Morphological Studies on the two Scandinavian Subspecies of *Bombus lapponicus* Fabricius (Hym. Apidae)

By Bo G. Svensson

Department of Entomology, Uppsala University, S-751 22 Uppsala, Sweden

Abstract

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The two subspecies of *Bombus lapponicus* Fabricius in Scandinavia have been studied in order to obtain morphological differences to accompany the differences earlier found in the cephalic secretions of the males. In queens and males various parts of the body of the two subspecies have been compared. In the males the seventh sternite was shown to have distinct characteristics for each subspecies. In the queens no differences were found.

The function of the cephalic secretions of the males is briefly discussed.

Introduction

Bergström and Svensson (1973 a) reported that the scents differ between the males of the two forms of *Bombus* (*Pyrobombus*) *lapponicus* Fabr. Analysis of their cephalic secretions showed that the main component in the form *B. lapponicus lapponicus* Fabr. was all-*trans*-geranylcitronellol and in *B. lapponicus scandinavicus* Friese, hexadecenyl acetate. No similar chemical difference within the same species has previously been found in the 14 *Bombus* species analyzed, exept in *B. lucorum* L., in which the taxonomical situation is somewhat confused (Calam 1969, Kullenberg et al. 1970, Bergström et al. 1973 and Bergström and Svensson 1973 a, b).

It was therefore suspected that the two colour-forms of *B. lapponicus,* regarded as subspecies, could in fact be separate species. If this is so, the chemical difference is likely to be accompanied by morphological differences.

Insect material

Numbers and collection dates for the studied material of *B. lapponicus* are given in Table I. Most of the specimens studied were from Abisko, a locality within the area of sympatry for the two forms (cf. Løken 1973, Fig. 63).

Males of the other four Scandinavian species of *Pyrobombus* were studied in order to investigate the interspecific variation of the seventh and eighth sternites within the subgenus. The numbers of specimens examined are (in parentheses): *B. cingulatus* Wahlberg (5), *B. hypnorum* L. (8), *B. jonellus* Kirby (10), and *B. pratorum* L. (10).

Methods

Body parts examined

Information derived from the chemical analysis of 34 males was collated with

Table I. Numbers, localities and collection dates for the studied material of *B. lapponicus*.

Number of males examined	Locality	Collection date
56	Abisko, Torne Lappmark, Sweden	11.7—16.8 1970—1972
1	Sarek, Lule Lappmark, Sweden	20.7. 1971
1	Åre, Jämtland, Sweden	21.7. 1914
2	Dovrefjell, Oppland, Norway	30.7. 1909 6.8. 1910
Number of queens examined		
70	Abisko, Torne Lappmark, Sweden	17.6—12.8 1970—1972

various morphological structures. In the males the genitalia, the sixth, seventh and eighth sternites, the head, legs, surface sculpture and colour pattern were studied. The sternites were mounted in glycerin on slides. The seventh sternite was measured: two lengths proved to be suitable for further morphometric studies. These were as follows: the length from the middle of the anterior edge to the posterior middle hair (A), and the length from the posterior middle hair to the middle of the posterior edge (B), see Fig. 1. If there was no middle hair, the hair closest to the middle was regarded as being in the middle. The numbers of hairs between the lateral hair-tufts of the seventh sternite (see Fig. 1) was counted twice. The mean value (M) was used. A Leitz binocular microscope equipped with an eyepiece micrometer was used. For A the magnification was 12.5 ×4 and for B, 12.5×8.

On queens, various parts of the sting, the sixth sternite, the head, legs and surface sculpture were studied. The determinations were made according to descriptions by Friese (1902) and Elfving (1960), and several parts of the body of the two forms were compared.

The method used to remove the sting and the sixth sternite from dried specimens was modified from that briefly described by Hazeltine and Chandler (1964). Queens were placed in a moisture-chamber for one day. A hypodermic needle was then inserted between the fourth and the fifth abdominal segments laterally, and about 0.1 ml of water was injected. After about 30 min the sting and the sixth sternite could be removed. By this method the tissues are softened rapidly and the hair coat is not destroyed. This method was also used to remove the sternites and the genitalia from males.

The terminology and the subgeneric division proposed by Richards (1968) are followed in this paper.

Results

No morphological differences were apparent in the sixth sternite of the males of the two forms.

