No. 6.— *Description of a new Psithyrus, with an Account of Psithyrus laboriosus, and Notes on Bumblebees.*

By Joseph Bequaert and Otto E. Plath.

Introduction.

In the course of his biological studies of the New England Bremidae, the junior author has, during the last four years, bred and collected many hundreds of specimens of the several species occurring near Boston. A number of unusual color forms were thus brought to light, and it is the purpose of the present joint paper to discuss their taxonomic and biological significance.

Although Franklin, in his fundamental monograph has followed a different practice, we propose varietal names for several new color variants which seem well characterized, in order that they may be concisely and clearly referred to in general discussions. In some cases the distinction between two forms may also be of biological importance, as we shall endeavor to show for *Psithyrus laboriosus* and its variety *citrinus*. Franklin's main objection to naming the color varieties of bumblebees will be discussed later.

The types of the new forms are in the collection of the Museum of Comparative Zoölogy, Cambridge.

Description of a new Psithyrus from Oregon and California.

Psithyrus wheeleri, sp. nov.

Female.— Face black; occiput with yellow pile; thorax with the dorsum in front and the upper part of the pleura yellow, otherwise mostly dark; abdomen with the fourth tergite extensively yellow, otherwise dark.

Face entirely covered with black pile. Occiput with a triangular patch of pure yellow pile. Malar space about as long as wide at apex, about one fourth as long as the eye. Clypeus with a smooth space anteriorly, in the middle, otherwise densely punctate. Labrum with the basal tubercles low and rather inconspicuous. Apical margin of mandibles with a notch in the middle. Third and fifth antennal segments subequal in length, the fourth considerably shorter than either (Figure 1*a*). Dorsum of thorax anteriorly covered with yellow pile to the bases of the wings, the remainder black. The disk rather thinly clothed, but without bare patch. Mesopleura with yellow pile in the

upper part of the anterior portion only; the remainder of the sides and propodeum black. Fourth tergite of abdomen covered with yellow pile, except in the middle, where there is a somewhat triangular patch of black hairs, the apex of which reaches the hind margin. Remainder of abdomen with black hairs; the apex of the last segment with brownish ferruginous pubescence. The fifth tergite with extremely fine and much scattered punctures in the

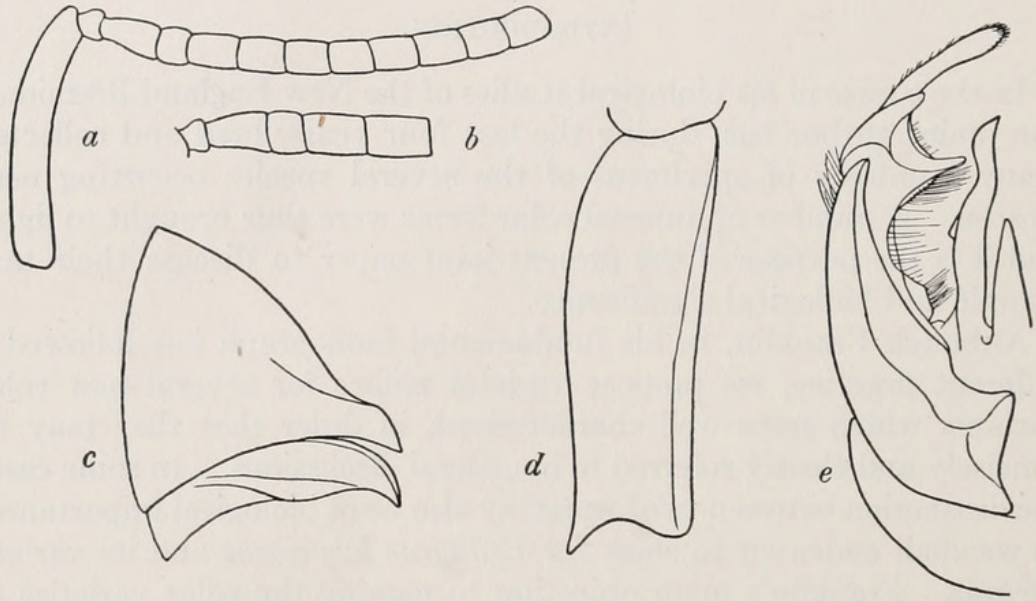

FIG. 1. *Psithyrus wheeleri* Bequaert and Plath. *a*. antenna of female; *b*, basal segments of male flagellum; *c*, apical tergite and sternite of female abdomen; *d*, hind metatarsus of female from the outer side; *e*, dorsal aspect of male genitalia.

middle, moderately punctate on the sides. The middle part of the exposed portion of the sixth tergite (epipygium) with very few and minute punctures or nearly impunctate, somewhat raised longitudinally into a faint ridge; the tergite slightly depressed before the apex, which is very pointed and narrow. Sixth sternite (hypopygium) extending much beyond the tergite, pointed and somewhat recurved at apex; the lateral carinae moderately and uniformly elevated throughout, ending much before the tip of the abdomen (Figure 1*c*). Wings much stained with brown, the fore pair darker in the region beyond the veins. Legs mostly black; the tarsi with some short ferruginous pubescence, especially on the posterior face of the hind metatarsi. Upper margin of hind tibiae and hind metatarsi with long hairs. Hind metatarsi three times as long as their greatest width, drawn out into a sharp and rather narrow point at the upper apex, the upper margin distinctly arcuate (Figure 1*d*).

Length of holotype, 15 mm.; length of fore wing, 14 mm.; (spread of wings, 34 mm.). Length of paratype, 13 mm.; length of fore wing, 13 mm.; (spread of wings, 31 mm.).

Male.— Face and clypeus entirely covered with black pile. Occiput with a large, triangular patch of yellow pile. Malar space about as long as wide at apex, about one fourth as long as the eye. Antennae with the third and fifth

segments subequal in length, the fourth shorter than either (Figure 1*b*); the flagellum nearly three times as long as the scape. Dorsum of thorax anteriorly covered with yellow pile to the bases of the wings, the remainder black. Mesopleura yellow only in the extreme upper part of the anterior portion; the remainder of sides and propodeum black. Fourth tergite of abdomen entirely covered with yellow pile; the fifth black, with a few yellow hairs on the extreme sides; the pile of the two last segments slightly ferruginous; the remainder of the abdomen black. Legs mostly dark; hairs fringing the hind tibiae and upper margin of hind metatarsi very long, as long as the width of the metatarsus. Branches of claspers of genitalia (Figure 1*e*) strongly pointed at tip dorsally; squamae bilobed, the inner lobe the longer and narrowly triangular in outline, the outer lobe short triangular and pointed at tip; volsellae very slender and somewhat more elongate than in *fernaldae;* sagitta shaped as in *fernaldae*, its shaft with a prominent tooth ventrally.

