Apidologie, 1981, **12** (3), 211-220.

NATIVE LEAFCUTTER BEE SPECIES AND ASSOCIATED PARASITES IN COMMERCIAL HIVES IN SASKATCHEWAN, CANADA

G. H. RANK and D. W. GOERZEN

Dept. of Biology, University of Saskatchewan
Saskatoon, Saskatchewan, Canada, S7N 0WO

SUMMARY

Native leafcutter bee cells were sampled from four different commercial populations. The predominant native leafcutter bee species found in these commercial populations were *Megachile relativa* (99.7 %) and *M. nivalis* (0.3 %). *Coelioxys funeraria* and *C. moesta*, major parasites of *M. relativa*, were not observed to emerge from *M. rotundata* cells. Chalcids found in *M. relativa* cells were *Dibrachys maculipennis, Melittobia chalybii* and *Pteromalus venustus*. These could be removed from *M. relativa* by taking advantage of the earlier chalcid emergence. However, X-ray identification in the pupal stage was required for the removal of *Coelioxys* spp. since their emergence coincided with that of *M. relativa*. Limited success in domestication of *M. relativa* is reported.

INTRODUCTION

Three ground nesting species of the *Megachile latimanus* group, *M. diligens, M. perihirta* and *M. latimanus* were identified by Sladen (1918) as the major native pollinators of alfalfa *(Medicago sativa)* in Canada. A study by PECK and BOLTON (1946) near Prince Albert, Saskatchewan (53° 12′ 105° 46′) indicated that the main genera capable of tripping alfalfa flowers were *Megachile* and *Bombus*, while the genera *Osmia, Coelioxys* and *Anthrophora* were of limited value. They observed the following species of *Megachile* pollinating alfalfa : *M. relativa, M. nivalis, M. gemula, M. frigida, M. melanophaea, M. inermis* and *M. latimanus*. HOBBS and LILLY (1954) identified 14 species of *Megachile* in the alfalfa seed growing region of southern Alberta. Two ground nesting species, *M. dentitarsus* and *M. perihirta*, were the most important native pollinators of alfalfa while less important, in decreasing order, were *M. brevis, M. melanophaea, M. frigida*, and *M. relativa*. STEPHEN (1955) reported that in Manitoba *M. frigida* and *M. latimanus* consistently tripped greater than 90 % of alfalfa flowers visited whereas the efficiency of *M. relativa, M. melanophaea,*

M. inermis and *M. brevis* was lower and more varied. Although numerous studies in other locations have identified *Megachile* species in natural settings (GENTRY, 1874; FYE, 1965; KROMBEIN, 1967; MEDLER and KOERBER, 1958; HOLM and SKOU, 1972) there is no information to the authors' knowledge on native leafcutters attracted to commercial hives of *M. rotundata.* We report here on the biology of native leafcutter bee cells from four commercial Saskatchewan populations.

MATERIALS AND METHOD

Source of Cells

Cells of immigrant native leafcutter bees were identified by their distinctive morphology (Fig. 1). The cells are larger than those of *M. rotundata* and are smooth due to the firm packing of the

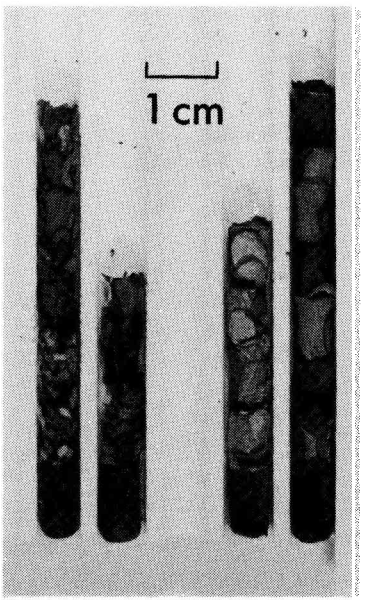

FIG. 1. — *Photograph of* Megachile *cells showing* M. relativa *cells in the bottom of each of four tunnels. After the native leafcutters emerged,* M. rotundata *occupied the empty cells and continued to fill the tunnels.*

leaf fragments. Native leafcutter cells were obtained from four commercial Saskatchewan populations located at Veregin (51° 35′ 102° 05′), Aberdeen (52° 19′ 106° 17′), Rockford (52° 10′ 102° 56′) and Hagen (52° 56′ 105° 33′). *M. rotundata* cells were taken from the Veregin population for comparative analyses (Tables 2 and 5).

