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Nectar Production for the Hungarian Honey Industry

Ágnes Farkas[1*] • Edit Zajácz[2]

[1] Institute of Pharmacognosy, Faculty of Medicine, University of Pécs, Rókus u. 2., H-7624 Pécs, Hungary
[2] Research Institute for Animal Breeding and Nutrition, Research Group for Honeybee Breeding and Biology, H-2100 Gödöllő, Isaszegi út, Hungary

Corresponding author: * **farkasa@gamma.ttk.pte.hu**

ABSTRACT

The review gives an overview of the nectar and honey production of the most important melliferous plants in Hungary, where apiculture is a small but significant segment of agriculture. The climatic and soil conditions are favourable for beekeeping, with a flowering period that lasts from April to September, offering abundant nectar sources for bees. The most important bee-pollinated plants yielding unifloral honeys are: black locust/robinia (*Robinia pseudoacacia* L.), lime (*Tilia* spp.), rape (*Brassica napus* L.), sunflower (*Helianthus annuus* L.), sweet chestnut (*Castanea sativa* Mill.), goldenrod (*Solidago canadensis* L.), milkweed (*Asclepias syriaca* L.) and wild garlic (*Allium ursinum* L.). Robinia and milkweed honeys belong to the speciality honeys, so-called “Hungaricums”, while robinia and sunflower honey are popular export products of Hungary. Among the rare unifloral honey sources the nectar of *Brassica*, *Fagopyrum*, *Melilotus*, *Phacelia* and *Trifolium* species can be mentioned. Other nectar-producing plants of the Hungarian flora contribute to multifloral honeys, which are also popular with consumers. The nectar of early blooming fruit trees is important for honeybees in the brood rearing season, but rarely can provide unifloral honey, as well. The quantity and quality of the available nectar sources can show huge differences depending on the season, environmental conditions, the blooming stage of the plant, the age of the flowers and the time of the day.

Keywords: bee forage plants, black locust, lime, milkweed, oilseed rape, phacelia, sunflower

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INTRODUCTION

Hungary traditionally belongs to countries with significant honey production. According to the data of the Society of Hungarian Beekeepers, there are 15-17,000 beekeepers with 600-900,000 colonies in Hungary (out of 50 million colonies worldwide), having an essential role in maintaining the ecological balance. In the past decade, honey production

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ranged from 10,000 to 22,000 t, averaging 15,000 t/year (out of 1.1 million tons in the world) (OMME, National Program of Beekeeping 2004). The honey bee density in Hungary is one of the highest in the world. However, the 20 kg honey yield per colony (900,000 bee colonies, 18,000 tons honey) is very low, but can be sold unrestrictedly. A possible solution could be the drastic decrease in the number of bee colonies, especially that of bee density, or the improvement of bee pasture. The first alternative cannot be expected from an economic, social or environmental aspect either, therefore the improvement of bee pasture is desirable (Mariák 2003). The climatic and soil conditions of Hungary are favourable for beekeeping, with a relatively long flowering period that lasts from April to September, when abundant nectar sources are available for bees. Results, however, may change year to year, depending on the weather (Örösi 1968).

In Hungarian honey production overall, robinia honey has a decisive role, followed by fruit trees, oilseed rape, ramson, milkweed, lime, sweet chestnut, sunflower, phacelia, sages, lavender, mints, buckwheat etc. The quality of Hungarian honeys can be competitive also in the international market. The quality control system can guarantee that only excellent honey is produced and sold both for inland consumption and for export purposes.

The present paper intends to give an overview of the nectar and honey production of the most important melliferous plants in Hungary, mainly based on literature that has been available so far only in Hungarian. Page limits did not allow to summarise all relevant literature on a given nectar plant, thus the paper focuses rather on the specific Hungarian aspects of bee pasture. However, with the aim of comparing or completing data on nectar production or nectary structure of plants growing also outside Hungary, some relevant articles from foreign authors have been cited throughout the paper. Nevertheless, if not otherwise indicated, observations and data were recorded in Hungary. Also, instead of providing the full botanical description of the presented nectar plants, rather their various uses and ecological requirements in Hungary were highlighted.

With the development and modification of agricultural practices some of the discussed plants have lost their importance in Hungarian apiculture, but the knowledge of their nectar production might still evoke interest and provide valuable data for apiculture in other countries.

EARLY SPRING BEE PASTURE

Cornus mas L., *Cornaceae* (Cornelian cherry dogwood or European cornel)

Cornelian cherry dogwood flowers already in February or March (**Fig. 1A**), providing an early pollen and nectar source for developing colonies of honeybees (Nyárády 1958; Klotz 1990; Halmágyi 1991). So it would be desirable to plant this shrub in order to improve bee pasture, and also for medicinal use (Vicze 1986).

Salix (willow) species, *Salicaceae*

Willows are the most valuable plants of early spring bee pasture, blooming for 3 weeks, following elms (Sas 1956a). Providing an abundant early nectar and pollen source, they have an important role in the spring development of bee colonies (Halmágyi and Suhayda 1961; Bauecker 1967; Tompa 1973; Klotz 1990). From the staminate catkins honeybees can collect both nectar and pollen, while pistillate flowers provide only nectar (Tompa 1973; Klotz 1990). Bees can collect also honeydew from some willows towards the end of summer, which can be however harmful for them as winter feed (Halmágyi and Suhayda 1962a; Tompa 1973). Besides floral nectaries, extrafloral glands can also be observed on the petioles of *Salix* species (Gulyás 1964). Willows have a high importance in apiculture, because colonies foraging on willows will thrive by the time of the main honey flow of black locust. Willow honey is mostly consumed up by the nest, used in brood rearing (Tompa 1973), but sometimes willows can yield even surplus honey (Sas 1956a). Where willows grow in great numbers, it is worth introducing one's bee colonies there (Tompa 1973). Their propagation is desirable not only for apiculture, but also for forestry. The industrial utilisation of willows has increased in Hungary from the 1950s and '60s (Bauecker 1967).

The majority of willows start blooming at the beginning of March, but some species flower until the end of June (Tompa 1973; Klotz 1990). In mild weather some species may flower already in February. Therefore, willows may enhance the development of bee colonies already at the time when it is not usual to feed them (Halmágyi and Suhayda 1961). The first blooming species is usually *S. daphnoides* Vill. (violet willow), its catkins appearing already in February. Two varieties are known: *S. daphnoides* var. *pulchra* Wim. and *S. daphnoides* var. *pomeranica*. The next species to flower is *S. viminalis* L. (osier) and its hybrid with *S. caprea* L., called *S. smithiana* Willd., blooming in March and readily visited by honeybees (Bauecker 1967). *S. caprea* L. (goat willow) itself is also one of the earliest flowering species, a tall shrub or smaller tree, wide-spread across Europe and Asia (Bauecker 1967; Péter 1975a). A few weeks after the above species, *S. alba* L. (white willow) starts blooming in March-April. The most well-known variety, *S. alba* var. *tristis* Gaud. *S. eleagnos* var. *angustifolia*, is often planted in parks, and flowers in late March, early April, simultaneously with foliation. *S. repens* var. *rosmarinifolia* Koch. flowers in early April and prefers calcareous soils (Bauecker 1967). *S. fragilis* L. (crack willow) and *S. purpurea* L. (purpleosier willow) bloom also in March-April, *S. triandra* L. in April-May, all of them offer-ing nectar and ample pollen (Halmágyi and Suhayda 1962a). From the latest blooming willows, *S. amygdalina* L. is worth mentioning. Its catkins appear in May, together with or later than foliation. Its long-blooming variety flowers also in summer (Bauecker 1967).