Length of allotype 14 mm. and paratype 15 mm.; length of fore wing 12.5 mm.; (spread of wings 30 mm.).

HOLOTYPE, M. C. Z. 15,280. Female, Oregon: Benton Co., Mary's Peak, July, 1916 (W. J. Chamberlin Coll.). PARATYPE. Female, Cala.: Sierra Nevada, (Edwards Coll.). ALLOTYPE and PARATYPE. Males, Cala.: Alta Meadow, Sequoia National Park, 9,000 ft., August 23, 1917. (Cornell University Biological Expedition, W. M. Wheeler Coll.).

In Franklin's key (1912, p. 449–451) both sexes of this new species run to *P. crawfordi* and they were at first believed to be that species. *Psithyrus crawfordi*, however, belongs to the *laboriosus* group; while *P. wheeleri* possesses all the morphological features of the *fernaldae* group, including those pointed out in a later paper by Franklin (1915, p. 416). In coloration *P. wheeleri* is strikingly unlike *P. fernaldae*, of which we have examined six males and eleven females. Moreover, there are some structural differences, such as the shape of the hind metatarsus in the female and certain details of the male genitalia, so that we feel justified in regarding *wheeleri* as a distinct species and not merely as a color variation of *fernaldae*.

The two sexes of *P. wheeleri* are colored much alike, which is somewhat unusual in Psithyrus. There can hardly be any doubt that they are conspecific, although they were not taken together. They are remarkably similar to queens, workers, and males of *Bremus vosnesenskii* (Radoszkowsky) and *B. californicus* (Smith), both of which occur in California and Oregon. Probably *B. vosnesenskii* is the host of *P. wheeleri*, since it was by far the more common of the two at Alta Meadow. So great is the resemblance of *P. wheeleri* with the male and female of *B. vosnesenskii*, that our specimens were at first confused with that species.

The two Races of Psithyrus laboriosus (Fabricius).

Franklin (1912, p. 451) united with *laboriosus* Fabricius, based upon a female, the males described as *Apathus citrinus* Smith and *Apathus contiguus* Cresson, although, as far as he knew, they had not been taken *in coitu* or together in the nests of Bremus. On September 7, 1921, the junior author bred a female of *laboriosus* from a nest of *Bremus vagans*, in which a similar Psithyrus female had been found laying eggs on August 10 (Plath, 1922*a*, p. 29–31). In a later paper (Plath, 1922*b*, p. 195–197) he also recorded finding Psithyrus of the *laboriosus* group in nests of *Bremus vagans* and *B. impatiens*, males and females having been bred in each case. He pointed out that the males and females reared from the *B. impatiens* nest were different from those obtained from the nest of *B. vagans*. In 1923 and 1924 additional specimens of both sexes were found in other nests of these two species of Bremus.

An examination of this extensive material, comprising thirty-four females and seventy-five males, obtained from eight nests of Bremus, shows that they all belong to the species *Psithyrus laboriosus* in Franklin's sense. Yet they are rather easily arranged into two groups, based upon the color of the pile, each of the two types being restricted to one species of Bremus.

1. Psithyrus laboriosus (Fabricius). Typical form.

Fabricius's (1804, p. 352) original description of *Bombus laboriosus* was based upon a female and reads as follows: —

"B. thorace villoso cinereo, corpore atro immaculato. Habitat in Carolina Mus. Dom. Bosc. Statura praecedentium. Corpus totum atrum thorace solo pilis dorsi cinereis hirto. Alae obscurae. Pedes nigri."

This type of female, with the abdomen entirely covered with black pile or occasionally with a touch of yellow on the extreme sides of the third tergite (as mentioned in Cresson's description, 1863, p. 111), was obtained by us from the nests of *Bremus impatiens*. The corresponding males, found in the same nests, agree with Cresson's description (1863, p. 112) of *contiguus*:—

"*Male*. Head black, yellowish on the vertex. Thorax lemon-yellow, more or less black between the wings. Wings fusco-hyaline. Legs black, tarsi pale, inner side of the basal joint rufous. Abdomen with the first two segments

above lemon-yellow; rest black. Beneath black. Length 7–8 lines. *Variety.* The anterior portion of the second abdominal segment above mixed with black, especially on the sides."

It should be added that in certain specimens the third tergite of the abdomen shows a faint admixture of yellow in the anterior corners.

2. Psithyrus laboriosus (Fabricius) var. citrinus (Smith).

Smith (1854, p. 385) describes *Apathus citrinus* as follows: —

"Male. Length 6½ lines.— Black, the face densely clothed with long black pubescence; on the vertex it is obscurely yellow. Thorax thinly clothed above with long lemon-coloured pubescence, having a black band between the wings; the wings fusco-hyaline, slightly clouded at their apical margins; the sides of the thorax have a yellow pubescence, but beneath and also on the legs it is black. Abdomen, the three basal segments clothed with lemon-coloured pubescence, the apical ones with black; beneath black. *Hab.* United States."

This type of male, with the three first tergites entirely or mostly covered with yellow pile, was bred or obtained from nests of *Bremus vagans*. In some males the fourth tergite also shows an admixture of yellow hairs, especially in the extreme anterior corners. A specimen with this coloration was described by Cresson (1863, p. 112) as a possible variety of *citrinus*. From the same nests of *B. vagans* were obtained females which differ from those of typical *laboriosus* in having the pile of the third abdominal tergite extensively or wholly yellow instead of black. In some specimens the hind margin of the second tergite has a narrow fringe of yellow hairs on the sides, while there is a patch of yellow pile on the extreme corners of the first tergite also, and a strong admixture of yellow hairs between the ocelli and the base of the antennae. No name appears to have been proposed for this particular type of female, which should henceforth be known as that of the var. *citrinus*.

