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Preliminary studies on propagating natural mason bee (mixed *Osmia cornuta* and *O. rufa*) populations in artificial nesting media at the site for fruit orchard pollination

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Summary: Preliminary field management studies were made to increase the population density of native early spring *Osmia* species (*O. cornuta, O. rufa*) at fruit tree plantations in Hungary. Initial bee activity around artificial nesting media and the population increase during consecutive years were much smaller at large commercial fruit orchards under intense chemical plant protection than in small mixed fruit plantation with moderate or low pesticide usage. *Osmias* accepted all the four kinds of tested artificial nesting media (reed, bamboo rods, hardwood blocks and light walling blocks with drilled holes). Reed provided the best nesting conditions so it is suggested to be used in the practice. Calculations showed that under favourable conditions more than 50 to 100 thousand incoming flights (arrivals or landings) occurred in a single day around a single bee shelter and this makes enormous number of possible bee visits at fruit tree flowers. For this reason it is strongly recommended to put simple bee shelters filled with artificial nesting media into fruit orchards. Experiences show that the population sizes of *Osmias* increase during consecutive years without any specific additional maintenance except providing shelters and nesting media.

Key words: fruit orchards, bee pollination, *Osmia cornuta, Osmia rufa*, bee shelter, nesting media, propagation of native populations

Introduction

A native early spring mason bee species (*Osmia cornuta*) has been found to be a very effective pollinating agent of fruit trees in Europe (*Bosch* 1994a; *Bosch & Kemp* 2002; *Krunic* et al. 1995; *Maccagnani* et al. 2003; *Pinzauti* 1991; *Vincens & Bosch* 2000a) and as introduced also in North America (*Torchio* et al. 1987). In the nature one more closely related species, *Osmia rufa*, is on wing at the same time in several European countries. Both species are short season early spring bees (Benedek, 1968) exploiting early spring flowers as pollen and nectar sources (*Westrich*, 1990). Efforts were made to discover their general biology and their nesting behaviour (*Bosch* 1992, 1994b; *Bosch & Blas* 1994a, 1994b; *Bosch & Kemp*, 2002; *Marquez* et al. 1994; *Tasei* 1973a, b). Several studies report on their management for controlled fruit tree pollination (*Bosch* 1994c, 1995; *Bosch & Blas* 1994a, b; *Krunic* et al. 1995; *Vincens & Bosch* 2000b, c). Mostly artificially managed populations were used and bee stocks were selected to remove parasitized pupae and individuals perished for other reasons and so controlled number of bees were released at controlled time intervals for pollinating fruit orchards in the proper time. However, little experience is available how the number of natural bee populations can be increased simply by providing them artificial nesting media only with no other supplementary maintenance (e.g. *Bosch,* 1994c). For this approach could be a very simple mode to increase natural pollinating wild bee populations in commercial fruit tree plantations we made some preliminary studies in this respect.

Material and methods

Experimental sites: Experiments were carried out at three fruit plantations at three different localities from 2006 to 2008.

The first place was a fruit and vine garden area outside the settlement at the village Tök (North Central Hungary). At this place several relatively small mixed orchards and vineyards (some 2–3000 sq metres each) were surrounding each other in an area of several tens of hectares large collectively. Minor pesticide usage was typical at this area restricted to some gardens only. The garden, however, where a bee shelter was placed received some 3–5 pesticide treatments a year on fruit trees, the number of treatments varied according to fruit species.

Two other sites (Újfehértó: Eastern Hungary, Siófok: Central Hungary) were some tens of hectares large commercial fruit orchards consisting of some large sour

cherry and apple plantations and also smaller plantations of some other fruit tree species. At these places fruit plantations received intense chemical plant protection involving several insecticide (6–8) and fungicide (10–14) treatments every year.

Trap nests applied: Bee shelters ("wild bee hives") were made of wood panels with four compartments open on the front side and covered elsewhere (*Figure 1*). The shelters had a roof covering the top against rainfall. The shelters had four legs keeping a 60 cm distance between the lower compartments and the soil surface to prevent field rodents to settle.

