

BULLETIN OF THE CALIFORNIA INSECT SURVEY

Volume 23

Bumble Bees and
Cuckoo Bumble Bees of California
(Hymenoptera: Apidae)

by Robbin W. Thorp, Donald S. Horning, Jr., and Lorry L. Dunning

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Contents

Abstract, vii

Acknowledgments, viii

INTRODUCTION

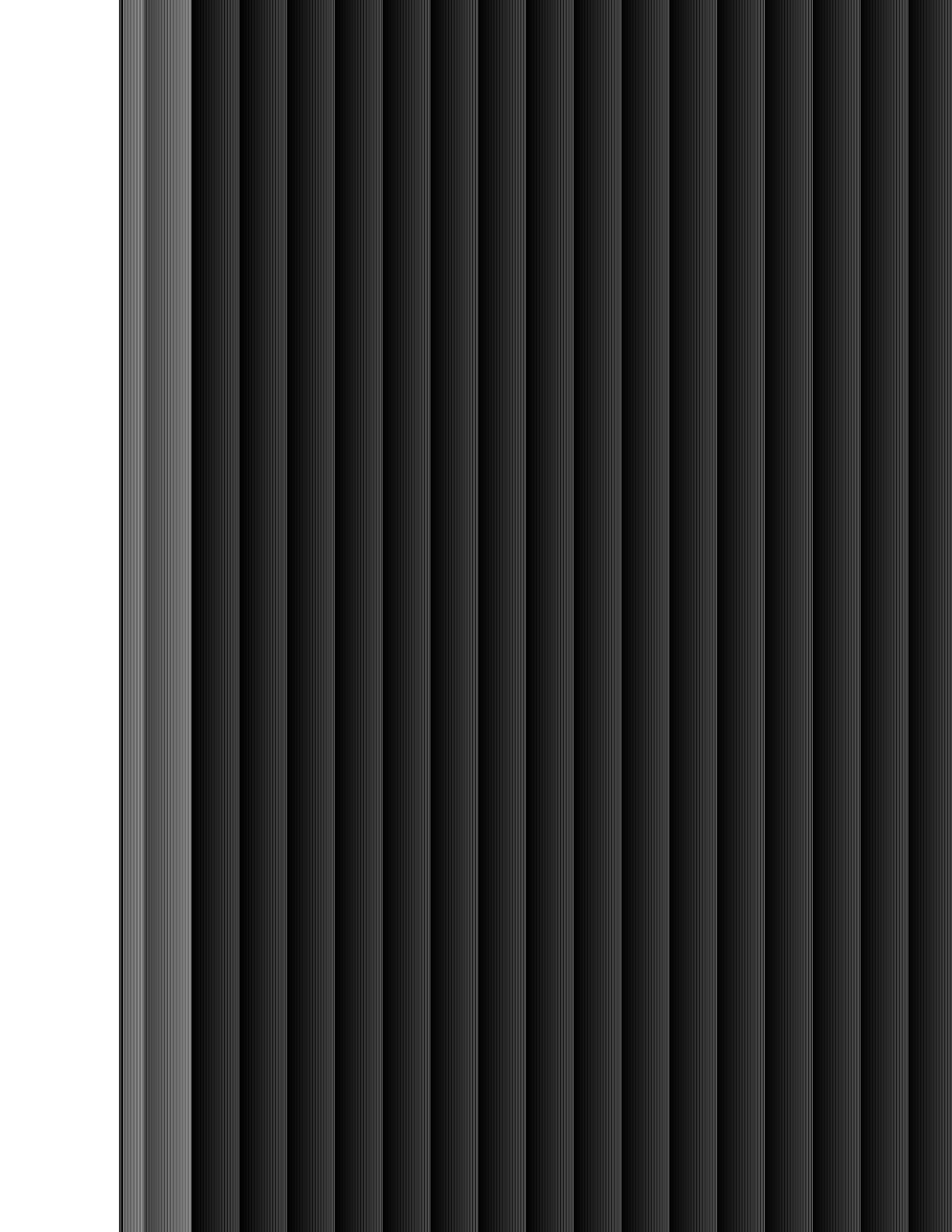
1

- Biology and Domestication, 1
 - Life history, 1
 - Seasonal flight periods, 2
 - Nest associates and biotic enemies, 3
 - Domestication, 3
- Flower Relationships, 3
- Distribution and Abundance, 5
- Mimicry, 8
- Taxonomic Methods, 11

SYSTEMATICS

13

- Key to the Genera of Bombini, 13
- Genus *Bombus* Latreille, 14
- Key to Subgenera and Species of *Bombus* in California, 14
 - Subgenus *Bombias* Robertson, 18
 - Subgenus *Separatobombus* Frison, 19
 - Subgenus *Crotchiibombus* Franklin, 21
 - Subgenus *Cullamanobombus* Vogt, 23
 - Subgenus *Subterraneobombus* Vogt, 24
 - Subgenus *Fervidobombus* Skorikov, 25
 - Subgenus *Bombus* Latreille, 29
 - Subgenus *Pyrobombus* Dalla Torre, 32
 - Subgenus *Alpinobombus* Skorikov, 48
- Genus *Psithyrus* Lepeletier, 49
- Key to Subgenera and Species of *Psithyrus* in California, 49
 - Subgenus *Ashtonipsithyrus* Frison, 49
 - Subgenus *Citrinopsithyrus* Thorp, 50
 - Subgenus *Fernaldaepsithyrus* Frison, 52
- List of Plant Genera Visited by California Bombini, 55*
- Literature Cited, 61*
- Plates 1-12, 65*
- Index to Bombini and Synonyms, 79*



Abstract

The bumble bees (*Bombus*) and cuckoo bumble bees (*Psithyrus*) constitute the tribe Bombini. The 24 species of *Bombus* and 3 species of *Psithyrus* occurring in California are treated in this bulletin. Keys to and diagnoses of the genera, subgenera, and species of California Bombini are presented.

Life histories, floral associations, geographic distribution and abundance, mimicry, and taxonomic characters are discussed. Distribution and seasonal flight patterns, taxonomic characters, color patterns, and biological features are illustrated.

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INTRODUCTION

As Sladen (1912) so aptly stated, "Everybody knows the burly, good-natured humble-bee." Because they are large, colorful, and often abundant, bumble bees are readily noticed and collected. Species concepts changed little between the works of Franklin (1913) and Stephen (1957) and are still in use (but see Milliron, 1971:40-42). The higher categories have recently been debated (Milliron, 1961; Richards, 1968).

Current interest in the behavior and ecology of the group is high; e.g., experimental mimicry (Brower and Brower, 1962), domestication for crop pollination (Holm, 1966), pollinator energetics (Heinrich and Raven, 1972; Heinrich, 1975), resource partitioning in coexisting species (Heinrich, 1976), and modeling of foraging behavior and population growth (Oster, 1976; Oster and Heinrich, 1976).

This bulletin presents new taxonomic and distributional data accumulated during the past 20 years and analyzes the available ecological information as a basis for future studies. The literature cited has been selected with preference given to recent review articles and papers in English.

BIOLOGY AND DOMESTICATION

The two genera of Bombini, *Bombus* and *Psithyrus*, exhibit strikingly different biological patterns. Bumble bees, *Bombus*, are social insects with three castes: queens or principal egg-laying females, workers or principal foraging and nesting females, and males. Cuckoo bumble bees, *Psithyrus*, are inquilines or social parasites without worker castes, which usurp bumble bee nests and propagate themselves at the expense of their bumble bee hosts. General biology of the bombini is considered by Sladen (1912), Plath (1934), Free and Butler (1959), and Alford (1975), and 7 of the 10 North American subgenera of *Bombus* are treated in detail

by Hobbs (1964, 1965a, 1965b, 1966a, 1966b, 1967b, 1968). Therefore, biologies are treated summarily here.

Life history. The colony cycle in temperate-zone bumble bees is annual, not perennial as in the honey bee. Colonies are initiated each year by inseminated queens which hibernate. Queens emerge from their hibernacula in spring, feed on nectar and pollen, and search for suitable nest sites, usually in abandoned rodent or bird nests. Nests are usually well concealed, often underground, sometimes on the surface, and occasionally 9 to 12 meters above ground in trees or attics. Once a suitable site is located, the queen constructs her brood nest. She collects pollen to form a food mass for her young, and constructs a wax cup for nectar storage (Fig. 158). She deposits eggs vertically in two rows on the food mass and covers them with wax so that each is in its own cell, except *Alpinobombus* (Hobbs, 1964). As the larvae from these eggs increase in size, the wax canopy is enlarged and the septa between the cells become obliterated.

The queen incubates the initial brood, raising her body temperature by shivering the thoracic muscles (Heinrich, 1972) and releasing this heat through her abdominal venter. Energy for this activity comes from consumption of nectar stored in the initial wax cup (Fig. 157). Larvae of the first brood feed initially on the food mass provided by the queen. The queen subsequently regurgitates food through an opening in the top of the brood cell which is usually closed after each feeding, except in the subgenus *Bombus*. When feeding is complete, each larva spins a cocoon (Fig. 161) in which it pupates (Fig. 159). As workers emerge, they assume the field-foraging and much of the nest-building activities, while the queen restricts her activities to egg laying and feeding herself from the stores provided by her worker progeny.

Before the first brood has emerged, eggs of the second brood are laid in communal wax cells on top of the cocoons of the first brood. Egg cells for subsequent broods contain groups of eggs laid horizontally, except *Bombias* (Hobbs, 1965), and are constructed on top of cocoons of preceding broods (Figs. 159, 160), producing random layers of different-aged cells (Fig. 162). In the pocket makers, *Alpinobombus*, *Fervidobombus*, and *Subterraneobombus*, larvae of workers of all three groups and of males and queens of *Subterraneobombus* receive pollen through pockets constructed at the side of each brood mass (Fig. 165). Larvae of reproductives of *Alpinobombus* and *Fervidobombus*, and all larvae of other subgenera, the pollen storers, are fed through an opening in the top of the brood cell as described above for larvae of the first brood. After the cocoon is completed, the workers remove most of the wax covering. They use it to line old cocoons for pollen and nectar storage or, in some species, to construct special cylinders for pollen storage, and often in older nests to build a roof or involucre for the nest.

Additional broods of worker progeny are produced until the workers equal or outnumber the brood to be fed. By this time some unfertilized eggs which produce males have been laid, while the fertilized eggs become new queens rather than workers. The males leave the colony within a few days after they emerge from their cocoons, and rarely return. The young queens may take up household activities for several days before they take their first flight, and then may assist with the field-foraging activities for several days. Initial mating contact usually takes place in the air, with the male mounting the back of the female. The pair then tumble to the nearest surface and remain in coitus often for several minutes. Mating is terminated by the queen, who kicks the male off with her hind legs. Both sexes may mate more than once, and they mate freely when confined together in small containers. After mating, the new queens feed to build up their fat bodies for overwintering. Next, each digs a small cell in the soil in which she will hibernate (Fig. 166). The rest of the colony (the old queen, workers, and males) dies out.

Inseminated females of the genus *Psithyrus* overwinter like *Bombus*. *Psithyrus* females emerge from hibernation later in spring than their hosts. They feed on pollen and nectar and search for established nests of bumble bees. When one has

found a suitable bumble bee nest, she moves in and dominates or often kills the resident queen. The *Psithyrus* female then lays eggs in the wax cups provided. Fertilized and unfertilized eggs produce females and males respectively. The worker bumble bees continue to forage and to feed the developing broods of *Psithyrus*. Since species of *Psithyrus* lack a worker caste and their females lack a pollen transport apparatus, they are dependent upon bumble bee colonies to rear their progeny.

Seasonal flight periods. Each sex and caste has its typical seasonal activity pattern (Figs. 1-27). The queens exhibit a bimodal curve, with the early peak due to foundress queens and the late peak due to hibernating queens (e.g., Figs. 9, 11). Despite their large size, queens are less commonly collected than the other castes, especially at the end of the nesting season. This has several explanations: queens spend much of their time in the nest; foundress queen activity precedes much of the entomological collecting activities; queens are more expensive (energetically) to produce than the other castes, and thus are actually less numerous than workers or males. Worker and male flight curves are unimodal, with workers reaching their peak slightly before the males. The male flight peak usually precedes or coincides with the second peak of queen activity.

Bombus edwardsii and *vosnesenskii* (Figs. 15, 23) are the earliest species to appear in California. Foundress queens are found in December and January, the first workers appear in January and February, and males appear as early as February and March. Because they are widespread, both these species have extremely long activity seasons, with queens on the wing somewhere in almost every month. For example, *B. vosnesenskii* populations in the Inner Coast Ranges are active from about January through July, and those on the cool damp Pacific coast continue activity into August, while populations above 2740 m, such as at Sonora Pass, are active from June through September.

The next-earliest group of species occurs principally in the North Coast zone and includes *B. californicus*, *occidentalis*, *caliginosus*, *melanopygus*, and *sitkensis* (Figs. 7, 11, 13, 18, 20). *B. crochii* (Fig. 4), a species with southern affinities, also is active in relatively early spring.

The late-appearing species include several which occur principally in the Great Basin and Great Basin Montane zones: *B. nevadensis*, *griseocollis*, *morrisoni*, and *fervidus* (Figs. 1, 2, 3, 8). Typically Boreal

species such as *B. appositus* and *sylicola* (Figs. 6, 21) also appear late and have a brief season.

Nest associates and biotic enemies. The variety and impact of the more important associates and enemies of bumble bees are discussed by Sladen (1912), Frison (1926), Plath (1934), Cumber (1949b), Free and Butler (1959), and Alford (1975).

Some of the more important enemies include: the nematode *Sphaerularia bombi* Dufour, which effectively sterilizes hibernating queens (Poinar and Van der Laan, 1972); many mites (Husband, 1968), including the scavenger *Kunzinia* (= *Tyrophagus*) *laevis* (Dujardin), which has a phoretic relationship with and overwinters on hibernating queens; cryptophagid beetles such as *Antherophagus*, whose adults enter bumble bee nests by phoresy (Frisch, 1952) and whose larvae are scavengers; pyralid moths such as *Aphomia*, *Vitula*, and *Plodia*, whose larvae feed principally as scavengers on old combs and pollen, but will sometimes kill and consume bumble bee larvae and pupae; larvae of muscid and syrphid flies *Fannia* and *Volucella*, which are scavengers, but the latter will occasionally kill and consume immature bumble bees (Hobbs, 1967b); robber flies such as *Mallophora*, *Laphria*, and *Promachus*, which capture and feed on adult bumble bees (Fig. 168); larvae of conopid flies *Physocephala*, which develop as parasites in abdomens of adult bumble bees (Ryckman, 1953); the protozoan parasite *Nosema bombi* Fartham & Porter, which kills adults (Skou et al., 1963); shrikes, which capture and impale adults on sharp objects; skunks, which dig up nests and feed on adult and immature bees (Plath, 1923); and man, who through his impact in altering the environment exerts an important and usually negative influence on bumble bee abundance.

Domestication. Bumble bee colonies can be maintained in observation hives with glass tops for studies of colony biology. Colonies for study may be obtained by several methods: (1) Established colonies are located and transferred to hive boxes (Sladen, 1912; Plath, 1934; Free and Butler, 1959). (2) Hive boxes containing nesting materials (upholsterer's cotton) are placed in areas where foundress queens are abundant (Fye and Medler, 1954; Hobbs et al., 1960; Hobbs, 1967a). (3) Foundress queens are captured, confined in hives, and provided with food until sufficient workers have been produced so that the colony can be allowed

free flight (Hasselrot, 1960; Holm, 1960; Plowright and Jay, 1966). The latter two domestication methods, developed principally to produce colonies for pollination of forage legumes, especially red clover (Medler, 1958; Hobbs et al., 1962; Holm, 1966), provide useful techniques for obtaining information on early stages of nest development.

FLOWER RELATIONSHIPS

The following analyses are based entirely on flower visitation records appended to the specimens examined, without distinguishing the type of visitation made (pollen, nectar, other). Flower relationships among the Bombini are complicated by a number of factors: size, tongue length, polylecty (females of a species collecting pollen from diverse plant taxa), species preferences, prolonged seasonal activity, social organization, caste preference, macro- and micro-geographic differences in availability of floras, and pollen and nectar availability from different plant species. Most are based on specimens from California, but some other records are included. Because of the polylectic behavior of Bombini, records of infrageneric plant taxa are lumped.

Although the records analyzed here were accumulated randomly by general collectors, some trends and generalizations can be derived which may serve as useful bases for future studies directed specifically at the understanding of specific flower relationships of Bombini.

The 7,437 flower records for the 27 species of Bombini in California include 61 plant families and 226 genera. These represent 42% of the families and 26% of the genera of flowering plants listed by Munz and Keck (1959). Only the plant families and genera from which bumble bees are most commonly taken (Tables 1 and 2) are discussed here.

The numbers of flower records are uneven as to species and caste among the California *Bombus*, and this may bias some of the following analyses. Over 25% of the worker records come from *B. vosnesenskii*, with another 37% shared among *B. sonorus*, *occidentalis*, *bifarius*, and *edwardsii*. About 39% of the queen records come from *B. vosnesenskii*, *fervidus*, and *californicus*. Of the male records, 57% are from *B. vosnesenskii*, *edwardsii*, *occidentalis*, and *bifarius*. About 59% of all flower records for *Bombus* are based on *B. vosnesenskii*, *edwardsii*, *bifarius*, *occidentalis*, and *sonorus*.

TABLE 1. PLANT FAMILIES WITH MORE THAN 50 RECORDS OF VISITS BY BOMBINI

Family	Genera Visited		No. of Bombini Visitors				
	No.	% in Calif.	Spp.	Indivs.	Q	W	M
Compositae	49	28%	26	2877	125	1169	1583
Leguminosae	20	57	25	1423	292	929	196
Labiatae	20	40	25	469	44	283	142
Ericaceae	5	38	13	317	72	189	56
Scrophulariaceae	12	41	20	262	27	217	18
Hydrophyllaceae	5	36	18	258	32	193	33
Rhamnaceae	2	40	11	229	23	195	23
Polygonaceae	2	17	18	224	5	83	136
Solanaceae	5	50	4	182	1	180	1
Rosaceae	13	35	17	166	26	98	42
Saxifragaceae	2	10	16	131	87	38	6
Onagraceae	4	36	14	80	4	25	51
Asclepiadaceae	1	25	8	74	4	44	26
Ranunculaceae	5	38	11	64	7	51	6
Capparidaceae	3	50	12	63	6	45	12
Cruciferae	8	15	10	62	26	27	9
Malvaceae	5	36	12	61	6	39	16
Boraginaceae	7	44	8	56	19	32	5
Caprifoliaceae	5	100	11	54	10	36	8
Salicaceae	1	50	12	53	14	29	10
All 61 plant families	226	26	27	7437	874	4124	2439

Q = Queen
W = Worker
M = Male

Compositae, Leguminosae, and Labiatae are each associated with over 90% of the species of California Bombini. Among the remaining families, those associated with at least half the species of California Bombini include the Hydrophyllaceae, Onagraceae, Polygonaceae, Rosaceae, Scrophulariaceae, and Saxifragaceae.

The number of plant genera per family visited by California Bombini bears little relation to the number of genera available. The 49 genera of Compositae visited represent only 28% of those available, while the 20 genera of Leguminosae represent 57% of those available (Table 1 and List of Plant Genera). Most of the 20 plant families in Table 1 have 25-57% of their California genera associated with Bombini. Exceptions to this are the Caprifoliaceae (100%) and the Polygonaceae (17%), Cruciferae (15%), and Saxifragaceae (10%).

Among the plant genera in Table 2, the 6 with the most abundant records of association with California Bombini belong to the Compositae (*Cirsium*, *Chrysothamnus*, and *Helianthus*) and the Leguminosae (*Lupinus*, *Trifolium*, and *Melilotus*).

Floral records for the castes of many species of Bombini are disproportionate in comparison with the ratio (1q:4.7w:2.8m) derived from records for each caste of all bees associated with all 61 plant families (Table 1). This is due to the correspondence between seasonal flight periods of the castes and the phenological patterns of the plant families. Queens have disproportionately higher representation on spring-blooming Ericaceae, Saxifragaceae, Cruciferae, Boraginaceae, and Salicaceae, especially since most records are for foundress rather than end-of-season queens. Workers are relatively more abundant on spring- and summer-blooming Compositae, Scrophulariaceae, Rhamnaceae, Polygonaceae,

TABLE 2. PLANT GENERA
WITH MORE THAN 50 RECORDS
OF VISITS BY BOMBINI

Genera	No. of Bombini Visitors				
	Spp.	Indivs.	Q	W	M
<i>Cirsium</i> (C)	23	870	46	341	483
<i>Chrysothamnus</i> (C)	13	434	6	188	240
<i>Helianthus</i> (C)	12	296	6	125	165
<i>Lupinus</i> (Le)	17	264	22	221	7
<i>Trifolium</i> (Le)	18	258	13	167	78
<i>Melilotus</i> (Le)	17	255	7	201	47
<i>Eriogonum</i> (P)	17	220	5	79	136
<i>Haplopappus</i> (C)	12	210	2	85	123
<i>Ceanothus</i> (Rh)	11	209	22	181	6
<i>Centaurea</i> (C)	8	207	—	67	140
<i>Aster</i> (C)	17	201	4	45	151
<i>Solidago</i> (C)	18	183	7	102	74
<i>Solanum</i> (Sol)	3	176	1	175	—
<i>Phacelia</i> (H)	15	169	27	131	11
<i>Penstemon</i> (Scr)	17	167	19	136	12
<i>Medicago</i> (Le)	12	167	20	127	20
<i>Monardella</i> (La)	12	150	17	99	34
<i>Rhododendron</i> (E)	11	143	24	95	24
<i>Ribes</i> (Sax)	16	130	87	37	6
<i>Arctostaphylos</i> (E)	7	124	39	79	6
<i>Vicia</i> (Le)	19	118	41	64	13
<i>Astragalus</i> (Le)	11	114	74	37	3
<i>Caragana</i> (Le)	6	102	96	6	—
<i>Mentha</i> (La)	16	92	8	53	31
<i>Salvia</i> (La)	10	90	16	52	22
<i>Rubus</i> (Ro)	10	85	9	42	34
<i>Senecio</i> (C)	12	83	5	33	45
<i>Lotus</i> (Le)	9	75	4	58	13
<i>Asclepias</i> (A)	8	74	4	44	26
<i>Wyethia</i> (C)	8	61	13	14	34
<i>Salix</i> (Sal)	12	53	14	29	10
<i>Eriodictyon</i> (H)	7	50	4	27	19

A = Asclepiadaceae
C = Compositae
E = Ericaceae
H = Hydrophyllaceae
La = Labiatae
Le = Leguminosae
P = Polygonaceae
Rh = Rhamnaceae
Ro = Rosaceae
Sal = Salicaceae
Sax = Saxifragaceae
Scr = Scrophulariaceae
Sol = Solanaceae

Solanaceae, Asclepiadaceae, Ranunculaceae, and Capparidaceae. Males are overrepresented on summer- and fall-blooming Compositae, Polygonaceae, Onagraceae, and Asclepiadaceae. These relationships hold for most of the genera of these families (Table 2). However, *Vicia*, *Astragalus*, and *Caragana* have disproportionately higher ratios of queens to workers than the other legume genera, because they bloom earlier, and males are rare or absent from *Lupinus* and *Solanum*, because they lack nectar.

Among the 15 bee species for which we have 50 or more flower records for males, 60-99% of the 9 *Bombus* and 3 *Psithyrus* are with Compositae. Over 36% of these records are with the genera *Cirsium*, *Chrysothamnus*, and *Helianthus*. Among 18 species with 50 or more flower records for workers, 55% or more of those for 3 (*B. fervidus*, *bifarius*, *sylvicola*) are with Compositae, and *B. rufocinctus* has 69% of its records with Leguminosae. Of 6 species for which we have 50 or more flower records for queens, *B. californicus* and *fervidus* have 53% and 84% with Leguminosae, and *B. edwardsii* queens have 59% with Ericaceae.

Plant families in over 25% of the records for a bee species having more than 100 flower records are: Compositae (for 12 Bombini), Leguminosae (7), Labiatae (1), Asclepiadaceae (1), and Solanaceae (1). The Compositae make up more than 50% of the records for *B. morrisoni*, *occidentalis*, *bifarius*, and *sylvicola* and *Psithyrus insularis*, and the Leguminosae constitute over 50% of the records for *B. rufocinctus*.

Most species of Bombini have their principal relationship with two or three plant families. However, *B. edwardsii* and *caliginosus* are each associated with 4 plant families, with no family representing more than 30% of the records; *B. vandykei* is associated with 5 plant families, none in more than 25% of the records; and *B. mixtus* is associated with 6 families, none in more than 20% of the records.

DISTRIBUTION AND ABUNDANCE

The 24 species of *Bombus* and 3 of *Psithyrus* in California represent 12 subgenera, all that occur in America north of Mexico, except *Fraternobombus*. At least one species, *B. balteatus*, is Holarctic. A second, *B. sylvicola*, may be conspecific with *B. lapponicus* Fabricius (Thorpe, 1962; Milliron, 1971) and therefore also Holarctic. Both are restricted to the

TABLE 3. DISTRIBUTION AND INTRASPECIFIC ABUNDANCE OF SPECIES OF BOMBINI IN CALIFORNIA
(Numbers indicate relative intraspecific abundance:
1 = common, 4 = rare)

Species	Boreal				Austral				
	North Coast	Sierran	South. Calif. Montane	Great Basin Montane	Great Basin	Mojave Desert	Colorado Desert	Cali-fornian	Great Valley
<i>Bombus</i>									
<i>nevadensis</i>	3	2	—	1	—	—	—	4	—
<i>griseocollis</i>	3	—	—	1	2	—	—	—	—
<i>morrisoni</i>	4	3	—	1	2	—	—	—	—
<i>crotchii</i>	—	—	—	—	4	3	4	1	2
<i>rufocinctus</i>	3	2	—	1	—	—	—	—	—
<i>appositus</i>	4	1	—	2	—	—	—	—	—
<i>californicus</i>	2	3	3	4	—	—	—	1	4
<i>fervidus</i>	—	3	—	2	1	—	—	—	—
<i>sonorus</i>	—	—	—	—	—	—	—	2	1
<i>franklini</i>	1	—	—	—	—	—	—	—	—
<i>occidentalis</i>	1	2	—	4	—	—	—	3	4
<i>bifarius</i>	2	1	—	3	—	—	—	4	—
<i>caliginosus</i>	1	—	—	—	—	—	—	2	—
<i>centralis</i>	—	1	3	2	—	—	—	—	—
<i>edwardsii</i>	2	3	3	—	4	—	—	1	4
<i>flavifrons</i>	2	1	—	3	—	—	—	—	—
<i>huntii</i>	—	3	—	2	1	—	—	—	—
<i>melanopygus</i>	1	2	—	—	—	—	—	—	—
<i>mixtus</i>	2	1	—	—	—	—	—	—	—
<i>sitkensis</i>	1	—	—	—	—	—	—	—	—
<i>sylvicola</i>	3	1	—	2	—	—	—	—	—
<i>vandykei</i>	4	2	3	—	—	—	—	1	4
<i>vosnesenskii</i>	2	3	4	4	—	—	—	1	4
<i>balteatus</i>	—	1	—	2	—	—	—	—	—
<i>Psithyrus</i>									
<i>suckleyi</i>	1	—	—	—	—	—	—	—	—
<i>insularis</i>	2	1	—	4	—	—	—	3	—
<i>fernaldae</i>	2	1	—	—	—	—	—	—	—
Total species	21	20	5	16	6	1	1	11	7

Hudsonian and Arctic-Alpine zones in North America from Alaska to Labrador, and from above the Arctic Circle southward only in the highest mountains of the western states. Of the 27 California species, 19 occur entirely west of 100° W longitude, with 7 of these—*B. crotchii*, *franklini*, *caliginosus*, *edwardsii*, *flavifrons* ("dimidiatus" populations), *vandykei*, and *vosnesenskii*—restricted to the Pacific Coast states. An additional western species, *P. suckleyi*, also occurs rarely between 100° and 96°

W longitude. The remaining 5 species—*B. griseocollis*, *rufocinctus*, and *fervidus* and *P. insularis* and *fernaldae*—range from California to the Atlantic Coast states.

Many California bumble bees are replaced to the east, north, or higher elevation by close relatives; e.g., *B. californicus* by *fervidus*, *caliginosus* by *vandykei*, *edwardsii* by *melanopygus*, *vandykei* by *flavifrons*, and *vosnesenskii* by *huntii*. These and other obvious ecogeographic displacements and the more

TABLE 4. RELATIONSHIPS AMONG 9 FAUNAL ZONES FOR THE BOMBINI IN CALIFORNIA
(Number of Bombini in each zone given in parentheses)

	North Coast (21)	Sierran (20)	Great Basin Montane (16)	Califor- nian (11)	Great Valley (7)	Great Basin (6)	South. Calif. Montane (5)	Mojave & Colorado Deserts (1)
North Coast	—	21.9	31.5	43.7	64.2	77.7	69.2	100.0
Sierran	80.0	—	16.6	46.8	62.8	69.2	60.0	100.0
Great Basin Montane	75.0	93.7	—	55.5	73.9	63.5	71.3	100.0
Califor- nian	81.8	72.8	54.5	—	22.2	76.5	50.0	83.3
Great Valley	71.4	71.4	42.8	100.0	—	69.2	33.3	75.0
Great Basin	50.0	66.7	66.7	33.3	33.3	—	81.8	71.3
South. Calif. Montane	80.0	100.0	60.0	80.0	80.0	20.0	—	100.0
Mojave & Colorado Deserts	0.0	0.0	0.0	100.0	100.0	100.0	0.0	—

Difference (upper right) = $\frac{\text{no. not shared}}{\text{sum of species}} \times 100$

0 = no difference
100 = total difference

Resemblance (lower left) = $\frac{\text{no. shared}}{\text{no. in smallest fauna}} \times 100$

0 = no species shared
100 = all species from the smaller fauna occur in the larger

subtle sympatric microhabitat displacements would be fruitful areas for ecological studies.

For convenient analyses of species distributions within the state, we have subdivided California into the zones used by Hurd and Michener (1955) (Table 3). The Boreal area contains 92.5% of the species occurring in California, whereas the Austral area contains only 55.5%. Two species (7.4%) are restricted to the Austral region, while 12 (44.4%) occur only in the Boreal. The 13 shared species represent 86.7% of the Austral fauna, but only

52.0% of the Boreal. Most California Bombini occur in the North Coast and Sierran zones, with the Great Basin Montane and Californian zones next in importance. The Mojave and Colorado deserts contain only one species, *B. crotchii*, and it is encountered only rarely along the western margins of these deserts. Only 3 species are limited to 1 faunal zone in California, and these all occur in the North Coast; 14 species occur in 2 to 3 zones, and 10 species have a range of 4 to 6 zones, while no species occurs in more than 6 of the 9 zones.

The North Coast as delimited by Hurd and Michener (1955) includes the Klamath Mountains, which other authors include with the Sierra-Cascade ranges. However, only 6 of the 21 Bombini in the North Coast zone do not actually reach the coast. Of these, *B. griseocollis* and *morrisoni* are most abundant in the transmontane Great Basin zones; *B. appositus* and *syvicola* have been most commonly collected in the Sierras; and *B. franklini* and *P. suckleyi* occur only in the Klamath Mountain area in California. Only *B. caliginosus* and *sitkensis* occur primarily along the coast, with the former intruding into the Californian zone. The remaining species reach the coast but are most abundant elsewhere. Most of the records of *B. nevadensis* and *rufocinctus* are from the Great Basin Montane zone. *B. californicus*, *edwardsii*, and *vosnesenskii* are most abundant in the Californian. The remaining 8 species have been most commonly collected in the Sierras.

Relationships among the faunal areas are expressed as "resemblance" or "difference." Resemblance (Table 4) is the number of species shared between two areas, divided by the number in the smallest fauna times 100 (Miller, 1951). By this method, differences in size of the faunas compared are eliminated. However, the differences in size between units compared, as well as differences in species composition of the faunas, are reflections of zonal differences. Therefore an index of difference has also been employed (Table 4). It is the number of species that occur in one but not the other, divided by the sum of the species represented in both times 100. The index of difference between the Boreal and Austral areas is 35.0, and that of resemblance is 86.5.

The Great Basin fauna of Bombini shows the greatest consistent difference (69.2 or above) with all cismontane areas, differing most from the Southern California Montane zone. Another high degree of difference (73.9) is between the Great Basin Montane and the Great Valley. None of these areas are contiguous. Pairs of zones with lowest indices of difference (below 22.2) are the Sierran-Great Basin Montane, Sierran-North Coast, and Californian-Great Valley. These zones are contiguous or in close proximity to one another. Indices of resemblance generally confirm that faunal associations are greatest between contiguous areas and least between disjunct areas. All 5 species of the

Southern California Montane are shared with the Sierran zone.

Based on estimates of relative intraspecific abundance, each species was ranked from 1 (most common) to 4 (rarest) for each different zone in which it occurs (Table 3). In the Sierran and North Coast zones, 15 of their 25 species are most common and 9 of 21 species are most abundant in the Californian and Great Basin Montane zones. None exhibit their greatest abundance in the Southern California Montane, Mojave, or Colorado Desert zones. The only species occurring in the Mojave and Colorado deserts, *B. crotchii*, is rare there and is found principally along their western borders rather than well out on the desert floor. Of the 7 species occurring in the Great Valley, 5 have their fewest records here. They appear to be marginal in this area, while their principal abundance is in the Californian or North Coast zones.

The most common species of California Bombini, *B. vosnesenskii*, *edwardsii*, and *californicus*, are also the most widespread. Each occurs in 6 faunal zones and in 52 to 56 of the 58 counties. The rarest species include *B. balteatus*, *griseocollis*, and *franklini* and *P. suckleyi*, which are known in 1 to 3 faunal zones and 1 to 5 counties. Many Bombini coexist at single localities in California: *e. g.*, Sonora Pass, Tuolumne Co. (Sierran)—11 *Bombus*, 2 *Psithyrus*, Eureka, Humboldt Co. (North Coast)—11 *Bombus*, 2 *Psithyrus*, and Palo Alto, Santa Clara Co. (Californian)—9 *Bombus*. Most of the species at any locality belong to different subgenera or, in the case of *Pyrobombus*, different species groups.

MIMICRY

Female bumble bees sting. This makes them unattractive as prey to most potential predators. Their aposomatic (warning) colors, principally combinations of yellow, black, red, and white, and buzzing serve as warning signals to predators. A discriminating predator requires relatively few painful encounters to associate the warning signals with the experience and to avoid female bumble bees and insects which resemble them (Brower et al., 1960).

An efficient warning system which lessens the chance that a species will be preyed upon is selectively advantageous. Other insects may also derive

benefits from this if they resemble the protected species (model) closely enough to deceive predators. This resemblance or mimicry, usually based on similarities in color and form, may also involve behavioral similarities.

Of the forms of mimicry (Rettenmeyer, 1970), two relate to Bombini. Batesian mimicry, in which the mimic is not distasteful nor does it cause harm to the predator, is exemplified by members of several families of flies: Syrphidae, Asilidae, Tabanidae, Oestridae, and Bombyliidae (Gabritschevsky, 1926). Müllerian mimicry, in which the mimic is rejected or avoided because it is also distasteful or harmful to the predator, is exemplified by the convergent resemblances of many species of *Bombus* and *Psithyrus* to one another. Since females of all Bombini sting, this reinforces the warning value of the group color pattern. A third possibility, aggressive mimicry, in which the mimic preys on its model with the resemblance presumably allowing close approach to its prey, is not supported by experimental evidence. The selective advantage of all putative examples can be explained best as Batesian or Müllerian mimicry.

In any area where bumble bees occur, there is a high probability of color convergence among two or more of the species present. This Müllerian mimicry is often overlooked. The photographs in the paper by Brower and Brower (1962) clearly show that more than one species of bumble bee was investigated in their experiments, although they mention only *B. pennsylvanicus* (Degeer) [as *americanorum* (Fabricius)].

Of the several Müllerian mimetic groups of Bombini in California, the most widespread and abundant group includes the predominantly black: *B. californicus*, *caliginosus*, *vandykei*, and *vosnesenskii* and *P. insularis* ("crawfordi" populations) and *fernaldae* ("wheeleri" populations) (Figs. 135, 142, 151, 152, 155, 156). This group is abundant throughout cismontane California and occurs sparingly in the Great Basin and Great Basin Montane zones.

Another important Müllerian group in California includes the banded yellow and black: *B. rufocinctus*, *bifarius* ("nearcticus" populations), *edwardsii*, *mixtus*, and *sylicola* (Sierran populations) (Figs. 132a, 141, 144, 148, 150b). This group is principally North Coast and Sierran with some Californian elements.

A third Müllerian complex includes *B. nevadensis*, *morrisoni*, *fervidus*, *sonorus*, and *appositus* (Figs. 131a, 134, 136-138). These species are predominantly yellow. Only *B. sonorus* is allopatric from the other species in California, but is sympatric with *B. morrisoni* over a large area of southern Arizona. This group occurs principally in the Great Basin, Great Basin Montane, and Sierran zones, with *B. sonorus* principally Great Valley and Californian.

A fourth Müllerian group includes species with red hair centrally on the abdomen: *B. rufocinctus*, *centralis*, *huntii*, *melanopygus*, and *sylicola* (Great Basin Montane populations) (Figs. 132b, 132c, 143, 146, 147, 150a). This group occurs in the North Coast, Sierran, Great Basin, and Great Basin Montane zones.

Another Müllerian group includes species with yellow centrally and reddish or light hair apically on the abdomen: *B. nevadensis* ("miguelensis" population), *crotchii*, *occidentalis* ("nigroscutatus" populations), and *sitkensis* (Figs. 130a, 131b, 131c, 140a, 140c, 149). This group occurs principally in the North Coast and Californian zones, with the principally allopatric *B. crotchii* extending onto the edges of the Mojave and Colorado deserts.

Perhaps other species should also be included in the above groups. *B. franklini* and *occidentalis* (nominant color form) are principally dark species and tend to resemble *vosnesenskii*, while *B. flavifrons* ("dimidiatus" and especially "ambiguous" populations) is sometimes confused with *B. sitkensis*. The remaining species, *B. griseocollis* and *balteatus* and *P. suckleyi*, are rare in California and represented by color forms which belong to Müllerian groups occurring outside of California.

Females of some species of Bombini are highly variable in color pattern and enter into different Müllerian groups. *B. rufocinctus* may have sympatric females belonging to two different Müllerian groups (e.g., groups containing *edwardsii* or *huntii*). In most cases these variants tend to be allopatric (e.g., *B. sylicola* females in the Sierran area resemble *edwardsii*, but in the Great Basin Montane area they resemble *huntii*).

Species of Bombini in a Müllerian group usually belong to different genera or subgenera—e.g., *B. (Pyrobombus) vosnesenskii*, *B. (Fervidobombus) californicus*, *P. (Citrinopsithyrus) insularis*, and *P. (Fernaldaepsithyrus) fernaldae*. Where they belong to the same subgenus, they belong to different species

TABLE 5. PRINCIPAL BATESIAN MIMICS OF CALIFORNIA BUMBLE BEES AND THEIR PROBABLE MODELS

Order	Batesian Mimics		Bumble Bee Models
	Family	Genus	Species
DIPTERA			
Asilidae	<i>Laphria</i>	<i>astur</i> O.S. <i>columbica</i> Walker <i>sackeni</i> (Banks) <i>fernaldae</i> (Back) <i>rapax</i> O.S.	<i>vosnesenskii</i> <i>vosnesenskii</i> <i>vosnesenskii</i> <i>huntii</i> <i>centralis</i>
Bombyliidae	<i>Mallophora</i> <i>Villa</i>	<i>fautricoides</i> Curran <i>fulviana</i> (Say) <i>harveyi</i> Hine	<i>sonorus</i> <i>centralis</i> <i>centralis</i>
Syrphidae	<i>Arctophila</i>	<i>flagrans</i> O.S.	<i>centralis</i> and <i>flavifrons</i> ("dimidiatus" populations)
	<i>Criophora</i>	<i>harveyi</i> (Osburn) <i>alopex</i> O.S. <i>lupina</i> (Will.) <i>caudata</i> Curran <i>kincaidii</i> Coquillett <i>nigripes</i> Will. <i>tricolor</i> Coquillett	<i>californicus</i> <i>vosnesenskii</i> <i>vosnesenskii</i> <i>edwardsii</i> and <i>mixtus</i> <i>edwardsii</i> and <i>mixtus</i> <i>edwardsii</i> and <i>mixtus</i> <i>edwardsii</i> and <i>mixtus</i>
	<i>Eristalis</i>	<i>bardus</i> (Say)	<i>edwardsii</i> , <i>fervidus</i> , and <i>huntii</i>
	<i>Haydromyia</i> <i>Mallota</i> <i>Merodon</i>	<i>grandis</i> Will. <i>sackeni</i> Will. <i>equestris</i> Rabr.	<i>vosnesenskii</i> <i>vosnesenskii</i> <i>edwardsii</i> , <i>sonorus</i> , and <i>vosnesenskii</i>
	<i>Procota</i> <i>Volucella</i>	<i>bomboides</i> Hunter <i>bombylans</i> L.	<i>vosnesenskii</i> <i>edwardsii</i> and <i>sylvicola</i>
COLEOPTERA			
Scarabaeidae*	<i>Euphoria</i> <i>Lichnanthe</i> <i>Tricotinus</i>		
Cerambycidae	<i>Ulochaetes</i>	<i>leoninus</i> Lec.	<i>edwardsii</i>
LEPIDOPTERA			
Arctiidae	<i>Kodiosoma</i>	<i>fulva</i> Strech (males)	<i>vosnesenskii</i>
Sphingidae*	<i>Hemarius</i>	<i>senta</i> Stkr. <i>brucei</i> B.V.D. <i>diffinis</i> B.V.D.	
HYMENOPTERA			
Cimbicidae	<i>Trichiosoma</i>	<i>languinosum</i>	<i>edwardsii</i>
Anthophoridae	<i>Anthophora</i>	<i>bomboides</i> Kirby	<i>centralis</i> and <i>occidentalis</i>

* Mimic Bombini color and flight patterns in general.

groups—e.g., *B. bifarius* and *edwardsii*, *B. caliginosus* and *vosnesenskii*, *B. fervidus* and *sonorus*. On the rare occasion when two closely related species belong to the same Müllerian mimetic group, they are principally allopatric—e.g., *B. caliginosus* and *vandykei*, *B. edwardsii* and *sylvicola*.

In general, color patterns among Bombini tend to be limited geographically and may be repeated in disjunct areas. A prominent Bombini color pattern in Europe is all black except for the tip of the abdomen, which is red. This pattern reappears in Japan and in the Neotropical Region.

Batesian mimics of bumble bees occur in several different orders of insects. The most prominent among these are the flies. Principal Batesian mimics in California and their probable *Bombus* models are listed in Table 5.

Some of the Batesian mimics are highly variable in color pattern and mimic more than one kind of bumble bee model—e.g., *Arctophila flagrans*, *Eristalis bardus*, *Merodon equestris*, *Volucella bombylans*, and *Anthophora bomboides*. Occasionally mimetic color variants will appear in areas which are allopatric from the proper model. It would be of interest to know what percentage of a population exhibits the wrong color pattern, and the effects of these “mistakes” on subsequent generations.

Anthophora bomboides is an anthophorid bee, but its females do not sting and therefore it is considered as a Batesian mimic. The predominantly coastal subspecies *A. b. stanfordiana* Cockerell closely resembles *Bombus occidentalis*, while the Sierran subspecies *sodalis* Cresson has red hair on the abdomen, as is typical of many Boreal bumble bees.

Bombus and *Psithyrus* males cannot sting, even though they will go through the appropriate motions and buzz when handled. Therefore they also are protected by resembling the females. Males of *B. caliginosus* and *vosnesenskii* closely resemble the female color pattern (cf. Figs. 115 and 142; 125 and 152), but there is considerable variation in male color patterns of *B. californicus*, *P. insularis*, and *P. fernaldae*, with many having much more yellow than the females (cf. Figs. 109 and 135; 127 and 155; 129 and 156). Most of the males of *B. vandykei* are predominantly yellow (Fig. 124a), and are thus very different from the female color pattern. In general, males of Bombini tend to be more variable in color pattern than their females; and occasionally, as in *B. vandykei*, they do not

resemble the Müllerian mimetic group of their females. The males, however, are only “winged gametes” and therefore much more expendable in the reproduction of the species than are the colony-founding queens. Thus the selection pressures on males to conform to the color pattern of a Müllerian group should be less than on the females. Divergence of male from female color patterns also reduces the load of harmless individuals resembling the females.

The cerambycid beetle *Ulochaetes* resembles a bumble bee in several characteristics (Hardy and Preece, 1926)—appearance, coloration, flight behavior, buzzing sound—and even “makes a bluff at stinging with the ovipositor.” This whole range of characteristics, including attempts at stinging, occurs in most Batesian mimics of bumble bees, except in the scarab beetles. None of the scarab beetles look much like bumble bees while at rest; however, their flight behavior and sound are very bumble bee-like.

TAXONOMIC METHODS

Our anatomical terminology follows Michener (1944), especially in the use of the terms *mesosoma* and *metasoma* for the middle and hind portions of the body. Thus abdominal segment I, the propodeum, is fused with the thorax and is considered with that body division as the mesosoma. Abdominal segments II onward form the apparent abdomen following the constriction, and are renumbered as *metasomal tergites* or *sternites* 1 onward.

Most couplets in the keys begin with external anatomical features used as primary characters. Hidden structures—male genital capsules and metasomal sternites 7 and 8 or female sting capsules—are used as secondary characters. Hair color is used only as a tertiary character. Thus our keys tend to separate natural groupings of subgenera and species groups.

The shapes of male gonostyli and penis valve apices (Figs. 35-52) provide diagnostic species and group characters. The shapes of male sternites 7 and 8, the subgenital plates (Figs. 53-76), are valuable as group characters. Occasionally the apices of the genital capsule are visible if the tip of the abdomen is open, but usually the capsule and subgenital plates must be extruded, but not necessarily detached, for examination.

The shape of the inner margin of the second valvular ramus on the anterior aspect of the queen sting capsule (Figs. 77-99) is useful, especially at the species group level (Hazeltine and Chandler, 1964). In some taxa—e.g., *Pyrobombus* and *Cullumanobombus*—the membrane between the valvulae contains isolated, irregular-shaped, blackened, paired thickenings (Figs. 79-81, 88-95). These thickenings are scars resulting from copulation and therefore only occur in mated queens (Cumber, 1949a). In *Psithyrus*, but not in *Bombus*, the lateral sting plates are fused dorsally above the anus and sting palps (Figs. 97b-99b). To observe these characters, the entire sting capsule must be

extruded. It does not need to be detached, but should be rotated upward to expose the anterior face.

We have examined over 46,000 specimens of Bombini during this study. Many were from outside California, but these aided in formulating taxonomic decisions and evaluating distribution and ecological data for the California species. Our flight distributions (Figs. 1-27) are based on over 30,000 records. The flower records are based on over 7,400 specimens with associated flower data. All plant names have been corrected to agree with Munz and Keck (1959).