Storage

Celles were placed in storage at 4 °C on October 10, 1979. Relative emergence times (Fig. 3) were evaluated by removing the cells from cold storage on April 25, 1980 and incubating at 25 °C or 30 °C.

Field Placement of Native Cells

In an attempt to domesticate native leafcutter bees, 8200 native cells were placed at the bottom of tunnels in polystyrene hives and « Pollitec » circular hives. The cells were then incubated at 30 °C for 12 days and placed in a five acre alfalfa field surrounded by native vegetation. Wooden hives of aspen and pine were also placed in the shelter. Tunnel diameters varied from 6.5 to 7.0 mm in both aspen and polystyrene hives to 6.0 mm in the pine hives.

X-ray Analyses

X-rays were taken on a Picker unit (751-501, 502) with a molybdenum X-ray tube. A 28 kilovolt setting was used to provide a 100 milliampere current for a 0.3 second duration. The tube was set at small focus approximately 26 inches from the leafcutter cells being exposed. The X-ray film was DuPont Nuclear Medicine Base F 31 vacuum pack, emulsion one side.

RESULTS

Analysis of Leafcutter Cell Contents

Virtually all of the immigrant native leafcutter bees observed were *M. relativa*, the only exceptions being two female *M. nivalis*. The proportion of females varied from 37 % in the Veregin population to 63.8 % in the Hagen population (Table 1). The

TABL. 1. — *Leafcutter and parasite composition of four populations* (expressed as percent of emerged cells).

Location	No. cells emerged	*Megachile* ♂	*relativa* ♀	*Coelioxys* ♂	spp. ♀	Chalcids
Veregin[1]	184	53.8	37.0	3.8	4.9	0.5
Aberdeen	90	46.7	44.4	0.0	0.0	8.9
Rockford	104	39.4	56.7	3.8	0.0	0.0
Hagen[1]	221	28.1	63.8	0.0	0.9	7.2

[1] Samples from each of these locations included 1 *M. nivalis*♀.

parasite populations were also variable since Veregin and Rockford native bee cells were infested with *Coelioxys* spp. whereas those from Aberdeen and Hagen populations were parasitized mainly by chalcids. A detailed comparison of the composition of cells sampled from the Veregin population is presented in Table 2. The most striking differences between native and domestic cells were the higher frequency of unemerged pupae in *M. relativa* and the absence of parasitism by *Coelioxys* spp. in *M. rotundata*. The viability of cells of *M. rotundata* (84.0 %) was higher than that of the native leafcutter cells (69.6 %).

TABL. 2. — *Comparison of contents of* Megachile rotundata *and* M. relativa *cells from Veregin population* (expressed as percent of whole).

Cell Contents	*M. rotundata* (264 cells in sample)	*M. relativa* (248 cells in sample)
Megachile	84.0	69.6
Coelioxys spp.	0.0	6.3
Chalcids	0.0	0.4
Unemerged larvae	7.2	10.6
Unemerged pupae	0.8	8.3
Pollen, egg imprint	4.0	1.6
Pollen, no egg imprint	2.4	2.0
Empty[1]	1.6	1.2

[1] Cell constructed but not filled with pollen.

Species Distribution of Parasites

Cells containing chalcids were identified prior to incubation by X-ray analysis. Typical X-rays of cells containing *Dibrachys maculipennis, Melittobia chalybii* and *Pteromalus venustus* are shown in Fig. 2. The large Veregin sample included all three chalcid species whereas the Hagen sample contained *D. maculipennis* and *P. venustus* and cells from Aberdeen were infested with *P. venustus* only (Table 3).

TABL. 3. — *Proportion of chalcid species present in four* Megachile relativa *populations.*

Location	Sample size	Species identified	No.
Veregin	8.200	*Dibrachys maculipennis*	28
		Melittobia chalybii	1
		Pteromalus venustus	2
		Pteromalidae (undeveloped)	2
Aberdeen	90	*Pteromalus venustus*	8
Rockford	104	—	—
Hagen	221	*Dibrachys maculipennis*	4
		Pteromalus venustus	11

Coelioxys spp. were identified prior to emergence on the ninth day of incubation. Female *Coelioxys* spp. were easily distinguished from *M. relativa* by their pointed abdomen (Fig. 2 E) while male *Coelioxys* spp. were identified by their slender abdomen (Fig. 2 F). *C. funeraria,* the predominant Veregin species, was approximately 10 times more abundant than *C. moesta* (Table 4). Both species had similar sex ratios. The Rockford sample contained the same species with *C. funeraria* the more frequent.

