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EXPERIENCE IN REARING COMMON CARDER BEES (*BOMBUS PASCUORUM* SCOP.), WITH SOME NOTES ON THREE SIMILAR SPECIES: SHRILL CARDER BEE (*B. SYLVARUM* L.), RED-SHANKED CARDER BEE (*B. RUDERARIUS* MÜLL.), AND BROWN-BANDED CARDER BEE (*B. HUMILIS* ILL.) (HYMENOPTERA: APIDAE)

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Abstract

PTÁČEK VLADIMÍR, VOTAVOVÁ ALENA, KOMZÁKOVÁ OLGA. 2015. Experience in Rearing Common Carder Bees (*Bombus pascuorum* Scop.), with Some Notes on Three Similar Species: Shrill Carder Bee (*B. sylvarum* L.), Red-shanked Carder Bee (*B. ruderarius* Müll.), and Brown-banded Carder Bee (*B. humilis* Ill.) (Hymenoptera: Apidae). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 63(5): 1535–1542.

The rearing method under controlled conditions known for *Bombus terrestris* was successful in initiating egg-laying for 83% of *B. pascuorum* queens. After larvae had hatched, fresh pollen pellets needed to be inserted into brood pockets daily. After the first workers had emerged, colony development was advanced by placing them outdoors and supplying them with a sugar solution and pollen. The bees were able to use tightly pressed pollen from small plastic pots inserted near the brood. This feeding resulted in large colonies that produced dozens of young queens. In contrast, colonies managed in the laboratory were unable to utilize pollen in a similar manner. They raised only a few workers and several queens. Mating young queens was easy. It was stimulated by daylight, but in the case of *B. humilis* by direct sunshine. Several *B. pascuorum* and *B. sylvarum* queens were overwintered and began the new generation under artificial conditions. However, a lack of fresh pollen limited the development of colonies outside of the vegetation period.

Keywords: bumble bee, rearing, *Bombus pascuorum, B. sylvarum, B. ruderarius, B. humilis*

INTRODUCTION

Bumble bees are important pollinators of many agricultural crops and species of wild flora. They have important advantages in their ability to visit flowers in closed spaces (Biliński, 1973, 1976), buzz mechanism while collecting pollen from anthers (Buchmann, 1983), and especially long proboscis in some species (Sladen, 1912). Nevertheless, there are considerable differences among species regarding their rearing and use (Velthuis and van Doorn, 2006). The most frequently managed species, *Bombus terrestris*, belongs to the group known as "pollen storers" (Sladen, 1912). Members of this group are able to ingest pollen supplied inside the hive and bring it to larvae. A disadvantage of this easily managed group is their proboscis, which in workers is usually not much longer than that of honey bees (Hanski, 1982). Regarding pollination of flowers with deep corollas, species from the second group, denoted by Sladen (1912) as "pocket makers," are therefore more suitable. In this group, adults unload pollen pellets into wax pockets constructed beneath the brood clumps. Larvae then at least partially feed themselves on these reserves. While the techniques for rearing these species are therefore not simple, there are good reasons for improving upon these that go even beyond the group's pollination potential. Studying and rearing the bees constitute a source of more detailed knowledge about their biology, and that could subsequently enable the protection and/or rescue of rare species.

Lindhard (1912) attempted the first trials in rearing some species of this group. During the following decades, a great deal of information was published regarding the structure and development of bumble bee colonies (Richards, 1946; Cumber, 1949; Brian, 1951, 1952; Alford, 1970), but all of the observations cited above related to colonies established by queens in the wild. Zapletal (1961) and Wojtowski and Majewski (1964) tried to rear bumble bees in artificial hives and to overwinter queens. However, their technique was also dependent on environmental status and the willingness of queens to stay in the offered hives. Valle and Aaltonen (1969) tested the establishment of broods of nine species in nest boxes equipped with fresh flowers. In the case of *Bombus pascuorum*, 76% of queens began broods which were subsequently abandoned or demolished. Biliński (1973, 1976, 1981) and Bornus (1975) published a successful method for acceptance of wooden hives in several species that were fed on white dead-nettle (*Lamium album*) flowering under netting cages that were about 1 m^3. The limits of this method consisted in the number of flower beds and cages that a person was able to manage as well as, again, a dependence on the environment.

