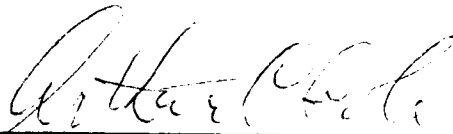


July 7, 1967

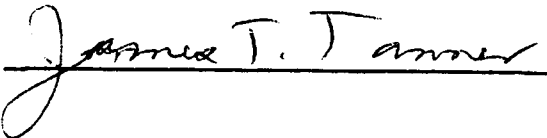
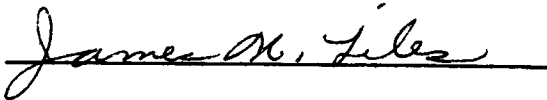
To the Graduate Council:

I am submitting herewith a thesis written by David Larry Speight entitled "The Bumblebees (Hymenoptera, Apidae, Bombinae) of East Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Entomology.



Major Professor

We have read this thesis and
recommend its acceptance:



Accepted for the Council:



Vice President for
Graduate Studies and Research

THE BUMBLEBEES (HYMENOPTERA, APIDAE, BOMBINAE)
OF EAST TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
David Larry Speight
August 1967

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CHAPTER I

INTRODUCTION

This study concerns a group of bees which almost everyone recognizes at sight--the bumblebees. The large hairy bees of the genera Bombus and Psithyrus have drawn the attention of almost every young boy and girl at some time. Bumblebees, however, are conspicuous not only because of their size or their striking coloration pattern of yellow and black, but also largely on account of their noisy flight. In fact, the name "bumblebee" has been acquired because of this buzzing noise. Although here in America we know these insects commonly as bumblebees, in England they are commonly known as humblebees.

Unlike the vast majority of insects, bumblebees are social in their behavior and therefore live together in colonies. In the genus Bombus this colony consists of a queen, workers, and males. In the inquiline genus Psithyrus only females and males are produced. Sometimes the queen, who is responsible for establishing the colony, builds her nest on top of the ground while in other cases

rather lengthy tunnels lead to underground homes. The different species of the two genera in this study vary greatly in their nest founding habits and also in the way their young or brood are reared.

The importance of bumblebees has often been overlooked and taken far too lightly by those who did not readily recognize what a significant contribution they have made to our civilization. Normally, when one speaks of bees, thoughts turn to the great economic contributions of the honeybees. Except for those persons who are closely associated with flowers, the real significance of bees is often overlooked. Even many of those ladies who love to have flower gardens, have told this investigator that they would appreciate his catching all their bees. Actually, the evolution of bees and flowers has gone hand in hand. The most valuable aspect of bumblebee behavior with respect to man is the pollination of our flowers. Flowers benefit from bumblebee visits because the bumblebees incidentally transfer pollen from the male to the female organs, thereby bringing about pollination and subsequent seed production. Competition among bumblebees and other insects as pollinating agents has undoubtedly played an important role in the

evolution of flowering plants, since the color, shape, and scent of their flowers are all instrumental in attracting such visitors.

To demonstrate the real economic importance of bumblebees as pollinators, especially in the production of legume seeds and fruit crops, one has only to turn to the interesting history of red clover in New Zealand. Prior to 1885 and 1886 the red clover crop in New Zealand was practically nil because the plants failed to set seed properly. However, in 1885 and 1886 the Canterbury Acclimatization Society shipped queen bumblebees from England, and the following years brought a considerable increase in the red clover seed crop in New Zealand (Free and Butler, 1959). Records of the importance of bumblebees as pollinators of alfalfa are also available (Stephen, 1955; Nogaard, 1966).

Various workers have completed taxonomic studies on bumblebees in various parts of the United States, both east and west of the Mississippi River. Some of these are Frison (1919), Milliron (1938), Chandler (1950), Stephen (1957), LaBerge and Webb (1962), Mitchell (1962), Medler and Carney (1963), and Chandler and McCoy (1965). Although Mitchell's (1962) work included the entire eastern United States, many

states in that region still have very incomplete checklists of species. Among these is Tennessee. It was, then, primarily for the purpose of completing a checklist that this study was undertaken in East Tennessee. Although the study area for the main part, has been confined to East Tennessee, species identifications from the other two Grand Divisions of the state were included when information could be obtained from museum collections.

CHAPTER II

REVIEW OF LITERATURE

The literature in general pertaining to bumblebees is quite voluminous. Although this study was intended to involve only taxonomic aspects, still the investigator would like to acquaint the reader with some of the early workers, both European and American. Some of these workers were noted more for their ecological studies than they were for any taxonomic work.

The bumblebees have probably received as much attention as any other group of bees except the honeybees. The first page in the history of the bumblebees came with the establishment of the genera Bombus and Psithyrus by Latreille and Lepeletier, respectively. Subsequently, the more prominent early taxonomists in Europe were Fabricius, Latreille, Kirby, Dahlbom, Lepeletier, Illiger, Nylander, Schenck, Thomson, Smith, Gerstaecker, Morawitz, Kriechbaumer, Schmiedeknecht, Radoszkowski, Handlirsch, and Friese (Franklin, 1912). The American pioneer was Cresson (1863, 1887). His early works provided lists of North American species.

After the turn of the century the monographic work of Sladen (1912) in England stole the limelight, but this was quickly followed by Franklin's (1912, 1913) monumental monograph here in America. Sladen's work, however, seemed to be much more knowledgeable due to the fact that the habits of individual species were included. Franklin, as a leader, gave way in America to Frison (1917, 1918, 1919, 1923, 1924, 1926a, 1926b, 1927, 1928, 1929a, 1929b, 1930a, and 1930b), who not only published descriptions, keys, and new local records, but also contributed greatly to the knowledge of the bionomics of several species.

Plath (1934) produced the next landmark in the history of this group, a work which founded the grouping of species on the basis of biological habits. Since that time the literature has contained many more taxonomic studies of a sectional geographic nature in this country.

One dilemma with which this investigator has been faced is the proper placement of the genera into a collective taxonomic unit. Some authors (Franklin, 1912; Frison, 1919; Comstock, 1940; and Chandler, 1950) have seen fit to designate the family Bombidae to include the genera. The majority of taxonomic specialists seem to be more

conservative, for they place the genera into the family Apidae or superfamily Apoidea (Ross, 1956; Imms, 1957; LaBerge and Webb, 1962; Medler and Carney, 1963; Borror and Delong, 1964). The latest study in the literature similar to this study was one carried out by Chandler and McCoy (1965) in Arkansas. The decision of those workers was to place Bombus and Psithyrus into the subfamily Bombinae of the family Apidae, order Hymenoptera. It is this procedure that the present investigator has decided to follow, although there remains some doubt in his mind that it is necessarily better than that of recognizing Bombidae as the family name.

CHAPTER III

METHODS AND MATERIALS

This study is based largely upon approximately 2,000 specimens which have been collected from the 30 counties of East Tennessee. East Tennessee is defined as comprising those counties in the Eastern Time zone of the state. However, specimens from the other two grand divisions of the state were examined and collection data were included in the summaries to those species involved. Specimens from student collections at the University of Tennessee, Martin, Tennessee, served as basis for evaluation from the western grand division. Twenty specimens from Vanderbilt University, Nashville, Tennessee, were also examined and valuable assistance was received from this small collection for information pertaining to the middle grand division of the state. The bulk of the entire study, however, as is noted in the thesis title, deals with those specimens which were collected in East Tennessee. The museum collection of The University of Tennessee, Knoxville, Tennessee, did provide in some cases supplementary specimens from which very important

collection data were obtained. Those specimens which were collected by this investigator were verified for him by Dr. T. B. Mitchell of North Carolina State University, Raleigh, North Carolina, and by Dr. Leland Chandler, Purdue University, Lafayette, Indiana. A personal visit was also paid to Dr. Mitchell on May 15, 1967, at which time the investigator not only received some very important verifications but was also able to view specimens in Mitchell's collection which had originated in this state and adjoining states of the eastern United States.

The materials used in this study were the basic tools of most general entomologists. Among these items were two aerial nets (one which was a standard Ward's aerial net, the other a homemade net of smaller nature which the investigator's wife made of Navy surplus mosquito netting and the remains of a kitchen colander), killing jars of cyanide, and an assortment of baby food jars and plastic containers of similar size.

The general procedure was to drive through the counties designated previously as constituting East Tennessee. Stops were made at various locations where flowers were in bloom and available for observation; when available, bees

were collected. This method of finding bees during the drier weeks of the summer sometimes presented complications due to a lack of available flowering vegetation. When bees were collected, they were first placed in the killing jars. They were later removed and placed into individual jars or containers, all the collections from one type of vegetation being placed together. To each jar was added the information that was needed for locality and flower records. Although this project was strictly intended from the very first to be a taxonomic study, additional information of ecological nature was kept in a field notebook. At the conclusion of each trip, the bees were removed from the individual jars, pinned, and placed on styrofoam to dry. Styrofoam was found most useful for drying purposes because the ventral surface of the pinned specimen could be pushed into the styrofoam so that the abdomen of the specimens could be lifted into a horizontal position. This horizontal "positioning" of the abdomen not only gave the specimens a better appearance, but also facilitated the examination of taxonomic features of the abdomen.

CHAPTER IV

INFORMATION PERTAINING TO THE TAXONOMIC KEYS AND THE DESCRIPTION OF SPECIES

The taxonomic keys included in this paper are limited to the genera and species found in Tennessee. They are adapted, for the most part, from those of Milliron (1938), Chandler (1950), Mitchell (1962), and Chandler and McCoy (1965). The descriptions, for the most part, are patterned after the latest ones which are available, namely those of Mitchell (1962). In cases where specimens were not available (due to a failure of collection) for description, Dr. Mitchell's descriptions were used, and he received the credit. Even though, in some cases, this investigator's descriptions are similar to Mitchell's, a considerable number of changes were made, particularly in such things as length measurements. This opportunity has also been taken to list in the descriptions some variations which may prove to be beneficial to future workers. These variations are not those listed by authorities in the field as varieties.

Any information pertaining to recognized variants as such are listed in the discussion concluding each species.

The descriptions are not as complete as Mitchell's (1962), but they are believed to be sufficient if supplemented by the keys provided. In the treatment of each genus and species a complete synonymy is not used. Instead, a brief synonymy including the citation of the original description and a few salient citations to indicate the present status of the name are given. This brief synonymy is a compilation of synonymies from Mitchell (1962), LaBerge and Webb (1962), Medler and Carney (1963), and Krombein (1967).

