens from the nests: 10 ♂♂, 27 ♀♀ and 45 ♀♀ (in coll. BS). For further data on the nests, see Svensson & Lundberg (1977).

Chemical analyses: Sweden, Torne Lappmark: 26 ♂♂ (cf. Bergström & Svensson 1973, Svensson & Bergström 1977).

Redescription

QUEEN

Structure and shape

Surface of malar space shiny, lower part delimited by large punctures each with a long hair; dorsally of this area there are small punctures with a shallow furrow (length 2–3x diameter of puncture), each of them running towards lower part of mandibular base and with very short hairs; at the angle above mandibular condyle a limited area with densely packed small punctures; upper part with a few punctures nearly reaching sparsely punctured middle basal part.

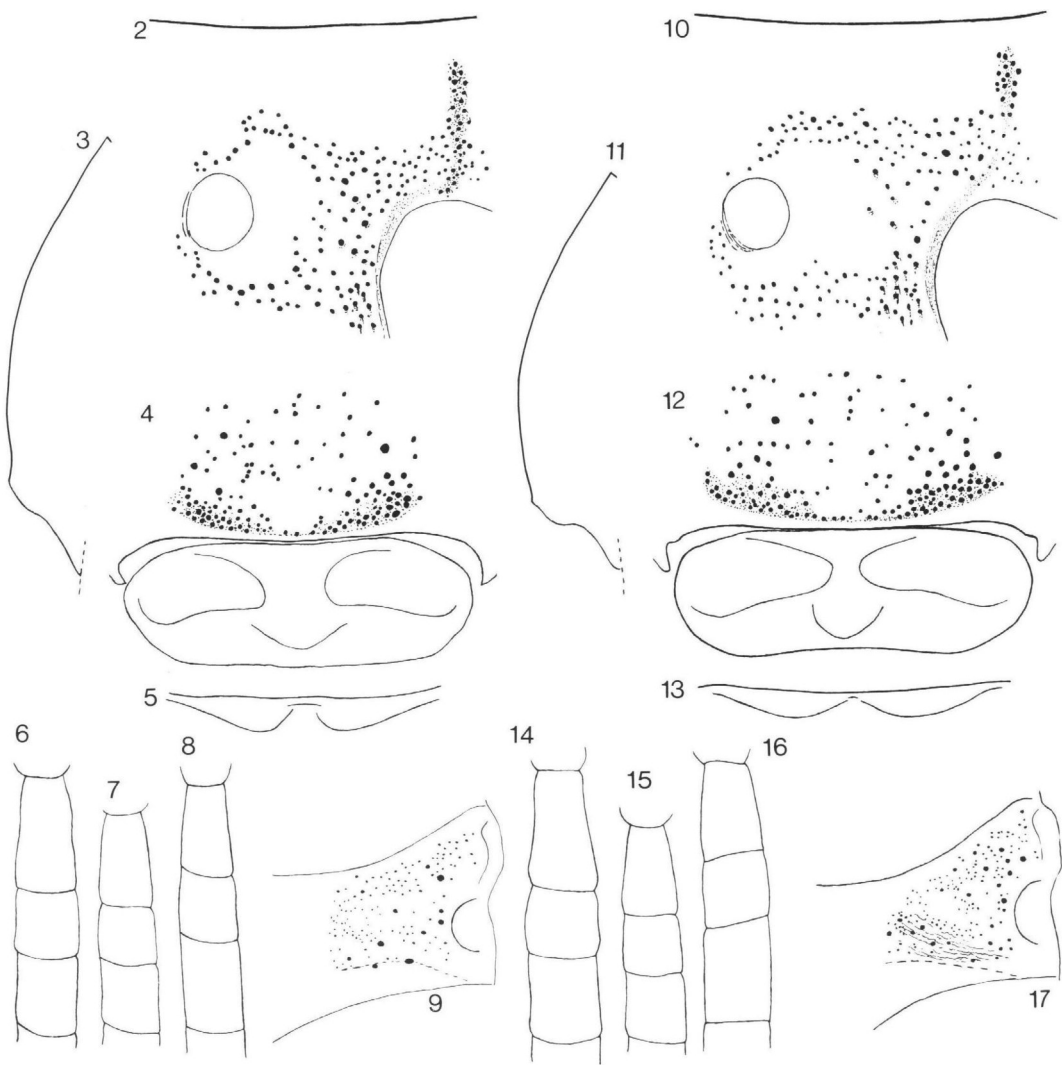
Surface of basal area of left mandible shiny with very superficial chagreenation; puncturation fine and sparser in middle, large punctures few and scattered; "basal keel" shiny (fig. 9).

Labrum, medial furrow broad, tubercles granulated on inner corners, otherwise shiny with few punctures on lateral parts, lamella wider than long – semicircular (figs 4, 5).

Clypeus in lateral view evenly convex, apical lateral margin even and weakly emarginate (fig. 3); in front view, surface shiny with lower central half with large punctures of variable sizes and small punctures of nearly uniform size, the large punctures being deep; in front of apical margin in the middle a row of punctures which laterally widen to a fairly well delimited, slightly depressed small patch of punctures; puncturation becomes gradually denser basally and laterally of the central part (fig. 4).

Supra-orbital line touching lateral ocelli posteriorly.

Surface around ocelli and upper part of compound eye. A little less than half distance OOL (lateral ocellus – compound eye) adjacent to the lateral ocellus shiny and unpunctated, the other part, close to compound eye, with a few scattered punctures; below the ocellar-orbital field



Figs 2-17. *Pyrobombus lapponicus*, 2-9, and *P. monticola*, 10-17. Queen 2-6, 9, 10-14, 17. Worker 7, 15. Male 8, 16. - Ocellar-orbital field and dorsal furrow of gena, 2 and 10. - Clypeus in lateral left view, 3 and 11. - Labrum and lower part of clypeus in front, 4 and 12. - Labrum in dorsal view, 5 and 13. - Antenna, joints I-III, 6-8 and 14-16. - Surface of basal part of left mandible, 9 and 17.

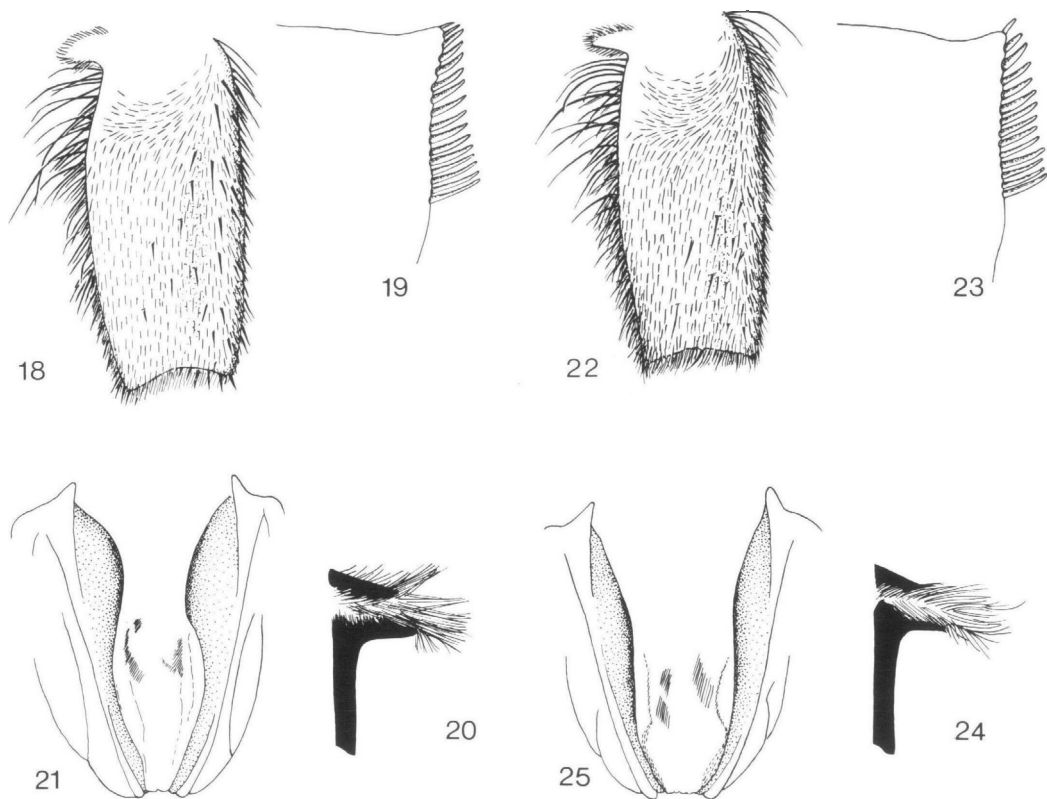
puncturation denser (1-3 Ø) and close to compound eye much denser (0.5-1 Ø); above ocellar-orbital field puncturation 0.5-1 Ø with smaller punctures in between, so puncturation appears dense; above compound eye small punctures dominate and through this area the dorsal furrow of gena is distinct, nearly reaching compound eye with some punctures; surface between the punctures on vertex rugose and dull (fig. 2).