As Horber (1961) had found, young *Bombus hypnorum* queens produced in a nest which had originated in the wild copulated in the laboratory. Some of these queens, which were left in the lab at 33–35 °C, laid eggs without passing through diapause. He was able to obtain three generations of colonies under high temperatures. Plowright and Jay (1966) were partially successful in initiating egg-laying with several Canadian bumble bee species under constantly high temperatures. Röseler (1985) demonstrated an ability to break queens' diapauses using CO_2 narcoses and improved the method for year-round rearing of *B. terrestris*. Under constant laboratory conditions, Ptáček (1983, 1985) tested the possibility of stimulating oviposition in several Czech species through the presence of young honey bee workers. The method was successful with *B. terrestris* but not successful for either *B. pascuorum* or *B. sylvarum.* Přidal and Hofbauer (1998) attempted to rear *B. pascuorum* under laboratory conditions, but they did not achieve any success, as queens abandoned their larvae and colonies failed to develop. Later, Ptáček *et al.* (2000) reported successful stimulation of brood-rearing using the double-queen method. It was found to be very suitable, and particularly so for *B. pascuorum* queens due to their modest temper.

The present article summarizes experience with rearing *B. pascuorum*, *B. sylvarum*, *B. ruderarius*, and *B. humilis* under constant laboratory conditions as well as with their maturation outdoors. Some observations on inter-relationships among different species in brood-rearing are included.

MATERIAL AND METHODS

The trials in rearing *B. pascuorum*, *B. sylvarum*, *B. ruderarius*, and *B. humilis* were carried out during 2000–2011 in the laboratories of the Faculty of Science, Masaryk University in Brno, as well as at Agricultural Research, Ltd., Troubsko, Czech Republic. This paper presents the findings from this period. Generally, the constant-temperature laboratory rearing technique was used (in darkness, 28–30 °C, 70% relative humidity). Another experimental location was the first author's garden, which is situated in the woody surroundings of the village of Střelice, west of Brno. Continued development of colonies previously started in the laboratory was observed there.

Some *B. pascuorum* colonies were regularly used for pollination in a gene bank. In such cases, the colonies were not under conditions comparable to those as would be necessary for a proper scientific trial. Despite this atypical approach, we were able to acquire experience that could be generalized as recommendations for rather successful management of this species.

Bumble bee queens were captured in the wild during spring, before they had established their own nests. Of the four mentioned species, *B. pascuorum* was the most abundant. As it could be acquired anywhere, it became the model for the rearing technique and the remaining three species were treated similarly.

Since some *B. pascuorum* colonies were used for pollination every year, there were no precise experimental groups. Each queen or colony was managed individually according to its actual condition.

Common plastic kitchen containers with inside dimensions 185×125×55 mm and lids were used as rearing boxes. Several small openings on the side walls provided aeration. There was a cardboard underlay on the bottom to absorb feces. Bumble bees were fed with a 60% sugar solution (the sugar component consisted of 90% sucrose and 10% fructose) and pollen pellets that were taken continuously from honey bee pollen traps. The pollen was used fresh in the spring or else deep frozen for trials during the offseason, and it was changed daily during the experiment. Pollen was served in suitable small plastic containers. Bumble bees were kept in darkness at 28–30 °C. Relative humidity ranged between 65% and 70%.

Queens taken outside were divided into pairs. Some were kept single until another one was ready to form a pair and others were left alone all of the time.