CHAPTER V

KEY FOR THE SEPARATION OF SEXES AND GENERA

1. Antennae with twelve segments; six visible
ventral abdominal segments; inner tarsal
claws much shorter than outer ones and
diverging from them; possessing stings ...
... queens and workers of Bombus;
females of Psithyrus 2
Antennae with thirteen segments; seven
visible ventral abdominal segments; inner
tarsal claws nearly equal in length to the
outer ones and nearly parallel to them;
without stings
..... males of Bombus and Psithyrus 3
2. Outer surface of each hind tibia flattened or
concave, bare centrally, with a fringe of
long hairs on the lateral margins forming a
corbicula (pollen basket); abdomen covered
with hairs obscuring the surface; last abdominal
segment straight in profile, not at all or

weakly ridged(queens and workers) Bombus

Outer surface of each hind tibia convex,

covered with hairs leaving no central

portion bare (without a pollen basket);

abdomen shining, hair sparse and not

obscuring the surface to any extent;

last abdominal segment curved downward

in profile with strong lateral ridges ...

..... (females) Psithyrus

3. Hind tibia somewhat flattened, with short hairs rather irregularly distributed on the outer surface; face usually with some yellow pile; volsellae and squamae of genitalia corneous; gonostylus of genital armature very short, not much exceeding apex of gonocoxite Bombus

Hind tibia more convex, the outer surface

being uniformly covered with short hairs;

face usually covered with black pile, never

with an admixture of yellow; volsellae and

squamae of genitalia membraneous; gonostylus

more elongate, much exceeding apex of

gonocoxites Psithyrus

CHAPTER VI

THE GENUS BOMBUS LATREILLE

Bremus Jurine, 1801. Intell. Blatt. Litt.-Ztg. Erlangen

1, p. 164. Name suppressed by Internatl. Comm.

Zool. Nomencl., Op. 135, 1939. Type: Apis

terrestris Linnaeus. Desig. by Morice and Durrant,

1915.

Bombus Latreille, 1802. Hist. Nat. Fourmis, p. 437.

Type: Apis terrestris Linnaeus. Monob.

Bremus Panzer, 1804 (?). Faunae Ins. German., p. 85.

Type: Apis agrorum Fabricius. Desig. by Sandhouse,

1943.

Bombus subg. Leucobombus Dalla Torre, 1880.

Naturhistoriker, 2, p. 40. Type: Apis terrestris

Linnaeus. Desig. by Sandhouse, 1943.

Bombus subg. Megabombus Dalla Torre, 1880.

Naturhistoriker, 2, p. 40. Type: (Bombus ligusticus

Spinola) = Apis argillacea Scop. Monob. Desig. by

Sandhouse, 1943.

Bombus subg. Pyrobombus Dalla Torre, 1880. (=Pyrrhobombus)
 Naturhistoriker, 2, p. 40. Type: (Apis) Bombus
hypnorum (Linnaeus). Monob. Desig. by Sandhouse,
 1943.

Bombias Robertson, 1903. Amer. Ent. Soc. Trans. 29,
 p. 176. Type: Bombias auricomus Robertson. Orig.
 desig.

Bombus subg. Terrestribombus Vogt., 1911. Gesell, Naturf.
 Freunde Sitzber., p. 55. Type: Apis terrestris
 Linnaeus. Desig. by Frison, 1927.

Bombus subg. Pratobombus Vogt., 1911. Gesell. Naturf.
 Freunde Sitzber., p. 49. Type: Apis pratorum
 Linnaeus. Desig. by Frison, 1927.

Bombus subg. Cullumanobombus Vogt., 1911. Gesell. Naturf.
 Freunda Sitzber., p. 57. Type: Apis cullmanus
 Kirby. Desig. by Frison, 1927.

Bombus: Franklin, 1913. Amer. En. Soc. Trans. 38. pp.
 177-486. (revision)

Bombus: Lutz and Cockerell, 1920. Amer. Mus. Nat. Hist.
 Bul. 42, pp. 502-544 (catalog).

Nevadensibombus Skorikov, 1922. Sta. Region. Protect.

Plantes Petrograd Bull. 4, p. 149.

Alpigenobombus subg. Fraternobombus Skorikov, 1922. Sta.

Region. Protect. Plantes Petrograd Bull. 4, p. 156.

Type: Apathus fraternus F. Smith. Desig. by Frison, 1927.

Fervidobombus Skorikov, 1922. Sta. Region. Protect.

Plantes Petrograd Bull. 4, p. 153. Type: Apis fervida Fabricius. Desig. by Frison, 1927.

Bremus subg. Separatobombus Frison, 1927. Amer. Ent.

Soc. Trans. 53, p. 64. Type: (Bombus separatus Cresson) = Apis griseocollis Degeer. Orig. desig.

Bremus subg. Rufocinctobombus Frison, 1927. Amer. Ent. Soc.

Trans. 53, p. 78, pl. xvii, fig. 9. Type: Bombus rufocinctus Cresson. Monob.

Bombus: Plath, 1934. Bumblebees and their ways, 201 pp., New York, Macmillan. (biology)

Bombus, Megabombus and Pyrobombus: Milliron, 1961. Kans.

Ent. Soc. Jour. 34, pp. 55-58.

This genus consists of the true bumblebees, the nest-building bumblebees. The three castes of true bumblebees

are queens, workers, and males. This is quite different from the parasitic genus Psithyrus which is composed only of males and females.

Possibly the hardest distinction to make, taxonomically speaking, falls within this genus Bombus. This problem is the differentiation of queens from workers. Early in the season the distinction is not so great because under normal circumstances the workers are considerably smaller. This is due to the fact that the queen mother has had to forage alone for the brood. Under these circumstances the first few broods are usually undernourished, therefore resulting in smaller size adults. However, as the season progresses later broods receive bountiful nourishment as their sister workers provide a richer and more complete food supply. In the latter part of the season, then, it becomes quite difficult to distinguish between larger workers and young queens which begin to appear. To this date no effective method has been derived for the separation of queens and workers other than size (queens are referred to as being bulkier), which is certainly not a good criterion. Male Bombus are often difficult to distinguish

phenotypically, but they can readily be separated by the study of genitalia processes.

Queens and workers of Bombus can very readily be separated from the females of Psithyrus by the absence of the corbicula or pollen basket in the Psithyrus females. Psithyrus males are best distinguished from Bombus males by the black pile on the face with little or no admixture of yellow, the hind tibia is somewhat convex and uniformly covered with hairs, and the volsellae and squamae of the genitalia are membraneous.

Other characteristics for the genus Bombus include the following. In the front wing the marginal cell is rather short, separated from the apex of the wing by its own length; in the hind wing the jugal lobe is absent. Usually there is a distinct and often quite extensive malar space separating the lower end of the eye from the mandible. Finally, the gonostyli of the male genital armature are very short in the majority of species. They normally extend only slightly beyond the tips of the gonocoxites and penis valves (Mitchell, 1962).

Key to Species (Queens)

1. Lateral ocelli distinctly below
supraorbital line 2
Lateral ocelli located at or near
level of supraorbital line 4
2. First abdominal tergite largely black,
second and third tergites yellow; remainder
of abdomen black nevadensis auricomus (Robertson)
First abdominal tergite yellow,
second tergite with yellow or
ferruginous pile, third tergite
black 3
3. Dorsum of thorax with a definite
interalar band between the wing-
bases fraternus (Smith)
Dorsum of thorax entirely yellow except
for a small median area which may be
bare with a few black overlapping
hairs griseocollis (Degeer)
4. Posterior half of scutum and all of
scutellum black pubescent;
pennsylvanicus and terricola

- occasionally have apical margin of
scutellum fringed in yellow) 5
- Posterior portion of dorsum of thorax
with some yellow pubescence 6
5. Lateral ocelli considerably nearer
eyes than to hind margin of vertex;
first abdominal tergite largely
yellow pennsylvanicus (Degeer)
- Lateral ocelli subequally distant from
eyes and margin of vertex, or nearer to
margin of vertex; first abdominal tergite
black terricola Kirby
6. Dorsum of thorax with a transverse band
of black pubescence, or posterior half
of scutum black 7
- Dorsum of thorax without a transverse
black band, with at most a small
inconspicuous central black spot,
largely yellow pubescent 8
7. Abdominal terga 1 and 2 entirely
yellow, at least tergum 3 black
pubescent sandersoni Franklin

- Abdominal terga 1-4 yellow fervidus Fabricius
8. Pubescence of thorax laterally
entirely yellow, that on tergum 3
entirely black 9
- Lower half of mesopleura with dark
pubescence, or tergum 3 with some
admixture of yellow pubescence perplexus Cresson
9. Tergum 2 of abdomen entirely yellow
pubescent 10
- Tergum 2 black pubescent at least in
part 11
10. Malar space usually shorter than width of
mandible at base; vertex with only a
few pale hairs affinis Cresson
- Malar space at least as long as width
of mandible at base; vertex with a
tuft of yellow hairs vagans Smith
11. Tergum 2 of abdomen entirely black
pubescent impatiens Cresson
- Abdominal tergum 2 largely black
pubescent, with a limited amount of
yellow medially at base bimaculatus Cresson

Key to Species (Workers)

1. Lateral ocelli distinctly below
supraorbital line, (ocelli in
griseocollis occasionally only
slightly below 2
Lateral ocelli approximately at level
of supraorbital line 4
2. Malar space fully equal in length to
basal width of mandible; first abdominal
tergite largely black
..... nevadensis auricomus (Robertson)
Malar space considerably shorter than
basal width of mandible; first
abdominal tergite yellow 3
3. Dorsum of thorax with a distinct
interalar band; tergum 2 entirely
covered with yellow pubescence fraternus (Smith)
Dorsum of thorax without interalar
band; tergum 2 narrowly black on
apical margin, otherwise with a
basal median ferruginous patch
..... griseocollis (Degeer)

4. Scutellum and posterior half of scutum
 black pubescent; (scutellum occasionally
 with apical yellow fringe in
pennsylvanicus and terricola) 5
 Scutellum largely or entirely yellow
 pubescent 6
5. Basal abdominal tergum entirely black
 pubescent; lateral ocelli nearer hind
 margin of vertex than to eyes terricola Kirby
 Basal tergum of abdomen largely yellow;
 lateral ocelli subequally distant from
 eyes and hind margin of vertex, or
 nearer the eyes pennsylvanicus (Degeer)
6. Dorsum of thorax largely pale pubescent,
 scutum with only a small median area of
 black pubescence, if any 7
 Dorsum of thorax with considerable black
 pubescence, either with a distinct,
 interalar band, or scutum largely black.
 being only narrowly yellow along
 anterior margin 10

7. First abdominal tergite yellow; remainder
of abdomen black impatiens Cresson
First abdominal tergite yellow; second
tergite also with yellow pubescence 8
8. Second abdominal tergite with a basal
median yellow patch; (malar space equal
in length to basal width of mandible)
..... bimaculatus Cresson
Second abdominal tergite largely or
entirely yellow 9
9. Lower half of thorax with dark
pubescence; or tergum 3 yellow, at
least in part perplexus Cresson
Lower half of thorax yellow pubescent;
tergum 3 black; (malar space fully
equal to basal width of mandible) vagans Smith
10. Malar space much shorter than basal
width of mandible affinis Cresson
Malar space at least nearly equal in
length to basal width of mandible,
or longer 11
11. Abdominal tergum 3 entirely yellow
pubescent; (pubescence of head entirely
black); (color lemon--or greenish--yellow)
..... fervidus (Fabricius)