Inner margins of compound eyes parallel and each eye in the middle slightly concave.

Three first joints of flagellum as in fig. 6.

Mesonotum anteriorly and laterally densely punctured (0.5-1 Ø), towards middle gradually decreasing in density, in the middle shiny with a few scattered punctures.

Mid basitarsus with posterior apical process rounded, apical form in lateral view somewhat angled.



Figs 18–25. Queens of *Pyrobombus lapponicus*, 18–21, and *P. monticola*, 22–25. – Right hind basitarsus, 18 and 22. – Inner posterior apical part of right hind tibia, 19 and 23. – Auricle, 20 and 24. – Sting sheath, 21 and 25.

Hind tibia, inner apical posterior part straight in front of the process (fig. 19), surface of corbicular area shiny and moderately chagreened – apically more distinctly chagreened.

Hind basitarsus, maximal width situated apically of the diverging transversely directed hair whorls of outer basal surface (figs 18, 49), the basal part shiny with traces of chagreenation, apical form in lateral view slightly angled (fig. 18), auricle short and broad (fig. 20).

Number of hamuli: left hind wing 22; right hind wing 23.

Surface of abdominal tergites 5–6; 5th, apical membranous pale part chagreened and surface weakly chagreened, in front of apical part puncturation dense (0.5–1 Ø), while in the middle punctures more scattered (2–6 Ø) but laterally denser, all punctures with slightly elevated anterior rim; 6th, in front of upwards curved apical part, surface with weak longitudinal wrinkles and puncturation variable in density

(1–4 Ø), laterally these punctures slightly crater-like, surface in middle shiny with traces of chagreenation, punctures scattered, laterally the puncturation denser and crater-like form of punctures more obvious (the surface of the tergite is somewhat dirty, sternite 6 is withdrawn and partly hidden by 5th).

Sting sheath: inner thickenings ventrally broad (fig. 21).

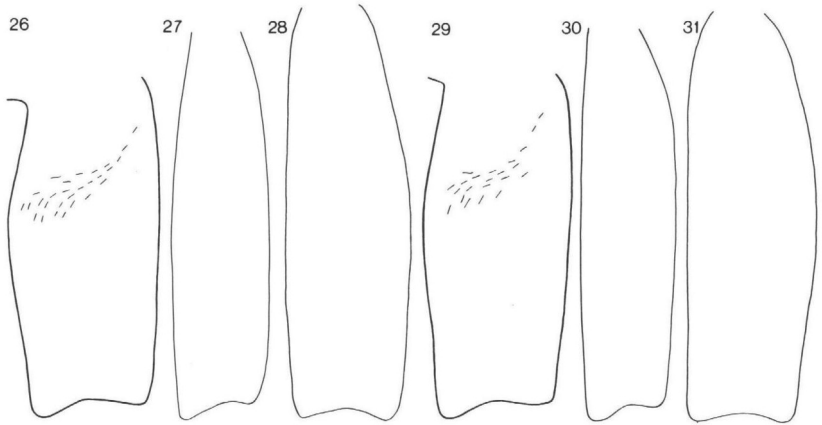
Body length about 15 mm. Wing length about 13 mm. Malar space/mandibular base 45/51. Mid ocellus 23.5. Distance between lateral ocellus and compound eyes 48–50.

Colour

Front wing, venation brownish black to blackish brown, membrane evenly brownish with anterior part somewhat darkened.

Sclerites, black to brownish black, apical part of abdominal tergites yellowish brown, apical part of malar area reddish (especially dorsal and ventral parts).

Figs 26–31. *Pyrobombus lapponicus*, 26–28, and *P. monticola*, 29–31. – Right hind basitarsus of workers, 26 and 29. – Left mid basitarsus of males, 27 and 30. – Left hind basitarsus of males, 28 and 31.



Hair-coat. (The dark black colour of coat of lectotype seems to have become reddish/brownish because of aging.) Head black and vertex with yellow hair mixed with some black hair extending laterally to lateral ocelli – dorsal furrow of gena, labrum with stiff orange-coloured hair. Thorax black with yellow collar which extends posteriorly to parapsidal lines and laterally down on the episternum, lower part of episternum with some light hair, apical part of scutellum yellow and laterally with yellow tuft-like hair. Legs brownish black, coxae, trochanters and femora with some light brownish hair. Abdominal tergites, 1st, in the middle with scattered black hair and laterally with tuft-like yellow hair; 2–3rd red; 4th base red and laterally and apically yellow-haired; 5th yellow and in middle with some dark reddish hair; 6th with a few brownish black hairs.

WORKER

Structure and shape

Surface of basal area of left mandible shiny with a few scattered large and small punctures.

Labrum, medial furrow shallow and broad, lamella short and about twice as broad as long.

Clypeus, surface shiny, lower central part with a few large and small scattered punctures.

Ocellar-orbital field, less than half the distance between lateral ocellus to compound eyes adjacent to the compound eye with a few scattered punctures, towards compound eyes somewhat denser.

Three first joints of the flagellum as in fig. 7.

Dorsal furrow of gena quite well developed

with some small punctures nearly reaching compound eye.

Hind-basitarsus as in fig. 26.

Number of hamuli: left hind wing 18; right hind wing 19.

Wing length about 10.5 mm. Body length 12–13 mm. Malar space/mandibular base 38/43. Mid-ocellus 20. Distance between lateral ocellus to compound eyes 40.

Colour

Hair coat, similar to lectotype.

MALE

Structure and shape

Surface of malar space similar to queen.

Supra-orbital line touching lateral ocelli posteriorly.

Surface of ocellar-orbital field shiny and with a few single punctures from about the middle of the distance from lateral ocelli to compound eye, towards compound eye puncturation slightly denser. Dorsal furrow of gena quite distinct, nearly reaching compound eye. (Distribution of punctures largely similar to that on the queen but punctures are not so distinct, more like those of large workers.)

Three first joints of flagellum as in fig. 8.

Mid basitarsus, towards basal part gradually narrowing (fig. 27).

Hind basitarsus, towards basal part, from about middle, gradually narrowing (fig. 28).

Surface of hind tibia shiny with traces of chagreenation.

Abdominal sternites 7–8: The 7th, cuticle in the middle with two delimited dark patches,

lateral apical hair-tufts distinct and between these an average of 47 hairs (counted twice) which apically form an almost straight line between lateral hair-tufts, lateral margins of the sternite almost parallel (fig. 38, cf. fig. 48). The 8th, the two middle lines well apart and slightly diverging apically, apically of these lines an aperture (fig. 37).

Genitalia, width a little less than combined length of gonocoxite and volsella, the general form appearing slightly elongate (fig. 32). Gonocoxite, outer contour apically more or less straight and inner apical part somewhat curved inwards, forming an angle with basal part (figs 33, 36). Gonostylus completely lacks basal inner process (fig. 33). Volsella, lateral form rounded and inner apical process pointed and slightly hooked (fig. 35). Penis valvae, the straight tip slightly narrowing apically (fig. 34).

Body length 16.0 mm (abdomen drawn out). Wing length 11.5 mm. Malar space/mandibular base 44/37. Mid-ocellus 21. Distance between lateral ocelli to compound eyes 41–42.

Colour

Hair coat. Head black with vertex yellow laterally to dorsal furrow of gena and anteriorly to middle ocellus. Clypeus and dorsally up to antennal sockets, bright yellow. Thorax black with broad yellow collar continuous over whole episternum and with yellow hairs on scutellum. Legs, all trochanters and femora ventrally with light yellowish hair. Abdominal tergites, 1st laterally yellow and in middle with a few black hairs; 2–3rd red with a few black hairs laterally; 4–5th laterally yellow and in middle with light reddish hairs; 6th light reddish with a few yellow hairs laterally and in middle a few black hairs; 7th reddish with some black hairs. Abdominal sternites apically with light yellow hair, the hairs shorter in middle.