A broody queen would grabble with her elongated abdomen on the surface of the cardboard underlay, spreading wax on it. Within the next several days, the dominant queen would construct a brood cell and lay eggs. Egg-laying was the signal to remove the submissive queen. She was given a separate box together with a submissive queen from another pair. The process could be repeated up to the third level of pairs.

In a special trial, several groups of single *B. pascuorum* queens were given a male cocoon of *B. terrestris*, three young honey bee workers, or else a single *B. pascuorum* worker.

Once the larvae had hatched in the brood cell, the queen constructed a wax cup beneath it. Each day, larvae were fed with fresh pollen pellets inserted into the pockets until they spun cocoons. The same was done for eventual second and/or third brood generations. When the last queens began brood-rearing, the first ones had their cocoons at a stage prior to emergence. As soon as the first workers began to appear, one young worker was given to some queens falling behind with their broods. Colonies that had workers were transferred into wooden hives with inside dimensions 225×160×170 mm. Each hive had 2 potential entrances (15 mm in diameter) at the bottom of the front walls. Two holes (20 mm in diameter) in the upper part of the side walls enabled aeration. From the outside, these holes were covered with pieces of wire mesh to prevent bumble bees from escaping. Finally, each hive could be covered by a telescopic cover, which had a roof for eventual insulation later.

The standard for a colony to be transferred into a hive was that it had several (approximately five) well-developed workers. During this procedure, the brood cluster was placed onto a layer of insulation material. Pollen and a sugar feeder were supplied. More fine insulation material was added to cover the brood. The ventilation holes were closed, each using a cluster of the insulation material in order to prevent airflow. Finally, the hive was closed with a cover containing an insulation layer made of several layers of creased newspaper. The young colony was held at room temperature and permitted to adapt to the new conditions. The following day, the hive was placed outdoors on a stand consisting of an iron pole 750 mm high and equipped with a sheet-metal cross on its top to hold the hive. About 120 mm down from the top of the pole there was welded a cup made of iron that encircled the pole. Later, in the field, this cup was filled with oil to prevent ants from accessing the hive. The stand was placed into soil in a moderately shaded location. Finally, an additional outer cover was added as protection from the rain.

The colonies placed outdoors were fed ad libitum with sugar solution and pollen. The pollen was served as pressed into small plastic containers (e.g., lids from PET bottles). The containers with pollen were placed rather in a vertical position close to the brood clumps and enclosed by the insulation material.

Seven queens that overwintered during 2008 were allowed to start colonies in the laboratory under constant temperature and humidity conditions. They were supplied weekly with sugar solution and pollen pressed into plastic containers in order to compare the technique known for pollen storers.

For controlled queen management, young queens were removed from their outdoor colonies as soon as they emerged and then fed with both pollen and sugar under dark laboratory conditions. At the age of 5–7 days, they were placed into the presence of unrelated males. When some queens emerged in laboratory colonies, they were placed into the copulation room when they indicated a desire to leave the hive.

A glass aquarium or a glass pickle jar covered with netting was used as the copulation room. Filter paper covered the bottom to absorb feces and to facilitate bumble bees' walking. There was also a source of food inside. The copulation process was monitored and mating pairs were gathered into a plastic (rearing) box to complete the copulation. The males were then released and the queens kept in darkness and supplied with sugar solution for a few more days to fill their honey stomachs. They were then stored in cold (4 °C and maximum humidity). Queens that survived hibernation were allowed to start new laboratory colonies.

With one exception, queens from the remaining three species were managed similarly, Because of their mutual intolerance, they were kept as single from the start. Moreover, six *B. sylvarum* queens were offered a male cocoon of *B. terrestris* and one *B. ruderarius* queen was stimulated using three callow honey bee workers. Several atypical methods were attempted regarding interspecific cooperation.

In the case of *B. sylvarum*, six workers were caught in a field of red clover. They were then kept under laboratory conditions to test their ability to rear their own brood.