SYSTEMATICS

The Bombini belong to the family Apidae (*s. str.*), which also includes the Neotropical, metallic, euglossine bees (Euglossini: Bombinae); the Pan-tropical stingless bees (Meliponinae); and the Palearctic-Oriental (now Cosmopolitan) honey bees (Apinae). The family is represented in California by 24 species of *Bombus*, 3 species of *Psithyrus*, and the introduced honey bee, *Apis mellifera* L. The Bombini are distinguished readily from the honey bee by their generally larger size; their longer, more dense, brightly colored hair; the presence of metatibial spurs; the absence of hairs on the compound eyes; and the absence of the jugal lobe of the hindwing.

Most Bombini vary tremendously in color pattern. In many species or species complexes, color varies geographically so that many of the variants have been recognized as subspecies. However, many of these color forms have such broad zones of intergradation that the use of subspecies names has little value, since they can be identified only in the extreme (see *B. occidentalis*). In addition, several distinct color forms of one or both sexes may occur sympatrically or sporadically throughout the species range without any geographic pattern (see *B. rufocinctus*). Taxonomists have overworked color differences among Bombini, naming species and subspecies which were no more than color variants. This has resulted in long lists of synonymies, many of which may become longer as biosystematic studies are completed.

Our classification of *Bombus* is essentially that used by Stephen (1957) and Richards (1968). For *Psithyrus*, we use the subgenera proposed by Frison (1927a). We are not recognizing subspecies as formal taxonomic categories here for the reasons expressed above and since most Bombini in California are represented by a single color form. We use available intraspecific names only for convenience in discussions of population variation. We

have been conservative in retaining traditional species concepts, while recognizing that some may deserve no more than subspecies or color-form status. Since the critical areas for population studies of many of these species complexes are principally outside California, we will not attempt to resolve the taxonomic questions. Some of the pairs of species which need critical examination in areas where they coexist include: *B. appositus* and *borealis* Kirby; *B. californicus* and *fervidus*; *B. sonorus* and *pennsylvanicus*; *B. occidentalis* and *terricola* Kirby; *B. centralis* and *flavifrons*; *B. edwardsii* and *melanopygus*; and *P. suckleyi* and *ashtoni* (Cresson).

In the treatment of species below, q = queen, w = worker, and m = male.

KEY TO THE GENERA OF BOMBINI

1. Females; antennae with 10 flagellomeres; metasoma with 6 visible tergites.....2
Males; antennae with 11 flagellomeres; metasoma with 7 visible tergites.....3
2. (1) Metatibia expanded, concave, shiny, naked outwardly with elongate hairs posteriorly (with corbicula); metasomal sternite 6 without carinae *Bombus*
Metatibia not expanded, convex, opaque, hairy outwardly, posterior hairs no longer than outer hairs (without corbicula); metasomal sternite 6 with distinct lateral carinae (Figs. 100-102).....
..... *Psithyrus*
3. (2) Outer surface of metatibia bare and shiny; volsella and gonostylus hardened and darkened; face usually with yellow hairs..... *Bombus*
Outer surface of metatibia with abundant short dark hairs; volsella and gonostylus membranous; face with black hairs *Psithyrus*

GENUS BOMBUS LATREILLE

Bombus contains about 200 species distributed on all the major land masses except Australia and Africa from the Sahara Desert southward. Approximately half of the species found in America north of Mexico occur in California. The genus is divided into a number of subgenera (Richards, 1968). Of the 10 recognized for America north of Mexico, only *Fraternobombus* is not represented in California.

Characters which in combination are diagnostic for the genus *Bombus* include: (1) annual society with sterile female (worker) caste; (2) dense coat of brightly colored hair; (3) malar space elongate; (4) jugal lobe of hindwing absent; (5) females with metatibial scopa (pollen transport apparatus) modified to corbicula (shiny, expanded, concave plate with long marginal hairs); (6) males with outer face of metatibia flattened, shiny, and largely bare; (7) females without lateral carinae on metasomal sternite 6; (8) males with volsella and gonostylus of genital capsule hardened and darkened.

KEY TO SUBGENERA AND SPECIES OF BOMBUS IN CALIFORNIA

- | | | | | | | |
|----|--|----|-----|------|--|----------------------------|
| 1. | Females..... | 2 | 6. | (5) | Tergite 4 with yellow hair (transmontane California) | <i>fervidus</i> (p. 27) |
| | Males | 25 | | | Tergite 4 with black hair (cismontane California) | <i>sonorus</i> (p. 28) |
| 2. | (1) Malar space (Fig. 30) longer than wide | 3 | 7. | (3) | Ocelli small, at or above supraorbital line, lateral ocelli more than two diameters from compound eye; flagellomere 1 shorter than 2 and 3 combined; clypeus irregularly punctate | 8 |
| | Malar space as long as or shorter than wide..... | 13 | | | Ocelli large, below supraorbital line, lateral ocelli less than two diameters from compound eye (Fig. 28); flagellomere 1 as long as 2 and 3 combined; clypeus uniformly punctate (<i>Bombus</i>) .. | 8 |
| 3. | (2) Mesobasitarsomere with posterior apical angle usually spinose, at least very distinctly elongate | 4 |  |  | ..... | <i>nevadensis</i> (p. 18) |
| | Mesobasitarsomere with posterior apical angle obtuse, more or less rounded | 7 | 8. | (7) | Malar space less than twice as long as flagellomere 1; facial hair pale, yellowish (<i>Pyrobombus</i> part) | 9 |
| 4. | (3) Elevated central part of clypeus with numerous coarse and fine punctures intermixed; facial hair black (<i>Fervidobombus</i>)..... | 5 | | | Malar space at least twice as long as flagellomere 1; facial hair black (<i>Alpinobombus</i>)..... | <i>balteatus</i> (p. 48) |
| | Elevated central part of clypeus with few minute punctures; facial hair pale, whitish (<i>Subterraneobombus</i>) | | 9. | (8) | Tergites 1 and 2 with black hair; tergite 3 or 4 with yellow hair | 10 |
| 5. | (4) Scutellum and terga 1 to 3 with yellow hair..... | 6 | | | Tergites 1 and 2 with yellow hair, at least laterally; tergites 3 and 4 with hair red, black, or black basally and laterally and reddish medioapically | 11 |
| | Scutellum and terga 1 to 3 with black hair, scutellum occasionally with some yellow intermixed laterally | | 10. | (9) | Tergite 3 with black hair; tergite 4 with yellow hair; only sternites 3 and 4 with yellowish hair apically, 2 and 5 with black hair apically | <i>caliginosus</i> (p. 33) |
|  | ..... |  |  |  | Tergite 3 with black hair basally and yellow apically; tergite 4 with black hair; sternites 2 through 5 with yellow hair apically | <i>vandykei</i> (p. 45) |
|  | ..... |  | 11. | (9) | Tergites 3 and 4 with predominantly black hair; thorax anterior to tegulae with yellow and black hair intermixed, giving clouded appearance | 12 |
|  | ..... |  |  |  | Tergites 3 and 4 with red hair; thorax anterior to tegulae with yellow hair | <i>centralis</i> (p. 35) |
|  | ..... |  | 12. | (11) | Face with mixture of pale and black hairs, giving clouded appearance; scutellum with predominantly black hair; tergites 5 and 6 with predominantly pale hair.... | |
|  | ..... |  |  |  | ..... | <i>sitkensis</i> (p. 42) |
|  | ..... |  |  |  | Face with yellow hair; scutellum with predominantly yellow hair; tergites 5 and 6 with predominantly black hair | |
|  | ..... |  |  |  | ..... | <i>flavifrons</i> (p. 37) |
|  | ..... |  | 13. | (2) | Lateral ocelli less than two diameters from eyes; ocelli below supraorbital line; face with black hairs | 14 |
|  | ..... |  |  |  | Lateral ocelli more than two diameters from eyes; ocelli at supraorbital line; | |

- face with yellow or yellow and black hair intermixed.....17
14. (13) Clypeus centrally with coarse and fine punctures intermixed; frons with dense band of coarse and fine punctures along inner margin of eyes laterad from ocelli; scutellum and tergite 1 with yellow hair15
 Clypeus centrally with minute sparse punctures; frons sparsely punctate with cluster of fine punctures and single row of coarse punctures along inner margin at eye laterad from ocelli; scutellum and tergite 1 with black hair (*Crotchiibombus*) *crotchii* (p. 21)
15. (14) Integument of tergites 1 and 2 dull; pubescence of scutum and scutellum short, dense, virtually obscuring integument, and all yellow (*Separatobombus*).....16
 Integument of tergites 1 and 2 shiny; pubescence of scutum and scutellum long, sparse, with integument readily visible, with much black hair medially between tegulae (*Cullumanobombus*).....
 *rufocinctus* (p. 23)
16. (15) Mesosomal pleurae with hair yellow; vertex with hair predominantly black; tergite 2 with hair black laterally and apically; tergite 3 with hair all black.....
 *griseocollis* (p. 19)
 Mesosomal pleurae with hair black; vertex with hair predominantly yellow; tergite 2 with hair yellow; tergite 3 with yellow hair at least basomedially ...
 *morrisoni* (p. 20)
17. (13) Flagellomere 1 equal to 3; malar space wider than long; sting capsule with inner margin of second valvular ramus with teeth (2 or 3) projecting mesad (Figs. 86, 87) (*Bombus*)18
 Flagellomere 1 longer than 3; malar space as long as or longer than wide; sting capsule with inner margin of second valvular ramus smooth and without teeth (Figs. 88-95) (*Pyrobombus* part)19
18. (17) Yellow hair on scutum extending posteriorly beyond tegulae, broadly emarginate medially (U-shaped) (Fig. 139); scutellum with black hair; metasomal tergites with black hair, except for few pale hairs in extreme lateral margins of tergite 5 *franklini* (p. 29)
 Yellow hair on scutum usually not extending posteriorly beyond tegulae, or if so, then scutellum with yellow hair (Figs. 140a, 140b); metasomal tergites 4 apically and 5 and 6 with white or brownish white hair, sometimes tergites 2 apicolaterally and 3 with yellow hair *occidentalis* (p. 30)
19. (17) Tergite 4 with black hair laterally and basally, reddish or brownish white medioapically; tergite 2 with yellow hair, at least centrally; tergites 5 and 6 with reddish or brownish white hair.....
 *mixtus* (p. 41)
 Tergite 4 with hair all yellow, all black, or yellow laterally and black centrally; tergite 2 with predominantly red or black hair; tergite 5 with hair all black or with yellow laterally, tergite 6 with hair all black.....20
20. (19) Tergites 2 and 3 with red hair; if red hair reduced to small apicolateral patches as in Sierran *sylicola*, then face with yellow hair centrally and black hair peripherally21
 Tergites 2 and 3 with black hair; face with yellow hair23
21. (20) Pubescence of scutum anterior to tegulae yellow.....22
 Pubescence of scutum anterior to tegulae yellow and black intermixed, giving clouded appearance *melanopygus* (p. 40)
22. (21) Tergite 5 with black hair; face with yellow hair; pubescence short, uniform.....
 *huntii* (p. 39)
 Tergite 5 with yellow hair laterally; face with black hair predominant above antennal bases; pubescence long, shaggy *sylicola* (p. 43)
23. (20) Scutellum, tergite 1, and pleura with black hair *vosnesenskii* (p. 46)
 Scutellum (at least laterally), tergite 1, and pleura (at least anteriorly) with yellow hair24
24. (23) Scutellum and pleura with hair all yellow; tergite 5 with yellow hair laterally
 *edwardsii* (p. 36)
 Scutellum with V-shaped notch of black hair centrally extending to posterior border, dividing yellow hair into two lateral patches (Fig. 141); pleura with hair black ventroposteriorly; tergite 5 with hair all black *bifarius* (p. 32)
25. (1) Eyes large, protuberant, width in profile (anterior to posterior) equal to or wider than gena; ocelli large, well below supraorbital line; lateral ocelli about one diameter or less from inner margin of eye (Fig. 29).....26

- ✓ Eyes as in females, not protuberant, width in profile much narrower than width of gena; ocelli small, at supraorbital line; lateral ocelli about two diameters or more from inner margin of eye.....30
26. (25) Eyes distinctly convergent above, with interocular distance at top only half that at bottom (Fig. 29); lateral ocelli 1/5 diameter or less from eye; flagellum twice as long as scape; flagellomere 1 as long as 2 plus 3; penis valves straight, without subapical teeth (Fig. 33); malar space about as long as wide (*Bombias*) *nevadensis* (p. 18)
- Eyes slightly convergent above, with interocular distance at top at least 3/4 that at bottom; lateral ocelli 1/3 to one diameter from eye; flagellum three times as long as scapel; flagellomere 1 shorter than 2 plus 3 (subequal to or shorter than 3); penis valves with apex curved mesad or laterad (Figs. 35b-48b) or with subapical teeth laterally (Fig. 49b); malar space shorter than wide.....27
27. (26) Flagellomere 1 shorter than 3; scutum with band of black hair between tegulae28
- Flagellomere 1 subequal to 3; scutum between tegulae with predominantly yellow hair, except occasionally with few black hairs centrally surrounding naked disc (*Separatobombus*)29
28. (27) Lateral ocelli about one diameter or slightly more from eye; metabasitarsomere short, wide, length 2.4 to 2.6 times width; head width 4/5 of distance between tegulae; volsella long and protruding beyond gonostylus by at least its length (Fig. 38a) (*Cullumanobombus*) *rufocinctus* (p. 23)
- Lateral ocelli 1/3 to 1/2 diameter from eye; metabasitarsomere long, narrow, length 4 to 5 times width; head width subequal to distance between tegulae; volsella barely extending beyond gonostylus (Fig. 37a) (*Crotchiibombus*) *crotchii* (p. 21)
29. (27) Scutum with some black hair surrounding naked central disc; tergite 3 with black hair; penis valve with short abrupt apex curved mesad, but not bent back on itself (Fig. 35b) *griseocollis* (p. 19)
- Scutum completely covered with yellow hair; tergite 3 with yellow hair; penis valve with long, tapering apex curved mesad and doubled back on itself (Fig. 36b) *morrisoni* (p. 20)
- ✓ 30. (25) Antennal flagellum twice as long as scape; head round, wider than long; penis valves wide, sinuate, vertical plates (Figs. 42b, 42c) (*Bombus*)31
- Antennal flagellum 2.5 or more times as long as scape; head triangular, longer than wide; penis valves narrow, linear, sometimes recurved apically32
31. (30) Scutum with yellow hair extending latero-posteriorly behind tegulae to scutellum, and black hair centrally around disc (Fig. 112); scutellum with black hair; metatibia with fringe hairs predominantly black..... *franklini* (p. 29)
- Scutum with yellow hair not extending posteriorly beyond tegulae, except when scutellum with yellow hair (Fig. 113); metatibia with fringe hairs predominantly ferruginous *occidentalis* (p. 30)
32. (30) Antennal flagellum more than three times as long as scape; malar space twice or more as long as wide; penis valves apically not hooked, some with subapical lateral teeth or projections (Figs. 39b-41b, 49b)33
- ✓ Antennal flagellum 2.5-3 times as long as scape; malar space less than twice as long as wide; penis valves apically recurved inward, hook-shaped or sickle-shaped (Figs. 43b-48b) (*Pyrobombus*)37
33. (32) Metatibia with fringe hairs longer than width of tibia, disc bare; penis valves straight apically, with three short subapical teeth projecting outward (Fig. 49b); gonostylus longer than wide, not projecting inward basally beyond inner margin of gonocoxa (Fig. 49a) (*Alpinobombus*) *balteatus* (p. 48)
- Metatibia with fringe hairs shorter than width of tibia, disc covered throughout with short hairs; penis valves bent outward apically, without subapical short teeth; gonostylus wider than long, projecting inward basally nearly to penis valves.....34
34. (33) Malar space nearly half length of eye; penis valves apically with inward and outward projections, subapically with trilobed plate-like outward projection (Figs. 41b-d); gonostylus with basal inward projection dorsoventrally,

- flattened and curved back on itself distally (Fig. 41a) (*Subterraneobombus*).
 *appositus* (p. 24)
- Malar space less than 1/3 length of eye; penis valves apically turned outward, without subapical plate-like projection; gonostylus with basal inward projection anteroposteriorly flattened, not recurving distally (*Fervidobombus*) 35
35. (34) Tergite 5 with hair predominantly yellow; penis valves with apex hatchet-shaped, about as long as wide (Fig. 39b) 36
- Tergite 5 with hair predominantly black; penis valves with apex about three times longer than wide (Fig. 40b)
 *sonorus* (p. 28)
36. (35) Scutellum and tergites 1 through 3 with predominantly black hair
 *californicus* (p. 25)
- Scutellum and tergites 1 through 3 with yellow hair *fervidus* (p. 27)
- ✓ 37. (32) Basal flagellomeres uniformly covered with microscopic hairs, without any dense tufts on inner faces 38
- Basal flagellomeres with dense tufts of elongate appressed hairs on inner faces (Fig. 34) *mixtus* (p. 41)
- ✓ 38. (37) Flagellomere 1 subequal to or slightly longer than 3; penis valves with recurved apices broad, smoothly rounded, sickle-shaped (Fig. 44b); sternite 8 apically membranous, medially pointed, occasionally with small pointed lateral lobes (Figs. 63, 64, 66) 39
- Flagellomere 1 shorter than 3; penis valves with recurved apices narrowed, often sharply bent, often pointed at apex and hook-shaped (Figs. 43b, 45b-48b); sternite 8 of uniform thickness, truncate or medially emarginate (Figs. 62, 65, 67-72) 42
39. (38) Scutellum, pleura, and tergites 1 and 2 with black hair *caliginosus* (p. 33)
- Scutellum, pleura, and tergites 1 and 2 with yellow hair 40
40. (39) Tergites 3 through 5 with red hair
 *centralis* (p. 35)
- Tergites 3 through 5 with yellow or black hair 41
41. (40) Tergites 3 and 4 with yellow hair, rarely with few black hairs medioapically on tergite 4 *vandykei* (p. 45)
- Tergites 3 and 4 with black hair at least basally, with at most only small fringes of yellow hair apicolaterally
 *flavifrons* (p. 37)
- ✓ 42. (38) Gonostylus elongate, narrow, basally curving inward beyond and below inner apical margin of gonocoxite (Fig. 43a); penis valve evenly recurved with apex narrowed, almost pointed (Fig. 43b) 43
- Gonostylus short, broad, basally not extending inward beyond inner apical margin of gonocoxite; penis valve with sharp angle at middle of apical curvature, rounded apically 45
43. (42) Scutellum and tergite 1 with black hair; gonostylus about twice as long as broad and broadly rounded apically
 *vosnesenskii* (p. 46)
- Scutellum and tergite 1 with yellow hair; gonostylus less than twice as long as broad, and narrowed, almost pointed apically 44
44. (43) Tergites 2 and 3 with red hair; scutellum with hair all yellow; metatibia with black hair on outer and posterior surfaces (transmontane in California)
 *huntii* (p. 39)
- Tergite 2 with hair yellow medially, black laterally, tergite 3 with black hair; scutellum with lateral patches of yellow hair separated by median V-shaped notch of black hair (Fig. 114a); metatibia usually without black hair on outer and posterior surfaces (cismontane in California) *bifarius* (p. 32)
45. (42) Apex of penis valve bulbous, broader than portion leading up to it (Fig. 46b); scutellum with short V-shaped emargination of black hairs anteriorly (Fig. 123a) *sylicola* (p. 43)
- Apex of penis valve rounded, but not swollen, as wide as portion leading to it (Figs. 45b, 48b); scutellum with hair all yellow 46
46. (45) Tergites 2 and 3 with black or red hair; scutellum with all yellow hair; tergite 4 with yellow hair; tergites 6 and 7 with black hair 47
- Tergites 2 and 3 with predominantly yellow hair, at least apically, scutellum with black hair basomedially, only fringe of yellow hair apically and laterally; tergite 4 with black hair; tergites 6 and 7 with coppery hair
 *sitkensis* (p. 42)
47. (46) Tergites 2 and 3 with red hair
 *melanopygus* (p. 40)
- Tergites 2 and 3 with black hair
 *edwardsii* (p. 36)

Subgenus *Bombias* Robertson

Brief diagnosis. FEMALES: ocelli large, below supraorbital line; malar space longer than wide; flagellomere 1 as long as 2 plus 3; clypeus uniformly punctate; sting capsule with inner margin of second valvular ramus smooth, without projections. MALES: compound eyes large, protuberant, distinctly convergent above; flagellum short, twice as long as scape; flagellomere 1 as long as 2 plus 3; penis valves straight, not recurves apically.

Bombus nevadensis Cresson

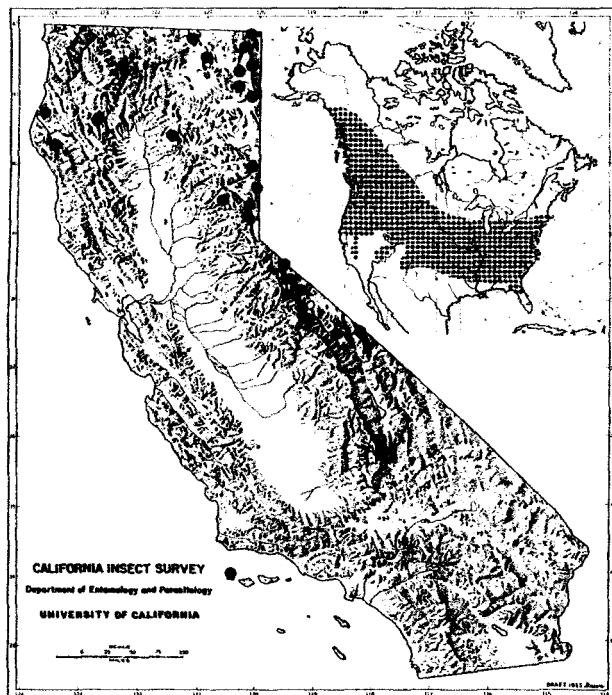
(Figs. 1, 28-33, 77, 103, 131; Map 1)

Bombus nevadensis Cresson, 1874, Trans. Amer. Entomol. Soc., 5:102. q.m. Lectotype q, Nevada (#2637, ANSP) (selected by Cresson, 1916).

Bombus nevadensis miguelensis Cockerell, 1937, Pan-Pac. Entomol., 13:148. m. Holotype m, San Miguel Island, Santa Barbara Co., California (#4649 CAS).

Bombus croichii semisuffusus Cockerell, 1937, Pan-Pac. Entomol., 13:148. q. Holotype q, San Miguel Island, Santa Barbara Co., California (#4650, CAS).

Geographic range (Map 1). W. of 100° longitude, from western Nebraska W to California and N to Saskatchewan and Yukon Territory (Canada). The eastern subspecies *auricomus* continues to the East Coast from Massachusetts to Florida.



Map 1. Nearctic distribution of *Bombus nevadensis*.

California records. HUMBOLDT CO.: Eureka; Mad River beach; Shively. INYO CO.: Long Valley. LASSEN CO.: Blue Lake; Hallelujah Junction; Susanville. MODOC CO.: Alturas, and 8 km E; Cedar Pass, 5 km NE; Cedarville; Davis Creek; Goose Lake Valley; Hackamore; Lake City; Likely; Newell; New Pine Creek. MONO CO.: Bridgeport; Crestview, 17.5 km S; Crooked Creek, White Mtns.; Fales Hot Springs; Grant Lake; Leavitt Meadows; Mill Creek Canyon; Mono Lake; Pickel Meadow; Sonora Junction; Topaz Lake. NEVADA CO.: Truckee. PLUMAS CO.: Quincy, 6.5 km W. SANTA BARBARA CO.: San Miguel Island. SHASTA CO.: Shingletown. SIERRA CO.: Sierraville. SISKIYOU CO.: Etna; Tule Lake. TRINITY CO.: Helena. TUOLUMNE CO.: Mt. Dana; Sonora Pass.

Seasonal flight period (Fig. 1). QUEENS (104): early April to late September. WORKERS (81): late May to late September. MALES (13): early July to late August.

Flower records. QUEENS (19): Leguminosae 58%; Compositae 10%; Saxifragaceae 10%. WORKERS (33): Leguminosae 64%; Compositae 21%; Labiatae 12%. MALES (1): Leguminosae. Total: 53 in 7 families with 14 genera as follows: *Althaea*: 1q, 1w; *Astragalus*: 4q, 6w; *Balsamorhiza*: 1q; *Ceanothus*: 1q; *Cirsium*: 1q, 3w; *Helianthus*: 4w; *Lupinus*: 1q; *Medicago*: 1m; *Melilotus*: 13w; *Mentha*: 1q, 4w; *Mesembryanthemum*: 1q; *Ribes*: 2q; *Thermopsis*: 1q; *Vicia*: 5q, 2w.

Discussion. *B. nevadensis* is not closely related to other California Bombini. It is recognized by the characters given in the subgeneric diagnosis.

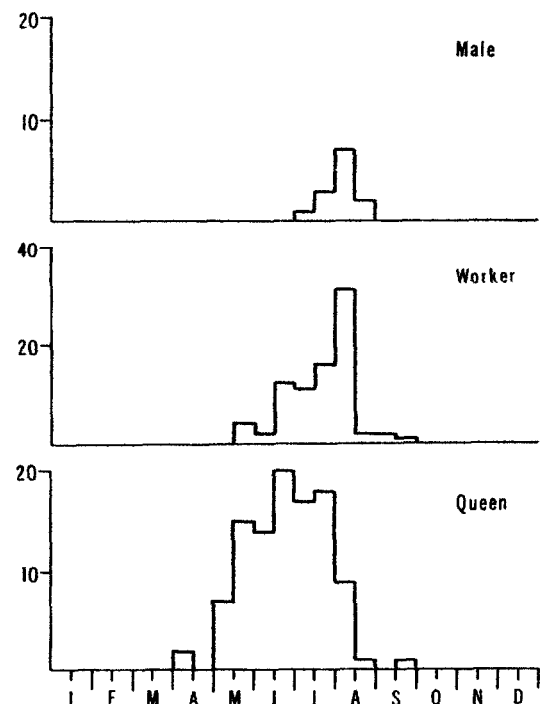


Fig. 1. Histograms of seasonal flight activity for *Bombus nevadensis*.

Stephen (1957: 61) was "inclined to question the conspecificity of this form (*c. semisuffusus*) with the typical *crotchii*" mainly on the basis of its much longer malar space. The type of *semisuffusus* in the California Academy of Sciences collection was examined by RWT, who found that in addition to the long malar space it has the long flagellomere 1 and fine, uniform clypeal punctation which makes it unquestionably a color variant of *nevadensis* and not of *crotchii*. The female of *semisuffusus* was collected in the same locality and within two days of the male *nevadensis miguelensis*. Both resemble *crotchii* in color pattern; however, Cockerell (1937) correctly assigned the male because "The genitalia are of the *B. nevadensis*, not *B. crotchii* type." Milliron (1971) correctly synonymized *crotchii semisuffusus* and *nevadensis miguelensis* as color variants of *nevadensis*, but he provided no discussion supporting his action and did not include San Miguel Island or any coastal California localities in his distribution records.

This species exhibits considerable color variation. The most common female color pattern in California, the nominate form, resembles *B. morrisoni* (cf. Figs. 131a, 134). It occurs principally from transmontane California E to 100° W longitude, where it is replaced by a darker eastern form, *auricomus* (Robertson), which resembles *B. pennsylvanicus*. These two forms of *nevadensis* intergrade between 102° and 98° W longitude in Nebraska (LaBerge and Webb, 1962). The nominate form also grades into a darker color form in Humboldt County (Eureka, Mad River beach, Shively), some of which have the same color pattern as *miguelensis* from Santa Barbara County (San Miguel Island) (Figs. 131a, 131b). This intergradation and chromatic variability in the Humboldt County populations suggest the inappropriateness of using a subspecific epithet for the coastal California populations. These coastal forms resemble *B. crotchii* and "nigroscutatus" populations of *B. occidentalis*, especially in the females (cf. Figs. 130, 140a).

The San Miguel Island population is geographically isolated from other *nevadensis*. The nearest coastal populations with the color pattern of *miguelensis* are over 725 km NNW in Humboldt County. The nearest populations, almost 320 km ENE in Inyo County, are of the nominate color pattern. It appears then that the *miguelensis* form represents a disjunct relict of the northern coastal populations.

The biology of the nominate form is discussed by Hobbs (1965a), and Frison (1917, 1918) discussed the biology of *auricomus*. Hobbs (1965a) found that *Psithyrus insularis* and *P. suckleyi* established in nests, and that *Physocephala texana* (Williston) parasitized adults of *B. nevadensis* in Alberta, Canada.

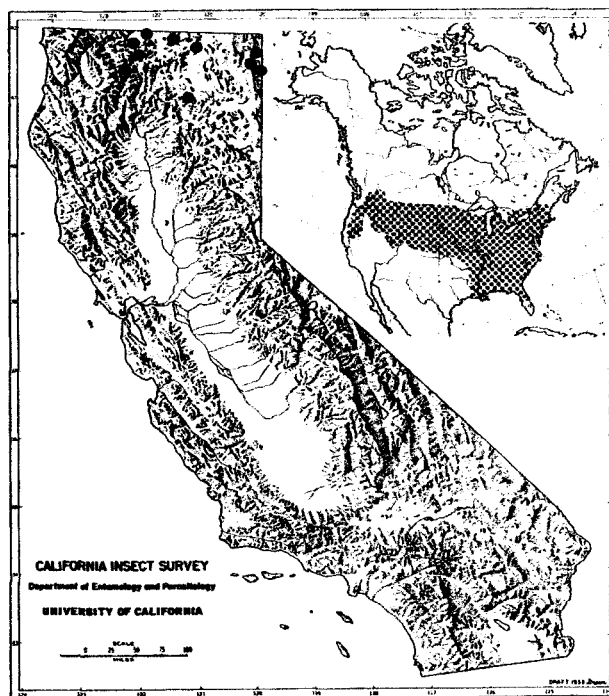
Subgenus *Separatobombus* Frison

Brief diagnosis. FEMALES: ocelli large, below supraorbital line; malar space shorter than wide; flagellomere 1 shorter than 2 plus 3; clypeus with coarse and fine punctures intermixed centrally; frons with dense band of coarse and fine punctures along inner margins of eyes; sting capsule anteriorly with inner margin of second valvular ramus projecting inward medially. MALES: compound eyes large, protuberant, slightly convergent above; flagellum long, three times as long as scape; flagellomere 1 subequal to 3; penis valve with apex curved mesad, short and blunt.

Bombus griseocollis (Degeer) (Figs. 2, 35, 53, 78, 106, 133; Map 2)

Apis griseocollis Degeer, 1773, Mem. Serv. Hist. Insectes, 3:576 w. Lectotype w, no locality (Natl. Riksmus., Stockholm, Sweden) (selected by Milliron, 1960).

Geographic range (Map 2). Southern Canada and most of the United States, except the southwestern states; Maine to Florida W to British Columbia and northeastern California.



Map 2. Nearctic distribution of *Bombus griseocollis*.

California records. MODOC CO.: Cedarville; Davis Creek; Fandango Pass; Newell. SHASTA CO.: McArthur, and 11 km E. SISKIYOU CO.: Copco; Etna; Gazelle, 5 km N; Lower Klamath Lake; Montague, and 16 km NE; Yreka, 5 km W.

Seasonal flight period (Fig. 2). QUEENS (86): late March to early October. WORKERS (357): late April to late September. MALES (307): late June to early October.

Flower records. QUEENS (17): Compositae 41%; Leguminosae 35%; Asclepiadaceae 12%; Rosaceae 12%. WORKERS (137): Leguminosae 45%; Compositae 29%. MALES (106): Compositae 75%; Leguminosae 19%. Total: 260 in 13 families with 29 genera as follows: *Althaea*: 4w, 1m; *Asclepias*: 2q, 8w; *Borago*: 1w; *Brunnichia*: 4w; *Caragana*: 1q; *Cercis*: 1q; *Chrysothamnus*: 10w, 24m; *Cirsium*: 1q, 3w, 9m; *Convolvulus*: 2w; *Gossypium*: 4w; *Helianthus*: 2q, 25w, 42m; *Lotus*: 1w; *Medicago*: 2q, 27w, 1m; *Melilotus*: 25q, 18m; *Mentha*: 1m; *Monarda*: 3w; *Petalostemon*: 1w; *Pontederia*: 1w, 2m; *Prunus*: 1q; *Pycnanthemum*: 3w, 2m; *Pyrrhopappus*: 1w; *Rhus*: 2w; *Robinia*: 1q; *Rubus*: 1q, 1w; *Sedum*: 1w; *Solidago*: 1q, 1w, 4m; *Trifolium*: 1q, 8w, 1m; *Verbena*: 1w; *Wyethia*: 3q.

Discussion. *B. griseocollis* is most closely related to *B. morrisoni*. Its females are readily recognized by the yellow hair on the pleura and black hair on metasomal tergite 3 (cf. Figs. 133, 134). Males can be distinguished from *morrisoni* by the apices of the penis valves, which are short, abrupt, and curved mesad but not recurved (cf. Figs. 35b, 36b).

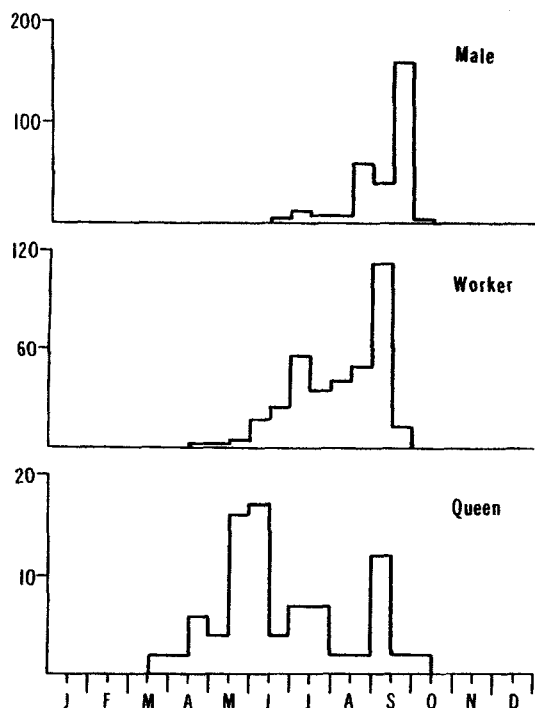


Fig. 2. Histograms of seasonal flight activity for *Bombus griseocollis*.

This species is rare in California and occurs principally in the northern transmontane area. Most of the flight and flower records are based on data from specimens collected outside the state.

The biology of this species is discussed by Plath (1927, 1934) and Medler and Carney (1963). The perching habit of males is mentioned by Plath (1934). In southern Michigan, RWT observed males perching and darting out at approaching insects or small objects tossed near them and returning to their original perch.

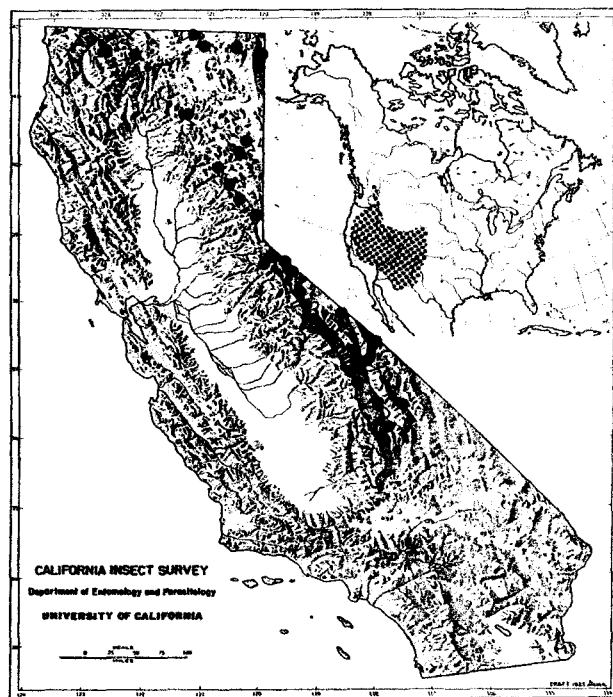
Bombus morrisoni Cresson

(Figs. 3, 36, 54, 79, 107, 134, 167; Map 3)

Bombus morrisoni Cresson, 1878, Proc. Acad. Nat. Sci. Phila., p. 183. q, w, m. Lectotype q, Colorado (#2632 ANSP) (selected by Cresson, 1916).

Geographic range (Map 3). W of 100° longitude, western South Dakota S to New Mexico and W to southern British Columbia, Canada, and S to Sonora, Mexico.

California records. ALPINE CO.: Carson Pass; Leviathan Peak, 2710 m; Woodfords. INYO CO.: Alabama Hills; Big Pine, and 5 km E and 6.5 km S; Bishop, 16 km N; Deep Spring Lake; Independence; Lone Pine; Mazourka Canyon; Oak Creek; Onion Valley, Inyo Natl. For.; Panamint Mtns.; Silver Canyon, White Mtns.; Surprise Canyon; Westgard Pass; Whitney Portal;



Map 3. Nearctic distribution of *Bombus morrisoni*.

Wyman Canyon, White Mtns. LASSEN CO.: Honey Lake, Janesville; Standish, 6.5 km W. MODOC CO.: Cedar Pass; Juniper Flat; Lake City; Newell; Saddleblanket Flat. MONO CO.: Benton; Bridgeport; Convict Lake; Crestview, 13 km S; Crooked Creek, White Mtns.; Crowley Lake; Grant Lake; Mill Creek; Monitor Pass; Mono Lake, 16 km N Lee Vining; Pickel Meadows; Rock Creek; Tom's Place; Topaz Lake. NEVADA CO.: Truckee. PLUMAS CO.: Blairsden; Keddie, 3 km W. SHASTA CO.: Hat Creek P.O. SIERRA CO.: Sierraville. SISKIYOU CO.: Montague; Scott Bar; Tule Lake. TUOLUMNE CO.: Sonora Pass.

Seasonal flight period (Fig. 3). QUEENS (158): early March to late September. WORKERS (521): early June to late September. MALES (230): early July to late October.

Flower records. QUEENS (25): Compositae 36%; Cruciferae 24%; Gentianaceae 12%. WORKERS (163): Compositae 32%; Leguminosae 16%; Ranunculaceae 12%; Capparidaceae 11%; Labiatae 10%. MALES (120): Compositae 96%. Total: 308 in 15 families with 32 genera as follows: *Althaea*: 1q, 7w; *Asclepias*: 6w; *Aster*: 9m; *Astragalus*: 1q; *Balsamorhiza*: 1w; *Brassica*: 1q; *Chrysothamnus*: 1q, 11w, 26m; *Cirsium*: 7q, 15w, 12m; *Cleome*: 18w; *Dalea*: 4w; *Delphinium*: 20w; *Eriogonum*: 1w; *Frasera*: 3q, 3w; *Gaillardia*: 1w; *Geranium*: 1m; *Gutierrezia*: 1w, 2m; *Helianthus*: 3w; *Helianthus*: 15w, 62m; *Marrubium*: 7w, 1m; *Mediticago*: 14w; *Melilotus*: 4w; *Mentzelia*: 2q, 10w; *Monarda*: 1w; *Penstemon*: 1w; *Salvia*: 8w, 1m; *Senecio*: 5w, 4m; *Solanum*: 2w; *Sphaeralcea*: 1q, 1w, 2m; *Stanleya*: 5q; *Tamarix*: 2q; *Taraxacum*: 1q; *Trifolium*: 4w.

Discussion. *B. morrisoni* is most closely related to *B. griseocollis* and may be distinguished from it by

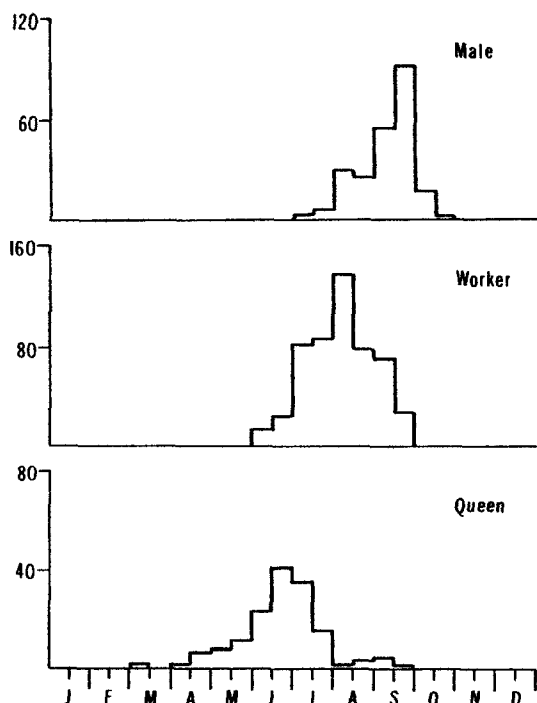


Fig. 3. Histograms of seasonal flight activity for *Bombus morrisoni*.

the characters mentioned in the discussion under that species.

This species occurs principally in transmontane California. Three California specimens are not listed in the above records because of the improbable validity of the data associated with them. The putative localities include Davis, Yolo Co.; Ahwahnee, Madera Co.; and Yosemite Valley, Mariposa Co. None of these localities have produced additional specimens, and even if the bees were collected where the labels indicate, they may have been accidental introductions without species establishment and therefore of little biogeographical importance.

Subgenus *Crotchiibombus* Franklin

Brief diagnosis. FEMALES: ocelli large, below supraorbital line; malar space shorter than wide; flagellomere 1 shorter than 2 plus 3; clypeus with sparse minute punctures centrally; frons sparsely punctate with cluster of fine punctures and single row of coarse punctures along inner margin of eyes; sting capsule anteriorly with inner margin of second valvular ramus projecting inward medially. MALES: compound eyes protuberant, slightly convergent above; flagellum long, three times as long as scape; flagellomere 1 shorter than 3; penis valve with apex recurved mesad, and acuminate.

Bombus crotchii Cresson

(Figs. 4, 37, 55, 80, 104, 130; Map 4)

Bombus crotchii Cresson, 1878, Proc. Acad. Nat. Sci. Phila., p. 184. q. Lectotype q, California (#2168 ANSP) (selected by Cresson, 1916).

Geographic range (Map 4). Central California to Baja California del Norte, Mexico.

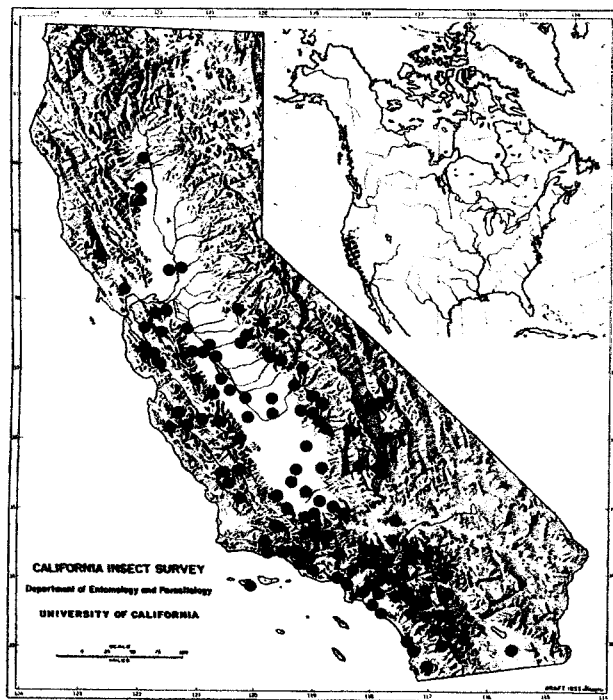
California records. ALAMEDA CO.: Berkeley; Pleasanton; San Leandro. CONTRA COSTA CO.: Antioch; Moraga; Mt. Diablo. FRESNO CO.: Coalinga, 6.5, 11, and 23 km W; Firebaugh, 10 km NW; Five Points; Fresno; Huntington Lake; Jacolitos Canyon; Little Panoche Canyon; Mercey Hot Springs, 8 km E; Orange Cove, 6.5 km N; Oxalis; Panoche; Parlier; Piedra; Trimmer, 11 km SW and 27 km E; Trimmer Springs; Watts Valley. GLENN CO.: Artois; Orland. IMPERIAL CO.: Brawley. INYO CO.: Haiwee; Lone Pine; Owens Lake; Pine Creek. KERN CO.: Arvin; Bakersfield, and 24 and 29 km E; Caliente, 5 km S; Camelo Jct.; Cummings Valley; Frazier Park, 2 km S; Fort Tejon; Kern Canyon; Kernville; Lebec; McFarland, 14 km E; McKittrick, 16 km E; Mill Potrero; Mojave, 13 km W; Rosamond; Shafter; Taft; Tehachapi, and 39 km W; Wheeler Ridge; Woody. LOS ANGELES CO.: Altadena; Azusa, 5 km N, San Gabriel Canyon; Baldwin Hills; Big Pines, Angeles Natl. For.; Big Rock Public Camp, Angeles Natl. For.; Castaic, 16 km N; Claremont; Devils Gate Dam, Flint Ridge; El Segundo; El Segundo Sand Dunes; Glendale; Gorman, and 6 km E; Griffith Park; Jonsons Peak; Littlerock; Llano, and 8 km SE; Los Angeles; Mt. San Antonio; Newhall; Pasadena; Palmdale; Pomona; Santa Monica; Tanbark Flat; Walnut; Westwood Hills; Whittier. MADERA CO.:

Nipinnawasee; San Joaquin Experimental For. MARIPOSA CO.: Exchequer Dam; Wawona. MERCED CO.: Delhi, 3 km S; Dos Palos; Livingston; Merced Falls, 6 km SE; West Panoche Hills. MONTEREY CO.: Arroyo Seco Camp; King City, 14 km E; Soledad. ORANGE CO.: Costa Mesa; Laguna Beach; Newport Beach; Santa Ana; Yorba Linda. RIVERSIDE CO.: Anza, 6 km W; Banning; Corona; the Gavilan, 610 m; Hemet; Magnesia Canyon; Palm Springs; Perris, and 2 km W; Sage, 10 km W; Sunnymead, 13 km E; Temecula. SACRAMENTO CO.: Sacramento. SAN BENITO CO.: Bitterwater, 8 km S; Idria, 10 km SE. SAN BERNARDINO CO.: Bear Valley; Bloomington; Cushenbury Spring, San Bernardino Mtns., 1220 m; Kramer Hills; Loma Linda; Mojave River, near Deep Creek, Mojave Desert; Morongo Valley; Ontario; Phelan; Seeley Flat, San Bernardino Mtns.; Sidewinder Well, Mojave Desert; Verdmont. SAN DIEGO CO.: Anza-Borrego State Park; Banner, 5 km E; Borrego; Carlsbad; Encinitas; La Mesa; Lake Henshaw; Ramona; Santa Ysabel; Spring Valley; Warner Ranch; Warner Springs. SAN JOAQUIN CO.: Tracy. SAN LUIS OBISPO CO.: Atascadero; Paso Robles; Pozo, 16 km E; Shandon, 11 km SW. SANTA BARBARA CO.: Aliso Canyon, 10 km SW New Cuyama; Cachuma Lake, 5 km W; Carpenteria; Cuyama; Cuyama Valley; Goleta; San Marcos Ranch Hqtrs.,

Santa Inez Mtns.; Santa Barbara; Santa Rosa Island. SANTA CLARA CO.: Palo Alto; San Antonio Valley; San Jose. SONOMA CO.: Cloverdale; Sonoma. STANISLAUS CO.: Newman; Patterson; Turlock, and 16 km E. TEHAMA CO.: Red Bluff. TULARE CO.: Ash Mt., Sequoia Natl. Park; Bubbs Creek; Idlewild; Kaweah; Kings Canyon; Lemoncove; Mineralking; Orosi; Porterville; Sequoia Natl. Park; Visalia; Woodlake. TUOLUMNE CO.: Jamestown; Oakland Recreation Camp; Rawhide. VENTURA CO.: Camarillo; Hungry Valley, 8 km S Gorman; Mt. Pinos; Ojai; Santa Paula, Ventura. YOLO CO.: Davis.