***Salix alba* L. (white willow)** is a 6-25 m high, fast growing tree, living in Europe, Asia and North Africa (Bauecker 1967). It is the most common willow species in Hungary, occurring in great stands in willow-poplar gallery forests and on flood areas (Halmágyi and Suhayda 1961), where it is the most important early spring nectar plant, providing abundant nectar and pollen. Honeybees tend to neglect other willows when white willow is in bloom (Halmágyi and Suhayda 1962a), and it is worth keeping bees there (Gulyás 1984a). White willow flowers for two weeks in March-April, simultaneously with foliation (Halmágyi and Suhayda 1961; Gulyás 1984a).

White willow is dioecious (Gulyás 1984a), the flowers in the catkins opening acropetally (Halmágyi and Suhayda 1961). The staminate catkins are a bit longer than pistillate ones, and more conspicuous because of their yellow colour. At the base of the staminate flowers there are 2 nectar glands, while only one can be found next to the pistillate flower. Nectar can be measured in the same flower for 2 or rarely 3 days (Halmágyi and Suhayda 1961; Gulyás 1984a). Nectar was often found in wilting flowers with brownish anthers, although much less and more concentrated than in young flowers (Halmágyi and Suhayda 1961). The nectary of the pistillate flowers is less developed, and not each of them is able to secrete nectar (Gulyás 1984a). Staminate flowers secrete much more nectar than pistillate ones (Halmágyi and Suhayda 1961), and they are more significant also because they are open for a longer time and are present in greater numbers. In the majority of pistillate flowers, no nectar was found at the time when high amounts of nectar were measured in staminate flowers. Therefore it was not surprising that male trees were visited by a large number of honeybees, and only few of them could be seen on female individuals (Halmágyi and Suhayda 1961; Gulyás 1984a).

Halmágyi and Suhayda (1961) measured 0.010-0.012 and 0.0352-0.0428 (maximum 0.3 mg) nectar/flower and 0.007 and 0.024 mg sugar value in pistillate and staminate

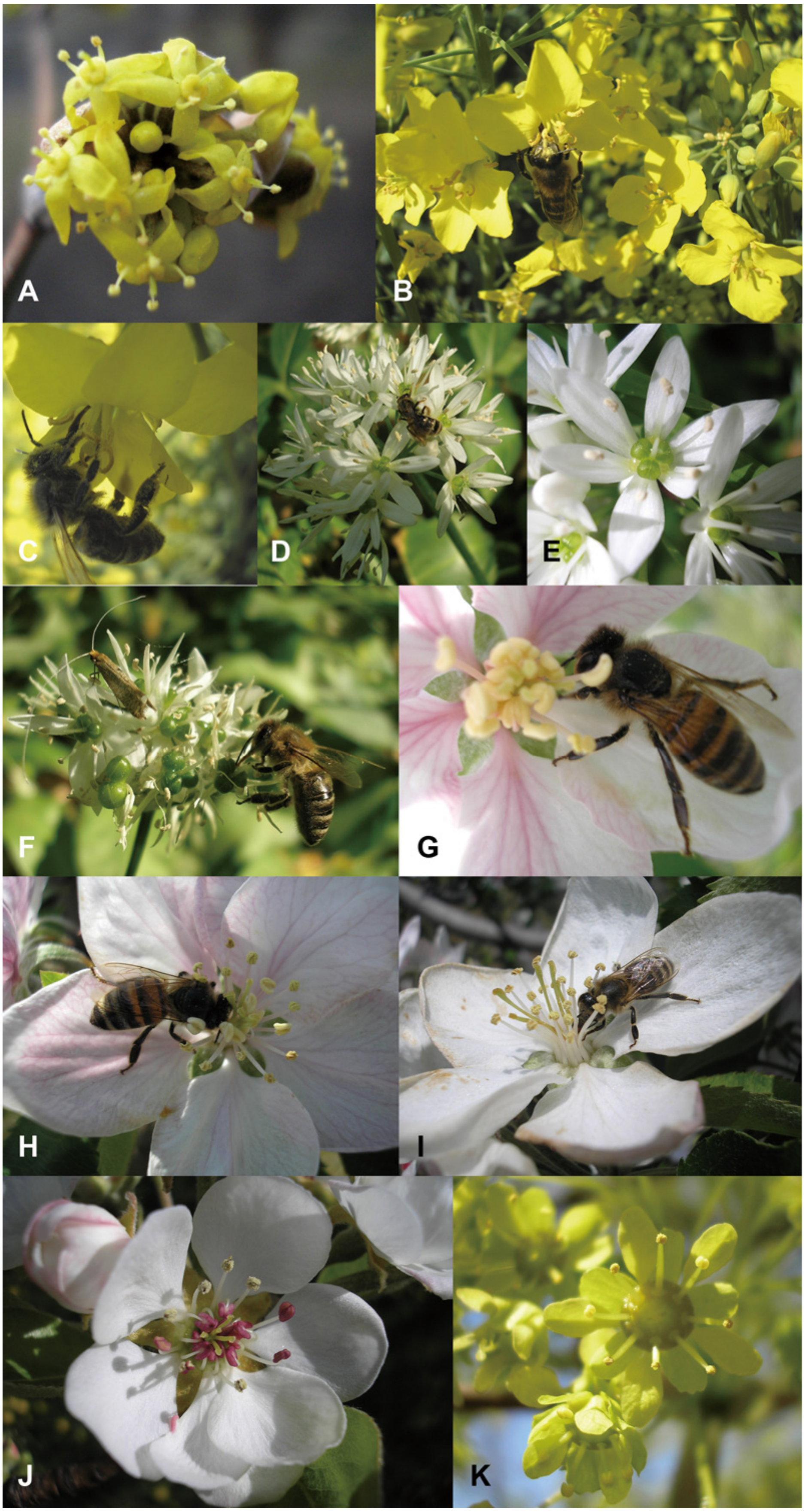

Fig. 1 Flowers of spring bee pasture in Hungary. *Cornus mas* flowers before foliation (**A**), Pollen shedding flowers of *Brassica napus* var. *oleifera* are the best nectar producers (**B, C**), *Allium ursinum* (**D-F**): Inflorescence (**D**), Nectar drops at the base of the ovary (**E**), Old flowers are still visited by various insects for nectar (**F**), Nectar can be extracted with difficulty from young apple (*Malus domestica*) flowers (**G**), but can be reached more easily by honeybees in pollen shedding (**H**) and old flowers (**I**), The nectary is exposed, easy to access in pear (*Pyrus communis*) flowers (**J**), Disc-shaped nectary in the flowers of *Acer platanoides* (**K**).

flowers, respectively. Sugar content varied between 30-70% depending on relative humidity. Although sugar values are low, there are 100-140 small flowers in a single catkin, which increases the apicultural significance of the plant. Cold nights do not have a negative effect either on the opening of flowers or nectar secretion (Halmágyi and Suhayda 1961). The nectar of white willow contains sucrose, glucose and fructose. Daily honey flow may reach 1-2 kg/colony. Additionally, there are 2-5 extrafloral nectaries on the petioles that produce nectar only in spring (Gulyás 1984a).

***Salix caprea* L. (goat willow)** is dioecious, distinguished from other willows by not requiring a wet habitat. Since it serves as an ample pollen and nectar source in early spring (end of March), and thus has a very beneficial effect on spring development of bee colonies, it is highly valued in apiculture (Vámos 1959; Péter 1975a). Under favourable weather conditions good colonies are able to store great amounts of honey, and weight gains might be comparable to those of black locust through a few days (Vámos 1959; Suhayda 1991; Szalay 1992). According to Vámos (1959, 1963, 1969), nectar production and honey flow is the best when flowering is rapid, lasting only 4-6 days. The most favourable temperatures for nectar secretion are 18-20ºC. Under such conditions daily weight gain might reach several kg, e.g. in 1959 the highest weight gain recorded was 10 kg/colony. Total weight gain was 20 and 10 kg in 1968 (favourable weather) and 1969 (average year), respectively (Vámos 1969). In Europe, the estimated honey potential is 10-25 kg/colony and 26-120 kg/ha. The colour of willow honey is orange (Halmágyi 1991).