In view of our observations that typical *laboriosus* generally breeds in nests of *Bremus impatiens*, while the var. *citrinus* selects those of *Bremus vagans*, we have been at great pains to discover possible morphological differences between the two forms, but without result. A careful comparison of the male genitalia discloses no differences; but it should be kept in mind that these are always slight, and perhaps not quite reliable, between the several species of the *laboriosus* group. On the average the females of typical *laboriosus* are slightly smaller than those of the var. *citrinus*.

Occasionally one may find in a *B. vagans* nest a male of the *contiguus* type and *vice versa*, a male of the *citrinus* type in a nest of *B. impatiens*. These may possibly be stray males that have reached the nest from outside. However, we find also in both nests among the males a number of intermediate forms, which it is possible to arrange in a series leading from typical *laboriosus* to the var. *citrinus*.

The following analysis of the several nests, condensed in the Table below, shows the proportions of the different color types in each case.

NESTS OF BREMUS VAGANS. — (1) Nest of August 10, 1921, with a female *citrinus*. Another female, also of the var. *citrinus*, was bred on September 7.

TABLE.

	Nests of *Bremus vagans*				Nests of *Bremus impatiens*			
	1	2	3	4	5	6	7	8
Psithyrus laboriosus.								
Females: typical	—	—	—	—	1	1	—	18
with touch of yellow on tergite 3	—	—	—	—	4	—	2	—
var. *citrinus*	2	6	—	—	—	—	—	—
Males: with mixture of yellow and black on tergite 2	—	—	—	—	1	—	—	1
typical	—	—	—	—	7	3	1	7
with touch of yellow on tergite 3	—	1	1	—	5	1	—	1
var. *citrinus*, with mixture of yellow and black on tergite 3	—	10	4	—	—	—	1	3
var. *citrinus*	—	7	9	8	—	3	—	1

(2) Nest of June 26, 1922, containing a *citrinus* female when taken. Later five females, all of the var. *citrinus* were found in it, and eighteen males, divided as follows: — seven *citrinus;* six *citrinus*, with a slight admixture of black hairs on the third tergite; four *citrinus*, with a larger amount of black on the third tergite; one typical *laboriosus*, with but few yellow hairs at extreme anterior corners of third tergite.

(3) Nest of August 4, 1923. Of fourteen males obtained, nine are of the var. *citrinus;* four show a mixture in various proportions of black and yellow hairs on the third tergite; and one is typical *laboriosus* with a trace of yellow in the corners of the third tergite.

(4) Nest of July 27, 1923. The eight males obtained are all of the var. *citrinus.*

NESTS OF BREMUS IMPATIENS.— (5) Nest of August 8, 1922, containing one female and two males of typical *laboriosus,* when taken. From this nest were obtained four females nearly typical *laboriosus* and eleven males which may be called *laboriosus,* although the extent of black pile on the abdomen varies a great deal; in five specimens the third tergite is wholly black, but the second and even the first shows an admixture of black hairs; in one of them the abdomen is almost wholly black, with a few yellow hairs on the first tergite; the five remaining males are like the so-called "*laboriosus*" of *Bremus vagans* nests, that is with a few yellow hairs in the corners of the third tergite.

(6) Nest of July 30, 1923. In this were found later, one female of typical *laboriosus* and seven males, of which three are typical *laboriosus,* one is *laboriosus* with some admixture of yellow pile on the sides of the third tergite, and three are of the var. *citrinus.*

(7) Nest of July 31, 1924. From this were bred, in September, two female *laboriosus* with a touch of yellow pile on the sides of the third tergite; and two males, one typical *laboriosus,* the other with a mixture of black and yellow pile on third tergite.

(8) Nest of August 13, 1924. From this were later obtained eighteen females, all typical *laboriosus,* and thirteen males divided as follows: — seven typical; one *laboriosus* with a few yellow hairs on sides of the third tergite, and another *laboriosus* with much black pile mixed with the yellow on the second tergite; three with a mixture of yellow and black pile on the third tergite; one of the var. *citrinus.*

Franklin's treatment of *laboriosus* and *citrinus* masks the interesting biological fact that each of these two forms shows a decided preference for a particular species of bumblebee. Owing to the absence of structural differences and the occurrence of occasional intergrades, especially among the males, we could not, however, regard them as distinct species. It may well be argued that they should be ranked as races or subspecies. Unfortunately there is no agreement among systematists concerning the concept of "race." In the case under discussion, the two forms are certainly not geographical races, since they occur in the same locality and have on the whole the same distribution. Perhaps they might be regarded as

biological races. For the present we shall call *citrinus* a variety of *laboriosus*.

As known at present, the distribution of the two forms is as follows:

1. *Psithyrus laboriosus* (Fabricius), typical form (= *contiguus* Cresson). Cresson described *contiguus* from Connecticut, Pennsylvania, and Delaware. We have seen specimens from Maine (Brunswick, Bar Harbor, and South West Harbor, Mt. Desert). Vermont (Bennington, Chittenden). Massachusetts (Sherborn, Wellesley, Brookline, Forest Hills, Auburndale, Manomet, Stony Brook, Blue Hills Reservation). Connecticut (Colebrook). New York (Port Maitland, Yarmouth Co., Ithaca, Otto, Kings Park, Springs, Long Island). Maryland (Plummer Island). Virginia (Glencarlyn). Texas (Dallas).

A small male of Forest Hills (total length, 10 mm.) represents an extreme melanistic form, in which only the first tergite is covered with pale yellow hairs; the second tergite as well as the remainder of the abdomen are exclusively black pilose. The genitalia of this specimen are exactly like those of typical *laboriosus*.

2. *Psithyrus laboriosus* var. *citrinus* (Smith). Cresson records it from Massachusetts, Connecticut, New York, and Illinois. We have seen specimens from Nova Scotia, Maine (Bar Harbor, and South West Harbor, Mt. Desert). Vermont (Grand Isle, Chittenden). New Hampshire (Camp Asquam, Squam Lake). Massachusetts (Wellesley, Brookline, Forest Hills). Connecticut (Colebrook). New York (Huntington, and Wyandanch, Long Island, Ithaca), and Pennsylvania (Pottstown).

