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Bionomics and Nest Structure of *Pogonomyrmex occidentalis* (Hymenoptera: Formicidae)[1]

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ABSTRACT

Twenty colonies of *Pogonomyrmex occidentalis* (Cresson) were excavated at Casper, Wyoming to determine the total number of ants occurring in colonies during the winter and to ascertain the location of the queen. An additional 13 colonies were excavated at Casper at the rate of 1 colony per month over an entire year to observe the effect of soil temperatures on the activities of this ant. The structure of each colony was mapped, and the location of seed chambers and amount of seed stored were determined. Inquilines associated with *P. occidentalis* were the cetoniids *Cremastocheilus knochi* LeConte, *C. saucia* LeConte, and the tenebrionid *Araeoschizus armatus* Horn. The 2 last-mentioned species were collected from chambers containing the overwintering worker ants.

Many papers have been written about the western harvester ant, *Pogonomyrmex occidentalis* (Cresson); however, most of these papers have dealt with control. As a result of Cole's 1966 revision of the *P. occidentalis* complex, it should be noted, for the sake of studies that will be carried out in the future, that some of the earlier papers referring to biological activities of *P. occidentalis* really deal with *P. owyheei* Cole. The following papers must refer to *P. owyheei,* judged from the presently known distribution of that species, i.e., northwestern Wyoming, Washington, Oregon, Idaho, Montana, and northern Utah (Cole 1932a (in part), b, c (in part), 1933, 1934). Consequently, with the exception of the papers by McCook (1882, 1883), Dean (1903–04), Headlee and Dean (1908), Lavigne and Fisser (1966), and Race (1966), there appears to be a dearth of ecological and biological information on *P. occidentalis.*

MATERIALS AND METHODS

In this study, western harvester ant colonies were excavated by 2 different methods. Colonies collected at Casper, Wyo. elevation 5123 ft in March and/or April of 1966 and 1967, were excavated with the aid of a backhoe. Since I had previously determined that these ants tunnel more or less directly downward beneath the mound proper, except in rare instances, the backhoe was positioned in such a way that a straight-edged hole, 7–8 ft deep, at the edge of the mound was scooped out (Fig. 1). Straight-edged shovels were used to slice downward revealing chambers and tunnels. Trowels and forceps were then utilized to follow the tunnels.

I excavated the other group of colonies with a pick and shovel, 1 colony being dug each month of the year. These colonies were situated on Dry Cheyenne Creek, elevation 5500 ft, 23 miles E of Riverton, Wyo. In all cases, the ants had constructed their mounds within 5 ft of the edge of the deeply eroded creek bed. Since the depth of this intermittent stream bed was 6–8 ft it was possible to dig laterally into the bank until the tunnel system was reached.

The characteristic soil type in both areas was loamy sand. At the Dry Cheyenne Creek site, the soil consisted of 80% sand, 4% clay, and 16% silt, while at the Casper site it consisted of 80% sand, 10% clay, and 10% silt.

The nest structure was mapped and the depth of each chamber was recorded. At the Dry Cheyenne Creek site, chambers were measured and the numbers of workers, larvae, pupae, inquilines, and seeds in each were noted. Where the queen was found, the depth at which she was situated and the number of workers surrounding her were recorded. Soil temperatures were taken at intervals from a depth of 4 in. to that of the deepest chamber. The temperatures were obtained at the time the colony was excavated by inserting a thermometer 6 in. into the soil and reading it ½ hr later. During winter months the depth at which the 1st worker ants were found was also noted.

The surface area of the mound as presented in Tables 1 and 2 was derived from the formula for the surface area of a cone [$A = \pi r \sqrt{(r^2 + h^2)}$]. While the figures obtained were not exact they provide an approximation which can be used to show the relationship between numbers of workers and size of mound.

RESULTS AND DISCUSSION

Structure of Nest.—The internal structure of the nest depended upon the number of workers and the age of the colony. While the mound proper and 1st 12–18 in. of soil below the surface were honeycombed with chambers, the remaining chambers arose from 1 or more main tunnels. A young colony (less than 700 workers) (Fig. 2, 3) had a single tunnel descend-

[1] Published with approval of the Director, Wyoming Agricultural Experiment Station as Journal Paper no. 357. Accepted for publication Dec. 17, 1968.

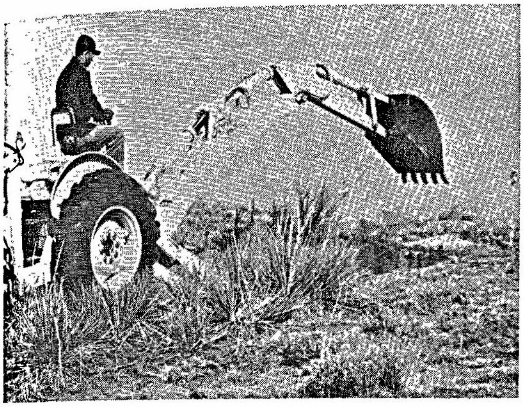

FIG. 1.—Use of a backhoe to excavate to the edge of a *P. occidentalis* colony prior to examining it.

ing directly below the entrance to a depth of 50–74 in. (Tables 1, 2). As a colony increased in size more tunnels were added. These tunnels were initiated in chambers in the top 12 in. or arose from the opposite end of large chambers at a greater depth. An old colony had as many as 5 main tunnels each with additional short branches (Fig. 3).

FIG. 2.—Excavated colony of *P. occidentalis* showing the tunnel system of a fairly young colony.