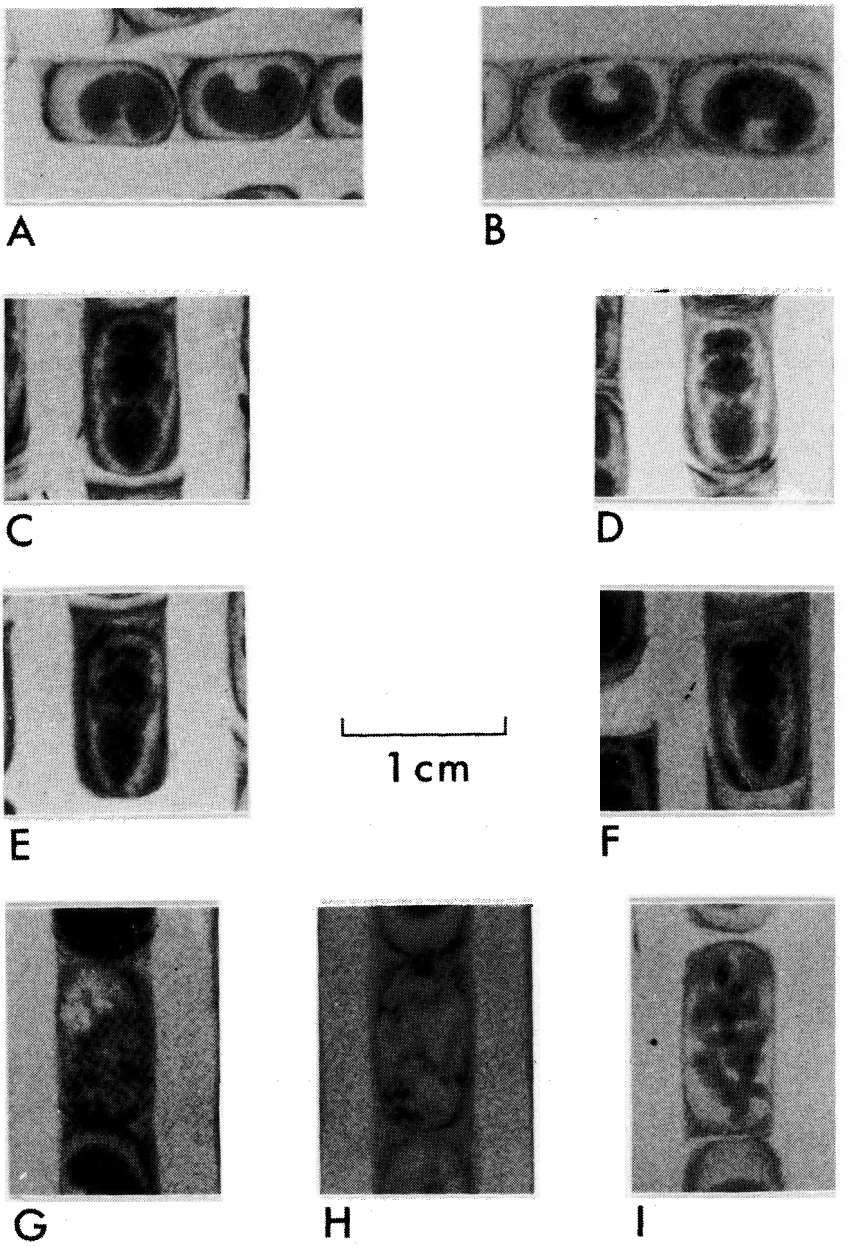

FIG. 2. — *Photographs of X-rays of intact cells, distinguishing :*

A) Megachile rotundata *prepupae*
B) Megachile relativa *prepupae*
C) M. relativa *pupa* ♀
D) M. relativa *pupa* ♂
E) Coelioxys sp. *pupa* ♀
F) Coelioxys sp. *pupa* ♂
G) Melittobia chalybii
H) Dibrachys maculipennis
I) Pteromalus venustus

TABL. 4. — *Proportion of* Coelioxys *species present in four* Megachile relativa *populations.*