Two females from Vermont represent an extreme variation in which the face has a considerable amount of yellow pile, forming a transverse band below the ocelli and a small tuft above the clypeus; the first tergite not only has the sides wholly covered with yellow hairs, but these extend over the middle along the apical margin; second tergite black, with a very broad apical yellow margin, slightly widened on the sides; third tergite entirely pure yellow; fourth tergite black, with a tuft of yellow hairs on the extreme sides. Due to the abundance of yellow pile amidst the black hairs of the face, these specimens run to *P. insularis* in Franklin's key (1912, p. 450). They differ, however, from *insularis* in having the dorsum of the thorax wholly covered with yellow pile. We were at first inclined to propose a varietal name for this rather striking color variant, but having found a series of gradations connecting it with *citrinus*, we regard it as an extreme variation of that form.

Miscellaneous Notes on Psithyrus.

Psithyrus fernaldae Franklin.

This species is apparently common at Colebrook, Connecticut, where Professor Wheeler took nine females in June and July, 1911. In the same locality he obtained four males of *P. tricolor* Franklin during July, 1911, and another in 1922. This further confirms that *fernaldae* and *tricolor* are the two sexes of one species, as was suggested by Franklin (1912, p. 475) and more definitely by Frison (1923, p. 321 and 1924, p. 295). The collection of the Boston Society of Natural History also contains specimens from Maine (Machias, and Bar Harbor, Mt. Desert), New Hampshire (Halfway House, Mt. Washington, 4,000 ft.), Massachusetts (Coldbrook Springs).

An additional character, not mentioned by Franklin, is found in the labrum of the female: the basal tubercles are rather inconspicuous, forming low ridges which are not angular toward the middle line. In *P. wheeleri* they are similarly formed and, since they are very prominent and triangular in the other species which we have examined (*laboriosus, insularis, variabilis, latitarsus,* and *ashtoni*), we believe that this character might be used for the *fernaldae* group as a whole. In the European *P. globosus* Eversmann, which Franklin places in the *fernaldae* group, the basal tubercles of the labrum are also quite low.

Psithyrus crawfordi Franklin.

We have seen a male from Alta Meadow, California, 9,000 ft., August 23, 1917 (W. M. Wheeler Coll.) and another from Truckee, California, August 4, 1914 (L. Bruner Coll.), which agree quite well, in coloration, with Franklin's description of *P. crawfordi.* The fifth antennal segment is distinctly longer than the third, the third slightly longer than the fourth (Figure 2*a*). The genitalia were apparently not examined by Franklin. In our specimens (Figure 2*b*) they show the main characteristics of the *laboriosus* group: — claspers with their branches broadly rounded at the end (dorsally), somewhat more projecting at apex than in *laboriosus;* squamae broadly bilobate, the lobes about equal in size, obtusely pointed and hardly different from those of *laboriosus;* volsellae in general outline like those of *laboriosus.*

We also surmise that the host of *P. crawfordi* is either *Bremus vosnesenskii* or *B. californicus,* since the similarity in coloration is

equally striking as in the case of *P. wheeleri*. In collections males of *P. crawfordi* or *P. wheeleri* have undoubtedly been confused with those of the above-named species of Bremus.

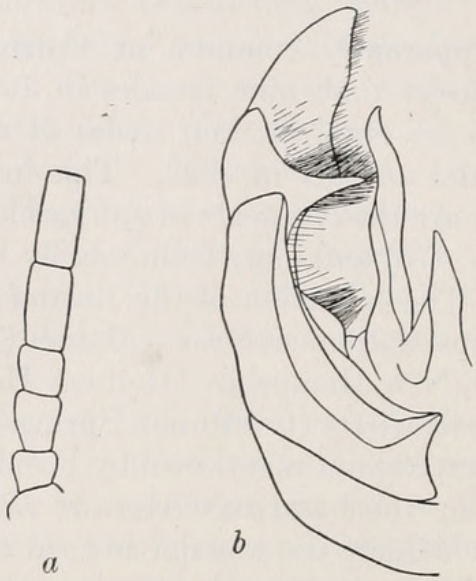

FIG. 2. *Psithyrus crawfordi* Franklin. *a*, basal segments of male flagellum; *b*, dorsal aspect of male genitalia.

Psithyrus ashtoni (Cresson).

In two former papers, the junior author has recorded *Bremus affinis* (Cresson) as the host of this Psithyrus (Plath, 1922*a*, p. 26 and 1922*b*, p. 191).

On July 15, 1924, a female of *P. ashtoni* was found living in a colony of *Bremus terricola* (Kirby), kept in an observation box and consisting of about twenty-five workers, a dozen young queens and several males. This female of *P. ashtoni* was left unmolested in the colony, a good indication that *B. terricola* also might be its host; for the junior author has observed on several occasions that, if a female of *Psithyrus laboriosus* enters a *B. terricola* colony, it is attacked and killed. Later the association of *P. ashtoni* with *B. terricola* was confirmed by the following observation. On August 8, 1924, the junior author found in a plowed field, at Forest Hills, a nest of *B. terricola* containing three workers, three young females of *P. ashtoni*, and several *P. ashtoni* males and females which had died in the cocoons before hatching.

Psithyrus suckleyi (Greene).

The collection of the Museum of Comparative Zoölogy contains a male from Umatilla, Oregon, (S. Henshaw Coll.) and two females

(*latitarsus* Morrill) from Bridger Basin, Wyoming (S. Garman Coll.); also a female from Tolland, Colorado, on Frasera, July, 1915 (L. A. Kenoyer Coll.; received from Prof. T. D. A. Cockerell). We have also seen three males from Mary's Peak, Benton Co., Oregon (W. J. Chamberlin Coll.).

Psithyrus insularis (Smith).

Colorado: Tolland, 1 female, on Pentstemon, July, 1915 (L. A. Kenoyer Coll.; received from Prof. T. D. A. Cockerell). Mus. Comp. Zoöl.

New York: Keene Valley, 1 male (*consultus* Franklin), September 7, 1917 (H. Notman Coll.).

Some Varieties of Bremus from the Vicinity of Boston.

Bremus separatus var. **nero**, var. nov.

Worker.— Differs from typical *separatus* in the presence of a considerable amount of rufous pile on the fourth abdominal tergite, forming a transverse band, which covers about the posterior half of the segment; the band is notched in the middle, where there is a small patch of black hairs. The second tergite is almost entirely covered with brownish yellow pile.