Results of morphometric studies on the seventh sternite are shown in Fig. 2, with

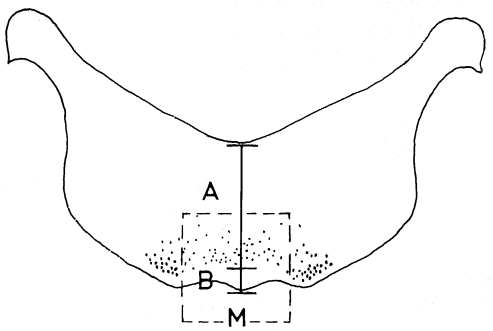

Fig. 1. Morphometrically studied characteristics of seventh sternite. (Dots indicate base of hairs.)

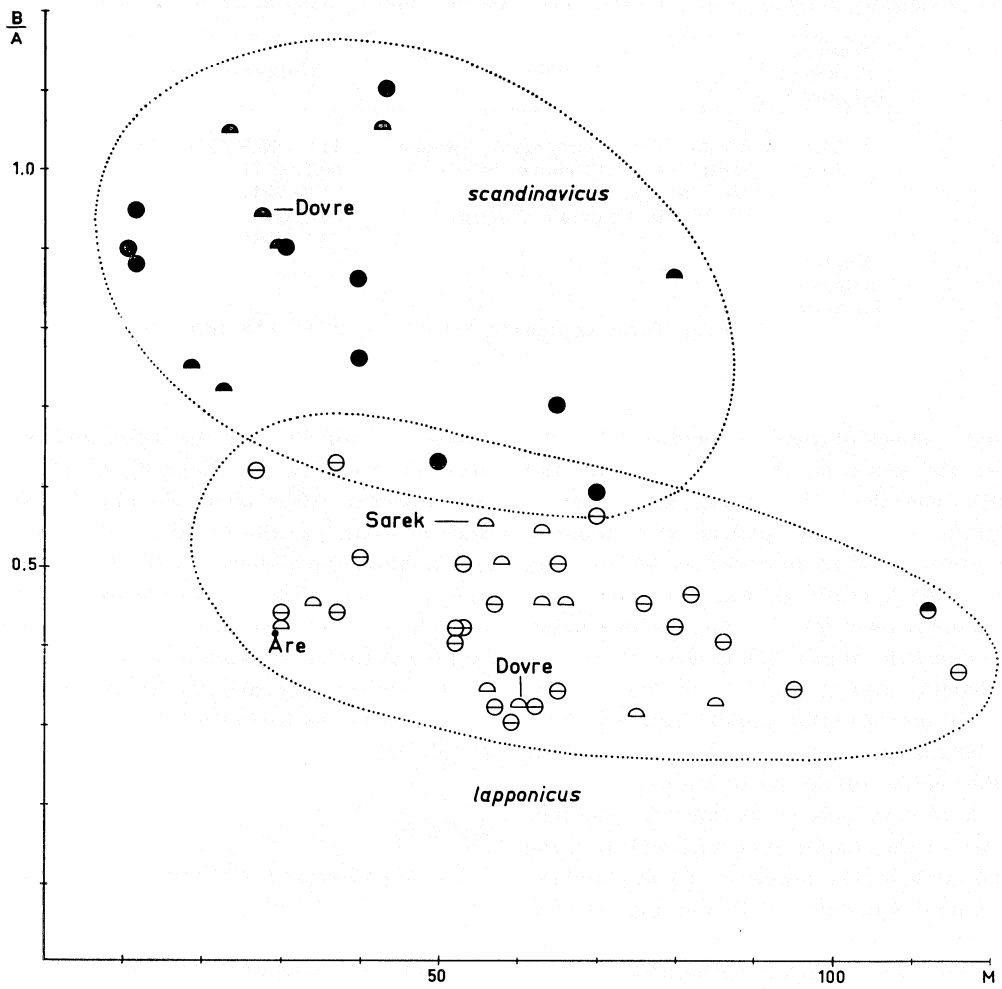

Fig. 2. Results of morphometric studies in relation to one colour and one chemical character. (The axes: A, B lengths; M number of hairs. See also figure 1.)

- 1st tergite with yellow hairs
- 1st tergite without yellow hairs
- Chemically analyzed, main component: all-*trans*-geranylcitronellol
- Chemically analyzed, main component: hexadecenyl acetate

the chemical composition and one colour character added. The chosen characters had a good correlation within each form. Only one specimen of the form *lapponicus* was confusing, its first tergite lacking yellow hairs, see Fig. 2. The first tergite was red-haired instead of yellow-haired laterally; this was also unusual, since this was the only specimen with red hairs on the first tergite. According to the colour pattern, it should belong to the form *scandinavicus*, but both chemical and structural morphology revealed a closer association with the form *lapponicus*. The seventh sternite of *B. l. lapponicus* and *B. l. scandinavicus* males is shown in Figs. 3 and 4.