- Tergum 3 black pubescent 12
12. Malar space no longer than its apical
width, often slightly shorter; mesal
margin of mandible with a decided
notch; head rounded sandersoni Franklin
- Malar space fully as long as basal
width of mandible, often longer than
its apical width; head elongate vagens Smith

Key to Species (Males)

1. Eyes large, bulging from the sides
of the head; ocelli large and set
below the supraorbital line, also
nearer to margins of the eyes than
to each other 2
- Eyes normal, not bulging from the sides
of the head; ocelli small and set about
the supraorbital line or slightly above,
the ocelli distant from the eye margin 4
2. First abdominal tergum yellow, second
with a median ferruginous patch or
nearly all ferruginous griseocollis (Degeer)

- First abdominal tergum yellow or
occasionally black, second segment
wholly yellow without ferruginous
hairs 3
3. First two abdominal terga yellow,
remainder of abdomen black; black
band between wings sharply defined;
malar space reduced to a line fraternus (Smith)
First abdominal tergum yellow or
black; second and third terga always
yellow; malar space distinct
..... nevadensis auricomus (Robertson)
4. Basal abdominal tergum black
pubescent terricola Kirby
Basal tergum yellow pubescent 5
5. Dorsum of thorax with a median
transverse band of black between
the wing bases 6
Dorsum of thorax entirely yellow
pubescent, or with a median patch of
black hairs that does not reach the
tegulae 8

6. Second abdominal tergum bearing
 admixture of yellow and ferruginous
 or entirely ferruginous pile affinis Cresson
 Second abdominal tergum never bearing
 other than yellow pile 7
7. Interalar black band narrow but
 distinct; first to fifth terga
 (inclusive) lemon-yellow; sixth
 (usually) and seventh black;
 scutellum without numerous black
 hairs; pleura always largely
 yellow fervidus (Fabricius)
 Interalar band not well defined or
 mixed with much yellow; scutellum
 frequently largely black; first
 four tergites dull yellow; remainder
 of abdomen any combination of yellow
 and ferruginous or black; pleura
 frequently largely black pennsylvanicus (Degeer)
8. Pubescence of abdominal terga 1-4
 usually pale yellow perplexus Cresson

- At least tergum 3 with black
pubescence 9
9. Segment 2 of abdomen entirely black
pubescent; malar space shorter than
width of mandible at base impatiens Cresson
- Segment 2 of abdomen with at least
some yellow pubescence; malar space
longer than width of mandible at base 11
10. First abdominal tergum yellow; only
basal median patch of yellow on
second tergum, remainder of
abdomen black bimaculatus Cresson
- Pubescence of tergum 2 entirely
yellow 12
11. Basal segment of flagellum not
much longer than segment 2,
distinctly shorter than segment 3 vagans Smith
- Segments 1 and 3 of flagellum
about equal, segment 2 considerably
shorter sandersoni Franklin

Description and Discussion of Species

Bombus affinis Cresson

Bombus affinis Cresson, 1863. Ent. Soc. Phila. Proc. 2,
p. 103.

Bombus affinis var. novae-angliae (Bequaert), 1920. Psyche
27, p. 6.

Bombus affinis: Plath, 1922. Psyche 29, pp. 190-192.

Bombus affinis: Plath, 1934. Bumblebees and their ways,
New York, Macmillan, p. 135.

Queen--Length 21-22 mm., breadth of abdomen 9.5-11 mm.; pubescence copious, entirely black on head; pronotum, tubercles, scutum, scutellum, pleura largely, and abdominal terga 1 and 2 with yellow pubescence; median area of scutum, posteriorly, with black pubescence, with intermixed black and yellow hairs between this patch and the tegulae; abdominal terga 3-6 entirely black; clypeus finely and closely punctate laterally and above with median area shining, very sparsely and minutely punctate, becoming more closely punctate along the apical margin; basal ridge of labrum is interrupted medially, this area being somewhat excavated; malar space shiny and smooth, its median length being considerably shorter than basal width of the mandible;

puncture of face quite dense and coarse medially, laterad of ocelli being smooth and shiny; basal segment of flagellum very slightly longer than 3, 3 longer than 2, punctures of abdominal terga 6 hardly evident.

Worker--Length 11-17.5 mm., breadth of abdomen 5.5-8.0 mm.; basically the same pattern of pubescence as for queen, except that posterior median area of scutum and lateral area to tegulae possibly possesses more black hair, also pubescence of second abdominal tergum possesses pile which is in some cases quite heavily ferruginous in color; however, second abdominal tergum may possess only pale yellow pile, in some cases the second abdominal tergum is also notched apically, medially.

Male--Length 14.5-17 mm., breadth of abdomen 6.5-7.5 mm.; head and face covered with elongate black pubescence, some pale yellow pubescence intermixed with black on vertex and occiput, medially; pronotum, scutum, scutellum, and pleura largely with yellow pubescence, posterior median portion of scutum and the area laterally to tegulae covered with mixture of yellow and black hair; abdominal terga 1 and 2 yellow pubescent although tergum 2 many times is covered with ferruginous pile along basally margin medially and

laterally, terga 3-7 entirely black; clypeus covered quite heavily with pubescence, that portion which shows through shiny and minutely punctate; labrum broadly truncate, shiny, and punctate irregularly; malar space smooth and shiny, its median length slightly longer than basal width of mandible; segments 1 and 3 of flagellum about equal with segment 2 slightly shorter; median area of face finely and densely punctate becoming less punctate around ocelli.

This species had not been previously recorded from Tennessee. This investigator's collection contains one queen, thirty-four workers and six males. Collections were made in Johnson, Sevier, Loudon, Monroe, Knox, Unicoi, Blount, McMinn, and Sullivan counties. The earliest date of collection was May 15; the latest date was September 12.

The flower record for this species included Solidago, Medicago, Trifolium pratense, Laportea, Abelia grandiflora, Prunella vulgaris, Rhus, Polymnia, Verbesina occidentalis, Coreopsis major, and Philadelphus.

There is one noticeable variant in this species. It can best be described as having additional abdominal terga (other than the customary second abdominal tergum) with

ferruginous pile. This variant was not taken by this investigator.

Bombus bimaculatus Cresson

Bombus bimaculatus Cresson, 1863. Ent. Soc. Phila. Proc.
2, p. 92.

Bombus bimaculatus: Plath, 1922. Psyche 29, pp. 194-195.

Bombus bimaculatus: Frison, 1928. Ent. Amer. (n.s.) 8,
pp. 159-223.

Bombus ridingsi Robertson, 1929. Flowers and Insects,
Lancaster, Pa. Science Press.

Bombus bimaculatus: Plath, 1934. Bumblebees and their
ways, New York, Macmillan, p. 141.

Queen--Length 17-22 mm., breadth of abdomen 8.5-10 mm.; pubescence copious and dense but rather short, largely black on head but with some conspicuous yellow pubescence on vertex medially just posterior to a dense fringe of black hairs; thorax largely yellow pubescent, with only a rather small, median posterior area of black hairs and some dark hairs on lateral faces of propodeum below; basal abdominal tergum yellow pubescent and tergum 2 with a small amount of yellow toward base across the median third, abdomen otherwise densely black pubescent; clypeus smooth and shiny, with

rather close, fine, irregular punctures along the narrow lateral and upper margins, the broad median, apical area nearly impunctate; labrum quite broadly truncate, with a basal ridge which is interrupted medially; malar space smooth and shining, median length about equal to basal width of mandible; median area of face very finely and closely punctate, punctures becoming somewhat more distinct and separate toward ocelli, surface largely smooth and impunctate between ocelli and eyes; punctures minute and densely crowded on vertex medially, very fine and close even laterally; basal segment of flagellum only slightly shorter than segments 2 and 3 combined, 3 somewhat longer than 2 (Mitchell, 1962).

Worker--Length 11-16 mm., breadth of abdomen 5-7.5 mm. Size is the only significant difference between worker and queen.

Male--Length 14-14.5 mm., breadth of abdomen 5.5-6.0 mm.; black pubescence of head situated above and below antennae, also above ocelli, quite erect and long, yellow pubescence of head quite dense on clypeus and on face (both above and below antennal base), also medially on vertex, the cheek below also with some yellowish pubescence; thorax

covered entirely with yellow pubescence except for median posterior portion of scutum which is somewhat bare and may contain a few black hairs; tergum 1 of abdomen yellow pubescent and basal median area of tergum 2 likewise yellow, remainder of abdomen black pubescent; venter of abdomen also with yellow pubescence, especially on segments 3-6; only latero-apical portions of clypeus not covered with heavy pubescence, this area very coarsely and sparsely punctate, labrum truncate apically with only basal and apical portions medially finely and closely punctate; malar space smooth and shiny, its length only slightly greater than basal segment, basal segment slightly longer than segment 2; area of face beneath ocelli rather coarsely and closely punctate, area just lateral to ocelli shiny and impunctate.

This species has been collected in Monroe, Blount, Sevier, Greene, Cocke, Scott, Anderson, Jefferson, Claiborne, Union, Knox, and Hamilton counties. This species has also been recorded from Weakley County, West Tennessee, and Davidson County, Middle Tennessee.

The earliest date of appearance for this species from this collector's data was April 5; the latest date was

August 14. The earliest date recorded for the male of this species was July 27.

The flower record for bimaculatus included Trifolium pratense, Solanum carolinense, Medicago, Abelia grandiflora, Rosa, Trifolium incarnatum, Vicia, Lamium amplexicaule, and Berberis.

If variants exist in any species, the males are normally the ones to present a different coloration pattern. In B. bimaculatus the more noticeable variants are those that have additional yellow pubescence on the fourth abdominal tergum, and those that have a substitution of rufous pubescence for the ordinary black pubescence of all additional terga past the second. A variant described by Frison (1928) has a black occiput and a broad black interalar band on the thorax. None of these variants has been collected in this study.

Bombus fervidus (Fabricius)

Apis fervida Fabricius, 1798. Sup. Ent. Syst. p. 274.

Bremus fervidus: Plath, 1922. Psyche 29, pp. 198-200.

Bremus fervidus: Brittain and Newton, 1933. Canad. Jour.

Res. 9, p. 343.

Bombus fervidus: Plath, 1934. Bumblebees and their ways,

New York, Macmillan, p. 166.

Queen--Length about 19 mm., breadth of abdomen 9-9.5 mm.; pubescence of head entirely black, small amount of grayish pubescence immediately above base of the antennae; pubescence yellow on pronotum, tubercles, anterior half of scutum, pleura above, and scutellum, posterior half of scutum with a band of black pubescence between the wing bases, also pleura below and posterior with black pubescence; abdominal terga 1-4 with yellow pubescence, terga 5-6 entirely black; clypeus largely punctate throughout, more sparsely punctate in median shiny area; labrum rather broadly rounded, elevated basally on each side of midline where it is somewhat excavated with a median, transverse row of short, fuscous hairs (Mitchell, 1962); malar space smooth and shiny with a few minute punctures, noticeably longer than basal width of mandible; median area of face punctate with punctures becoming more coarse above, even the area surrounding ocelli with few punctures; basal segment of flagellum slightly shorter than segments 2 and 3 combined, noticeably longer than segment 3 alone.