Variation

QUEENS

Structure and shape

The punctured part adjacent to compound eye varies in number of punctures, the punctures

rarely absent near the unpunctured part so that the shiny area dominates. Punctured part often continuous from compound eye to shiny area. Dorsal furrow of gena usually reaches compound eye with at least some punctures. However, if furrow is weak in middle, it is less distinct close to compound eye. Labral furrow usually broad but quite variable and lamella semicircular, seldom pointed. The form of the hind-basitarsus is discussed in the "comparative diagnosis". Surface in the middle of abdominal tergite 6 variable in the strength of chagreenation and the crater-like punctures may be few or absent in middle but laterally always recognisable. The punctures of this species usually have a markedly elevated anterior rim.

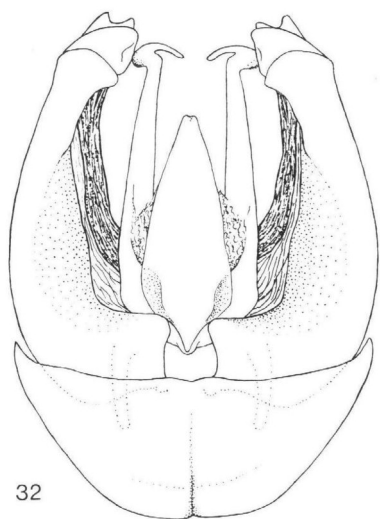
Colour

Hair coat: The extent of yellow hairs is highly variable in Fennoscandia. The lectotype has a large number of yellow hairs, corresponding to the former interpretation of the nominate form. However, the species ranges from specimens with numerous yellow hairs to those with none, even though the hairs on the collar, scutellum and tergites do not necessarily exhibit the same degree of yellowness. Moreover, specimens with very few yellow hairs usually have a slight yellowish-red tinge laterally on abdominal tergites 4–5. Specimens from N Fennoscandia vary from those with a coat consisting of numerous yellow hairs to those with none. In contrast, in S Scandinavia no specimen was found with bright yellow hairs on the collar, scutellum, or on abdominal tergites 1, 4 and 5 (fig. 47). Thus, melanism seems to increase southwards on the Scandinavian peninsula. A similar tendency was demonstrated by Løken (1973) for *Alpinobombus balteatus* (Dahlbom). Furthermore, in Torne Lappmark, Sweden, no melanistic specimens were found outside the alpine/subalpine areas.

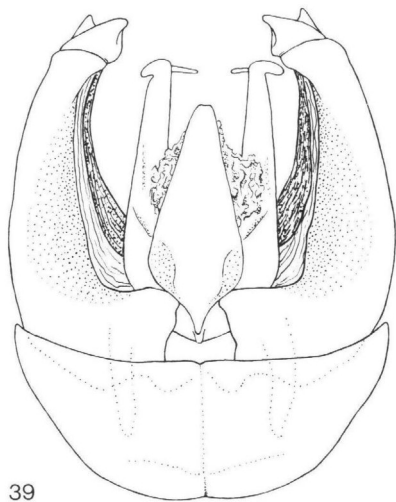
WORKERS

The morphological characters are more variable and not so distinctive as those in the queens due to variation of size. Thus, large workers are easier to identify. Fennoscandian specimens

Figs 32–45. Genitalia and abdominal sternites 7–8 of *Pyrobombus lapponicus*, 32–38, and *P. monticola*, 39–45 (nest specimens), males. – General shape of genitalia, dorsal view, 32 and 39. – Gonostylus and apical part of gonocoxite in dorsal view, 33 and 40. – Apical part of penis valve, 34 and 41. – Left volsella, ventral view, 35 and 42. – Penis valve and gonocoxite in latero-dorsal view, 36 and 43. – The 8th abdominal sternite, 37 and 44, and the 7th, 38 and 45.



32



39



33



34



35



36



40



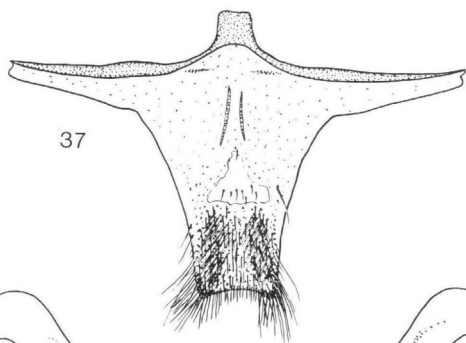
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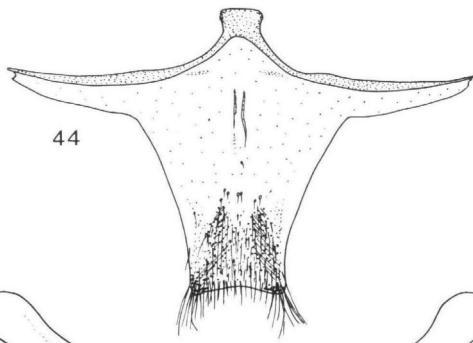
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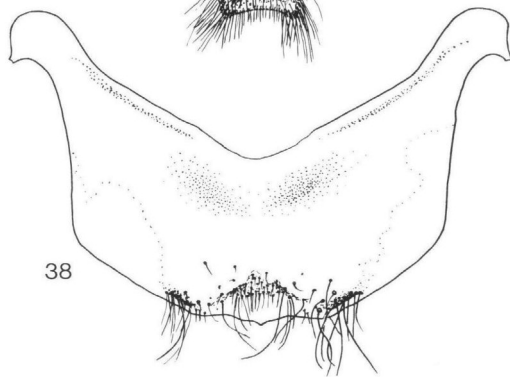
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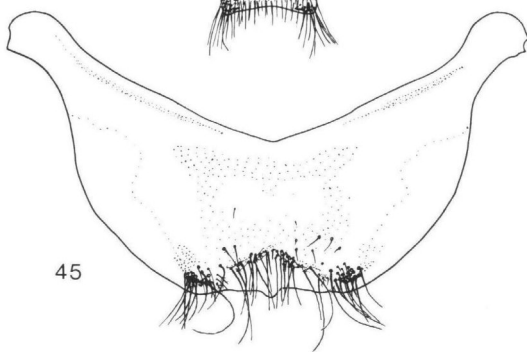
37



44



38



45

with a large number of yellow hairs belong to this species.

MALES

Structure and shape

The dorsal furrow of the gena seems to be more variable than in the queens. The basal form of mid and hind tibia proved to be a good external feature of the species. However, there is some variation so both pairs of legs should be examined. The genitalia and abdominal sternites 7–8 show several features which vary to some extent. The variations of some characteristics of abdominal sternite 7 are shown in fig. 48 A–B. Abdominal sternite 8 is less chitinated at the basal middle part between the dark lines and also apically of these lines. The general form of the genitalia in dorsal view does not vary, so even when viewed with the naked eye its slightly elongate form is obvious. As regards the individual parts of the genitalia there is a fairly large variation. It is a combination of characteristics, seldom a single feature, that identifies a specimen.

Colour

Hair coat: The variation in the extent of yellow hairs does not vary as much as in the queens. Collar, scutellum and abdominal tergite 1 usually with bright yellow hair, some of these parts darkened but always abdominal tergites 4–5 with yellowish hair. Specimens without yellow hairs were not seen.

Further comments on the variation of queens and males are given in the “comparative diagnosis” below.

Biology

The nests are often located below ground in rodents' nests. Colony size small; maximal number of cocoons found: 61. Number of cells of the first brood: mean 10 (9–12). Colour of cocoons light yellow. Wax nest envelope absent. **Colony cycle** short, in N Sweden less than two months (from first appearance of queens in the spring to production of sexuals). **Habitat:** in Scandinavia found in alpine, subalpine and northern coniferous forest habitats. **Temperament** mild. **Composition of male marking pheromone:** main component geranylcitronellol (Bergström & Svensson 1973). **Route-flight behaviour** different from that of *P. monticola*.

Pyrobombus (P.) monticola (Smith, 1849)

Figs 10–17, 22–25, 29–31, 39–46, 47 H–L, 48–50, 52–53.

The redescription of the queen and worker is based on lectotype and a paralectotype selected from Smith's collection (2 ♀♀, 2 ♂♂, 1 ♂) in HDZ. No specimen bears Smith's specific determination labels. The label “Loch Rannoch 1861” for the single male, disqualifies this specimen as a syntype; furthermore the specimen is in poor condition. The male is described from a specimen of the HDZ collection. Most of the illustrations are based on material from one nest, Sweden, Torne Lappmark, Njulla (cf. Svensson & Lundberg 1977).

From the subspecies distinguished by Reinig (1965) two forms were studied: *scandinavicus* ♀ (holotype, TMN) and *rondoui* (2 ♂♂, 4 ♀♀, probably syntypes, ZMA).