Seasonal flight period (Fig. 4). QUEENS (225): late February to late October. WORKERS (349): late March to late October. MALES (122): late May to early September.

Flower records. QUEENS (50): Leguminosae 36%; Labiatae 12%; Hydrophyllaceae 10%. WORKERS (95): Leguminosae 36%; Asclepiadaceae 24%; Compositae 14%. MALES (41): Asclepiadaceae 54%; Leguminosae 22%; Compositae 22%. Total: 186 in 15 families with 33 genera as follows: *Amsinckia*: 4q; *Asclepias*: 2q, 23w, 22m; *Astragalus*: 5q; *Brassica*: 3q, 1w; *Chaenactis*: 1q, 11w; *Delphinium*: 2w; *Eriodictyon*: 2w; *Eriogonum*: 3w; *Eschscholtzia*: 3q, 5w; *Gutierrezia*: 1w; *Helianthus*: 6m; *Hemizonia*: 2m;



Map 4. Nearctic distribution of *Bombus crotchii*.

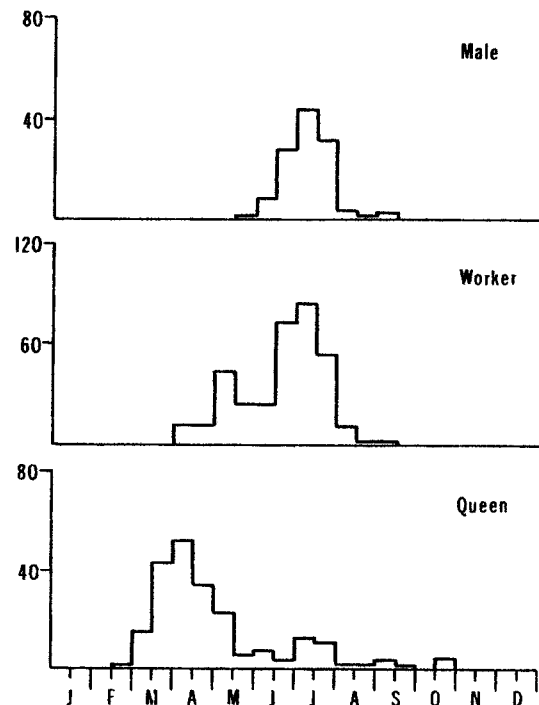


Fig. 4. Histograms of seasonal flight activity for *Bombus crotchii*.

Hypericum: 1w; *Isomeris*: 3q; *Lantana*: 1q; *Lathyrus*: 1q, 1w; *Lepidospartum*: 1m; *Lotus*: 6w, 1m; *Lupinus*: 6q, 92; *Medicago*: 1q, 16w, 7m; *Oenothera*: 1q; *Orthocarpus*: 1q; *Parkinsonia*: 1q; *Penstemon*: 7w; *Phacelia*: 5q, 2w; *Raphanus*: 1q; *Salvia*: 5q, 2w; *Solidago*: 1q, 1w; *Trichostema*: 1q; *Trifolium*: 1q, 1m; *Vicia*: 2w; *Wislizenia*: 1m; *Wisteria*: 3q.

Discussion. *B. crotchii* appears most closely related to members of the subgenus *Separatobombus*. It can be separated from them by the characters given in the subgeneric diagnoses.

The queen which Cockerell named *B. crotchii semisuffusus* is actually a female of *B. nevadensis* (see discussion for that species). Other infraspecific names represent extremes of infrapopulation color variants and do not merit subspecific rank.

Most color variation occurs in the amount of reddish hair on the apical metasomal tergites. In both sexes, reddish hair may be present on all tergites from the apex of tergite 3 to the last tergite, or replaced by black hair on one or all of these. Replacement by black hairs occurs from anterior to posterior.

Subgenus *Cullumanobombus* Vogt

Brief diagnosis. FEMALES: ocelli slightly below supraorbital line; malar space shorter than wide; flagellomere 1 shorter than 2 plus 3; clypeus with coarse and fine punctures intermixed centrally. Sting capsule anteriorly with inner margin of second valvular ramus nearly parallel with outer margin and finely saw-toothed above. MALES: compound eyes large, protuberant, only slightly convergent above; flagellum long, three times as long as scape; flagellomere 1 shorter than 3; penis valve with apex recurved mesad and acuminate; volsella long, protruding beyond gonostylus by at least its length.

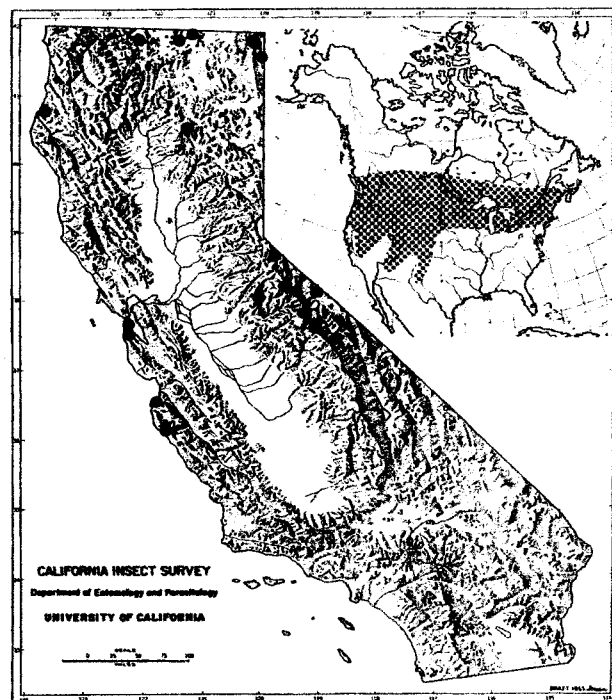
Bombus rufocinctus Cresson (Figs. 5, 38, 56, 81, 105, 132; Map 5)

Bombus rufocinctus Cresson, 1863, Proc. Entomol. Soc. Phila. 2:106. m, w. Lectotype m, Pike's Peak, Colorado (#2643 ANSP) (selected by Cresson, 1916).

Bombus henshawi Franklin, 1913, Trans. Amer. Entomol. Soc., 38(34):446. q. Holotype q, San Francisco or Palo Alto, California (MCZ, Harvard?).

Geographic range (Map 5). Southern Canada and northern United States; Quebec, Maine, New York, W to British Columbia, New Mexico, Arizona, and northern California.

California records. ALPINE CO.: Woodfords, 5 km NE. HUMBOLDT CO.: Eureka. MODO CO.: Cedarville; Goose Lake; Lake City, 6.5 km N. MONO CO.: Bodie; Bridgeport; Grant Lake; Hammil; Hilton Creek; Leavitt Meadow; Long Valley; Mill Creek; Pickel Meadow; Whitmore Hot Springs. MONTEREY CO.: Pacific Grove; Pfeiffer State Park. SAN FRANCISCO CO.: San Francisco. SAN MATEO CO.: Daly City; San Bruno Mtns. SHASTA CO.:



Map 5. Nearctic distribution of *Bombus rufocinctus*.

Hat Creek P.O. SISKIYOU CO.: Dorris, 3 km N; Lower Klamath Lake; Montague; Tule Lake. TUOLUMNE CO.: Cow Creek; Sonora Pass; Strawberry.

Seasonal flight period (Fig. 5). QUEENS (157): late February to early October. WORKERS (432): late May to early October. MALES (299): late June to late September.

Flower records. QUEENS (41): Leguminosae 54%; compositae 15%; Hydrophyllaceae 15%. WORKERS (126): Leguminosae 69%; Compositae 17%. MALES (23): Compositae 70%; Malvaceae 13%. Total: 190 in 11 families with 27 genera as follows: *Althaea*: 1q, 7w, 3m; *Asclepias*: 1m; *Aster*: 6w, 1m; *Astragalus*: 4q; *Balsamorhiza*: 1q; *Brassica*: 1q; *Caragana*: 9q; *Ceanothus*: 1q; *Chamaebatiaria*: 3w, 1m; *Chrysothamnus*: 2m; *Cirsium*: 2q, 1w; *Cleome*: 1w; *Grindelia*: 5w, 4m; *Haplopappus*: 1m; *Helianthus*: 1q, 2w; *Lupinus*: 2w; *Medicago*: 6q, 2w; *Melilotus*: 1q, 81w, 2m; *Mentha*: 1w; *Nasturtium*: 5w; *Penstemon*: 3q; *Phacelia*: 6q; *Rosa*: 1q; *Solidago*: 8w, 8m; *Taraxacum*: 2q; *Trifolium*: 2w; *Vicia*: 2q.

Discussion. *B. rufocinctus* is most closely related to the European *B. cullumanus* and more distantly related to members of the subgenus *Separatobombus*. In addition to the characters in the subgeneric diagnoses, *B. rufocinctus* differs from *B. griseocollis* and *morrisoni* in having longer, more sparse hair and more shiny integument.

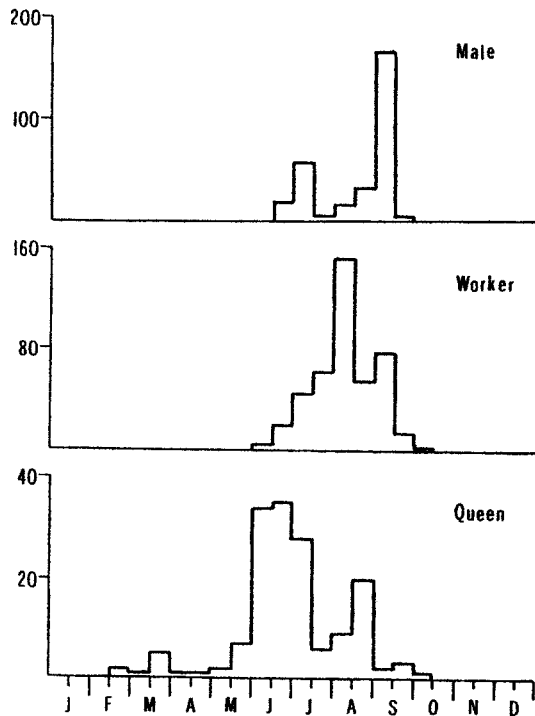


Fig. 5. Histograms of seasonal flight activity for *Bombus rufocinctus*.

This species varies greatly in color pattern (Figs. 105, 132). As a consequence, many infraspecific names have been applied (Milliron, 1973b). However, the color patterns do not vary in any ecogeographic pattern. Several color patterns occur at single localities (Thorp, 1962) and even in the same nest (Stephen, 1957). Thus, the application of subspecies names to these patterns is inappropriate.

The biology of this species has been discussed in considerable detail by Hobbs (1965b). He found females of all three species of *Psithyrus* (*suckleyi*, *insularis*, and *fernaldae*) and eggs laid by some *P. insularis* in nests of *B. rufocinctus*. However, he was unable to determine whether any *Psithyrus* were reared to adults. He also found that a conopid fly, *Physocephala texana*, killed a founding *B. rufocinctus* queen.

Subgenus *Subterraneobombus* Vogt

Brief Diagnosis. FEMALES: ocelli small, at supraorbital line; malar space longer than wide; flagellomere 1 shorter than 2 plus 3; clypeus with few minute and no coarse punctures centrally; mesobasitarsomere with posterior apical angle spinose; sting capsule anteriorly with inner margin of second valvular ramus swollen above, but not toothed. MALES: compound eyes not

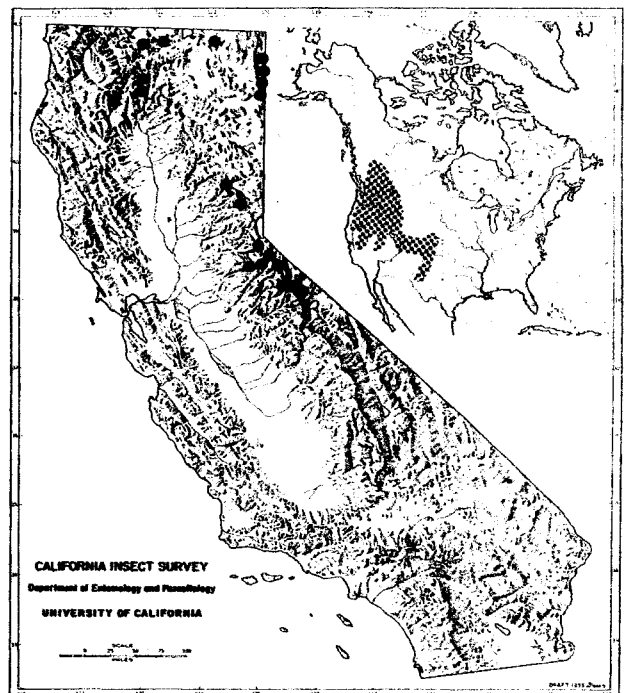
protuberant; flagellomere 1 shorter than 3; mesobasitarsomere with posterior apical angle spinose; penis valves apically with inward and outward projections, subapically with trilobed plate-like outward projection; gonostylus with basal inward projection dorsoventrally flattened, curving back on itself distally.

Bombus appositus Cresson (Figs. 6, 41, 57, 82, 108, 138; Map 6)

Bombus appositus Cresson, 1878, Proc. Acad. Nat. Sci. Phila., p. 1833. q, w, m. Lectotype q, Colorado (#2639 ANSP), (selected by Cresson, 1916).

Geographic range (Map 6). W of 100° longitude; Alberta, western South Dakota, and Nebraska, and New Mexico west to British Columbia and boreal California.

California records. ALPINE CO.: Blue Lake, and 3 km N, 2740 m; Forestdale Meadow; Hope Valley; Markleeville, 27 km S; Round Top Lake. AMADOR CO.: Silver Lake. EL DORADO CO.: Angora Lakes. LASSEN CO.: Blue Lake, South Warner Mtns. MODOC CO.: Cedarville, 10 km NW; Clear lake, 8 km NE; Lake City; Patterson Meadow, 16 km SW Eagleville. MONO CO.: Bridgeport; McGee Creek; Sardine Creek, 2590 m; Sonora Junction; Sonora Pass, 2740 m. PLUMAS CO.: Johnsville. SHASTA CO.: Castella. SIERRA CO.: Webber Lake, and 8 km E. SISKIYOU CO.: Macdoel; Montague; Mt. Shasta City. TRINITY CO.: Coffee Creek near Big Flat; Carrville; Nash Mine. TUOLUMNE CO.: Blue Canyon, Sonora Pass; near Sonora Peak.



Map 6. Nearctic distribution of *Bombus appositus*.

Seasonal flight period (Fig. 6). QUEENS (155): early May to early September. WORKERS (189): late May to late August. MALES (107): late June to early September.

Flower records. QUEENS (9): Compositae 44%; Leguminosae 22%. WORKERS (42): Leguminosae 45%; Compositae 43%. MALES (15): Compositae 80%. Total: 66 in 9 families with 18 genera as follows: *Astragalus*: 1q, 7w; *Cirsium*: 3q, 17w, 11m; *Cleome*: 1m; *Dipsacus*: 3w; *Frasera*: 1w; *Helianthus*: 1w; *Lathyrus*: 1w; *Lonicera*: 1q; *Medicago*: 1q, 2w; *Melilotus*: 2w; *Mentha*: 1w, 2q; *Phacelia*: 1q; *Rhus*: 1q; *Rudbeckia*: 1m; *Solidago*: 1q; *Thermopsis*: 2w; *Trifolium*: 2w; *Vicia*: 2w.

Discussion. *B. appositus* is most closely related to *B. borealis*, which does not occur in California, and more distantly related to members of the subgenus *Fervidobombus*. *B. appositus* differs from all other California species in having whitish hair on the face, vertex, and anterior portion of the scutum.

This species is one of the most constant in color pattern, except for fading of the yellow hair in older specimens.

The biology is described by Hobbs (1966b). He records females of *Psithyrus suckleyi*, *insularis*, and *fernaldae* in nests of *B. appositus*, and some *P. insularis* succeeded in producing adults. Hobbs also found *Phyocephala texana* parasitizing workers and

a founding queen.

Subgenus *Fervidobombus* Skorikov

Brief diagnosis. FEMALES: ocelli at supraorbital line; malar space longer than wide; flagellomere 1 shorter than 2 plus 3; clypeus with coarse and fine punctures intermixed; mesobasitarsomere with posterior apical angle spinose; sting capsule with inner margin of second valvular ramus projecting sharply mesad above or below middle. MALES: compound eyes not protuberant; flagellomere 1 shorter than 3; mesobasitarsomere with posterior apical angle spinose; penis valves apically turned outward; gonostylus with basal inward projection anteroposteriorly flattened.

Bombus californicus F. Smith

(Figs. 7, 39, 58, 83, 109, 135, 164; Map 7)

Bombus californicus F. Smith, 1854, Cat. Hymen. British Mus., 2:400. q, m. Holotype q, California (#17B1223 BMNH).

Bombus consanguineus Handlirsch, 1888, Ann. K. K. Naturhist. Hofmus. 3:239. q, w, m. Type and its location unknown.

Geographic range (Map 7). W of 100° longitude; Alberta to Colorado W to British Columbia and Baja California del Norte.

California representative records. ALAMEDA CO.: Alameda; Arroyo Mocho, 32 km S Livermore; Berkeley; Pleasanton; Tesla. ALPINE CO.: Woodfords. AMADOR CO.: Sutter Creek;

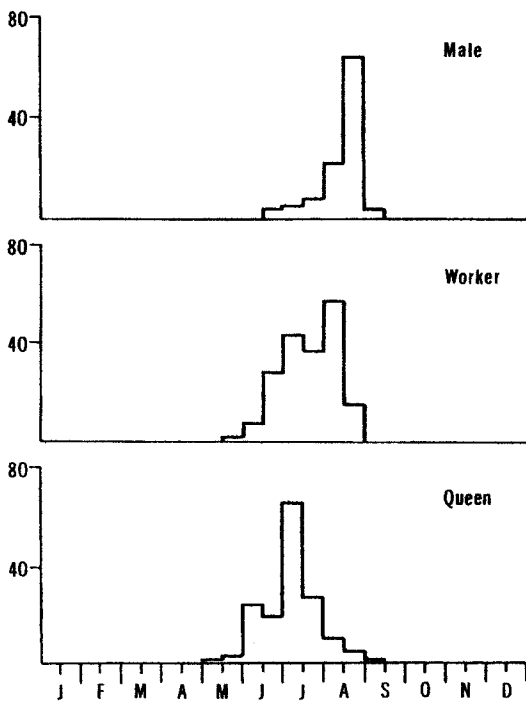
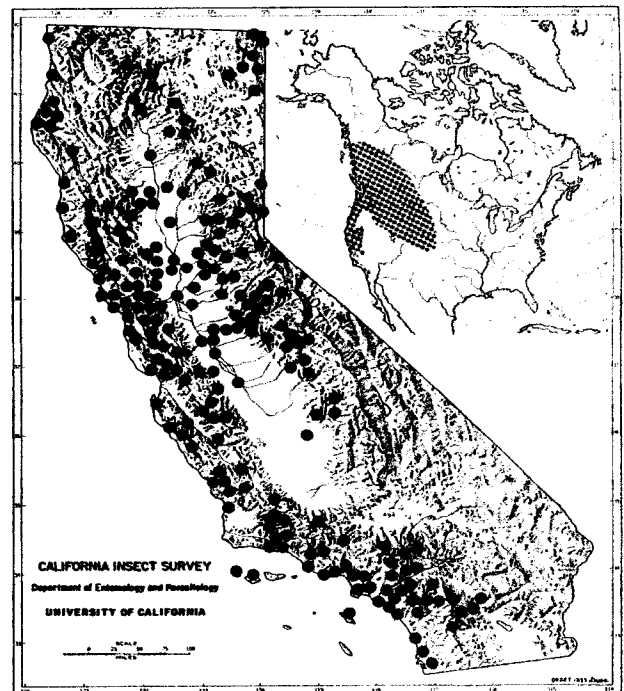


Fig. 6. Histograms of seasonal flight activity for *Bombus appositus*.



Map 7. Nearctic distribution of *Bombus californicus*.

Volcano; White Station. BUTTE CO.: Chico; W. branch Feather River. CALAVERAS CO.: Murphys, 610 m; Valley Springs, 2 km E. COLUSA CO.: Lodoga, 10 km W. CONTRA COSTA CO.: Antioch; Briones Hills; Concord; Martinez; Mt. Diablo; Orinda Village; Point Richmond; Walnut Creek. DEL NORTE CO.: Crescent City. EL DORADO CO.: Angora Lakes; Latrobe; Placerville; Pollock Pines. FRESNO CO.: Auberry; Firebaugh; Huntington Lake; Mercey Hot Springs; Squaw Valley. GLENN CO.: Artois; Fruto; Grindstone Canyon, 11 km N Weir Canyon. HUMBOLDT CO.: Arcata; Ferndale; Fort Seward; Kneeland; Orick. KERN CO.: Frazier Park, 2 km S. LAKE CO.: Elk Mtn.; Lake Pillsbury; Lower Lake. LASSEN CO.: Blue Lake, South Warner Ridge; Hallelujah Junction; Plumas. LOS ANGELES CO.: Avalon, Santa Catalina Island; Claremont; Crystal Lake; Malibu; Pasadena; San Gabriel Canyon. MADERA CO.: Bass Lake; Nipinnawasee; Oakhurst. MARIN CO.: Alpine Lake; Bolinas; Fairfax; Mt. Tamalpais; Novato; Olema; Pt. Reyes; Tomales. MARIPOSA CO.: Coulterville; Exchequer Dam; Mariposa; Yosemite Valley. MENDOCINO CO.: Fort Bragg; Hopland; Manchester; Westport; Willits. MERCED CO.: Livingston; Los Banos; W Panoche Hills. MODOC CO.: Adin Pass, 1525 m; Alturas; Cedarville; Davis Creek; Ft. Bidwell. MONTEREY CO.: Arroyo Seco Camp; Big Sur; Carmel; Carmel Valley; Junipero Serra Peak; Santa Lucia Mtns.; King City; Soledad. NAPA CO.: Calistoga; Napa; Pope Valley. NEVADA CO.: Boca; Emigrant Gap; Nevada City; Ruckers Lake. ORANGE CO.: Newport Beach; San Clemente; Trabuco Canyon; Yorba Linda. PLACER CO.: Alta; Auburn; Forest Hill; Roseville. PLUMAS CO.: Bucks Lake; Meadow Valley, Quincy. RIVERSIDE CO.: Anza; Banning; Corona; Elsinore; Hemet; Idyllwild; Indio; Riverside; Temecula. SACRAMENTO CO.: Folsom; Galt; Michigan Bar; Sacramento. SAN BENITO CO.: Bitterwater; Hollister; Idria; Pinnacles Natl. Mon. SAN BERNARDINO CO.: Cajon Valley; Forest Home; Lake Arrowhead; Loma Linda; Oak Glen Lodge. SAN DIEGO CO.: Encinitas; La Jolla; Sunnyside; Warner Springs. SAN FRANCISCO CO.: San Francisco. SAN JOAQUIN CO.: Stockton. SAN LUIS OBISPO CO.: Atascadero; Morro Bay; San Luis Obispo; Shandon; Simmler. SAN MATEO CO.: Daly City; Pacifica; San Bruno Mtns. SANTA BARBARA CO.: San Miguel Island; Santa Barbara; Santa Rosa Island; Zaca Peak. SANTA CLARA CO.: Gilroy; Mt. Hamilton; Palo Alto; San Jose. SANTA CRUZ CO.: Mt. Herman; Soquel; Watsonville. SHASTA CO.: Burney; Hat Creek P.O.; Shingletown; Viola. SIERRA CO.: Goodyear's Bar; Sierraville. SISKIYOU CO.: Eina; Mt. Shasta City. SOLANO CO.: Vacaville; Vallejo. SONOMA CO.: Cazadero; Cloverdale; Glen Ellen; Monte Rio; Petaluma; Santa Rosa; Shell Beach. STANISLAUS CO.: Empire; La Grange; Patterson; Turlock. SUTTER CO.: Marysville Buttes. TEHAMA CO.: Red Bluff. TULARE CO.: Giant Forest; Kaweah; Mineralking; Porterville. TUOLUMNE CO.: Big Oak Flat; Columbia; Dardanelle; Mather; San Pedro Dam; Sonora Pass; Strawberry. VENTURA CO.: Fillmore; Oxnard; Santa Paula. YOLO CO.: Capay; Davis; Dunnigan; Elkhorn Ferry; Putah Canyon.

Seasonal flight period (Fig. 7). QUEENS (380): early February to early October. WORKERS (568): early March to late October. MALES (600): early May to late October.

Flower records. QUEENS (78): Leguminosae 53%; Compositae 12%. WORKERS (101): Leguminosae 34%; Compositae 32%. MALES (97): Compositae 33%; Leguminosae 27%. Total 276 in 24 families with 52 genera as follows: *Agastache*: 1w; *Althaea*: 3w, 2m; *Amsinckia*: 1w; *Antirrhinum*: 1q, 1w; *Astragalus*: 13q,

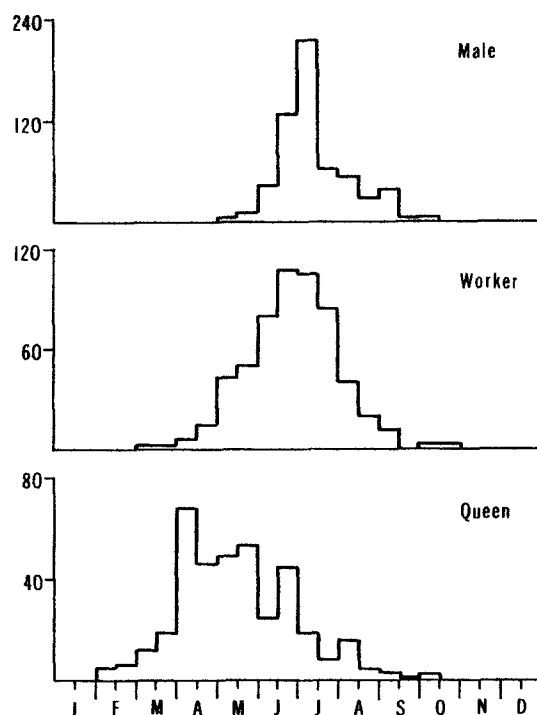


Fig. 7. Histograms of seasonal flight activity for *Bombus californicus*.

10w, 1m; *Brassica*: 3q; *Canna*: 1m; *Castilleja*: 1q; *Centaurea*: 6w, 9m; *Chlorogalum*: 5m; *Cirsium*: 2q, 24w, 8m; *Clarkia*: 3m; *Collinsia*: 2w; *Coreopsis*: 7m; *Cosmos*: 4m; *Delphinium*: 2q, 4m; *Eriodictyon*: 1w; *Eriogonum*: 3m; *Eschscholzia*: 2w; *Foeniculum*: 1w; *Glycyrrhiza*: 5m; *Haplopappus*: 2m; *Helianthus*: 1q, 2w; *Isomeris*: 1q; *Lathyrus*: 1q, 4w; *Linaria*: 1w; *Lonicera*: 3w; *Lotus*: 1q, 9w, 1m; *Lupinus*: 5q, 8w; *Medicago*: 2q, 10m; *Melilotus*: 2m; *Mentha*: 1w, 1m; *Mentzelia*: 1q; *Monardella*: 1m; *Opuntia*: 1q; *Orthocarpus*: 4q, 3w; *Penstemon*: 1w, 4m; *Potentilla*: 2w; *Raphanus*: 2q, 4w, 2m; *Rhododendron*: 2q, 2m; *Ribes*: 1m; *Rosa*: 1q; *Salix*: 1q; *Salvia*: 4q, 3w, 2m; *Scabiosa*: 2m; *Solidago*: 1m; *Stachys*: 1w, 4m; *Trichostema*: 1m; *Trifolium*: 1q, 3w, 5m; *Vicia*: 21q, 4w, 2m; *Wyethia*: 6q; *Zinnia*: 2m.

Discussion. *B. californicus* is most closely related to *B. fervidus* and is considered by Milliron (1973a) to be conspecific with it. However, they are ecologically separated where sympatric (Hobbs, 1966a) and show no signs of intergradation in broad areas of sympatry. They are recognized principally by difference in color pattern: *B. californicus* has predominantly black hair on thoracic pleura, scutellum, and metasomal tergites 1 to 3; *B. fervidus* has yellow hair on these areas.

Some males in California are indistinguishable from the more yellowish color variant *consanguineus*. They approach the color of *B. fervidus*,

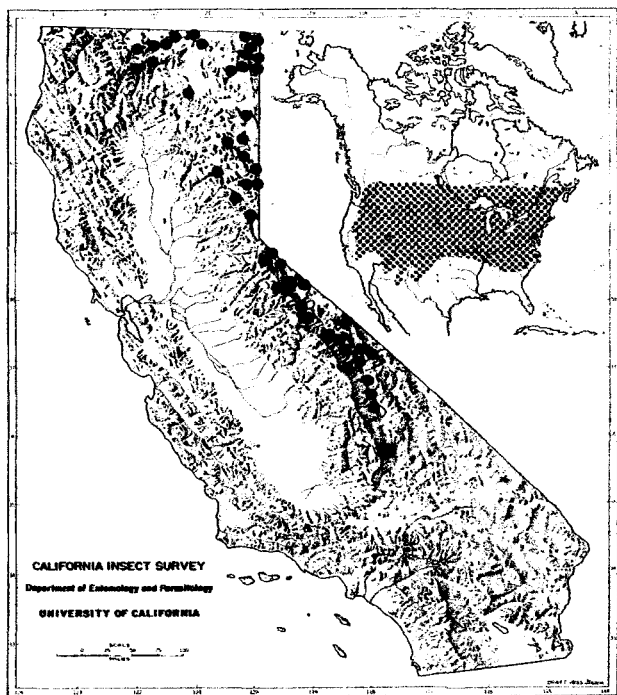
but may be separated from *fervidus* by having more lemon-yellow hair and some black hair medially and laterally on metasomal tergites 1 to 3. No females in California can be assigned to *consanguineus*. Thus, its subspecific status is not appropriate.

Hobbs (1966a) described the biology of *B. californicus* and documented the ecological differences in nest habitats for *californicus* (wooded areas of the foothills) and *fervidus* (prairie) in southern Alberta. He also found that *Psithyrus insularis* and *P. suckleyi* females had invaded nests of *B. californicus*, and the former species produced some adults.

Bombus fervidus (Fabricius)
(Figs. 8, 59, 84, 110, 136; Map 8)

Apis fervida Fabricius, 1798, Supl. Entomol. System., p. 274. w. Lectotype w, no locality (Univ. Zool. Mus., Copenhagen, Denmark) (selected by Milliron, 1960).

Geographic range (Map 8). Southern Canada and most of the United States, except the extreme south; New Brunswick to Georgia W to British Columbia and eastern California.



Map 8. Nearctic distribution of *Bombus fervidus*.

California records. ALPINE CO.: Fredericksburg; Hope Valley; Monitor Pass; Woodfords. INYO CO.: Big Pine; Bishop, 5 km E; Carroll Creek; Glacier Lodge, Big Pine; Independence; Laws; Lone Pine; Long Valley; Oak Creek; Pine Creek, Round Valley, NW of Bishop; Westgard Pass Plateau. LASSEN CO.: Doyle, 3 km S; Hallelujah Junction; Honey Lake, 5 km N Milford; Litchfield, 18 km N; McArthur, 11 km E; Ravendale, 6.5 km S; Susanville. MODOC CO.: Alturas, 8 km E, and 32 km N; Fort Bidwell, 13 km N; Canby, 3 km E; Cedarville; Davis Creek; Goose Lake; Lake City; Newell; Saddleblanket Flat. MONO CO.: Benton Crossing, Mono Geysers; Black Lake; Bridgeport; Coleville; Cottonwood Creek; Crowley Lake; Grant Lake; Leavitt Meadow; McGee Creek; Mono Lake, 16 km N Lee Vining; Sardine Creek; Tom's Place; Topaz Lake; Whiskey Creek; Whitmore Springs. NEVADA CO.: Truckee. PLUMAS CO.: Quincy, 6.5 km W; Vinton, 10.5 km S. SHASTA CO.: Carbon; McArthur, and 11 km E. SIERRA CO.: Sattley; Sierraville. SISKIYOU CO.: Etna, 3 km W; Gazelle; Lower Klamath Lake; Macdoel; Montague; Mt. Hebron, and 11 km S; Tulelake, and 34 km S; Willow Creek.

Seasonal flight period (Fig. 8). QUEENS (272): early April to late October. WORKERS (529): early May to late October. MALES (232): early July to early October.

Flower records. QUEENS (118): Leguminosae 84%. WORKERS (146): Compositae 55%; Leguminosae 27%. MALES (86): Compositae 98%. Total: 350 in 15 families with 34 genera as follows: *Althaea*: 9w; *Aster*: 1w, 1m; *Astragalus*: 30q, 8w; *Baptisia*: 2w; *Calendula*: 1m; *Caragana*: 62q, 5w; *Carduus*: 2m;

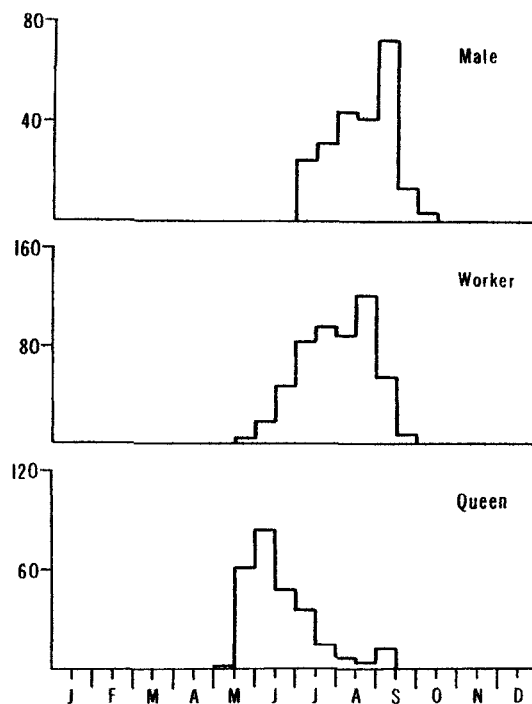


Fig. 8. Histograms of seasonal flight activity for *Bombus fervidus*.

Chrysothamnus: 8m; *Cirsium*: 6q, 60w, 51m; *Cleome*: 1w, 1m; *Digitalis*: 1w; *Epilobium*: 1w; *Geranium*: 1q; *Grindelia*: 1q, 1w; *Helianthus*: 16w, 17m; *Hypericum*: 2w; *Iris*: 2q; *Lathyrus*: 2w; *Linaria*: 7w; *Lupinus*: 8w; *Medicago*: 1q, 2w; *Melilotus*: 4w; *Mentzelia*: 1w; *Penstemon*: 1q; *Phacelia*: 1q; *Prenanthes*: 1w; *Rhus*: 1q; *Salix*: 1w; *Solidago*: 4m; *Stachys*: 3w; *Trifolium*: 1q, 3w; *Vicia*: 5q, 6w, 1m; *Weigela*: 6q; *Wyethia*: 1q.

Discussion. *B. fervidus* is most closely related to *B. californicus*, and may be separated from it by the characters listed in the discussion of that species.

The color pattern of *B. fervidus* is uniform in California.

The biology of this species is discussed by Hobbs (1966a). He found two *Psithyrus insularis* females in *B. fervidus* nests, but no adults were produced, and that the conopid fly *Physocephala texana* killed two queens.

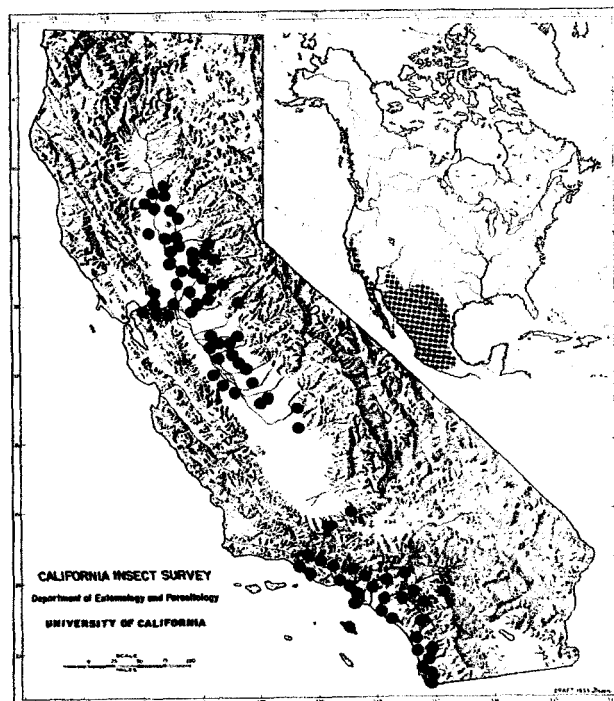
Bombus sonorus Say

(Figs. 9, 40, 60, 85, 111, 137, 165, 166; Map 9)

Bombus sonorus Say, 1837, Boston J. Nat. Hist., 1:413. q. Holotype q, Mexico, location of type unknown.

Geographic range (Map 9). Mexico and the southwestern United States; Puebla, Mexico, to southwestern Texas W to Baja California del Sur and central California.

California records. AMADOR CO.: Ione, and 3 km W; Sutter Creek, 10 km NW. BUTTE CO.: Biggs, and 8 km W; Chico; Dayton; Gridley. CALAVERAS CO.: Altaville. COLUSA CO.: Williams, 6.5 km SW. CONTRA COSTA CO.: Antioch; Bethel Island; Oakley. EL DORADO CO.: Coloma, 11 km NW; Pilot Hill; near Plymouth. FRESNO CO.: Firebauh, 6.5km NW; Fresno; Kerman, 14 km W; Orange Cove; Oxalis. GLENN CO.: Artois; Glenn, and 3 km N; Hamilton City, 5 km N; Willows, 6.5 km NW. KERN CO.: Fort Tejon; Tehachapi. LOS ANGELES CO.: Baldwin Hills; Claremont; El Segundo; El Segundo Sand Dunes; Eve Canyon; Glendale; Glendora; Inglewood; Los Angeles; Middle Ranch, Santa Catalina Island; Palos Verdes Peninsula; Placerito Canyon; Playa del Rey; Pomona; San Pedro; Santa Monica; Santa Monica Mtns.; Venice; Westwood Hills; Whittier; Yorba Linda; Zuma Beach. MADERA CO.: Madera; Willow Slough, 42 km W Madera. MERCED CO.: Delhi; Dos Palos; Le Grand; Livingston; Los Banos; Merced, and 16 km SE; Winton. NAPA CO.: Monticello Dam. ORANGE CO.: Back Bay; Balboa Island; Corona del Mar; Costa Mesa; Fullerton; Laguna Beach; Newport Beach; Santa Ana; Yorba Linda. PLACER CO.: Auburn; Lincoln, and 6.5 km W; Loomis; Roseville. RIVERSIDE CO.: Banning; Beaumont, 8 km E; Chino; Corona; Hemet, and 10 km SW; Perris; Riverside; Soboba Hot Springs; Temecula, and 11 km N. SACRAMENTO CO.: Carmichael; Fair Oaks; Folsom; Folsom Lake; Galt; Grand Island; Michigan Bar; Perkins; Natoma; Rio Linda; Sacramento, and 21 km S. SAN BERNARDINO CO.: Lytle Creek. SAN DIEGO CO.: Camp Pendleton; Cardiff; Carlsbad; Carrizo Creek; Clairemont; Coronado; Del Mar, 2 km E; Encinitas; Escondido; Fairbrook, 5 km E; La Jolla; La Mesa; Oceanside; Palm Canyon; Pine Valley; Rancho Santa Fe; San Diego; Santee;



Map 9. Nearctic distribution of *Bombus sonorus*.

Sentenac Canyon; Solana Beach; Spring Valley. SAN JOAQUIN CO.: Clements; Lockeford; Lodi; Stockton. SOLANO CO.: Fairfield; Ryer Island; Suisun, 5 km SE. STANISLAUS CO.: Ceres; Hickman; La Grange; Linden; Turlock, and 18 and 19 km E; Waterford; Westley. SUTTER CO.: Meridian, 3 km SE; Robbins, 5 km E, and 8 km E; Yuba City, 8 km W. TULARE CO.: Visalia. VENTURA CO.: Ojai; Oxnard; Santa Paula; Santa Susana; Ventura. YOLO CO.: Clarksburg; Davis, and 10 km E; Elkhorn Ferry; Winchester Lake; Woodland. YUBA CO.: Marysville; Rio Oso, 6.5 km N.

Seasonal flight period (Fig. 9). QUEENS (276): early January to early December. WORKERS (1491): late February to early December. MALES (377): early June to late November.

Flower records. QUEENS (44): Leguminosae 27%; Boraginaceae 14%. WORKERS (423): Solanaceae 41%; Compositae 25%; Leguminosae 16%. MALES (86): Compositae 69%; Labiatae 12%. Total; 553 in 30 families with 73 genera as follows: *Athaea*: 1q; *Amsinckia*: 6q; *Antirrhinum*: 1q; *Argemone*: 1q; *Asclepias*: 4w, 1m; *Aster*: 1w, 4m; *Astragalus*: 5q; *Baccharis*: 2w; *Brassica*: 2q, 1w; *Centaurea*: 2w, 7m; *Chilopsis*: 4w; *Chlorogalum*: 1w; *Chrysanthemum*: 1m; *Cirsium*: 11w, 7m; *Cleome*: 1w; *Coreopsis*: 1w; *Croton*: 2w; *Cryptantha*: 1m; *Cucurbita*: 1q, 2w; *Dahlia*: 1w; *Dalea*: 1w; *Datura*: 3w; *Daucus*: 1w; *Delphinium*: 2q; *Echinocactus*: 1q; *Epilobium*: 1w; *Eriogonum*: 2w, 3m; *Eschscholzia*: 3q; *Gaillardia*: 1q, 10w; *Grindelia*: 1q, 2w, 1m; *Gutierrezia*: 2w; *Haplopappus*: 3w, 1m; *Helianthus*: 1q, 52w, 30m; *Hoffmannseggia*: 1w; *Isocoma*: 1m; *Lantana*: 1q; *Larrea*: 1w; *Lathyrus*: 1q; *Lonicera*: 1q; *Lotus*: 1q, 7w, 1m; *Lycopersicon*: 1w;

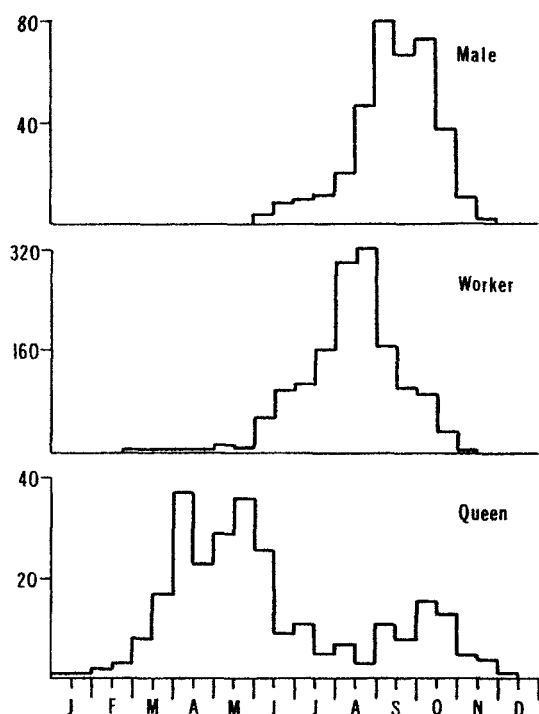


Fig. 9. Histograms of seasonal flight activity for *Bombus sonorus*.

Lythrum: 1w; *Medicago*: 1q, 44w, 1m; *Melilotus*: 1q, 4w, 1m; *Mentzelia*: 1q, 10w; *Monarda*: 3w, 1m; *Oenothera*: 1q; *Orthocarpus*: 1q; *Osmorhiza*: 2w; *Parkinsonia*: 1m; *Penstemon*: 4w; *Petalostemon*: 2w; *Phacelia*: 1q; *Proboscidea*: 1w; *Prosopis*: 1m; *Raphanus*: 1q; *Rubus*: 1w; *Salix*: 1m; *Salvia*: 2q, 3w; *Scabiosa*: 1w; *Senecio*: 3w, 2m; *Sida*: 1w; *Solanum*: 1q, 170w; *Solidago*: 1w, 1m; *Sphaeralcea*: 4w, 5m; *Stachys*: 2w; *Tagetes*: 1q; *Trichostema*: 16w, 9m; *Trifolium*: 1w; *Verbesina*: 3w, 2m; *Vicia*: 3q, 6w; *Viguiera*: 11w, 3m; *Wislizenia*: 9w.

Discussion. *B. sonorus* is most closely related to *B. pennsylvanicus*, which does not occur in California, and somewhat related to *californicus* and *fervidus*. It can be separated from the latter two in the male by having apices of penis valves longer than wide, and in the female by having black hair on metasomal tergite 4.

Peters (1968) and Milliron (1973a) considered *sonorus* to be conspecific with *pennsylvanicus*. Their evidence is not based on intergradation. RWT has seen specimens of both species from the same localities in southern Texas without signs of intergradation. The resolution of this problem awaits further studies in southern Texas and central Mexico where these bees occur together.

We have taken several late season nests, and successfully reared a nest from a confined queen

which was originally produced, mated, and overwintered in our lab. Nests are typically located underground in abandoned pocket gopher burrows. This species is extremely pugnacious in defense of its nest. Brood rearing is typical for the subgenus *Fervidobombus* (see Hobbs 1966a). Ryckman (1953) recorded *Physocephala texana* as a parasite of this bee, in southern California, and we confirmed this for the Central Valley.

Subgenus *Bombus* Latreille

Brief diagnosis. FEMALES: ocelli at supraorbital line; malar space wider than long; flagellomere 1 equal to 3; sting capsule with inner margin of second valvular ramus with two or three teeth projecting mesad. MALES: compound eyes not protuberant; antennae short, flagellum only twice as long as scape; penis valves wide, sinuate, vertical plates; gonostylus with narrow basal inward projection separated by broad emargination from flared, distal, inward projection.

Bombus franklini (Frison) (Figs. 10, 86, 112, 139; Map 10)

Bremus franklini Frison, 1921, Entomol. News, 32:147, q. Holotype q, erroneously recorded from Nogales, Arizona (111. NHS).

Geographic range (Map 10). Restricted to Klamath Mountain region of southern Oregon and northern California.