Worker--Length 14.5-17.5 mm., breadth of abdomen 5-6.5 mm.; median area of clypeus even less punctate than

queen, some worker specimens also exhibit gray pubescence medially on vertex; otherwise quite similar to queen except in size.

Male--Length 11-20 mm., breadth of abdomen 5-7 mm.; apical margins of abdominal terga 1-5 narrowly yellowish hyaline; pubescence copious and elongate, largely black on head, but face and cheeks with some obscure, short, greyish pubescence intermixed at base of the elongate black hairs, and a few yellowish hairs intermixed among the black at the vertex; pubescence yellow on pronotum, anterior half of scutum, scutellum, pleura in large part, and propodeum, black on posterior half of scutum, resulting in a conspicuous black interalar band; pubescence bright yellow, short and dense on abdominal terga 1-5, largely black on 6 and 7 (often confused with pennsylvanicus male, requiring comparison of genitalia); clypeus closely and rather finely punctate laterally and above, median apical area shining and largely impunctate, punctures of two distinct sizes; labrum rather broadly rounded, narrowly shining and impunctate across base, elsewhere closely and rather finely punctate; malar space smooth and shining, with a few scattered, minute punctures, considerably longer than basal width of mandible;

median area of face finely and closely punctate, becoming shining and sparsely punctate above, largely impunctate beneath interior ocellus and adjacent to lateral ocelli, vertex very densely punctate medially, becoming more distinctly and rather coarsely punctate laterally; basal segment of flagellum distinctly longer than segment 2, 3 nearly twice as long as 2 (Mitchell, 1962).

This species has not been previously recorded from Tennessee. Collection data show fervidus to have been found in Unicoi, Johnson, and Knox counties. Dates of collection ranged from May 1 through August 21. Trifolium pratense is the only flower associate recorded by this investigator. Collections of fervidus consist of five workers and one queen.

The noticeable variant of fervidus is one which displays the loss of the customary interalar band and which also has the third and fifth antennal segments unequal. This variant is considered very rare and was not collected in this study.

Bombus fraternus (Smith)

Apathus fraternus Smith, 1854. Cat. Hym. Brit. Mus. 2,
p. 385.

Bombus scutellaris Cresson, 1863. Ent. Soc. Phila. Proc.

2, p. 96.

Bombias scutellaris: Swenk, 1907. Ent. News, 18, p. 294.

Bombus fraternus: Franklin, 1912. Trans. Amer. Ent. Soc.

38, p. 421.

Bombus scutellaris: Robertson, 1929. Flowers and Insects,
Lancaster, Pa., Science Press.

Queen--Length 24-25 mm., breadth of abdomen 11-12 mm.; pubescence in general, short but quite dense, entirely black on head; pubescence yellow on pronotum, anterior half of scutum, scutellum, and in large part on pleura, lower and anterior surface of pleura black, the apical portion of the scutum black, forming a distinct wide interalar band; pubescence yellow, dense and short on abdominal terga 1 and 2, terga 3-6 being entirely black; upper half of clypeus quite finely, closely and deeply punctate, the apical two-thirds shining, with minute, irregular and rather sparse punctures; labrum rather broadly rounded, with a basal, elevated ridge which is interrupted medially, this area abruptly depressed to the margin; outer face somewhat shining, with minute, irregular and vague punctures; malar space shining, very short, about one half the basal width of mandible;

basal segment of flagellum slightly shorter than segments 2 and 3 combined.

Worker--Length 13-18 mm., breadth of abdomen 6.5-9 mm.; with no evident structural or color differences from the queen (Mitchell, 1962).

Male--Length 19-25 mm.; breadth of abdomen 8-10 mm.; pubescence in general quite short but dense and copious, that on head entirely black, although somewhat hoary on lower part of face and cheeks; pubescence yellow on pronotum, scutellum, and in a large part on pleura and scutum, the latter with a small median area of short fuscous hairs posteriorly; pubescence fuscous on propodeum and on pleura beneath and anteriorly; abdominal terga 1 and 2 entirely and densely, short, yellow pubescent, 3-7 entirely black, the more apical terga with elongate and erect hairs; clypeus very finely and closely punctate except along apical margin; labrum somewhat more shining, irregularly and minutely punctate, slightly depressed medially, margin broadly rounded or subtruncate; malar space linear, hardly evident, eyes nearly reaching base of mandible, strongly convergent above; basal segments 1 and 3 of flagellum subequal in length, segment 2 considerably shorter (Mitchell, 1962).

This species has not previously been recorded from Tennessee. The present investigator was not successful in collecting it in the eastern portion of the state where his efforts were concentrated. However, material on loan by The University of Tennessee, Martin, yielded three specimens, all believed to be queens, and the Vanderbilt collection contained one specimen from Davidson County, Middle Tennessee. The earliest collection date was May 13; the latest was November 2. Inasmuch as this material was taken from student collections, no flower records for the state were available.

Dr. Mitchell (1967) informed this investigator that fraternus was found in North Carolina only along some of the lower sandy elevations. This could partially explain why fraternus might not be found in East Tennessee, although being found in the lower elevations of West Tennessee such as Weakley County where some of the above specimens were collected.

Bombus griseocollis (Degeer)

Apis griseocollis Degeer. 1773. Mem. Serv. Hist. Insects
3, p. 576.

(?) Apis virginia Oliver, 1789. Encycl. Meht. 4, p. 66

(?) Apis virginia Fabricius, 1793. Ent. System. 2, p. 318.

(?) Bombus virginicus Fabricius, 1804. Syst. Piez. p. 346.

Bombus separatus Cresson, 1863. Ent. Soc. Phila. Proc. 2, p. 165.

Bombus separatus: Plath, 1927. Psyche 34, pp. 125-127.

Bombus separatus: Robertson, 1929. Flowers and Insects, Lancaster, Pa., Science Press.

Bremus separatus var. nero Bequaert and Plath, 1925. Mus. Compar. Zool. Bul. 67, p. 275.

Bombus separatus: Plath, 1934. Bumblebees and their ways, New York, Macmillan, p. 155.

Bombus griseocollis: Babyi, 1939. Ent. News 50, p. 22.

Queen--Length 20-22 mm., breadth of abdomen 9-10.5 mm.; pubescence of head largely black with some admixture of pale yellow to grey hairs medially at the vertex and occiput, also medially right above the base of the antennae; pubescence of prothorax, tubercles, scutum, scutellum, and pleura yellow, quite short but dense, only a small median bare area on scutum which is surrounded with a few black hairs; abdominal tergum 1 entirely yellow, tergum 2 yellow or tinged with brown basally and medially, apical margin black, abdominal terga 3-6 entirely black, lateral ocelli

set definitely below supraorbital line, clypeus with broad median area, smooth, shiny, largely impunctate, laterally and above finely punctate; labrum rather broadly rounded with two basal ridges or mounds which are separated medially some distance by a very slightly excavated area; basal segment of flagellum slightly shorter than segments 2 and 3 combined; malar space quite short, much shorter than basal width of mandible; vertex finely punctate medially and laterally, face below antennal base rather coarsely punctate, area lateral and posterior to lateral ocelli somewhat smooth and shiny.

Worker--Length 13.5-17.5 mm., breadth of abdomen 5.5-9.0 mm.; resemble queen very closely; some noticeable variances include a heavier concentration of yellow pubescence mixed with black on the face around the base of the antennae, and medially on the vertex and occiput, lateral ocelli range from about on the supraorbital line to distinctly below supraorbital line, and second abdominal tergum is nearly always tinged with brown basally and medially.

Male--Length 15-19 mm., breadth of abdomen 6.5-8.0 mm.; pubescence in general quite dense and short, largely yellow on head (vertex, clypeus, and around base of

antennae), a few black hairs mixed with yellow on vertex and occiput; a small median area of scutum bare, otherwise entire thorax yellow; abdominal tergum 1 entirely yellow, tergum 2 yellow or ferruginous basally and medially with black pubescence apically, terga 3-7 entirely black; eyes very large, ocelli distinctly below supraorbital line, with lateral ocelli being nearer the margin of the compound eye than they are to each other; clypeus densely covered with yellow pubescence but with shiny medial area on apical margin; labrum with mild basal ridges laterally with a rather flat area medially, broadly truncate; malar space very short, shiny, with a few punctures medially; basal segment of flagellum subequal with segment 3, segment 2 considerably shorter.

This species has not previously been recorded from this state. Collection data show griseocollis to have been taken in Morgan, Monroe, Hamblen, Sevier, Blount, Scott, Jefferson, Knox, Loudon, Claiborne, Cocke, Sullivan, Anderson, Grainger, McMinn, Johnson, Hawkins, Campbell, Carter, Washington, Polk, and Hamilton counties. Records also came from Weakley County, West Tennessee, and Davidson County, Middle Tennessee.

Collection dates ranged from around the middle of April until the middle of August. The males of this species were collected rather early (third week in July).

The flower record for griseocollis included Trifolium pratense, Polymnia, Solanum carolinense, Asclepias, Convolvulus, Gossipyium, Medicago, Berberis, Rosa, Cirsium, Trifolium incarnatum, Rubus odoratus, and Vicia.

A variant of this species has the substitution of red pubescence for the customary black abdominal terga past the second tergum. This study did reveal a few specimens which fit this description.

Bombus impatiens Cresson

Bombus impatiens Cresson, 1863. Ent. Soc. Phila. Proc. 2, p. 90.

Bombus impatiens: Plath, 1922. Psyche 29, pp. 195-197.

Bombus impatiens: Frison, 1929. Brooklyn Ent. Soc. Bul. 24, pp. 261-282.

Bombus impatiens: Robertson, 1929. Flowers and Insects, Lancaster, Pa., Science Press.

Bombus impatiens: Plath, 1934. Bumblebees and their ways, New York, Macmillan, p. 144.

Bombus impatiens var. deayi Chandler, 1956. Ind. Acad.

Sci. Proc. 65, p. 116.

Queen--Length 20-21 mm., breadth of abdomen 9-10.5 mm.; pubescence of head largely black except for admixture of yellow hairs medially on vertex and on occiput (for that portion that lies between the inner margins of the compound eyes); thorax covered entirely with short, copious, yellow pubescence; abdominal tergum 1 likewise with yellow pubescence, abdominal terga 2-6 entirely black; clypeus punctate in its entirety, being punctate less noticeably on the broad median area; labrum excavated medially with a basal elevation rising on each side; malar space smooth and shining, its length considerably less than basal width of 2; face with the exception of space between lateral ocelli and eyes covered with fine close punctures.

Worker--Length 9-17.5 mm., breadth of abdomen 4.5-7.5 mm.; description of the worker fits very closely to that of the queen with these possible variations, the pubescence of the scutum seems to be not quite as dense, and the pubescence of abdominal terga 2-6 may appear reddish in color rather than black.