Location	Sample size	Species identified	No.
Veregin	8.200	*Coelioxys funeraria*	116 ♂
			147 ♀
		Coelioxys moesta	12 ♂
			15 ♀
Aberdeen	90	—	—
Rockford	104	*Coelioxys funeraria*	3 ♂
		Coelioxys moesta	1 ♂
Hagen	221	*Coelioxys* sp.	1 ♀

Emergence

Mean emergence times of *M. relativa* at 25 °C and 30 °C were 21 and 14 days, respectively (Fig. 3). Emergence of chalcids from native leafcutter cells incubated at

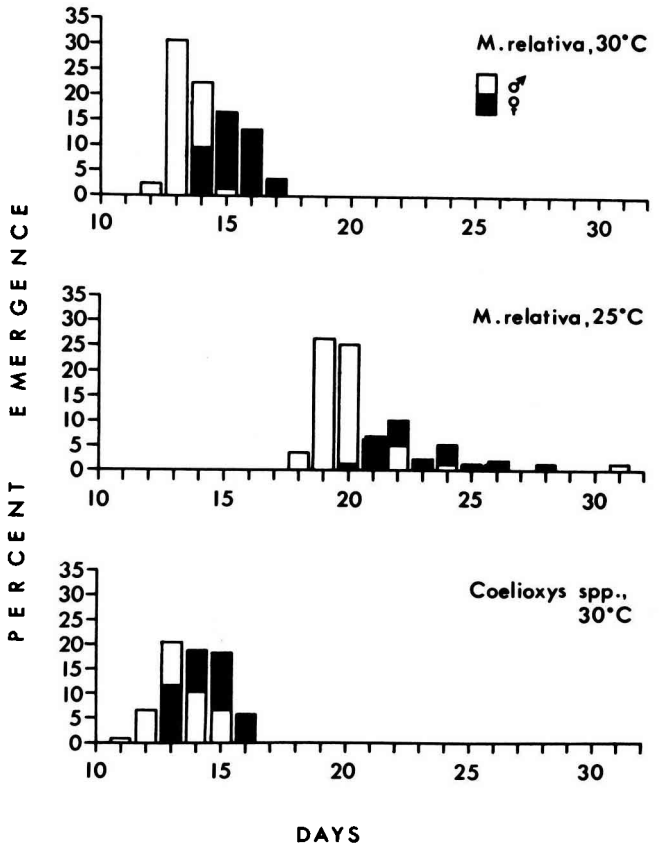

FIG. 3. — *Emergence of* M. relativa *and* Coelioxys *spp.*

30 °C peaked at day 9 and was complete by day 14. Chalcid emergence from *M. rotundata* cells was similar (HOBBS, 1968). Emergence of *Coelioxys* spp. coincided with that of *M. relativa* (Fig. 3).

Comparison of Native and Domestic Leafcutter Cells

As seen in Fig. 1, cells of *M. relativa* are distinguishable by their large size and smooth texture. Weight differences are given in Table 5. *M. relativa* cells contained approximately 20 % more pollen than those of *M. rotundata*. Both species showed a preference for the leaves of *Rosa* and *Prunus* species in construction of cells.

Field Observations of M. relativa

Although 8,200 *M. relativa* cells were placed in hives, only 1,280 cells were harvested from these hives at the end of the field season. Assuming a production of eight cells per female (MEDLER and KOERBER, 1958), the resident female population would theoretically have been about 160. This represents 4.8 % of the original population's female component if we consider the male : female ratio to have been approximately 1.5 : 1 (Table 1, Veregin population). Our field observations during emergence in early summer indicated that few females remained in the vicinity of the hives, whereas male *M. relativa* were seen in abundance hovering over hives and inspecting tunnels. Occasionally empty cells of *M. relativa* were used by *M. rotundata* (Fig. 1), the latter having drifted from commercial shelters in the same field. *M. relativa* females were not observed to be aggressive to each other, choosing tunnels relatively close (often adjacent) to each other. The majority of the occupied tunnels were in a small area of one polystyrene hive. *M. relativa* was observed to collect alfalfa pollen but had a strong preference for that of *Sonchus arvensis* (sow thistle).