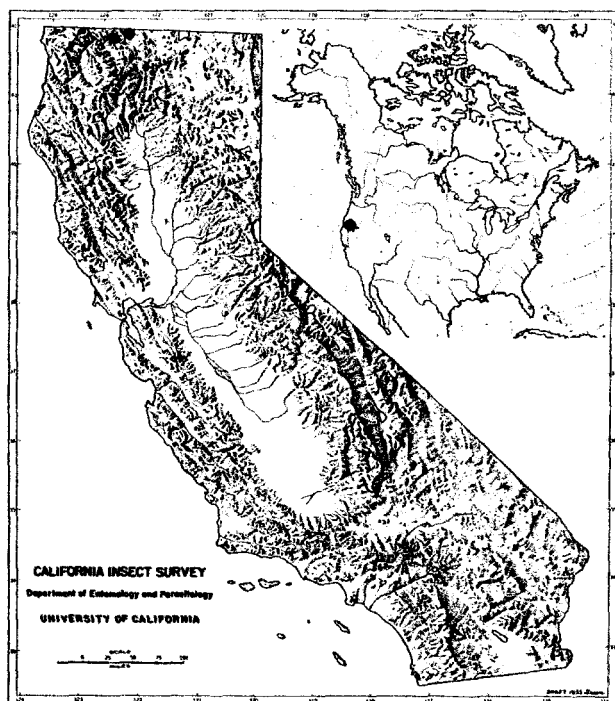
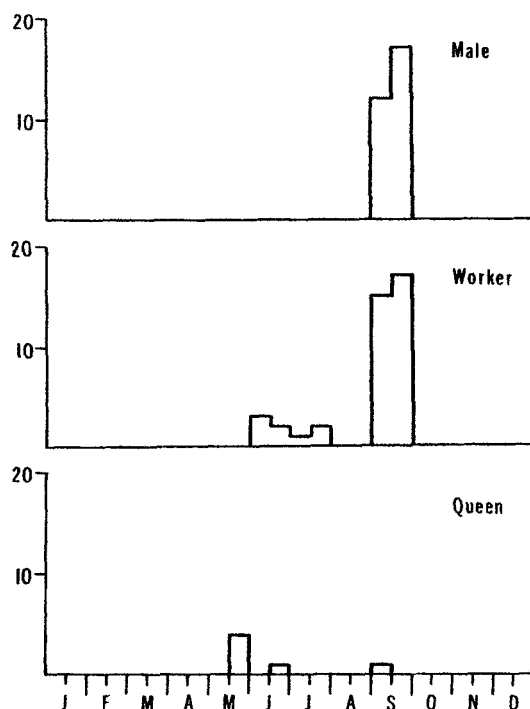
California records. SISKIYOU CO.: Hilt, 12 and 27 km W, and 3.5 km S.

Seasonal flight period (Fig. 10). QUEENS (6): late May to early September. WORKERS (40): early June to late September. MALES (29): early to late September.

Flower records. QUEENS (5): Leguminosae 80%. WORKERS (12): Compositae 42%; Leguminosae 42%. MALES (10): Compositae 70%; Leguminosae 30%. Total: 27 in 5 families with 6 genera as follows: *Ceanothus*: 1q; *Centaurea*: 5w, 7m; *Eriogonum*: 1w; *Lupinus*: 4q; *Trifolium*: 5w, 3m; *Veratrum*: 1w.

Discussion. *B. franklini* is most closely related to *B. occidentalis* and is considered by Milliron (1971) to be conspecific with it. They differ principally in color pattern: *B. franklini* is unique in having the scutum yellow anteriorly and laterally, with a broad U-shaped emargination of black mesoposteriorly, and the scutellum and first four metasomal tergites black. Queens of *B. franklini* tend to be larger, with the metasoma more elongate than *B. occidentalis*.

Thorpe (1970) discussed the putative type locality for *B. franklini* and pointed out the narrow endemism of this bee. We have collected it at several localities sympatrically with *B. occidentalis*, but have not found intergrades between them. Since

Map 10. Nearctic distribution of *Bombus franklini*.Fig. 10. Histograms of seasonal flight activity for *Bombus franklini*.

Milliron (1971) does not present evidence to support his synonymy and our evidence supports their distinctness, we consider them as separate species.

Color patterns of each caste are uniform.

Bombus occidentalis Greene

(Figs. 11, 42, 61, 87, 113, 140, 157-162; Map 11)

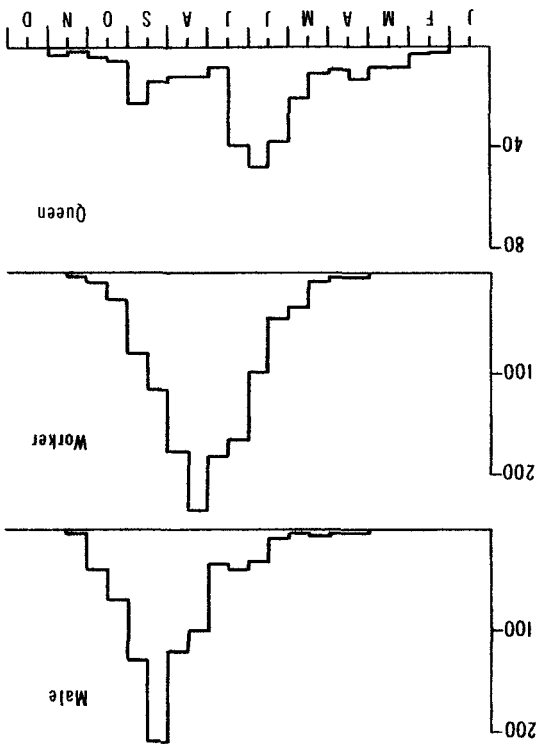
Bombus occidentalis Greene, 1858, Ann. Lyc. Nat. Hist. N.Y., 7:12. q, m. Types presumably lost.

Bombus nigroscutatus Franklin, 1908, in Fletcher and Gibson, Ann. Rept. Entomol. Soc. Ontario, 39:111. q, w, m. Cotypes presumably in the USNM, Stanford (now CAS), and Mass. Univ. collections.

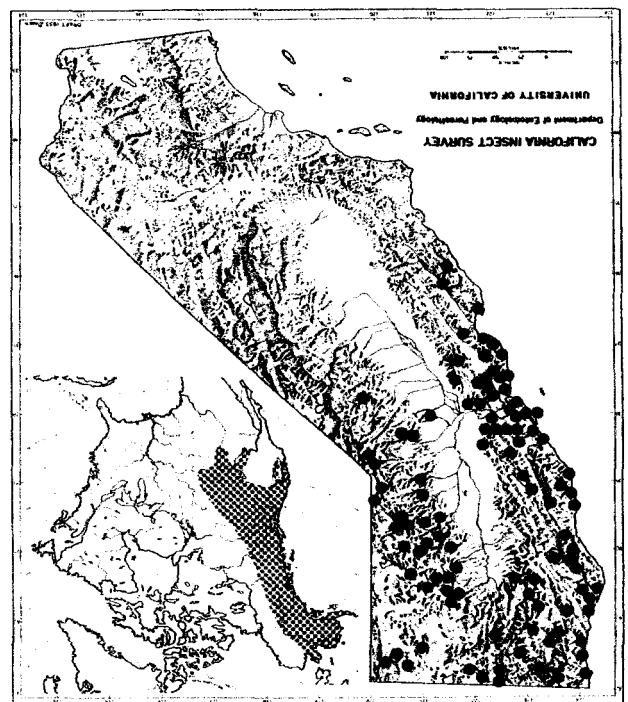
Geographic range (Map 11). W of 100° longitude; western South Dakota to northern New Mexico W to southern Alaska to northern California.

California representative records. ALAMEDA CO.: Alameda; Albany; Hayward; Niles; Pleasanton. ALPINE CO.: Hope Valley. BUTTE CO.: Brush Creek; Butte Meadows. CALAVERAS CO.: Murphy, 610 m; San Andreas, 305 m. CONTRA COSTA CO.: Antioch; Avon; Brentwood; Concord; Moraga; Mt. Diablo; Richmond; Walnut Creek. DEL NORTE CO.: Crescent City; Idlewild; Requa. EL DORADO CO.: Glen Alpine Creek, Tahoe. HUMBOLDT CO.: Arcata; Fortuna; Garberville; Hoopa; Kneeland; Orick; Orleans; Weott. LAKE CO.: Blue Lake; Lakeport. LASSEN CO.: Bridge Creek Camp; Hat Lake, Lassen Natl. Park; Manzanita Lake; Susan River Camp. MARIN CO.: Bolinas; Fort Barry; Inverness; Nicasio; Novato; Pt. Reyes; San Rafael. MENDOCINO CO.: Fort Bragg; Little River; Navarro; Piercy; Pt. Arena; Willits. MODOC CO.: Alturas, 32 km N; Davis Creek; Hackmore Reservoir; Juniper Flat. MONTEREY CO.: Carmel; Hunter Liggett Military Reservation; San Lucas. NAPA CO.: Calistoga; Napa. NEVADA CO.: Boca; Nevada City. PLACER CO.: Colfax; Tahoe City. PLUMAS CO.: Bucks Lake; Greenville; La Porte; Portola; Quincy. SAN FRANCISCO CO.: Ft. Funston; Golden Gate Park; Presidio; Twin Peaks. SAN JOAQUIN CO.: Clements; Corral Hollow. SAN MATEO CO.: Burlingame; Daly City; Half Moon Bay; Pescadero State Beach; Redwood City. SANTA CLARA CO.: Gilroy; Mt. Hamilton; Palo Alto; San Jose; Stevens Creek. SANTA CRUZ CO.: Ben Lomond; Big Basin; Santa Cruz; Watsonville. SHASTA CO.: Burney Falls; Eiler Lake; Hat Creek; Lewiston; Viola. SIERRA

Fig. 11. Histograms of seasonal flight activity for *Bombus occidentalis*.



Discussion. B. occidentalis is most closely related to *B. franklini* and can be distinguished from it by the characters mentioned under that species. Franklin (1913) considered *B. nigroscutatus* as a subspecies of *B. occidentalis*, based principally on California specimens, but included individual variants from the Rocky Mountains which had similar coloring. Stephen (1957) redefined the subspecies, limiting it to coastal California populations. Although populations from the San Francisco Bay region are distinctively colored (except when compared to specimens from the San Francisco Mountains of northern Arizona), there is such a broad zone of intergradation from Mendocino County northward that recognition of this color form as a subspecies is unwarranted. Indeed, Milliron (1971) went so far as to place *B. nigroscutatus* and *franklini* in synonymy with *occidentalis* and then reduced *occidentalis* to subspecific status under *B. terricola* Kirby. Since the area of sympatry is the eastern slopes of the Rocky Mountains, we cannot resolve the question here. However, Stephen (1957) found no intergradation between them in British Columbia, and Hobbs (1968) found them distinct in southern Alberta, where they coexist. Since these



Map 11. Nearctic distribution of *Bombus occidentalis*.

CO: Gold Lake, Siskiyou Co.; Cecilville, Etna; Happy Camp; Hill: Macdoel; Montague; Mt. Shasta City; Somesbar. SOLANO Co.: Glen Cove; Vacaville; Vallejo; Winters. SONOMA Co.: Bodega Bay; Kenwood; Petaluma; Santa Rosa; Sebastopol; Sonoma; Jenner. TEHAMA Co.: Mineral. TRINITY Co.: Eagle Creek; Scott Min.; Trinity Center; Weaverville; Zenia. TUOLUMNE Co.: Eleanor Lake.

Seasonal flight period (Fig. 11). QUEENS (277): early February to late November. WORKERS (1282): early April to early November. MALES (791): early April to early November.

Flower records. QUEENS (37): Rhamnaceae 24%; Leguminosae 22%; Compositae 13%; ROSACEAE 13%. WORKERS (331): Leguminosae 34%; Compositae 28%; Rhamnaceae 10%. MALES (293): Compositae 83%. Total: 661 in 21 families with 54 genera as follows: *Abelia*: 4w, 2m; *Adenostoma*: 1q; *Aster*: 14w, 39m; *Brasica*: 1w, 2m; *Ceanothus*: 9q, 32w; *Centaurea*: 17w, 13m; *Chrysothamnus*: 5w, 6m; *Crinum*: 1q, 18w, 135m; *Clematis*: 1w; *Cosmos*: 10m; *Dahlia*: 1q; *Dianthus*: 1q; *Epilobium*: 1w, 1m; *Eriogonum*: 11w, 5m; *Eschscholzia*: 5w; *Foeniculum*: 6w; *Fuchsia*: 1w; *Geranium*: 2w; *Gladolus*: 2w; *Grindelia*: 4w, 5m; *Haplopappus*: 9w, 2m; *Hydrangea*: 1w; *Hypochaeris*: 1m; *Lathyrus*: 2w; *Lous*: 1w; *Lupinus*: 2q, 26w; *Medicago*: 7w; *Melilotus*: 1q, 54w, 5m; *Menlha*: 1w; *Monarda*: 5w; *Nana*: 3w; *Organum*: 1m; *Orthocarpus*: 1m; *Penstemon*: 1q, 14w; *Phacelia*: 1q; *Picris*: 1w; *Potentilla*: 1w; *Prunus*: 5w; *Raphanus*: 1w; *Rhododendron*: 3q; *Salvia*: 1w; *Senecio*: 8w, 2m; *Solidago*: 2q, 16w, 22m; *Salix*: 2q; *Tanacetum*: 1w, 4m; *Taraxacum*: 1q, 1w, 5m; *Trichostema*: 5w; *Trifolium*: 2q, 22w, 5m; *Vicia*: 3q, 2w; *Zea*: 1m.

data fit with the few specimens we have seen from the area of sympatry, we prefer to treat *occidentalis* as a species distinct from *terricola*.

Color variation in *B. occidentalis* is extensive (Figs. 113, 140). There is a broad area of gradation from the *nigroscutatus* form near San Francisco to the *occidentalis* pattern in northern and eastern California. The only apparent general trend in this highly polychromatic species is for the appearance of increasing amounts of yellow hair in populations from north to south in the Rocky Mountains, the Cascade-Sierra Nevada, and the North Coast Ranges of California.

The biology of *B. occidentalis* is discussed by Hobbs (1968). We have taken nests of this species in the San Francisco Bay area and in Humboldt County. All were underground except for one beneath a house in San Francisco, where the bees entered through a hole in the basement door and crossed over the dirt floor for about 3 m, under an old refrigerator to an old comforter, behind which the nest was established in the cotton stuffing. Hobbs (1968) identified invading females of all three species of *Psithyrus* (*suckleyi*, 17; *insularis*, 6; and *fernaldae*, 1) in nests of *B. occidentalis*, and at least one nest produced adult progeny of *P. suckleyi*.

Subgenus *Pyrobombus* Dalla Torre

Brief diagnosis. FEMALES: ocelli at supraorbital line; malar space as long as or longer than wide; flagellomere 1 shorter than 2 plus 3; sting capsule with inner margin of second valvular ramus smooth, without teeth. MALES: compound eyes not protuberant; antennal flagellum 2.5-3 times as long as scape; penis valves apically recurved inward, hook-shaped or sickle-shaped; gonostylus with inner face not projecting mesad.

Bombus bifarius Cresson

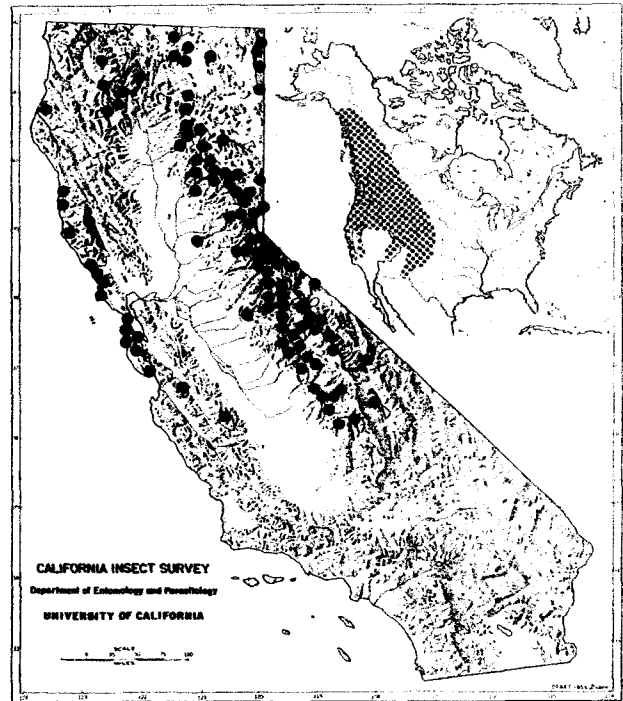
(Figs. 12, 43, 62, 88, 114, 141; Map 12)

Bombus bifarius Cresson, 1878, Proc. Acad. Nat. Sci. Phila., p. 185. q, w. Lectotype q, Colorado (#2628 ANSP) (selected by Cresson, 1916).

Bombus nearcticus Handlirsch, 1888, Ann. K. K. Naturhist. Hofmus. 3:243. q, w, m. Types, British Columbia, presumably lost. NEW SYNONYMY.

Geographic range (Map 12). W of 105° longitude from Alaska and western Northwest Territories south to Utah, Nevada, and northern California.

California representative records. ALPINE CO.: Blue Lakes; Carson Pass; Ebbetts Pass, 2660 m, and Highland Lake; Lake Alpine; Markleeville; Woodfords. AMADOR CO.: Silver Lake.



Map 12. Nearctic distribution of *Bombus bifarius*.

BUTTE CO.: Brush Creek. EL DORADO CO.: Camp Sacramento; Echo Lake; Fallen Leaf Lake; Luther Pass; Meyers; Stalene; Wrights Lake. FRESNO CO.: Bullfrog Lake, 3230 m; Humphreys Basin, 22 km SW Bishop, south base Humphreys Peak, 3500 m; Huntington Lake; Mono Hot Springs. HUMBOLDT CO.: Eureka. INYO CO.: Big Pine; Lone Pine Canyon; Mono Pass, 3655 m, Ruby Lake. LASSEN CO.: Blue Lake, S Warner Mtns.; Bridge Creek Camp; Hallelujah Junction; MADERA CO.: Agnew Meadow; Ediza Lake, 3045 m; Jackass Meadows; Moraine Meadow; Rainbow Falls. MARIN CO.: Dillon Beach; Pt. Reyes; Tomales. MARIPOSA CO.: Cathedral Lake, Lukens Lake, Porcupine Flat, and Wawona, Yosemite Natl. Park. MENDOCINO CO.: Fort Bragg; Mendocino; Pt. Arena; Ukiah. MODOC CO.: Cedar Pass; Fandango Pass; Fort Bidwell; Hackamore. MONO CO.: Crestview; Coleville; Convict Lake; Fales Hot Spring; June Lake; Leavitt Meadow; Mammoth Lakes; Saddlebag Lake; Tom's Place; Virginia Lakes. NEVADA CO.: Boca; Donner Summit; Floriston; Norden; Sagehen Creek near Hobart Mills; Truckee. PLACER CO.: Baxter; Carnelian Bay; Cisco; Lincoln; Squaw Valley. PLUMAS CO.: Blairsden; Bucks Lake; Lake Almanor; Little Grass Valley; Mt. Ingalls; Quincy; Tobin. SAN BENITO CO.: San Juan Bautista. SAN FRANCISCO CO.: San Francisco. SAN MATEO CO.: Colma; Half Moon Bay; Jasper Ridge, Sand Hill Rd.; San Mateo. SANTA CRUZ CO.: Santa Cruz. SHASTA CO.: Hat Creek; Mt. Lassen Natl. Park. SIERRA CO.: Calpine; Gold Lake; Independence Lake; Sierraville; Webber Lake. SISKIYOU CO.: Ash Creek, Mt. Shasta, 1830 m; Cecilville; Harris Spring; Lava Beds Natl. Mon.; Macdoel; Marble Mtns.; Mt. Shasta City; Tennant. SONOMA CO.: Bodega Bay; Jenner. TEHAMA CO.: Mineral. TRINITY CO.: Carrville; Grizzly Meadows;

Scott Mtn. TULARE CO.: Bearpaw Camp; General Grant Grove; Giant Forest; Kanawyer Flat; Mineralking; W Mt. Whitney, 3500 m. TUOLUMNE CO.: Bumble Bee; Camp Lake, Conness Creek, Yosemite Natl. Park; Eleanor Lake; Emigrant Lake; Jacksonville; Kennedy Meadow; Sonora Pass, 2440-3045 m; Strawberry; Tuolumne Meadow.

Seasonal flight period (Fig. 12). QUEENS (366): early March to late October. WORKERS (1825): early April to early October. MALES (763): early June to early October.

Flower records. QUEENS (58): Saxifragaceae 41%; Labiatae 21%; Compositae 17%. WORKERS (407): Compositae 61%. MALES (256): Compositae 91%. Totals: 721 in 20 families with 45 genera as follows: *Achillea*: 1q; *Arctostaphylos*: 1q, 1w; *Artemisia*: 1q, 2w; *Aster*: 2q, 13w, 24m; *Calyptidium*: 2w; *Ceanothus*: 1w; *Centaurea*: 12w, 53m; *Chrysopsis*: 2m; *Chrysothamnus*: 2q, 74w, 81m; *Cichorium*: 2w; *Cirsium*: 2q, 12w, 18m; *Convolvulus*: 1w; *Epilobium*: 10w, 12m; *Eriogonum*: 2w, 2m; *Eupatorium*: 1w, 5m; *Frasera*: 1q, 5w; *Grindelia*: 4w; *Haplopappus*: 1q, 26w, 23m; *Helenium*: 1q, 21w, 2m; *Linum*: 1w; *Lupinus*: 16w; *Melilotus*: 5w, 3m; *Mentha*: 1m; *Mimulus*: 4w, 3m; *Monardella*: 12q, 24w, 6m; *Nama*: 10w; *Oxypholis*: 1m; *Penstemon*: 1q, 29w; *Phacelia*: 11w; *Prunus*: 5q, 1w; *Ranunculus*: 11w; *Rhus*: 1q; *Ribes*: 24q, 2w; *Rudbeckia*: 18w; *Salix*: 3q, 4w; *Salvia*: 1w; *Sanicula*: 1w; *Senecio*: 3w, 1m; *Solidago*: 60w, 10m; *Sonchus*: 1w; *Sphenosciadium*: 11w, 4m; *Symphoricarpos*: 3w; *Tanacetum*: 5m; *Taraxacum*: 1w; *Vicia*: 1w.

Discussion. *B. bifarius* belongs to the species group which includes *B. huntii* and *vosnesenskii*, and is most closely related to *B. huntii*. The California color form ("nearcticus" populations) differs from *B. huntii* in having the yellow hair of the scutellum divided into the lateral patches by a central V-shaped notch, and the usual absence of red hair on metasomal tergites 2 and 3.

This widespread western montane bumble bee has two extreme color forms. The nominate form occurs in the Rocky Mountain regions and has considerable red hair on tergites 2 and 3. The most common form ("nearcticus" populations) occurs throughout the range of the species and is the dominant form in the Cascade-Sierran ranges. It lacks red hair on tergites 2 and 3. These color extremes intergrade over a wide range, and occasional red males are found in California. Thus subspecific status is unwarranted.

The nest biology of this species is discussed by Hobbs (1967b). We found one nest in the Sierra Nevada (El Dorado Co., 2490 m) in an old rodent burrow beneath a pile of rocks.

Bombus caliginosus (Frison)

(Figs. 13, 44, 63, 114, 142, 163; Map 13)

Bremus caliginosus Frison, 1927, Proc. Calif. Acad. Sci., (4)16:376. m. Holotype m, Arcata, California (111. NHS).

Geographic range (Map 13). Known only from the Coast Ranges from northern Washington to southern California.

California records. ALAMEDA CO.: Berkeley; Berkeley Hills, E Univ. California campus; Oakland; Oakland Hills; E Oakland Hills; Redwood Regional Park; Strawberry Canyon, Berkeley Hills; Tilden Park. CONTRA COSTA CO.: Martinez, 2 km NW; Orinda; Pt. Molate, Richmond. DEL NORTE CO.: Crescent City, and 21 km S; Ft. Dick, 2 km NE; junction of Dunn Creek and E fork of Illinois River; Elk Valley; Gasquet; Patrick Creek, 14 km NE, on Hwy. 99; Requa; Smith River Camp; Trees of Mystery. GLENN CO.: Alder Springs. HUMBOLDT CO.: Arcata, and 16 km N; Bayside; Blocksburg; Bluff Creek; Clam Beach; Eureka; Ferndale; Fieldbrook; Garberville; Kneeland; Kneeland School; Maple Creek; McKinleyville; Myers Flat; Orick; Orleans; Patrick Creek; Prairie Creek State Park; Richardson Grove State Park, 6.5 km W; Trinidad, 13 km N; Weott, and 2 km E. LAKE CO.: Boggs Lake; Hopland Grade; Middletown, 5 km S; Pillsbury Lake. MARIN CO.: Alpine Lake; Bolinas; Carson Ridge; Cypress Ridge; Dillon Beach; Duxbury Bay; Fairfax; Inverness, and 2 km SE; Lake Lagunitas; Marshalls, 3 km S; McClures Beach, and 6.5 km SE; Mill Valley, and 5 km W; Mt. Tamalpais; Muir Woods; Point Reyes; Stinson Beach; Tocaloma; Tomales, 2 km S; Tomales Point. MENDOCINO CO.: Anchor Bay; DeHaven to Laytonville; Fort Bragg; Little River; Manchester, 19 km and 26 km E; N Navarro River; Pt. Arena; Ryan Canyon; Ryan Creek.

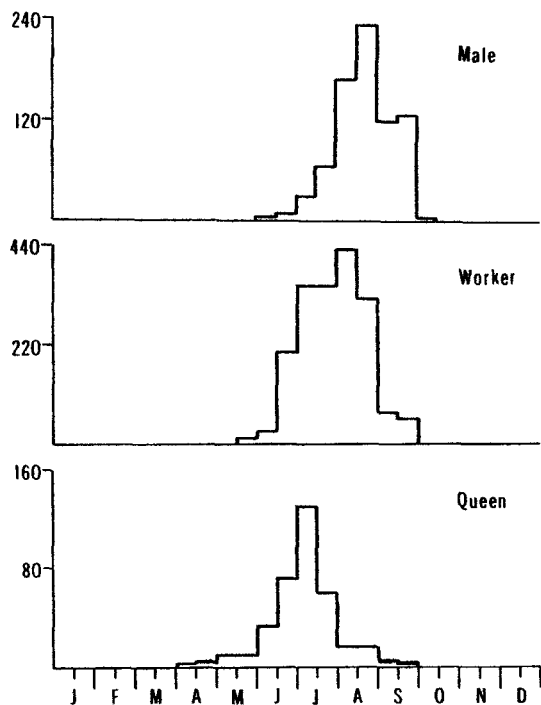
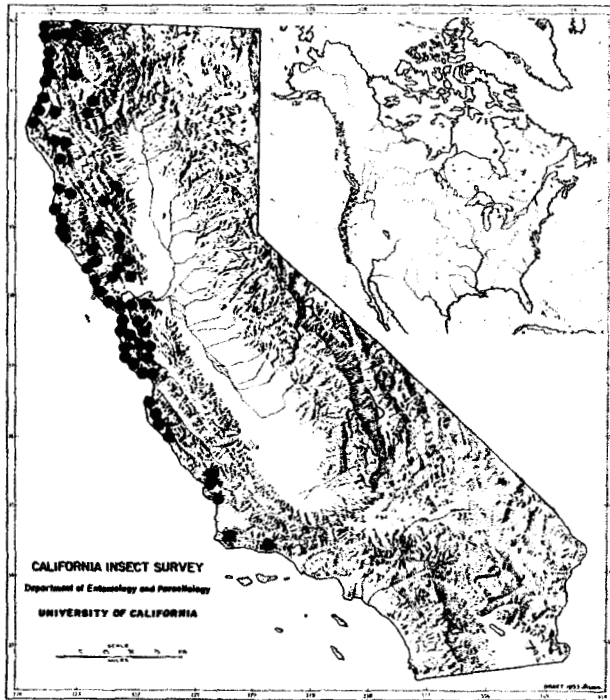


Fig. 12. Histograms of seasonal flight activity for *Bombus bifarius*.



Map 13. Nearctic distribution of *Bombus caliginosus*.

MONTEREY CO.: Asilomar; Carmel; Carmel Hills; hills above Pt. Lobos; Kirk Creek Camp, Los Padres Natl. For.; Lucia; Mill Creek Picnic Area; Monterey; Pacific Grove; Pfeiffer Park, Big Sur; Pine Canyon; Redwood Gulch, near Salmon Creek. NAPA CO.: Angwin; Napa, 11 km NE; Rutherford, 18 km E; St. Helena; Samuel Springs. SAN FRANCISCO CO.: Ft. Funston; Lake Merced; Lobos Creek; San Francisco. SAN LUIS OBISPO CO.: Arroyo Grande; Atascadero, and 8 km W; Baywood Park, Morro Bay; Grover City; Morro Bay; Oso Flaco Lake. SAN MATEO CO.: Daly City; Gazos Creek; Half Moon Bay; La Honda; Moss Beach; Pacifica; Pescadero; San Bruno Mtns.; Woodside. SANTA BARBARA CO.: Lompoc, 10 km SE; Los Prietos, 6.5 km E; Santa Ynez Mtns. SANTA CLARA CO.: Alum Rock State Park; Los Gatos; Palo Alto; San Jose; Saratoga; Stevens Creek area; Uvas Dam. SANTA CRUZ CO.: Big Basin; Highland district; Mission Springs; Mt. Hermon; Santa Cruz, and 11 km NW; Swanton; Weedwordia. SISKIYOU CO.: Happy Camp, 11 km S. SONOMA CO.: Bodega Bay; Cazadero; Cloverdale, 2 km N; Jenner, 3 km E; Russian River near Rio Nido; Santa Rosa; Shell Beach, Bodega Bay; Sobre Vista; Stillwater Cove; Willow Creek, 2 km S Jenner. TRINITY CO.: Del Loma; Hobo Gulch Campground, 26 km N Helena.

Seasonal flight period (Fig. 13). QUEENS (107): late January to early October. WORKERS (528): early March to early October. MALES (192): late April to late September.

Flower records. QUEENS (13): Ericaceae 38%; Rosaceae 15%. WORKERS (80): Leguminosae 31%; Rosaceae 18%; Ericaceae 14%. MALES (21): Compositae 29%; Ericaceae 24%;

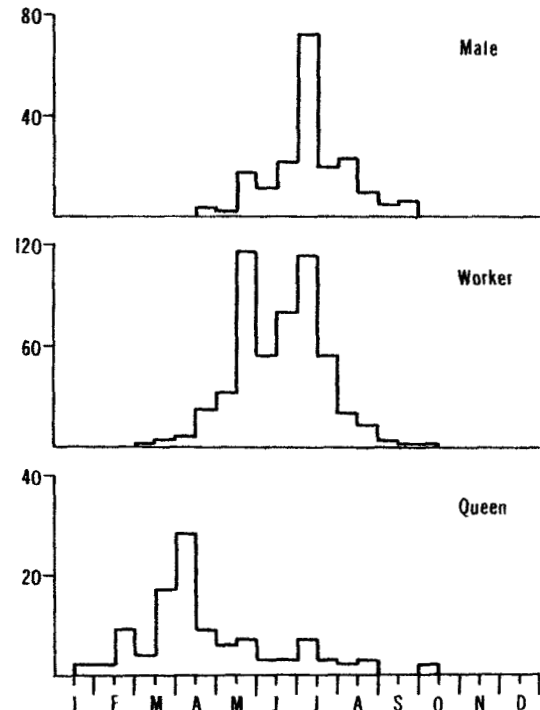


Fig. 13. Histograms of seasonal flight activity for *Bombus caliginosus*.

Leguminosae 24%; Hydrophyllaceae 14%. Total: 114 in 19 families with 32 genera as follows: *Arctostaphylos*: 2q, 1m; *Brodiaea*: 1w; *Ceanothus*: 5w; *Cirsium*: 1q, 6w, 5m; *Collinsia*: 1w; *Cotula*: 1m; *Darlingtonia*: 1w; *Dicentra*: 1w; *Eriodictyon*: 2m; *Eriogonum*: 1q; *Eschscholzia*: 1w; *Eucalyptus*: 1w; *Lathyrus*: 1q, 3w, 5m; *Lotus*: 3w; *Lupinus*: 3w; *Lycoris*: 2w; *Marah*: 1w; *Melilotus*: 1w; *Mentha*: 1q; *Phacelia*: 2w, 1m; *Potentilla*: 2w, 1m; *Rhododendron*: 1q, 8w; *Rhus*: 1q; *Ribes*: 1q, 1w; *Rosa*: 1q, 1w; *Rubus*: 1q, 11w, 4m; *Salix*: 5w; *Scrophularia*: 1w, 1m; *Solidago*: 1w; *Trifolium*: 13w; *Vaccinium*: 2q, 3w; *Vicia*: 2w.

Discussion. *B. caliginosus* belongs to the species group which includes *B. centralis*, *flavifrons*, and *vandykei*, and appears most closely related to *B. vandykei*. It differs from the California female color form of *B. vandykei* in the placement of the yellow hair band on the metasoma. In *B. caliginosus*, the yellow is on the apical half of tergite 4, while in *B. vandykei* it is on the apex of tergite 3. The predominantly black males of *B. caliginosus* are distinct from the predominantly yellow males of *B. vandykei* (cf. Figs. 115 and 124a).

This species exhibits little color variation. One male was described as a new variety (*tardus*) by Frison (1927b) because it lacked the yellow band on the metasoma. No further specimens of this color variant have been seen, and it was

synonymized by Stephen (1957).

An arboreal nest of this species from Berkeley was described by Pitelka (1954). Johansen (1967) noted the similarity of *B. caliginosus* nests in Washington to those of *B. mixtus*. We have taken a surface nest in a garage in Eureka, Humboldt Co. It was using the cotton stuffing of a hammock stored behind some scrap lumber.

***Bombus centralis* Cresson**
(Figs. 14, 64, 116, 143; Map 14)

Bombus centralis Cresson, 1864, Proc. Entomol. Soc. Phila. 3:41. q. Holotype q, Fort Crook, California (#2629 ANSP).

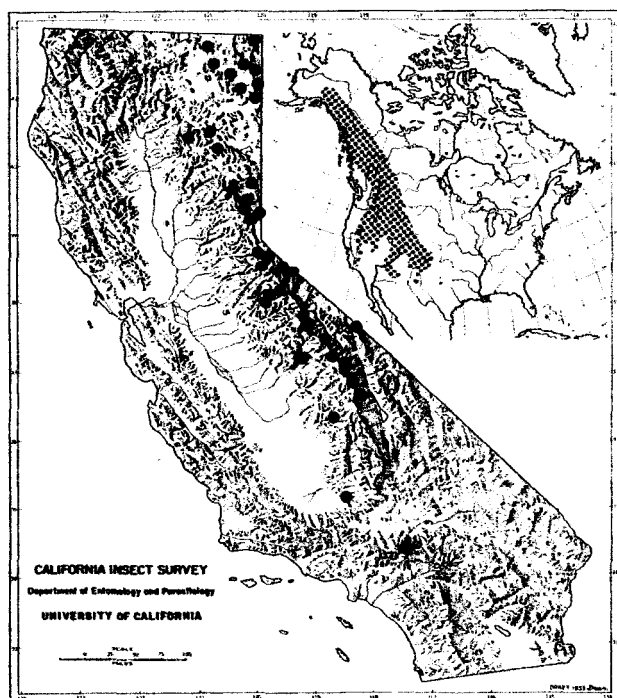
Geographic range (Map 14). W of 100° longitude, Alberta and British Columbia south to New Mexico, Arizona, and California.

California records. ALPINE CO.: Carson Pass; Hope Valley; Winnemucca Lake. EL DORADO CO.: Glen Alpine Creek. FRESNO CO.: Humphreys Basin, 23 km SW Bishop, N fork Bishop Creek Pass, 3200 m; Squaw Valley. INYO CO.: Big Pine Creek; Glacier Lodge, 2440 m, Lone Pine Creek, 3125 m; near Mono Pass, 3660 m; North Lake, near Camp Sabrina; Ruby Lake, 3500 m; Whitney Trail, 2740 m. KERN CO.: Tehachapi. LASSEN CO.: Blue Lake, South Warner Mtns.; Crater Mt.; Jess Valley, Blue Lake Rd.; Summit Camp. MODOC CO.: Alturas, 16 km N; Canby;

Cedar Pass, and 5 km NE; Cedarville, 10 km NW; Clear lake, 8 km NE; Hackamore; Likely; Lily Lake; Patterson Meadow, 16 km SW Eagleville. MONO CO.: Cottonwood Basin, White Mtns.; Crooked Creek, White Mtns.; Grant Lake; June Lake; Leavitt Lake; Leavitt Meadow; near Monitor Pass; Rock Creek; Sardine Creek; Silver lake; Slate Creek Valley, 3200 m; Sonora Pass, 2740-3045 m; Tioga Pass. NEVADA CO.: Boca; Russell Valley; Sagehen Creek near Hobart Mills; Truckee. PLUMAS CO.: Portola; Vinton, 6 km S. SAN BERNARDINO CO.: Big Bear City. SHASTA CO.: Lassen Volcanic Natl. Park. SIERRA CO.: Independence Lake; Sierraville. TULARE CO.: Mineralking. TUOLUMNE CO.: Blue Canyon, near Sonora Pass; Bumble Bee; Sonora Pass, and 3 km W; near Sonora Peak; Strawberry.

Seasonal flight period (Fig. 14). QUEENS (119): late April to early September. WORKERS (574): early May to early September. MALES (297): early June to early October.

Flower records. QUEENS (13): Compositae 54%; Leguminosae 23%. WORKERS (99): Labiatae 28%; Compositae 24%; Scrophulariaceae 12%. MALES (68): Compositae 60%; Labiatae 28%. Total: 181 in 16 families with 34 genera as follows: *Aconitum*: 1w; *Agastache*: 6w; *Althaea*: 2w; *Aster*: 4m; *Caragana*: 2q; *Centaurea*: 2m; *Chrysothamnus*: 2w, 18m; *Cirsium*: 4q, 17w, 12m; *Cleome*: 1w, 6m; *Delphinium*: 4w; *Epilobium*: 1q, 1w, 1m; *Eriogonum*: 1w, 1m; *Frasera*: 5w; *Geranium*: 1w; *Haplopappus*: 1w; *Helianthus*: 4w, 5m; *Linaria*: 8w; *Lupinus*: 1w; *Melilotus*: 1q, 3w; *Mentha*: 3w; *Mentzelia*: 3w; *Mimulus*: 1w; *Monarda*: 3w; *Monardella*: 16w, 19m; *Penstemon*: 3w; *Phacelia*: 2w; *Ribes*: 2q, 1w;



Map 14. Nearctic distribution of *Bombus centralis*.

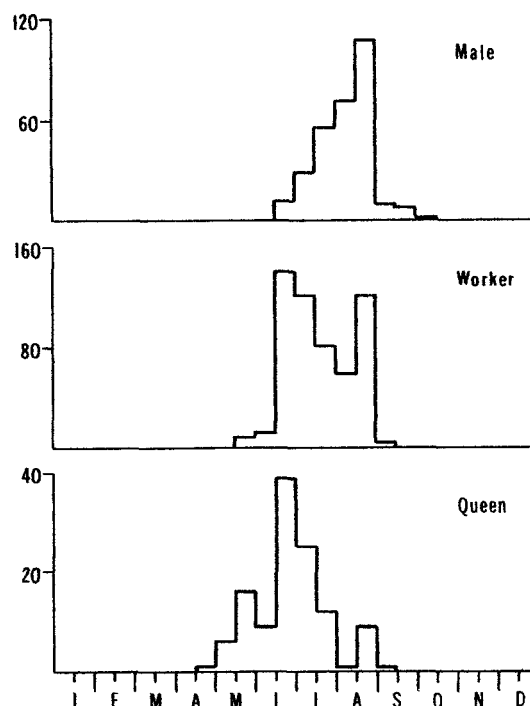


Fig. 14. Histograms of seasonal flight activity for *Bombus centralis*.

Robinia: 1w; *Rosa*: 1w; *Sorbaria*: 3w; *Symphoricarpos*: 3w; *Taraxacum*: 3q; *Trifolium*: 1w; *Vicia*: 1w.

Discussion. *B. centralis* belongs to the species group which includes *B. caliginosus*, *flavifrons*, and *vandykei*, and appears most closely related to *B. flavifrons*. It differs from the California color form of *B. flavifrons* ("dimidiatus" populations) in having red hair on metasomal tergites 3 and 4 and lacking the intermixture of black hairs among the yellow hair of the anterior scutum.

This species exhibits little color variation. Occasionally the red hair fades to yellowish in older specimens.

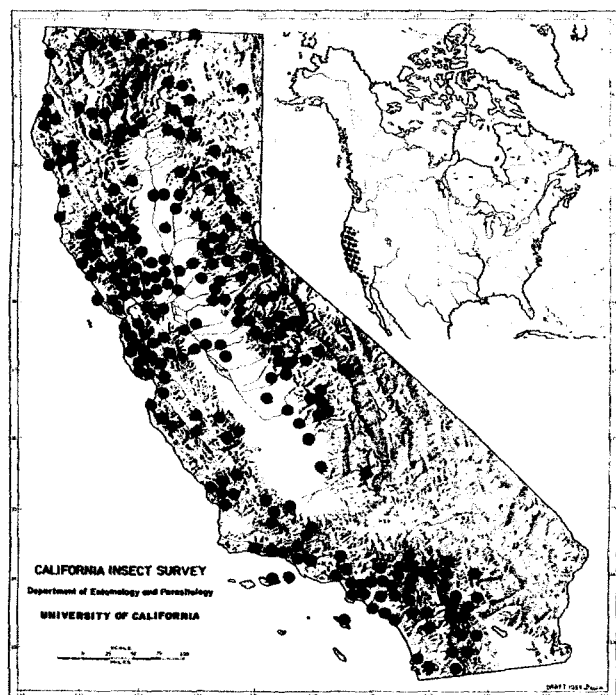
Nests of *B. centralis* were found by Hobbs (1967b).

Bombus edwardsii Cresson

(Figs. 15, 65, 89, 117, 144; Map 15)

Bombus edwardsii Cresson, 1878, Proc. Acad. Nat. Sci. Phila., p. 184. q, w, m. Lectotype w, California (#2649 ANSP) (selected by Cresson, 1916).

Geographic range (Map 15). Oregon, western Nevada, and California.



Map 15. Nearctic distribution of *Bombus edwardsii*.

California representative records. ALAMEDA CO.: Arroyo Mocho, 48 km S Livermore; Berkeley; Mission San Jose. ALPINE CO.: Charity Valley; Woodfords. AMADOR CO.: Cook's Station; Plymouth; Silver Lake; Volcano. BUTTE CO.: Butte Meadows; Chico; Nimshe; Oroville; Yankee Hill. CALAVERAS CO.: San Andreas; Murphys, 610 m. COLUSA CO.: junction of State Hwys. 20 and 16; Stoneyford. CONTRA COSTA CO.: Antioch; Canyon; Mt. Diablo. DEL NORTE CO.: Trees of Mystery. EL DORADO CO.: Blodgett Forest, 16 km E Georgetown; Cool; Fallen Leaf Lake; Placerville; Pollock Pines; Rescue. FRESNO CO.: Coalinga; Fresno; Huntington Lake; Lone Indian Lake. GLENN CO.: Ordbend; Plaskett Meadows, 1890 m. HUMBOLDT CO.: Arcata Airport; Fort Seward; Fortuna; Garberville; Shelter Cove. INYO CO.: Glacier Lodge. KERN CO.: Frazier Park; Glennville; Taft; Walker Pass. LAKE CO.: Blue Lakes; Hopland Grade; Lakeport; Lower Lake; Middletown; Pillsbury Lake; Upper Lake. LASSEN CO.: Fredonyer Pass. LOS ANGELES CO.: Avalon, Santa Catalina Island; Castaic; Claremont; Crystal Lake; Glendale; Mint Canyon Campground; Santa Monica; Tarzana. MADERA CO.: North Fork; Oakhurst; O'Neals. MARIN CO.: Alpine Lake; Fairfax; Ft. Baker; Inverness; Mill Valley; W Novato; Pt. Reyes. MARIPOSA CO.: Briceburg; Camp Curry, Yosemite Natl. Park; Coulterville; Fish Camp; Mariposa. MENDOCINO CO.: Boonville; Hopland; Mendocino; Potter Valley; Rockport; Ryan Creek. MERCED CO.: Atwater. MODOC CO.: Likely. MONO CO.: Leavitt Meadow. MONTEREY CO.: Arroyo Seco Camp; Carmel Valley; King City; Monterey; Tassajara Hot Springs. NAPA CO.: Calistoga; Knoxville; Lake Berryessa; Napa; Oakville; Pope Valley; Wooden Valley. NEVADA CO.: Grass Valley; Lake Spalding; Sagehen Creek; Truckee; Washington. ORANGE CO.: El Toro; San Clemente; Santa Ana. PLACER CO.: Auburn; Dutch Flat; Foresthill. PLUMAS CO.: Blairsden; Bucks Lake; La Porte; Quincy. RIVERSIDE CO.: Banning; Cathedral City; Hemet Reservoir, San Jacinto Mtns.; Idyllwild; Murrieta; Perris; Riverside; Sage; Santa Rosa Mtn., 1765 m. SACRAMENTO CO.: Folsom; Michigan Bar; Walnut Grove. SAN BENITO CO.: Idria; Pinnacles. SAN BERNARDINO CO.: Barton Flats; Cajon Pass; Calimesa; Cedar Springs; Forest Home; Highland; Lake Arrowhead; Mojave River, near Deep Creek; Snow Crest Camp; Waterman Canyon. SAN DIEGO CO.: Barrett Springs; Mt. Laguna; Pala; San Diego; Scissors Crossing. SAN FRANCISCO CO.: Golden Gate Park, San Francisco. SAN JOAQUIN CO.: Lathrop; Tracy, 16 km SW. SAN LUIS OBISPO CO.: Arroyo Grande; Atascadero; Morro Bay; Pozo; Shandon; Simmler. SAN MATEO CO.: Daly City; La Honda; Woodside. SANTA BARBARA CO.: Cuyama; Santa Barbara; Santa Cruz Island. SANTA CLARA CO.: Los Gatos; Mt. Hamilton; New Almaden; Palo Alto; San Jose. SANTA CRUZ CO.: Ben Lomond; Big Basin; Santa Cruz; Watsonville. SHASTA CO.: Burney; Manzanita Lake; McArthur; Old Station; Ono; Redding; Shingletown; Whiskey Town. SIERRA CO.: Gold Lake. SISKIYOU CO.: Castle Lake; Hamburg; Happy Camp; Klamath River; Macdoel; McCloud; Pondosa; Tulelake; Weed. SOLANO CO.: Dixon; Rockville, Vacaville. SONOMA CO.: Cloverdale; Jenner; Kellogg; Plantation; Rio Nido; Santa Rosa; Sobre Vista; Sonoma. STANISLAUS CO.: Del Puerto Canyon. SUTTER CO.: Marysville Buttes. TEHAMA CO.: Mud Flat Camp, 56 km W Corning. TRINITY CO.: Carrville; Del Loma; Hayfork; Salyer; Weaverville. TULARE CO.: Ash Mt., Sequoia Natl. Park; Dinuba; General Grant Park; Porterville; Three Rivers; Visalia. TUOLUMNE CO.: Bumble Bee; Chinese Camp; Columbia; Don Pedro Dam; Kennedy Meadow; Mather; Pincrest. VENTURA CO.: Anacapa

Island; Upper Cuyama River; Hungry Valley; Mt. Pinos; Ojai; Santa Paula. YOLO Co.: Davis; Putah Canyon; Rumsey. YUBA Co.: Robbins.