Four kinds of nesting media were used. One of the four compartments was partly filled with reed (*Figure 2*) having been cut to some 40 cm long pieces. The inner diameter of the reed was some 6–10 mm. The second compartment was partly filled with 40 cm long pieces of bamboo rods (*Figure 3*) with inner hole diameter of some 7–10 mm. The third kind of nesting media was made of 25×25 cm wide hardwood blocks with 10 cm long drilled holes of 8 mm inner diameter (*Figure 4*). Drilled holes were equally made in the front and the rear part of the blocks. Finally the fourth kind of nesting media was made of lightweight walling blocks (*Figure 5*) with similar drilled holes at the front as well as the rear sides as with the hardwood blocks. In the case of all the four kinds of nesting media at least 10 cm space was left between the media and the rear wall of the shelter to enable wild bees to approach nesting possibilities not only from the front but also from the rear side.

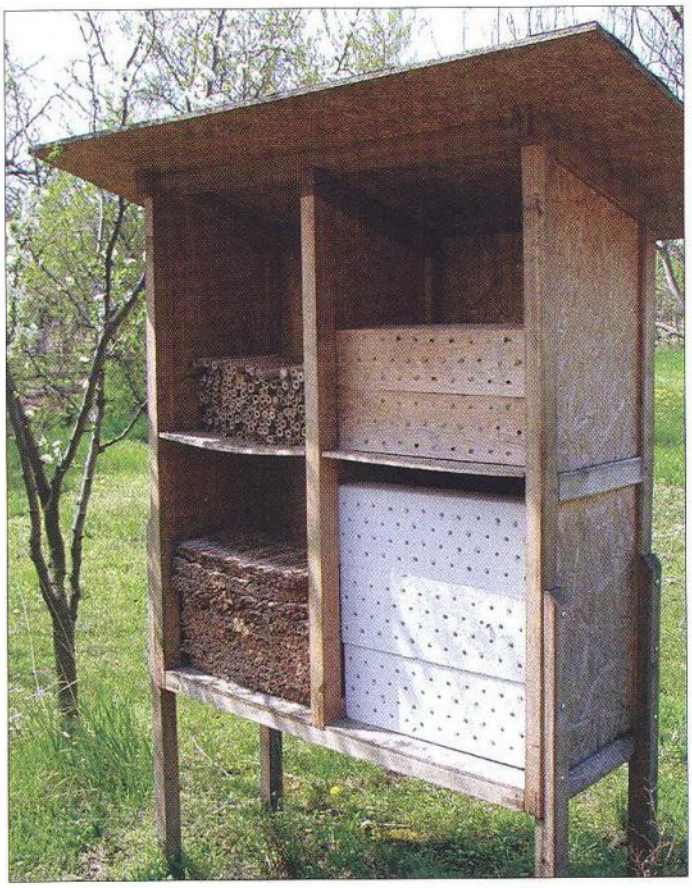

Figure 1 Bee shelter ("wild bee hive") with artificial nesting media for *Osmia* bees

Figure 2 Reed as nesting media with a number of covered *Osmia* nests

Figure 3 Stock of bamboo rods as nesting media for *Osmias* (some covered nests can bee seen)

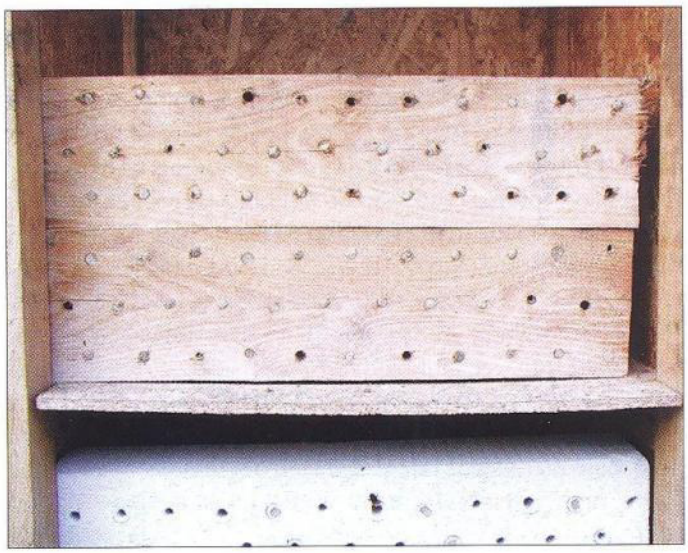

Figure 4 Harwood blocks with drilled holes as nesting media for *Osmias* (largely rejected in 2007 but fully accepted in 2008: a number of covered *Osmia* nests can be seen)