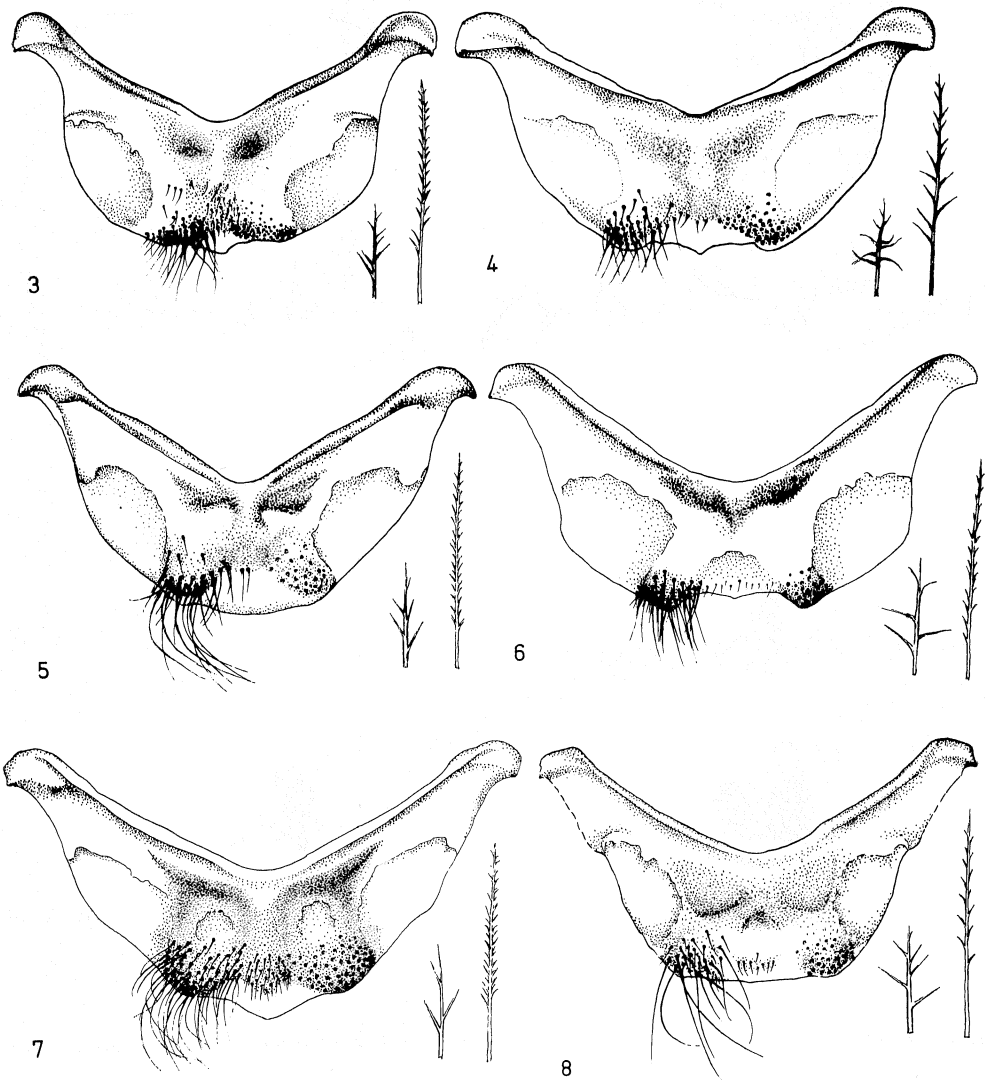

Fig. 3—8. Seventh sternite of *Pyrobombus*-males in Scandinavia. 3. *B. lapponicus lapponicus* Fabr., 4. *B. lapponicus scandinavicus* Friese, 5. *B. cingulatus* Wahlb., 6. *B. hypnorum* L., 7. *B. jonellus* Kby. and 8. *B. pratorum* L. Some characteristic hairtypes on the sternite added.

Studies of the other four species of *Pyrobombus* in Scandinavia showed that the seventh sternite has several species-specific structures. The seventh sternite of Scandinavian *Pyrobombus*-males is illustrated in Figs. 3—8. There is a wide variation in various parts of the sternite. To make the figures more comprehensible it should be mentioned that the species-specific characteristics are as follows: distribution of hairs, length and structure of hairs, distribution of pigment, number of hairs and general shape; the variable characteristics are: form of distal edge, lateral margin to the membraneous part, intensity of pigmentation, number of hairs, and general shape.