TABL. 5. — *Cell, prepupal and pollen weights (mg. ± S.E.) for* M. rotundata *and* M. relativa *from Veregin population.*

	Cell	Prepupa	Pollen (dry wt.)
M. rotundata	37 ± 2.9	52 ± 3.4	81 ± 5.0
M. relativa	65 ± 4.7	63 ± 3.3	107 ± 7.8

DISCUSSION

In view of earlier reports on the many different species of leafcutter bees found active on alfalfa (SLADEN, 1918; PECK and BOLTON, 1946; HOBBS and LILLY, 1954; STEPHEN, 1955) it was of interest that the main leafcutter we found in commercial nests

was *M. relativa.* Only two *M. nivalis* females appeared in the identification of 599 adults (Table 1) indicating that this species infiltrated commercial populations to a lesser extent in areas from which samples were taken. Ground nesting species *(M. dentitarsus, M. perihirta, M. diligens, M. latimanus)* would not be expected to nest in commercial hives. However, the absence of *M. gemula, M. frigida, M. melanophaea, M. inermis* and of appreciable numbers of *M. nivalis* is not easily explained. PECK and BOLTON (1946) found that artificial nests bored in logs and stumps resulted in the capture of *M. frigida* and *M. nivalis.* The large size of *M. inermis* and *M. frigida* likely prevents their acceptance of commercial tunnels (6.0 to 7.0 mm diameter) but these tunnel sizes should not restrict *M. nivalis, M. gemula,* or *M. melanophaea* more than *M. relativa.*

A comparison of *M. rotundata* and *M. relativa* cells in the Veregin population (Table 2) shows that there is a much higher pupal mortality in *M. relativa,* the basis of which is unknown. The absence of *Coelioxys* parasitism in *M. rotundata* has been verified by analyses of many populations (authors, unpublished data). Although there are reports of parasitism by *Coelioxys* spp. in native Canadian leafcutters (FYE, 1965; PECK and BOLTON, 1946), the only reports of *Coelioxys* parasitism in *M. rotundata* are in European populations. ASENSIO and RODRIGUEZ (1972), in Spain, and MANNINGER (1972), in Hungary, report *C. rufocaudata* as an important parasite. TASEI (1975, 1977, 1979) reported that in France, *Coelioxys* has become the major parasite in some *M. rotundata* populations. *C. rufocaudata* may be adapted to *M. rotundata* in Europe because the latter is native to southern Europe. However, in Canada, *C. funeraria* and *C. moesta* have adapted to larger native species such as *M. relativa.* The larger prepupa of native *Coelioxys* spp. may not be able to develop on the provisions of a *M. rotundata* cell. This interpretation is supported by the observation that 20 % more pollen is stored by *M. relativa* (Table 5). Control of *Coelioxys* spp. is difficult in *M. relativa* because of similar emergence times (Fig. 3), however, X-ray analysis of pupae could be used to identify *Coelioxys* in time for removal.

Three species of chalcids, *D. maculipennis, M. chalybii* and *P. venustus,* were observed in *M. relativa* cells (Table 3). This is in agreement with reports on *M. relativa* in Wisconsin, where *M. chalybii* and *Dibrachys* sp. were observed (MEDLER and KOERBER, 1958), and in northwestern Ontario, where *M. chalybii* was observed in a few *M. relativa* cells (FYE, 1965).

Chalcid species reported to parasitize *M. rotundata* in Canada are *Monodontomerus obscurus, P. venustus* and *M. chalybii* (HOBBS, 1968; PECK, 1969; HOBBS and KRUNIC, 1971). This suggests that *M. obscurus* may be specific to *M. rotundata,* and that *D. maculipennis* is a successful parasite only on native species. Further investigation is required to substantiate this possibility, in view of the varied chalcid composition in the four populations studied (Table 3).

Domestication of *M. relativa* is an interesting possibility since it has been observed to fly at lower temperatures than *M. rotundata*. The solitary nature of *M. relativa* and related species (HOLM and SKOU, 1972) was verified by our low recovery of cells under domestic conditions. However, the 1280 cells recovered may represent the progeny of selected *M. relativa* females with a gregarious habit. This possibility will be evaluated by further field studies.

ACKNOWLEDGEMENTS

We gratefully acknowledge M. IVANOCHKO, Biosystematic Research Institute, Ottawa, for the identification of *Megachile, Coelioxys* and chalcid species, and the Department of Radiology, University Hospital, Saskatoon, for X-ray exposures.

Received for publication in January 1981.