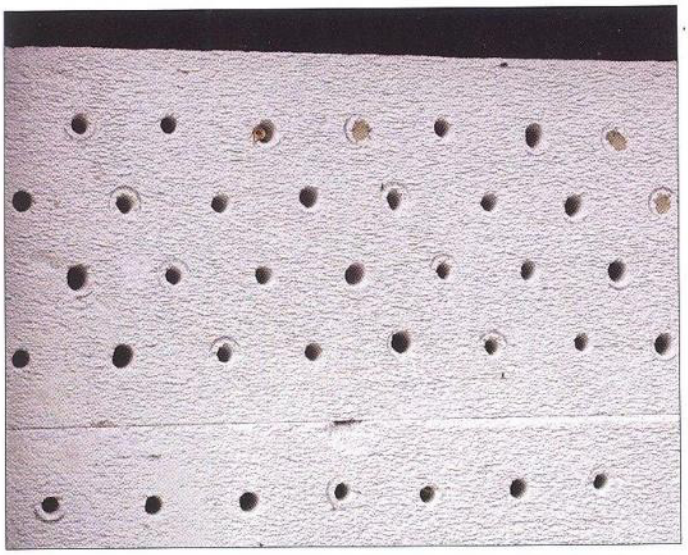

Figure 5 Light walling brick blocks as nesting media for *Osmias* (completely rejected in 2007 but partly accepted in 2008)

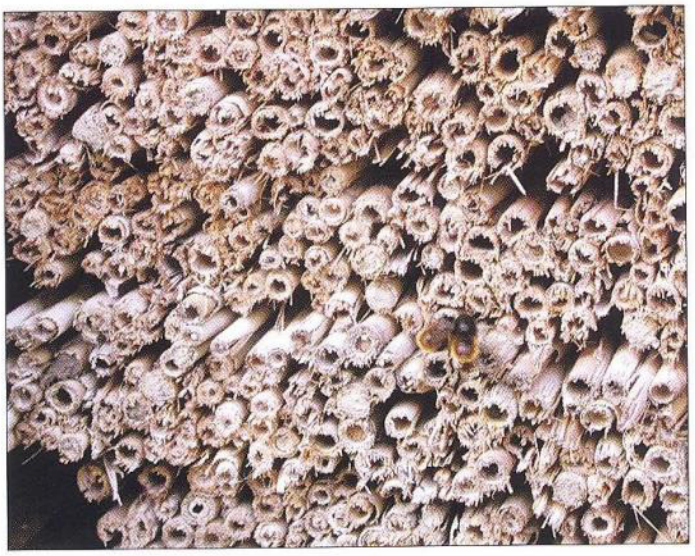

Figure 6 *Osmia* cornuta females approaching their nests under construction at reed

Each shelter was facing south-west with the open front. The shelters were placed by that side of the fruit plantations where no pesticide applications were made at the neighbouring vicinity to prevent direct contact with pesticide applications during the growing season. A single bee shelter was placed at each site.

Observations:

In the first year of the experiments (2006) we were waiting for *Osmias* to inhabit trap nest media, so only the appearance and the presences *Osmias* were detected.

Observations on bee activity were made in the second year (2007). At the locality near Tök bee activity was inspected for 5 minutes periods at the four kinds of nesting media separately on several days, counting the number of arriving and landing bees early or late morning or early afternoon in days with favourable weather for bee activity. Results were expressed as bee (*Osmia*) landings in average at the front side or bee arrivals at the rear part (where landings were unable to see) calculated to one minute periods.

Flowering period of fruit trees was registered in the experimental orchard at Tök and the neighbouring close vicinity.

Finally, by the end of the seasonal the ratio of fully nested (covered) holes was counted at Tök as compared to the total number of available wholes at the four kinds of nesting media tested.

At the two other experimental sites, that is at the commercial fruit orchards at Újfehértó and Siófok no detailed observations could be made, only simple observation of the intensity of incoming and outgoing activity of *Osmias* were estimated for very short observation periods to compare general bee activity measured at the fist site, Tök.

In the last year of the studies (in 2008) nothing more than some very early observations could been made in March and early April on bee activity at the nesting media at a single locality, Tök, because we were obliged to finish the work untimely.