Nectar is secreted at the base of the stamens in the staminate flowers and at the base of the pistil in pistillate flowers. Honeybees visit staminate flowers more frequently, since they can collect not only pollen, but also significant amounts of nectar. In staminate flowers, nectar weight is 0.19-0.48 mg, and sugar content varies between 20.0-47.6%, depending on weather. Sugar value is usually 0.04-0.08 mg, and sometimes reaches 0.11 mg (Péter 1975a).

SPRING BEE PASTURE

Allium ursinum L., *Alliaceae* (ramson or wild garlic)

Ramson is wide-spread in Central Europe from the plains to subalpine regions (Soó 1973-1980; Nagy 1997). Ramson grows wild in Hungary in hornbeam-oak and beech forests of the Mts. Bakony and Mecsek (Transdanubia), but it is almost absent from Eastern Hungary (Kevey 1978). Flowering in late April, early May (**Fig. 1D**), it provides an excellent spring bee pasture with good nectar flow. Honeybees collect both nectar and pollen from morning to evening (Vámos 1959; Péter 1975b).

The bee pasture is huge; ramson plants form an almost continuous stand e.g. on the northern slopes of Mt. Mecsek. It can propagate well both with bulbs and seeds, and thus it is spreading, despite being collected as a medicinal plant, both for domestic usage and export purposes. Its medicinal effects are similar to those of garlic; it reduces blood pressure, acts against arteriosclerosis, and can be used also as an anthelmintic, against diarrhoea and indigestion (Nagy 1997, 2005; Szabó and Perédi 1999).

Its flowering period overlaps with oilseed rape (*Brassica napus*), but the nectar flow is uneven and does not give as much as rape, even in favourable weather (Nagy 2005). According to Péter (1975b), ramson flowers produce 0.16-0.42 mg nectar/day, with significant sugar content (mean value: 52.13%). Its sugar value is 0.14-0.25 mg in sunny weather, but remains below 0.1 mg in changeable, cool weather.

Our own investigations in Mt. Mecsek from 2005 to 2007 confirmed that ramson flowers produce little (extreme values are 0.1-1.8 μl/flower), but highly concentrated nectar. In the petal expansion stage nectar production is exceptional. Freshly opened flowers secrete more nectar, but the best nectar producers are the pollen shedding flowers. Nectar refraction reaches the highest values (often around 50%) in pollen shedding and old flowers (**Fig. 1F**). The duration of nectar secretion in a single flower is usually four days. From the three main nectar sugar components (sucrose, glucose and fructose), no sucrose could be detected with thin layer chromatography in the nectar samples of 2005. In 2006, however, all three sugars were present in the nectar. The laboratory analysis of 2007 samples will answer the question if these differences were due to the effect of the year or can be related to various habitats.

A. ursinum, similarly to other members of *Alliaceae*, possesses a septal nectary. The gland appears in the form of three radial slits and surrounding glandular tissue along the septa of the gynoeceum. At the basis of the pistil the epithelial cells of the nectary are palisade, usually arranged in two rows. As a continuation of the slit surrounded by epithelial cells, a narrow canal can be observed, which is limited by isodiametric cells. Nectar can get to the surface through the pores at the middle or the base of the ovary (**Fig. 1E**) (Farkas and Molnár 2005).

At the time of blooming the plant emits a strong garlic odour that can be smelled also in the nectar and in front of the beehives. However, the odour of ripe ramson honey is different, with a pleasant, special aroma, its colour being dark yellowish-greenish or greenish-brownish, granulating easily (Péter 1975b; Nagy 1997, 2005). Ramson honey can be sold at higher prices than robinia honey. It has been suggested that it should be one of the Hungaricums, however, it cannot be produced on a regular basis and sufficient amount. In certain years the needs of Hungarian consumers cannot be satisfied either, especially if the weather is cool and rainy in the blooming period (Nagy 2005).

From related melliferous *Allium* species, ***A. cepa* L. (onion)** is the most important, cultivated all over the world. Some Hungarian onion cultivars are world-famous. In Hungary, onion flowers in June-July for 3-4 weeks (Szilva 1968a; Molnár1981). For apiculture only the plots left for seed growing are valuable. Honeybees visit the flowers for both nectar and pollen. Nectar accumulates between the base of inner stamens and the ovary (Szilva 1968a).

Guba (1964) observed that honeybees frequented onion flowers all the time, collecting mainly pollen and only little nectar. According to his measurements hive weights did not indicate the accumulation of onion honey, but intensive brood rearing could be observed during the time of bloom.

Onion honey is yellow, viscous, smells and tastes like onion in the beginning, but it loses the unpleasant smell later on (Guba 1964; Szilva 1968a; Molnár 1981). In certain pulmonary illnesses, a positive effect is attributed to onion honey (Lakatos 1989).

Brassica napus L., *Brassicaceae* (oilseed rape and canola)

Several *Brassica* species are important crop plants in Hungary, similarly to other temperate regions of the world. The most important, both as an oilseed and honey crop is *Brassica napus* L. var. *oleifera* Metzg., oilseed rape, whose sown area was 145,000 ha in 2006 (Jakubecz 2006), showing an almost 3-fold increase as compared with 50,000 ha 25 years ago (Eöri 1983). In Hungary, oilseed rape is cultivated all over the country; both autumn and spring varieties of *B. napus* v. *oleifera* are grown, as well as *B. rapa* [syn. *campestris*] v. *oleifera* (Sajermann 1971). Medium-compact brown forest soils are the most suitable for oilseed rape cultivation (Nikovitz and Szalai-Mátray 1985).

Rapeseed oil has been used for culinary purposes since the ancient times, but it is also suitable for preparing ointments, especially in veterinary practice (Eöri 1983). Since high erucic acid content in the oil can be unwholesome, breeders have made an effort worldwide to develop cultivars with low (0-5%) erucic acid content. However, such cultivars proved to be more frost-sensitive in Eastern Hungary (Nikovitz and Szalai-Mátray 1985).

Oilseed rape provides the first mass blooming (**Fig. 1B**) in the early spring period (Eöri 1983) and is considered to be an excellent early nectar plant that fills the gap between fruit tree and black locust bloom (Sajermann 1971; Bede Fazekas 1974). Based on a ten-year study in Hungary from 1981 to 1991, flowering began in May in 70% of the years, and in April in 30% of the years (Halmágyi *et al*. 1992). It can provide bee pasture for 3 bee colonies/ha for as long as 5 weeks thanks to differences in blooming time of various cultivars (Eöri 1983). *Brassica rapa* var. *rapifera*, flowering from April until July, also provides nectar, but rather ample pollen for honeybees (Szilva 1968b; Benedek 1974).

Oilseed rape is partially (70%) self-fertile and mainly autogamous (Rudloff and Schweiger 1984), but the plant still benefits from insect visitation. The flowers attract large numbers of honeybees, which can ensure cross pollination and higher levels of pod set (Mesquida *et al*. 1988), while collecting pollen and nectar (Nyárády 1958; Szilva 1968a; Benedek *et al*. 1972; Benedek 1974; Péter 1975c; Nikovitz *et al*. 1982; Eöri 1983). The inner nectaries of rape flowers can be reached easily by honeybees (**Fig. 1C**), and in deeper flowers they can suck the nectar from the side. The amount of nectar and pollen collected by honeybees varies from cultivar to cultivar, and bee visitation is largely influenced also by weather conditions (Szilva 1968a; Eöri 1983).