Length 15 mm.; length of fore wing 11 mm.; (spread of wings 26 mm.).

The only specimen (M. C. Z. 15,279) seen is fully colored and was taken at Forest Hills (O. E. Plath Coll.).

Bremus bimaculatus var. **ahenus**, var. nov.

Queen.— Head and thorax as in typical *bimaculatus*. First tergite of abdomen covered with yellow pile; second tergite with a short, basal, middle patch of yellow pile, covering about one third of the width, a small patch of black hairs in the extreme anterior corners, the remainder of the tergite bright rufous; third tergite covered with bright rufous pile, a few black hairs near the anterior margin, especially at the sides; remaining tergites and all sternites with black hair. Legs with black pile, but the corbicular fringes bright rufous.

Length 19 mm.; length of fore wing 15 mm.; (spread of wings 36 mm.).

Male.— Head and thorax as in typical *bimaculatus*. First tergite of abdomen with yellow pile; second tergite mostly yellow, with a small, round patch of black hairs on the sides near the anterior margin; the posterior margin covered with rufous hairs, narrowly in the middle, quite broadly on the sides; third tergite mostly with rufous pile, a small patch of black hairs anteriorly on the sides; remainder of dorsum black; venter mostly covered with light pile. Legs as in typical *bimaculatus*.

In a second male the rufous of the second and third tergites is distributed in a similar manner, but much less bright.

Length 12 to 13 mm.; length of fore wing 12 mm.; (spread of wings 28 mm.).

The queen (holotype M. C. Z. 15,281) was found in a nest of typical *B. bimaculatus* kept in an observation box and originally taken at Forest Hills. The two males (allotype and paratype) were taken July 23, 1924, hovering about a nest of *B. bimaculatus* situated in a stone wall at Forest Hills (O. E. Plath Coll.).

Bremus bimaculatus var. **arboreti**, var. nov.

Queen.— Head entirely covered with black pile; a few pale hairs on sides of occiput. Thorax with anterior third and hind margin of dorsum as well as scutellum covered with yellow pile, these two areas sharply separated by a broad, black, interalar band; pleura bearing yellow pile nearly to the base of the legs; sides of median segment and under side of thorax black. Abdomen with first tergite bearing only yellow pile; second tergite with a very few yellow hairs in the center, close to the anterior margin; the remaining tergites and all the sternites black. Legs with black pile only.

Length 13 mm.; length of fore wing 15 mm.; (spread of wings 35 mm.).

The queen (holotype M. C. Z. 15,282) was taken June 2, 1924, by the junior author, in the Arnold Arboretum, at Forest Hills, Mass. It was evidently looking for a nesting site; kept in an observation box with some workers of typical *B. bimaculatus*, it laid eggs, but died June 14.

The coloration of this specimen is so aberrant that we were in doubt for some time concerning its relationship. It possesses, however, all the structural characters of *B. bimaculatus* and we feel quite certain that it belongs to that species. It is readily distinguished from the typical form by the black occiput and the broad, black, interalar band. Franklin (1912, p. 306) only mentions that in *bimaculatus* the occiput sometimes has "a very strong admixture of black hairs," while on the dorsum of the thorax the black hairs of the disk are occasionally "slightly suggestive of a black interalar band."

Bremus vagans var. **coctus**, var. nov.

Queen.— Differs from typical *vagans* in the third, fourth, and fifth abdominal tergites being mostly pale russet, instead of black. There is a rather strong admixture of yellow hairs about the bases of the antennae, but this is often found in typical *vagans*.

Length 14 mm.; length of fore wing 14 mm.; (spread of wings 32.5 mm.).

Male.— Head, thorax, and legs as in typical *vagans*. Abdomen of allotype with first and second tergites entirely covered with yellow pile; third with black pile; fourth mostly black, with an admixture of russet hairs posteriorly; fifth and sixth entirely covered with bright russet hairs; seventh black; venter mostly clothed with yellow pile. In the paratype, the sixth and seventh tergites are entirely covered with russet; the fifth is mostly black, with a few russet hairs in the apical half; third and fourth entirely black.

Length of allotype 13 mm. and of paratype 11 mm.; length of fore wing 12 and 10 mm.; (spread of wings 28 and 24 mm.).

The holotype (M. C. Z. 15,283) is a queen from Lahaway, Ocean Co., New Jersey, May 30, 1916 (J. Bequaert Coll.). The allotype a male from Forest Hills, Massachusetts (O. E. Plath Coll.); the paratype male is from Flushing, Long Island, New York (G. Engelhardt Coll.).

Franklin mentions no variation of *B. vagans* in which the black pile is replaced by russet. Of the several color variants which he describes we have seen specimens of the following: —

Color Variant 1. Queen and worker with only the basal portion of the second tergite covered with yellow pile. Lahaway, Ocean Co., New Jersey, May 30, 1916, 1 ♀, on *Robinia pseudo-acacia* (J. Bequaert Coll.). Oakdale, Long Island, New York, June, 1919, 1 ♀ (E. L. Bell Coll.).

Color Variant 2. Queen and worker with the extreme side margins of third and fourth tergites bearing yellow hair and fifth tergite entirely yellow. Ramsey, New Jersey, 1 ♀, on *Pedicularis canadensis*, June 4, 1916 (J. Bequaert Coll.). The corresponding male appears to be Franklin's *Male Color Variant* 2, of which we have seen several specimens from Big Indian, Catskill Mountains, New York and Chittenden, Vermont (J. Bequaert Coll.).

Male Color Variant 1. Third tergite with strong admixture of yellow pile, though still distinctly darker than the second. Upper Ausable Lake and Keene Valley, Essex Co., New York; and Chittenden, Vermont (J. Bequaert Coll.).

B. vagans subsp. *sandersoni* Franklin. Queen with pile of finer texture and malar space not longer than its width at apex. Chittenden, Vermont, August 15, 1916 (J. Bequaert Coll.).