Type area: Wales (cf. Smith 1844:549).

Type material: **Lectotype** ♀, labelled: 1) “Perths.” (grey label), 2) “Smith coll., Hope Dept., Univ. Museum, Oxford,” 3) “*Pyrobombus monticola* (Smith) ♀ lectotype, B. G. Svensson design. 1977.” Condition: good, on 1st and 2nd left tarsi the two last joints and on the 3rd the three last joints are missing, wings worn. – **Paralectotype:** ♀, labelled: 1)–2) as the lectotype 3) “*Pyrobombus monticola* (Smith) ♀ morphotype, B. G. Svensson design. 1977.” Condition: The last joint of right middle tarsus and the right hind tibia and tarsus are missing, otherwise in good condition.

Additional material studied

The total number of specimens is given for each country together with the number of specimens from the different collections studied. Workers are omitted on account of the occasional identification difficulties. Administrative areas (“Provinces”) from which material was studied are shown in fig. 52, together with a rough distribution of the species in Europe.

The description of the male is based on a specimen labelled: 1) “Montgomeryshire, Myherin Forest at Epilobium, C. O'Toole, 29-8-75, SN/0/70” 2) “*Bombus lapponicus* (Fabr.) det. C. O'Toole 1975” 3) “*Pyrobombus monticola* (Smith) ♂ allotype, B. G. Svensson design. 1977”. Condition: good, abdominal sternites 7–8 and genitalia on card.

Austria: 23 ♂♂, 1 ♀ (BS). – **British Isles:** 25 ♂♂, 29 ♀♀ (19 ♂♂ BML; 5 ♂♂ 28 ♀♀

HDZ; 1 ♂, 1 ♀ MNH). – *Finland*: 4 ♂♂, 16 ♀♀ (ZMH). – *France*: 7 ♂♂, 4 ♀♀ (ZMA). – *Italy*: 3 ♂♂ (MNH). – *Norway*: 25 ♂♂, 10 ♀♀ (3 ♂♂ BS; 1 ♀ MNH; 18 ♂♂ 9 ♀♀ ZMB; 2 ♂♂ ZMU). – *Sweden*: 121 ♂♂, 87 ♀♀ (13 ♂♂ AP; 1 ♀ BC; 76 ♂♂ 30 ♀♀ BS; 4 ♀♀ HB; 6 ♂♂ 17 ♀♀ HL; 13 ♂♂ 14 ♀♀ MNH; 1 ♂ 3 ♀♀ ZML). – *Switzerland*: 7 ♂♂, 2 ♀♀ (MNH). – *USSR*: 1 ♂ Lp. Ponoj (ZMH).

Nest examined: Sweden, Torne Lappmark: Njulla 675 m, 12 ♂♂, 18 ♀♀, 25 ♀♀. For further data on this nest, see Svensson & Lundberg (1977).

Chemical analyses: Sweden: Torne Lappmark, 27 ♂♂; Austria: Tirol, 12 ♂♂ (cf. Bergström & Svensson 1973, Svensson 1979, Svensson & Bergström 1977).

Redescription

QUEEN

Structure and shape

Surface of malar space shiny, lower part with large punctures, above these smaller punctures each with a shallow furrow leading from the puncture, 1–3 Ø long, directed towards lower part of mandibular base; apically with scattered punctures, upper part with a few punctures nearly reaching the sparsely punctured middle part.

Surface of basal area of left mandible shiny with a superficial chagreenation, puncturation fine and basally dense, large punctures few and scattered, “basal keel” slightly reticulate/chagreened (fig. 17).

Labrum, medial furrow narrow (fig. 13); tubercles on inner parts dull and lateral parts shiny, above with scattered large punctures; lamella as wide as long, semicircular (fig. 12).

Clypeus, in lateral view distinctly convex, apical lateral margin emarginate (fig. 11); in front view surface shiny, lower central half with large punctures of variable sizes and small punctures of nearly uniform size, the large punctures being deep; in front of apical margin in the middle a row of punctures which laterally widen, extending laterally almost as far as labrum is wide and dorsally (from edge of clypeus) as far as the middle joints of the antenna are thick (fig. 12).

Supraorbital line touching lateral ocelli posteriorly.

Surface around ocelli and upper part of compound eye, much less than half the distance OOL adjacent to the lateral ocellus unpunctated and shiny, the other part, close to compound eye, with few and scattered punctures (fig. 10); below ocellar-orbital field puncturation denser (1–3 Ø) and close to compound eye much denser (0.5–1 Ø); above the ocellar-orbital field scattered large and small punctures and area slightly shiny, above compound eye regularly distributed small punctures and scattered large ones; dorsal furrow of gena indicated as slight depression with some punctures near compound eye, surface between punctures on vertex shiny.

Inner margins of compound eye parallel, each being slightly concave in middle.

Three first joints of flagellum similar to those shown in fig. 14.

Mesonotum, anteriorly and laterally densely punctuated, (0.5–1 Ø), puncturation gradually decreasing in density towards middle, which shows only a few scattered punctures.

Mid basitarsus, posterior apical process rounded, apical form in lateral view somewhat angled.

Hind tibia, inner apical posterior part slightly excavated in front of the process which is slightly pointed – to some extent like that of *Alpinobombus* workers (fig. 23), corbicular area chagreened, less distinctly so on basal parts.

Hind basitarsus, maximal width attained at level of the transversely directed diverging hair whorls of basal outer surface (figs 22, 49), basal part shiny with traces of chagreenation, apical form in lateral view slightly angled (fig. 22), auricle (fig. 24).

Number of hamuli: left hind wing 22; right hind wing 24.

Surface of abdominal tergites 5–6; 5th, apical pale part chagreened and surface shiny, in front of apical part puncturation dense (0.5–1 Ø), in middle more scattered (1–5 Ø), but laterally denser; 6th, in front of the upwards curved apical part, surface dirty, surface in middle shiny and punctures scattered, laterally puncturation increasing in density and all punctures regularly shaped – at most with slightly elevated anterior part.

Sting sheath: inner thickenings ventrally narrow (fig. 25).

Body length about 16 mm. Wing length about 14 mm. Malar space/mandibular base 53/56. Mid-ocellus 23. Distance between lateral ocellus and compound eyes 48.

Colour

Front wing, venation brownish black to blackish brown, membrane evenly brownish with anterior part somewhat darkened.

Sclerites black, apical part of abdominal tergites yellowish brown, apical part of malar area, dorsal and ventral parts, reddish.

Hair coat. Head black, vertex with admixture of some light hairs, extending laterally to lateral ocelli, labrum with stiff orange-coloured hair. Thorax black with yellow collar which extends posteriorly almost to parapsidal lines and laterally to tegulae, apical part of scutellum sparsely fringed with yellowish hairs. Legs brownish black, coxae, trochanters with brownish hairs. Abdominal tergites, 1st black with some light hairs laterally; 2nd red with some black hairs in the basal middle; 3–5th red; 6th with some brownish black hairs.

WORKER

Structure and shape

Surface of basal area of left mandible with few scattered large and small punctures.

Labrum, medial furrow shallow but quite narrow, lamella incompletely developed.

Clypeus shiny, lower central part with few large and small punctures.

Ocellar-orbital field, adjacent to the compound eye for a distance about half OOL with very few punctures, close to the compound eye the puncturation denser.

Three first joints of flagellum (cf. fig. 15).

Dorsal furrow of gena towards compound eye hardly indicated.

Hind basitarsus: hair not so distinctly directed as shown in fig. 29.

Number of hamuli: left hind wing 15; right hind wing 19.

Wing length, about 9.5 mm. *Body length* about 10 mm. *Malar space/mandibular base* 35/37. *Mid-ocellus* 18. *Distance between lateral ocelli and compound eyes* 37.

Colour

Hair coat very similar to lectotype.

MALE

Structure and shape

Surface of malar space similar to that of queen but not so distinctly punctuated.

Supraorbital line touching lateral ocelli posteriorly.

Surface of ocellar-orbital field shiny with a few scattered punctures from about the middle of the distance OOL.

Dorsal furrow of gena indicated by shallow furrow towards compound eye.

Three first joints of flagellum similar to those figured in fig. 16.

Mid basitarsus towards basal part abruptly narrowing (fig. 30).

Hind basitarsus: posterior form rounded (fig. 31).

Surface of hind tibia shiny with traces of chagreenation.