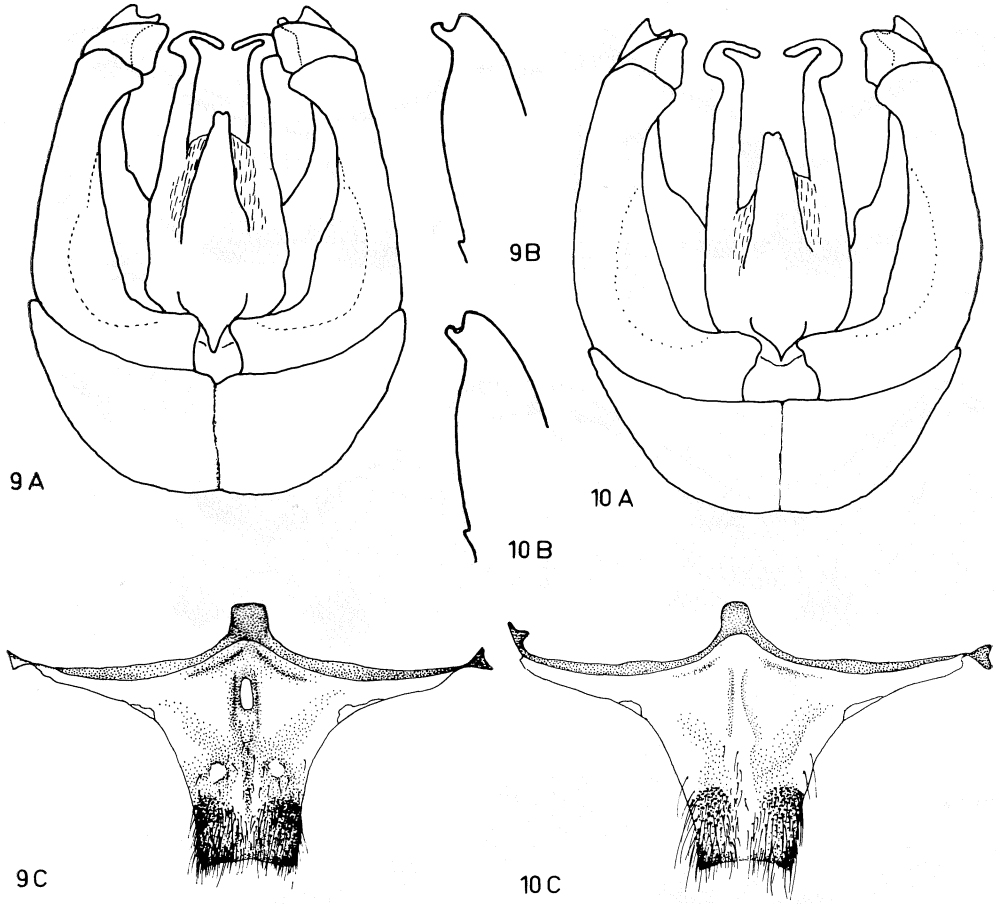

Fig. 9—10. Males of *B. lapponicus lapponicus* Fabr. (9) and *B. lapponicus scandinavicus* Friese (10). A: Genitalia. B: Ventral view of right lacinia. C: Eighth sternite.

Study of the eighth sternite of the males showed the intraspecific variation to be greater than in the seventh and that the eighth is less rich in structures. The eighth sternite is therefore less useful for diagnostic purposes. Løken (1973) illustrated the eighth sternite of *Pyrobombus* males. Her figure of *B. lapponicus* (Løken 1973, fig. 37 A, p. 21) agrees very well with the form *lapponicus*. The eighth sternite of both forms is shown in Figs. 9 C and 10 C. The appearance of the chitinised parts in the middle is the most distinguishing characteristic, no aperture usually being found in the sternite of *B. l. scandinavicus*. The distal edge may vary from convex to deeply incised, rarely to half the depth of the tongue.

The genitalia of *B. l. lapponicus* and *B. l. scandinavicus* are illustrated in Figs. 9 A and 10 A. The inner apical projection of the lacinia is longer and more curved in *B. l. lapponicus* than in *B. l. scandinavicus,* see Figs. 9 B and 10 B. The inner apical part of the stipes is inclined further inwards in *B. l. lapponicus* and the outer contour of the stipes is more rounded in *B. l. scandinavicus*.