Male--Length 12.5-16 mm., breadth of abdomen 4.5-7 mm.; very dense yellowish pubescence on clypeus, face medially, occiput, and vertex medially, also on cheeks posteriorly and below, some rather long black hairs along inner margins of eyes and immediately above the eyes; thorax entirely with yellow pubescence including the ventral side; basal abdominal tergum also with yellow pubescence, remaining terga with black pubescence; labrum largely impunctate in appearance with no noticeable elevations; malar space smooth and shiny, length nearly equal to basal width of mandible; segment 3 of flagellum considerably longer than 1 and 2 which are about equal in length; punctures of the head are fine and close where area is punctate.

Bombus impatiens has been collected in Sevier, Roane, Knox, Blount, Campbell, Rhea, Anderson, Loudon, Jefferson, Greene, Unicoi, McMinn, Scott, Monroe, Meigs, Hamblen, Sullivan, Grainger, Johnson, Claiborne, Hawkins, Union, and Polk counties. This species was also identified in student collections from Weakley and Davidson counties of West and Middle Tennessee, respectively.

The earliest collection date was April 5; the latest was October 29. The earliest appearance of males was August 4.

Flower records for this species included Solidago, Rhus, Daucus carota, Berberis, Gossypium, Trifolium pratense, Laportea, Convolvulus, Asclepias, Chamaecrista fasciculata, Tradescantia, Prunella vulgaris, Rhododendron, Verbesina virginica, Verbesina occidentalis, Cirsium, Solanum carolinense, Polymnia, Medicago, Aster, Rosa, Abelia grandiflora, Desmodium, Eupatorium purpureum, and Rubus odoratus.

A noticeable variant of this species has red pubescence on the abdomen instead of the customary black on all abdominal terga past the first. Two specimens were collected in this study which fit this description.

Bombus nevadensis auricomus (Robertson)

Bombias auricomus Robertson, 1903. Amer. Ent. Soc. Trans. 29, p. 176.

Bombus auricomus: Frison, 1917. Ent. Soc. Amer. Ann. 10, pp. 277-286.

Bombus auricomus: Frison, 1918. Ent. Soc. Amer. Ann. 11, pp. 43-48.

Bombus auricomus: Robertson, 1929. Flowers and Insects.

Lancaster, Pa., Science Press.

Bombus auricomus: Plath, 1934. Bumblebees and their ways,

New York, Macmillan, p. 153.

Auricomus Group, Milliron, 1961. Kans Ent. Soc. Jour. 34,

p. 56.

Bombus nevadensis auricomus: Mitchell, 1962. Bees of the

eastern United States. Vol. II. North Carolina

Agric. Exp. Sta. Tech. Bul. 152, p. 520.

Queen--Length 21-27 mm., breadth of abdomen 10-12.5

mm.; pubescence of head largely black, with a few yellow hairs mixed with black on vertex medially, occiput with two yellow lines (Chandler, 1950), ocelli set distinctly below supraorbital line; anterior portion of scutum, pronotum, and upper half of pleura covered with dense yellow pubescence (a variation to this is a heavy concentration of yellow pubescence mixed with black on scutellum, especially on apical margin); the basal abdominal tergum largely with black pubescence with varying amounts of yellow pubescence laterally in many specimens, abdominal terga 2 and 3 yellow pubescent, remainder of abdominal terga black; clypeus with punctures which generally are minute and sparse; labrum

broadly rounded, with slight basal elevation which is interrupted briefly medially; malar space smooth and shiny, its length slightly longer than basal width of mandible; basal segment of flagellum approximately equal to segments 2 and 3 combined; punctures of face quite dense and quite fine, slight area just postero-lateral to ocelli which is impunctate.

Worker--Length 16-20 mm., breadth of abdomen 7-11 mm.; otherwise description of queen can be used for worker also.

Male--Length 17-20 mm., breadth of abdomen 8-9 mm.; pubescence short but quite copious and dense, pale yellowish on vertex and occiput, with some intermixed yellowish and black hairs on face medially, blackish on cheeks and lower part of face; pubescence yellowish on scutum, scutellum and pleura, with a slight tawny tinge, scutum posteriorly with an admixture of short, more fuscous hairs, that on scutellum more elongate and conspicuous on each side of a narrow, median, nearly bare line; pubescence fuscous on propodeum and venter along mid line; abdominal terga 1-3 entirely yellow pubescent, this with a slightly reddish tinge at

certain angles, the hairs quite short but dense, 4-7 entirely black, the hairs more elongate and erect except on 7 medially; eyes large and bulging, strongly converging above, lateral ocelli nearly contiguous with the inner margin; clypeus finely and closely punctate in large part, apical margin somewhat more shining and more minutely and vaguely punctate; labrum rather broadly rounded or subtruncate apically, shining laterally, more densely and finely punctate medially; malar space shining and nearly impunctate, short, its length only slightly more than half the basal width of mandibles; basal segment of flagellum subequal in length to 2 and 3 combined.

Collections of B. n. auricomus have been made in Johnson, Unicoi, Blount, Hawkins, Grainger, Greene, Morgan, Monroe, Jefferson, Campbell, Claiborne, Hamblen, Union, Loudon, Cocke, Sevier, Scott, Carter, Knox, Hancock, Anderson, Washington, Polk, Bradley, and Hamilton counties. This subspecies was also present in collections from Weakley and Davidson counties.

The earliest collection date was April 5; the latest was August 21.

Flower records included Convolvulus, Asclepias,
Trifolium pratense, Trifolium incarnatum, Lanium amplexi-
caule, Solanum carolinense, Medicago, Cirsium, Vicia, and
Gossypium.

Mitchell (1962) has demoted auricomus to subspecific rank on the basis of a study carried out by Milliron (1961). Milliron found auricomus to be a subspecies of nevadensis and informed Mitchell by correspondence that all intergradations between the two forms are to be found. Typical nevadensis occurs very sparingly east of the Mississippi River which leaves B. n. auricomus to be the eastern form (Mitchell, 1962).

Bombus pennsylvanicus (Degeer)

Apis pennsylvanicus Degeer, 1773. Mem. Serv. Hist. Insects
 3, p. 575.

Apis americanorum Fabricius, 1775. Syst. Ent. p. 575.

(?) Apis nidulans Fabricius, 1798. Sup. Ent. Sys., p. 274.

Bombus pallidus Cresson, 1863. Ent. Soc. Phila. Proc. 2,
 p. 92.

Psithyrus cevalliae Cockerell, 1899. Entomologist 32,
 p. 157.

Bombus titus Ashmead, 1902. Ent. News 13, p. 50.

Bombus pennsylvanicus: Rau, 1922. Acad. Sci. St. Louis,
Trans. 24, p. 40.

Bombus americanorum: Robertson, 1929. Flowers and Insects,
Lancaster, Pa., Science Press.

Bremus americanorum: Frison, 1930. Ent. Soc. Amer. Ann. 23,
pp. 644-665.

(?) Bombus americanorum var. ambratus Friese, 1931.
Konowia 10, p. 301.

Bombus americanorum: Rau, 1934. Acad. Sci. St. Louis,
Trans. 28, p. 223.

Bombus americanorum: Plath, 1934. Bumblebees and their
ways, New York, Macmillan, p. 163.

Bombus (Fervidobombus) americanorum Michener, 1953. Kans.
Univ. Sci. Bul. 35, p. 1087.

Queen--Length 22-25.5 mm., breadth of abdomen 10.5-
11.5 mm.; pubescence of head entirely black except for a
slight amount of greyish admixture occasionally on the ver-
tex medially and both posteriorly and anteriorly to the
antennae base; pronotum, tubercles, and anterior margin of
scutum covered with a short, dense, bright yellow pubescence,
in most cases the remainder of the thorax is entirely black
with one variation, this variation being the varying

admixture of black and a greyish to yellow mixture of hairs on the scutellum, particularly on the apical margin of the scutellum, on the whole the scutellum is considered largely black; abdominal terga 1-3 covered with yellow pubescence with this variation (the variation being the noticeable amount of black hairs that may exist on the antero-lateral portions of the first abdominal tergum), remainder of the abdominal terga (4-6) entirely black; clypeus generally punctate over entire area except along a basal median line with punctures of varying degrees and spacing; labrum with a basal ridge which is interrupted medially for a considerable distance, this area being excavated rather deeply in some instances, the basal ridges possess punctures which are rather coarse and numerous in some cases; malar space shining with a few fine punctures, its length just slightly less than basal width of mandible; punctures of face fine and close but deep and distinct medially, becoming somewhat coarser and somewhat more distinctly separated just below ocelli (Mitchell, 1962); basal segment of flagellum considerably shorter than segments 2 and 3 combined.

Worker--Length 14-19 mm., breadth of abdomen 5.5-8.5 mm.; details and description follow that of queen except for the difference in size.

Male--Length 18-21.5 mm., breadth of abdomen 8 mm.; black pubescence of head erect and quite long, face and cheeks (lower portions) covered with a dense, short greyish-white pubescence which possibly appears on the vertex medially in some cases, the occiput is largely black; pronotum, tubercles, anterior margin of scutum, and upper half of pleura covered with yellow pubescence, in some cases the scutellum likewise covered with yellow pubescence, however, the posterior portion of the scutum, scutellum, and lower half of pleura possibly covered with pubescence which ranges from black to a pale grey pubescence; abdominal terga 1-4 covered with yellow pubescence of various shades, tergum 5 yellow in some specimens, black in others, terga 6-7 may be entirely black, admixture of black and yellow, admixture of yellow and ferruginous pile, or admixture of yellow, black, and ferruginous pile; clypeus normally covered with dense greyish-white pubescence, beneath generally punctate very distinctly except along apical margin and possibly in shiny

median area; labrum quite irregularly punctate on lower half, basal half largely impunctate, but when punctate, very noticeably so; malar space shiny with less obvious, minute punctures, length of malar space about equal to basal width of mandible; segment 3 of flagellum slightly shorter than segments 1 and 2 combined.

The male pennsylvanicus can be easily confused with that of fervidus. Phenotypically fervidus is lemon yellow with all areas well demarcated (Chandler, 1967). Although Mitchell (1962) lists other physical features which might be compared for identification, this investigator found the only positive mode of identification to be comparison of male genitalia.

This species, pennsylvanicus, has been known as Bombus americanorum (Fabricius). The latest synonymic list (Krombein, 1967) places americanorum as a synonym of pennsylvanicus. This unfortunate incident of two names has arisen due to disagreement over Degeer's original description.

Bombus pennsylvanicus was collected in more counties in this East Tennessee study than were any of the other species involved. County records included Morgan, Loudon,

McMinn, Blount, Sevier, Roane, Knox, Meigs, Rhea, Unicoi, Grainger, Claiborne, Jefferson, Sullivan, Anderson, Johnson, Hawkins, Greene, Hamblen, Campbell, Monroe, Scott, Washington, Hancock, Cocke, Union, Bradley, Hamilton, and Polk.