Abdominal sternites 7–8: The 7th, cuticle in the middle diffusely darkened with central part lighter, lateral apical hair-tufts distinct and between these about 29 hairs (counted twice) which form a concave line apically (fig. 46 and cf. figs 45, 48). The 8th, the two middle lines fused basally and diverging apically, apically of these lines some small apertures (cf. fig. 44). *Genitalia*, width similar to combined length of gonocoxite, and volsella, making the general form roundish (fig. 39); gonocoxite, outer contour apically slightly rounded and inner apical contour bent inwards and joining a continuous curved line to basal parts (cf. figs 39, 43); gonostylus with very minute basal inner process (in fig. 40 somewhat exaggerated); volsella, lateral form apically straight and inner apical process pointed and slightly hooked (cf. fig. 42); penis valvae, the straight tip slightly widened apically (cf. fig. 41).

Body length about 13.5 mm. *Wing length* about 11 mm. *Malar space/mandibular base* 46/40. *Mid ocellus* 21. *Distance between lateral ocelli and compound eyes* 45.

Colour

Hair coat: Head black. Vertex, laterally to lateral ocelli anteriorly to middle ocellus, and clypeus dorsally to antennal sockets, all yellow. Thorax black with broad yellow collar continuous over whole episternum and with yellow hairs on scutellum. Legs brownish black with hair-tips reddish, all trochanters and femora ventrally with some yellowish hairs. Abdominal tergites; 1st with few black hairs, laterally with tuft-like yellowish hairs; 2nd red, basally with some black hairs in middle; 3–7th red, on 4–5th with some yellowish red hairs laterally. Abdominal sternites with light yellowish hairs.

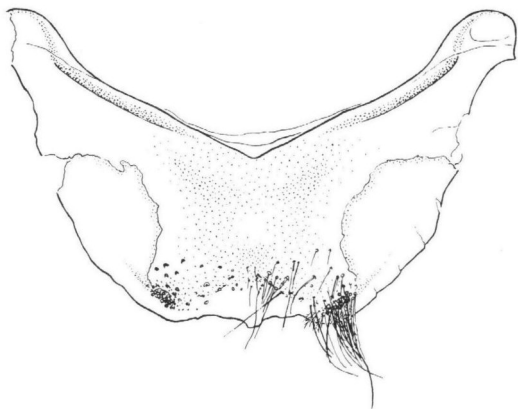


Fig. 46. Abdominal sternite 7 of *Pyrobombus monticola*. The hairs on the right side are excluded to show the position of their bases.

Variation

QUEENS

Structure and shape

The punctured part adjacent to compound eye varies in number of punctures, but they are rarely few, in which case the shiny part of ocellar-orbital field may dominate. Dorsal furrow of gena may be recognized near compound eye, but in some cases the furrow appears only as slight depression with some small punctures. Labral furrow usually narrow – V-shaped in dorsal view, and lamella is usually pointed but quite variable regarding its apical form. The form of the hind basitarsus is discussed in the “comparative diagnosis” below. Surface of abdominal tergite 6 is always shiny in middle, no chagreenation being present, and the punctures are regular with no elevated rim surrounding them. Laterally the punctures sometimes have an anteriorly raised rim, the surface there appearing more or less rugose.

Colour

Hair coat. Specimens from the British Isles show a fairly homogeneous colour pattern. Abdominal tergites 4–5 vary from entirely red to a more or less distinct yellowish-red pattern laterally. There are also a few specimens in which the yellow collar is almost absent and the scutellum vaguely fringed with light hairs. These specimens are very similar to a few queens found in southern Norway. However, the Fennoscandian

population exhibits an extraordinary constancy except for the few southern Norwegian specimens, the species is characterized by the entirely black and red patterns. Queens from the Pyrenees also seem to be very constant, although this form is not like the Fennoscandian form at all, instead exhibiting a chromatic similarity with the typical form of *P. lapponicus* (cf. Delmas 1976). The form *hypsophilus* shows a large variation, abdominal tergites 2–3 are more or less black. In the Alps there are also specimens very like *rondoui*, and *konradini* is quite similar to *rondoui* (Reinig 1965, Delmas 1976).

Abdominal tergite 2 of *P. monticola* is often basally covered by black hairs, which seem to be the most reliable of specific chromatic characteristics. Fig. 47 shows some colour patterns from different parts of Europe.

WORKERS

The morphological characters are more variable and not so distinct as in the queens due to variation in size.

MALES

Structure and shape

The dorsal furrow of the gena is more variable than in the queens. The basal form of mid and hind tibia varies very little. The genitalia and abdominal sternites 7–8 show several specific characteristics, although the variation is quite large. The variations of some characteristics of sternite 7 are shown in fig. 48 A–F. The dark “lines” in the middle of sternite 8 are basally most often very close together and there is no large aperture is situated in between them. The general shape of the genitalia is characteristic. There is a limited variation in the different described parts of the genitalia (cf. Krüger 1943).

Colour

Hair coat. The variation of the extent of yellow hairs does not vary as much as in the queens. In Torne Lappmark, Sweden, a few specimens lacking yellow hairs have been found.

Further comments on the variation of queens and males is also given in the “comparative diagnosis” below.

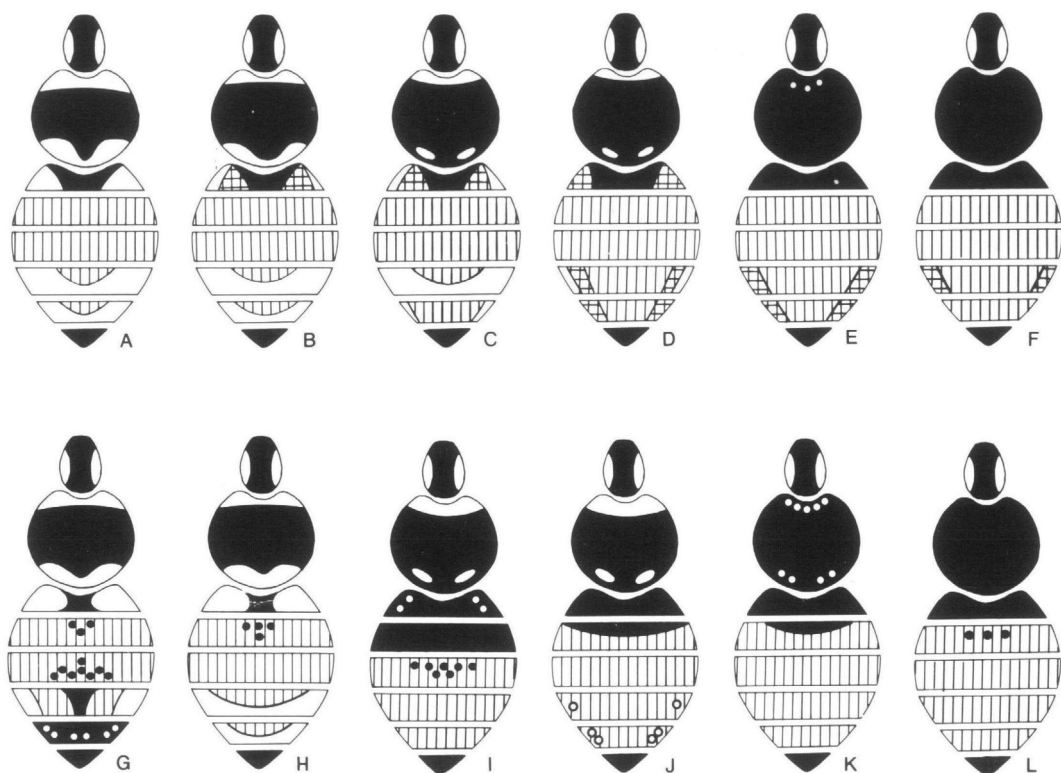


Fig. 47. Variation of the hair coat pattern of queens of *Pyrobombus lapponicus* (A–F), the form *glacialis* (G) and *P. monticola* (H–L) in Sweden, Torne Lappmark (A–F); S Scandinavia (D–F); Novaya Zemlya (G); the Pyrenees (H); the Alps (I); the British Isles (J); S Norway (K–L) and N Scandinavia (L). – The symbols represent: white = yellow hairs; black = black hairs; black and white dots = respectively black and yellow sparse hairs; lined areas = red hairs; chequered areas = yellowish red hairs.

Biology

The nests are presumably located in a similar way as those of *P. lapponicus*. One nest was found located below ground in a rodent's nest. Colony size relatively small, 103 cocoons recorded from one nest. Number of cells of the first brood: 11. Colour of cocoons light yellow. Wax nest envelope absent. Colony cycle short, less than two months. Habitat: in Sweden, Torne Lappmark only found in alpine and sub-alpine habitats. Temperament mild. Composition of male marking pheromone: main component hexadecenylacetate (Bergström & Svensson 1973). Route-flight behaviour different from that of *P. lapponicus*.