The greatest depth at which overwintering ants were situated was 109 in. (Table 2). It is probable that the original tunnel was extended as a colony grew older even though other tunnels were constructed. The depth which the ants attained was apparently limited by the presence of a coarse gravel horizon, since the tunnels ended where the ants penetrated this horizon. The bottom chambers that were excavated were on many occasions in a layer of gravel which crumbled when touched.

Distances between chambers varied considerably. Those chambers in the mound and in the 1st 12 in. of soil tended to be close together, ½–2 in. separating them. Below the 1st foot of soil the chambers were separated by as little as ½ in. and as much as 13 in. The average distance between chambers below the 12-in. level for 15 colonies was 3.27 in.

The workers tended to construct chambers alternately on opposite sides of the tunnel as it was extended downward (Fig. 3). However, occasionally one chamber might be directly above another on the same side, separated by from 1 to 11 in. of soil.

Chambers were roughly oval and varied in size from ½×½ to 5×4½ in. These dimensions are in agreement with those recorded by McCook (1882) and Bohart and Knowlton (1953). Some chambers were constricted near the center giving a bilobed appearance. The larger chambers were found within the mound, immediately below the mound, and again toward the bottom of the nest. The large top chambers were used as "nurseries," and those deep within the nest as overwintering chambers (Fig. 4) for large numbers of workers. The number of workers jammed into these large lower chambers usually exceeded 1000 and may have exceeded 2000 ants in an old colony.

There was no average number of workers per colony, a possibility suggested by Chew (1960), since the size of the mound is not a reliable index. The actual number of worker ants found in the 33 excavated colonies varied from 412 to 8796 (Tables 1, 2). Colonies containing 8796, 7761, 7551, and 6593 workers were obtained from mounds having surfaces of 645, 953, 544, and 909 in.^{2}, respectively. Based upon a comparison of mound surface in square inches and the number of worker ants in a given colony, there appeared to be no direct relation between the amount of soil piled on the mound and the number of workers available to pile it (Tables 1, 2). Neither did there appear to be a direct ratio between the number of chambers below the 12-in. depth and the number of workers present in the colony (Table 1). However, these data could be expected, since small colonies are known to move from their own small quarters into larger abandoned quarters (Lavigne 1966). The ants, moving in both directions between mounds, formed a wide trail that was readily observed.

Number and Position of Entrances.—Photographs taken at monthly intervals in the summer of 1965 of 5 mounds at Dry Cheyenne Creek had shown a displacement by 3–5 in. of the main entrance from its first observed position. Consequently, from Apr. 1 to Sept. 30, 1967, 25 colonies were inspected biweekly

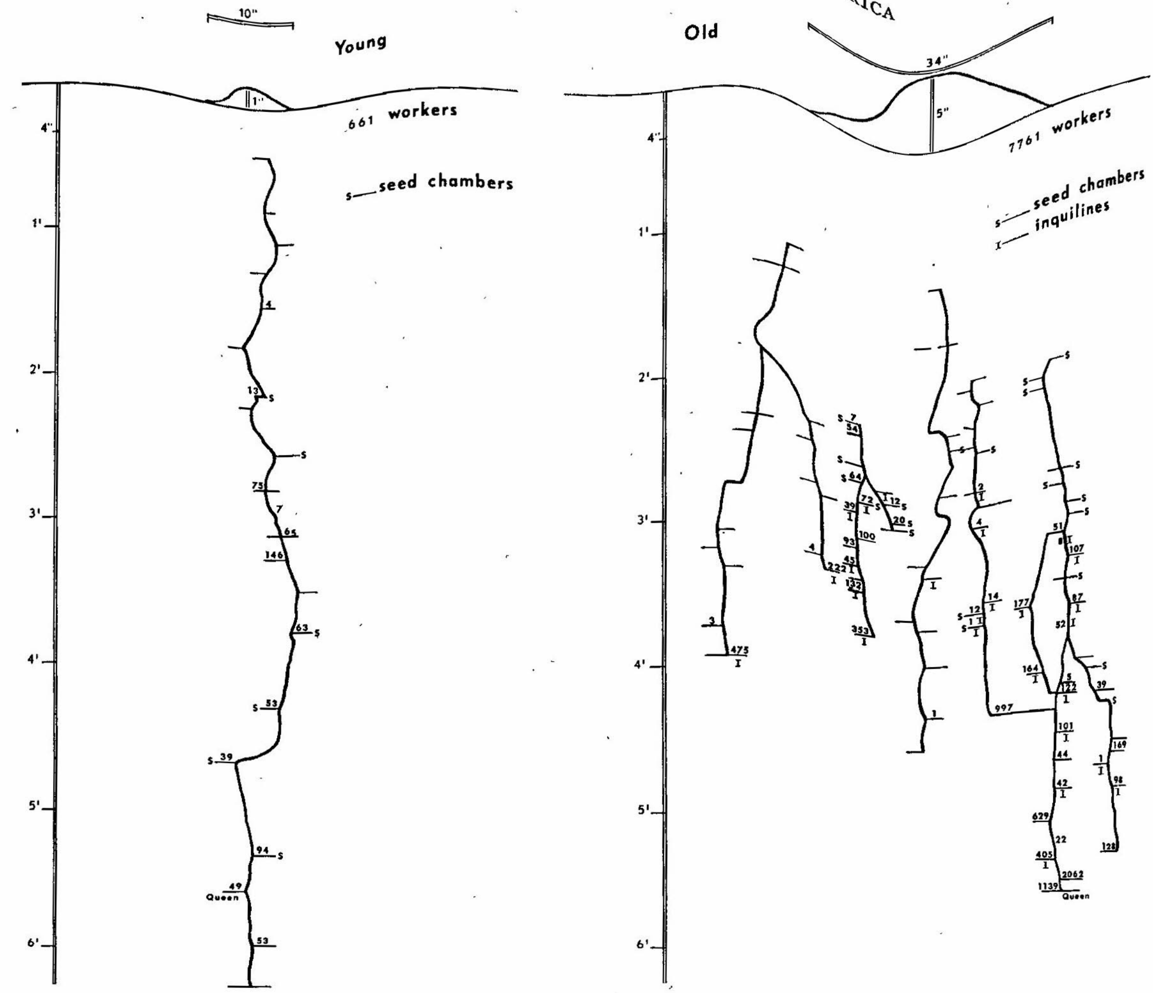

FIG. 3.—Diagrammatic representation of a young and an old colony of *P. occidentalis* showing tunnels and location of inquilines, seed chambers, workers, and queen during the winter. The actual number of workers in individual chambers is represented by the numerals.