RÉSUMÉ

LES ESPÈCES DE MÉGACHILES INDIGÈNES ET LEURS PARASITES DANS LES NICHOIRS COMMERCIAUX DU SASKATCHEWAN

On a récolté des cellules de mégachiles indigènes dans 4 populations utilisées commercialement au Saskatchewan et identifié les adultes sortis de 599 cellules provenant de ces populations. 597 d'entre eux étaient des *Megachile relativa* et 2 des *M. nivalis.*

La comparaison du parasitisme dans les cellules de *M. relativa* et *M. rotundata* montre que seules les cellules de *M. relativa* sont parasitées par *Coelioxys funeraria* et *C. moesta.* On a identifié 3 espèces de chalcidés dans les cellules de *M. relativa : Dibrachys maculipennis, Melittobia chalybii* et *Pteromalus venustus.* Puisque *M. rotundata* est connu pour être parasité par *Monodonterus obscurus, P. venustus* et *M. chalybii,* il est possible que *M. obscurus* soit spécifique de *M. rotundata,* alors que *D. maculipennis* ne se développe que sur les espèces indigènes.

La durée moyenne de développement de *M. relativa* à 25 °C et 30 °C est respectivement de 21 et 14 jours. Les chalcidés éclosent du 9^{e} au 14^{e} jour lorsque l'incubation des cellules a lieu à 30 °C, tandis que l'éclosion de *Coelioxys* spp. coïncide avec celle de *M. relativa.*

L'analyse aux rayons X permet d'identifier les nymphes mâles et femelles de *M. relativa* et *Coelioxys* spp. le 9^{e} jour de l'incubation. Ce procédé permet de supprimer *Coelioxys* spp. avant de lâcher en champ *M. relativa.* On a introduit 8 200 cellules de *M. relativa* (indemnes de *Coelioxys* spp.) dans des nichoirs que l'on a placés à l'extérieur. Seules 1 280 cellules filles ont été récoltées car les insectes ont déserté l'abri.

ZUSAMMENFASSUNG

EINHEIMISCHE ARTEN DER BLATTSCHNEIDEBIENE UND IHRE PARASITEN IN DEN KOMMERZIELLEN NISTSTÄTTEN IN SASKATCHEWAN, CANADA

Zellen von einheimischen Blattschneiderbienen wurden aus vier kommerziellen Populationen in Saskatchewan gesammelt. Die geschlüpften adulten Tiere aus insgesamt 599 Zellen aus diesen vier Populationen wurden bestimmt. Von diesen wurden 597 als *Megachile relativa* und zwei als *M. nivalis* identifiziert.

Ein Vergleich der Parasitierung bei *Megachile relativa* und *M. rotundata* ergab, dass nur die Zellen von *M. relativa* von *Coelioxys funeraria* und *C. moesta* parasitiert waren. Die drei Chalcididen-Arten, die in *M. relativa*-Zellen bestimmt wurden, waren folgende : *Dibrachys maculipennis, Melittobia chalybii* und *Pteromalus venustus*. Da für *M. rotundata* die Parasitierung durch *Monodontomerus obscurus, P. venustus* und *M. chalybii* gemeldet worden ist, stellen wir die Möglichkeit zur Diskussion, dass *M. obscurus* für *M. rotundata* spezifisch sei, während *D. maculipennis nur* bei einheimischen Arten erfolgreich ist.

Die mittlere Zeitspanne bis zum Schlüpfen betrug für *M. relativa* bei 25 °C und bei 30 °C 21 Tage, bzw. 14 Tage. Die Chalcididen schlüpften von Tag 9 bis Tag 14, wenn die Zellen bei 30 °C erbrütet wurden; der Schlüpftermin von *Coelioxys* spp. hingegen fiel mit dem von *M. relativa* zusammen.

Durch Röntgen-Analyse gelang es, am 9. Bruttag männliche und weibliche Puppen von *M. relativa* und *Coelioxys* spp. zu bestimmen. Mit dieser Methode wurde es möglich. *Coelioxys* spp. vor der Aussetzung im Feld von den *M. relativa*-Puppen auszusondern. 8.200 *M. relativa*-Zellen (frei von *Coelioxys* spp.) wurden in Kästen gesetzt und unter Freilandbedingungen aufgestellt. Als Folge des Verfluges von diesem Freiland-Nistplatz wurden nur 1.280 Nachkommen-Zellen gewonnen.

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