In *B. napus* flowers, four nectaries develop in the form of a crescent or ring around the base of the filaments (Szilva 1968a), two at the inner side of the two short filaments (lateral nectaries), the other two at the base of the long filaments, on the outer side (median nectaries). In agreement with Beutler (1930) who considered the lateral and median nectaries as "fertile" and "sterile", respectively, Nikovitz and Szalai-Mátray (1985) suggested that the median nectaries be considered as modified filaments rather than nectar glands, since they do not produce nectar (Nikovitz *et al*. 1982), and no nectariferous tissue can be seen at the connection with the pistil base. Davis *et al*. (1994, 1998), however, could detect limited nectar production by median nectaries, too, using more refined analytical techniques. They also confirmed that there is a difference in the anatomy of the lateral and median nectary, reflecting differences in their nectar production. The lateral pair has an extensive phloem supply and produces most of the flower's nectar, whereas the median pair is supplied by limited phloem and produces relatively little nectar (Davis *et al*. 1986, 1994, 1998). Microscopic studies revealed that in some cases lateral glands were connected, by narrow strands of nectarial tissue, with adjacent median glands (Davis *et al*. 1996). In six *Brassicaceae* species, including *B. napus*, on average 95% of the total nectar carbohydrate was collected from the lateral nectaries, and nectar from these glands possessed a higher glucose/fructose ratio (1.0-1.2) than that from the median nectaries (0.2-0.9) within the same flower (Davis *et al*. 1994, 1998). The difference in the nectar production of the two types of glands is reflected in the behaviour of honeybees: median nectaries of oilseed rape are only occasionally visited, while most visits are confined to the lateral nectaries (Free and Nuttall 1968).

On the basis of nectar production data from ten years, Sajermann (1971) classified oilseed rape as a nectar plant with medium honey flow. It provides good bee pasture in favourable weather, and the most valuable period is the beginning and mid-bloom. Bede Fazekas (1974) measured good nectar flow at or above 20°C and the greatest honey flow in the first half of bloom, usually at the end of April, beginning of May. In accordance, Free and Nuttall (1968) observed in Great-Britain that the mean number of honeybees and bumblebees counted per day decreased as the stage of flowering advanced. They also found that on 8 of the 9 days the number of honeybees collecting only nectar increased during the day. Similarly, during field observations in Brazil from 9.00 h to 15.00 h, the population density of pollinators increased from 11.00 h to 15.00 h, and simultaneously, larger nectar yield was recorded in this period (Mussury and Fernandes 2000). In hot, windy weather, flowers lose their nectar content (Várallay 1968). The changeable spring weather often decreases or completely ceases nectar secretion (Sajermann 1971).

According to Benedek (1974), oilseed rape flowers secrete nectar for 1.5-2 days. Nectar weight/flower varied from 0.20 to 1.13 mg (averaging 0.74 mg), with sugar contents ranging from 5 to 70% (averaging 36%) under Hungarian conditions. He also reported that daily nectar production can be as high as 9 to 27 mg/flower (much higher compared to any other studies, probably due to several samplings throughout the day), with a sugar content of 32-39%. Nikovitz *et al*. (1982) observed that nectar production started already in the yellow bud stage and was continuous throughout the lifetime of a flower. In 'Savaria' nectar drops could be seen even after the wilting of the stamens, following fruit set. In the 1982 study of 6 cultivars, nectar weight and sugar content varied to a great extent depending on the cultivar, region, and time of sampling. Nectar weight averaged 0.37-0.79 mg/flower (extreme values: 0.02-1.39 mg), sugar content was 29.43-42.95% (11-69%), mean sugar value varied from 0.14 to 0.29 mg (0.01-1.39 mg). The apicultural ranking of the studied cultivars on the basis of sugar value was: 1. Új-Fertődi 2. Savaria 3. IR-I. 4. IR-022 (Hungarian cultivars) 5. Gorczanski (Polish cultivar) 6. Primor (French cultivar). From the Hungarian cultivars low in erucic acid, 'GK Savaria' can be highlighted, a cultivar with large flowers and easy-to-access nectaries, whose sugar value was the second highest. Honeybees could collect more nectar from cv. 'Gorczanski' compared to 'Új-Fertődi' during the same interval, because of the synchronized blooming of the first cultivar (Eöri 1983). However, the erucic acid content of both cultivars was about 50%, which allowed only the industrial application of the oil (Nikovitz *et al*. 1982).

Nectar production of some oilseed rape cultivars that are currently grown in Hungary was studied by Farkas (2007). Young and pollen shedding flowers were the best nectar producers, but in some cases nectar was found already in the balloon (yellow bud) stage, and also in old flowers with all anthers dehisced, in agreement with Nikovitz *et al*. (1982). In 2005 in 'Bekalb Catonic', both nectar volume and refraction increased in the order of balloon stage, young open flower, to pollen shedding flower. Pollen shedding compared to young flowers produced more than twice as much nectar (2.3 μl and 0.8 μl, respectively) under sunny and windy weather conditions and even four times more nectar (4 μl and 1 μl, respectively) under cloudy weather conditions. Similar trends could be observed in the other two cultivars ('Baldur' and 'Colombo'), suggesting that weather conditions had a pronounced effect on nectar production/flower and sugar concentration in the nectar. Nectar refraction of flowers in the balloon stage was significantly lower compared to young and pollen shedding flowers in 'Bekalb Catonic' (8-15%, 14.8-31.4% and 15-37%, respectively) and in 'Baldur' (8.2-10.0%, 7.3-31.1% and 7.3-36.9%, respectively). Also, in 'Colombo' and 'Baldur', refraction of nectar was significantly lower in young flowers (16.3-27.8% and 7.3-31.1%, respectively) compared to pollen shedding flowers (14.2-40.3% and 7.3-36.9%, respectively).

In a Canadian study comparing nectar secretion of 28 varieties and breeder's lines of two rapeseed species (*B. napus* and *B. campestris*), all of them produced nectar, but there were significant differences in nectar amounts (Szabo 1982). Nectar yield per flower was 0.348 and 0.165 μl/24 h for *B. napus* and *B. campestris*, respectively. 'Regent' (*B. napus*) and 'Candle' (*B. campestris*) contained 38.7 and 41.8% sugar and the sugar value was 0.177 and 0.064 mg, respectively. The estimated sugar yield of blooming 'Candle' was 13.3 kg/24h/ha. It was difficult to explain the twofold higher nectar production of *B. napus* varieties compared to *B. campestris*, since *B. napus* varieties are largely self-pollinated, while *B. campestris* varieties are self-sterile. A factor that might explain this difference is the larger flower size of *B. napus* (Szabo 1982). Similarly, Mohr and Jay (1990) also measured higher daily nectar production and sugar concentration for cultivars of *B. napus* (0.90 μl and 62%) than for *B. campestris* (0.68 μl and 57%), respectively, in Canada. The flowers of both species produced more nectar, with a lower sugar concentration, in the morning. Flowers sampled repeatedly produced more nectar, with a lower sugar concentration than did those sampled only once per day.

Kevan *et al*. (1991) investigated the nectar sugar composition of 25 canola (*B. napus*) varieties in Canada. None of them had sucrose, and the glucose:fructose ratio was 0.95 or more in all but three varieties, indicating that resulting honeys would tend to granulate readily. Davis *et al*. (1994) found that the nectar carbohydrates of *B. rapa* and *B. napus* lines consisted almost exclusively of glucose and fructose, and the quantities of glucose usually slightly exceeded those of fructose, thus the average ratio of the monosaccharides (G/F) ranged from 1.02 to 1.13. Sucrose was detected in only 15% of samples, usually in trace amounts. Similarly, our investigation on the nectar sugar composition of some currently grown oilseed rape cultivars in Hungary showed that only hexoses could be detected in the nectar. Similarly to the findings of Canadian researchers, the glucose:fructose ratio reached or exceeded 0.95 in cvs. 'Baldur', 'Bekalb Catonic' and 'Colombo', referring to a tendency of fast granulation in the honey (Farkas 2007).

Oilseed rape is highly attractive for honeybees; they are willing to fly over quite great distances to reach the flowers (Várallay 1968). Honeybees collect both pollen and nectar from oilseed rape flowers, which help the spring development of colonies, being important for brood rearing. In good years it can provide surplus honey and it is worth introducing bee colonies there (Szilva 1968a; Sajermann 1971). It is, however, not advisable to place the hives directly next to the rape field. Honeybees tend to fly out on the strong odour even in highly unfavourable weather, and might stay out at night, become numbed and perish by morning. On the other hand, at the end of rape bloom, mainly the colonies next to the rape field become the victims of robbing (Várallay 1968).