in Wheatland Canyon, ca. 30 miles NW of Laramie, for change in number and position of entrances. With the exception of 1 colony, the ants of all colonies inspected utilized an entrance other than the main one at some time during the season. Mounds tended to have more entrances early in the summer; the number of entrances per colony varied from 1 to 8 with an average of 3/colony on June 10, and all colonies had only 1 entrance on Sept 16. In addition, the position of the entrances changed continually during the season with an average displacement of 3.79 in. for the main entrance.

Foraging.—Stevens (1965[2]) studied the foraging behavior of *P. occidentalis* at Dwyer, Wyo., elevation 4500 ft. He found that the forage taken over the entire season as collected from foragers returning to the nest averaged 42.0% forb seed, 46.7% grass seed, and 11.3% insect parts and grasshopper fecal pellets. In addition: "Nearly all of the forage collected early in the season consisted of seeds that were old and weathered. These were apparently seeds that had been overlooked during the previous season's foraging. The remainder of the early season forage was composed of dead insects or various parts of insects such as legs and abdomens. No new seeds were brought to the mound before the middle part of June.

"Weekly activity checks indicated that spring activity is, for the most part, confined to repairing the mound, cleaning out the nest, removing dead ants and useless seeds, and clearing rubbish and new vegetation from the surrounding disc. Although isolated instances of foraging behavior were observed as early as May 13, they presumably resulted from ants coming upon a dead insect or other suitable forage in their search for materials with which to rebuild the nest.

"The first indication of foraging activity was observed during the first week in June. At that time approximately one half of the active worker ants were engaged in foraging activity. Consistent foraging activity was not observed until the second week in June at which time most of the active workers were engaged in foraging with only a few still performing

[2] L. J. Stevens. 1965. The food preference and foraging habits of the western harvester ant, *Pogonomyrmex occidentalis* (Cresson). M.S. thesis, University of Wyoming, Laramie. 67 p.

Table 1.—Data from excavation of 20 colonies of *P. occidentalis* at Casper, Wyo. 1966–67.

Mound	Date excavated	Mound: Height (in.)	Mound: Diam (in.)	Mound: Surface area (in.^{2})	No. worker ants/colony	Depth queen located (in.)	No. ants in "queen chamber"	Depth final chamber (in.)	No. chambers below 12 in.
1	Mar. 16, 1966	10½	44	1684	7506	25	38	71	64
2	Apr. 6–8	4	33	879	1017	34	53	70	31
3	"	8	25	582	2357	69	254	77	18
4	"	3	33	868	412	50	139	50	9
5	"	3	16	214	254	10½	10	62	9
6	"	6½	39	1258	1605	23	151	57	18
7	"	2½	10	87	1022	38	tunnel	57	35
8	"	3½	18	272	1397	18	27	87	26
9	Mar. 23–26, 1967	4	14	177	1822	68	141	85	29
10	"	4	20	339	1439	56	482	82	30
11	"	...	..	...	2686	74	71	79	28
12	"	5	22	417	2647	66	135	82	64
13	"	4	15	200	1548	55	216	81	33
14	"	4	19	307	1172	56	36	73	39
15	"	1	10	80	661	68	49	77	17
16	"	4	18	278	1169	69	81	84	54
17	"	4	15	200	1568	70	192	77	23
18	"	3	18	268	1394	45	259	89	45
19	"	4½	21	376	1442	69	78	78½	38
20	"	5	19	319	2055	68	120	80	38

repairs on the mound and nest. Mound repair and maintenance continues throughout the season but is done by only a small portion of the total number of worker ants." Forgaging continues until mid- or late October depending on the weather.

Stevens' study showed that, on the average, the colony became active when the temperature on the mound face reached 24.5°C and the temperature in the center of the mound was 21.1°C. At 26.7°C on the mound surface, workers would be active, but extensive foraging did not begin until the ground temperature was ca. 29.4°C. When the soil temperature reached ca. 47.3°C, foraging ceased until the soil recooled. The ants retired into the mound in the evening when the soil temperature dropped to 25.0°C.

Stevens further stated: "During the midday cessation of activity the ants are probably employed in working on the interior of the nest because as soon as the temperature is low enough for the ants to start work again, many of the emerging ants carry seed husks or small bits of soil out with them. Also during the daily period of inactivity the ants employ what the author has termed 'temperature checkers.' These are ants that remain just inside the mound entry but repeatedly leave the mound and move rapidly in a circle about two and one-half inches in diameter around the entry before retiring. This type of activity is continued every 30 seconds to one minute during the inactive period. As soon as the temperature on the surface of the mound is cool enough, the 'checkers' do not return to the nest and shortly thereafter the worker force emerges and begins its normal activity."

Seed Storage. — With the exception of seeds brought into the nest late in the season, the seeds were husked for later consumption. The only unhusked seeds found were those of *Oryzopsis hymenoides* in chambers of a colony examined in November 1967.