According to Franklin, in certain queens of western Ontario, Assiniboia, Alberta, and Montana, the disk of the mesonotum shows enough black hairs to form a somewhat indefinite dark interalar band. We have, however, seen a series of workers and one male of *vagans* from the Adirondacks, New York, in which the black interalar band is quite pronounced. These specimens were taken at Upper Ausable

Lake, July 30, 1920 (☿ ♂); Mt. Marcy, 5,300 ft., July 21, 1920 (☿); and Mt. Skylight, 4,900 ft., July 22, 1920 (☿), on *Vaccinium uliginosum*, *Solidago alpestris*, and *Oxycoccus oxycoccus* (J. Bequaert Coll.). Probably this color variant deserves to be named, but before doing so we shall await the discovery of the queen.

Bremus affinis var. **novae angliae** (J. Bequaert).

This color variant was described from Forest Hills and Sherborn, Massachusetts, and Brooklyn, New York (J. Bequaert, 1920, p. 6–8). Frison (1923, p. 324) has since recorded two males, from Virginia and North Carolina. We have also seen one male from N. Egremont, Massachusetts, September 18, 1922, and three males from Colebrook, Connecticut, September, 1918, August, 1919, and August, 1922 (W. M. Wheeler Coll.) in which the fourth tergite is mostly covered with rufous pile.

At Forest Hills the var. *novae angliae* is frequently seen, but it should be noted that *Bremus affinis* is one of the more common bumblebees of that locality. As we have now before us thirty-one males, twenty-two workers, and four queens, it is possible to describe this color variant more fully.

Queen (undescribed). Differs from the typical *affinis* queen in having the black pile of the fourth abdominal tergite almost entirely or to a large extent replaced by vinaceous rufous hairs. The pile of the second tergite is pure yellow as usual in the queen of *affinis*.

In the allotype and two paratypes the rufous pile covers nearly the whole width of the tergite, forming a conspicuous fascia between the black third and fifth tergites. In another paratype the sides of the fourth tergite are covered with black pile only.

These four queens of *novae angliae* were part of a lot of twenty young queens found in a nest of *affinis*, at Forest Hills, August 14, 1924. Two other queens showed a faint sprinkling of rufous hairs on the fourth tergite, while the remainder were without a trace of rufous pile, *i.e.* typical *affinis*. The nest also contained seven workers of the usual *affinis* pattern; the old queen was no longer present. On April 23, 1925, the junior author also observed a queen of *novae angliae* on willow in the Arnold Arboretum, at Forest Hills.

Worker.— In the majority of the specimens the rufous pile is, as in the queen, restricted to the fourth tergite, which it often covers almost entirely; in some specimens there is an admixture of black hairs in the basal half or on the sides. Rarely the fifth tergite also is partly rufous

and such specimens generally show an admixture of rufous pile along the hind margin of the third tergite. We have not yet seen workers which are as extensively rufous as some of the males.

Male.— The most common type is similar to that usually found in the queen and worker; the fourth tergite alone is almost entirely covered with rufous pile. Sometimes there is an even admixture of black hairs; more often the rufous pile forms a median, somewhat triangular patch. When the rufous is more extended, it invades the fifth tergite, more rarely the sixth also. We have seen no examples in which the seventh tergite is not covered with black pile. The third tergite also is almost always pure black; in but one specimen is there an abundant sprinkling of rufous hairs.

The junior author has recorded (Plath, 1922, p. 191) finding two nests of *B. affinis* containing workers of the typical form as well as of the var. *novae angliae*. Similar observations were made during the summer of 1923. One nest, taken July 7, contained the old queen (normal *affinis*), fifty-seven workers of typical *affinis* and twelve workers of var. *novae angliae*. A second nest (July 25) contained the old queen (normal *affinis*) and forty workers, several of which were of the var. *novae angliae*. A third nest (July 28) contained a normal old queen and forty-five workers, several of the var. *novae angliae*. A fourth nest (July 29) was queenless; the twenty workers were all normal *affinis*, but a number of the ten males were of the var. *novae angliae*.

As mentioned above, the description of the queen of var. *novae angliae* is based upon four specimens obtained with sixteen others from a single nest (August 14, 1924). One of these queens showing no trace of rufous pile on the abdomen, represents an extreme melanistic variation, which, we believe, has not yet been recorded. In this specimen the second tergite of the abdomen is almost wholly covered with black pile; along the basal margin only there is a narrow strip of yellow hairs.

Twenty-one nests of *B. affinis* were examined by the junior author at Forest Hills during the summers of 1921 to 1924 and seven of these contained specimens of the var. *novae angliae*. But not a single pure colony of that variety was ever observed.

In normally colored *B. affinis*, the differences between the queen and the worker are more marked than usual among bumblebees, so much so that Franklin was at first in doubt that they were conspecific. In the worker, as well as in the male, the dorsum of the thorax usually shows a strong admixture of black pile with the yellow, forming an indefinite or a rather distinct black interalar band; in addition, the

second abdominal tergite is extensively covered with brown ferruginous pile. In the queen, the dorsum of the thorax is almost wholly yellow, there being but a slight admixture of black hairs near the bare area of the disk; the second abdominal tergite is entirely clothed with pure yellow pile. Occasionally, however, one finds queens that present one or the other, or both these characteristics of the worker. We have before us two queens, collected this spring (1925) at Forest Hills, with a fairly distinct interalar black band and one of these also shows a faint indication of brownish pile near the base of the second tergite. Moreover, during 1924, the junior author observed in the same locality a number of queens which were colored like the worker.

Suggestions as to the Significance of Color Variation in Bumblebees.

Many species of the Bremidae are unusually variable in color and, since they are of large size and rather readily collected in extensive series, they have become great favorites with certain students of variation in Europe. The literature of this subject is already quite extensive and we do not intend to review it at present. As this aspect of the study of bumblebees has been rather neglected in this country, we wish, however, to present briefly some considerations suggested by a study of the local species.

A multitude of names has been proposed in recent years for the several color variants of Palaearctic Bremidae. Perhaps somewhat too rashly; for some European students do not appear to have heeded the rather wide range of fluctuating variation within the limits of the same color form. On the other hand, to merely regard all color variations of the species as unimportant "variants" of equal value, does not, in our opinion, do justice to the facts; neither does it stimulate further research. It is mainly for this reason that we have proposed varietal names for a number of color variants, not mentioned by Franklin, which seem to fall beyond the range of individual variation. It is important that the geographical distribution as well as the genetic relationship of such variants be properly studied. We feel, however, no inclination to pilfer other people's work, and we have therefore refrained from naming any of the "color variants" described by Franklin, although some of them should eventually receive recognition in nomenclature.