Since oilseed rape is one of the best nectar plants among crop plants, special attention should be paid to applying only chemical protection that does not harm honeybees. Treatments done before bloom are not dangerous for bees, unless there are flowering weeds in the rape field or the decomposition of the compound used is too slow. There are several products available that do not harm honeybees at all if sprayed before or after their period of flying (Benedek 1989).

In a ten-year study in Hungary from 1981 to 1991, weight gain of colonies changed between 0.0-30.8 kg. The daily increase was highest at the late blooming cultivars, with amounts of 0.5-4.0 kg (Halmágyi *et al.* 1992), while Szabo (1980) recorded an average hive gain of 5.1 kg/day in Canada.

The honey is colourless or yellow in the beginning, but crystallizes quickly, already in a few days, and then it becomes white (Örösi 1968; Szilva 1968a). The crystals are characteristically small, and granulation takes place simultaneously, without separating into phases, therefore rape honey is highly suitable for preparing cream honey. The taste of pure rape honey can be unpleasant, so it is usually mixed with another honey that has a pleasant flavour. It is generally used in the baking industry (http://www.magyarmez.hu/mezfajtak.html).

Fruit trees and shrubs (*Rosaceae* and *Grossulariaceae*)

In Hungary the majority of fruit trees belongs to the *Rosaceae* family, blooming in April and May, in the order almond, apricot, peach, sweet cherry, plum, sour cherry, pear, apple and quince. The apicultural significance of fruit trees is huge, because they bloom in spring-time when abundant pollen and nectar sources are essential for the sufficient development of honeybee colonies (Örösi 1962; Halmágyi and Suhayda 1966a). On the other hand, fruit growers also need the pollination done by honeybees. Honeybee pollination is highly effective in fruit production, and even self-fertile trees will produce higher fruit yield, if they receive cross pollen (Szilva 1969).

Prunus dulcis **(Mill.) D.A. (almond)** is the earliest blooming of our fruit trees, flowering in late March, early April, together with willows. Consequently it is the most threatened by frosts, and daily mean temperature values are usually too low for nectar secretion. Therefore, in Hungary beekeepers cannot rely on the nectar flow of almonds, but the pollen can greatly help brood rearing (Sas 1956a; Halmágyi and Suhayda 1966a; Szilva 1969). Honeybees are essential for almond fertilisation, because almond cultivars are self-sterile. The nectary lines the receptacle, and nectar can be reached easily by honeybees. The main growing area is around Buda and Balaton and also in Southern Transdanubia, in the surroundings of Pécs (Halmágyi and Suhayda 1966a).

The significance of ***P. armeniaca*** **L. (apricot)** is greater than that of almond, because these trees can be found in larger numbers. The main growing areas can be found around Kecskemét and North Hungary. Apricots flower in March, April, sometimes May according to the cultivar and weather. Because of its early blooming time, honeybees cannot always utilize it (Örösi 1928), although they can easily access nectar that is produced by the receptacular nectar gland. Weight gain (0.2-0.9 kg) from apricot is possible only under especially favourable conditions. The flowers also provide pollen for honeybees (Halmágyi and Suhayda 1966a).

Similarly to other stone fruits, floral nectar secretion in apricot is periodic. Nectar production maxima occur every 6 hours in homogamic flowers, whereas in dichogamous flowers nectar production has a periodicity of 12 hours (Orosz-Kovács *et al.* 1995). In most apricot cultivars the sugar content of nectar does not reach 10% at the beginning of bloom. The lowest sugar concentration was recorded in self-fertile cultivars, somewhat higher in self-sterile ones, and the highest sugar content was found in the partially self-sterile cultivars. These data indicate that nectar can have only a minor role in attracting honeybees (Bordács *et al.* 1995).

P. persica **L. (peach)** trees flower in late March and April for 2-3 weeks. Although nectar production is abundant, it is so deep in the flower that honeybees cannot reach it in some cases; therefore it is important rather as a pollen source. The main growing regions include the vicinity of Buda and Pécs, Balaton and the area between the rivers Danube and Tisza (Örösi 1928; Halmágyi and Suhayda 1966a).

Péter (1972a) measured 0.68-1.02 mg sugar value/flower under favourable weather conditions, when sugar content often exceeded 50%. In rainy weather more, but less concentrated, nectar was produced.

P. avium **L. (sweet cherry)** trees flower at the same time as peaches for 2-3 weeks. The main growing areas are in Eger and Gyöngyös (North-East Hungary), the Danube-bend, and the vicinity of Szeged and Nagykőrös (South Hungary). Cherry cultivars are usually self-sterile, thus foreign pollination by honeybees is essential. In turn bees can often make use of the relatively long flowering period, visiting the flowers for nectar and pollen. Foraging activity can reach 3-4 or even 7-8 kg/colony. The nectar gland is located in the receptacle (Örösi 1928; Halmágyi and Suhayda 1966a).

In the early blooming cv. 'Jaboulay', less nectar could be measured, compared to the later blooming 'Germersdorfi óriás' (0.12-0.84 mg and 0.61-3.46 mg), with lower sugar values (0.03-0.31 mg and 0.16-1.01 mg, respectively) (Péter 1972a).

The growing area of ***P. cerasus*** **L. (sour cherry)** is overlapping with that of sweet cherry, also including county Szabolcs-Szatmár-Bereg in North-East Hungary. Sour cherry flowers in late March and April for 12-16 days. Most of the cultivated varieties are self-sterile and thus require pollen transfer by honeybees. They readily visit sour cherry flowers that provide pollen and nectar that can be reached easily (Örösi 1928; Halmágyi and Suhayda 1966a; Gulyás 1985). The nectary is receptacular, covering the whole surface of the receptacle (Orosz-Kovács 1991; Bukovics 2005).

According to Halmágyi and Suhayda (1966a) its apicultural significance is low, because of the small number of trees and their weak nectar flow. In their study of 10 years there was no weight gain from sour cherry alone. Gulyás (1985), however, claims that sour cherry precedes plum, pear, sweet cherry and most apple cultivars in the apicultural ranking of fruit trees. Some apple and peach cultivars produce more nectar than sour cherry flowers, but honeybees cannot suck nectar completely from those flowers because of the rigid, close-standing filaments. The apicultural significance of sour cherry is further increased by the presence of extra-floral nectaries on the petioles that are also visited by the bees on humid, windless mornings (Gulyás 1985).

In sour cherries, nectar secretion is mostly periodical. In homogamous cultivars a peak in nectar secretion can be observed every 6 h, while dichogamous trees secrete nectar with 12 h intervals. In the hybrids of sweet and sour cherries, 3-hour gaps can be observed in nectar production (Orosz-Kovács *et al*. 1989; Orosz-Kovács 1990, 1991).

A flower may secrete nectar for 2-4 days and, depending on the cultivar, produces 0.2-9.0 mg nectar with 12-65% sugar content. 'Cigánymeggy' type sour cherries yield less but more concentrated nectar, with sugar values of 0.1-1.8 mg/flower/day, while cultivated varieties produce more but rather dilute nectar (Gulyás 1985). Nikovitz (1980) reported that 'Pándy' sour cherries were much less visited by honeybees compared to 'Cigány' sour cherries, indicating that the bees were attracted by sugar concentration rather than nectar weight. The nectar of the 'Pándy' clones is very dilute, hence not attractive enough for pollinators, even if secreted in great amounts.