Results

Flowering period of fruit trees in 2007: Table 1 shows the flowering period of fruit tree species in 2007 at the mixed orchards at Tök. Flowering started with almond as early as the 2nd of March and finally quince was in bloom up to the

Table 1 Flowering period of fruit tree species at the mixed orchards at Tök in 2007

Fruit tree species	Phases of flowering period		
	commencement of flowering	mass flowering	end of flowering
Almond	March 2	March 6–15	March 23
Apricot	March 15	March 18–24	March 30
Peach and nectarine	March 21	March 28–April 8	April 15
Sour and sweet cherries	March 31	April 4–10	April 15
Plum	April 6	April 8–11	April 15
Pear	April 10	April 12–18	April 21
Apple	April 12	April 15–22	April 29
Medlar	April 18	April 22–May 2	May 10
Quince	April 22	April 26–May 7	May 14
Flowering time of fruit tree altogether	March 2	March 10–April 30	May 14

Table 2 Bee activity at different artificial nesting media at Tök in 2007 (complete season)

Date and time of observation		Number/minute of landings by *Osmia* females at the front side and arrivals at the rear part of the stocks of nesting media							
		stocks of reed		stocks of bamboo rods		hardwood blocks with artificial holes		light weight (Ytong) walling blocks with artificial holes	
		front	rear	front	rear	front	rear	front	rear
March 5: 11:00–12:00		1	2	2	0	0	0	0	0
March 30: 11:0–12:00		2	1	5	0	1	0	0	0
April 12: 14.30–15.30		6	7	8	0	2	0	0	0
April 13: 11:00–12:00		6	9	6	0	3	0	0	0
April 20: 9.00–10:00		8	13	6	0	2	0	0	0
April 29: 9.00–10:00		6	11	2	0	1	0	0	0
Total	**number of bees/minute**	**31**	**43**	**29**	**0**	**9**	**0**	**0**	**0**
	per cent	**27%**	**39%**	**26%**	**0**	**8%**	**0**	**0**	**0**
Per cent ratio of total bee activity according to the nesting media		**66%**		**26%**		**8%**		**0**	

14th of May. So the flowering period of fruit trees lasted more than two months and that was a period long enough to provide pollen sources to *Osmia cornuta* and *Osmia rufa*.

Seasonal activity of mason bees in fruit orchards: Observed mason bee species appeared as early as early March in all the three experimental years and their activity was going on up to late May or very early June. *Osmia cornuta* was more abundant in the first few weeks in this period and later on *Osmia rufa* become more numerous but, in fact, both species were on wing almost continuously during the whole period mentioned.

Bee activity at different artificial nesting media: Table 2 and *3* demonstrate the results of bee counts at different artificial nesting media at the experimental site near Tök. In spite of the fact that in the first experimental year sporadic bee activity was detected only, in the second year of the experiments (2007) significant number of *Osmias* visited the artificial nesting media (*Table 2*). One year later (in 2008) bee activity was even much more frequent (*Table* 3) than in 2007. The rate of increase seems to be two to three folds.

Interestingly in the case of reed and bamboo both the front and the rear sides of the nesting media were frequented and accepted by females to make their nests in 2007 but the rear parts of wooden blocks and light weight walling bricks were neglected. In 2008, when the number of occupied (fully nested) holes was much greater in reed and bamboo, both wooden and walling blocks were substantially more frequented than in 2007 and also their rear sides were more or less utilized (*Table 3*).

Table 3 Bee activity at different artificial nesting media at Tök in 2008 (not a complete season)

Date and time of observation		Number/minute of landings by *Osmia* females at the front side and arrivals at the rear part of the stocks of nesting media							
		stocks of reed		stocks of bamboo rods		hardwood blocks with artificial holes		light weight (Ytong) walling blocks with artificial holes	
		front	rear	front	rear	front	rear	front	rear
March 5: 11:00–12:00		1	2	2	0	0	0	0	0
March 8: 10:00 -11:00		36	18	8	4	5	2	4	0
March 30: 12:00 -13:00		21	16	11	6	6	4	6	2
April 12: 11:00-12.00		32	22	15	7	8	3	9	3
Total	**number of bees/minute**	**79**	**56**	**34**	**17**	**19**	**9**	**9**	**5**
	per cent	**35%**	**25%**	**15%**	**7**	**8%**	**4%**	**4%**	**2%**
Per cent ratio of total bee activity according to the nesting media		**60%**		**22%**		**12%**		**6%**	

In fact, both in 2007 and 2008 reed was much more frequented than bamboo and wooden blocks as well as light weight walling blocks were much less utilized than bamboo.