A comparative diagnosis, *P. lapponicus* – *P. monticola*

Evaluation of some diagnostic characters

The variation of the posterior form of the hind basitarsus of *P. lapponicus* and *P. monticola* queens, expressed by the width, w , measured along the parting of the hairs, in relation to the maximal width, W , is shown in fig. 49. All the queens were collected in Torne Lappmark, Sweden, except the *P. monticola* type specimen. The two selected parameters are also an expression of the position of the hair pattern compared to the location of the maximal width and/or to the auricle. A slight overlap existed between the two

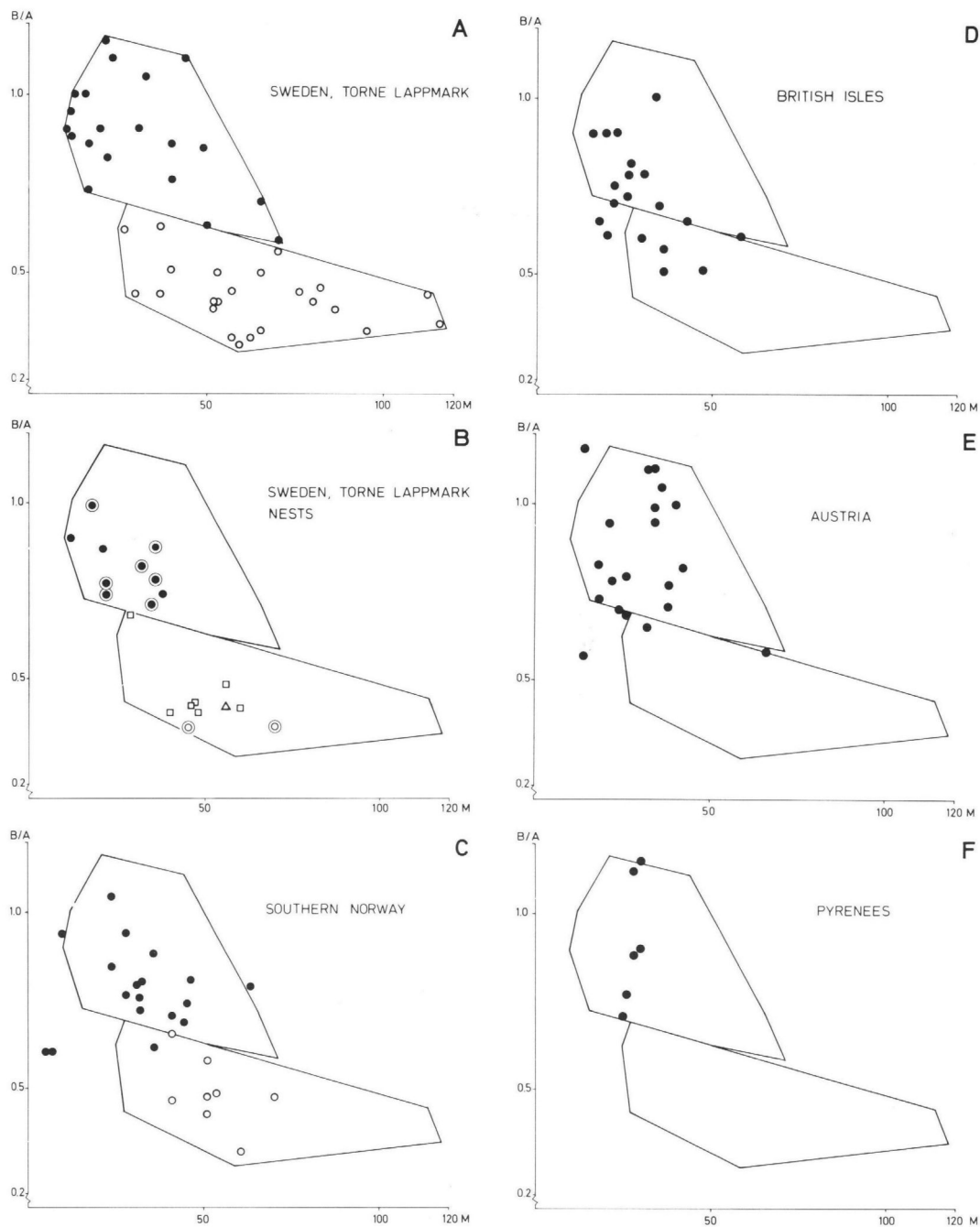


Fig. 48. Metric studies on abdominal sternite 7 of *Pyrobombus lapponicus* (open symbols) and *P. monticola* (dark symbols) males. In B, different shapes of symbols represent specimens from separate nests and the encircled symbols, chemically analyzed specimens. For further explanation, see text.

species but the type specimens fell into the average appearance of each species. Ten queens from the British Isles coincided with those from Torne Lappmark (range $w/W\%$: 98–100; not shown in fig. 49). The form of the hind basitarsus and the position of the hair pattern are often useful diagnostic characters.

Studies on the position of the ocelli on the vertex showed the existence of a small difference between queens of the two species in the relation between three measurements (fig. 50). In total, 102 specimens from Torne Lappmark, Sweden, together with the types were measured. The distance between the lateral ocelli to the compound eye (Z) was found to be the most distinguishing parameter. The two other distances (X and Y) seemed to be of poor practical diagnostic value, especially the distance between the lateral ocellus and the preoccipital ridge (Y). Sakagami (1975) had a similar result when he studied the variation of this parameter as a specific characteristic of five species of *Bombus* (s.s.). However, the statistical differences between the mean values for Z , X and Y of *P. lapponicus* and *P. monticola* *scandinavicus* were all found to be very highly significant (Tab. I). In fig. 50 the mean value for *P. lapponicus* and *P. monticola* *scandinavicus* was: Z (23.86, 25.04), X (49.20, 48.62), Y (26.93, 26.34). The ten queens plotted from one nest of each species show the large variation within one nest. The specimens compared earlier thus originated from an area of sympatry. However, the type specimen (plotted in fig. 50) and 15 additional queens from the British Isles (not plotted although similar to the type specimen), totally diverged from the Swedish *P. monticola*. Furthermore, the males also diverged slightly from the general metric appearance (see below and fig. 48 D) in comparison with males from Austria, the Pyrenees and Scandinavia. Thus, there is a population on the British Isles which is not merely separated from the others by its chromatic pattern, but in addition by some features of shape or form. The parameter Z may in some cases be of importance for identification of species and (?) subspecies, but a long series of specimens has to be studied.

A comparative metric study of male sternite 7 from different populations of both species was performed. According to Reinig (1965) these populations belonged to five subspecies. Most of the material was collected at Abisko, Torne Lappmark, Sweden, where both *P. lapponicus*

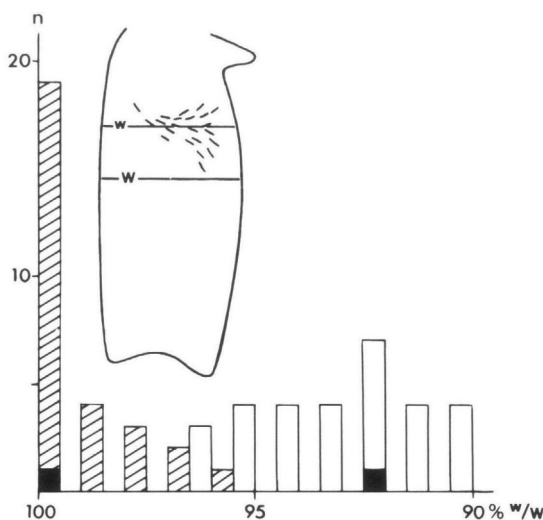


Fig. 49. Form and hair-pattern of hind basitarsus of *Pyrobombus lapponicus* (white) and *P. monticola* (hatched) queens as revealed by the maximal width, W , and the width on the level of the diverging hairs, w . Types indicated by black squares.

and *P. monticola* occur frequently. Chemically analyzed males (cf. Svensson 1973) from Abisko are plotted in fig. 48 A. Open circles represent *P. lapponicus* and black symbols, *P. monticola*. The morphological and specific chemical characteristics of each specimen were absolutely correlated. Each species was encircled by a "frame" and the metric studies on males from other parts of Europe were compared to this chemical and morphological pattern from Abisko. In addition, males from three nests of *P. lapponicus* and from one nest of *P. monticola* were measured. Males from one nest of each species were chemically analyzed (circles in fig. 48 B). Fig. 48 C–F shows the results of the metric studies on males from southern Norway, the British Isles, the Pyrenees and Austria. The material from Torne Lappmark revealed that only a slight overlap existed between the two species and that the degree of variation within the same nest was quite large. The males from southern Norway, both species, and from the Pyrenees and Austria, *P. monticola*, fell closely within the metric picture of the respective species from Torne Lappmark. The specimens from the British Isles, in contrast, showed a remarkable overlap. However, their identity is clear in view of other diagnostic characters (see Comparison of diagnostic characters). The features of sternite 7 (hair pattern, form and

pigmentation) are useful for the identification of *P. lapponicus* and *P. monticola* as well as other species of the genus *Pyrobombus* (Svensson 1973, but see also Tkalců 1973).