Seasonal flight period (Fig. 15). QUEENS (281): virtually all year, mainly late December to late July. WORKERS (1340): early February to early August, with scattered records in late September, October, and December. MALES (1376): early February to late September.

Flower records. QUEENS (51): Ericaceae 59%; Boraginaceae 16%. WORKERS (377): Ericaceae 20%; Rhamnaceae 19%; Compositae 12%; Leguminosae 11%. MALES (314): Compositae 27%; Leguminosae 15%; Polygonaceae 13%; Ericaceae 11%. Total: 742 in 28 families with 65 genera as follows: *Abronia*: 1q; *Althaea*: 1m; *Amsinckia*: 6q, 18w; *Arbutus*: 1q, 2w, 1m; *Arctostaphylos*: 23q, 62w, 40m; *Astragalus*: 5w, 1m; *Baccharis*: 1q; *Barbarea*: 1m; *Berberis*: 8w, 1m; *Calyptridium*: 1w; *Ceanothus*: 65w, 3m; *Cercis*: 2w, 1m; *Cirsium*: 6w, 15m; *Clarkia*: 1m; *Collinsia*: 1w; *Coreopsis*: 6m; *Cryptantha*: 2w, 2m; *Eriodictyon*: 3q, 8w, 15m; *Eriogonum*: 40m; *Erodium*: 23w, 1m; *Haplopappus*: 26w, 29m; *Hypochoeris*: 1w; *Hyptis*: 1q; *Isomeris*: 1m; *Lantana*: 1q; *Lasthenia*: 1w; *Layia*: 3m; *Ledum*: 1w; *Limonium*: 1m; *Lonicera*: 7w; *Lotus*: 3m; *Lupinus*: 11w, 2m; *Malus*: 3w; *Marrubium*: 8m; *Monardella*: 2w, 1m; *Myrica*: 1w; *Oenothera*: 1q; *Penstemon*: 10w; *Phacelia*: 4w, 2m; *Phalacroseris*: 1m; *Physalis*: 1w; *Plagiobothrys*: 2q, 5w, 1m; *Platystemon*: 1w; *Prunus*: 1w, 1m; *Ranunculus*: 4w, 2m; *Raphanus*: 2m; *Rhamnus*: 7w, 4m; *Rhododendron*: 6q, 4w, 11m; *Ribes*: 3q, 6w, 1m; *Rosa*: 1w; *Rubus*: 1w;

Salix: 15w, 8m; *Salvia*: 13w, 16m; *Sarcodes*: 2w; *Senecio*: 2w, 4m; *Solanum*: 3w; *Solidago*: 2w, 2m; *Streptanthus*: 1w; *Symphoricarpos*: 1m; *Taraxacum*: 1w, 1m; *Trichostema*: 2w; *Trifolium*: 1q, 21w, 39m; *Vaccinium*: 6w, 19m; *Viburnum*: 1q; *Wyethia*: 52, 25m.

Discussion. *B. edwardsii* belongs to the group of species which includes *B. melanopygus*, *mixtus*, *sitkensis*, and *sylvicola*, and is most closely related to *B. melanopygus*. It differs from *melanopygus* in having black, not red, hairs on metasomal terga 2 and 3.

In color pattern, *B. edwardsii* most closely resembles *B. bifarius* ("nearcticus" populations) and *mixtus*. It differs from *bifarius* in having the scutellum entirely yellow and not interrupted by a broad V-shaped notch. It differs from *mixtus* females in having black hair on the last two tergites instead of reddish or golden hairs. The males are easily separated, because the males of *mixtus* have unique brush-like fringes of hair on the inner faces of the basal antennal flagellomeres.

This species is remarkably uniform in color pattern, but may intergrade with *B. melanopygus* (see discussion under that species).

We have encountered 5 nests of this species. Three taken in Berkeley and El Cerrito were above ground (1.8 to 12.2 m) in old bird nests. Two others (near Pope Valley, Napa Co., and near Santa Margarita, San Luis Obispo Co.) were underground in old rodent burrows. Nest associates included *Volucella* larvae (Syrphidae) (Pope Valley) and *Cratidus* adults (Tenebrionidae) (Santa Margarita), the latter probably only incidental.

***Bombus flavifrons* Cresson**
(Figs. 16, 66, 90, 118, 145; Map 16)

Bombus flavifrons Cresson, 1863, Proc. Entomol. Soc. Phila., 2:105. q, w, m. Lectotype m, Fort Yukon, Alaska (#2630 ANSP) (selected by Cresson, 1916).

Bombus dimidiatus Ashmead, 1902, Proc. Wash. Acad. Sci., 4:129. q, w. Holotype q, Fox Point, Alaska (#5722 USNM). NEW SYNONYMY.

Geographic range (Map 16). Pacific Coast states, including extreme western Nevada, from Alaska to California.

California records. APINE CO.: Carson Pass; Ebbetts Pass, 2660 m; Forestdale Meadow; Highland Lake; Hope Valley; Markleeville, 23 km S; Round Top Lake. AMADOR CO.: Silver Lake. EL DORADO CO.: Angora Lakes; Angora Peak; Desolation Valley Primitive Area; Echo Lake; Fallen Leaf Lake, Tamarack Trail; Glen Alpine Creek; Lake Sylvia, 23 km NE Kyburz; Mt. Ralston, 5 km NE Camp Sacramento; Pollock Pines; Strawberry

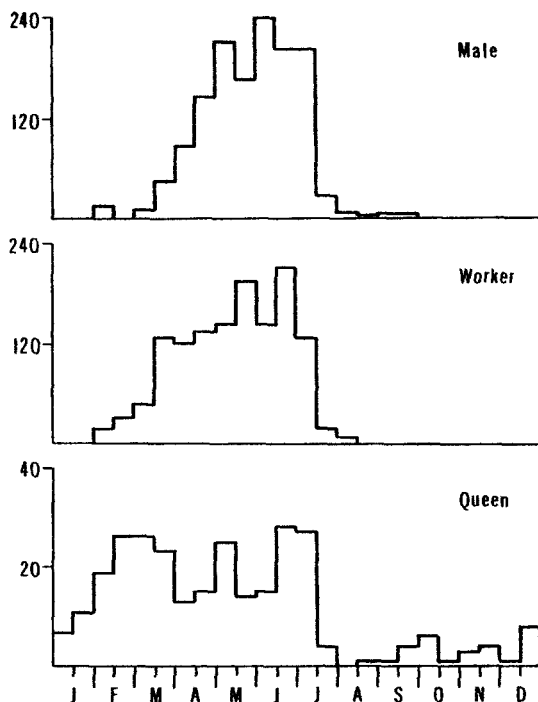
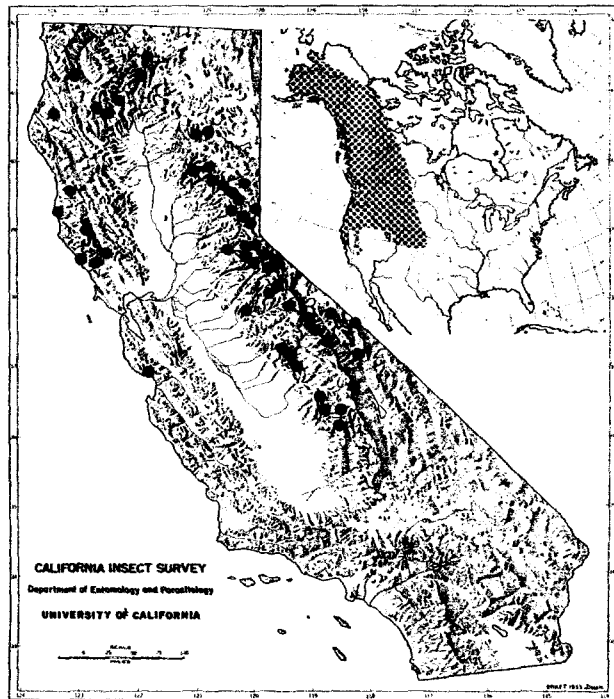
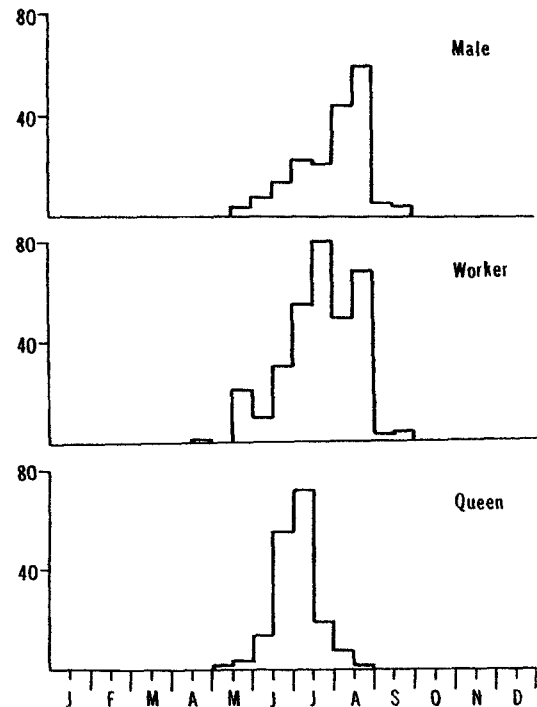


Fig. 15. Histograms of seasonal flight activity for *Bombus edwardsii*.

Map 16. Nearctic distribution of *Bombus flavifrons*.

Valley; Wrights Lake. HUMBOLDT CO.: Kneeland; Orleans; Van Duzen River. INYO CO.: Big Pine; Bishop; Glacier Lodge; near Mono Pass, 3660 m, Rock Creek; North Lake, near Camp Sabrina; Onion Valley, Inyo Natl. For. LASSEN CO.: Hat Lake, Lassen Natl. Park; Norval Flats. MADERA CO.: Buck Camp; Lake Ediza; Moraine Meadow. MENDOCINO CO.: Boonville; Leggett; Litterriver; Ryan Creek. MERCED CO.: Peregoy Meadows. MONO CO.: Leavitt Meadow; Mammoth Lakes; Saddlebag Reservoir; Sardine Creek; Slate Creek Valley, 3200 m; near Sonora Pass; Tioga Lake; Tioga Pass, Yosemite Natl. Park. NEVADA CO.: Donner Lake; Donner Summit; Russell Valley; Sagehen Creek, near Hobart Mills; Sand Ridge Lake near Soda Springs; Truckee. PLACER CO.: Emigrant Gap; Five Lakes; Lake Tahoe; Sugar Bowl Lodge, near Norden. PLUMAS CO.: Bucks Lake; Johnsville, 16 km S, 19 km E, and 23 km W; Little Bear Lake; Onion Valley; Quincy; Summit, 305 m. SANTA CRUZ CO.: Mission Springs; Santa Cruz. SIERRA CO.: Bassets; Gold Lake; Independence; Snow Lake; Webber Lake; Yuba Pass. SISKIYOU CO.: Grass Lake; Sisson. SONOMA CO.: Guerneville; Sebastopol; Stillwater Cove. TRINITY CO.: Carrville; Coffee Creek Ranger Station, and 16 km W; Eagle Creek; Nash Mine. TULARE CO.: Bear Paw Meadow, Sequoia Natl. Park; Bird Lake; General Grant Natl. Park; Giant Forest; Mineralking; Monarch Lake, Mineralking. TUOLUMNE CO.: Blue Canyon, Sonora Pass; Bumble Bee; Chipmunk Flat; Dardanelle; Jacksonville; Kennedy Lake; Mt. Lyell; Sonora Pass, 2440-2740 m.

Seasonal flight period (Fig. 16). QUEENS (178): late March to late August. WORKERS (318): late April to late September. MALES (187): late May to late September.

Fig. 16. Histograms of seasonal flight activity for *Bombus flavifrons*.

Flower records. QUEENS (10): Compositae 40%; Saxifragaceae 30%. WORKERS (46): Labiatae 37%; Compositae 22%; Scrophulariaceae 13%. MALES (39): Compositae 44%; Labiatae 26%; Onagraceae 26%. Total: 95 in 11 families with 20 genera as follows: *Aconitum*: 2w; *Aster*: 5m; *Castilleja*: 1q, 5w; *Chrysothamnus*: 1m; *Cirsium*: 4q, 9w, 3m; *Epilobium*: 1w, 10m; *Eriogonum*: 1w; *Frasera*: 1w; *Grindelia*: 2m; *Haplopappus*: 6m; *Lathyrus*: 2w; *Lupinus*: 2w; *Mentha*: 1q, 12w, 8m; *Mimulus*: 1w; *Monardella*: 5w, 2m; *Phacelia*: 1q; *Rhododendron*: 4w; *Ribes*: 3q, 1m; *Rudbeckia*: 1w, 1m; *Vicia*: 1m.

Discussion. *B. flavifrons* belongs to the group of species which includes *B. caliginosus*, *centralis*, and *vandykei*, and is most closely related to *B. centralis*. In California, it differs from *centralis* in having predominantly black instead of red hair on metasomal tergites 3 and 4, and in the admixture of black to the yellow hair on the anterior scutum. Males of *B. flavifrons* in California may have yellow hairs on much of tergites 3 and 4, thus resembling faded males of *centralis* or yellow males of *vandykei*. They can be separated from both by the presence of some black hairs basally on tergites 3 and 4.

The California color form ("dimidiatus" populations) exhibits some color variation to include females with some reddish hair apically on tergites

3 and 4, thus tending toward the nominate color form. The males exhibit more variation, especially in the amount of yellow hair on tergites 3 and 4.

Nests of the nominate color form in Alberta, Canada, are discussed by Hobbs (1967b).

***Bombus huntii* Greene**
(Figs. 17, 67, 91, 119, 147; Map 17)

Bombus huntii Greene, 1860, Ann. Lyc. Nat. Hist., N.Y., 7:172. q. Holotype, Utah Territory, lost?

Geographic range (Map 17). W of 100° longitude; from southern Saskatchewan, Canada, to northern Chihuahua, Mexico, W to southern British Columbia and eastern California.

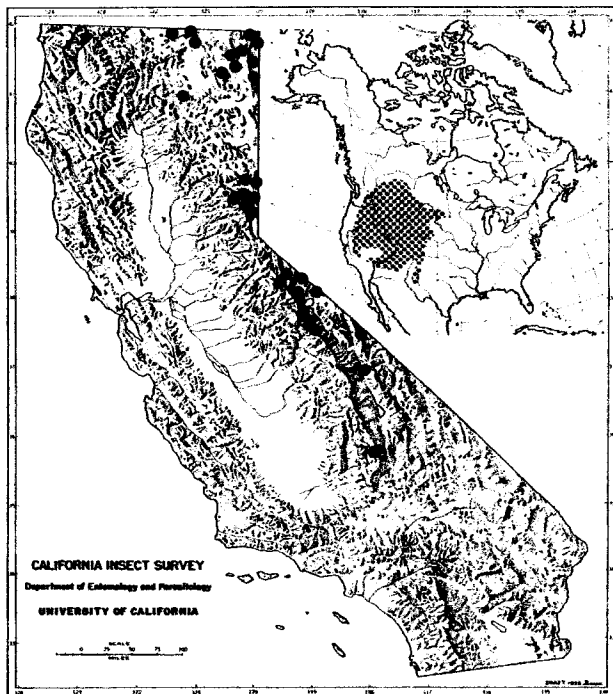
California records. INYO Co.: Long Valley; Owens Valley. LASSEN Co.: Hallelujah Junction. MODOC Co.: Alturas; Canby; Cedar Pass; Cedarville; Davis Creek; Fort Bidwell; Juniper Flat; Lake City; Mason Creek Ranger Station; New Pine Creek; Newell; Tulelake, and 34 km S. MONO Co.: Black Lake; Bodie; Bridgeport; Convict Lake; Crestview, 13 km W; Crooked Creek; White Mtns., 2785 m; Devils Gate; Fales Hot Spring; Grant Lake; Hot Canyon; Hot Creek Hatchery; Lee Vining; Mammoth Lakes; Mono Lake; Pickel Meadow; Rock Creek; Sonora Junction; Willow Springs; near Whitmore Springs. NEVADA Co.: Boca; Hobart Mills, 11 km N; Truckee. PLUMAS Co.: Vinton, 5.5 km S. SHASTA Co.: McArthur. SIERRA Co.: Calpine; Loyalton;

Sierraville. SISKIYOU Co.: Lower Klamath Lake. TUOLUMNE Co.: Sonora Pass.

Seasonal flight period (Fig. 17). QUEENS (177): late March to late September. WORKERS (458): late May to early October. MALES (248): late May to late October.

Flower records. QUEENS (47): Leguminosae 47%; Saxifragaceae 17%; Compositae 13%. WORKERS (85): Compositae 42%; Leguminosae 28%; Scrophulariaceae 13%. MALES (57): Compositae 75%; Leguminosae 19%. Total 189 in 18 families with 37 genera as follows: *Allium*: 1w; *Artemisia*: 7w; *Asclepias*: 2w, 1m; *Aster*: 4w, 9m; *Astragalus*: 2q; *Caragana*: 13q, 1w; *Chrysothamnus*: 1q, 9w, 27m; *Cirsium*: 1q, 6w, 2m; *Cleome*: 2w; *Daucus*: 1w; *Dodecatheon*: 2q; *Erigeron*: 1q, 1w; *Eriogonum*: 1w; *Gutierrezia*: 1m; *Helianthus*: 4w, 2m; *Hemizonia*: 1m; *Hydrophyllum*: 1q; *Linaria*: 7w; *Lupinus*: 4w; *Medicago*: 5q, 8w; *Melilotus*: 5w, 5m; *Mentha*: 2w; *Mentzelia*: 1w; *Mertensia*: 1q; *Penstemon*: 4w, 2m; *Prunus*: 4q; *Ribes*: 8q, 2w; *Rosa*: 1w; *Salix*: 2q; *Sedum*: 1w; *Senecio*: 1q, 3w; *Solidago*: 2w, 1m; *Taraxacum*: 2q; *Thermopsis*: 2q; *Trifolium*: 5w, 6m; *Vicia*: 1w; *Weigela*: 1q.

Discussion. *B. huntii* belongs to the group of species which includes *B. bifarius* and *vosnesenskii*, and can be separated from both by the bright red hair covering its metasomal tergites 2 and 3, and the completely yellow hair of the scutellum.



Map 17. Nearctic distribution of *Bombus huntii*.

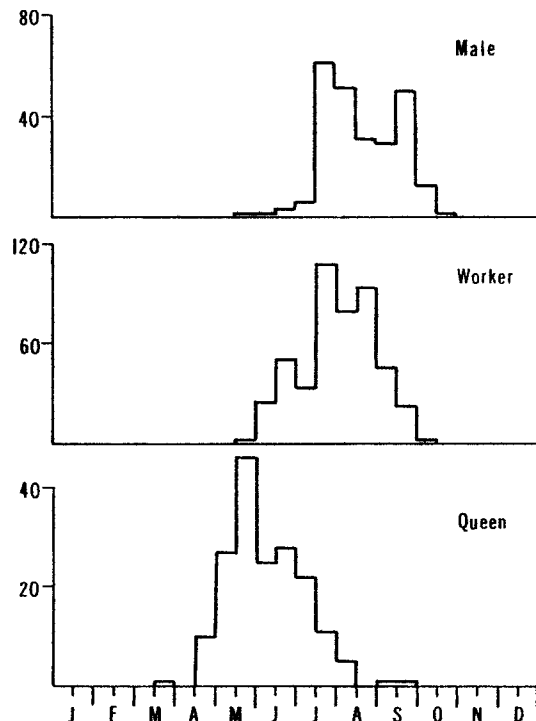


Fig. 17. Histograms of seasonal flight activity for *Bombus huntii*.

This species is extremely uniform in color pattern, with only occasional specimens having the red metasomal hairs fading to yellowish.

Nests of this species are discussed by Medler (1959) and Hobbs (1967b).

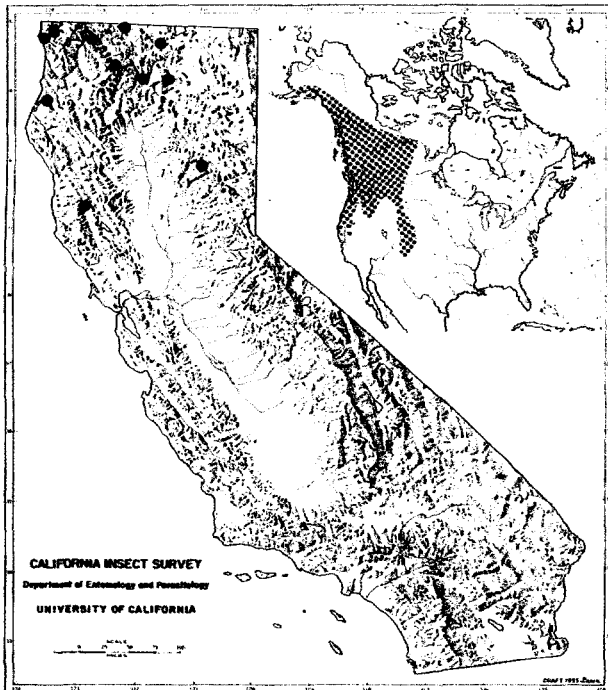
Bombus melanopygus Nylander
(Figs. 18, 45, 68, 121, 146; Map 18)

Bombus melanopygus Nylander, 1848, Notiser Sällskapetets Fauna et flora Fenn. Förhandl., 1:236. m. Lectotype m, Sitka, Alaska (Zool. Mus., Univ. Helsinki, Finland) (selected by Milliron, 1960).

Geographic range (Map 18). W of 100° longitude; from western Manitoba to Colorado, W to Alaska and northern California.

California records. DEL NORTE Co.: Crescent City; Patrick Creek Rd.; Patrick Creek, 14 km E on Hwy. 199. HUMBOLDT Co.: Arcata. MENDOCINO Co.: Ryan Creek. PLUMAS Co.: Meadow Valley, 1830-2130 m. SHASTA Co.: Moose Camp. SISKIYOU Co.: Bartle, 8-16 km NE; Etna; Happy Camp, 11 km S; Hilt, 11 km W; Macdoel; McCloud, 16 km NE. TRINITY Co.: elev. 1675 m.

Seasonal flight period (Fig. 18). QUEENS (91): early February to late October. WORKERS (293): early April to late September. MALES (149): early May to early September.



Map 18. Nearctic distribution of *Bombus melanopygus*.

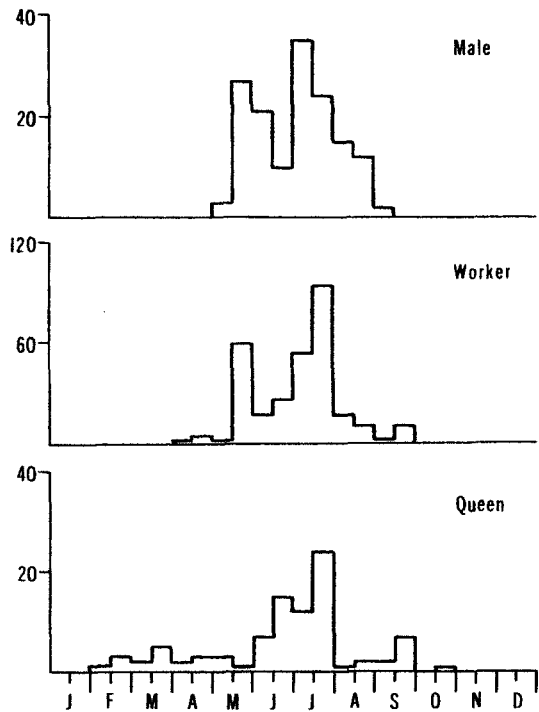


Fig. 18. Histograms of seasonal flight activity for *Bombus melanopygus*.

Flower records. QUEENS (6): Salicaceae 50%; Violaceae 50%. WORKERS (47): Caprifoliaceae 19%; Leguminosae 19%; Rhamnaceae 15%; Berberidaceae 13%. MALES (22): Compositae 36%; Leguminosae 23%; Hydrophyllaceae 18%. Total: 75 in 13 families with 18 genera as follows: *Berberis*: 6w; *Ceanothus*: 7w; *Craetagus*: 2w; *Darlingtonia*: 1m; *Lonicera*: 6w, 2m; *Lupinus*: 5w, 2m; *Malus*: 1w; *Origanum*: 1m; *Phacelia*: 2w, 4m; *Rhododendron*: 3w; *Ribes*: 4w; *Salix*: 3q; *Senecio*: 2w; *Symphoricarpos*: 3w; *Vaccinium*: 1w, 1m; *Vicia*: 4w, 3m; *Viola*: 3q; *Wyethia*: 1w, 8m.

Discussion. *B. melanopygus* belongs to the group of species which includes *B. edwardsii*, *mixtus*, *sitkensis*, and *sylvicola*, and is most closely related to *B. edwardsii*. It differs from *edwardsii* in having red instead of black hair on metasomal tergites 2 and 3 and usually having black instead of yellow hair on tergites 4 and 5.

In color pattern it looks most like *B. huntii* and the Great Basin color form of California *B. sylvicola*. It differs from both in having black hairs intermixed among the yellow hairs of the anterior scutum, which give the area a clouded appearance.

The principal color variation occurs in the amount of yellow hair replacing the black hair on metasomal tergites 4 and 5. An increase in yellow on these tergites is often accompanied by a decrease in the number of black hairs intermixed

on the anterior scutum. The resulting extreme looks like an *edwardsii* with red instead of black hair on tergites 2 and 3. Occasional males of this form are found in areas where *edwardsii* is abundant and no females of *melanopygus* have been taken. These two taxa may be conspecific color forms. The area of overlap, northern California and west central Oregon, between *edwardsii* and *melanopygus* needs to be looked at more critically for signs of intergradation.

The nest biology of *B. melanopygus* is described by Johansen (1967) and Hobbs (1967b). Johansen (1967) found 11 of 14 colonies in surface nest boxes, which coincides with our observations on the above-ground nesting tendencies in *B. edwardsii*. However, Hobbs (1967b) found four nests underground or at least with the entrance tunnel leading underground. The larvae of a sarcophagid fly, *Brachicoma*, fed on larvae and pupae of this bumble bee, and were considered the most destructive parasites found by Johansen (1967).

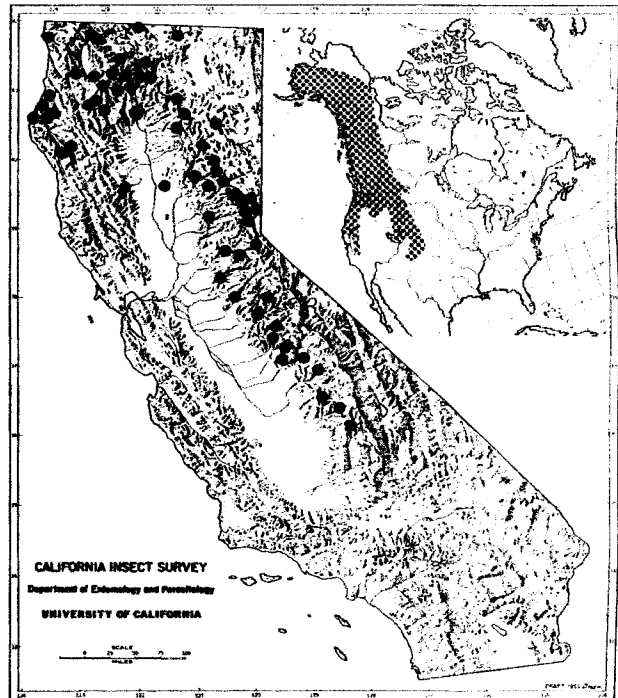
Bombus mixtus Cresson

(Figs. 19, 34, 47, 69, 92, 120, 148; Map 19)

Bombus mixtus Cresson, 1878, Proc. Acad. Nat. Sci., Phila., p. 186. q, w. Lectotype q, Colorado (#2642 ANSP) (selected by Cresson, 1916).

Geographic range (Map 19). W of 105° longitude; from Saskatchewan to Colorado, W to Alaska to California.

California records. AMADOR CO.: Sutter Creek. BUTTE CO.: Chico. CALAVERAS CO.: Murphys, 610 m. DEL NORTE CO.: Crescent City, and 21 km S. EL DORADO CO.: China Flat; Echo Lake; Fallen Leaf Lake; Glen Alpine Creek; Lake Sylvia, 23 km NE Kyburz; Snowline Camp; Strawberry Valley. FRESNO CO.: Dinkey Ranger Station; Huntington Lake. GLENN CO.: Plaskett Meadows, 1585 m. HUMBOLDT CO.: Arcata; Eureka; Ferndale; Fort Seward; Fortuna; Garberville; Kneeland; McKinleyville; Orleans; Samoa. LASSEN CO.: Manzanita Lake. MADERA CO.: Big Sandy Flat; Upper E fork Chiquito Creek; Oakhurst. MARIPOSA CO.: Camp Curry; Lukens Lake; North Dome; Yosemite Valley. NEVADA CO.: Boca; Donner Pass; Hobart Mills; Nevada City, Sagehen Creek near Hobart. PLACER CO.: Bear Valley; Lake Tahoe; Sugar Bowl. PLUMAS CO.: Bucks Lake; Chester; Greenville; Johnsville; La Porte; Little Bear Lake; Meadow Valley, 1830-2130 m; Quincy; Silver Lake; Spencer Lakes. SHASTA CO.: Burney Creek Hatchery; Cameron Pass; Hat Creek; Manzanita Lake; Moose Camp; Snow Mt. Rd.; Summit Lake; Viola. SIERRA CO.: Bassets, 1645 m; Gold Lake; Sierraville; Webber Lake; Yuba Pass. SISKIYOU CO.: Castle Lake; Cecilville; 19 km NE Etna; Happy Camp; Hilt; Lower Klamath Lake; McCloud; Mt. Shasta City; Mt. Shasta, 1830 m; Six Mile Creek; Summit Lake, Marble Mtns. TRINITY CO.: Backbone Ridge Lookout, 19 km N Helena; Big Flat, Coffee Creek; Carrville, 730-760 m; Coffee Creek Ranger Station; Del Loma; Eagle Creek; Hell Creek, 26



Map 19. Nearctic distribution of *Bombus mixtus*.

km E Trinity Center; North Fork Guard Station, 37 km N Helena; Scott Mtn., 1630 m; Weaverville. TULARE CO.: General Grant Grove, King's Canyon Natl. Park; Giant Forest; Mineralking; Sequoia Natl. Park, Crescent Meadow. TUOLUMNE CO.: Hardin; Pincrest; Strawberry, and 18 km N.

Seasonal flight period (Fig. 19). QUEENS (114): early April to late October. WORKERS (544): early April to late September. MALES (419): early May to late September.

Flower records. QUEENS (25): Compositae 24%; Ericaceae 20%; Scrophulariaceae 20%. WORKERS (158): Leguminosae 20%; Rhamnaceae 20%; Ericaceae 12%; Scrophulariaceae 12%; Labiatae 11%; Compositae 10%. MALES (24): Compositae 37%; Labiatae 25%; Leguminosae 18%. Total: 207 in 16 families with 32 genera as follows: *Apocynum*: 1w; *Aster*: 3m; *Berberis*: 1q, 2w; *Ceanothus*: 1q, 27w; *Cirsium*: 1q, 5w; *Crataegus*: 1w; *Darlingtonia*: 1w; *Epilobium*: 1w; *Eriogonum*: 1w; *Fuchsia*: 1w; *Geranium*: 1w; *Heracleum*: 1m; *Lupinus*: 21w, 3m; *Mentha*: 1w, 1m; *Monardella*: 1q, 12w, 1m; *Origanum*: 4m; *Penstemon*: 5q, 18w; *Phacelia*: 2q, 9w, 1m; *Prunus*: 1q, 4w, 1m; *Rhamnus*: 4w; *Rhododendron*: 5q, 17w, 2m; *Ribes*: 2q; *Rubus*: 1q, 6w; *Rudbeckia*: 2w; *Salvia*: 2w; *Senecio*: 4q, 3w, 5m; *Solidago*: 1q; *Stachys*: 2w; *Taraxacum*: 5w, 1m; *Trifolium*: 2w; *Vaccinium*: 1w; *Vicia*: 8w, 1m.

Discussion. *B. mixtus* belongs to the group of species which includes *B. edwardsii*, *melanopygus*, *sitkensis*, and *sylvicola*. It appears to be most closely

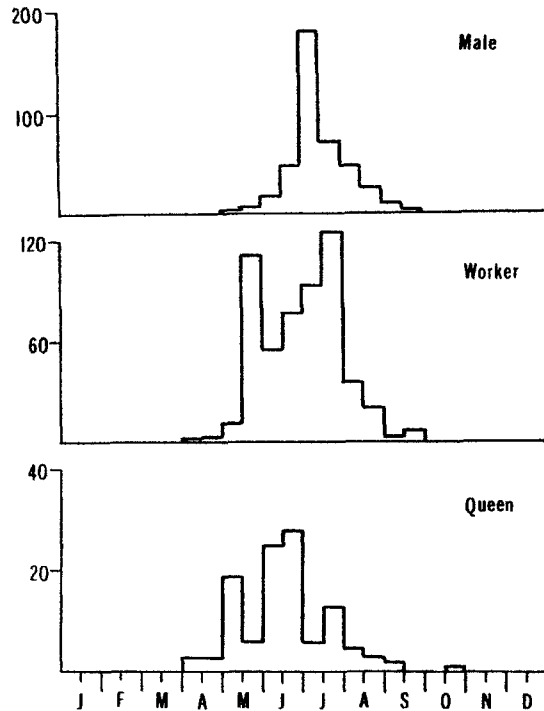


Fig. 19. Histograms of seasonal flight activity for *Bombus mixtus*.

related to *B. sitkensis*. Its females differ from those of *sitkensis* in having the malar space about as long as wide rather than longer than wide, and having black rather than yellow hair laterally and apically on metasomal tergite 2. Males of *B. mixtus* can be distinguished from all other North American bumble bees by the presence of the fringes of hair on the inner faces of their antennal flagellomeres (Fig. 34).

Females of *mixtus* exhibit minor variations in color, usually in shade or intensity rather than position. Reduction of black hairs intermixed on the anterior scutellum, and an increasingly orange cast to the hairs of metasomal tergites 5 and 6, occur in populations from the north coast east and south in the Sierra Nevada. Male color patterns vary considerably (Fig. 120) and may resemble the colors of *sitkensis* or *edwardsii*.

Johansen (1967) and Hobbs (1967b) have described the nest biology of this species. Both authors found considerable variation in nest sites selected. Hobbs (1967b) records 7 underground, 11 surface, and 7 above-ground nests. Johansen (1967) found 22 underground and 12 surface nests. Johansen (1967) also records *Brachicoma*

(Sarcophagidae) as the principal parasite in nests of *B. mixtus*.

Bombus sitkensis Nylander

(Figs. 20, 48, 70, 93, 122, 149; Map 20)

Bombus sitkensis Nylander, 1848, Notiser Sällskapetets Fauna et Flora Fenn. Förhandl., 1:235. q, w, m. Lectotype q, Sitka, Alaska (Zool. Mus., Univ. Helsinki, Finland) (selected by Milliron, 1960).

Geographic range (Map 20). W of 100° longitude, Alaska and British Columbia S to northern Idaho and Montana and coastal California.

California records. ALAMEDA CO.: Berkeley; Berkeley Hills; Boy Scout Camp, Diamond Canyon; Oakland; Redwood Regional Park; Strawberry Canyon, Berkeley Hills. CONTRA COSTA CO.: Redwood Canyon. DEL NORTE CO.: Crescent City, 21 km S; junction of Dunn Creek and E fork of Illinois River; junction of Hoppaw Creek and Klamath River; Requa; Trees of Mystery. HUMBOLDT CO.: Arcata, 32 km N; Bayside; Big Lagoon; Dyerville; Eureka; Ferndale; Fortuna; McKinleyville; Orick; Patrick Creek; Scotia; Shelter Cove, 21 km S; Trinidad, and 13 km N; Van Duzen River; Weott; Williams State Park; Willow Creek. MARIN CO.: Bear Valley; Bolinas; Inverness, and 2 km SE; McClures Beach; Mill Valley; Muir Woods. MENDOCINO CO.: Albion, 14 km E; Fort Bragg; Glen Blair Rd.; Laytonville; Little River; Mendocino; Rockport; Ryan Creek; Willits.



Map 20. Nearctic distribution of *Bombus sitkensis*.

SAN FRANCISCO CO.: Golden Gate Park; Lobos Creek; Mt. Davidson; sand dunes, Ocean Beach; Twin Peaks. SAN MATEO CO.: Daly City; Pescadero; San Bruno Mtn.; Woodside. SANTA CLARA CO.: Palo Alto. SANTA CRUZ CO.: Ben Lomond; Santa Cruz. SONOMA CO.: Cazadero; Cotati Flats; Glen Ellen; Guerneville; Willow Creek near Jenner; Occidental; Plantation; Stillwater Cove. TRINITY CO.: Del Loma.

Seasonal flight period (Fig. 20). QUEENS (81): late January to early December. WORKERS (327): early March to late September. MALES (181): early April to early September.

Flower records. QUEENS (14): Ericaceae 43%; Saxifragaceae 29%; Compositae 14%. WORKERS (61): Ericaceae 46%; Saxifragaceae 21%; Rhamnaceae 11%. MALES (15): Ericaceae 53%; Compositae 33%. Total 90 in 10 families with 14 genera as follows: *Aquilegia*: 1w; *Aster*: 1w; *Brassica*: 1q; *Ceanothus*: 7w, 1m; *Cirsium*: 2q, 1w, 5m; *Lathyrus*: 3w; *Rhododendron*: 1q, 27w, 3m; *Ribes*: 4q, 13w; *Rubus*: 3w, 1m; *Salix*: 1w; *Solidago*: 1w; *Stachys*: 1w; *Vaccinium*: 5q, 1w, 5m; *Vicia*: 1q, 1w.

Discussion. *B. sitkensis* belongs to the group of species which includes *B. edwardsii*, *melanopygus*, *mixtus*, and *sylvicola*. It appears to be most closely related to *B. mixtus*. Its females differ from *mixtus* in having the malar space longer than wide rather than about as long as wide, the hair of metasomal tergite 2 predominantly yellow rather than black

laterally and apically, and generally longer body hairs. The males closely resemble some color forms of *B. mixtus*, but lack the fringe of hairs on the inner faces of the antennal flagellomeres of *mixtus*.

Females resemble the California color form of *B. flavifrons* ("dimidiatus" populations), but have the scutellum predominantly covered with black rather than yellow hair, and have predominantly pale hair instead of predominantly black hair on the apical two metasomal tergites. Males also resemble *flavifrons* ("dimidiatus" populations), but differ by the same characters as for the females and in having an apical fringe of yellow instead of all black on metasomal tergite 3. Males of *sitkensis* also have antennal flagellomere 1 shorter than, not longer than, 3.

Bombus sylvicola Kirby
(Figs. 21, 46, 71, 94, 123, 150; Map 21)

Bombus sylvicola Kirby, 1837, in Richardson, Fauna Bor. Amer., 4:272. q?. Holotype q?, 65° latitude [presumably in the BMNH, but not located by Stephen (1957)].

Geographic range (Map 21). Northern North America from Newfoundland to Alaska and S (in the higher western mountains only) to New Mexico, Utah, Nevada, and California.

California records. ALPINE CO.: Blue Lakes; Carson Pass; Highland Lake; Hope Valley; Markleeville, 27 km S; Round Top Lake; Winnemucca Lake, 2740-2895 m. EL DORADO CO.: Desolation Valley Primitive Area; Lake Sylvania, 23 km NE Kyburz; Mt. Ralston near Camp Sacramento; Mt. Tallac. FRESNO CO.: Humphreys Basin, 23 km SW Bishop; Pioneer Basin, 3350-3500 m; Sixty-Lake Basin, 3045 m. INYO CO.: Big Pine Creek, near Glacier Lodge, 2400-3350 m; Big Pine Lakes; Mono Pass, 3655 m; Ruby Lake, 3045 m, and NW at 3500 m. MARIPOSA CO.: Cathedral Lake, Yosemite Natl. Park. MONO CO.: Barcroft Lab, 3810 m, White Mtns.; Barney Lake; Bodie; Cottonwood Creek, 2835 m; Crooked Creek Lab, White Mtns., 3090 m; 32 km S junction of Hwys. 120 and 395; Leavitt Lake; Rock Creek near Tom's Place; Saddlebag Lake, near Tioga Pass; Sardine Creek, 2590 m; Sheep Mtn., 3410 m; Tioga Lake; Tioga Pass, Yosemite Natl. Park; Virginia Lakes; White Mtn., 4265 m; Wyman Canyon, White Mtns. SHASTA CO.: Hat Lake, Lassen Natl. Park. SISKIYOU CO.: Castle Lake; Man Eater Lake, Marble Mtns. TULARE CO.: Bird Lake; near Forester Pass, 3655 m; Mineralking; W Mt. Whitney, 3500 m; Pear Lake, Sequoia Natl. Park. TUOLUMNE CO.: Blue Canyon, Sonora Pass; Bumble Bee; Conness Creek, Yosemite Natl. Park; Dana fork, Tuolumne R., Yosemite Natl. Park, 3045 m; Emigrant Basin, Stanislaus Natl. For.; Kennedy Meadow; Kuna Crest, Yosemite Natl. Park; Lyell Canyon; Mt. Dana, 3350 m; Yosemite Natl. Park; near Sonora Pass, 2440-3350 m; near Sonora Peak, 3350 m.

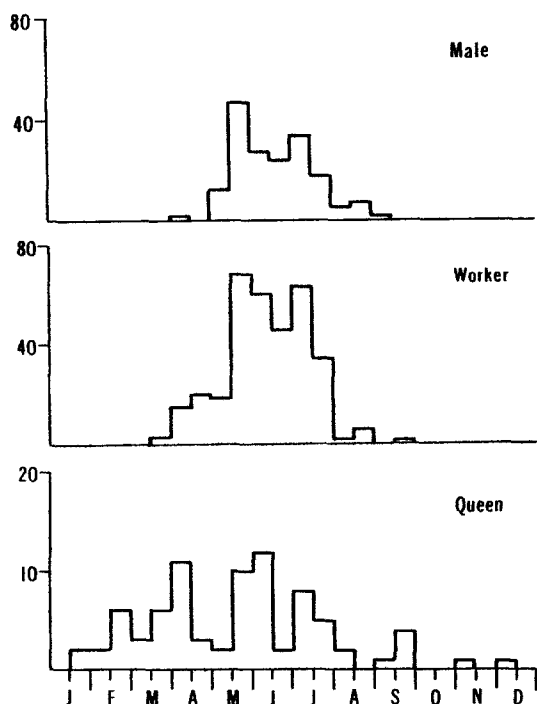
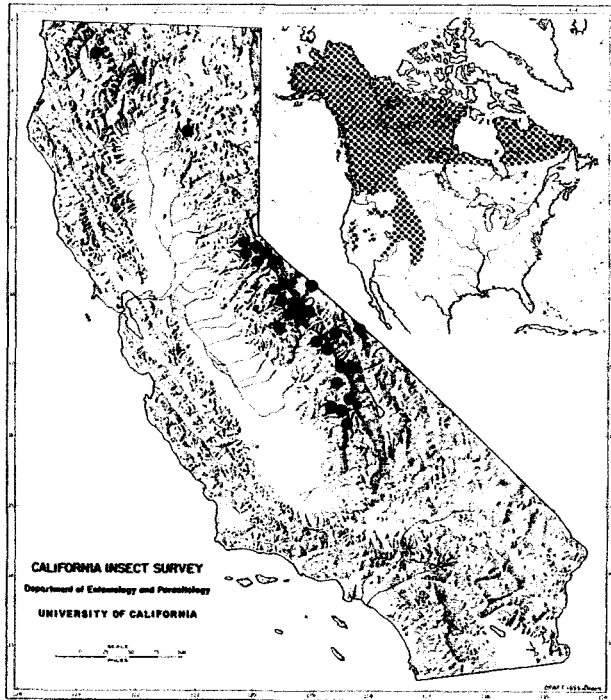


Fig. 20. Histograms of seasonal flight activity for *Bombus sitkensis*.

Seasonal flight period (Fig. 21). QUEENS (206): early June to early September. WORKERS (303): late June to late September. MALES (210): early July to early October.



Map 21. Nearctic distribution of *Bombus sylvicola*.

Flower records. QUEENS (20): Compositae 55%; Labiatae 35%. *WORKERS (57):* Compositae 65%; Labiatae 19%. *MALES (46):* Compositae 98%. Total: 123 in 8 families with 17 genera as follows: *Aster*: 2m; *Chamaebatiaria*: 1w; *Chrysothamnus*: 1q, 14w; *Cirsium*: 1q; *Dodecatheon*: 1w; *Epilobium*: 2w; *Frasera*: 1q, 3w; *Grindelia*: 1w; *Haplopappus*: 1q, 8w, 39m; *Helenium*: 2w, 4m; *Mentha*: 5q, 3w, 1m; *Monardella*: 2q, 8w; *Penstemon*: 1q; *Petasites*: 5q, 10w; *Sphenosciadium*: 2w; *Taraxacum*: 3q; *Wyethia*: 2w.

Discussion. *B. sylvicola* belongs to the group of species which includes *B. edwardsii*, *melanopygus*, *mixtus*, and *sitkensis*. It is most closely related to the Palearctic *B. lapponicus* Fabricius and may be conspecific with it (cf. Thorp, 1962). In California it most closely resembles *B. melanopygus*, but differs in having the anterior scutum covered with yellow rather than yellow and black hairs intermixed. The color pattern of some *sylvicola* may be confused with the sympatric *B. bifarius*. But the

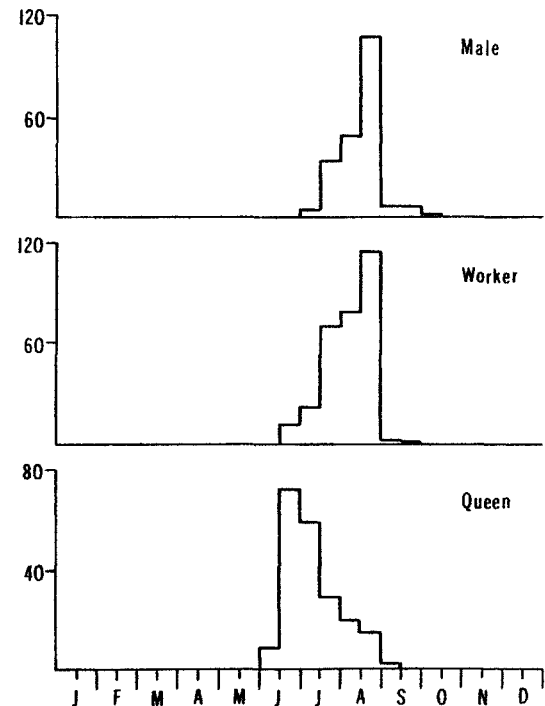


Fig. 21. Histograms of seasonal flight activity for *Bombus sylvicola*.

male genitalia of *B. sylvicola* are unique in North American *Bombus* in the abruptly swollen bulbous apices of their penis valves (Fig. 46). The females have predominantly black facial hair with yellow only around the antennal bases rather than all yellow facial hair.