Ratio of occupied (fully nested and covered) holes: All the four kinds of nesting media were accepted by the two *Osmia* species. Taking the number of nesting holes into consideration acceptance at the front sides was fairly similar in the case of reed, bamboo and hardwood blocks being round 25 to 30 per cent at each (*Table 4*). In case of bamboo and hardwood occupied holes existed at the front side only and no one was found at the rear side in 2007 (*Table 4*). Light weight walling blocks neither were accepted at all in 2007 as nesting material (*Table 4*). Contrarily, in the case or reed almost as many occupied holes existed in the rear side than in the front (*Table 4*). Accordingly, taking the total number of available holes into account (front plus rear sides) reed housed twice as much complete nests than other nesting media. In 2008 when bee activity was much more intense around the bee shelter (*Table* 3), and so more holes were becoming occupied, surprisingly rear sides of bamboo and hardwood were also accepted in some extent and also walling blocks started to incorporate some fully occupied and covered holes. The final calculation of acceptance, however, was impossible to make because of the untimely closing of the experiments.

Table 4 Ratio of occupied, fully nested (covered) and empty holes at different nesting media at Tök in 2007

Rows from the top		Ratio of fully nested holes: total number/fully nested (covered)			
		stocks of reed	stocks of bamboo rods	hardwood blocks with artificial holes	light weight (Ytong) walling blocks with artificial holes
		Number of holes	Number of holes	Number of holes	Number of holes
row 1	front	44/2	39/12	11/5	0
	rear	44/4	0	0	0
row 2	front	46/7	52/16	11/3	0
	rear	46/19	0	0	0
row 3	front	42/4	51/18	11/3	0
	rear	42/8	0	0	0
row 4	front	50/14	44/13	11/2	0
	rear	50/30	0	0	0
row 5	front	45/8	49/20	11/2	0
	rear	45/11	0	0	0
row 6	front	38/6	–	11/10	–
	rear	36/15	–	0	–
Total	front	235/39	–	–	–
	rear	235/87	–	–	–
Grand total (front plus rear)		**470/124**	**235/79**	**66/25**	**0**
Ratio of covered holes		**26%**	**34%**	**33%**	**0**

Conclusions

Natural propagation of native early spring *Osmia* species (*O. cornuta, O. rufa*) seems to be a proper method to increase pollinating wild bee density around fruit tree plantations in Hungary.

Great differences were observed in the rate of initial bee activity around nesting media and in the population increase during consecutive years at the three different experimental sites. At two large commercial fruit orchards under intense chemical plant protection much smaller bee activity was found in the first year around the artificial nesting media than at a small mixed fruit plantation with moderate or low pesticide usage. Fast population increase was detected at the small mixed fruit plantation from year to year. At the commercial orchards the rate of population increase was much smaller but it was also detected gradually. Therefore, there is the hope that substantial gradual population increase can be achieved at commercial plantations, too, at least the population increase will not be so rapid than in small, mixed fruit gardens with much less pesticide impact.

Applying more bee shelters, more *Osmias* can be expected during consecutive years. The only condition is to avoid their poisoning du to pesticide applications in the orchard. Accordingly, bee shelters should be placed at pesticide free safe points at the sides of (and not inside) the plantations where no pesticide drifts can be expected even from neighbouring areas. Population increase will probably much faster at plantations where the surrounding vicinity is comprised of mixed fruit orchards under a moderate or low impact of pesticides. It is an additional important factor, that the mixed orchards support pollen and nectar sources to the *Osmia* species in question during their whole period of activity from March till end of May.