Comparison of diagnostic characters of *P. lapponicus* and *P. monticola*

QUEENS

P. lapponicus

Labral furrow broad (figs 4–5).

Clypeus weakly convex, lateral apical projections rounded (fig. 3).

Apical punctured part of clypeus (fig. 4).

Lower basal part of mandibles shiny (fig. 9).

Dorsal furrow of gena strongly developed, usually with some large punctures reaching compound eye (fig. 2).

Ocellar-orbital field moderately punctured (fig. 2).

Apical inner posterior process of hind tibia, straight in front of the process (fig. 19).

Hind basitarsus (fig. 18).

Auricle short and broad (fig. 20).

Abdominal tergite 6 $\pm$ chagreened and with crater-like punctures.

Inner ventral thickenings of sting sheath broad (fig. 21).

Colour of coat variable regarding the extent of yellow hair, abdominal tergites 4–5, usually with yellowish hair (Fennoscandian specimens) (fig. 47).

WORKERS

As in the queens but the morphological characteristics are usually poorly developed so identification of small and black/red specimens are difficult in the area

P. monticola

Labral furrow narrower (figs 12–13).

Clypeus distinctly convex, lateral apical projections with a notch (fig. 11).

Apical punctured part of clypeus wider (fig. 12).

Lower basal part of mandibles $\pm$ reticulated, puncturation denser (fig. 17).

Dorsal furrow of gena indicated, close to the compound eye shiny – at most with a few small punctures (fig. 10).

Ocellar-orbital field more sparsely punctured (fig. 10).

Apical inner posterior process of hind tibia slightly emarginate in front of the process (fig. 23).

Hind basitarsus (fig. 22).

Auricle longer and narrower (fig. 24).

Abdominal tergite 6 shiny and with regular punctures.

Inner ventral thickenings of sting sheath narrower (fig. 25).

Colour of coat without bright yellow hair, (Fennoscandian specimens) (fig. 47).

of sympatry. This seems only to be valid for specimens from alpine/subalpine areas in northern Europe. However, specimens with a large extent of yellow hair belong to *P. lapponicus*.

MALES

P. lapponicus

Lateral apical projections of clypeus rounded (cf. fig. 3).

Dorsal furrow of gena usually strongly developed.

Middle and hind basitarsus gradually narrowing towards basal part (figs 27–28).

General shape of genitalia, ovalish (fig. 32).

Inner apical process of gonocoxite strongly curved inwards (figs 33, 36).

Inner basal part of gonostylus without any process (fig. 33).

Apical part of penis valve narrow, parallel-sided, or weakly diverging/narrowing towards apex (fig. 34).

Volsella, lateral form rounded, apical process usually long and curved (fig. 35).

Cuticle of abdominal sternite 8 usually with an aperture between and apically of the two middle dark lines (fig. 37).

Cuticle of abdominal sternite 7 with two darkened spots, limits of middle apical hairs forming a shallow emarginate form (fig. 38).

Colour of coat variable. Abdominal tergites 1, 4 and 5 usually with yellow hair (Fennoscandian specimens).

P. monticola

Lateral apical projections of clypeus usually with a notch (cf. fig. 11).

Dorsal furrow of gena indicated.

Middle and hind basitarsus rapidly narrowing towards basal part (figs 30–31).

General shape of genitalia, roundish (fig. 39).

Inner apical process of gonocoxite weakly curved inwards, (figs 40, 43).

Inner basal part of gonostylus with a small elevation seen as a process in dorsolateral view (fig. 40).

Apical part of penis valve broader, towards the apex slightly diverging, (fig. 41).

Volsella, lateral form more straight, apical process shorter and usually not curved (fig. 42).

Cuticle of abdominal sternite 8 usually without an aperture, middle lines close together basally (fig. 44).

Cuticle of abdominal sternite 7 diffuse darkened, limits of middle apical hairs forming a deeply emarginate form (figs 45–46).

Colour of coat variable. Abdominal tergites 1, 4 and 5 without yellow hairs (Fennoscandian specimens).

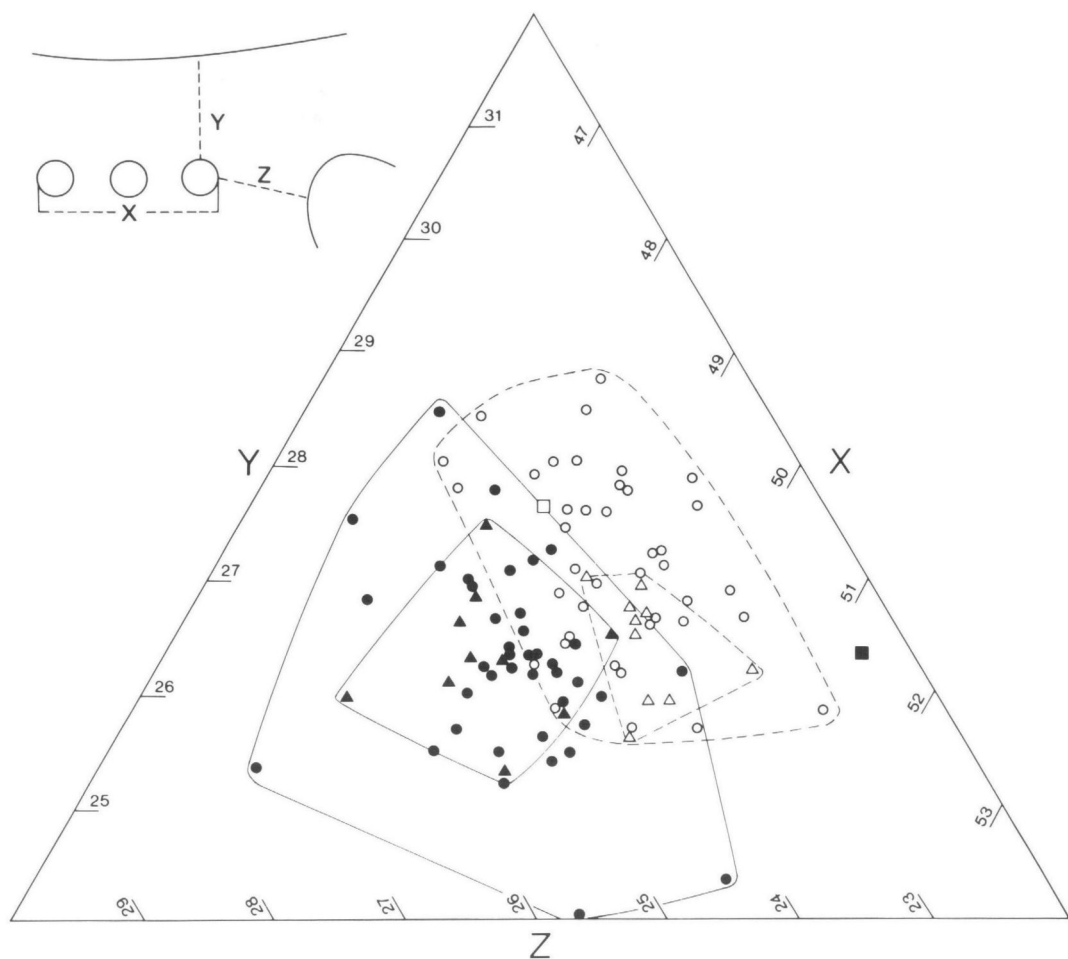


Fig. 50. Triangle diagram showing the position of the ocelli on the vertex of *Pyrobombus lapponicus* (open symbols) and *P. monticola* (dark symbols) queens. Different shapes of symbols represent: circles = collected specimens in Torne Lappmark, Sweden; triangles = nest specimens, Torne Lappmark, Sweden and squares = types.

Tab. 1. Distances X, Y and Z (cf. fig. 50) obtained from heads of queens of *P. lapponicus* and *P. monticola*. – In the table 10 units correspond to 1/8 mm.