According to recent studies (1994-2004), from 25 sour cherry cultivars the best nectar producers were 'Meteor korai' and 'Debreceni bőtermő', with 10.27 μl and 7.21 μl nectar volume/flower/day, with 13.96% and 16.6% sugar content, respectively. Sugar values were similarly high in 'Pándy 48', 'Oblacsinszka', 'Újfehértói fürtös', 'R', 'Cigánymeggy C.404' and 'Cigánymeggy 59'. With the aging of the flower usually both nectar weight and sugar content increases. In most cultivars, daytime nectar is more concentrated compared to nectar secreted at night. The nectar was either sucrose-rich or sucrose-dominant, according to the classification of Baker and Baker (1983). On the basis of the sucrose/(glucose + fructose) quotient and the sugar values, 'Meteor korai' and 'Pándy 48' were the most attractive for bees (Bukovics 2005).

The nectar of sour cherry is used mainly for brood rearing. Sour cherry honey tastes like bitter almond, and granulates weakly (Gulyás 1985).

The main growing areas of ***P. domestica*** **L. (plum)** are the Transdanubian and Northern regions of Hungary. Plum cultivars flower in late March and April, sometimes in May for 10-14 days. The apicultural significance of plum lies in its wide-spread distribution. It produces nectar, but not as much as sweet cherry, for example. Honey flow may show huge differences among various cultivars (Örösi 1928; Halmágyi and Suhayda 1966a). Certain plum cultivars (belonging mostly to self-fertile Besztercei plums) do not secrete any nectar, whereas others secrete continuously or periodically. Nectar secretion dynamics may vary even within a cultivar, depending on the developmental stage of the flowers (Horváth and Orosz-Kovács 2004). In successful years, 1-2 kg weight gain is possible from plum flowers (Örösi 1928; Halmágyi and Suhayda 1966a).

Investigating the nectar production of several plum cultivars between 1995 and 2002, Horváth (2003) reported that the mean nectar volume/flower/day ranged from 3.0 to 4.8 μl, with 23.9-28.0% sugar content. Daily nectar volumes and refraction values were higher than those from hourly sampling (0.05-1.06 μl /flower/hour and 3.9-31.9%, with mean values around only 10%) (Horváth 2003). In self-fertile cultivars, nectar was either hexose-rich or sucrose-dominant, while in self-sterile cultivars sucrose-rich nectar was characteristic (Horváth *et al*. 2001). The most attractive cultivars for honeybees were 'Déli Vengerka', 'Monfort', 'Paczelt', 'Ruth Gerstetter', 'Sermina', 'Sötétkék tojás' and 'Stanley', while the hexose-dominant or hexose-rich nectar of 'Althann ringló', 'Bódi szilva', 'Čačanska najbolja' and 'Čačanska rodna' attracted honeybees much less. However, because of the early blooming time of plums, honeybees may visit the latter cultivars, as well, in the lack of nectar with higher sucrose content (Horváth 2003).

Róka *et al*. (1997) investigated the relationship between nectary structure and nectar production in Besztercei plum clones, claiming that the structure of the nectary changes to a small degree with environmental effects, therefore it is more suitable for predicting the amount of nectar. The intrafloral nectary of Besztercei plums is automorphic, receptacular, lining the inner, adaxial side of the receptacle, between the base of the stamens and the pistil. Large differences were found in the size of the glandular tissue between Besztercei and TV clones. TV 46, 48 and 58 clones had the largest nectaries and produced the most nectar, therefore they could attract the most pollinators and thus were the most significant for apiculture (Róka *et al*. 1997).

Similarly to sour cherry cultivars, nectary stomata of plums can be mesomorphic (stomatal guard cells at the same level as epidermal cells), xeromorphic (guard cells below epidermis) or meso-xeromorphic, but in plums hygromorphic stomata (guard cells higher than the epidermal cells) can be also observed (Orosz-Kovács *et al*. 1998). The small glandular cells are arranged mostly in 5-10 cell rows parallel with the surface. A strong positive linear correlation was found between the total size of the nectary and the size of glandular tissue (Horváth 2003).

Malus domestica **L. (apple)** is one of our most important fruit trees. The main growing regions are in county Szabolcs-Szatmár-Bereg (North-East Hungary), the area between Danube and Tisza and county Zala (South Hungary). It is important for apiculture especially in the main growing areas. Flowering lasts for 2-3 weeks in April and early May. Its honey flow is moderate, but provides abundant pollen. Honeybees can access the nectar with difficulty (**Fig. 1G**), because the nectary is located hidden within the hypanthium (Orosz-Kovács *et al*. 2002), and filaments are connate at their base to varying degrees, so bees can reach nectar only from the top. As flowering proceeds, bees can access nectar easier thanks to the loosening filaments (**Fig. 1H-I**). In average years 1.0-1.5, in better years 2-3 kg weight gain is possible (Örösi 1928; Halmágyi and Suhayda 1966a).

The surface of the receptacular nectary is covered with a wrinkled cuticle. Nectary stomata are mainly mesomorphic, but also weak xeromorphy and hygromorphy can be observed (Orosz-Kovács *et al*. 2002, 2004).

The amount of nectar in apple flowers increases with the aging of the flower: 0.5-2 μl, 2-6 μl and up to 8 μl was measured in freshly opened, pollen shedding and old flowers, respectively, in the average of 10 apple cultivars in 3 years. This might be related to the aging and loss of function of nectary stomata. In the protogynous stigma phase, sugar content did not reach 20% in four out of ten cultivars, but it was higher during pollen-shedding (Orosz-Kovács *et al*. 2001a). The nectar in most apple cultivars was sucrose-rich, which made them attractive for honeybees (Botz *et al*. 2001), especially in the second half of blooming, when sugar content was usually above 20%.

Orosz-Kovács *et al*. (1990) and Scheid-Nagy Tóth (1991, 2000) reported that on drier sandy soils (Érsekhalma), the nectar production of apple cultivars was periodical, with 4-hour-long intervals. The peaks of nectar secretion could be observed usually an hour later than maximal anther dehiscence. In North-East Hungary (Nyírség), some nectar production could be measured even between the secretion peaks, which appeared more often, every 2 or 3 h, depending on the weather (Orosz-Kovács *et al*. 2001b).

Pyrus communis **L. (pear)** cultivars flower in April and May. Nectar is easily available for honeybees, and they can collect also pollen. Honeybees visit the flowers less than related apple trees, which might be caused by the unpleasant smell of the flowers. However, its early pollen is advantageous for brood rearing, and it is worth introducing bee colonies to big pear orchards (Örösi 1928).

The nectary of pear is receptaculo-ovarial (Kartashova 1965; Orosz-Kovács *et al*. 2002), plate-like and exposed (**Fig. 1J**). A positive linear correlation was found between the size of the nectary and nectar production and also between nectary size and nectar sugar value. The surface of the nectar gland is covered with a smooth cuticle, lacking ornamentation (Werysko-Chmielewska and Konarska 1995; Farkas 2001; Orosz-Kovács *et al*. 2002). In pear cultivars no hygromorphic stomata were observed, the ecological type of the cultivars was meso- or xeromorphic on the basis of nectary stoma position. The size of nectar chambers below stomata varies, and shows no correlation with the amount of secreted nectar (Farkas 2001). In some pears the glandular tissue can be well distinguished from the nectary parenchyma; in most cases, however a mosaic-like structure can be observed, when smaller, dark-staining glandular cells are mixed with larger, light-staining parenchyma cells (Orosz-Kovács *et al*. 2002).

Pear cultivars can be classified into three groups on the basis of nectar secretion dynamics: 1. no nectar production, 2. continuous secretion, 3. periodical secretion. Nectar production peaks could be measured at 9.00-10.00 h, 14.00-15.00 h and 18.00-19.00 h, so nectar-poor intervals lasted for 4-5 hours, similarly to apples (Farkas 2001; Farkas and Orosz-Kovács 2003).

In pear flowers both the amount and concentration of nectar is low, thus the sugar content is lower compared to either apples or quinces. Studying the nectar production of more than 100 Hungarian local pear cultivars between 1994-2001, we found that nectar volume/flower/day was 0.43-8.80 μl, with sugar concentrations usually below 10%, in some cultivars approaching 20%.