This species also has been identified from collections in Henderson and Weakley counties in West Tennessee and Davidson county in Middle Tennessee.

The earliest date of appearance of this species was April 5; the latest was September 24. Males were not generally collected until within a week of the latter date. Two earlier occurrences were due to reasons beyond the scope of this study.

Flower records for this species included Trifolium pratense, Helianthus, Cirsium, Abelia grandiflora, Verbesina virginica, Trifolium incarnatum, Lithospermum arvense, Solanum carolinense, Convolvulus, Asclepias, Medicago, Verbesina occidentalis, Vicia, Gossypium, Polymnia, Aster, Prunella vulgaris, and Lonicera.

Bombus perplexus Cresson

Bombus perplexus Cresson, 1863. Ent. Soc. Phila. Proc. 2, p. 91.

Bombus hudsonicus Cresson, 1863. Ent. Soc. Phila. Proc. 2,
p. 92.

Apathus dorsalis Provancher, 1888. Addit. Corr. Faune Ent.
Canada, Hym. p. 343. New synonymy.

Bombus perplexus: Plath, 1927. Psyche 34 pp. 124-125.
(biology)

Bombus perplexus: Plath, 1934. Bumblebees and their ways,
New York, Macmillan, p. 146.

Queen--Length 17-21 mm., breadth of abdomen 8.5-9
mm.; pubescence copious and quite elongate, largely black on
head except for pale pubescence on occiput, vertex medially,
and for pale admixture of frons medially around the base of
the antennae; pubescence yellow on pronotum, tubercles,
scutum as a whole, scutellum, upper portion of pleura, and
abdominal terga 1 and 2 (a variation on the abdominal terga
finds yellow pubescence also on the basal median portion of
terga 3), the median posterior area of scutum relatively
bare, sometimes with a few marginal or intermixed black
hairs (Mitchell, 1962); remaining abdominal terga with black
pubescence, or tergum 6 with a few pale hairs laterally;
pleura either black, or yellow at bases of legs; clypeus
very finely and closely punctate laterally and above,

becoming quite sparsely and finely punctate over the broad median area, surface shining, labrum with a basal ridge which is slightly interrupted medially, this area somewhat excavated but slightly elevated above the margin on each side; malar space shiny, not noticeably punctate, just slightly shorter than basal width of mandible; face medially very minutely and densely punctate becoming somewhat more distinct, well separated, but still very fine toward ocelli, space between ocelli and eyes polished and only very sparsely and minutely punctate; basal segment of flagellum somewhat shorter than 2 and 3 combined [Mitchell (1962) describes basal segment as being considerably longer than segment 3 which is slightly longer than 2].

Worker--Length 11-12 mm., breadth of abdomen 5.5-6 mm.; pubescence somewhat more copious and elongate than queen, bright yellow above, that on pleura somewhat more whitish or possibly largely black (Mitchell, 1962); terga 1 and 2 vary from bright yellow to pale yellow entirely, tergum 3 either entirely pale yellow or pale yellow medially becoming intermixed with black hairs laterally, the more apical terga largely black but possibly also intermixed with paler hairs.

Male--Length 13.5-14 mm., breadth of abdomen 6-7 mm.; pubescence long and copious, largely whitish to bright yellow on head, with a few elongate, dark hairs along inner orbits, before ocelli, and on vertex laterally; pubescence of thorax entirely bright yellow, slightly whitish beneath and on femora of legs; clypeus shiny beneath rather dense whitish pubescence; labrum quite broadly rounded, more or less truncate medially, somewhat shining on each side basally, the median apical area with scattered, shallow punctures; malar space smooth and shining, only very vaguely punctate except below, its length slightly greater than basal width of mandible; median area of face heavily covered with pubescence, punctures becoming quite coarse and widely separated toward ocelli, space between ocelli and eyes largely polished and impunctate; basal segment of flagellum slightly shorter than 3, very slightly longer than 2.

Mitchell (1962) listed perplexus for the state in his checklist. In this present study, one queen, five workers, and one male specimen have been collected from the following counties: Knox, Sevier, and Monroe. The earliest date of collection was May 15; the latest date was August 4. The flower record for this species included Campanula divarcata,

Melampyrum latifolium, Laportea, Campanula americana,
Trifolium pratense, and Philadelphus.

Bombus sandersoni Franklin

Bombus vagans sandersoni Franklin, 1913. Amer. Ent. Soc.
Trans. 38, p. 353.

Bombus frigidus var. sandersoni Franklin, 1951. Hymenop-
tera of America North of Mexico--Synoptic Catalog.
United States Dept. of Agric., Agric. Monogr. No. 2,
p. 1252.

Bombus sandersoni: Mitchell, 1962. Bees of the eastern
United States. Vol II. North Carolina Exp. Sta.
Tech. Bul. 152, p. 534.

Queen--Length 15-16 mm., breadth of abdomen 6 mm.;
pubescence copious but rather short, largely pale on head,
with long, erect, black hairs on vertex and front, a small
amount of short, greyish, densely plumose hairs around
antennae, cheeks below becoming somewhat more greyish pubes-
cent, and a few pale hairs intermixed with the dark on ver-
tex; pubescence dense, erect and yellow on pronotum,
tubercles, narrow anterior margin of scutum, ost of pleura,
propodeum laterally and entire scutellum, that on venter
somewhat more greyish; abdominal terga 1 and 2, and sometimes

5 and 6, yellow pubescent, with no dark mixture on 1 and 2, tergum 3 erect and copious black pubescence; clypeus quite finely, closely and deeply punctate laterally and above, broad median area shining and nearly impunctate; malar space shining and impunctate, slightly shorter than basal width of mandible; punctures over median area of face very fine and rather densely crowded, becoming more distinct but still quite close toward ocelli, largely shining and impunctate between ocelli and eyes; vertex medially with very fine, densely crowded punctures, these becoming somewhat more distinct but still very fine and close laterally; basal segment of flagellum considerably longer than either 2 or 3, but somewhat shorter than the two combined (Mitchell, 1962).

Worker--Length 8-13 mm., breadth of abdomen 3.5-5.5 mm.; resembles queen, but pubescence relatively more elongate, with the same general pattern except that the apical abdominal terga are usually entirely black pubescent (Mitchell, 1962).

Male--Length 10-13 mm., breadth of abdomen 5-6 mm.; pubescence long and copious, in large part yellow on head, especially on face below antennae, on vertex medially and cheeks posteriorly, with intermixed, long, black hairs along

inner orbits, around and above antennae, behind ocelli, on cheeks above and posterior orbits; center of scutum thinly pubescent, usually posterior half black, the scutellum, pleura, and anterior half of scutum yellow; abdominal terga 1 and 2 with copious and elongate yellow pubescence, following terga black; clypeus with fine and close but quite distinct punctures beneath yellow pubescence; labrum rather broadly truncate, smooth and shining, with only minute scattered and rather obscure punctures; malar space smooth and shining, with only very vague and obscure punctures, length somewhat greater than basal width of mandible; median area of face beneath the dense pubescence very finely and closely punctate, the punctures becoming distinct and quite sparse above toward ocelli, space between ocelli and eyes shining and impunctate, vertex medially quite closely punctate becoming more sparse and irregular laterally; basal segment of flagellum very slightly longer than segment 2, about equal to segment 3 (Mitchell, 1962).

This investigator has not collected sandersoni. However, this species is recorded in the checksheet of Mitchell (1962) as occurring in Tennessee.

Although sandersoni was originally described as a form of vagans, Burks et al. (1951) placed it under frigidus. Mitchell (1962), after corresponding with Milliron, elevated sandersoni from a variety of frigidus to species rank. Milliron, after study, had concluded that sandersoni was quite distinct from frigidus, and that neither typical frigidus nor any of its forms occur in the eastern United States (Mitchell, 1962). Neither of these two decisions have been acceptable to other authorities in the field.

Bombus terricola Kirby

Bombus terricola Kirby, 1837. Fauna Bar.-Amer. 4, p. 273.

Bombus terricola: Plath, 1922. Psyche 29, pp. 192-193.

Bombus terricola: Plath, 1927. Psyche 34, pp. 122-124.

Bombus terricola: Brittain and Newton, 1933. Canad. Jour.

Res. 9, p. 343.

Bombus terricola: Plath, 1934. Bumblebees and their ways,

New York, Macmillan, p. 138.

Queen--Length 17-19 mm., breadth of abdomen 9-10 mm.; pubescence rather short, entirely black on head, yellow on pronotum, tubercles, adjacent area of pleura above, anterior margin of scutum, and abdominal terga 2 and 3, otherwise

black including that on legs and on base of abdomen; scutellum yellow or black, or with varying degrees of intermixture; clypeus finely and rather densely punctate laterally and above, the broad median area shining and more minutely and rather broadly subtruncate, with a basal elevated ridge which is interrupted medially, apical margin of this area broadly rounded, slightly elevated above margin on each side and fringed with rather elongate, yellowish hairs; malar space smooth and shining, only very minutely and obscurely punctate, length slightly less than basal width of mandible; punctures very fine and close on face medially, becoming somewhat more distinct but still close toward ocelli; surface lateral of ocelli rather narrowly shining and impunctate, becoming finely but rather distinctly punctate toward eye, vertex very densely and finely but rather distinctly punctate toward eye, vertex very densely and finely punctate medially, punctures becoming somewhat more distinct but still close laterally; basal segment of flagellum slightly longer than segment 3, and 3 slightly longer than 2 (Mitchell, 1962).

Workers--Length 9.5 mm., breadth of abdomen 5.5 mm.; resembles queen in general, but pubescence relatively longer.

Male--Length 13-17 mm., breadth of abdomen 6-8 mm.; pubescence copious and elongate in general, largely pale yellowish on clypeus, but with intermixed black hairs laterally, and chiefly black around antennae, vertex with pale yellowish hairs medially more or less intermixed with black, especially laterally, cheeks with blackish pubescence above becoming somewhat paler below; pubescence pale yellowish on pronotum, tubercles, anterior margin of scutum, pleura in large part, and usually scutellum, fuscous on propodeum and black over posterior two-thirds of scutum; abdominal terga 2 and 3 with bright yellow pubescence, 1 and 5-6 largely black, sometimes with some pale hairs on 6 and 7 laterally and apically; clypeus very finely and closely but quite distinctly punctate beneath dense pubescence; labrum quite smooth and shiny, with only very minute and vague punctures and medially, broadly subtruncate apically; malar space shining, punctures very vague and minute, length about equal to basal width of mandible; median area of face very finely and closely punctate, the punctures becoming somewhat more distinct and more widely separated toward ocelli, surface laterad of ocelli shining and impunctate, punctures very finely and closely crowded on vertex medially becoming

somewhat more distinct laterally; basal segment of flagellum subequal to segment 3, segment 2 somewhat shorter (Mitchell, 1962).