This species is represented in California by two color forms which differ principally in the amount of red or black hairs on metasomal tergites 2 and 3. The Sierran-Cascade form is somewhat variable, but tends to have predominantly black hair with little or no orangish or dark reddish tinges present, and to resemble the *edwardsii-bifarius* Müllerian mimicry complex. The form found in the White Mountains in the Great Basin Montane area has predominantly bright orange to red hairs on tergites 2 and 3 and bears a closer resemblance to populations from the Rocky Mountains of Colorado (Thorp, 1962).

The nest biology of *sylvicola* is discussed by Hobbs (1967b).

***Bombus vandykei* (Frison)**
(Figs. 22, 124, 151; Map 22)

Bremus flavifrons var. *vandykei* Frison, 1927, Proc. Calif. Acad. Sci., (4)16:375. w. Holotype w, Mt. Adams, Yakima Indian Forest Reservation, Washington (#2437, CAS).

Pyrobombus (*P.*) *cascadensis* Milliron, 1970, Can. Entomol., 102:382. q. Holotype q, Slate Peak, Whatcom County, Washington (USNM). NEW SYNONYMY.

Geographic range (Map 22). Pacific Coast states from Washington to southern California.

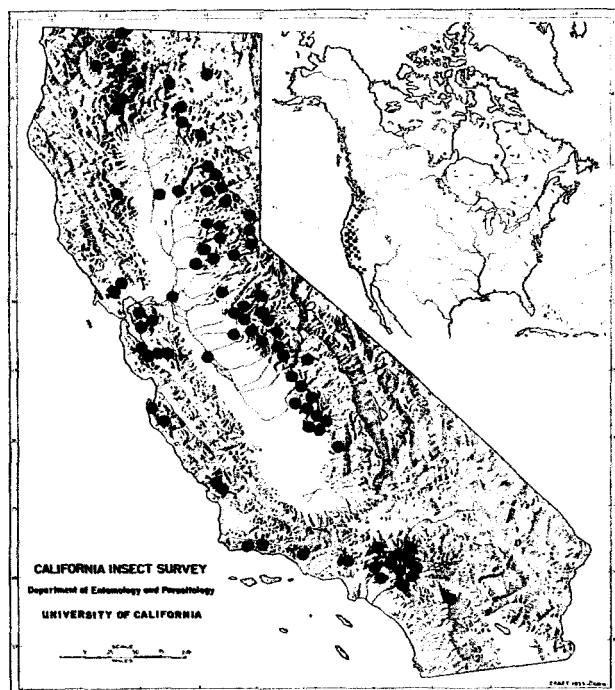
California records. ALAMEDA CO.: Berkeley. BUTTE CO.: Chico, and 19 km NE; Jarbo Pass. CALAVERAS CO.: Mokelumne Hill. CONTRA COSTA CO.: Diablo; Lafayette. EL DORADO CO.: Fallen Leaf Lake; Pilot Hill; Placerville; Pollock Pines; Riverton; Snow Line Camp. FRESNO CO.: Dunlap; Huntington Lake; Orange Cove; Pinehurst; Tollhouse; Trimmer. GLENN CO.: Alder Springs. LASSEN CO.: Bridge Creek Camp. LOS ANGELES CO.: Bell Canyon, San Dimas Experimental Forest; Claremont; Crystal Lake; Glendale; Prairie Fork, San Gabriel Mtns.; Tanbark Flat. MADERA CO.: Millerton Lake; San Joaquin Exp. Range. MARIPOSA CO.: Bagby, 27.8 km N; Camp Curry, Yosemite Natl. Park; Coulterville; El Portal; Exchequer Dam; Mariposa; Mariposa Grove; Midpines Summit; Mormon Bar; Peregrory Meadows;

Wawona Tunnel, Yosemite Natl. Park; Wawona; Yosemite Valley. MERCED CO.: Hilmar. MODOC CO.: Canby, 27 km W. MONO CO.: near Sonora Pass. MONTEREY CO.: Arroyo Seco; Arroyo Seco Camp; Carmel; Limekiln Creek. NEVADA CO.: Grass Valley; Nevada City; Sagehen Creek near Hobart Mills. PLACER CO.: Auburn; Dutch Flat; Foresthill; Green Valley; Lake Forest; Tahoe City. PLUMAS CO.: Blairsden; Greenville; Johnsonville; Lake Almanor; Meadow Valley, 1220-1525 m; Quincy; Taylorsville. RIVERSIDE CO.: Riverside; Tahquitz Peak. SACRAMENTO CO.: Andrus; Folsom; Sacramento; Sherman Island. SAN BERNARDINO CO.: Barton Flats; Bear Flat, Mt. San Antonio, 1675 m; Big Bear City; Big Bear Valley, Pine Crest Golf Course; City Creek Rd.; Dollar Lake Trail; Falls Public Campground; Fallsvale; Lake Baldwin; Little Mojave River, San Bernardino Mtns.; Lytle Creek; Mill Creek, 1830 m; Mojave River above Deep Creek, Mojave Desert; Sugar Loaf Mtn.; Vivian Creek Trail, 1980-2010 m; Wildwood Canyon; Calimesa. SAN LUIS OBISPO CO.: Atascadero; Santa Margarita. SANTA BARBARA CO.: Cachuma Park; Cañada del Venadito; Cañon de Refugio; San Marcos Ranch Hdqtrs., Santa Ynez Mtns.; Santa Ynez Mtns. SANTA CLARA CO.: Alum Rock Park; Los Altos; Los Gatos; Mt. Hamilton; Palo Alto; San Antonio Canyon; San Jose; Stanford Univ. SHASTA CO.: Cassel; Hat Creek P.O. SIERRA CO.: Downieville; St. Charles Hill. SISKIYOU CO.: Bartle; Deep Lake; Etna; Hilt, 27 km W; Klamath River P.O., 24 km E; Mt. Shasta City; Sky High Lake, Marble Mtns.; Yreka. SONOMA CO.: Glen Ellen; Petaluma; Sobre Vista. STANISLAUS CO.: La Grange. TRINITY CO.: Carrville; Coffee Creek Ranger Station; Hell Creek, 26 km E Trinity Center; Nash Mine. TULARE CO.: Ash Mtn. and Potwisha, 610-1525 m, Sequoia Natl. Park; Aukland; Fairview; Kaweah; Mineralking; Porterville; Springville; Three Rivers. TUOLUMNE CO.: Camp Bob Macbride, Pinecrest, 2895 m; Columbia, and at old Catholic Church; near Crane Flat, Yosemite Natl. Park; Dodge Ridge; Eleanor Lake; Groveland; Jacksonville; Mather; Pinecrest; Rawhide; Stanislaus River near Columbia; Strawberry; Tuolumne Camp; Twain Harte. VENTURA CO.: Wheeler Springs; Ojai.

Seasonal flight period (Fig. 22). QUEENS (83): late March to early November. WORKERS (200): early March to early September. MALES (239): early May to late September.

Flower records. QUEENS (16): Leguminosae 19%; Labiatae 19%; Hydrophyllaceae 13%; Saxifragaceae 13%. WORKERS (62): Leguminosae 26%; Hydrophyllaceae 23%; Labiatae 19%; Scrophulariaceae 13%. MALES (69): Onagraceae 29%; Compositae 26%; Leguminosae 22%; Labiatae 16%. Total 147 in 15 families with 34 genera as follows: *Agastache*: 2w, 1m; *Althaea*: 1w; *Amsinckia*: 1w; *Anaphalis*: 1m; *Arctostaphylos*: 1q; *Aster*: 1w, 5m; *Berberis*: 1q; *Calochortus*: 1m; *Cercis*: 2w; *Chrysopsis*: 1m; *Cichorium*: 3w, 1m; *Cirsium*: 6m; *Clarkia*: 3w, 18m; *Collinsia*: 1w; *Epilobium*: 2m; *Eriodictyon*: 4w; *Eriogonum*: 1q; *Grindelia*: 1m; *Hypericum*: 2w; *Linaria*: 1m; *Lotus*: 1q, 1m; *Lupinus*: 1q, 1w; *Monardella*: 2w, 1m; *Penstemon*: 1q, 7w, 2m; *Phacelia*: 2q, 10w; *Pyrus*: 1q; *Ribes*: 2q; *Rubus*: 1w, 1m; *Salvia*: 3q, 6w; *Senecio*: 3m; *Stachys*: 2w, 9m; *Taraxacum*: 1q; *Trifolium*: 1q, 12w, 14m; *Vicia*: 1w.

Discussion. *B. vandykei* belongs to the species group which includes *B. caliginosus*, *centralis*, and *flavifrons*, and appears to be most closely related to



Map 22. Nearctic distribution of *Bombus vandykei*.

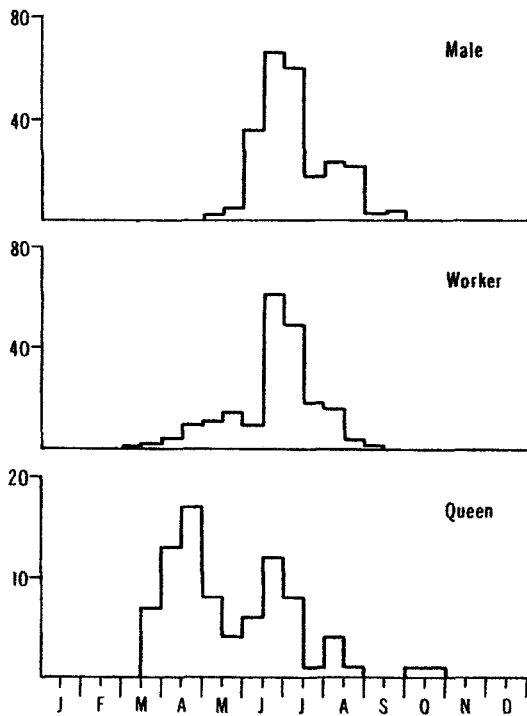


Fig. 22. Histograms of seasonal flight activity for *Bombus vandykei*.

B. caliginosus. Females of the California color form of *B. vandykei* differ from *caliginosus* in having yellow metasomal hair on the apex of tergite 3 rather than on tergite 4. The males differ from all *Pyrobombus* in having the first four metasomal tergites covered with yellow hair.

In California this species shows little color variation. Its females closely resemble the *B. caliginosus-vosnesenskii* color pattern, and have been confused with them by previous authors (Thorp, 1969). The females described as *Pyrobombus cascadenis* by Milliron (1970) belong to the nominate color form found in Washington and southern Oregon. A few males differ from the yellow color form by replacement of yellow by black hairs on the scutellum and anterior metasomal segments.

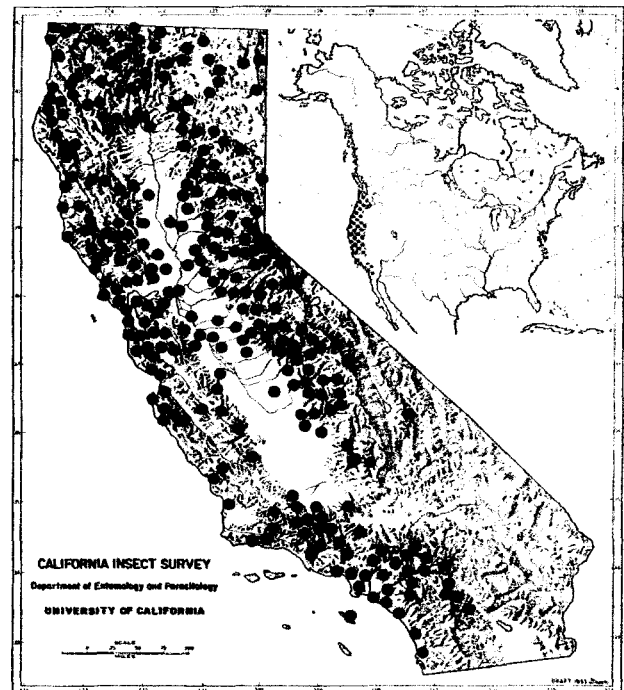
Bombus vosnesenskii Radoszkowski
(Figs. 23, 72, 95, 125, 152; Map 23)

Bombus vosnesenskii Radoszkowski, 1862, Bull. Soc. Nat. Moscou, 35:589. q, m. Holotype q, California (? Acad. Sci. USSR).

Geographic Range (Map 23). Pacific Coast states: Washington, Oregon, western Nevada, California, and northern Baja

California, Mexico.

California representative records. ALAMEDA CO.: Arroyo Mocho, 32 km S Livermore; Berkeley; Midway; Mission San Jose; San Leandro. ALPINE CO.: Ebbetts Pass; Monitor Pass; Winnemucca Lake; Woodfords. AMADOR CO.: Fiddletown; Ione; Sutter Creek; Tragedy Spring; Volcano. BUTTE CO.: Feather Falls; Pentz. CALAVERAS CO.: Mokelumne Hill; Murphys, 610 m. COLUSA CO.: Lodoga; Williams. CONTRA COSTA CO.: Antioch; Crockett; El Cerrito; Mt. Diablo; Walnut Creek. DEL NORTE CO.: Crescent City; Klamath. EL DORADO CO.: Cool; Eagle Lake; Garden Valley; Meyers; Riverton; Shingle Springs; Strawberry. FRESNO CO.: Coalinga Mineral Springs; Fresno; Heart Lake, 3200 m; Hume Lake; Mercey Hot Springs; Shaver Lake; Squaw Valley; Trimmer. GLENN CO.: Alder Springs; Artois; Plaskett Meadow. HUMBOLDT CO.: Arcata; Fort Seward; Garberville; Hoopa; Orleans; Rio Dell; Weott. INYO CO.: Glacier Lodge; Mono Pass, 3655 m; Panamint. KERN CO.: Cerro Noroeste, 2500 m; Kernville; Lebec; Taft; Walker Pass. LAKE CO.: Clear Lake Oaks; Elk Mtn.; Hopland Grade; Middletown. LASSEN CO.: Bieber; Black's Mtn.; Blue Lake; Fredonyer Pass; Hallelujah Junction; Janesville. LOS ANGELES CO.: Blue Ridge, 2560 m, San Gabriel Mtns.; Castaic; Claremont; Gorman; Green Valley; Mint Canyon; Palos Verdes; Santa Catalina Island; Santa Monica; Tanbark Flat; Whittier. MADERA CO.: Chiquito Lake; Miller-ton Lake; Minaret Summit; Nipinnawasee; North Fork. MARIN CO.: Bolinas; Dillon Beach; Fairfax; Inverness; Laguna, Chileno Valley; Mt. Tamalpais; Novato; Pt. Reyes; Sausalito. MARIPOSA CO.: Coulterville; El Portal; Exchequer Dam; Fish Camp;



Map 23. Nearctic distribution of *Bombus vosnesenskii*.

Mariposa; Yosemite Valley. MENDOCINO Co.: Covelo; Fort Bragg; Leggett; Pt. Arena; Rockport; Ukiah; Willits. MERCED Co.: Dos Palos; Livingston; Planada. MODOC Co.: Adin; Cedar Pass; Hackamore; Newell. MONO Co.: Sonora Junction. MONTEREY Co.: Arroyo Seco Camp; Big Sur; Carmel; Carmel Valley; Prunedale. NAPA Co.: Calistoga; Lake Berryessa; Napa; Pope Valley. NEVADA Co.: Chicago Park; Donner Summit; Floriston; Grass Valley; Hobart Mills; Lake Spaulding; North San Juan. ORANGE Co.: Costa Mesa; San Clemente; Seal Beach. PLACER Co.: Auburn; Emigrant Gap; Forest Hill; Lake Forest; Roseville. PLUMAS Co.: Bucks Lake; Chester; Dellecker; Onion Valley; Portola; Taylorsville. RIVERSIDE Co.: Banning; Gavilan; Hemet Reservoir, San Jacinto Mtns.; Riverside; Santa Rosa Peak. SACRAMENTO Co.: Folsom; Michigan Bar; Sherman Island. SAN BENITO Co.: Bitterwater; Idria; Pinnacles Natl. Mon. SAN BERNARDINO Co.: Baldwin Lake; Barton Flats; Cajon Pass; Camp Baldy; Crestline; Forest Home; Lake Arrowhead. SAN DIEGO Co.: La Jolla. SAN FRANCISCO Co.: Golden Gate Park, San Francisco. SAN JOAQUIN Co.: Corral Hollow; Mormon. SAN LUIS OBISPO Co.: Arroyo Grande; Atascadero; Morro Bay; Simmler. SAN MATEO Co.: Burlingame; Half Moon Bay; Pacifica; Pigeon Pt.; Redwood City. SANTA BARBARA Co.: Cuyama; Figueroa Mtn.; Los Prietos; Refugio Beach; Santa Barbara. SANTA CLARA Co.: San Antonio Valley; Saratoga; Uvas Creek. SANTA CRUZ Co.: Boulder Creek; Watsonville. SHASTA Co.: Burney; Lakehead; Lassen Peak; McArthur; Old Station; Redding. SIERRA Co.: Gold Lake; Independence Lake; Sierraville. SISKIYOU Co.: Bartle; Cecilville; Dorris; Dunsmuir; Etna; Happy Camp; Hilt; Lava Beds Natl. Mon.; Panther Meadow, Mt. Shasta, 2285 m; Somesbar; Summit Lake, Marble Mtns.; Tennant; Willow Creek Mtn.; Yreka. SOLANO Co.: Mix Canyon; Rio Vista. SONOMA Co.: Cloverdale; Jenner; Petaluma; Santa Rosa; Sonoma. STANISLAUS Co.: Del Puerto Canyon, 34 km W Patterson; La Grange; Oakdale; Turlock. SUTTER Co.: Sutter Buttes. TEHAMA Co.: Mineral. TRINITY Co.: Bully Choop Peak; Carrville, Del Loma; Forest Glen; North Fork Guard Station, 37 km N Helena; Scott Mtn.; Weaverville. TULARE Co.: Badger; Coffee Camp; Deadman Canyon, Kings Canyon Natl. Park; Fairview; Giant Forest; Lemoncove; Mineralking; Porterville; Troy Meadow, 2375 m; Tulare. TUOLUMNE Co.: Big Oak Flat; Bumble Bee; Dardanelle; Mather; Pinecrest; Sonora; Sonora Pass, 2935 m. VENTURA Co.: Camp Ozena, Upper Cuyama; Hungry Valley, 8 km S Gorman; Mt. Pinos; Santa Paula. YOLO Co.: Davis; Putah Canyon; Rumsey. YUBA Co.: Marysville; Strawberry Valley.

Seasonal flight period (Fig. 23). QUEENS (707): All months. WORKERS (3512): early February to late October. MALES (1318): early March to early November.

Flower records. QUEENS (128): Saxifragaceae 25%; Leguminosae 23%; Ericaceae 13%. WORKERS (1035): Compositae 26%; Leguminosae 23%; Hydrophyllaceae 12%. MALES (393): Compositae 62%; Polygonaceae 15%. Total: 1557 in 34 families with 98 genera as follows: *Agastache*: 1q, 1w; *Arbutus*: 1q, 2w; *Arctostaphylos*: 11q, 16w; *Asclepias*: 1w; *Aster*: 4w, 4m; *Astragalus*: 9q, 1w, 1m; *Berberis*: 1q; *Brassica*: 1q, 1m; *Brodiaea*: 2w; *Caragana*: 8q; *Carduus*: 1q; *Castilleja*: 2w; *Ceanothus*: 9q, 37w, 2m; *Centaurea*: 25w, 34m; *Cercis*: 4w; *Chaenactis*: 2w; *Chrysopsis*: 1w; *Chrysothamnus*: 63w, 39m; *Cichorium*: 1q, 10w, 4m; *Cirsium*: 6q, 127w, 129m; *Clarkia*: 1w, 2m; *Collinsia*: 11w; *Cordylanthus*: 3w; *Cotula*: 2w; *Crataegus*: 3w; *Cryptantha*: 2w; *Dicentra*: 1w;

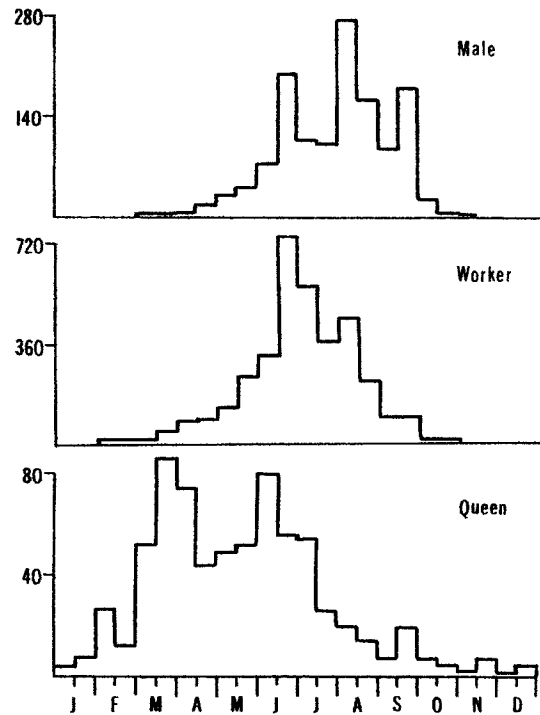


Fig. 23. Histograms of seasonal flight activity for *Bombus vosnesenskii*.

Duchesnea: 1m; *Epilobium*: 1w; *Eriastrum*: 1w; *Eriodictyon*: 1q, 12w; *Eriogonum*: 2q, 55w, 60m; *Erysimum*: 1w; *Eschscholzia*: 11w; *Eucalyptus*: 7w; *Eupatorium*: 1m; *Foeniculum*: 8w; *Grindelia*: 2m; *Haplopappus*: 15w, 2m; *Helenium*: 4m; *Heliotropium*: 2w; *Hesperochiron*: 3w; *Heteromeles*: 7w, 2m; *Horkelia*: 2w; *Hypericum*: 1w; *Iris*: 1w; *Isomeris*: 2q, 12w, 2m; *Lathyrus*: 1q, 6w, 2m; *Lepidospartum*: 1w, 2m; *Linaria*: 14w; *Lotus*: 1q, 28w, 9m; *Lupinus*: 3q, 104w; *Malvastrum*: 1m; *Marah*: 1m; *Marrubium*: 4w, 4m; *Matthiola*: 1q; *Medicago*: 1q, 5w; *Melilotus*: 1m; *Mentha*: 24w, 12m; *Mimulus*: 3w; *Monardella*: 1q, 25w, 1m; *Myosotis*: 1m; *Nama*: 19w, 3m; *Orthocarpus*: 1q; *Penstemon*: 5q, 38w, 3m; *Phacelia*: 7q, 89w, 3m; *Potentilla*: 1w; *Prosopis*: 2w; *Prunella*: 1q; *Prunus*: 8w; *Ranunculus*: 3q, 5w; *Raphanus*: 1q, 1m; *Rhamnus*: 1q, 3w, 1m; *Rhododendron*: 5q, 22w, 2m; *Rhus*: 2w; *Ribes*: 32q, 8w, 1m; *Rubus*: 10w, 4m; *Salix*: 2q, 3w, 1m; *Salpichroa*: 1m; *Salvia*: 2q, 13w, 3m; *Scabiosa*: 1m; *Senecio*: 4w, 10m; *Sidalcea*: 1m; *Solidago*: 9w, 13m; *Sphaeralcea*: 2w; *Stachys*: 5w, 9m; *Stanleya*: 1q, 10w; *Streptanthus*: 2w; *Symphoricarpos*: 6w; *Taraxacum*: 1m; *Trichostema*: 5w; *Trifolium*: 5q, 63w, 3m; *Veratrum*: 1w; *Verbascum*: 1w; *Veronica*: 1w; *Vicia*: 1q, 21w; *Wyethia*: 6w; *Zea*: 1w, 8m.

Discussion. *B. vosnesenskii* belongs to the group of species which includes *B. bifarius* and *huntii*. It appears to be most closely related to *huntii*, from which it differs in having black rather than red hair on metasomal tergites 2 and 3.

This species is extremely uniform in color pattern. It is the most common species throughout

California and belongs to the dominant Müllerian mimetic group in the state.

A nest of this species has been described by Hicks (1929). We have encountered nests most commonly in abandoned pocket gopher (*Thomomys bottae*) nests in the San Francisco Bay area and in Humboldt County.

Subgenus *Alpinobombus* Skorikov

Brief diagnosis. FEMALES: ocelli at supraorbital line; malar space longer than wide; flagellomere 1 shorter than 2 plus 3; sting capsule with inner margin of second valvular ramus projecting inward medially and subtended by a notch. MALES: compound eyes not protuberant; antennal flagellum more than three times as long as scape; malar space twice or more as long as wide; penis valves straight apically with two or three laterally directed teeth; gonostylus longer than wide, with apicomeral face truncate and separated by distinct notch from small basal tooth, tooth projecting mesally but not beyond inner margin of gonocoxa.

Bombus balteatus Dahlbom

(Figs. 24, 49, 73, 96, 126, 153; Map 24)

Bombus balteatus Dahlbom, 1832, Bombi Scand., p. 36. f (type not located by Løken, 1973). [Lectotype w, no locality (Dahlbom Colln., Zool. Inst., Univ. Lund, Sweden) designated by Milliron (1960) not valid (Ander, 1967; Løken, 1973)].

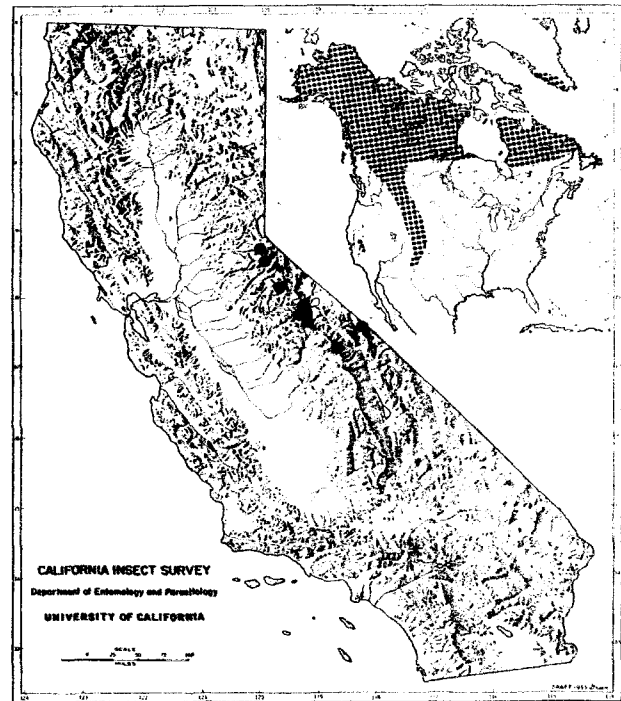
Geographic range (Map 24). Holarctic, in North America from Newfoundland to Alaska and S in the western higher mountains to northern New Mexico and California.

California records. ALPINE CO.: Round Top Lake. EL DORADO CO.: Ralston Peak, 2800 m. INYO CO.: Mono Pass, 3655 m. MONO CO.: Mt. Barcroft Lab., 3810 m, White Mtns.; Slate Creek Valley, 3200 m; Tioga Pass. TUOLUMNE CO.: Mt. Dana; Tuolumne Meadows, Yosemite Natl. Park; Mt. Lyell Trail, Yosemite Natl. Park; Sonora Pass.

Seasonal flight period (Fig. 24). QUEENS (9): early July to early August. WORKERS (14): late July to early September. MALES (8): late July to late August.

Flower records. QUEENS (0). WORKERS (1): Scrophulariaceae. MALES (2): Labiatae. Total 3 in 2 families with 2 genera as follows: *Mentha*: 2m; *Mimulus*: 1w.

Discussion. *B. balteatus* is not closely related to other California Bombini, but rather to a Boreal group of species which does not penetrate south of the Canadian border. It differs from other California species in having the combination of small ocelli at the supraorbital line and the malar space more than twice as long as wide.



Map 24. Nearctic distribution of *Bombus balteatus*.

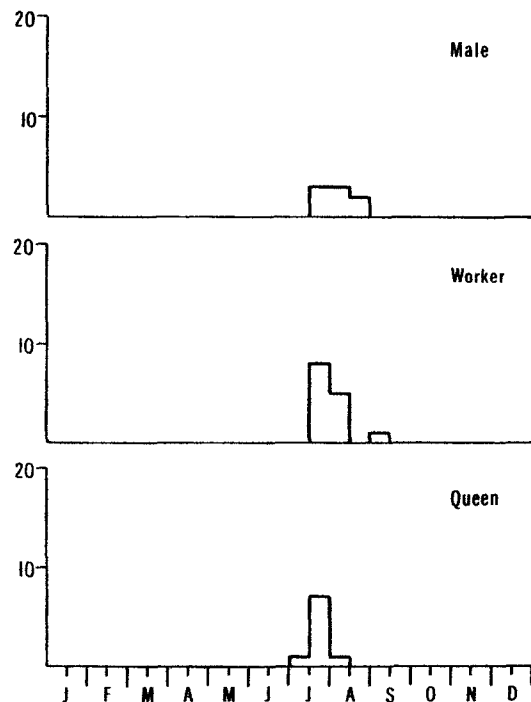


Fig. 24. Histograms of seasonal flight activity for *Bombus balteatus*.

This species is rare in California (Thorp, 1962), occurring only above 2740 m. It exhibits little variation other than that due to wear. Milliron (1973a) attempted to separate *B. balteatus* and *kirbyellus* Curtis, but his characters are not convincing, so we follow the species concept used by Richards (1931) and Løken (1973).

The biology of this species is described by Hobbs (1964).

GENUS *PSITHYRUS* LEPELETIER

Psithyrus contains about one-fifth as many species as *Bombus* and occurs in most areas where bumble bees are found. About half of the species found in America north of Mexico occur in California. Each of the three subgenera of cuckoo bees recognized in America north of Mexico (Frison, 1927a) is represented in California.

Characters which in combination are diagnostic for the genus *Psithyrus* include: (1) parasitic in *Bombus* colonies, without worker caste; (2) dense coat of brightly colored hair; (3) malar space elongate; (4) jugal lobe of hindwing absent; (5) females without scopa, metatibia not expanded, convex, hairy throughout; (6) males with outer face of metatibia with abundant short dark hairs; (7) females with prominent lateral carinae on metasomal sternite 6; (8) males with volsella and gonostylus of genital capsule membranous.

KEY TO SUBGENERA AND SPECIES OF *PSITHYRUS* IN CALIFORNIA

- 1. Females.....2
- Males.....4
- 2. (1) Sternite 6 with lateral elevations greatly produced, projecting slightly laterad (Fig. 100): occiput with predominantly black hair (*Ashtonipsithyrus*)
 *suckleyi* (p. 49)
- Sternite 6 with lateral elevations moderately produced, not projecting laterad (Figs. 101, 102); occiput with predominantly yellow hair.....3

- 3. (2) Metasomal segment 6 strongly recurved, with sternite 6 narrow and projecting distally beyond tergite (Fig. 102); face with black hairs around bases of antennae (*Fernaldaepsithyrus*)*fernaldae* (p. 52)
- Metasomal segment 6 not recurved, with sternite 6 broad and not projecting distally beyond tergite (Fig. 101); face with predominantly yellow hairs around bases of antennae (*Citrinopsithyrus*)*insularis* (p. 50)
- 4. (1) Flagellomere 3 about as long as 1; gonostylus rounded apically, subequal in width to volsella (Figs. 50a, 52a); usually without yellow hair just above antennal bases5
- Flagellomere 3 longer than 1, nearly as long as 1 and 2 combined; gonostylus acute apically, narrower than volsella (Fig. 51a); usually with yellow hair just above antennal bases (*Citrinopsithyrus*).
 *insularis* (p. 50)
- 5. (4) Malar space longer than wide; volsella beyond gonostylus narrow and parallel-sided (Fig. 52a); penis valve with median lateroventral tooth (*Fernaldaepsithyrus*)*fernaldae* (p. 52)
- Malar space wider than long; volsella beyond gonostylus broad and triangular (Fig. 50a); penis valve without median lateroventral tooth (*Ashtonipsithyrus*)*suckleyi* (p. 49)

Subgenus *Ashtonipsithyrus* Frison

Brief diagnosis. FEMALES: Occiput with predominantly black hair; malar space wider than long; flagellomere 1 longer than 3; sternite 6 with lateral elevations greatly produced, projecting slightly laterad. MALES: malar space wider than long; flagellomere 1 subequal in length to 3; gonostylus rounded apically, subequal to volsella in width; volsella beyond gonostylus triangular; penis valve without median lateroventral tooth.

Psithyrus suckleyi (Greene)

(Figs. 25, 50, 74, 97, 100, 128, 154; Map 25)

Bombus suckleyi Greene, 1860, Ann. Lyc. Nat. Hist. N.Y., 7:169. m. Holotype m, Puget Sound (probably lost).

Geographic range (Map 25). W of 95° longitude from Northwest Territories, Canada, to Nebraska, W to Alaska and California.

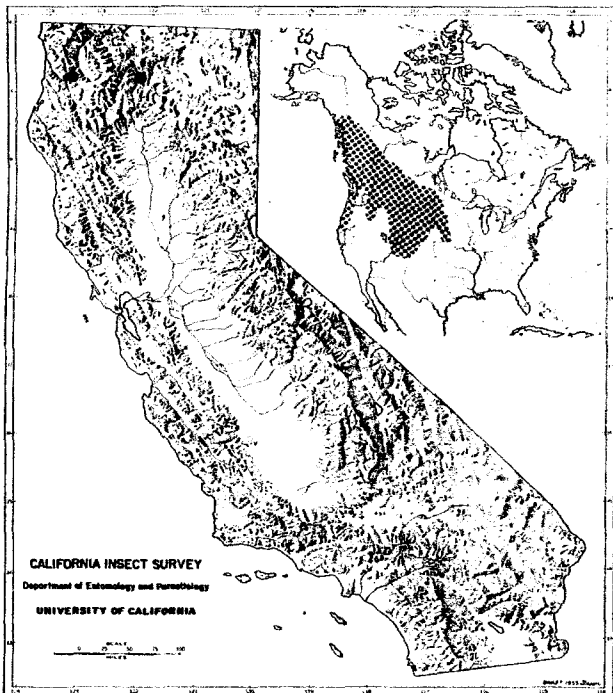
California records. HUMBOLDT Co.: Orleans. SISKIYOU Co.: Mt. Shasta City.

Seasonal flight period (Fig. 25). FEMALES (32): late May to late October. MALES (77): early July to late September.

Flower records. FEMALES (4): Compositae 50%. MALES (60): Compositae 99%. Total: 64 in 4 families with 8 genera as follows: *Aster*: 2f, 22m; *Centaurea*: 15m; *Cirsium*: 19m; *Haplopappus*: 1m; *Melilotus*: 1m; *Penstemon*: 1f; *Salix*: 1f; *Solidago*: 2m.

Discussion. *P. suckleyi* is not closely related to other California species; its closest relative is *P. ashtoni* (Cresson) of northeastern North America. It differs from other California species in having strongly produced lateral elevations on sternite 6, which project slightly laterad in the female, and in lacking the median lateroventral tooth on the penis valve of the male.

Hobbs (1965a, 1965b, 1966a, 1966b, 1967b, 1968) records *suckleyi* in nests of a number of bumble bees in 6 different subgenera. The most common associations were with the subgenera



Map 25. Nearctic distribution of *Psithyrus suckleyi*.

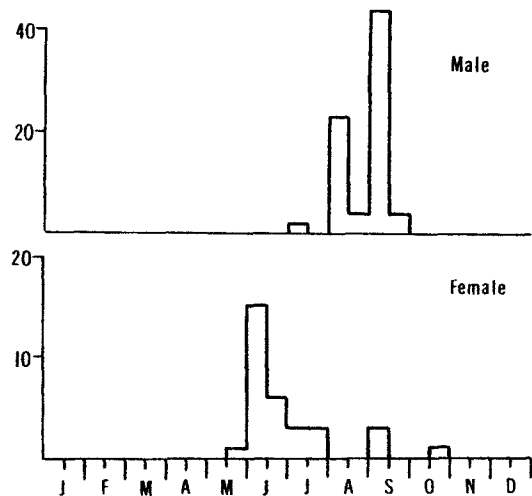


Fig. 25. Histograms of seasonal flight activity for *Psithyrus suckleyi*.

Pyrobombus and *Bombus*. The only nests in which *Psithyrus* adults were produced were those of *B. occidentalis*.

Subgenus *Citrinopsithyrus* Thorp, new name

Brief diagnosis. FEMALES: Occiput with yellow hair; malar space slightly wider than long; flagellomere 1 subequal in length to 3; sternite 6 with lateral elevations moderately produced. MALES: Malar space slightly wider than long; flagellomere 1 shorter than 3; gonostylus acute apically, narrower than volsella; volsella beyond gonostylus triangular; penis valve with median lateroventral tooth.

Psithyrus laboriosus (Fabricius) and *Laboriopsithyrus* Frison are synonyms of *Emphoropsis* (Milliron, 1960); therefore this subgenus requires a new name. Since *citrinus* (Smith) replaces *laboriosus*, the new name is based on that type.

Type: *Apathus citrinus* Smith, 1854. Cat. Hym. Brit. Mus., v. 2, p. 385. m.

Psithyrus insularis (F. Smith)

(Figs. 26, 51, 75, 98, 101, 127, 155; Map 26)

Apathus insularis F. Smith, 1861, J. Entomol., 1:155. f. Holotype f, Vancouver Island, British Columbia (#17B1061 BMNH).

Psithyrus crawfordi Franklin, 1913, Trans. Amer. Entomol. Soc., 38:464. f, m. Holotype f, Placer Co., California (#12193 USNM). NEW SYNONYMY.

Geographic range (Map 26). Most of Canada and northern United States from New Brunswick to New York W to Alaska and California.

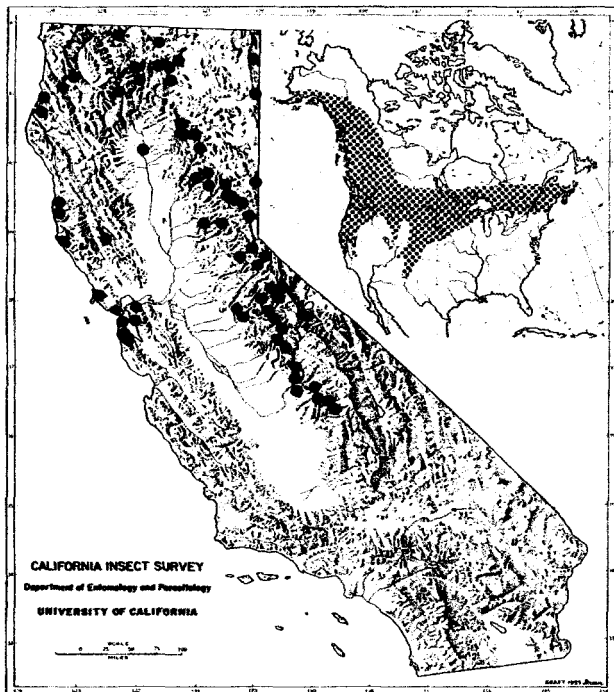
California records. ALAMEDA CO.: Berkeley. ALPINE CO.: Carson Pass; Hope Valley. CONTRA COSTA CO.: Martinez. EL DORADO CO.: Angora Lakes; China Point; Fallen Leaf Lake; Mt. Tallac; Strawberry Valley. FRESNO CO.: Hume Lake; Huntington Lake; Kings Canyon; S fork Kings River Canyon; Shaver Lake. HUMBOLDT CO.: Eureka; Fieldbrook; McKinleyville; Orleans; Weitchpec. LAKE CO.: Kelseyville. LASSEN CO.: Blue Lake; Bridge Creek Camp; Hallelujah Junction; Manzanita Lake, Lassen Natl. Park. MADERA CO.: Soquel Basin. MARIN CO.: McClures Beach; Mt. Tamalpais. MARIPOSA CO.: Fish Camp; Miami Ranger Station; Mirror Lake, 1250 m., Yosemite Natl. Park; Wawona; Yosemite Valley. MENDOCINO CO.: Fort Bragg; Mendocino; Pt. Arena. MODOC CO.: Cedar Pass; Cedarville. MONO CO.: Leavitt Lake; Sardine Creek; Silver Lake. NEVADA CO.: Grass Valley; Hobart Mills; Truckee. PLACER CO.: Alta; Dutch Flat. PLUMAS CO.: Bucks Lake; Chester; Graeagle; Johnsonville; Meadow Valley; Nelson Point; Onion Valley; Quincy; Silver Lake. SAN FRANCISCO CO.: Golden Gate Park; Twin Peaks. SAN MATEO CO.: Daly City; San Bruno Mtn. SHASTA CO.: Hat Creek; Old Station; Redding; Viola. SIERRA CO.: Calpine; Gold Lake; Sattley; Sierraville; Webber Lake; Yuba Pass. SISKIYOU CO.: Antelope Creek near Tennant; Bartle; Bray; Klamath Rural P.O.; Macdoel; Medicine Lake; Mt. Shasta City; Tennant; Weed. TRINITY CO.: Eagle Creek. TULARE CO.: Crescent Meadow; Dorst Creek Camp; General Grant Grove section,

Sequoia Natl. Park; Giant Forest; Mineralking; Redwood Meadow; Sequoia Natl. Park. TUOLUMNE CO.: Camp Bob MacBride, Pinecrest, 1645 m; Columbia; Eleanor Lake; Jacksonville; Kennedy Lake; Mather; Pinecrest; Sonora Pass, 2440-3045 m; Strawberry.

Seasonal flight period (Fig. 26). FEMALES (123): Late March to late October. MALES (874): late April to late September.

Flower records. FEMALES (19): Compositae 32%; Rosaceae 16%; Ericaceae 10%. MALES (121): Compositae 64%; Polygonaceae 17%. Total: 140 in 16 families with 30 genera as follows: *Althaea*: 1f; *Arctostaphylos*: 1f; *Asclepias*: 1m; *Aster*: 1m; *Barbarea*: 2f; *Chrysothamnus*: 6m; *Cirsium*: 1f, 30m; *Epitobium*: 1m; *Erigeron*: 1m; *Eriogonum*: 1f, 21m; *Haplopappus*: 15m; *Helenium*: 7m; *Helianthus*: 1f; *Iris*: 1f; *Malus*: 1f; *Melilotus*: 1f, 3m; *Mentha*: 2m; *Monardella*: 1m; *Penstemon*: 1m; *Rhododendron*: 1f, 1m; *Rhus*: 1f; *Ribes*: 1f, 2m; *Rubus*: 2f, 2m; *Senecio*: 12m; *Solidago*: 1f, 5m; *Sphenosciadium*: 1m; *Trifolium*: 1m; *Veratrum*: 1m; *Vicia*: 5m; *Wyethia*: 3f, 1m.

Discussion. *P. insularis* is not closely related to other California species; its closest relative is *P. citrinus* (F. Smith) of eastern North America. It most closely resembles *P. fernaldae* ("wheeleri" populations) in color, but differs in having yellow hair present on the face between the antennal bases, and shorter malar spaces.



Map 26. Nearctic distribution of *Psithyrus insularis*.

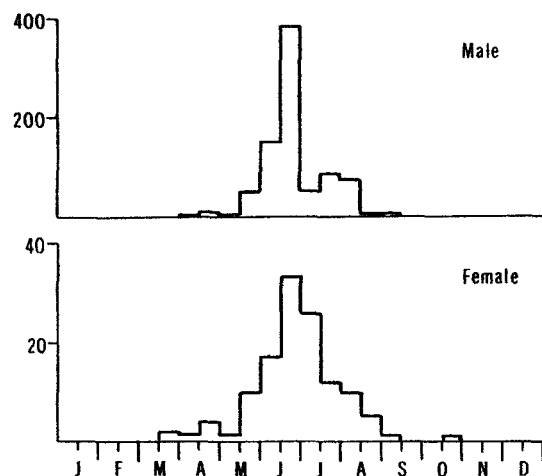


Fig. 26. Histograms of seasonal flight activity for *Psithyrus insularis*.

Adults of *insularis* and *crawfordi* differ only in color pattern, with *crawfordi* being the most abundant form in California. The occurrence of the yellow *insularis* males in *crawfordi* populations in the Warner Mountains and Sierra Nevada prompted our synonymy of the two. The darker *crawfordi* form resembles members of the *B. caliginosus-vosnesenskii* Müllerian mimicry complex.

Hobbs (1965a, 1965b, 1966a, 1966b, 1967b, 1968) records *insularis* in nests of bumble bees of six subgenera, the most common associations being with *Pyrobombus*, *Subterraneobombus*, and *Cullumanobombus*. Adults were produced in nests of *B. nevadensis*, *californicus*, and *appositus*.

Subgenus *Fernaldaepsithyrus* Frison

Brief diagnosis. FEMALES: Occiput with predominantly yellow hair; malar space as long as wide; flagellomere 1 longer than 3; sternite 6 narrow, lateral margins not produced, projecting distally beyond tergite 6. MALES: Malar space longer than wide; flagellomere 1 shorter than 3; gonostylus rounded apically, subequal to volsella in width; volsella beyond gonostylus narrow and parallel-sided; penis valve with median lateroventral tooth.

Psithyrus fernaldae Franklin

(Figs. 27, 52, 76, 99, 102, 129, 156; Map 27)

Psithyrus fernaldae Franklin, 1911, Trans. Amer. Entomol. Soc., 37:164. f. Holotype f (Mass. Ag. Coll.).

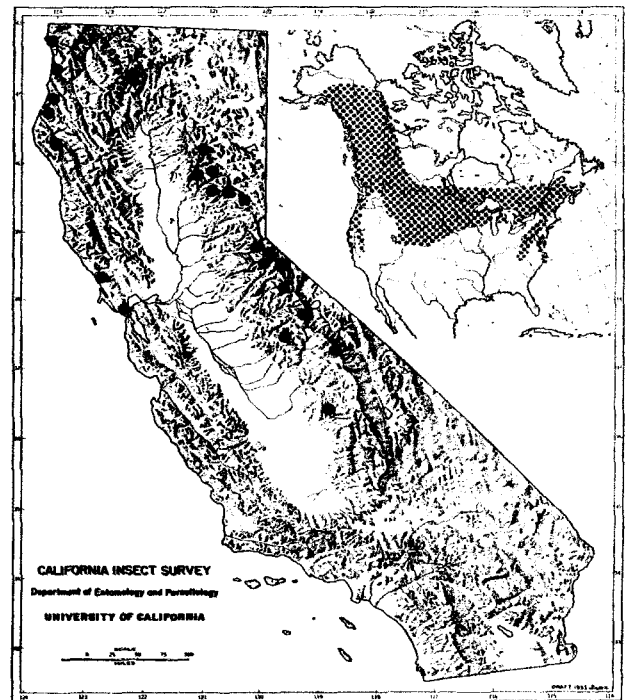
Psithyrus wheeleri Bequaert and Plath, 1925, Bull. Mus. Comp. Zool., 67(6):265. f. m. Holotype f, Mary's Peak, Benton Co., Oregon (#15,280 MCZ). NEW SYNONYMY.

Geographic range (Map 27). Newfoundland to North Carolina, W to Alaska and California.