Most pear cultivars can be characterised with a hexose-dominant nectar, containing only glucose and fructose, and the few cultivars with trace amounts of sucrose can be classified as hexose-rich (Farkas *et al*. 2002). Accordingly, honeybees visit those flowers for nectar, where sugar content is at least 8-9% (Örösi 1968). Honeybees were attracted by cultivars that produced abundant, concentrated nectar (e.g. 'Nyári Dunaföldvár', 'Vérbélű bőtermő' and 'Viki'), but also by pears with little, but concentrated nectar (e.g. *Pyrus betulifolia*). Few or no honeybees were observed on cultivars with abundant, but dilute nectar, as e.g. 'Adonyi 1' (Farkas 2001).

Cydonia oblonga **Mill. (quince)** cultivars flower late, in May and June, and are of reduced significance in apiculture. Honeybees can collect both nectar and pollen, the latter being more important. Similarly to pear, the nectary is located on the top of the ovary and within the receptacle (Kartashova 1965; Orosz-Kovács *et al*. 2002; Déri 2006). The surface of the nectar gland is slightly wrinkled (Werysko-Chmielewska and Konarska 1995). Similarly to pears, meso-xeromorphic stoma position is the most frequent in quinces (Déri 2006). Déri (pers. comm.) observed large parenchyma cells with crystal druses among glandular cells and plain parenchyma cells of the nectary.

In accordance with previous data from abroad (Simidchiev 1967, Weryszko-Chmielewska *et al*. 1997) and within Hungary (Péter 1972a), the quince cultivars studied by Déri produced little, but concentrated nectar (pers. comm.). In full bloom, mean nectar volume/flower/day ranged from 0.51 to 6.19 μl, with 24.14-49.50% sugar content. Among nectar sugars, sucrose could be detected in the highest amounts, its proportion reached 47-75% of total sugar content, thus the nectar of most quince cultivars was sucrose-dominant. The above nectar features, together with ample pollen, can make quinces highly attractive for honeybees (Déri *et al*. 2006).

The nectar production of two **flowering quince** species, ***Chaenomeles japonica*** **(Thunb.) Lindl.** and ***C. speciosa*** **(Sweet) Nakai**, was studied by Horváth *et al*. (1985). The nectary is located between the bases of filaments and pistils, lining the inner side of the receptacle. Nectar secretion began simultaneously with flower opening. In different phenological stages the amount and composition of nectar varied. *C. japonica* produced more nectar compared to *C. speciosa*, a significant percentage of the flowers secreting as much as 20.0 or even 37.9 mg nectar. Sugar content reached 44% in some flowers. Since a honeybee can store 40-50 mg nectar in its honey sac, one or two *Chaenomeles* flowers are sufficient for collecting the whole nectar load. Under optimal conditions, the flowers of a shrub can produce as much as 1 kg nectar per week. At the beginning of bloom two nectar production peaks were observed in the flowers: at 11.00 h and 17.00 h. At the end of bloom only one peak could be distinguished at 15.00 h. Nectar production also changed with flower age and position of flower. The amount of nectar increased, while sugar content decreased from the bottom of the branch towards the top.

Hawthorn species **(*Crataegus monogyna* Jacq. and *C. laevigata* (Poir) DC.)** flower before robinia, similarly to the majority of rosaceous fruit trees. According to Lengyel (1943) they are good nectar plants, but honeybees do not prefer them. In early blooming black locust forests their significance can be greater: if beekeepers arrive too early, honeybees can visit hawthorn flowers before robinia flowers start to open (Halmágyi and Suhayda 1962a).

Gooseberry and raspberry are the two most important berry fruits in apiculture. Gooseberry flowers early (late March, early April), while raspberries are late-blooming (May, June). They can be found in great numbers in few places, but here they can ensure a good foraging activity (Örösi 1928; Halmágyi and Suhayda 1966a).

The entomophilous, allogamous ***Rubus idaeus*** **L. (raspberry)** is considered one of the best melliferous plants in Hungary, and it is regarded as a good nectar plant also in surrounding countries (Gulyás 1984b). Although indigenous to Europe (Péter 1972b; Gulyás 1984b), in Hungary it occurs wild only in Mts. Mátra and Bükk (Northern Hungary), but it is also cultivated. The bloom of cultivated raspberry largely overlaps with that of black locust, flowering from May-June for about a month (Koltay 1961; Péter 1972b). Its sugar value is 7.6 mg, so the daily nectar production of a flower corresponds to that of black locust. The average sugar content of nectar is 46%. Consequently, it is an excellent bee pasture, where found in great numbers (Koltay 1961). Cool, rainy weather is favourable for the honey flow of raspberry, whereas black locust does not produce nectar below 16°C. Besides, in rainy weather honeybees cannot access the nectar of robinia flowers because of the turgid, swollen petals, while raspberry nectar is easily available in the exposed flowers (Koltay 1961).

In the course of a 14-day-long study, hive weights increased every day but one (Koltay 1961), and according to Örösi (1928), 1-2 kg foraging activity can be achieved in good years and some surplus honey can be gained, too. Where grown on large scale, it is worth keeping bees there (Péter 1972b). Despite all these favourable features, black locust should be still preferred, because the number of raspberry flowers per unit area is much lower than that of black locust. However, raspberry can be a great help when black locust flowers freeze completely or the weather is so cold at the time of bloom that robinia honey flow ceases. It is also worth introducing bee colonies to wild raspberry, which flowers after black locust (Koltay 1961).

The nectary of raspberry lines the receptacle in the form of a ring between the stamens and the pistil (Péter 1972b; Gulyás 1984b). Nectar secretion starts already in the bud stage and lasts until petal fall (Péter 1972b), visible in the form of small drops (Gulyás 1984b). Accordingly, honeybees visit already the balloon stage flowers and in main bloom flowers are crowded by bees from morning to evening, because nectar secretion is continuous (Péter 1972b; Gulyás 1984b). Besides nectar, bees can collect pollen, as well (Péter 1972b). A flower is usually open for two days and produces 20 mg nectar, as much as 10 robinia flowers (Gulyás 1984b). Péter (1972b) measured 6.2-12.6 mg nectar/flower/day (averaging 10.44 mg), with 53-63% (average 49%) sugar content and sugar value varied between 2.2-9.8 mg (averaging 5.15 mg) in cv.'Knewett' in the average of 3 years.

Raspberry honey granulates quickly. Honey potential is 100-160 kg/ha. By propagating cultivars that flower all year round (until frosts), bee pasture could be improved significantly (Gulyás 1984b).

Rubus caesius **L. (blackberry)** flowers in June-July for

3-4 weeks and is wide-spread in the southern flood area of Danube. Blackberries are considered as good nectar plants (Halmágyi and Suhayda 1962a).

Recently, from 2004, Schmidt has studied the nectar production of raspberry and blackberry, and confirmed that both are good nectar producers, which can be related to their well-developed nectar gland. In some cultivars, 20-30 µl nectar could be extracted from flowers just 1 hour after a previous sampling. Particularly high nectar yield was measured in the flowers of raspberry cvs. 'Fertődi Zamatos', 'Fertődi Kármin' and 'Fertődi Venus' and the blackberries 'Dirksen' and 'Loch Ness'. Sugar content reached 35% in blackberries and 48% in raspberries. Highest sugar values were measured in raspberry cv. 'Fertődi Venus' and blackberry cv. 'Dirksen'. The nectar of raspberries is hexose-dominant, while that of blackberries is dominated by sucrose (K. Schmidt, pers. comm.)

Honeybees cannot always sufficiently utilize the flowers of ***Ribes uva-crispa*** **L., Grossulariaceae, (gooseberry)** because of their early bloom, although they provide the best nectar source among berry fruits in Hungary. The nectary is receptacular. Its early pollen and honey is favourable for the development of bee colonies. Where a lot of gooseberry has been planted, the collected honey emits a characteristic leather smell (Örösi 1928; Halmágyi and Suhayda 1966a).