This species has not been previously recorded from Tennessee. Records (Brimley, 1938) of terricola from North Carolina indicated that it would probably be found only at the higher altitudes, 4,000-6,000 feet. Dr. Leland Chandler (1966) also had suggested to this investigator that terricola might occur at higher altitudes. Much to the surprise of this investigator, one worker of terricola was collected from Trifolium repens on the Trillium Gap Trail, Great Smoky Mountains National Park, Sevier County, August 10, 1966. The elevation at the point of collection was about 2,300 feet, indicating that terricola possibly does exist at lower elevations than believed and previously collected.

Bombus vagans Smith

Bombus vagans Smith, 1854. Cat. Hym. Brit. Mus. 2, p.399.

Bombus consimilis Cresson, 1864. Ent. Soc. Phila. Proc. 3, p. 41.

Bombus vagans: Plath, 1922. Psyche 29, pp. 197-198.

Bremus vagans var. coctus Bequaert and Plath, 1925. Mus.

Compar. Zool. Bul. 67, p. 276.

Bremus vagans var. helenae Frison, 1929. Amer. Ent. Soc. Trans. 55, p. 110.

Bombus consimilis: Robertson, 1929. Flowers and Insects, Lancaster, Pa., Science Press.

Bombus vagans: Frison, 1930. Brooklyn Ent. Soc. Bul. 25, pp. 109-122.

Bremus vagans: Brittain and Newton, 1933. Canad. Jour. Res. 9, p. 343.

Bombus vagans: Plath, 1934. Bumblebees and their ways, New York, Macmillan, p. 151.

Queen--Length 18.5 mm., breadth of abdomen 8.5 mm.; head largely with rather elongate, black pubescence, however, small patch of yellow pubescence on vertex medially, on occiput, and some yellow pale mixture just posteriorly to the antennae base; thorax nearly entirely yellow except for a small bare area medially on hind portion of scutum, which might be surrounded with a few black overlapping hairs; abdominal terga 1 and 2 entirely yellow pubescent, remainder of abdominal terga black; clypeus punctate mainly along lateral and basal margins, these punctures coarse and fairly close, any other punctures sparse and very minute; the slight basal elevation of the labrum interrupted medially by

a fairly strong concave area; malar space smooth and shiny, its length distinctly as long as or slightly longer than basal width of mandible; basal segment of flagellum somewhat longer than segment 3, very distinctly longer than segments 2 and 3 combined; punctures of vertex very fine and very close, area lateral to ocelli impunctate, punctures of area below ocelli more coarse and more separated, area of face also closely and minutely punctate.

Workers--Length 11-13.5 mm., breadth of abdomen 5-5.5 mm.; workers very similar to queen in description, except for size and that workers possess a greater admixture of black hairs in area between the wing bases.

Males--Length 12-15.5 mm., breadth of abdomen 5-7 mm.; very copious yellow pubescence dominates the head area, some scattered elongate black hairs along inner margins of eyes, above and below base of antennae, and just posterior to each compound eye; pubescence of thorax almost entirely bright yellow except for a few black hairs around bare median area on scutum posteriorly, these black hairs also intermixed laterally between wing bases, abdominal terga 1 and 2 also with bright yellow copious pubescence, remainder of abdomen entirely black, perhaps some of the latter terga

with a few yellow hairs laterally; clypeus very convincingly covered with dense yellow pubescence, lateral apical margins shining, very coarsely and sparsely impunctate; labrum impunctate medially with very slight basal elevation shining and smooth; malar space smooth and shining, its length slightly greater than basal width of mandible; segment 3 of flagellum notably longer than segments 1 or 2, somewhat shorter than segments 1 and 2 combined; area lateral to ocelli impunctate, area immediately above and lateral to this finely and quite irregularly punctate.

Mitchell (1962) has previously recorded this species from Tennessee. This investigator's data confirmed collection in the following counties: Sevier, Cocke, Anderson, Johnson, Hawkins, Scott, Knox, Monroe, and Polk.

B. vagans was collected from May 27 until September 12.

Flower records for vagans included Prunella vulgaris, Rhus, Trifolium pratense, Abelia grandiflora, Asclepias, Helianthus microcephalus, Solidago, Seriocarpus asteroides, and Rubus odoratus.

A noticeable variant of this species has in some cases acquired an interalar band and also has yellow hair on

some or all of the last three abdominal terga. This variety was not collected in this study.

CHAPTER VII

THE GENUS PSITHYRUS LEPELETIER

Psithyrus Lepeletier, 1832. Soc. Ent. France Ann. 1,
p. 372. Type: Apis rupestris Fabricius. Desig. by
Curtis, 1833.

Apathus Newman, 1835. Ent. Mag. 2, p. 404 (footnote).

Type: Apis rupestris Fabricius. Autobasic.

Psithyrus subg. Ashtonipsithyrus Frison, 1927. Amer. Ent.
Soc. Trans. 53, p. 69. Type: Apathus ashtoni
Cresson. Orig. desig.

Psithyrus subg. Fernaldaepsithyrus Frison, 1927. Amer.
Ent. Soc. Trans. 53, p. 70. Type: Psithyrus
fernaldae Franklin. Orig. desig.

Psithyrus: Milliron, 1961. Kans. Ent. Soc. Jour. 34, p. 59.

This genus consists of inquiline or parasitic bumble-
bees which are closely related to the genus Bombus which
serves as their host. The genus is composed entirely of
females and males. Psithyrus females are degenerate Bombus
structurally, but are specialized Bombus biologically.

The practice of the female Psithyrus is to invade the nest of a species of Bombus in which the queen has already successfully established a nest and started a colony. The female Psithyrus stings the Bombus queen to death in some instances while in other cases the two learn to live in harmony. In cases where the Bombus queen is stung to death, her eggs may or may not be destroyed. It is to the advantage of the Psithyrus female to destroy the eggs so that her eggs will receive all the nourishment which is supplied by the Bombus workers.

Actually, the Psithyrus female is almost a mimic of a large female queen of Bombus; she makes egg cells of the same type, lays eggs in the same manner, and broods the same (Frison, 1927). Although Psithyrus females do not collect pollen and nectar for the rearing of the young, there is still a vestigial production of wax which in the case of Bombus is used in making honeypots.

Plath (1922) believed that similarity in coloration between Psithyrus and Bombus species is probably due to genetic affinity, and not solely to mimicry or exposure to the same ecological conditions. Probably the best evolutionary explanation for the parasitism demonstrated by

Psithyrus can originate with those Bombus queens which do not take the trouble to build their own nests but instead enter nests which are already occupied. From this temporary social parasitism it is believed to be but a step to the permanent social parasitism of the members of the genus Psithyrus (Plath, 1922).

Each species of Psithyrus has specific hosts, generally not more than two species of Bombus; therefore, the range of any species of Psithyrus coincides with that of the hosts. Psithyrus is inquiline only in the nests of Bombus (Chandler, 1950).

Key to Species (Females)

1. General aspect of abdomen black, with
 no dorsal pale pubescence 2
 Abdominal terga 3-5 yellow pubescent in part 3
2. Posterior half of scutum black pubescent;
 hairs covering abdominal terga very
 short and only suberect variabilis (Cresson)
 Scutum with only a small amount of
 black pubescence medially on posterior
 half; abdominal terga covered with dense,
 erect black pubescence the individual

hairs nearly half the length of the

plate citrinis (Smith)

3. Apical sternum elongated beyond tip of

tergum, this slender projection down-

curved; pleura, vertex, and scutellum

yellow pubescent fernaldae Franklin

Apical sternum not produced beyond its

tergum; pleura, vertex, and scutellum

black pubescent at least in part; tergum

3 largely yellow pubescent, 4 and 5 black ...

..... citrinis (Smith)

Key to Species (Males)

1. Segment 3 of flagellum little if any

longer than basal segment; (abdominal

tergum 4 pale pubescent; pleura largely

pale pubescent; gonostyli slender,

abruptly dilated at base) fernaldae Franklin

Segment 3 of flagellum considerably

longer than basal segment, often equal

to segments 1 and 2 combined 2

2. Hypoepimeral area and posterior of
mesopleura fuscous or black pubescent;
(segment 3 of flagellum shorter than 1
and 2 combined; pubescence of abdominal
terga relatively short) variabilis (Cresson)
At least upper half of mesopleura,
including hypoepimeral area, covered
with yellow pubescence 3
3. Abdominal terga 1 and 2 yellow pubescent,
3-7 black, often with some black intermix-
ture across base of 2, or with some yellow
hairs among the black on 3 citrinus (Smith)
Abdominal terga 1-3 entirely yellow
pubescent; terga 4-7 entirely black
pubescent citrinus (Smith)

Description and Discussion of Species

Psithyrus citrinus (Smith)

Apathus citrinus Smith, 1854. Cat. Hym. Brit. Mus. 2,
p. 385.

Apathus contiguus Cresson, 1863. Ent. Soc. Phila. Proc. 2,
p. 112.

Psithyrus laboriosus Frison, 1921. Canad. Ent. 53, p. 100.

Psithyrus laboriosus: Bequaert and Plath, 1925. Mus. Compar.

Zool. Bul. 67, pp. 268-272.

Psithyrus laboriosus: Robertson, 1929. Flowers and insects,

Lancaster, Pa., Science Press.

Psithyrus laboriosus: Plath, 1934. Bumblebees and their

ways, New York, Macmillan, p. 175.

Psithyrus citrinus: Mitchell, 1962. Bees of the eastern

United States. Vol. II. North Carolina Agric. Exp.

Sta. Tech. Bul. 152, p. 540.

Female--Length 17-21 mm., breadth of abdomen 7-9.5

mm.; vertex with a median area of short, yellowish pubescence, somewhat interspersed with black hairs; admixture of pale pubescence with black on frons near base of antennae, pubescence of head otherwise entirely black, rather short, but erect and copious; pubescence yellow, quite dense and copious but rather short on scutum, scutellum and pleura, the venter narrowly black pubescent, propodeum with some dark hairs adjacent to a median polished, impunctate and more or less bare area; abdomen entirely black pubescent (a variation of this is for tergum 3 to be large yellow), the hairs quite dense and erect but very short; clypeus closely

and finely punctate above, becoming somewhat more coarsely so medially and at sides, apical margin rather broadly shining, sparsely and minutely punctate; labrum somewhat excavated medially, with a basal, triangular protuberance on each side, apical margin quite abruptly depressed; malar space smooth, shiny, finely, but rather irregularly punctate, somewhat shorter than basal width of mandible; space between lateral ocelli and margin of vertex fully twice that between ocelli and eyes, subequally distant from eyes and each other; segments 1 and 3 of flagellum longer than segment 2.