Table 2.—Data from excavation of *P. occidentalis* colony per month from November 1966 to November 1967.

Date excavated	Mound: Height (in.)	Mound: Diam (in.)	Mound: Surface area (in.^{2})	No. per colony of: Worker ants	Larvae	Worker pupae	Winged reproductive pupae	Winged reproductive adults	Est. no. seeds stored/colony	Wt. of seeds (g)	No. inquilines: *A. armatus*/colony	Depth final chamber (in.)
Nov. 16–18, 1966	4	24	476	2625					9,097	4.6	84	69
Dec. 15–21	9	26	645	8796					7,529	4.4	75	90
Jan. 13–18, 1967	4	19	307	4447					104	...	180	109
Feb. 14–16	5½	34	953	7761					46,263	22.8	188	67
Mar. 13–16	5	26	568	4146					...	...	105	79
Apr. 14–17	3	14	167	5321					20,445	10	46	95
May 12–14	3	12	126	691					0	0	5	74
June 14–16	6	25	544	7551	309				67,116	33	11	79
July 18–20	4	16	224	5181	614	397	942	980	345,401	54.3	99	64½
Aug. 15–17	10	37	1221	5698	1763	1460	41	91	447,014	66.9	8	71
Sept. 17–19	4	24	476	2419	459	556			26,715	3	37	65
Oct. 16–18	9	36	1137	3379	192	4			162,365	25.9	22	61½
Nov. 15–18	6	33	909	6593					117,926	44.2	130	63

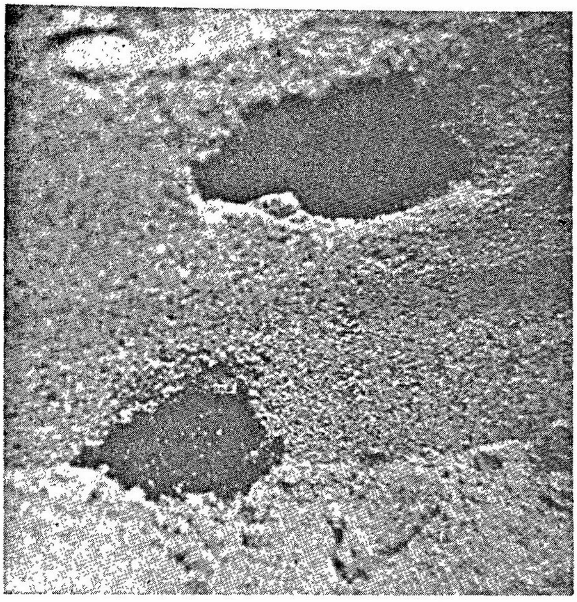

FIG. 4.—Overwintering chamber of *P. occidentalis* workers showing the congestion of the ants within the chamber.

Upon examination the seeds within these husks were found to be immature. One of 2 things might happen to husks; they were either carried out of the nest and deposited on the back side of the mound or they were placed in "trash" chambers. Each colony had a few trash chambers situated at or close to the surface of the ground and within the mound. Occasionally one was found as deep as 17 in. These chambers contained pebbles, seed husks, and insect parts. During the summer months, inquilines, *Araeoschizus armatus* Horn, were almost always found in these chambers. In trash chambers the following were found: chewed up seed husks of *Chenopodium* sp., lambsquarter; *Capsella bursa-pastoris,* shepherd's purse; *Bouteloua gracilis,* blue gamma grass; *Aster* sp.; *Delphinium* sp., field larkspur; and *Stipa* sp., needle grass; plus pebbles. I suspect that these trash chambers were utilized during periods of inclement weather when ants were "unable" or "unwilling" to carry trash to the outside area.

Once the seeds were husked they were stored in chambers situated throughout the nest. Fig. 5 presents the distribution of these "granaries" for 7 mounds. The numbers of these chambers in which seeds were stored, for 7 colonies, are: Nov. 1966, 32; Dec. 1966, 13; Feb. 1967, 64; Apr. 1967, 27; June 1967, 39; Oct. 1967, 53; and Nov. 1967, 54. There appeared to be little relationship between the number of chambers used and the amount of seed stored (Table 2). Because of constant consumption of food by ants during the summer, seed in some chambers was probably completely removed and one could not expect any correlation.

For the same reason it was almost impossible to ascertain the amount of food collected by the ants. Obviously a large amount of food must be consumed while most of the foraging was taking place, since the worker ants must have a constant supply of energy to keep them functioning. In addition, the period when the most seed was collected (Table 2) was also the time when the immatures were being produced; these stages also required large amounts of food. Larvae were found in chambers containing seed twice as often as in chambers without seed.

Rarely was just 1 kind of seed found in a given chamber unless only 1 kind was available to the worker ants. The more kinds of seeds gathered by the workers, the more kinds of seeds found in an individual chamber. For example, in a colony examined in November 1967, a chamber 11 in. below the soil surface contained: 5 *Picradeniopsis oppositifolia,* 553 unhusked *O. hymenoides,* 139 *Chenopodium* sp., 28 *Lepidium densiflorum,* 2300 *C. bursa-pastoris,* and 25 *Stipa comata* (*caryopsis*). However, in this colony most of the *Picradeniopsis* seed was stored separately, probably because it was collected at a different time of the season. The variety of seed stored was undoubtedly dependent upon the accessibility of plants, the size of the working force, and the amount of seed available, since these ants rarely foraged farther than 100 ft from the nest (Table 4).