The colour pattern of the males varies widely, several specimens, identified chemically as *B. l. lapponicus* and *B. l. scandinavicus* respectively, were almost identical in

colour pattern. In the specimens studied there were also entirely black and red males, typical *B. l. scandinavicus*, and males with an extensive distribution of yellow hairs, typical *B. l. lapponicus*. The form *scandinavicus* has usually only scattered yellow hairs on the scutellum laterally, and has rarely any yellow hairs on the first tergite; in *B. l. lapponicus* these parts are usually covered with yellow hair-tufts. The yellow colour is brighter in *B. l. lapponicus* and the fourth and fifth tergites are usually yellow-haired laterally (cf. Table V, Bergström and Svensson 1973 a).

The chemical analysis did not show any intermediates (Bergström and Svensson 1973 a).

Diagnostic characters for males of the two forms are summarized in table II.

Study of the queens provided no morphological characters by which the two forms could be recognized. Slight differences were found in the sting, but no correlation could be made with either form.

The distribution of the forms in Scandinavia may be otherwise than that earlier supposed (cf. Løken 1973 and Reinig 1965), since the males from Åre (one specimen) and Dovrefjell (one specimen) were identified as *B. l. lapponicus* on morphological characters, see Fig. 2. From these localities only *B. l. scandinavicus* should be expected.

Discussion

It seems as the cephalic secretions are species-specific in male bumblebees.

The function of the different scents produced should be considered first, on account of the behaviour associated with the route-flight. Along the route-flight circuit, the males perfume different objects. Observations on *B. jonellus, B. lapponicus lapponicus* and *B. pratorum* males in the same area, sub-alpine birchwood, showed that they chose different route-flight habitat for the flight (cf. Bringer 1973, Haas 1949, Krüger 1951). Because of this behaviour the scents produced are spread out at different heights above ground. The scent is assumed to attract the virgin queens, so that they meet at the scented places for mating (Free 1971, Haas 1949, Kullenberg *et al.* 1973). It has also been suggested that the scent serves as a territory recognition mark. It may also have a different function at copulation, so that interspecific mating is avoided (cf. Kullenberg 1973). The cephalic secretions, together with the route-flight behaviour, may thus serve as an isolation mechanism.

The chemical difference in *B. lapponicus* gave rise to the suggestion that the two Scandinavian subspecies should be treated as separate species. A similar state had been found in *B. lucorum* L. (Bergström et al. 1970, 1973). Recently, Løken (1973) demon-

Table II. Diagnostic characters for males of *B. l. lapponicus* and *B. l. scandinavicus*, based on material from Abisko, Sweden.

B. l. lapponicus	*B. l. scandinavicus*
7-th sternite, Fig. 3.	7-th sternite, Fig. 4.
8-th sternite, Fig. 9 C.	8-th sternite, Fig. 10 C.
Genitalia, Fig. 9 A—B.	Genitalia, Fig. 10 A—B.
First tergite more or less yellow-haired laterally, black hairs in the middle.	First tergite black-haired, usually without yellow hairs.
4—5-th tergites red-haired and usually more or less yellow-haired laterally.	4—5-th tergites red-haired.
Body yellow, black and red-haired.	Body red and black-haired, usually with more or less yellow hairs.
Main component from cephalic glands: all-*trans*-geranylcitronellol.	Main component from cephalic glands: hexadecenyl acetate.

strated that the form *magnus* Vogt of *B. lucorum* is a good species, on the basis of a description only of the queen, using colour pattern and sculptural characters. *B. lucorum* belongs to the subgenus *Bombus* Latr. s.s. The two other Scandinavian species of the subgenus are also chemically different.

The relationships within a subgenus, as regards the main component in the secretion, are less well defined than those between species from different subgenera, as well as between *Bombus* and *Psithyrus* Lep.

B. (*Bombus* s.s.) *terrestris* L. and *B.* (*Pyrobombus*) *jonellus* both have 2,3-dihydrofarnesol as the main component (Bergström *et al.* 1970, 1973, Bergström and Svensson 1973 b). But this is no proof that they are identical. A difference in the absolute configuration of the main component molecule, together with the various minor components of the secretion, may give differences in the behaviour. In the case mentioned above there are morphological differences that make the species easily distinguishable.

I am in complete agreement with Thorp (1969) when he says concerning some North American *Pyrobombus* species: 'In order to clarify the limit and rank of various taxa we will need more field collections and ecological studies from areas of sympatry among populations of the taxa, detailed biological studies, laboratory colonizations and controlled cross matings.'

Work now in progress may indicate whether the two forms studied are to be regarded as separate species.

Acknowledgement

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