California records. ALPINE CO.: Hope Valley; Markleeville, 27 km S; Round Top Lake; Winnemucca Lake. DEL NORTE CO.: Crescent City. EL DORADO CO.: Pyramid Ranger Station; Strawberry Valley. HUMBOLDT CO.: Arcata; Eureka; French Camp; Lukes Prairie; Pepperwood; Prairie Creek State Park. INYO CO.: near Mono Pass, 3655 m. MARIN CO.: Mt. Tamalpais. MARIPOSA CO.: Fish Camp. MONO CO.: Sardine Creek. PLUMAS CO.: Bucks Lake; Chester, 13 km NW; La Porte; Little Grass Valley; Meadow Valley; Quincy, 6.5 km W; Silver Lake. SIERRA CO.: Gold Lake; Volcano Lake. SONOMA CO.: Stillwater Cove. TRINITY CO.: Scott Mtn., 1630 m. TULARE CO.: Giant Forest. TUOLUMNE CO.: Blue Canyon, Sonora Pass; Kuna Crest, Yosemite Natl. Park; Sonora Pass, 2440-2740 m; vicinity of Sonora Peak.

Seasonal flight period (Fig. 27). FEMALES (72): early April to late August. MALES (271): early May to late September.

Flower records. FEMALES (8): Compositae 50%; Leguminosae 25%. MALES (54): Compositae 72%; Leguminosae 11%. Total: 62 in 9 families with 16 genera as follows: *Arctostaphylos*: 1m; *Aster*:



Map 27. Nearctic distribution of *Psithyrus fernaldae*.

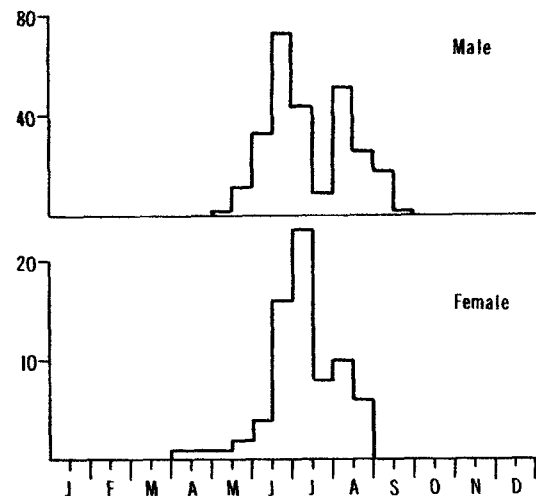


Fig. 27. Histograms of seasonal flight activity for *Psithyrus fernaldae*.

19m; *Chrysothamnus*: 1f, 2m; *Cirsium*: 6m; *Eriodictyon*: 2m; *Eriogonum*: 1m; *Haplopappus*: 3m; *Melilotus*: 2f, 6m; *Monardella*: 1f, 1m; *Rhododendron*: 2m; *Ribes*: 1f; *Senecio*: 2m; *Solidago*: 1m; *Sphenosciadium*: 1m; *Tanacetum*: 3f, 6m; *Veratrum*: 1m.

Discussion. *P. fernaldae* is not closely related to any North American *Psithyrus*. In California its predominant color form, "wheeleri," resembles that of *P. insularis* ("crawfordi" populations). It differs from *insularis* in lacking any yellow hair on the face near the base of the antennae and in having longer malar spaces.

Like *insularis*, the most abundant color pattern of *fernaldae* in California belongs to the *B. caliginosus-vosnesenskii* Müllerian mimicry complex. Females of *fernaldae* ("wheeleri" populations) show little variation in color pattern, but males of the nominate color form frequently occur in populations in the central Sierra Nevada.

Hobbs (1965b, 1966b, 1967b, 1968) recorded *P. fernaldae* in nests of bumble bees of four subgenera, but they were most commonly associated with *Pyrobombus*.

List of Plant Genera Visited by California Bombini

Aizoaceae

Mesembryanthemum: *B. nevadensis*

Amaryllidaceae

Allium: *B. huntii*

Brodiaea: *B. caliginosus*; *vosnesenskii*

Anacardiaceae

Rhus: *B. appositus*; *bifarius*; *caliginosus*; *fervidus*; *griseocollis*; *vosnesenskii*; *P. insularis*

Apocynaceae

Apocynum: *B. mixtus*

Asclepiadaceae

Asclepias: *B. crotchii*; *griseocollis*; *huntii*; *morrisoni*; *rufocinctus*; *sonorus*; *vosnesenskii*; *P. insularis*

Berberidaceae

Berberis: *B. edwardsii*; *melanopygus*; *mixtus*; *vandykei*; *vosnesenskii*

Bignoniaceae

Chilopsis: *B. sonorus*

Boraginaceae

Amsinckia: *B. californicus*; *crotchii*; *edwardsii*; *sonorus*; *vandykei*

Borago: *B. griseocollis*

Cryptantha: *B. edwardsii*; *sonorus*; *vosnesenskii*

Heliotropium: *B. vosnesenskii*

Mertensia: *B. huntii*

Myosotis: *B. vosnesenskii*

Plagiobothrys: *B. edwardsii*

Cactaceae

Echinocactus: *B. sonorus*

Opuntia: *B. californicus*

Cannaceae

Canna: *B. californicus*

Capparidaceae

Cleome: *B. appositus*; *centralis*; *fervidus*; *huntii*; *morrisoni*; *rufocinctus*; *sonorus*

Isomeris: *B. californicus*; *crotchii*; *edwardsii*; *vosnesenskii*

Wislizenia: *B. crotchii*; *sonorus*

Caprifoliaceae

Abelia: *B. occidentalis*

Lonicera: *B. appositus*; *californicus*; *edwardsii*; *melanopygus*; *sonorus*

Symphoricarpos: *B. bifarius*; *centralis*; *edwardsii*; *melanopygus*; *occidentalis*; *vosnesenskii*

Viburnum: *B. edwardsii*

Weigela: *B. fervidus*; *huntii*

Caryophyllaceae

Dianthus: *B. occidentalis*

Compositae

Achillea: *B. bifarius*

Anaphalis: *B. vandykei*

Artemisia: *B. bifarius*; *huntii*

Aster: *B. bifarius*; *centralis*; *fervidus*; *flavifrons*; *huntii*; *mixtus*; *morrisoni*; *occidentalis*; *rufocinctus*; *sitkensis*; *sonorus*; *sylvicola*; *vandykei*; *vosnesenskii*; *P. fernaldae*; *insularis*; *sucklei*

Baccharis: *B. edwardsii*; *sonorus*

Balsamorhiza: *B. morrisoni*; *nevadensis*; *rufocinctus*

Calendula: *B. fervidus*

Carduus: *B. fervidus*; *vosnesenskii*

Centaurea: *B. bifarius*; *californicus*; *centralis*; *franklini*; *occidentalis*; *sonorus*; *vosnesenskii*; *P. suckleyi*

Chaenactis: *B. crotchii*; *vosnesenskii*

Chrysanthemum: *B. sonorus*

Chrysopsis: *B. bifarius*; *vandykei*; *vosnesenskii*

Chrysothamnus: *B. bifarius*; *centralis*; *fervidus*; *flavifrons*; *griseocollis*; *huntii*; *morrisoni*; *occidentalis*; *rufocinctus*; *sylvicola*; *vosnesenskii*; *P. fernaldae*; *insularis*

Cichorium: *B. bifarius*; *vandykei*; *vosnesenskii*

- Cirsium:** B. appositus; bifarius; californicus; caliginosus; centralis; edwardsii; fervidus; flavifrons; griseocollis; huntii; mixtus; morrisoni; nevadensis; occidentalis; rufocinctus; sitkensis; sonorus; sylvicola; vandykei; vosnesenskii; P. fernaldae; insularis; suckleyi
Coreopsis: B. californicus; edwardsii; sonorus
Cosmos: B. californicus; occidentalis
Cotula: B. caliginosus; vosnesenskii
Dahlia: B. occidentalis; sonorus
Erigeron: B. huntii; P. insularis
Eupatorium: B. bifarius; vosnesenskii
Gaillardia: B. morrisoni; sonorus
Grindelia: B. bifarius; fervidus; flavifrons; occidentalis; rufocinctus; sonorus; sylvicola; vandykei; vosnesenskii
Gutierrezia: B. crotchii; huntii; morrisoni; sonorus
Haplopappus: B. bifarius; californicus; centralis; edwardsii; flavifrons; occidentalis; rufocinctus; sonorus; sylvicola; vosnesenskii; P. fernaldae; insularis; suckleyi
Helonium: B. bifarius; morrisoni; sylvicola; vosnesenskii; P. insularis
Helianthus: B. appositus; californicus; centralis; crotchii; fervidus; griseocollis; huntii; morrisoni; nevadensis; rufocinctus; sonorus; P. insularis
Hemizonia: B. crotchii; huntii
Hypochoeris: B. edwardsii; occidentalis
Isocoma: B. sonorus
Lasthenia: B. edwardsii
Layia: B. edwardsii
Lepidospartum: B. crotchii; vosnesenskii
Petasites: B. sylvicola
Phalacroseris: B. edwardsii
Picris: B. occidentalis
Prenanthes: B. fervidus
Pyrrhopappus: B. griseocollis
Rudbeckia: B. appositus; bifarius; flavifrons; mixtus
Senecio: B. bifarius; edwardsii; huntii; melanopygus; mixtus; morrisoni; occidentalis; sonorus; vandykei; vosnesenskii; P. fernaldae; insularis
Solidago: B. appositus; bifarius; californicus; caliginosus; crotchii; edwardsii; fervidus; griseocollis; huntii; mixtus; occidentalis; rufocinctus; sitkensis; sonorus; vosnesenskii; P. fernaldae; insularis; suckleyi
Sonchus: B. bifarius
Tagetes: B. sonorus
Tanacetum: B. bifarius; occidentalis; P. fernaldae
Taraxacum: B. bifarius; centralis; edwardsii; huntii; mixtus; morrisoni; occidentalis; rufocinctus; sylvicola; vandykei; vosnesenskii
Verbesina: B. sonorus
Viguiera: B. sonorus
Wyethia: B. californicus; edwardsii; fervidus; griseocollis; melanopygus; sylvicola; vosnesenskii; P. insularis
Zinnia: B. californicus
- Convolvulaceae**
 Convolvulus: B. bifarius; griseocollis
- Crassulaceae**
 Sedum: B. griseocollis; huntii
- Cruciferae**
 Barbarea: B. edwardsii; P. insularis
 Brassica: B. californicus; crotchii; morrisoni; occidentalis; rufocinctus; sitkensis; sonorus; vosnesenskii
 Erysimum: B. vosnesenskii
 Matthiola: B. vosnesenskii
 Nasturtium: B. rufocinctus
 Raphanus: B. californicus; crotchii; edwardsii; occidentalis; sonorus; vosnesenskii
 Stanleya: B. morrisoni; vosnesenskii
 Streptanthus: B. edwardsii; vosnesenskii
- Cucurbitaceae**
 Cucurbita: B. sonorus
 Marah: B. caliginosus; vosnesenskii
- Dipsacaceae**
 Dipsacus: B. appositus
 Scabiosa: B. californicus; sonorus; vosnesenskii
- Ericaceae**
 Arbutus: B. edwardsii; vosnesenskii
 Arctostaphylos: B. bifarius; caliginosus; edwardsii; vandykei; vosnesenskii; P. fernaldae; insularis
 Ledum: B. edwardsii
 Rhododendron: B. californicus; caliginosus; edwardsii; flavifrons; melanopygus; mixtus; occidentalis; sitkensis; vosnesenskii; P. fernaldae; insularis
 Vaccinium: B. caliginosus; edwardsii; melanopygus; mixtus; sitkensis
- Euphorbiaceae**
 Croton: B. sonorus
- Fumariaceae**
 Dicentra: B. caliginosus; vosnesenskii
- Gentianaceae**
 Fraxera: B. appositus; bifarius; centralis; flavifrons; morrisoni; sylvicola
- Geraniaceae**
 Erodium: B. edwardsii

- Geranium: *B. centralis*; *fervidus*; *mixtus*; *morrisoni*; *occidentalis*
- Gramineae
Zea: *B. occidentalis*; *vosnesenskii*
- Hydrophyllaceae
Eriodictyon: *B. californicus*; *caliginosus*; *crotchii*; *edwardsii*; *vandykei*; *vosnesenskii*; *P. fernaldae*
Hesperochiron: *B. vosnesenskii*
Hydrophyllum: *B. huntii*
Nama: *B. bifarius*; *occidentalis*; *vosnesenskii*
Phacelia: *B. appositus*; *bifarius*; *caliginosus*; *centralis*; *crotchii*; *edwardsii*; *fervidus*; *melanopygus*; *mixtus*; *occidentalis*; *rufocinctus*; *sonorus*; *vandykei*; *vosnesenskii*
- Hypericaceae
Hypericum: *B. crotchii*; *fervidus*; *vandykei*; *vosnesenskii*
- Iridaceae
Gladiolus: *B. occidentalis*
Iris: *B. fervidus*; *vosnesenskii*; *P. insularis*
- Labiatae
Agastache: *B. californicus*; *centralis*; *vandykei*; *vosnesenskii*
Hyptis: *B. edwardsii*
Marrubium: *B. edwardsii*; *morrisoni*; *vosnesenskii*
Mentha: *B. appositus*; *balteatus*; *bifarius*; *californicus*; *caliginosus*; *centralis*; *flavifrons*; *griseocollis*; *huntii*; *mixtus*; *nevadensis*; *occidentalis*; *rufocinctus*; *sylvicola*; *vosnesenskii*; *P. insularis*
Monarda: *B. centralis*; *griseocollis*; *morrisoni*; *sonorus*
Monardella: *B. bifarius*; *californicus*; *centralis*; *edwardsii*; *flavifrons*; *mixtus*; *occidentalis*; *sylvicola*; *vandykei*; *vosnesenskii*; *P. fernaldae*; *insularis*
Origanum: *B. melanopygus*; *mixtus*; *occidentalis*
Prunella: *B. vosnesenskii*
Pycnanthemum: *B. griseocollis*
Salvia: *B. bifarius*; *californicus*; *crotchii*; *edwardsii*; *mixtus*; *morrisoni*; *occidentalis*; *sonorus*; *vandykei*; *vosnesenskii*
Stachys: *B. californicus*; *fervidus*; *mixtus*; *sitkensis*; *sonorus*; *vandykei*; *vosnesenskii*
Trichostema: *B. californicus*; *crotchii*; *edwardsii*; *occidentalis*; *sonorus*; *vosnesenskii*
- Leguminosae
Astragalus: *B. appositus*; *californicus*; *crotchii*; *edwardsii*; *fervidus*; *huntii*; *morrisoni*; *nevadensis*; *rufocinctus*; *sonorus*; *vosnesenskii*
Baptisia: *B. fervidus*
Caragana: *B. centralis*; *fervidus*; *griseocollis*; *huntii*; *rufocinctus*; *vosnesenskii*
- Cercis: *B. edwardsii*; *griseocollis*; *vandykei*; *vosnesenskii*
Dalea: *B. morrisoni*; *sonorus*
Glycyrrhiza: *B. californicus*
Hoffmannseggia: *B. sonorus*
Lathyrus: *B. appositus*; *californicus*; *caliginosus*; *crotchii*; *fervidus*; *flavifrons*; *occidentalis*; *sitkensis*; *sonorus*; *vosnesenskii*
Lotus: *B. californicus*; *caliginosus*; *crotchii*; *edwardsii*; *griseocollis*; *occidentalis*; *sonorus*; *vandykei*; *vosnesenskii*
Lupinus: *B. bifarius*; *californicus*; *caliginosus*; *centralis*; *crotchii*; *edwardsii*; *fervidus*; *flavifrons*; *franklini*; *huntii*; *melanopygus*; *mixtus*; *nevadensis*; *occidentalis*; *rufocinctus*; *vandykei*; *vosnesenskii*
Medicago: *B. appositus*; *californicus*; *crotchii*; *fervidus*; *griseocollis*; *huntii*; *morrisoni*; *nevadensis*; *occidentalis*; *rufocinctus*; *sonorus*; *vosnesenskii*
Melilotus: *B. appositus*; *bifarius*; *californicus*; *caliginosus*; *centralis*; *fervidus*; *griseocollis*; *huntii*; *morrisoni*; *nevadensis*; *occidentalis*; *rufocinctus*; *sonorus*; *vosnesenskii*; *P. fernaldae*; *insularis*; *suckleyi*
Parkinsonia: *B. crotchii*; *sonorus*
Petalostemon: *B. griseocollis*; *sonorus*
Prosopis: *B. sonorus*; *vosnesenskii*
Robinia: *B. centralis*; *griseocollis*
Thermopsis: *B. appositus*; *huntii*; *nevadensis*
Trifolium: *B. appositus*; *californicus*; *caliginosus*; *centralis*; *crotchii*; *edwardsii*; *fervidus*; *franklini*; *griseocollis*; *huntii*; *mixtus*; *morrisoni*; *occidentalis*; *rufocinctus*; *sonorus*; *vandykei*; *vosnesenskii*; *P. insularis*
Vicia: *B. appositus*; *bifarius*; *californicus*; *caliginosus*; *centralis*; *crotchii*; *fervidus*; *flavifrons*; *huntii*; *melanopygus*; *mixtus*; *nevadensis*; *occidentalis*; *rufocinctus*; *sitkensis*; *sonorus*; *vandykei*; *vosnesenskii*; *P. insularis*
Wisteria: *B. crotchii*
- Liliaceae
Calochortus: *B. vandykei*
Chlorogalum: *B. californicus*; *sonorus*
Lycoris: *B. caliginosus*
Veratrum: *B. franklini*; *vosnesenskii*; *P. fernaldae*; *insularis*
- Linaceae
Linum: *B. bifarius*
- Loasaceae
Mentzelia: *B. californicus*; *centralis*; *fervidus*; *huntii*; *morrisoni*; *sonorus*
- Lythraceae
Lythrum: *B. sonorus*

Malvaceae

Althaea: *B. californicus*; *centralis*; *edwardsii*; *fervidus*; *griseocollis*; *morrisoni*; *nevadensis*; *rufocinctus*; *sonorus*; *vandykei*; *P. insularis*

Gossypium: *B. griseocollis*

Malvastrum: *B. vosnesenskii*

Sidalcea: *B. sonorus*; *vosnesenskii*

Sphaeralcea: *B. morrisoni*; *sonorus*; *vosnesenskii*

Martyniaceae

Proboscidea: *B. sonorus*

Myricaceae

Myrica: *B. edwardsii*

Myrtaceae

Eucalyptus: *B. caliginosus*; *vosnesenskii*

Nyctaginaceae

Abronia: *B. edwardsii*

Onagraceae

Clarkia: *B. californicus*; *edwardsii*; *vandykei*; *vosnesenskii*

Epilobium: *B. bifarius*; *centralis*; *fervidus*; *flavifrons*; *mixtus*; *occidentalis*; *sonorus*; *sylvicola*; *vandykei*; *vosnesenskii*; *P. insularis*

Fuchsia: *B. mixtus*; *occidentalis*

Oenothera: *B. crotchii*; *edwardsii*; *sonorus*

Papaveraceae

Argemone: *B. sonorus*

Eschscholzia: *B. californicus*; *caliginosus*; *crotchii*; *occidentalis*; *sonorus*; *vosnesenskii*

Platystemon: *B. edwardsii*

Plumbaginaceae

Limonium: *B. edwardsii*

Polemoniaceae

Eriastrum: *B. vosnesenskii*

Polygonaceae

Brunnichia: *B. griseocollis*

Eriogonum: *B. bifarius*; *californicus*; *caliginosus*; *centralis*; *crotchii*; *edwardsii*; *flavifrons*; *franklini*; *huntii*; *mixtus*; *morrisoni*; *occidentalis*; *sonorus*; *vandykei*; *vosnesenskii*; *P. fernaldae*; *insularis*

Pontederiaceae

Pontederia: *B. griseocollis*

Portulacaceae

Calyptidium: *B. bifarius*; *edwardsii*

Primulaceae

Dodecatheon: *B. huntii*; *sylvicola*

Pyrolaceae

Sarcodes: *B. edwardsii*

Ranunculaceae

Aconitum: *B. centralis*; *flavifrons*

Aquilegia: *B. sitkensis*

Clematis: *B. occidentalis*

Delphinium: *B. californicus*; *centralis*; *crotchii*; *morrisoni*; *sonorus*

Ranunculus: *B. bifarius*; *edwardsii*; *vosnesenskii*

Rhamnaceae

Ceanothus: *B. bifarius*; *caliginosus*; *edwardsii*; *franklini*; *melanopygus*; *mixtus*; *nevadensis*; *occidentalis*; *rufocinctus*; *sitkensis*; *vosnesenskii*

Rhamnus: *B. edwardsii*; *mixtus*; *vosnesenskii*

Rosaceae

Adenostoma: *B. occidentalis*

Chamaebatiaria: *B. rufocinctus*; *sylvicola*

Crataegus: *B. melanopygus*; *mixtus*; *vosnesenskii*

Duchesnea: *B. vosnesenskii*

Heteromeles: *B. vosnesenskii*

Horkelia: *B. vosnesenskii*

Malus: *B. edwardsii*; *melanopygus*; *P. insularis*

Potentilla: *B. californicus*; *caliginosus*; *occidentalis*; *vosnesenskii*

Prunus: *B. bifarius*; *edwardsii*; *griseocollis*; *huntii*; *mixtus*; *occidentalis*; *vosnesenskii*

Pyrus: *B. vandykei*

Rosa: *B. californicus*; *caliginosus*; *centralis*; *edwardsii*; *huntii*; *occidentalis*; *rufocinctus*

Rubus: *B. caliginosus*; *edwardsii*; *griseocollis*; *mixtus*; *occidentalis*; *sitkensis*; *sonorus*; *vandykei*; *vosnesenskii*; *P. insularis*

Sorbaria: *B. centralis*

Salicaceae

Salix: *B. bifarius*; *californicus*; *caliginosus*; *edwardsii*; *fervidus*; *huntii*; *melanopygus*; *occidentalis*; *sitkensis*; *sonorus*; *vosnesenskii*; *P. suckleyi*

Sarraceniaceae

Darlingtonia: *B. caliginosus*; *melanopygus*; *mixtus*

Saxifragaceae

Hydrangea: *B. occidentalis*

Ribes: *B. bifarius*; *californicus*; *caliginosus*; *centralis*; *edwardsii*; *flavifrons*; *franklini*; *huntii*; *melanopygus*; *mixtus*; *nevadensis*; *occidentalis*; *sitkensis*; *vandykei*; *vosnesenskii*; *P. fernaldae*; *insularis*

Scrophulariaceae

- Antirrhinum: *B. californicus*; *sonorus*
 Castilleja: *B. californicus*; *flavifrons*; *vosnesenskii*
 Collinsia: *B. californicus*; *caliginosus*; *edwardsii*; *vandykei*; *vosnesenskii*
 Cordylanthus: *B. vosnesenskii*
 Digitalis: *B. fervidus*
 Linaria: *B. californicus*; *centralis*; *fervidus*; *huntii*; *vandykei*; *vosnesenskii*
 Mimulus: *B. balteatus*; *bifarius*; *centralis*; *flavifrons*; *vosnesenskii*
 Orthocarpus: *B. californicus*; *crotchii*; *occidentalis*; *sonorus*; *vosnesenskii*
 Penstemon: *B. bifarius*; *californicus*; *centralis*; *crotchii*; *edwardsii*; *fervidus*; *huntii*; *mixtus*; *morrisoni*; *occidentalis*; *rufocinctus*; *sonorus*; *sylvicola*; *vandykei*; *vosnesenskii*; *P. insularis*; *suckleyi*
 Scrophularia: *B. caliginosus*
 Verbascum: *B. vosnesenskii*
 Veronica: *B. vosnesenskii*

Solanaceae

- Datura: *B. sonorus*
 Lycopersicon: *B. sonorus*
 Physalis: *B. edwardsii*

Salpichroa: *B. vosnesenskii*

Solanum: *B. edwardsii*; *morrisoni*; *sonorus*

Tamaricaceae

Tamarix: *B. morrisoni*

Umbelliferae

Daucus: *B. huntii*; *sonorus*

Foeniculum: *B. californicus*; *occidentalis*; *vosnesenskii*

Heracleum: *B. mixtus*

Osmorhiza: *B. sonorus*

Oxypolis: *B. bifarius*

Sanicula: *B. bifarius*

Sphenosciadium: *B. bifarius*; *sylvicola*; *P. fernaldae*; *insularis*; *suckleyi*

Verbenaceae

Lantana: *B. crotchii*; *edwardsii*; *sonorus*

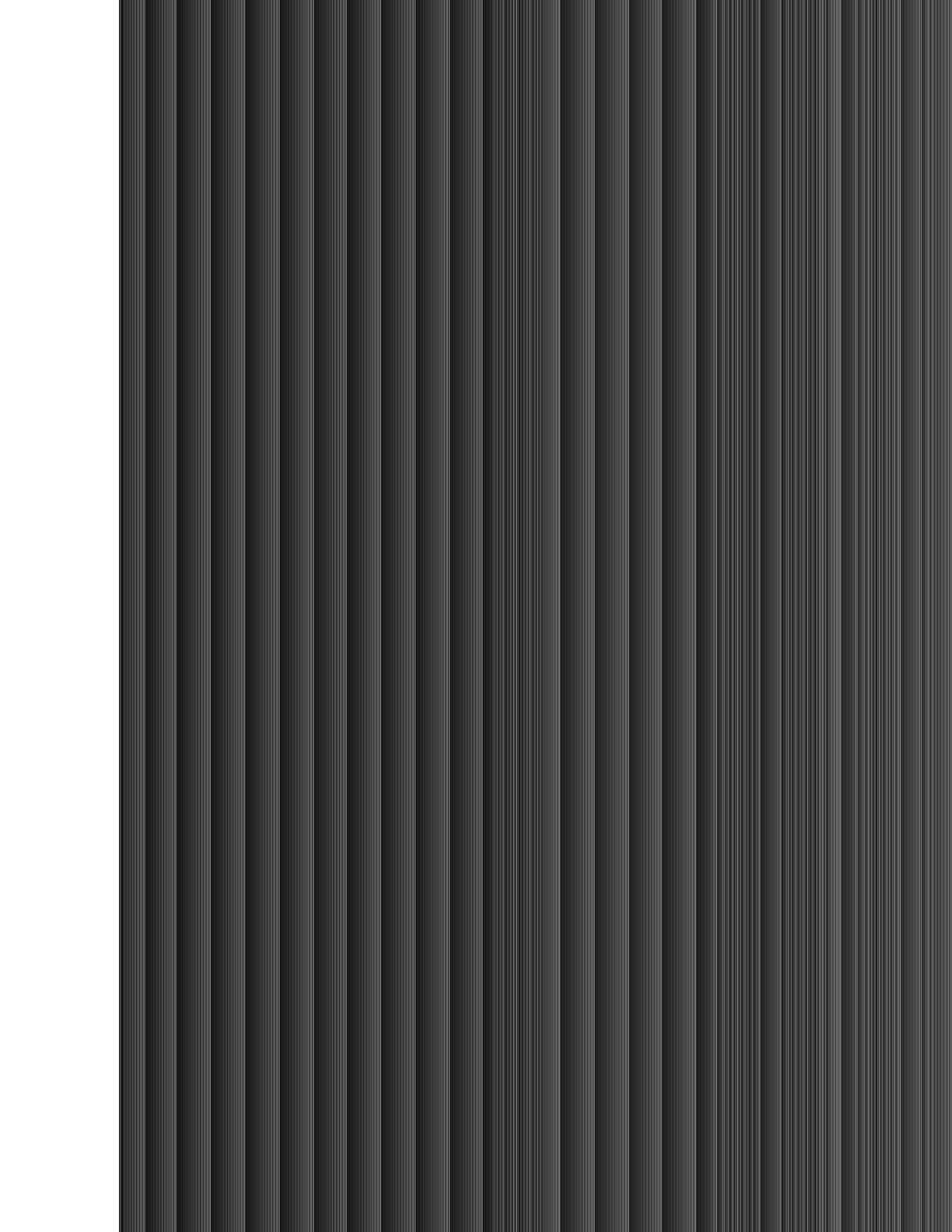
Verbena: *B. griseocollis*

Violaceae

Viola: *B. melanopygus*

Zygophyllaceae

Larrea: *B. sonorus*



Literature Cited

Only the references cited in the text by author and date are included here. References listed in the synonymies are cited here only if they are referred to in the text.

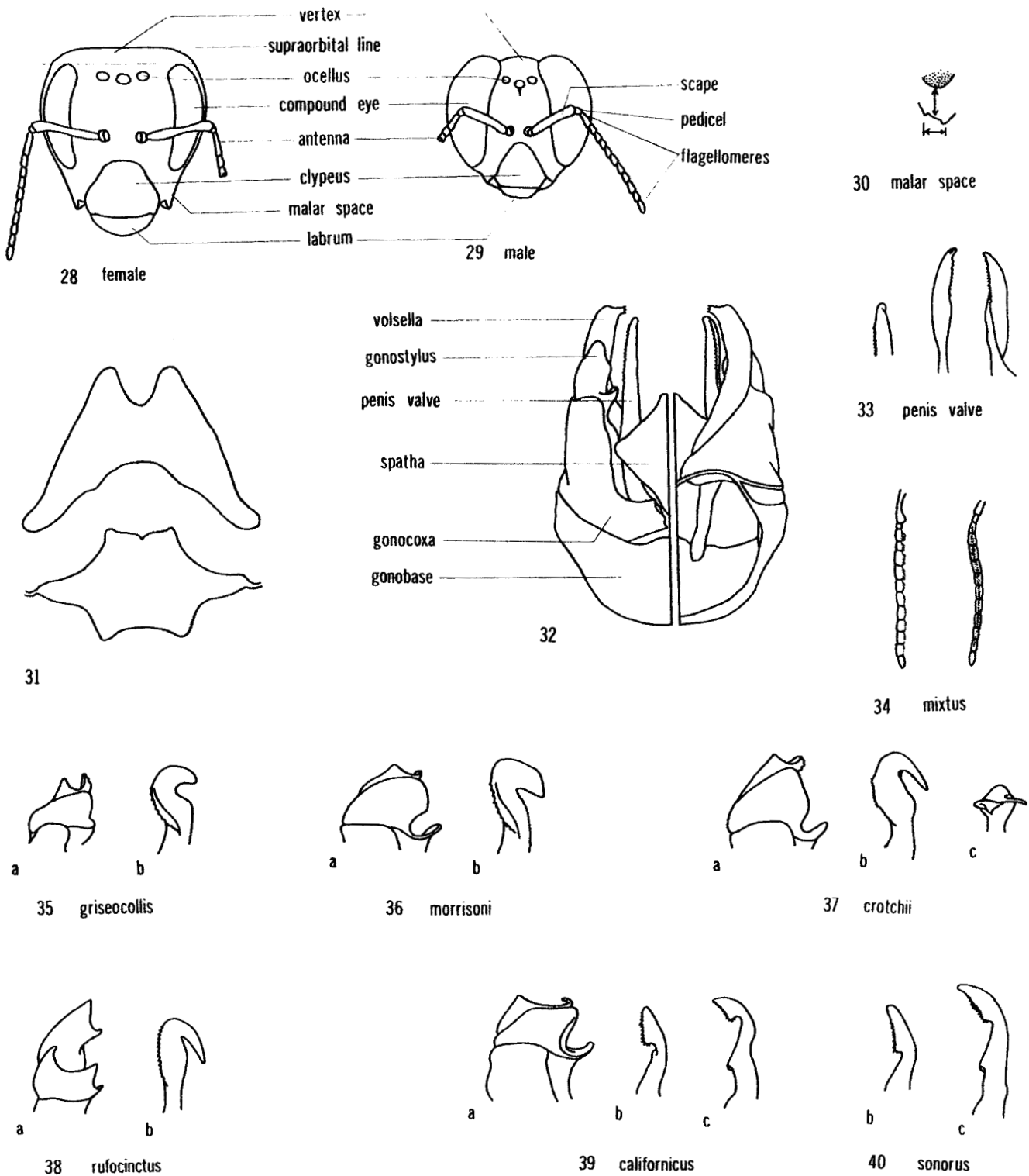
- Alford, D. V.
1975. Bumblebees. Davis-Poynter, London. 352 p.
- Ander, K.
1967. Designation of lectotypes in *Bombus* and *Psithyrus* described by Swedish authors. *Opusc. Entomol.* 32:184-187.
- Brower, L. P., and J. V. Z. Brower
1962. Investigations into mimicry. *Natur. Hist.* 71:8-19.
- Brower, L. P., J. V. Z. Brower, and P. W. Westcott
1960. Experimental studies of mimicry: 5. The reactions of toads (*Bufo terrestris*) to bumblebees (*Bombus americanorum*) and their robberfly mimics (*Mallophora bomboides*), with a discussion of aggressive mimicry. *Amer. Natur.* 94:343-355.
- Cockerell, T. D. A.
1937. Bees from San Miguel Island, California. *Pan-Pac. Entomol.* 13:148-157.
- Cresson, E. T.
1916. The Cresson types of Hymenoptera. *Mem. Amer. Entomol. Soc.* 1:1-141.
- Cumber, R. A.
1949a. The biology of bumble-bees with special reference to the production of the worker caste. *Trans. Roy. Entomol. Soc. London* 100:1-45.
1949b. Bumble-bee parasites and commensals found within a thirty-mile radius of London. *Proc. Roy. Entomol. Soc. London (A)* 24:119-127.
- Franklin, H. J.
1913. The Bombidae of the New World. *Trans. Amer. Entomol. Soc.* 38:177-486, 39:73-200, pls. I-XXII.
- Free, J. B., and C. G. Butler
1959. Bumblebees. *New Naturalist*, MacMillan, New York. 208 p.
- Frisch, K. von
1952. Hummeln als unfreiwillige Transportflieger. *Natur. u. Volk* 82:171-174.
- Frison, T. H.
1917. Notes on Bombidae, and on the life history of *Bombus auricomus* Robt. *Ann. Entomol. Soc. Amer.* 10:277-288.
1918. Additional notes on the life history of *Bombus auricomus* Robt. *Ann. Entomol. Soc. Amer.* 11:43-49.
1926. Contributions to the knowledge of the interrelationships of the bumble bees of Illinois with their animate environment. *Ann. Entomol. Soc. Amer.* 19:203-235.
1927a. A contribution to our knowledge of the relationships of the Bremidae of America north of Mexico (Hymenoptera). *Trans. Amer. Entomol. Soc.* 53:51-78.
1927b. Records and descriptions of western bumblebees (Bremidae). *Proc. Calif. Acad. Sci (4th ser.)* 16:365-380.
- Fye, R. E., and J. T. Medler
1954. Temperature studies in bumblebee domiciles. *J. Econ. Entomol.* 47:847-852.
- Gabritschewsky, E.
1926. Convergence of colouration between American pilose flies and bumblebees (*Bombus*). *Biol. Bull.* 51:269-286.
- Hardy, G. A., and W. H. A. Preece
1926. Notes on some species of Cerambycidae (Col.) from the southern portion of Vancouver Island, B.C. *Pan-Pac. Entomol.* 3:34-40.
- Hasselrot, T. B.
1960. Studies on Swedish bumblebees (genus *Bombus* Latr.): Their domestication and biology. *Opusc. Entomol. Suppl.* 17:1-192.
- Hazeltine, W. E., and L. Chandler
1964. A preliminary atlas for the identification of female bumble bees (Hymenoptera: Apidae). *J. Kansas Entomol. Soc.* 37:77-87.

- Heinrich, B.
 1972. Physiology of brood incubation in the bumblebee queen, *Bombus vosnesenskii*. *Nature* 239:223-225.
 1975. The role of energetics in bumblebee-flower interactions, pp. 141-158. In L. E. Gilbert and P. H. Raven, eds., *Coevolution of animals and plants*. Univ. Texas Press.
 1976. Resource partitioning among some eusocial insects: bumblebees. *Ecology* 57:874-889.
- Heinrich, B., and P. H. Raven
 1972. Energetics and pollination ecology. *Science* 176:597-602.
- Hicks, C. H.
 1929. Notes on a nest of *Bremus vosnesenskii* (Radoskowski). *Pan-Pac. Entomol.* 5:97-100.
- Hobbs, G. A.
 1964. Ecology of species of *Bombus* Latr. (Hymenoptera: Apidae) in southern Alberta: I. Subgenus *Alpinobombus* Skor. *Canad. Entomol.* 96:1465-1470.
 1965a. Ecology of species of *Bombus* Latr. (Hymenoptera: Apidae) in southern Alberta: II. Subgenus *Bombias* Robt. *Canad. Entomol.* 97:120-128.
 1965b. Ecology of species of *Bombus* Latr. (Hymenoptera: Apidae) in southern Alberta: III. Subgenus *Cullumanobombus* Vogt. *Canad. Entomol.* 97:1293-1302.
 1966a. Ecology of species of *Bombus* Latr. (Hymenoptera: Apidae) in southern Alberta: IV. Subgenus *Fervidobombus* Skorikov. *Canad. Entomol.* 98:33-39.
 1966b. Ecology of species of *Bombus* Latr. (Hymenoptera: Apidae) in southern Alberta: V. Subgenus *Subterraneobombus* Vogt. *Canad. Entomol.* 98:288-294.
 1967a. Obtaining and protecting red-clover pollinating species of *Bombus* (Hymenoptera: Apidae). *Canad. Entomol.* 99:943-951.
 1967b. Ecology of species of *Bombus* (Hymenoptera: Apidae) in southern Alberta: VI. Subgenus *Pyrobombus*. *Canad. Entomol.* 99:1271-1292.
 1968. Ecology of species of *Bombus* (Hymenoptera: Apidae) in southern Alberta: VII. Subgenus *Bombus*. *Canad. Entomol.* 100:156-164.
- Hobbs, G. A., W. O. Nummi, and J. F. Virostek
 1962. Managing colonies of bumble bees (Hymenoptera: Apidae) for pollination purposes. *Canad. Entomol.* 94:1121-1132.
- Hobbs, G. A., J. F. Virostek, and W. O. Nummi
 1960. Establishment of *Bombus* spp. (Hymenoptera: Apidae) in artificial domiciles in southern Alberta. *Canad. Entomol.* 92:868-872.
- Holm, S. N.
 1960. Experiments on the domestication of bumble bees (*Bombus* Latr.), in particular *B. lapidarius* L. and *B. terrestris* L. *Arsskr. Kgl. Vet.-Landbhøjsk.* 1-19.
 1966. The utilization and management of bumble bees for red clover and alfalfa seed production. *Ann. Rev. Entomol.* 11:155-182.
- Hurd, P. D., Jr., and C. D. Michener
 1955. The megachiline bees of California (Hymenoptera: Megachilidae). *Bull. Calif. Insect Surv.* 3:1-248.
- Husband, R. W.
 1968. Distribution of Acarina associated with Michigan Bombinae. *Pap. Mich. Acad. Sci., Arts Lett. Pt. I:*109-112.
- Johansen, C.
 1967. Ecology of three species of bumble bees in southwestern Washington. *Wash. Agr. Exp. Sta. Tech. Bull.* 57:1-12.
- LaBerge, W. E., and M. C. Webb
 1962. The bumblebees of Nebraska. *Univ. Nebr. Agr. Exp. Sta., Res. Bull.* 205. 38 p.
- Løken, A.
 1973. Studies on Scandinavian bumble bees (Hymenoptera, Apidae). *Norsk Entomol. Tidssk.* 20:1-218.
- Medler, J. T.
 1958. Principles and methods for the utilization of bumblebees in cross-pollination of crops. *Proc. 10th Int. Congr. Entomol.* (1956) 4:973-981.
 1959. A nest of *Bombus huntii* Greene (Hymenoptera: Apidae). *Entomol. News* 70:179-182.
- Medler, J. T., and D. W. Carney
 1963. Bumblebees of Wisconsin (Hymenoptera: Apidae). *Univ. Wisc. Res. Bull.* 240. 47 p.
- Michener, C. D.
 1944. Comparative external morphology, phylogeny, and a classification of the bees (Hymenoptera). *Bull. Amer. Mus. Natur. Hist.* 82:151-326.
- Miller, A. H.
 1951. An analysis of the distribution of the birds of California. *Univ. Calif. Publ. Zool.* 50:531-641.
- Milliron, H. E.
 1960. Recognition of bumblebee specimens, with notes on some dubious names (Hymenoptera: Apidae). *Bull. Brooklyn Entomol. Soc.* 55:87-99.
 1961. Revised classification of the bumblebees—a synopsis (Hymenoptera: Apidae). *J. Kansas Entomol. Soc.* 34:49-61.

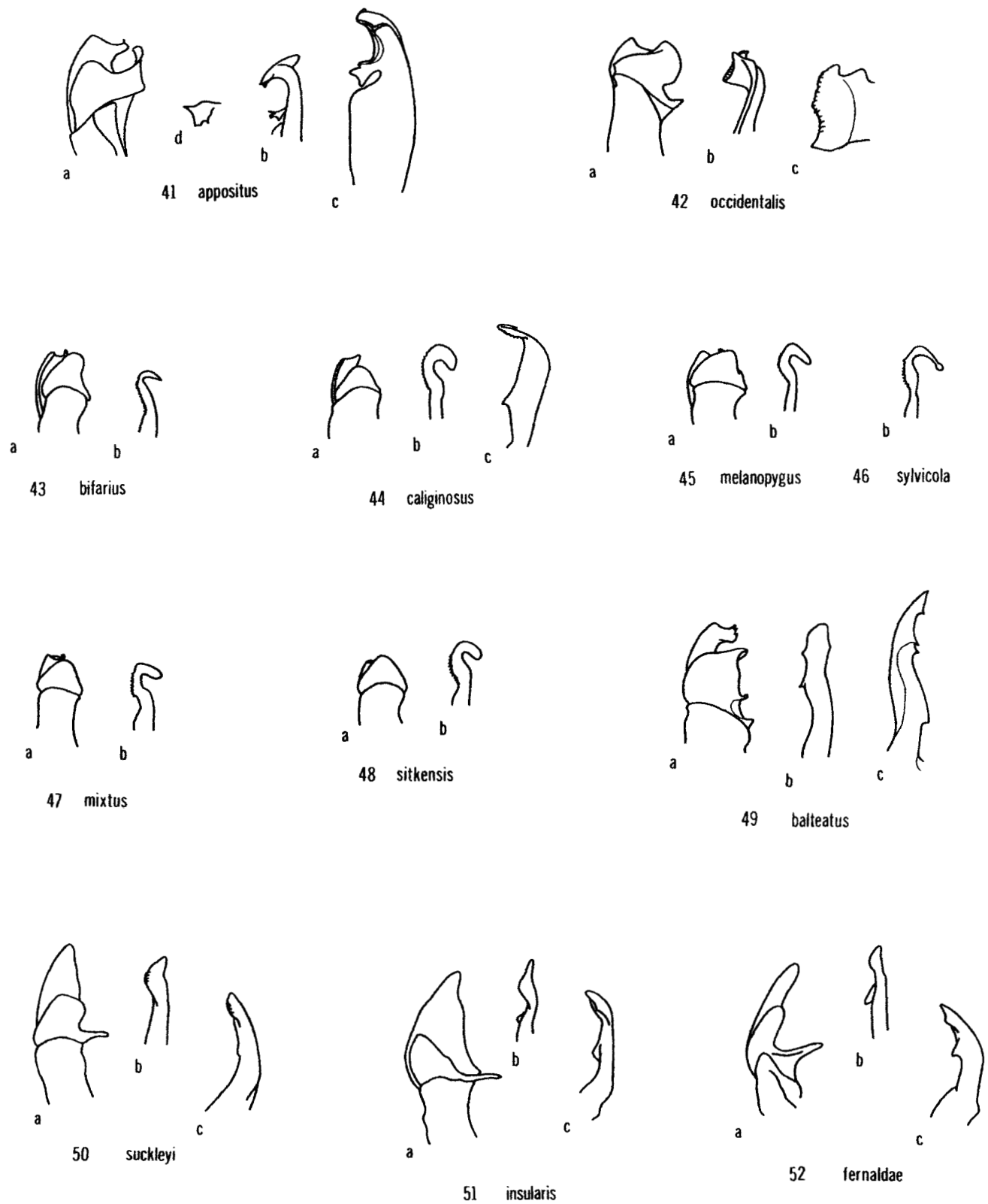
1970. *Pyrobombus (P.) cascadenis*, an undescribed species of bumblebee from the Pacific Northwest, U.S.A. (Hymenoptera: Bombinae). *Canad. Entomol.* 102:382-383.
1971. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae): I. The genera *Bombus* and *Megabombus* subgenus *Bombias*. *Mem. Entomol. Soc. Canad.* 82:1-80.
- 1973a. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae): II. The genus *Megabombus* subgenus *Megabombus*. *Mem. Entomol. Soc. Canad.* 89:81-237.
- 1973b. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae): III. The genus *Pyrobombus* subgenus *Culhumanobombus*. *Mem. Entomol. Soc. Canad.* 91:239-333.
- Munz, P. A., and D. D. Keck
1959. A California flora. Univ. Calif. Press, Berkeley and Los Angeles. 1681 p.
- Oster, G.
1976. Modeling social insect populations: I. Ergonomics of foraging and population growth in bumblebees. *Amer. Natur.* 110:215-245.
- Oster, G., and B. Heinrich
1976. Why do bumblebees major? A mathematical model. *Ecol. Monogr.* 46:129-133.
- Peters, D. S.
1968. Beiträge zur Kenntnis aculeater Hymenopteren von Mexiko: I. Apinae (Apidae, Apoidea). *Senckenbergiana Biol.* 49:237-248.
- Pitelka, F. A.
1954. Use of bird nest by bumblebee. *Pan-Pac. Entomol.* 30:220.
- Plath, O. E.
1923. The bee-eating proclivity of the skunk. *Amer. Natur.* 57:571-574.
1927. Notes on the nesting habits of some of the less common New England bumblebees. *Psyche* 34:122-128.
1934. Bumblebees and their ways. Macmillan, New York. 201 p.
- Plowright, R. C., and S. C. Jay
1966. Rearing bumble bee colonies in captivity. *J. Apic. Res.* 5:155-165.
- Poinar, G. O., and P. A. Van der Laan
1972. Morphology and life history of *Sphaerularia bombi*. *Nematologica* 18:239-252.
- Rettenmeyer, C. W.
1970. Insect mimicry. *Ann. Rev. Entomol.* 15:43-74.
- Richards, O. W.
1931. Some notes on the bumblebees allied to *Bombus alpinus* L. *Tromsø Mus. Arsh* 50 (1927):1-32.
1968. The subgeneric divisions of the genus *Bombus* Latreille (Hymenoptera: Apidae). *Bull. Brit. Mus. Natur. Hist. (Ent.)* 22:211-276.
- Ryckman, R. E.
1953. Notes on the ecology of *Bombus sonorus* in Orange County, California and new parasite records. *Pan-Pac. Entomol.* 29:144-146.
- Skou, J. P., S. N. Holm, and H. Haas
1963. Preliminary investigations on diseases in bumble-bees (*Bombus* Latr.). *Roy. Vet. Agr. Coll. Copenhagen Yearbook* 1963:27-41.
- Sladen, F. L. W.
1912. The Humblebee: Its life history and how to domesticate it. Macmillan, London, 283 p.
- Stephen, W. P.
1957. Bumble bees of western America (Hymenoptera: Apoidea). *Oregon St. Coll. Agr. Exp. Sta. Tech. Bull.* 40:1-163.
- Thorp, R. W.
1962. Notes on the distributions of some bumblebees of western North America (Hymenoptera: Apidae). *Pan-Pac. Entomol.* 38:21-28.
1969. The identity of *Bombus vandykei* (Hymenoptera: Apidae). *Pan-Pac. Entomol.* 45:87-96.
1970. The type locality of *Bombus franklini* and notes on putative Arizona records of other Bombini. *Pan-Pac. Entomol.* 46:177-180.