Headlee and Dean (1908) reported that the seeds of lambsquarter, *Chenopodium album* were "found abundantly in nearly all nests examined" in western Kansas. Interestingly, all colonies examined at Dry Cheyenne Creek contained seeds of lambsquarter, some colonies containing these seeds almost exclusively (Table 4). Based on the numbers of seed husks and numbers of seed collected by the ants at this location, shepherd's purse was another of the more available seeds present (Table 4). Cole (1932c), working with *P. occidentalis* in Tooele Valley, Utah, noted that in the sagebrush association, colonies of these ants contained "large quantities of *Lepidium* seeds." When the kinds of seed stored are compared with seed husks found in the trash chambers, it is evident that more kinds of seed are collected than are stored.

Of interest is the number of seeds produced by individual range weed plants according to Bohmont (1953): *Chenopodium* sp., 72,000/plant; *C. bursa-pastoris,* 38,500/plant; and *L. densiflorum,* annual peppergrass, 6000/plant. Not very many plants are needed to account for all the seed stored by the ants (Tables 2, 4).

Seed was not stored within the mounds during the winter months. The depth at which the 1st "granaries" were situated was from 1 to 6 in. below the soil surface.

Queen Activity.—In the 27 excavated colonies where a queen was situated, only 1 queen was found to be associated with each colony. In April the queen apparently began her ascent from the overwintering chamber. A queen was collected in the tunnel at 41 in. in mid-April. By mid-May in many colonies queens could be found within the mound proper, especially near the entrances. The queens were easily captured if the mound was spread out in a semicircle

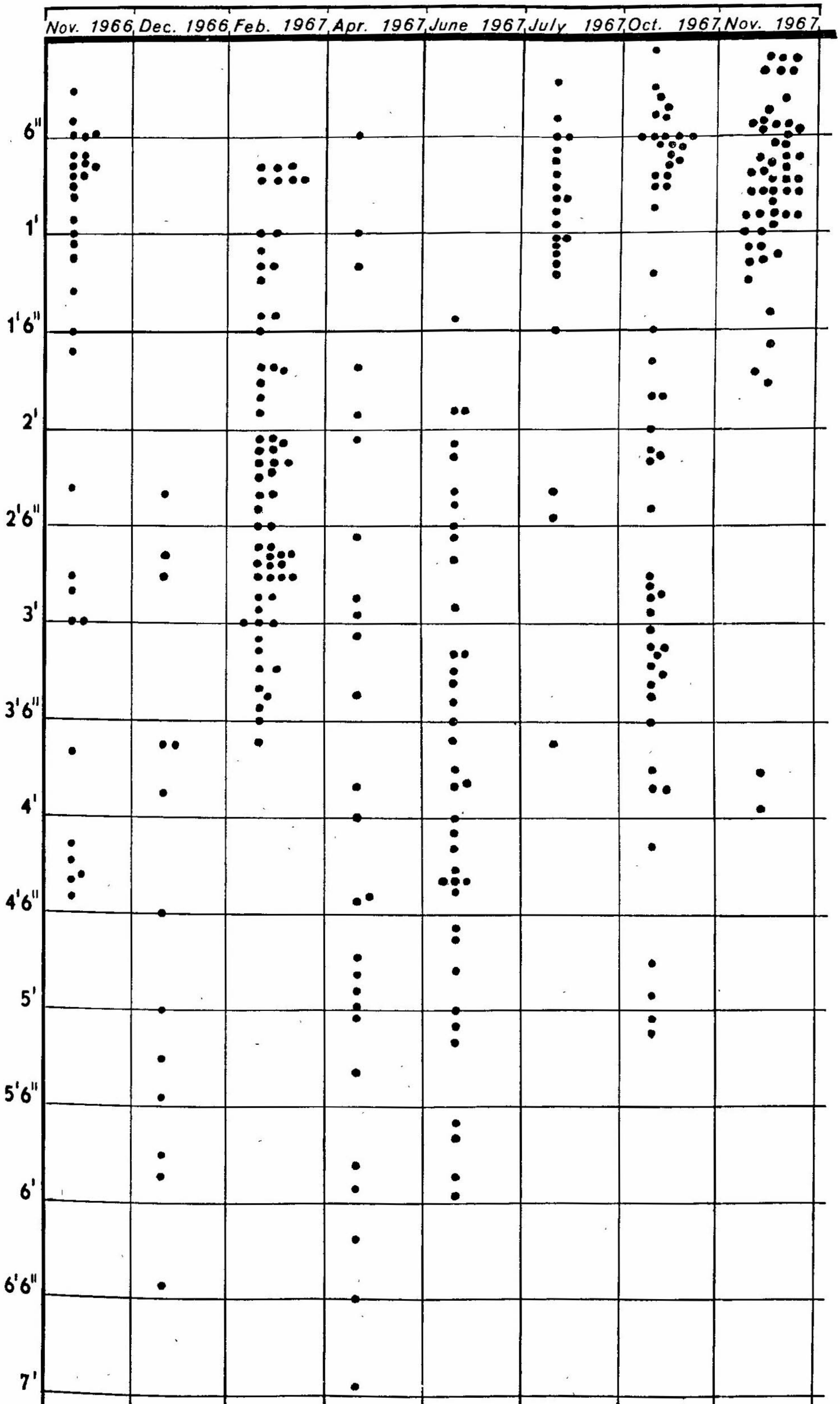

FIG. 5.—Distribution of seed storage chambers in nests of *P. occidentalis* at the Dry Cheyenne Creek area, E. of Riverton, Wyo.

Table 3.—Depth in the soil of worker *P. occidentalis* ants and queen in relation to soil temperature.