Male--Length 13.5-18 mm., breadth of abdomen 5.5-6.5 mm.; head largely black pubescent, with a few yellowish hairs interspersed among the black across vertex posteriorly (a variation to this is vertex with a median area of yellow pile, similar to what is found in the female); scutum anteriorly, tubercles and adjacent area below with copious elongate, yellow pubescence, scutellum fringed with long yellow pubescence posteriorly; pubescence otherwise black on scutum, scutellum, pleura, and propodeum; abdominal terga 1 and 2 with elongate, copious and erect, yellowish pubescence, with possibly some black hairs on 2 basally toward the sides (tergum 3 sometimes entirely yellowish pubescence

or sometimes admixture of yellow and black), and 3 sometimes with yellowish pubescence at extreme sides, but 3 medially and 4-6 or 7 entirely black pubescent, the hairs copious, elongate and erect; clypeus very finely and closely punctate except along apical margin medially; labrum somewhat shining, with a transverse line of erect, black hairs, surface somewhat shining below, margin shallowly depressed, broadly truncate; face very finely and closely punctate but becoming quite sparsely and more coarsely so above, around ocelli and across vertex; punctures of vertex medially quite close, ocelli surrounded in part by a shining, impunctate area laterally and below; malar space smooth and shining, very minutely and sparsely punctate, median length slightly less than basal width of mandibles; segment 1 of flagellum slightly longer than segment 2, segment 3 considerably longer than segment 1.

This species has been taken in Sevier, Carter, and Knox counties. The most recent collections are those of males taken in Carter County, August 21, 1966 and in Sevier County, September 12, 1966. The two females examined were from The University of Tennessee, Knoxville, museum collection. One female specimen was from The University of

Tennessee Farm, June 13, 1949; the other was from the Great Smoky Mountains, September 5, 1951.

This species has been taken on Cirsium, Solidago, and Verbesina occidentalis.

Plath (1934) has discovered this species breeding in nests of Bombus vagans and B. impatiens. Frison (1926b) in his studies discovered P. citrinus in colonies of B. fervidus and B. bimaculatus. B. fervidus, shortly, drove the invader from the nest by daubing while B. bimaculatus offered no resistance. In further studies he found a queen of citrinus in the nest of auricomus, suggesting that she might be an occasional lodger there also.

The present study yielded males of P. citrinus in areas where both B. vagans and B. impatiens were likewise collected, but no definite nest studies were undertaken.

Prior to Mitchell's (1962) work, this species bore the name of Psithyrus laboriosus (2-banded condition ♂) with P. laboriosus var. citrinus being a 3-banded condition ♂. The current name for the species, however, is Psithyrus citrinus which for some creates an unfortunate name change (Chandler, 1967). Mitchell made the name change under the supervision of Milliron (Mitchell, 1967).

Psithyrus fernaldae Franklin

Psithyrus fernaldae Franklin, 1911. Amer. Ent. Soc. Trans.
37, p. 164.

Psithyrus tricolor Franklin, 1911. Amer. Ent. Soc. Trans.
37, p. 167.

Psithyrus fernaldae: Franklin, 1913. Trans. Amer. Ent. Soc.
38, p. 473 (Described).

Psithyrus fernaldae: Bequaert and Plath, 1925. Bul. Mus.
Comp. Zool. Harvard 67, p. 273 (Distribution).

Psithyrus fernaldae: Neave, 1933. Canad. Jour. Res. 8,
p. 71.

Psithyrus fernaldae: Plath, 1934. Bumblebees and Their
Ways, New York, Macmillan, p. 171.

Psithyrus fernaldae: Milliron, 1939. Papers Mich. Acad.
Sci., Arts and Letters 24, p. 181.

Female--Length 14.5-17 mm., breadth of abdomen 7-8.5
mm.; pubescence of face and cheeks black, vertex with
copious and elongate, yellow pubescence, with a few inter-
mixed yellowish hairs just above antennae; thorax with long
and copious, largely yellowish pubescence, but scutum with a
median posterior patch of fuscous pubescence; pleura beneath
and legs largely dark pubescent, but posterior fringe of

front femora pale in part; pubescence of abdominal terga erect and copious, intermixed yellowish and fuscous on tergum, largely fuscous on terga 2 and 3, with some yellowish hairs along apical margin, and laterally also on 3, tergum 4 yellow pubescent, 5 black pubescent, 6 with only very short and inconspicuous, appressed pubescence; clypeus shining, punctures fine, rather deep and distinct along lateral and upper margins, becoming very minute and sparse apically; labrum slightly excavated medially, the basal margin slightly produced on each side, apical margin rounded, rather strongly depressed; malar space smooth and shining, length fully equal to basal width of mandibles; punctures of face and of vertex medially fine and close, vertex becoming more shining and more minutely and sparsely punctate laterally, a shining area adjacent to each lateral ocellus nearly impunctate; basal segment of flagellum very slightly longer than segment 3, and 3 slightly longer than 2; scutum with a median, shining, impunctate space, punctures otherwise rather fine and close over most of thorax; sternum 6 elongate, produced beyond apex of the tergum (Mitchell, 1962).

Male--Length 13-15 mm., breadth of abdomen 6-7 mm.; pubescence of face and cheeks entirely black, quite long and

copius, vertex with elongate, copious, yellowish pubescence; thorax with long, copious, largely yellow pubescence but posterior half of scutum with copious, erect black pubescence, that on ventor fuscous in part; abdominal terga 1 and 4 with elongate, yellowish pubescence, 2, 3, 5, and 6 with largely black pubescence, that on 7, and 6 laterally, yellowish; clypeus very finely and closely punctate, rather dull; labrum shining, punctures minute and to some degree separated, apical margin only slightly depressed, broadly subtruncate, with a transverse, median line of erect black hairs separating the lower and upper surfaces; malar space smooth and shining, with only exceedingly minute, well separated punctures, length equal to width of mandible; segments 1 and 3 of flagellum about equal in length, somewhat longer than segment 2 which is about as broad as long (Mitchell, 1962).

Although Mitchell has recorded this species from Tennessee (1962), it has not been collected during this study. P. fernaldae was also recorded by H. A. Pilsbury from Clingman's Dome, Blount County, Tennessee, August 4, altitude 6,000 feet (Frison, 1923).

Plath (1934) suggested the possibility that Bombus perplexus is the host of fernaldae, but positive evidence is lacking.

Psithyrus variabilis (Cresson)

Apathus variabilis Cresson, 1872. Amer. Ent. Soc. Trans 4,
p. 284.

Psithyrus variabilis: Swenk, 1907. Ent. News, vol. 18,
p. 297.

Psithyrus variabilis: Franklin, 1912. Trans. Amer. Ent.
Soc. 38, p. 461 (Described).

Psithyrus variabilis: Frison, 1916. Bul. Brooklyn Ent. Soc.
11, p. 46 (Biology).

Psithyrus variabilis: Robertson, 1929. Flowers and Insects,
Lancaster, Pa. Science Press.

Psithyrus variabilis: Stevens, 1948. N. Dak. Agr. Exp. Sta.
Bimonthly Bul. 11, p. 54.

Psithyrus variabilis: Chandler, 1950. Proc. Ind. Acad. Sci.
60, p. 176.

Psithyrus variabilis: Chandler, 1954. Proc. Ind. Acad. Sci.
63, p. 167.

Psithyrus variabilis: LaBerge and Webb, 1962. Neb. Agr.
Exp. Sta. Res. Bul. 205, p. 35.

Female--Length 17.5-19 mm., breadth of abdomen 8.5-
9 mm.; pubescence quite short in general, largely black on
head, with median area of vertex yellow pubescent with a few

black hairs intermixed; anterior third of scutum and area around tubercles with dense but rather short, copious, yellow pubescence, and scutellum densely yellow pubescent across posterior margin, the scutum posteriorly relatively bare medially but otherwise with short, black pubescence, continuing sparsely onto scutellum medially; pleura, propodeum and legs largely black pubescent; abdominal terga entirely black pubescent, hairs very short, no more than one-fourth the length of the terga; clypeus finely and densely punctate across upper margin, becoming deeply and rather coarsely punctate on each side below, the median apical area shining and sparsely, minutely punctate; labrum with a flattened basal tubercle on each side, separated by a deep and narrow depressed area, apical margin rounded, quite abruptly depressed; malar space shining, very minutely but rather closely punctate, median length about two-thirds basal width of mandible; face closely and finely punctate from clypeal margin to ocelli, becoming shiny and sparsely punctate between ocelli and eyes, vertex minutely and closely punctate medially, becoming shining, finely and sparsely punctate laterally; segments 1 and 3 of flagellum about equal,

somewhat longer than segment 2 which is broader than long (Mitchell, 1962).

Male--Length 14.5-18.5 mm., breadth of abdomen 6-7.5 mm.; vertex with copious and rather elongate yellowish pubescence medially (several specimens which were examined also had yellowish pubescence mixed with black on the face, immediately above the base of the antennae), pubescence of head otherwise largely black, rather short and dense; scutum anteriorly and area around tubercles with rather copious, elongate, yellow pubescence posteriorly, scutum posteriorly and scutellum medially with rather short, black pubescence, and pleura and propodeum largely black; pubescence of abdominal terga quite short, the individual hairs no longer than half the median length of the plates, largely black but with varying amounts of yellow on the more median terga laterally, terga 3 and 4 sometimes largely yellow, [Cresson, (1872), added]:

...the abdomen sometimes entirely black except a few yellowish hairs on lateral margins of third and fourth segments, sometimes the third and fourth segments except disk and sides of fifth segment are yellow, sometimes the first and sides of fourth segments are more or less yellow and sometimes the first and third entirely, the second except sides, and the sides of fourth and fifth segments are yellow ...;

clypeus dull, very finely and closely punctate; labrum somewhat more shining, punctures minute and rather vague, apical margin slightly depressed, broadly truncate; outer face densely covered with short, yellowish pubescence and fringed below with elongate, somewhat curved, dark hairs, malar space smooth and shining, somewhat shorter than basal width of mandible; face very finely and closely punctate from clypeus to area just below ocelli, surface shining and sparsely punctate between eyes and ocelli; vertex closely and finely punctate medially but becoming somewhat more distinctly separated laterally; basal segment of flagellum only very slightly longer than segment 2, segment 3 much longer.

Mitchell did not show in his work that variabilis had been collected in Tennessee; however, Frison (1926a) recorded variabilis as a new state record based on one queen from Knoxville, Tennessee, collected by S. S. Ainslie.

The specimens for this present investigation were taken from the museum collection at The University of Tennessee, Knoxville, and The University of Tennessee, Martin. No flower records are associated with the museum specimens. This material did increase the locality records to include Knox, Hamblen, and Sevier counties in East Tennessee,

Weakley county in West Tennessee, and Williamson county in Middle Tennessee. Collection dates for this species were from August until mid-November.

Bombus pennsylvanicus is considered to be the host of this species by most experts. Frison (1926b) observed that nests of B. fervidus, the closest ally of B. pennsylvanicus are not susceptible to a Psithyrus infestation possibly because of their peculiar "daubing" habits which have been observed by other authorities in the field. His experiments showed that B. bimaculatus workers would immediately attack a variabilis female. He further suggested that the success with which a P. variabilis female invades the nests of aggressive B. pennsylvanicus lies in her calm and deliberate attitude under all conditions.

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