Plates

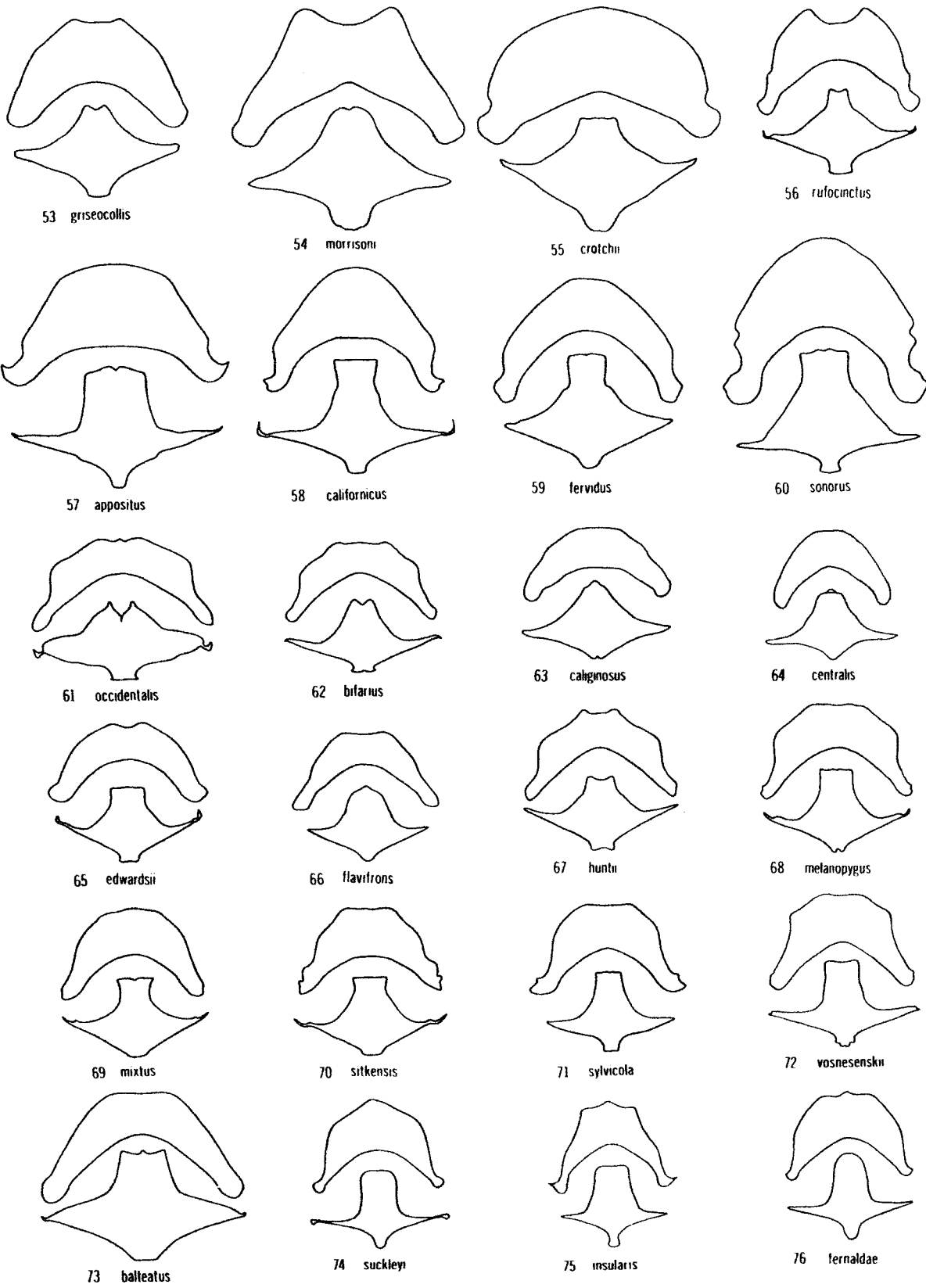




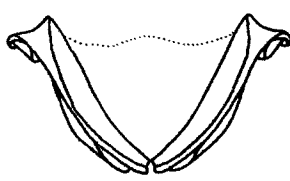
Figs. 28-33. *Bombus nevadensis*. Fig. 28. Head of female. Fig. 29. Head of male. Fig. 30. Malar space measurements. Fig. 31. Male metasomal sternites 7 (above) and 8 (below), apices at top. Fig. 32. Dorsal (left) and ventral (right) views of male genital capsule, apex at top. Fig. 33. Apex of penis valve, apicodorsal, lateral, and mesal faces respectively. Fig. 34. *Bombus mixtus* male antennae, lateral and inner faces. Figs. 35-40. Apices of gonostyli (a) and penis valves (b-d) for male *Bombus*; (b) dorsoapical view; (c) lateral view; (d) ventral view.



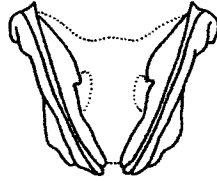
Figs. 41-52. Apices of gonostyli (a) and penis valves (b-d) for male *Bombus* (41-49) and *Psithyrus* (50-52); (b) dorsoapical view; (c) lateral view; (d) subapical trilobed process.



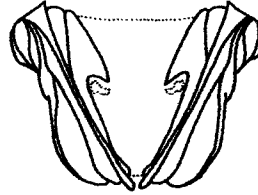
Figs. 53-76. Male metasomal sternites 7 (above) and 8 (below), apices at top, for *Bombus* (53-73) and *Psithyrus* (74-76).



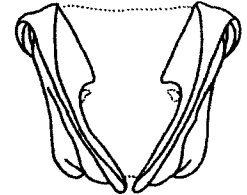
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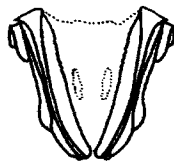
78 griseocollis



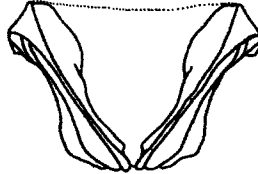
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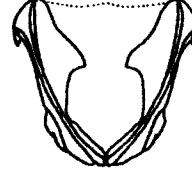
80 crotchii



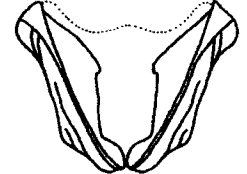
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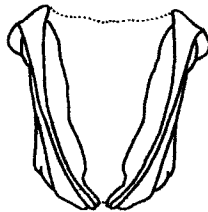
82 appositus



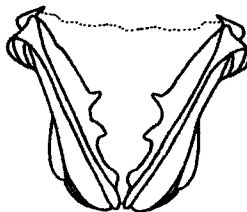
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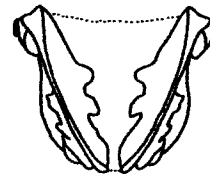
84 fervidus



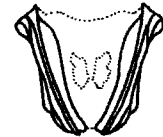
85 sonorus



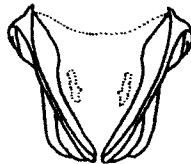
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87 occidentalis



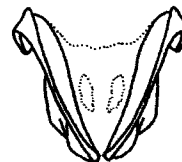
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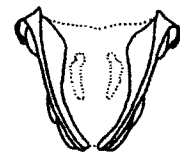
89 edwardsii



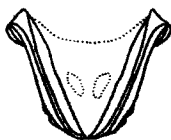
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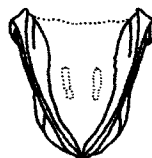
91 huntii



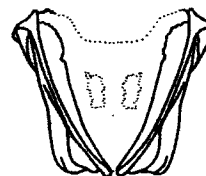
92 mixtus



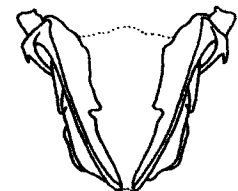
93 sitkensis



94 sylvicola

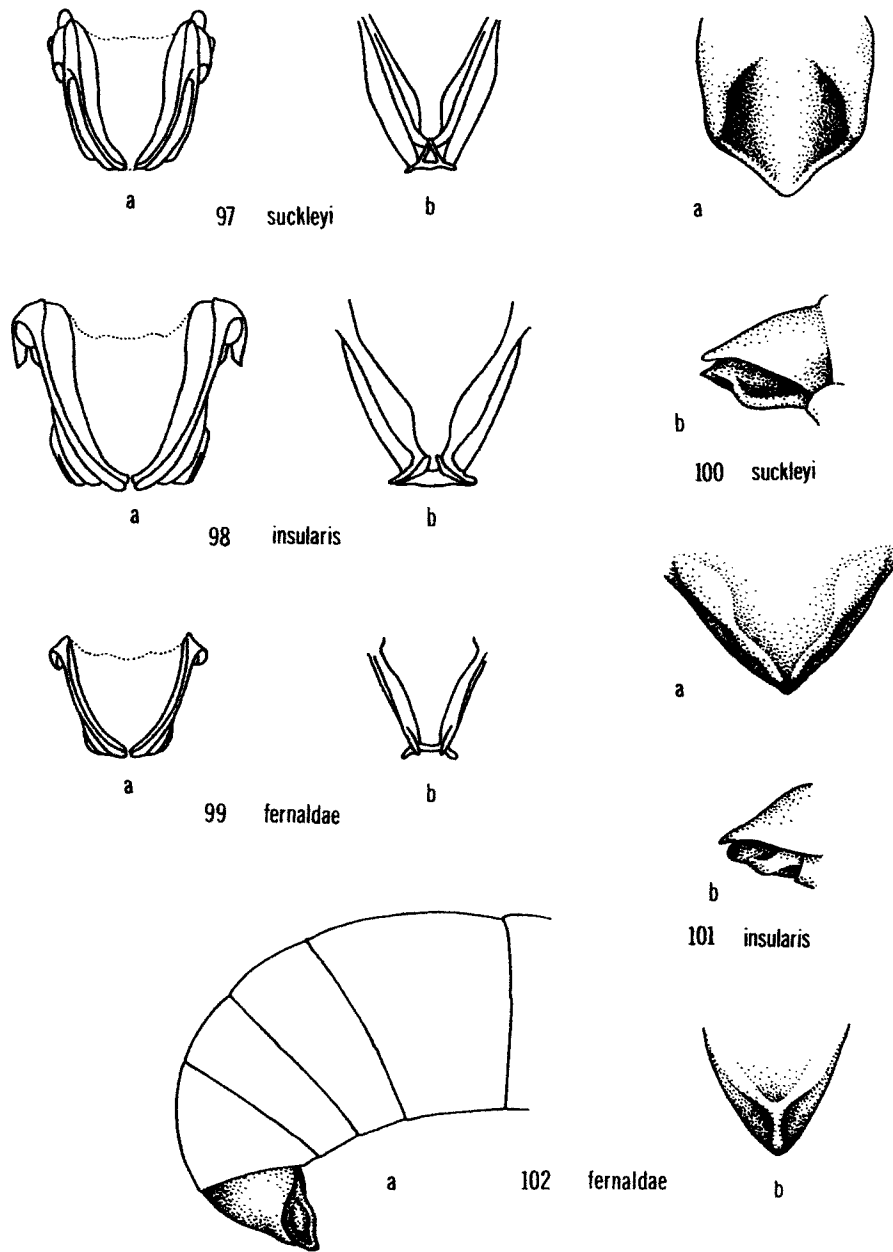


95 vosnesenskii

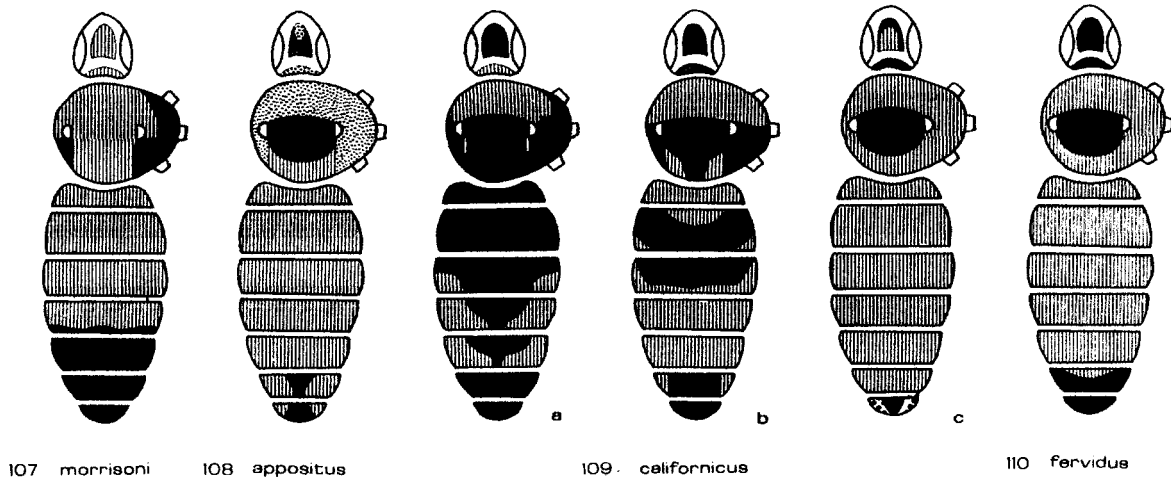
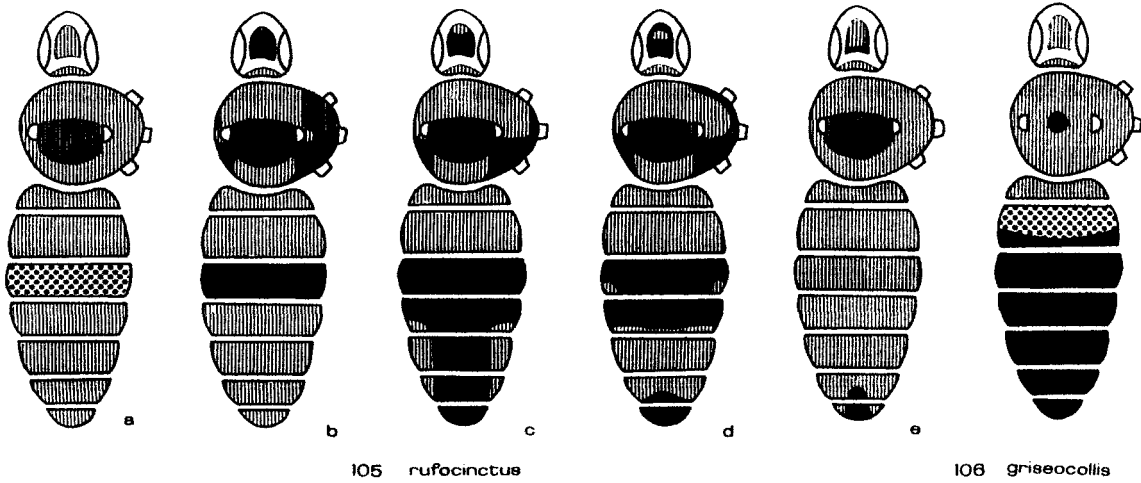
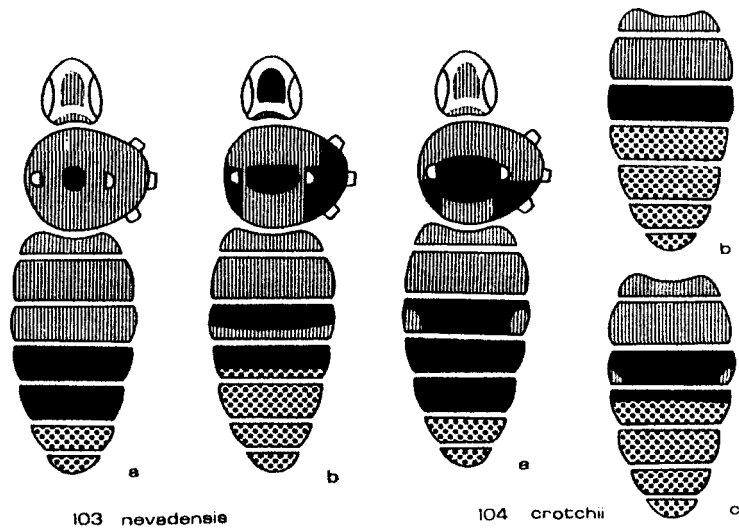
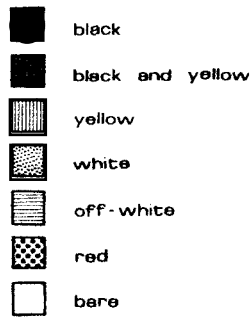


96 balteatus

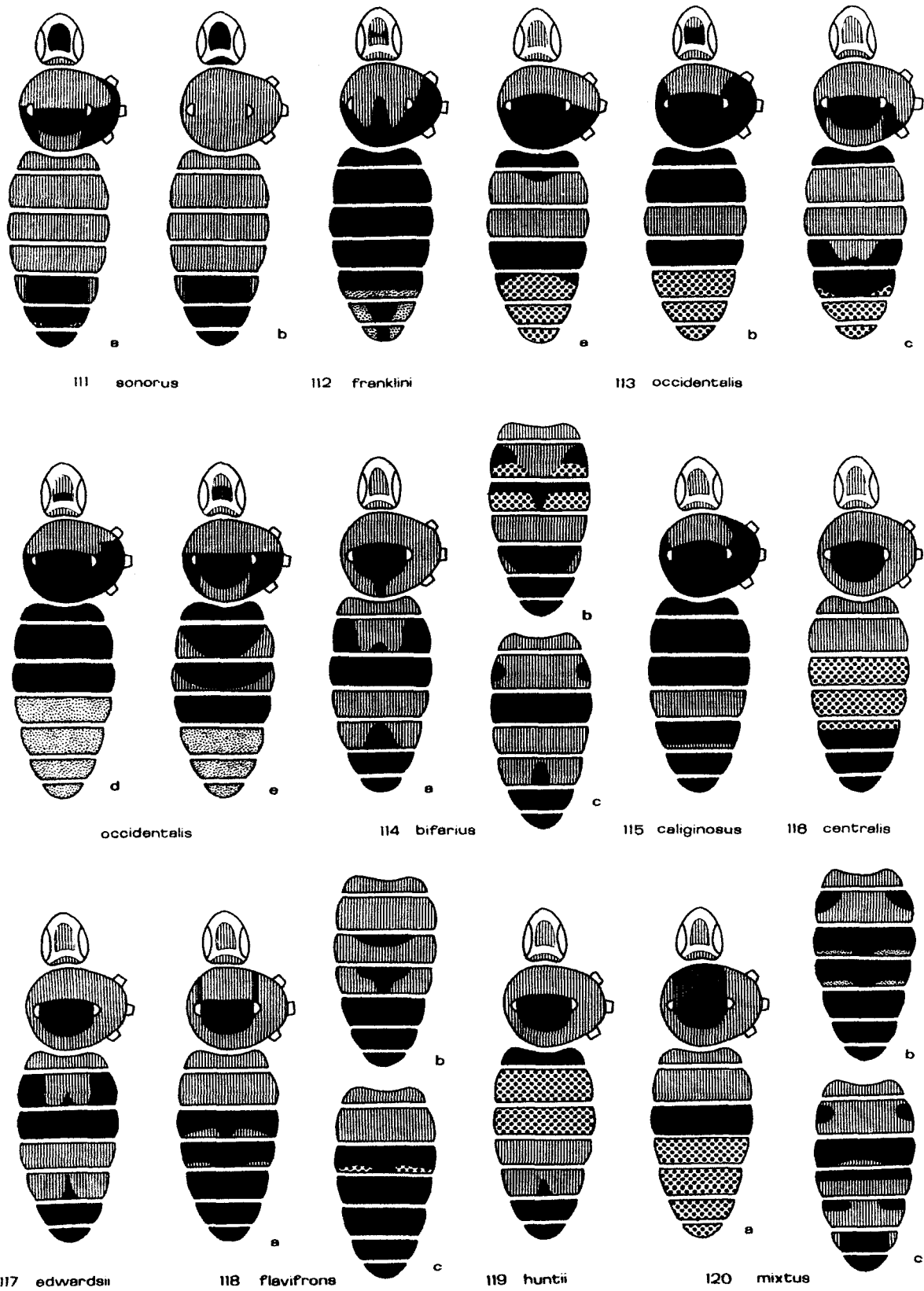
Figs. 77-96. Anterior face of sting capsule of queens of *Bombus* species. Paired, irregularly shaped, dotted outlines in mesal membrane (79-81, 88-95) represent darkened mating scars. These inclusions can be observed in mated queens of subgenera in which the penis valves of the males are hooked.



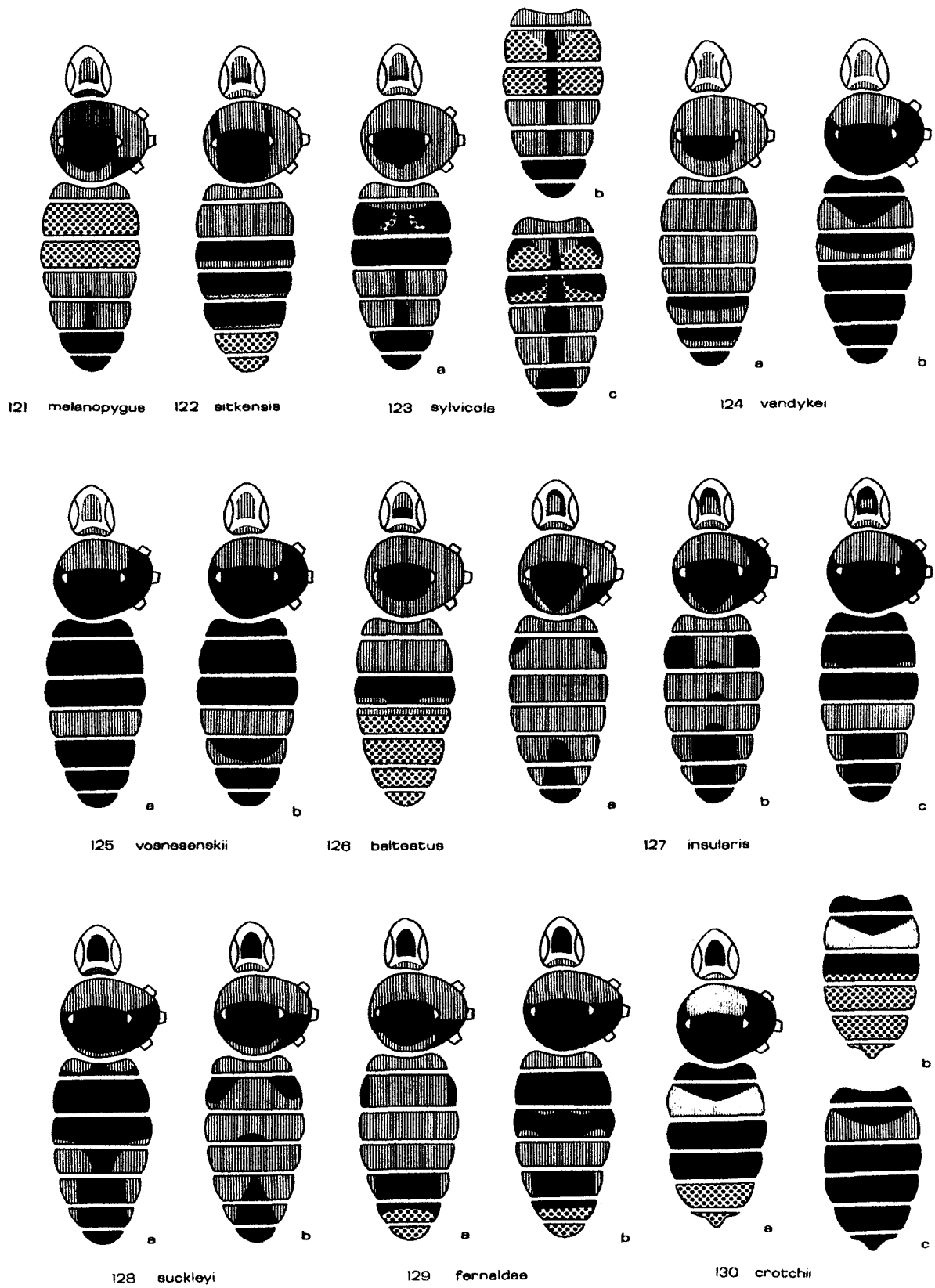
Figs. 97-102. *Psithyrus* females. Figs. 97-99. Anterior face of sting capsule (a); dorsal view of fusion at apex of inner margins of sting plates above anus (b). Figs. 100-101. Last visible sternite ventrally (a); last visible tergite and sternite, lateral view (b). Fig. 102. Metasoma laterally, showing sharply recurved apical segments with last sternite projecting beyond tip of last tergite (a); last visible sternite ventrally (b).



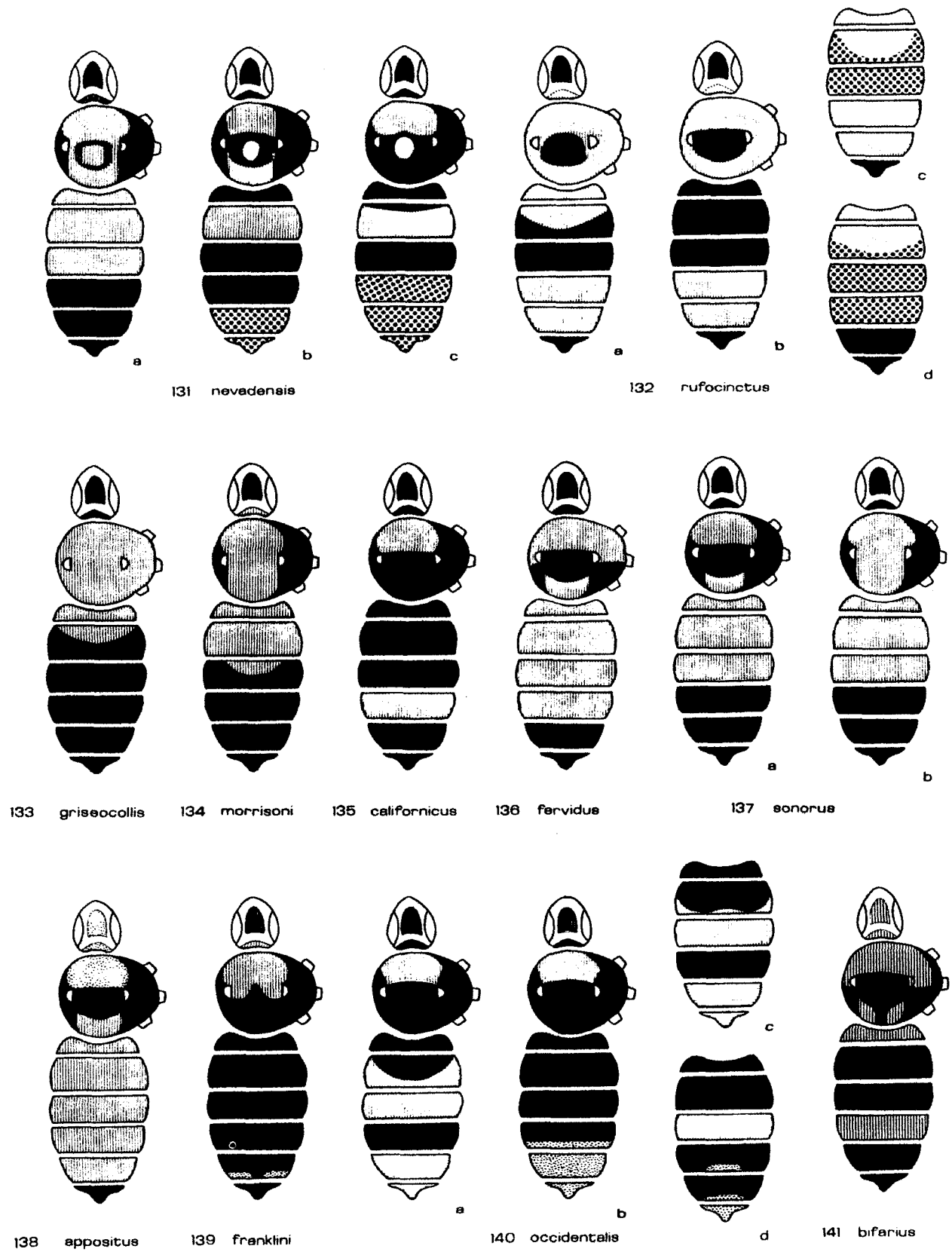
Figs. 103-110. Color patterns and variation (b-e) in males of *Bombus* species. Pleuron to leg bases of right side only shown.



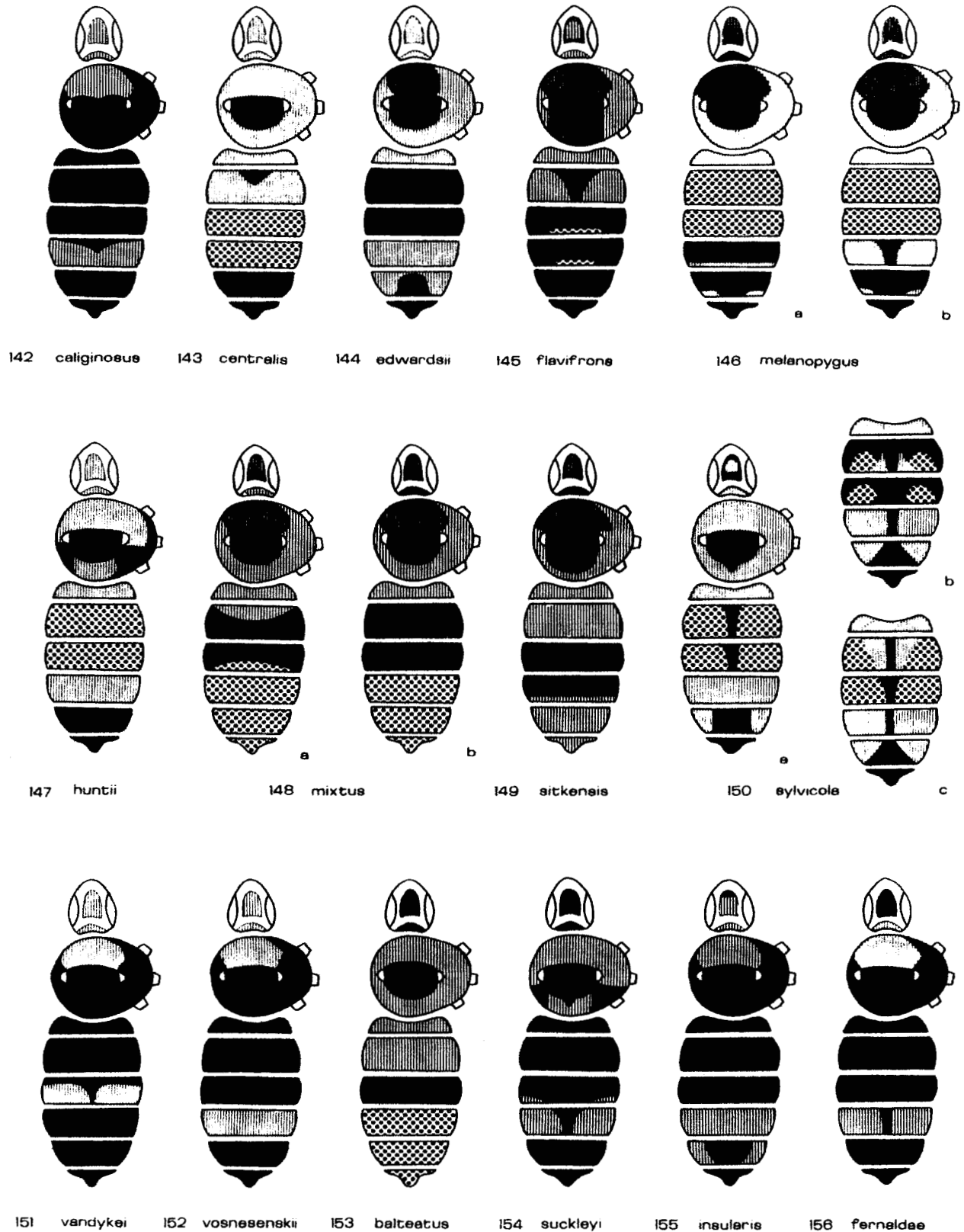
Figs. 111-120. Color pattern and variation (b-e) in males of *Bombus* species.



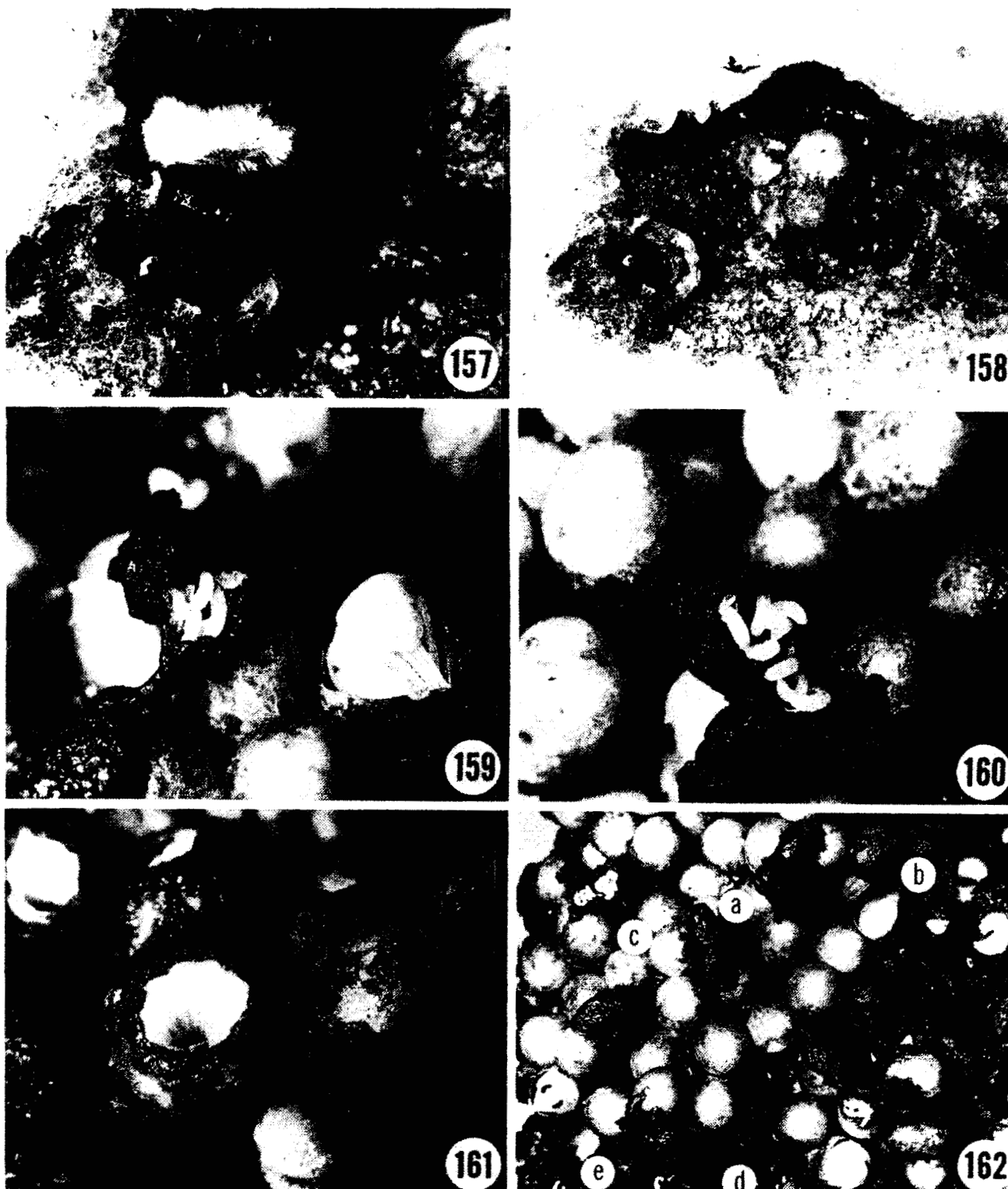
Figs. 121-130. Color patterns and variation (b-c) in males of *Bombus* species (121-126), males of *Psithyrus* species (127-129), and females of *Bombus* (130).



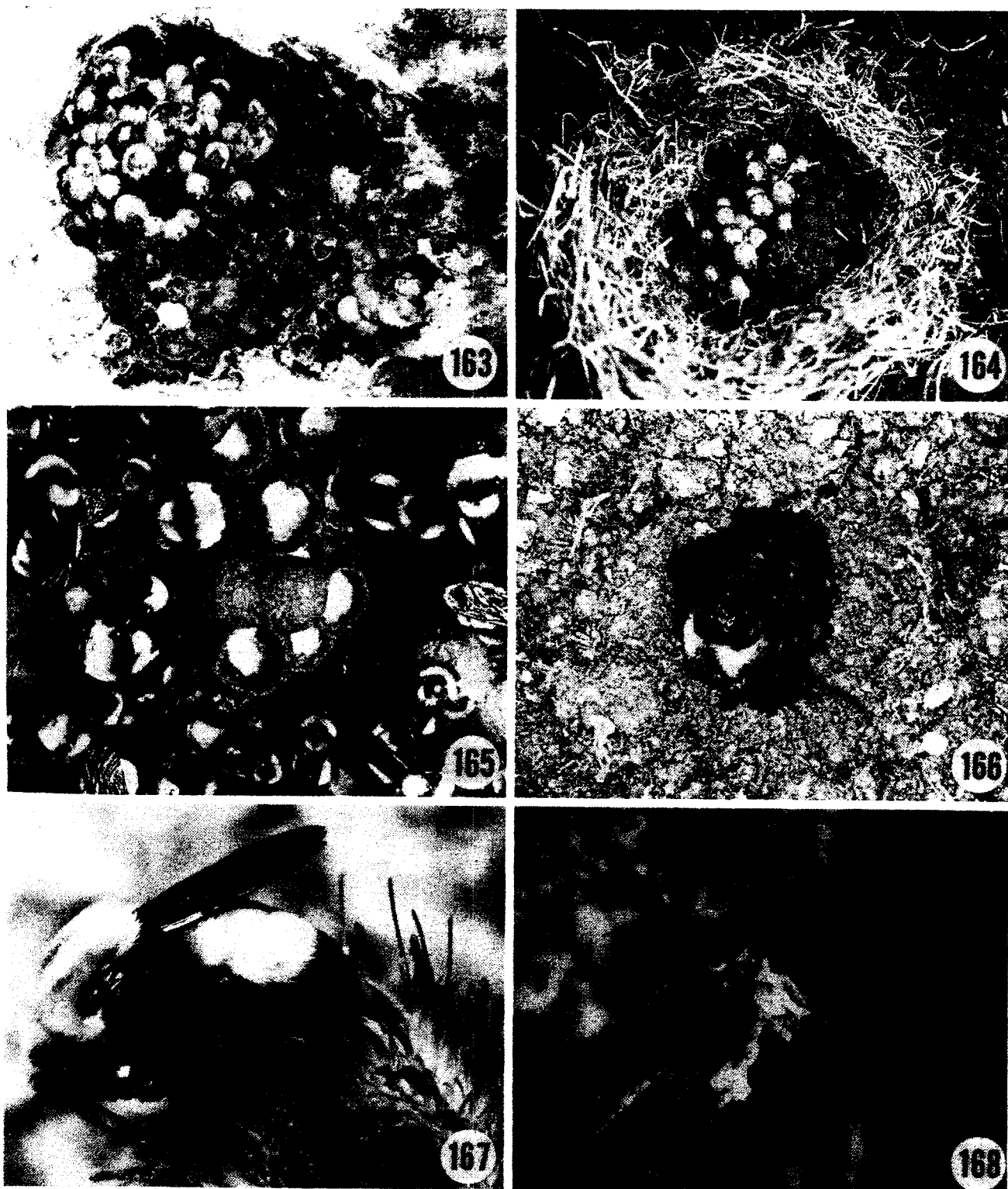
Figs. 131-141. Color patterns and variation (b-d) in females of *Bombus* species.



Figs. 142-156. Color patterns and variation (b-c) in females of *Bombus* species (142-153) and *Psithyrus* species (154-156).



Figs. 157-162. Colony development in *Bombus occidentalis*. Figs. 157-158. Incipient stages of a colony founded by a queen confined in the laboratory: Queen feeding at honey pot (157); honey pot (lower left) and first brood clump on pollen mass (center) (158). Fig. 159. Egg cell (left center) on top of cocoons opened to show group of eggs; cocoon (right) opened to show pale-eyed worker pupa. Fig. 160. Wax cell dissected, exposing egg (uppermost) and first instar larvae. Fig. 161. Partially constructed cocoons (center) being spun by fully fed postdefecating larvae; wax larval cell dissected (bottom), exposing feeding larva. Fig. 162. Portion of nest with wax egg cups (a) and larval cells (b), cocoons (c), old cocoons storing pollen (d), and honey (e); some of each type dissected to show contents.



Figs. 163-165. Nests of *Bombus*. Fig. 163. Surface nest of *B. caliginosus*, a pollen storer, in cotton stuffing of hammock discarded in the corner of a garage, Humboldt Co. Fig. 164. Subterranean nest of *B. californicus* from old rodent burrow in a pasture, Humboldt Co. Fig. 165. Nest of pocket-making species, *B. sonorus*. Fig. 166. Queen of *B. sonorus* in hibernacular cell dug into peat mound in cage. Fig. 167. Queen of *B. morrisoni* foraging on *Cirsium*. Fig. 168. Robber fly with bumble bee as prey.

Index to Bombini and Synonyms

(Synonyms in italics, main page references in boldface)

- Alpinobombus Skorikov, 1, 2, 14, 16, **48-49**.
ambiguus Franklin, 9.
americanorum (Fabricius), 9.
Apathus Newman, 50.
appositus Cresson, 3, 6, 8, 9, 13, 14, 17, **24-25**, 52.
ashtoni (Cresson), 13, 50.
Ashtonipsithyrus Frison, 49-50.
auricomus (Robertson), 18, 19.
balteatus Dahlbom, 5, 6, 8, 9, 14, 16, **48-49**.
bifarius Cresson, 3, 5, 6, 9, 11, 15, 17, **32-33**, 37, 39, 44, 47.
Bombias Robertson, 2, 14, 16, **18-19**.
Bombus Latreille, v, 1-3, 5, 6-9, 11-13, **14-49**, 50, 52, 53.
borealis Kirby, 13, 25.
Bremus Panzer, 29, 33, 45.
californicus F. Smith, 2, 3, 5, 6, 8-11, 13, 14, 17, **25-27**, 28, 52.
caliginosus (Frison), 2, 3, 6, 8, 9, 11, 14, 17, **33-35**, 36, 38, 45, 46, 52, 53.
cascadensis (Milliron), 45, 46.
centralis Cresson, 6, 9, 10, 13, 14, 17, 34, **35-36**, 38, 45.
Citrinopsithyrus Thorp, 9, 49, **50-52**.
citrinus (Smith), 50.
consanguineus Handlirsch, 25, 26.
crawfordi Franklin, 9, 50, 52, 53.
crotchii Cresson, 2, 6, 7-9, 15, 16, 18, 19, **21-23**.
Crotchiibombus Franklin, 15, 16, **21-23**.
Cullunanobombus Vogt, 12, 15, 16, **23-24**, 52.
cullumanus Kirby, 23.
dimidiatus Ashmead, 6, 9, 10, 36-38, 43.
edwardsii Cresson, 2, 3, 5, 6, 8-11, 13, 15, 17, **36-37**, 40-44.
fernaldae Franklin, 6, 9, 11, 24, 25, 32, 49, 51, **52-53**.
Fernaldaepsithyrus Frison, 9, 49, **52-53**.
Fervidobombus Skorikov, 2, 9, 14, 17, **25-29**.
fervidus (Fabricius), 2, 3, 5, 6, 9-11, 13, 14, 17, 26, **27-28**.
flavifrons Cresson, 6, 9, 10, 13, 14, 17, 34, 36, **37-39**, 43, 45.
franklini (Frison), 6, 8, 9, 15, 16, **29-30**, 31.
Fraternobombus Skorikov, 5, 14.
griseocollis (Degeer), 2, 6, 8, 9, 15, 16, **19-20**, 21, 23.
henshawi Franklin, 23.
huntii Greene, 6, 9, 10, 15, 17, 33, **39-40**, 47.
insularis (F. Smith), 5, 6, 9, 11, 19, 24, 25, 32, 49, **50-52**, 53.
kirbyellus Curtis, 49.
Laboriopsithyrus Frison, 50.
laboriosus (Fabricius), 50.
lapponicus (Fabricius), 5, 44.
melanopygus Nylander, 2, 6, 9, 13, 15, 17, 37, **40-41**, 43, 44.
miguelensis Cockerell, 9, 18, 19.
mixtus Cresson, 5, 6, 9, 10, 15, 17, 35, 37, 40, **41-42**, 43, 44.
morrisoni Cresson, 2, 5, 6, 8, 9, 15, 16, 19, **20-21**, 23.
nearcticus Handlirsch, 9, 32, 33, 37.
nevadensis Cresson, 2, 6, 8, 9, 14, 16, **18-19**, 23, 52.
nigroscutatus Franklin, 9, 19, 30-32.
occidentalis Greene, 2, 3, 5, 6, 9-11, 13, 15, 16, 19, 29, **30-32**, 50.
pennsylvanicus (Degeer), 9, 13, 19, 29.
Psithyrus Lepeletier, v, 1, 2, 5, 6, 9, 11-13, 19, 24, 25, 28, 32, **49-53**.
Pyrobombus Dalla Torre, 8, 9, 12, 14-16, **32-48**, 50, 52, 53.
rufocinctus Cresson, 5, 6, 8, 9, 13, 15, 16, **23-24**.
semisuffusus Cockerell, 18, 19, 23.
Separatobombus Frison, 15, 16, **19-21**, 23.
sitkensis Nylander, 2, 6, 8, 9, 14, 17, 37, 40, 41, **42-43**, 44.
sonorus Say, 3, 6, 9-11, 13, 14, 17, **28-29**.
Subterraneobombus Vogt, 2, 14, 17, **24-25**, 52.
suckleyi (Greene), 6, 8, 9, 13, 19, 24, 25, 32, **49-50**.
sylvicola Kirby, 3, 5, 6, 8-11, 15, 17, 37, 40, 41, **43-45**.
tardus (Frison), 34.
terricola Kirby, 13, 31, 32.
vandykei (Frison), 5, 6, 9, 11, 14, 17, 34, 36, 38, **45-46**.
vosnesenskii Radoszkowski, 2, 3, 6, 8-11, 15, 17, 33, 39, **46-48**, 52, 53.
wheeleri Bequaert and Plath, 9, 51-53.