Date excavated	Depth ants first located (in.)	Depth queen located (in.)	No. workers in "queen chamber"	Temperature (°C) at indicated depths (in.) 4	12	24	36	48	60	72	84
Nov. 16–18, 1966	27			0.56	2.22	3.33	5.56	6.67	7.78	8.33	
Dec. 15–21	28	70	254	.56	1.11	2.22	2.78	3.89	5.56	6.67	8.33
Jan. 13–18, 1967	25			−2.22	−1.11	0	1.11	2.22	2.22	2.22	2.78
Feb. 14–16	25	67	1139	1.11	0.56	0.56	1.11	1.67	2.22		
Mar. 13–16	33	61	960	0	0	0	0	0	0	0	
Apr. 14–17	at surface	41[a]	18	10.6	7.78	7.78	7.78	7.22	7.22	6.67	6.11
May 12–14	"			8.33	5.56	5.56	6.11	6.11	6.67	6.67	
June 14–16	"			13.9	16.7	16.1	16.1	15.0	15.0	14.4	14.4
July 18–20	"			28.9	26.7	26.1	26.1	25.0	24.4	24.4	23.3
Aug. 15–17	"	[b]		33.3	27.2	25.0	25.0	24.4	22.8	21.1	19.4
Sept. 17–19	"			13.9	15.6	16.7	17.8	17.8	17.8	18.9	
Oct. 16–18	"	61½	1203	11.1	8.89	8.89	8.89	8.89	7.78	7.78	6.11
Nov. 15–18	5	60	841	1.67	3.89	4.44	5.00	5.56	5.56		

[a] In tunnel in mound.
[b] In tunnel, depth not determined.

on the cleared disc area. Spring is the only time of year when queens can be collected in this fashion.

The queen probably began egg laying at Dry Cheyenne Creek in May, because eggs were not observed in a colony opened in mid-April. Workers carrying clumps of eggs were captured in mid-May in the aforementioned fashion for queen capture. Queens continued to deposit eggs until late September. They circulated throughout the nest during the summer months and were difficult to locate. During this season queens are probably crushed during the digging, explaining why they are not found.

By mid-October queens had retreated to an overwintering chamber. In only 3 instances was the bottom chamber chosen. The depth of chambers containing queens at Dry Cheyenne Creek varied from 41 to 70 in. (Table 3) and at Casper, from 10.5 to 70 in. (Table 1). The number of workers joining the queen in a chamber was equally variable: from 254 to 1203 at Dry Cheyenne Creek and from 10 to 482 at the Casper site (Tables 1, 3). The number of workers with the queen did not reflect the population of the colony since in December 1967 a colony with 8796 workers had only 254 ants joining the queen, while in October 1967 a colony with 3379 workers had 1203 ants jammed in with the queen.

Immature Stages and Winged Reproductives.—Eggs of *P. occidentalis* were first observed being carried by workers following destruction of 25 mounds in mid-May at Dry Cheyenne Creek. Eggs found in chambers as well as those carried by workers were in clumps containing 8–25 eggs. Eggs have been collected from colonies excavated as early as mid-May and as late as mid-September. The eggs were pearly white and roughly oval. Measurements of 143 eggs showed an average width of 0.36 mm and an average length of 0.57 mm. The smallest eggs were 0.2×0.4 mm and the largest, 0.5×0.9 mm. One newly mated queen, captured while attempting to construct a burrow, was brought into the laboratory and placed in a gallon jar containing compacted sand. She constructed a burrow and deposited ca. 80 eggs in the chamber before she died (Fig. 6).

Larvae were first collected at Dry Cheyenne Creek from a colony excavated in mid-June. The larvae were found in chambers at all levels including the

Table 4.—Kinds and numbers of seeds stored by *P. occidentalis* workers.

Kinds of seed	No. seeds at indicated date of mound excavation 1966 Nov.	1966 Dec.	1967 Feb.	Apr.	June	July	Aug.	Sept.	Oct.	Nov.
Chenopodium sp.	9095	7494	46,161	20,445	67,091	1,671	14,895	557	2,475	2,236
Legume (unknown)	2	37	5						8	
Capsella bursa-pastoris						342,059	427,983	19,561	151,612	89,191
Lepidium densiflorum						1,671	1,986			1,714
Stipa comata (caryopsis)										846
Oryzopsis hymenoides										10,393
Atriplex sp.										971
Carex sp.									4,053	
Salsola pestifer					25				4,225	
Camelina microcarpa										
Picradeniopsis oppositifolia							1			
Unidentified or misc.			100							8,370

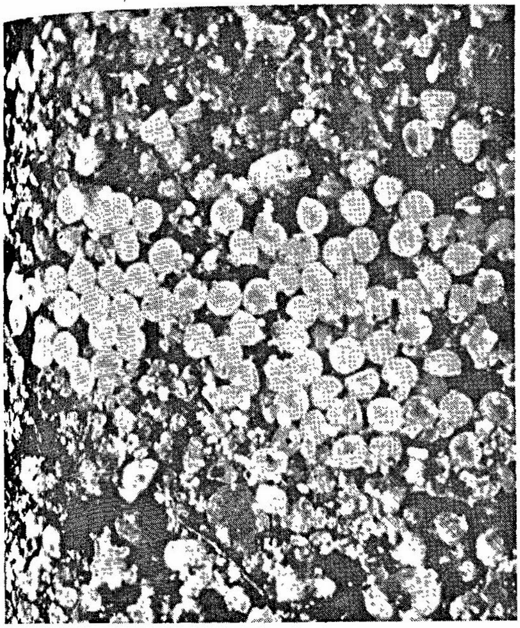

FIG. 6.—Eggs laid in the laboratory by a newly mated queen of *P. occidentalis.*

deepest chamber. All stages of ants were present in colonies excavated in July and August: eggs, larvae, worker pupae, adult workers, winged reproductive pupae, and winged reproductive adults. However, the number of winged reproductive pupae and adults was radically reduced in August. All winged reproductive adults were within 3 ft of the surface in July and more than ⅔ were within 12 in. In the colony excavated in July a total of 980 winged reproductive adults was divided almost equally between sexes, 495 ♂ and 485 ♀. In August a colony contained only 89 ♀ and 2 ♂ winged reproductives, indicating that the major mating flights had taken place; these females were probably mated before the males departed and probably acted similarly to those which have been observed burrowing during the fall (Lavigne and Fisser 1966).