Successful establishment of an egg cell in *B. pascuorum* or among species were compared using a Chi-square test. The tests were performed using Statistica 10 software (StatSoft Inc. 2011).

RESULTS

In all species, when a queen began to be fertile, she would begin to crawl with her elongated abdomen on the surface of the cardboard underlay spreading wax on it. She would construct the brood cell within several consecutive days and lay eggs. At the time of the first larva's emergence, the queen would construct a small pocket beneath the brood cell. The pocket enlarged with the larval growth. The queen, and later workers, would press the supplied pollen pellets into the pocket(s) beneath the brood. It is probable that they added also some fluid to the mass because it changed its structure.

Common Carder Bee (*B. pascuorum*)

The numbers of queens brought from the wild and entered into our trials in both laboratories are

I: *Efficiency of Bombus pascuorum queens in starting egg cells and raising the first workers*

Queen number	2000	2001	2002	2003	2004	2006	2007	2008	2009	2010	2011	Total
In trial	2	11	3	12	1	27	32	29	16	36	14	183
Established egg cell (% of total)	2 (100)	11 (100)	2 (67)	12 (100)	1 (100)	18 (87)	27 (84)	25 (86)	12 (75)	30 (83)	11 (78)	151 (83)
Raised workers (% of total)	1 (50)	8 (72)	2 (67)	11 (92)	1 (100)	16 (59)	23 (72)	19 (66)	8 (50)	19 (52)	10 (71)	118 (64)

II: *Comparison of different approaches to starting B. pascuorum colonies*

	Activation in pairs	Single queen and honey bees	Single queen and a *B. terrestris* cocoon	Single queen and a *B. pascuorum* worker
Number of queens	46	4	15	14
Established egg cell (% of total)	38 (83)	2 (50)	4 (27)	8 (57)

summarized in Tab. I. The results from another trial carried out in a Masaryk University lab are shown in Tab. II.

Queens in pairs established their first egg cell within approximately 13 days. This was significantly more often than was the case for queens in other variants ($\chi^2 = 16.9$; df = 3; p = 0.0007). In two cases, positive communication between the queen and honey bees was observed. Four queens adopted *B. terrestris* cocoons as the place for constructing their egg cells (Tab. II). Adding one *B. pascuorum* worker to the queen stimulated the queen positively in 8 of 14 cases.

Four normal young colonies were left to develop under laboratory conditions. They could be kept in comparatively slow development by strewing pollen onto the clumps of larvae. Due to the abundance of unconsumed pollen, moths and mites proliferated, which was aggravating for both the bees and brood. Despite these problems, each colony produced several generations of workers as well as some males and queens.

The development of colonies located outside was different. After they were given pollen pressed into small plastic bottle cups close to the brood, most of the colonies "knew" how to use it (unlike the colonies in laboratory). Bumble bees also accepted supplemental feeding as sugar, which was especially important during periods of cold weather. Nevertheless, only 33% of them matured to the point of queen production. Among the unsuccessful colonies, several remained weak despite the feeding while others became male producers after the queen's early death. About 20% of the colonies were destroyed by the moth *Aphomia sociella*.

For obtaining young queens, it helped to inspect the colonies inside the room. Callow queens could be removed with tweezers; those flying out were collected at the glass of a window where they had flown. Some queens were heavy and wanted to escape the hive. Probably, they had mated. In all queens with unknown mating status, it was possible to ensure their mating by putting them into the presence of unrelated males for 4 consecutive days in an aquarium supplied with pollen and sugar. They could then be stored in cold.

In daylight, pairs copulated readily (even in a pickle jar covered with mesh). Queens mated at the age of 5–7 days and only once. Mating lasted approximately 16 minutes (ranging from 3 to 25). Mated queens had heavy abdomens and wanted to leave the place.