Osmias have accepted all the four kinds of tested artificial nesting media during the three years of the experiments. Reed provides much more nesting possibility at a unit of surface than bamboo as well as than hardwood blocks or light weight walling blocks. In the case of reed both the front and the rear side was accepted and utilized for nesting purposes even at the beginning of the experiments

Table 5 Total estimated bee *(Osmia cornuta + O. rufa)* activity during a day at different artificial nesting media at Tök in 2007

Calculations		Bee activity as dependent on the nesting media			
		at stocks of reed	**at stocks of bamboo rods**	**at hardwood blocks with artificial holes**	**at light weight (Ytong) walling blocks with artificial holes**
A) in 2007					
Total estimated (calculated) daily bee activity (landings or arrivals/minute of females) at nesting media during an 8 hours period (between 9:00 and 17.00 o'clock)	landings/minute at the front side	14 880	13 920	4 320	0
	arrivals/minute at the rear part	20 640	0	0	0
Total daily activity at the front plus the rear parts in 2007		**35 520**	**13 920**	**4 320**	**0**
B) in 2008					
Total estimated (calculated) daily bee activity (landings or arrivals/minute of females) at nesting media during an 8 hours period (between 9:00 and 17.00 o'clock)	landings/minute at the front side	37 920	16 320	4 120	4 320
	arrivals/minute at the rear part	26 880	8 160	4 320	2 400
Total daily activity at the front plus the rear parts in 2008		**64 800**	**24 480**	**8 440**	**6 720**

when only small number of available holes were occupied. In the case of bamboo and hardwood only the front sides were accepted at first and the rear sides were accepted in the third year only when the number of available free holes started to decrease significantly. For this reason, first of all reed should be suggested to use in the practice.

Taking the figures on bee activity around artificial nesting media into account (*Tables 3* and *4*) total daily bee activity can be calculated as in *Table 5*. The figures in the table indicate that enormous number of flower visits can be expected by *Osmia* bees around a single bee shelter. In 2007 more than 50 thousand and in 2008 more than 100 thousand incoming flights (arrivals or landings) were calculated by female bees around a single shelter on a single day being favourable to bee activity (*Table 5*). This indicates the same number of foraging trips by female bees on a favourable day

Table 6 Potential importance of *Osmia cornuta* and *Osmia rufa* in the pollination of fruit tree species in Hungary

Fruit tree species	Osmia species					
	Osmia cornuta			Osmia rufa		
	coincidence of seasonal activity of bees to the flowering period of the fruit species	**intensity of flight activity during the flowering period**	**potential use in the pollination**	**coincidence of seasonal activity of bees to the flowering period of the fruit species**	**intensity of flight activity during the flowering period**	**potential use in the pollination**
Almond	very good	intense	very important	bad	minor	minor
Apricot	very good	intense	important	bad	minor	minor
Peach and nectarine	very good	intense	important	medium	medium	medium
Sweet cherry	very good	intense	important	very good	intense	important
Sour cherry	very good	intense	important	very good	intense	important
Plum	very good	medium	important	very good	intense	important
Pear	good	medium	important	very good	intense	important
Apple	good	medium	important	very good	intense	important
Quince	bad	minor	negligible	good	medium	minor
Medlar	bad	minor	negligible	good	medium	minor

around the shelter. This figure should be multiplied by at least 15–20 to calculate possible number of flower visits by bees flying around a single bee shelter.

As a conclusion from above considerations it is strongly recommended to put simple bee shelters (for example as illustrated in *Figure 1*) filled with artificial nesting media to fruit orchards and leave them at the site for years. *Osmias* seem to exploit this kind of nesting sources and their numbers seem to increase during consecutive years without any specific additional maintenance. Successful propagation of *Osmias* via this very simple method can result in an enormous number of bee visits at fruit tree flowers with practically no cost.

The potential importance of *Osmias* may be different for individual fruit tree species because the coincidence of their seasonal activity and the flowering period of fruit tree species as well as the intensity of their flight activity during the flowering are rather different. Additionally, there are some differences between the seasonal activities of the two species involved. Taking these factors into account their potential importance can be estimated as summarized in *Table 6*. So in the case of almond the importance of *Osmia cornuta* is very high. The same species is important for apricot, peach and nectarine, sweet and sour cherry, plum, pear and apple. The other species, *Osmia rufa*, is less important for early flowering species (almond, apricot, peach and nectarine) but more important for cherries, plum, pear and apple. On the other hand, late flowering fruit trees (quince and medlar) take a minor benefit of *Osmia* pollination because their flight activity is declining that time. Consequently, except quince and medlar at all other kinds of temperate zone entomophilous fruit tree species use of bee shelters and artificial nesting media for *Osmias* seems to be a profitable method to increase yields.

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