In mid-September the only immature forms present were larvae and pupae. At this time they were scattered throughout the nest, although 60% were concentrated between the 4- and 5-ft levels. In the colony excavated in mid-October, 93% of the larvae and 4 pupae had been placed in the bottom chamber in each of 2 tunnels. In 1 bottom chamber at 57 in. were 57 larvae, 3 pupae, 856 workers, 1 large legume seed, 2710 *Capsella bursa-pastoris* seeds, 18 *Chenopodium* seeds, and 173 *Carex,* sedge, seeds. In the other chamber at 61½ in. were 122 larvae, 1 pupa, an inquiline, 4 large legume seeds, ca. 700 mixed *Capsella* and *Chenopodium* seeds, and the queen. The soil temperature at this level was 13.9°C. The larvae were of various sizes. Since this species did not overwinter in the larval or pupal stages, as shown by excavations from December to April (Tables 1, 2), I assume that the larvae were fed and completed growth in these chambers. No immature stages were found in the colony excavated in mid-November, although several teneral adult workers were found in the upper portion of the colony.

During the summer of 1967 in Wheatland Canyon, 5 mounds were uncovered biweekly from Apr. 1 to Sept. 30 to ascertain what seasonal changes were taking place in the development of the colonies. Worker ants first appeared in the mound proper on Apr. 15 and were still present in mounds opened on Sept. 30. Larvae were present in the mounds from June 3 to Aug. 5. Reproductive pupae with wing pads were present from June 30 to Aug. 5, and worker pupae were observed from July 22 to Sept. 8. On this basis I assume that the 1st eggs laid by the queen in the spring gave rise to winged reproductives. Winged reproductive adults were present in the mounds from July 22 to Aug. 12.

Movement of Ants in Nest in Relation to Temperature.—In mid-April at Dry Cheyenne Creek, workers of several colonies examined were first observed both inside and outside the mound and were actively engaged in mount repair. At 1 mound, *P. occidentalis* workers were capturing winged reproductive termites, which had emerged nearby, and were dragging the termites into the nest alive. The soil temperature at all levels measured (Table 3) had risen considerably from the March low 0°C at all levels. The queen had left her "overwintering" chamber and was headed upward toward the surface (captured at 41 in.). However, relatively few ants were utilizing the tunnels. Most workers were still crammed in the chambers; those in the lowest chambers (60 in. and below) were still semicomatose, even through the soil temperature at that level was 7.22°C. A late spring snow occurred on Apr. 16 and temperatures at all levels dropped 3–4 degrees.

During the period from early April to late May, the Dry Cheyenne Creek site was subjected to intermittent wet snow and spring showers. Consequently the soil was moist for a considerable depth, and temperatures taken when the colony was excavated in mid-May were colder than expected. Overnight temperatures ranged from −2.22 to 0.56°C . About ⅙ of the workers were collected from inside the mound at this time. Workers were collected carrying eggs at various levels from the surface to 58 in. In the bottom chamber (74 in.) 52 lethargic ants were found.

By mid-June soil temperatures were ca. 10° warmer at all levels (Table 3). Workers were active at all levels, and larvae were found in the lowest chamber at a depth of 76 in. Interestingly, this bottom chamber contained also 671 workers. It was not until July that bottom chambers were empty of ants.

During July, August, and September, workers were active at all levels. By mid-September, subsurface soil temperatures had dropped ca. 10° from the August high. In the colony examined in September, 75% of the larvae and 38% of the pupae had been transported to chambers between 4 and 5 ft from the surface. The bottom chamber in this nest was 65 in. below the surface and contained only 28 workers;

workers had probably not begun to enter "overwintering" chambers.

By mid-October, subsurface soil temperatures had dropped another 7–8°, and the queen had already appeared in the chamber in which she was to overwinter. All immatures had been transported to the bottom chambers and many of the workers had retreated to these chambers. By mid-November of 1967 the ants in most colonies examined had moved to chambers below the soil surface; a few "hardy" ants were observed outside on the mound surfaces of 2 colonies. Within the excavated nest, less than 1% of the workers remained within the mound and in the tunnels; the remainder had retired to the chambers. Most of the inquilines were still present in the seed chambers and therefore probably moved downward in the nest under their own power rather than being carried by worker ants. Overnight temperatures were slightly below freezing, and the soil forming the mound was in a semifrozen condition in early morning and remained in this state until thawed by the sun later in the day.

In November, a fall temperature inversion occurred in the soil with temperatures at the surface being colder than those below. This inversion continued into mid-March when the soil temperature from the surface to a depth of 6 ft was the same, i.e., 0°C (Table 3). The frost line from January to March extended to a depth of 20 in. Between March and April the spring temperature inversion took place. Based on the data just presented, it appears that the spring and fall movements of *P. occidentalis* workers were related to temperature inversions in the soil.

Excavations during the winter months indicated that workers remained in a semi-comatose condition and neither fed nor moved about until the soil warmed up. Workers collected on site during the winter quickly revived when placed in the sun, and when left overnight many survived freezing temperatures.