Results from wintering 11 queens stored in the lab in Troubsko are shown in Tab. III: Of the 9 queens found alive, 2 died shortly after waking up. Of the others kept as singles, 5 began brood-rearing. The sixth and seventh did not start nesting, but they did establish an egg cell after they were placed together. In colonies of this trial, which were left to develop in the laboratory by feeding on pollen

III: *Ability of cold stored (11 September 2007–2 January 2008) B. pascuorum queens to establish brood cells under laboratory conditions in Troubsko*

Queen number	Days to 1st cell	Days to 1st worker	Production of new queens	Number of individuals per colony
1	14	36	0	40
2	9	39	0	20
3	15	36	0	15
4	14	37	0	15
5	22	43	0	25
6 + 7*	9	62	0	50
Average number	13.8	42.2	0	27.5

* Queens did not nest for a long time. After being placed together, they started a colony where they both remained laying eggs

pressed into small plastic containers (similarly as with *B. terrestris*), dying larvae were noted repeatedly. Despite this fact, the colonies raised several workers and males.

Shrill Carder Bee (*Bombus sylvarum*)

We had 27 queens in experiments during 2006–2011. Of these, 19 (70%) established brood in the laboratory and 17 of those (63% of the total) were able also to produce workers.

Of the 6 queens which were given the presence of *B. terrestris* cocoon(s), 4 queens incubated the cocoons, but only 2 queens established an egg cell on them. The remaining queens each constructed an egg cell on the pad.

Colonies taken outdoors could be given supplementary food, too, showing even more positive effects of this treatment than was the case with *B. pascuorum*. Females used completely the pollen loads pressed into bottle cups and inserted close to the larvae. More than 60% of colonies produced young queens in numbers ranging from 20 to 69 per colony. Of the unsuccessful colonies, one queen died after she became entangled in the fibers of the insulation material, another queen got lost as she flew out at a new stand, a third colony failed to develop for an unknown reason, and a fourth colony was destroyed by *Aphomia sociella*. Generally, the regular colonies lasted long into the season, until the end of September.

Four colonies which were allowed to continually develop in the laboratory by strewing pollen onto the brood produced several workers and 6, 13, 28, and 21 new queens.

Young queens copulated successfully in daylight and once only. In colonies placed outdoors, two queens were seen returning from their mating flight with the male hanging at the abdomen.

Two queens overwintered successfully in 2010. Nevertheless, they did not start colonies outside the growing period because they lacked proper pollen. Fresh pollen seems to be a precondition for rearing this species.

Of the 6 workers captured in the field and brought into constant laboratory conditions, 3 remained alive and produced 7 well-developed males using pollen served in small cups.

Red-shanked Carder Bee (*Bombus ruderarius*)

This species does not readily initiate egg-laying under artificial conditions. Queens in pairs resent one another. They need to be held individually, which, however, does not lead to oviposition. We had 10 queens at our disposal. One queen was killed by another in a free pair. Four queens began brood-rearing on their own and 2 others in the presence of a *B. pascuorum* worker. Another 1 was found dead after she was placed in the company of a *B. sylvarum* worker. One queen positively communicated with honey bee workers and raised 3 of her own workers in their presence. Single queens needed a long time to begin rearing brood. Similarly to *B. pascuorum* and *B. sylvarum*, the queens built a wax pocket beneath their brood cells.

Two colonies raised young queens in the laboratory (4 queens in the first case and 11 queens in the second) immediately following the first progeny of workers. We could not enable them to mate because of the lack of males so early in the season. Two colonies transferred to the outdoors were able to consume supplemental feed just as did the aforementioned species. The pollen used was freshly taken from honey bee colonies using pollen traps. The better colony had a brood even in mid-September and raised 57 individuals, including 3 queens. We obtained no experience in mating young queens and preparing them for diapause.