	N	Z		P	X		P	Y		P	Z/Y = Q		P
		$\bar{Z} \pm \text{S.E.}$			$\bar{X} \pm \text{S.E.}$			$\bar{Y} \pm \text{S.E.}$			$\bar{Q} \pm \text{S.E.}$		
<i>P. lapponicus</i>	50	49.07 ± 0.19		<0.001	101.11 ± 0.33		<0.005	55.58 ± 0.37		<0.001	0.485 ± 0.002		<0.001
<i>P. monticola</i>													
<i>scandinavicus</i>	52	51.06 ± 0.22			99.42 ± 0.39			53.76 ± 0.38			0.514 ± 0.003		

Comments on distribution, taxonomy and biology of *P. lapponicus*, *P. monticola* and allied nearctic forms

The distribution of *P. lapponicus* seems to coincide with that of the former known distribution of *P. lapponicus* in Fennoscandia and the northern Soviet Union (figs 1, 51). The species occurs in the temperate coniferous forests as well as high up in alpine areas. There is no evidence that the species is found in southern Europe. The isolated subspecies *glacialis* seems to diverge in several respects (size, form of hind basitarsus and colour of coat) in comparison with the nominate form. However, only a single queen was studied and further material should be examined before its identity can be established.

Some specimens of the Nearctic forms *sylicola* and *gelidus* were also preliminarily studied but no major morphological differences were found to exist between them and the European *P. lapponicus*. However, the variation is large and the colour of the coats diverge somewhat. There is a close resemblance between *gelidus* and *glacialis*, and *sylicola* seems to be an intermediate between *lapponicus* and *glacialis*. Before the status of the Nearctic forms can be finally stated further information on the forms must be collected. Several authors have regarded *P. melanopygus* as a species closely allied to *sylicola* (Stephen 1957, Milliron 1971). The features of the male genitalia however, indicate that the species is much unlike *sylicola* but closer to *P. edwardsii* (Cr.) of the *pratricula*-group (cf. Plowright & Stephen 1973, Thorp in lit. 1977). *P. monticola* has a boreo-alpine distribution in Europe (fig. 52). The species is distributed in Fennoscandia, eastwards on the Kola peninsula, the British Isles, in the Alps, the Pyrenees, the Apennines and in the Balkan Mountains. Thus, all the southern European forms belong to *P. monticola*. In Torne Lappmark, Sweden, the species was not found outside subalpine and alpine areas.

In the author's opinion previously published figures of abdominal sternites 7-8 and/or the genitalia are those of Radoszkowski (1884) - *P. monticola*, and Løken (1973) - *P. lapponicus*. Pittioni's figures (1939, pl. IV, figs 24, 25) agree very well with *P. lapponicus* and *P. monticola*, respectively.

The early appearance of post-hibernating



Fig. 51. Distribution of *Pyrobombus lapponicus*. Symbols represent: dot = single record; open circles = specimens from an administrative area, "province", studied by the author.

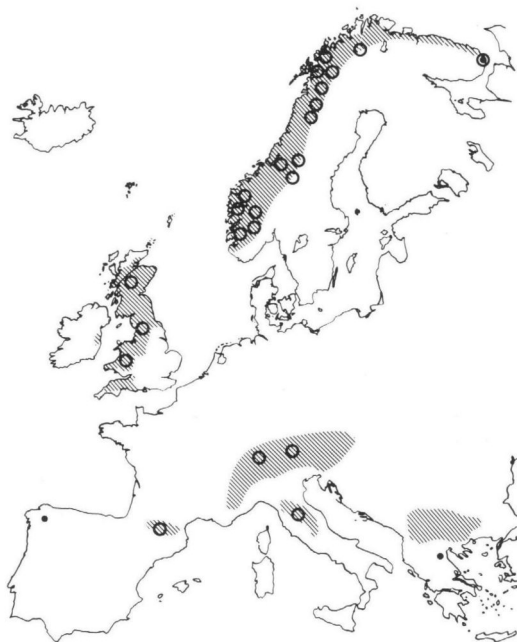


Fig. 52 Distribution of *Pyrobombus monticola*. Symbols as in fig. 51.

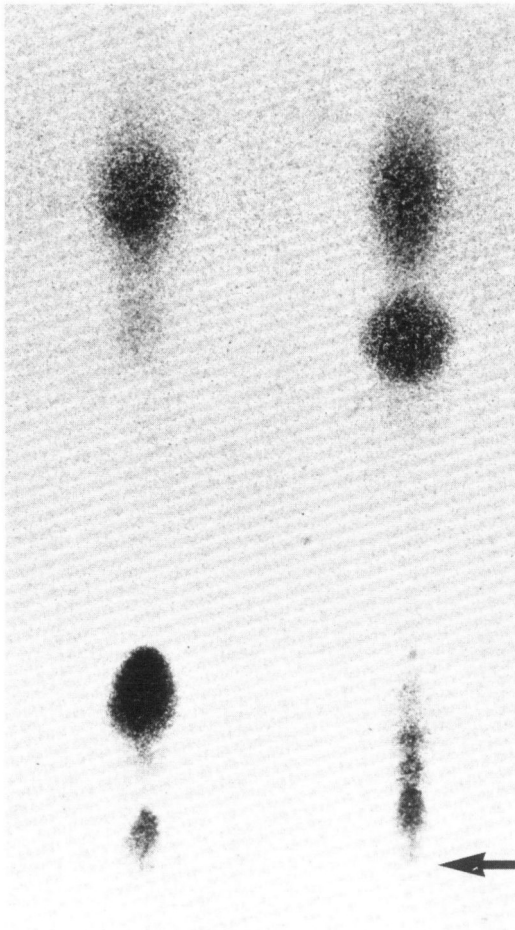


Fig. 53. Thin layer chromatogram of *Pyrobombus lapponicus* (left) and *P. monticola* (right) male labial gland phenomones. Arrow = starting point. The age of the two males is less than one week.

queens and a rapid colony development of the *Pyrobombus* species is a well confirmed generic characteristic (Free & Butler 1959, Alford 1975, Sakagami 1976). Thus, as expected, both *P. lapponicus* and *P. monticola* appear early in the season and complete their colonies rapidly in alpine/subalpine N Sweden (Lundberg & Svensson 1975, Svensson & Lundberg 1977). The workers usually appear in midsummer and males in the second week of July. Three further species of *Pyrobombus* (*P. hypnorum* (L.), *P. pratorum* (L.) and *P. jonellus* (K.)) occurring in the same area, exhibit a similar phenology. Due to the short active period the colonies of *P. lapponicus* and *P. monticola* are small; usually there are

about 30 cocoons and rarely more than 100 individuals are reared (Svensson & Lundberg 1977). A nest of *Bombus lucorum* (L.) found in the same area – a species known to have fairly large colonies (200–300 [Sladen 1912], 30–250 [Cederberg, pers. comm.]) – consisted of only slightly more than 100 cocoons (Svensson & Lundberg 1977). Thus, it seems that the major limiting factors for the colony size of bumble bees in mountainous habitats are climatic. The rapid colony development of the *Pyrobombus* species has given rise to the suggestion that *P. jonellus*, under favourable conditions, produces two generations per year (Meidell 1968, Douglas 1973) and recently, Løken (1977) maintained that *P. lapponicus* may also have a similar biotic potential. However, this has not been satisfactorily proved for any species under natural conditions and in the area studied (Svensson & Lundberg 1977) a double generation has never been apparent for any of the *Pyrobombus* species.

Observations on *P. lapponicus* males performing route-flight behaviour in the subalpine birch forest revealed that they prefer to fly at a height of about 1.5 m. At this height they marked leaves and twigs of birches with their marking pheromone. Several individuals often chose the same marked places for approach while in flight. Male *P. monticola* were not seen performing route-flight behaviour in the subalpine birch forest. It seems most probable that they chose a route-flight habitat separate from *P. lapponicus*. In alpine areas both species were observed performing route-flight behaviour and no interactions of the flight paths of the two species were observed. The main component of the marking pheromone for *P. lapponicus* was geranylcitronellol and for *P. monticola*, hexadecenylacetate (Bergström & Svensson 1973, Svensson & Bergström 1977). In the field, males of both species can be identified by the emitted pheromone from a newly caught specimen. A simple chemical method using thin layer chromatography can be used to identify the two species (cf. Mangold 1967, Ågren et al. 1979) (fig. 53). The specific behaviour and marking pheromones of the males, in addition to the morphological and distributional characteristics, supports the view that *P. lapponicus* comprises two separate species, *P. lapponicus* and *P. monticola*.

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