Although the Casper site is less than 400 ft lower in altitude than the Dry Cheyenne site, a few ants were present outside of an occasional mound as early as Mar. 23, 1967. Soil temperatures (°C) taken at the Casper site on Mar. 23 were: 4in., 7.22°; 12 in., 6.67°; 24 in., 5.56°; 36 in., 4.44°; 60 in., 4.44°; and 72 in., 5.00°. Air temperature was 18.9°C. However, in most of the colonies excavated on Mar. 23, the ants were first situated about 18 in. below the surface, indicating that the area probably has somewhat milder winters than does the Dry Cheyenne site where the 1st ants situated during the winter months were at depths of 25–33 in. (Table 3).

Inquilines.—Ant guests representing 3 families of Coleoptera: Tenebrionidae, Cetoniidae, and Staphylinidae, have been collected from nests of *P. occidentalis* in Wyoming. Only 2 representatives of the last-named family were found, both in the same colony. In addition, Collembola (undetermined) are common inhabitants of the upper chambers in most colonies. Mites are also present but were seldom noticed in the excavated colonies; they became noticeable when their numbers increased in colonies brought into the laboratory and they began to attack the ants.

Wheeler (1910) recorded several species of cetoniids (*Cremastocheilus* spp.) associated with ants; the beetles "bear tufts of golden yellow hairs (trichomes) which are assiduously licked by the ants; Cazier and Mortenson (1956), summarizing available information on the genus *Cremastocheilus*, recorded the collection of 2 ♂ of *C. saucia* LeConte on mounds of *P. occidentalis* and referred briefly to the above-ground mating of *C. knochi* LeConte.

Two species of cetoniids, *C. knochi* and *C. saucia*, have been collected in Wyoming in association with *P. occidentalis*. All specimens of *C. knochi* in the University of Wyoming collection were from southeast Wyoming. On May 14, 1964, I collected 4 live adults from excavated inactive *P. occidentalis* mounds which had been treated with mirex the previous July. A 5th adult was excavated from an inactive, treated *P. occidentalis* mound on May 7, 1963. Two adults were collected at Dwyer, Wyo., (10 miles W of Guernsey) on Oct. 23, 1959 and 1 adult was collected crawling across the soil on Apr. 27, 1962, 7 miles E of Guernsey.

At Dwyer, on June 12, a *P. occidentalis* worker was observed pulling an adult *C. saucia* into the colony entrance. One adult *C. saucia* was collected from atop a *P. occidentalis* mound on June 4, 1964, at Dwyer. Three live adults were removed from inactive *P. occidentalis* nests treated with mirex and/or Kepone® (decachlorooctahydro-1,3,4-metheno-2H-cyclobuta[*cd*]pentalen-2-one) on May 6, 1963, and May 5 and 14, 1964, at Dwyer. Additional *C. saucia* adults were excavated from active *P. occidentalis* colonies (previously chemically treated) on May 6, 1964, 23 miles E of Riverton (mid-State) and on May 27, 1967, at Dwyer. On Mar. 17, 1966, I excavated a complete active colony of *P. occidentalis* at Casper, at which time a single adult *C. saucia* was discovered in an ant chamber at a depth of 75 in. Subsequently on Mar. 20–24, 1967, at Casper, 1 adult *C. saucia* was situated in an ant chamber in each of the 5 colonies excavated. These chambers were at the following depths: 46 in. (with 256 worker ants), 46 in. (with 63 worker ants), 50 in. (with 4 worker ants), 61 in. (?), and 76 in. (with 100 worker ants). In 4 out of 6 *P. occidentalis* colonies examined May 25, 1968, 1 adult *C. saucia* was found within each mound. An additional 2 adults were found within an exceptionally large mound on the same date.

The most common beetle associated with *P. occidentalis* was a small brown tenebrionid of the genus *Araeoschizus*. At the Dry Cheyenne Creek site populations of *A. armatus* reached as high as 188 in a single ant nest. These beetles were not found associated with the ant colonies at the Casper site.

During April–September, *A. armatus* were most often found in seed or trash chambers where they apparently fed. They were found on the floor, sides, and ceilings of chambers. Copulation probably took place in June and July; 1 pair when placed together in a vial on July 20, 1967, copulated immediately.

Teneral adults were collected within a mound on Oct. 16, 1967.

During the winter months, *A. armatus* were scattered throughout the mound in chambers (Fig. 3) occupied by ants. Individuals were occasionally present in the bottom chamber of the nest. The number of beetles per chamber varied from 1 to 64. They tended to be gregarious; 32.7% of the chambers contained 1 inquiline, 38% contained 2–5, 13.7% contained 6–10, 9.2% contained 11–15, 4% contained 16–20, and 2.4% contained over 21 inquilines.

In some ant colonies, the 1st tenebrionids located were in chambers closer to the surface than were the ants. These inquilines tended to remain active at lower temperatures than did the ants. Beetles placed in the refrigerator at 0°C remained active even after 24 hr of confinement, whereas *P. occidentalis* workers were quickly rendered immobile. Both the beetles and worker ants were first collected in the mound proper in mid-April, and while there were proportionately more inquilines than ants (in relation to total nest population) in the mound in mid-September, it is uncertain whether this additional cold resistance has survival value. However, it is probable that *A. armatus* had access to the seeds both earlier and later than did the ants.

The total number of inquilines per ant colony did not seem to bear much relation to the number of ants or the amount of seed stored (Table 2), although the youngest colony contained the least number of beetles and 1 of the oldest colonies, the most. Since *A. armatus* exhibited thanatosis (death-feigning), were very small, had the color of wet sand, and were scattered throughout the tunnels and mound in summer, they could easily have been missed. Consequently some doubt is thrown on the accuracy of counts from June to September.

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