Brown-banded Carder Bee (*Bombus humilis*)

We obtained experience with three queens of the dark subspecies *B. humilis tristis*. At first, two of them were put into a rearing box as a pair separated by a simple piece of plastic brood excluder, a common piece of beekeeping equipment. After one of the queens built her egg cell, she killed her neighbor despite the excluder. Then she lost interest in the brood, perhaps due to unsuitable pollen. After repeated failed trials to construct a brood cell, she finally succeeded in producing four small workers. The next portions of the brood were males.

The third queen was left alone. She did not start nesting for 3 weeks. Then, after obtaining a young *B. pascuorum* worker, she started brood-rearing and raised her first progeny of workers. The colony then produced eight young queens. As there was no source of males in the laboratory, we brought some from the wild (104 km away). Pairs then copulated in a mesh-covered aquarium when they were situated in direct sunshine. Males were willing to copulate repeatedly while females were not. We were not successful, however, in preparing the queens for diapauses. They continued to sit quietly in the aquarium with unfilled abdomens until they died.

Inter-relationships Among Individuals of Different Species

On three occasions, one *B. pascuorum* queen was given one young *B. terrestris* worker when the queen had her larvae. In one case, the worker fed the *B. pascuorum* larvae in the “terrestris” way and helped the queen to raise *B. pascuorum* workers. Another *B. terrestris* worker helped the queen to raise the first progeny of *B. pascuorum* workers, but she also raised *B. terrestris* males from her own eggs. In the third case, the *B. terrestris* worker helped the *B. pascuorum* queen to feed one larva as a young *B. pascuorum* queen.

Similar treatment was repeated with five *B. sylvarum* queens. In two cases, the *B. terrestris* worker helped the queen in raising a *B. sylvarum* worker brood. In one of these cases, the helper remained in the nest even when the nest was placed outdoors. It may have collected food as it knew the hive's surroundings. In two other cases, the help of *B. terrestris* worker resulted in *B. sylvarum* male production. In a fifth case, no *B. sylvarum* brood occurred, but *B. terrestris* males, the sons of the helper, were produced instead.

In one case, a *B. sylvarum* queen began brooding after adding a young *B. pascuorum* worker.

In one occasion when a *B. sylvarum* worker was put together with a *B. ruderarius* queen, the worker probably killed the queen.

When two small queens of *B. pascuorum* and *B. sylvarum* were put together, they were able to start egg-laying in a free pair and remained together in a mixed colony outdoors.

DISCUSSION

It seems possible, at least in part, to adopt the so-called constant-condition laboratory rearing method known for *B. terrestris* (Plowright and Jay, 1966; Röseler, 1985; Ptáček, 1991; Ptáček *et al.*, 2000) for starting *B. pascuorum* and *B. sylvarum* colonies. The proportion of queens producing the first workers (64% and 63%, respectively) is very promising for using the method in bee management as well as further research. A disadvantage remains in the impossibility for workers to feed larvae in young colonies sufficiently. Generally, those remaining under "constant conditions" and with portions of pollen in cups did not develop properly. Workers were small and less numerous. This inability of queens and workers was the probable cause for larvae to die in trials performed earlier in the case of pocket makers (Plath, 1923; Frison, 1927; Plowright and Jay, 1966; Přidal and Hofbauer, 1998).

In spite of this fact, several queens in several colonies were produced in both species when pollen was supplied on the brood clumps from above. This allows hope for further improving the management technique.

Colonies transferred outdoors generally developed better because they were able to accept the pollen served in small plastic pots situated near the brood, while those left in the laboratory were not. A possible reason for this was the position of the cups, which was rather vertical, supported by the insulation in the hives. Pollen consumption considerably increased young queens' brood development. The young queens themselves used the pollen in the first days of their lives for the development of their fat bodies. In this way, supplemental feeding of colonies facilitated the production of well-developed young queens.