Franklin's main objection to giving his "color variants" of bumble-

bees any particular rank in nomenclature, is that "different gradations are often found together in the same nest." His conclusion, however, that in such cases the gradations are the offspring of the same queen, is not always warranted. It is by no means exceptional to find workers of two distinct species living in perfect harmony within the same nest. The junior author has recorded finding two nests of *Bremus affinis*, each containing a worker of *B. terricola* (Plath, 1922, p. 191), and in 1923 he observed two other similar cases. He has also shown (1923) that certain species of bumblebees rather readily adopt foreign workers or queens of the same or of different species, producing mixed colonies. In other cases, however, members of two closely related species may refuse to have anything to do with each other, even after they have been together for weeks, and although the members of one of these species have been reared by the other (Plath, 1924, p. 73). Moreover, queens which have started colonies are often killed by others of the same species which enter their nests, so that the members of one colony are not necessarily the offspring of one queen (Plath, 1924, p. 74). Incidentally it may be noted that such observations greatly impair the theoretical significance of Friese and F. v. Wagner's (1904, p. 563) distinction between "homonidal" and "heteronidal" color variants in bumblebees.

Color variation in insects is undoubtedly due to a variety of causes. Upon purely theoretical grounds, however, the various possibilities may be brought together into the following four groups: —

(1) *Individual differences due to fluctuating or continuous variation.* If a large number of individuals of a species be examined, all characters exhibit a certain amount of variation, although extreme aberrations from the average or majority are generally scarce. In certain characters the variation may be inconspicuous, while in others it is very pronounced. In bumblebees, the color of the pile is undoubtedly much less constant than the structural characters, and Franklin is quite right in relying mainly upon the latter in the determination of the species. Individual variants should not, we believe, be given a standing in nomenclature, although it is not always easy to recognize them as such.

(2) *Sports or mutations.* Discontinuous variation, in which a new character or group of characters suddenly appears and is inherited in its new form, has been observed in several groups of insects. Quite likely it is found in bumblebees as well, where its occurrence will, however, be rather difficult to prove experimentally. Mutations are of especial interest, since many naturalists believe that they are due to a modification of the germ plasm and consequently represent

incipient species. The relations between color variations of bumblebees and mutations have been discussed by Vogt (1911, p. 38–42).

(3) *Hybridism.* Upon finding forms that apparently connect two closely allied species, one is readily inclined to regard them as the result of crossing. Yet this explanation should be used with extreme caution, unless it is confirmed by experimental work. Franklin (1912, p. 237) remarks with regard to the Bremidae: "On account of the difficulties met in arranging the species, some have been led to think that hybrids are common. The writer has never yet seen a single specimen of this family which, in his opinion, was a hybrid." Franklin's extensive experience with North American bumblebees certainly permits him to speak with authority. W. Wagner (1906, p. 3–4), however, believes that hybridism is responsible for much of the polymorphism in bumblebees.

In a former paper the junior author suggested that *Bremus affinis* var. *novae angliae* might be a hybrid between *B. affinis* and *B. terricola* (Plath, 1922, p. 191), but he no longer adheres to that view.

It is quite possible that hybridism may account for some at least of the intergrades which connect what appear to be distinct color entities of the same species. It may, for instance, explain the occasional occurrence of individuals seemingly intermediate between *Psithyrus laboriosus* and its var. *citrinus.* If Mendelian segregation prevails among bumblebees, crossing might also elucidate the occurrence of two different color types in certain nests, as in the case of the mixed colonies of *Bremus affinis* and its var. *novae angliae.* Here again the chief difficulty will be to acquire absolute certainty that all the inmates of a given colony are the offspring of the same queen.

(4) *Somatic variation under the influence of the environment (climatic factors, food, parasites, etc.).* The far-reaching effect of changes in the environment upon the external characters of animals and plants is now generally recognized. In bumblebees it is, for instance, suggested by their climatic variation. Franklin (1912, p. 200–202) has some interesting remarks upon this subject. He points out that species of Bremus with a comparatively level habitat of wide extent are not usually very variable, whereas greatly variable species are only found in greatly diversified regions. "No North American species which has the greater part of its range east of the Pacific Highland is very variable, while several of those, the habitats of which are in Alaska, western Canada and the Pacific States of the United States, show astonishing variation in the coloration of their pile. * * * In South America, the most variable species have the greater part of their habitat in the highland of the Andes."

Franklin's remarks upon the geographic distribution of the several color types in Bremus so directly bear upon our discussion of rufous variants in certain New England species, that we quote them in full: "In the coloration of the pile, those colors which may, in general, be classed as ferruginous, rufous and white are, as a rule, brought out by high altitudes and also by Arctic or sub-Arctic latitudes, only traces, at most, as a rule of these colors being found on strictly lowland forms either in tropical or temperate climates. High altitudes appear to have a much stronger influence in bringing out these colors than do high latitudes, as among the New World species, these colors attain their maximum among the Cordilleras of the Andes in Ecuador and Peru where bumble-bees reach the highest elevations. Traces of ferruginous or rufous pile on lowland temperate or tropical species (*e.g.* — *affinis,* second dorsal segment of worker and male abdomen; *fraternus,* apex of male abdomen; *separatus,* second dorsal abdominal segment of all sexes) may, perhaps, be taken to indicate a mountain inhabiting ancestry." * * * "Yellow is more or less strongly suppressed in the coloration of the pile of tropical species of the genus *Bombus.* This suppression is marked in both lowland and highland forms, and is so strong that this color is entirely wanting in a large percentage of the species in the tropics of the New World. In the lowlands this has resulted in some cases in the production of entirely black species (*kohli, niger, atratus, brevivillus, solus*). In the mountain regions black is less prevalent, for the rufous or the white pile on the mountain forms replaces the suppressed yellow more or less."