After colonies started to produce young queen and/or male larvae, they fed them through the tiny openings in the wax envelope, similarly as did pollen storers. This is why *B. sylvarum* workers brought from the field succeeded in producing males under laboratory conditions. An additional advantage of this experience is the possibility to obtain unrelated males from the wild for mating queens produced when only one colony is available. The first author has similar positive (unpublished) experience with *B. hortorum* workers. Under laboratory conditions, male production in queenless colonies of various species is normal (Ptáček, 2008). At the time of sexual production, colonies built wax pollen containers from which young queens and males consumed pollen during their first days of maturation.

Young queens and males copulated without problems under laboratory conditions in *B. pascuorum* and *B. sylvarum* after they were 6 days old, which data is similar to findings by Přidal and Hofbauer (1996) for *B. terrestris*.

The possibility of cooperation among species appears to be a promising subject for further research. *B. pascuorum* workers seem to be the most promising candidates to become helpers because of their placidity. Similarly, the mild *B. pascuorum* queen can become an acceptable partner in the double-queen starting method (Ptáček *et al.*, 2000) for other, similar species. In the new approach, the rearing boxes must be divided using a doubled partition to prevent queens from killing one another.

The early production of young queens in two *B. ruderarius* colonies might have been due to the laboratory temperature, which was possibly too high for this species that nests on the surface (Sladen, 1912).

We cannot exclude that *B. terrestris* workers might be used to produce pocket makers' queens in laboratory trials. In this species, queenless workers rear queens from young larvae (Cnaani *et al.*, 2001; Ptáček, 2002, 2003). It is possible that callow *B. terrestris* workers would accept the larvae of another species to rear as queens. Ptáček (2008) has had some positive experience in this phenomenon with *B. hortorum* and *B. subterraneus*. On the other hand, using *B. terrestris* cocoons as stimulators of oviposition at the start does not seem to be a proper approach, as the other pocket maker, *B. hortorum,* does not use the cocoons of *B. terrestris* either (Bučánková and Ptáček, 2012).

CONCLUSION

In laboratories of the Faculty of Science, Masaryk University in Brno and the Research Institute for Fodder Crops in Troubsko, trials were conducted during 2000–2011 with the aim of rearing the pocket maker bumble bees *B. pascuorum, B. sylvarum, B. ruderarius*, and *B. humilis* under controlled laboratory conditions. Young queens from the wild as well as overwintered queens were kept in rearing boxes either in pairs (*B. pascuorum*) or singly (*B sylvarum* and *B. ruderarius*). Various anomalous approaches also were attempted in all species. Of the 191 *B. pascuorum* queens, 83% started oviposition in free pairs, at which time the submissive queens were removed and used for new pairs. In atypical trials, 57% of queens laid eggs when a conspecific worker was added, 50% with the presence of a honey bee, and 27% with the presence of a *B. terrestris* cocoon. In the case of *B. sylvarum*, 70% of 27 queens laid eggs.

As soon as larvae hatch, it is necessary at least daily to insert fresh bee pollen pellets into the pocket at the brood until the larvae spin cocoons. In this way, workers were produced. When queens were left alone with a store of pollen, they were not able to feed the brood. Better results were obtained when pollen was regularly strewn on the brood from above. Several workers and young queens were then produced in the lab, but moths and mites proliferated, which was aggravating for the colonies. The best development was obtained when colonies with the first workers were transferred outdoors. In such cases, paradoxically, they were able to consume pollen pressed into plastic containers after these were inserted in a vertical position close to the brood clumps. Supplemental feeding of sugar and pollen resulted in large colonies with dozens of young queens. The same was the case for *B. sylvarum* and also *B. ruderarius*. Young *B. pascuorum* and *B. sylvarum* queens copulated in an aquarium covered with mesh in daylight. *B. humilis* queens required direct sunshine for copulation. Several overwintered *B. pascuorum* and *B. sylvarum* queens did not raise colonies due to a lack of fresh pollen out of season. Six *B. sylvarum* workers taken from field raised males in the laboratory. Callow *B. terrestris* workers were tested as helpers in rearing broods of *B. pascuorum* and *B. sylvarum* queens.

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