An instructive example of modification of color of the pile in bumblebees through changes in external conditions, has been reported by Hoffer (1905). On August 10, 1890, a large nest of *Bremus agrorum* was found on sandy soil in the shade of a house; it contained 150 bumblebees, among them the old queen and two males, also many pupae, but no adult young queens. It was placed in a flower-pot on a substratum of loose earth and kept on a window-sill facing the south. As the sun was particularly hot on that window, Hoffer almost every day poured water in the flower-pot. The first individuals which hatched in captivity showed the normal coloration, with much black on thorax and abdomen. Most of those that developed after August 19, were magnificent examples of the yellow variety known as *floralis;* so that when later the older inmates had either died or left the nest, the colony consisted of the var. *floralis* only. Hoffer concludes that the high diurnal temperature, combined with light and humidity, produced the yellow coloration. He also states that, in later yea

he changed the pale var. *floralis* into typical *agrorum* and even into the dark varieties *mniorum* and *tricuspis*, by removing the sunlight and lowering the temperature.

The foregoing considerations may throw some light upon the occasional occurrence of rufous color variants in some of the North American species of Bremus. We know at present four species of bumblebees, viz. *Bremus separatus*, *B. bimaculatus*, *B. vagans*, and *B. affinis*, which in the vicinity of Boston show a marked tendency to produce a rufous modification of the black pile. We have evidently to do with a case of convergence or parallel variation, of which many beautiful illustrations are found among the Bremidae. In certain regions, such as the island of Corsica and the Caucasus Mountains, there is an unusually strong tendency to produce homomorphism in bumblebees (see Friese and F. v. Wagner, 1904, p. 564 and 568, and 1910, p. 74–79. Vogt, 1909, p. 47–54, and 1911, p. 65–69).

The four species of New England bumblebees under discussion are not genetically related; in fact they belong to three quite distinct morphological groups within the genus Bremus. It is not likely therefore that their rufous color variants are due to some common modification of the germ plasm, merely inherited through crossing. We are inclined to explain their appearance in the same locality through the action of certain environmental factors upon the development of pigment in the pile. In this connection it may be mentioned that Friese and Wagner (1910, p. 16–17 and p. 71–73) regard rufous as an intermediate coloration in the ontogenetic development of the black vestiture among bumblebees. When the young bumblebee freshly hatches from the pupa it is uniformly covered with whitish or grayish white pile; they claim that this first turns reddish yellow, later red, and finally black, reddish or rufous being a necessary step in the production of black pile. On the other hand, the yellow color, they state, develops quite independently from the original grayish white pile and does not belong in the development series white-red-black.

It is noteworthy that in *B. affinis* var. *novae angliae* and the other rufous color variants under discussion, the rufous coloration merely replaces the black, so that, if Friese and Wagner are correct, there might be some justification in regarding them as cases of arrested development. Yet the case is not quite so simple, for a study of a large number of individuals in the var. *novae angliae* shows that the rufous modification begins on the fourth tergite, at first as a mixture of rufous pile among the usual black hairs; it eventually spreads over the whole of this tergite, in some individuals invades the fifth, and

even occasionally the sixth tergite; but the third tergite either remains entirely black or shows only a slight admixture of rufous hairs along the hind margin.

Although we regard these rufous color variants as most likely due to the operation of external influences, it is nevertheless difficult to imagine how they might be adaptive or advantageous modifications. It is still more difficult to conceive how they might become the starting point of a selective process. Vogt (1909, p. 55–58) has alluded to some of the difficulties that beset any attempt at explaining color variation in bumblebees on the basis of the theory of natural selection.

The Bumblebee Fauna of Connecticut

For several years Prof. W. M. Wheeler has made a rather close study of the bumblebee fauna near his summer home at Colebrook, Connecticut. It seems worth while to list the species which he has observed in that locality.

1. *Bremus terricola* (Kirby). Common.
2. " *affinis* (Resson). Common.
3. " " var. *novae angliae* (J. Bequaert). Rare.
4. " *borealis* (Kirby). Very rare.
5. " *bimaculatus* (Cresson). Common.
6. " *impatiens* (Cresson). Common.
7. " *ternarius* (Say). Fairly common.
8. " *perplexus* (Cresson). Common.
9. " *vagans* (Smith). Common.
10. " *fervidus* (Fabricius). Moderately common.
11. " *americanorum* (Fabricius) (= *pennsylvanicus auct.*). Not common.
12. " *separatus* (Cresson). Moderately common.
13. *Psithyrus laboriosus* (Fabricius). Common.
14. " " var. *citrinus* (Smith). Common.
15. " *ashtoni* (Cresson). Common.
16. " *fernaldae* Franklin (=*tricolor* Franklin). Not rare.

The most interesting of these species is *B. borealis*, of which a single queen was obtained July 22, 1921. This is the first record for Connecticut and the southernmost locality known for the species. Viereck (1916, p. 759) also has one Connecticut record of *B. auricomus* (Robertson), a rather southern species, probably restricted to the coastal area of the state. Possibly *Bremus fraternus* (Smith) and *Psithyrus variabilis* (Cresson) may yet be discovered there. Viereck still lists *B.*

vagans var. *consimilis* Cresson as a form distinct from *B. vagans,* although Franklin has shown their identity. Upon referring to the original description of *consimilis* (Cresson, 1864, p. 41), one finds that it is "colored same as *vagans* Smith, but is much smaller and more robust in proportion to the size." According to Viereck's key (1916, p. 755) the vertex bears black pubescence only in the queen and worker of typical *vagans,* whereas it has yellow hairs in the var. *consimilis.* The color of the pile of the vertex is somewhat variable in this species; but we have not yet seen specimens in which it is entirely black. We are unable to separate our material of *vagans* into two races based upon the color of the pile of the vertex.

One species should be added to the list of the bumblebees of the vicinity of Boston previously published (J. Bequaert, 1920). The junior author has recorded a number of captures of *Bremus borealis* at Forest Hills (Plath, 1922*b*, p. 193–194 and 1923, p. 331–332), where Prof. W. M. Wheeler has also taken a queen July 31, 1911. We may note that *B. ternarius* has been taken during several successive years at Forest Hills.

The rarest of New England bumblebees appears to be *Bremus rufocinctus* (Cresson), which was of especial interest to us, because it rather frequently exhibits rufous variations somewhat similar to those described in the present paper for other species of Bremus. So far as we know there is only one definite record from New England in the literature. It concerns the nest taken by Putnam, about 1863, at Bridport, Vermont, specimens of which were recognized by Franklin (1912, p. 444) as belonging to *rufocinctus.* We have now before us one worker taken at Chittenden, Vermont, August, 1916 (J. Bequaert Coll.), which agrees quite well with the description of *rufocinctus.*

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