The flowers of ***Ribes nigrum*** **L. (black currant)** are less visited than those of ***R. rubrum*** **L. (red currant)**. The nectary is located between the base of the style and the stamens. Honeybees can collect both nectar and pollen from it. Flowering occurs in April and May (Örösi 1928).

R. aureum **Pursh (golden currant)** is rather planted as an ornamental. Honeybees cannot suck the nectar in the usual way from the narrow-tubed and deep flowers, but they can gnaw out the side of the flowers and thus they can already reach the nectar (Örösi 1928).

Fruit tree honey is very favourable for bee colonies, together with pollen, and honeybees usually consume it themselves. With the spread of large-scale orchards, however, there is a greater chance for extracting fruit tree honey. The honey of various fruit trees is different: e.g. apple honey is pale yellow and crystallizes quickly. Peach honey is darker, with little flavour. Sour and sweet cherry honeys have a characteristic, but not unpleasant, bitter almond aftertaste. Raspberry honey is pale yellow, with a mild flavour, and crystallizes quickly. Sometimes honey dew can get mixed into fruit tree honey. This is especially valid for sweet chestnut honey, which can be improved by honey dew. In forests, honey dew can get into raspberry honey, too (Szilva 1969). In new honey regulations fruit tree honeys are already involved, because some of them (e.g. apple honey and sour cherry honey) are produced in increasing amounts (Lukács 1987). In other countries, honeybees can forage on the flowers of several other fruit trees, e.g. *Citrus* honey is characteristic in the Mediterranean and the Near East (Szilva 1969).

Acer (maple) species, *Aceraceae*

Several maple species grow in Hungary, providing pollen and nectar for honeybees from March to May (Sas 1956a; Klotz 1990), thus they may have an important role in the spring development of colonies, but do not give surplus honey (Halmágyi 1975; Benyáts 1999). Koltay (1953) lists maples among trees that should be planted in shelter forest belts, because they serve as good pollen and nectar sources.

Crane *et al*. (1984) underline the importance of *A. campestre* and *A. platanoides*, and include ***A. campestre*** **L. (field or hedge maple)** among the 20 best melliferous plants of the world (500 kg honey/ha). Unfortunately, at this time of the year, neither the weather, nor the condition of the bee colonies ensure the full exploitation of nectar yield. The large (few mm in diameter), green, disc-shaped nectar glands of *A. campestre* are exposed, therefore nectar quickly dries on the surface in sunny weather, although the gland surface is wrinkled (Halmágyi 1975; Benyáts 1999). In Hungary field maple is quite widespread, being a stand-forming species in maple-oak forests in the Gödöllő hill-country, and also occurring in the margin area of the Great Hungarian Plain. It flowers in the second half of April and May, parallel to or after foliation (Halmágyi 1975; Benyáts 1999). It is light-requiring, but can tolerate shade better than other Hungarian maple species, and it has no special soil requirements. It is frost-hardy, although prefers mild climate (Halmágyi 1975).

A. platanoides **L. (Norway maple)** is the most widespread in Hungary (Sas 1956a), growing mostly in forests of medium height mountains, but it is also often planted in parks and alleys (Benyáts 1999). From maples with higher nectar production, this is the earliest blooming tree, flowering in April, before foliation (Benyáts 1999). According to Sas (1956a), it produces nectar only in warm weather. Comparing the nectar gland of three maples (*A. campestre*, *A. platanoides* and *A. pseudoplatanus*), Gulyás (cit. Halmágyi 1975) found the largest nectary in *A. platanoides* (**Fig. 1K**). The gland of Norway maple differed from that of field maple in the remarkably large number of nectary stomata on its surface. Besides, in some places, especially on the edge of the gland multicellular, club-shaped glandular hairs can be observed (Halmágyi 1975).

A. pseudoplatanus **L. (sycamore maple)** is a montane tree species, occurring mainly in beech forests (Benyáts 1999), but it is quite widespread everywhere except the plains (Halmágyi 1975). Sycamore maple requires good growing conditions, because it is sensitive to early frosts and drought (Halmágyi 1975). It blooms after foliation, at the end of April, beginning of May, parallel to apple trees. It is a good nectar plant, honeybees can collect both nectar and pollen from the flowers (Sas 1956a; Benyáts 1999).

A. tataricum **L. (Tatarian maple)** is a shrub or small tree (Halmágyi 1975), growing in the association called oak forests mixed with Tatarian maple on loess, flowering usually in May, following foliation. Honeybees collect both nectar and pollen; it belongs to medium nectar producers (Benyáts 1999).

A. negundo **L. (boxelder)** originates from North America, but it has spread almost all over Hungary (Benyáts 1999). It is the earliest blooming species from maples, flowering in March-April, but has smaller significance (Sas 1956a; Benyáts 1999), because it produces no nectar, similarly to early-blooming elm trees (Halmágyi and Suhayda 1962a). Honeybees visit the trees with staminate flowers in large numbers, collecting the brownish pollen. The pistillate flowers do not have a nectar gland, and thus produce no nectar (Benyáts 1999).

Acer saccharinum **L. (sugar maple)** was also introduced from North America. It is an excellent nectar plant, flowering in March, beginning of April, for 15-20 days, suitable for filling in the gap between apple and black locust bloom (Sas 1956a).

Cornus sanguinea L., *Cornaceae* (common dogwood or bloodtwig dogwood)

Common dogwood can be found in dry oak and mixed forests, as well as gallery forests, since it can adapt itself to the extremes of water supply. Flowers open after foliation, just before black locust, offering nectar and pollen for visiting insects (Halmágyi and Suhayda 1962a, 1963a), and honeybees visit the flowers for both (Nyárády 1958). Nectar is secreted by the ring-shaped nectar gland around the base of the pistil, similarly to other cornel species. The dry matter content of the nectar is highly variable, ranging from 14.5% to 74.0%, which can be explained by the strong influence of weather on nectar concentration, since the nectary is exposed. Sugar value is 0.303-0.565 mg, and honey flow can reach several kilograms. The wood, and especially the young cortex of bloodtwig dogwood has an unpleasant smell, which can be smelled on the flowers and even the nectar. It is not known, however, if the honey retains this smell, too, since we do not know unifloral cornel honey (Halmágyi and Suhayda 1962a, 1963a).

EARLY SUMMER BEE PASTURE

Robinia pseudoacacia L., *Fabaceae* (acacia, black locust, false acacia, robinia)

Black locust is indigenous in North America. According to Hanusz (1881) and Vadas (1911) it was brought to Europe in 1600, and first planted in Hungary at the beginning of the 18th century, first in parks and roadsides, and later with the purpose of binding sandy soils (Sajermann 1983). Its mass plantation started only in the second half of the 19th century, especially after the enactment of the XIX "forest plantation" law of 1898 (Szalóky 2004). The soil and climatic conditions in Hungary are as optimal for growing black locust trees as in its place of origin (Vadas 1911), where it grows 5-10 degrees more to the south than in Hungary, thus its climatic optimum is in South-Transdanubia. Locusts are tolerant of a wide range of soil types as long as there is good drainage, adequate moisture and it is not very clayey (de Gomez and Wagner 2001). The growth and wood yield of black locust is determined mainly by the water supply of the soil, and it is especially demanding with respect to soil aeration (Szalóky 2004). In Hungary it grows well also on much drier areas than in its native American habitat (Babos *et al*. 1966). In the 1970s and 1980s, continuous black locust stands in Europe were significant only in Hungary (Sajermann 1983), robinia trees representing 25% of forest stands (Koch 1974). In 1986 there were 271,000 ha of black locust forest, representing about 18% of Hungary's total forested area (Keresztesi 1988). One of the reasons for its great success as an exotic in Central European countries, as well as in China and South Korea, is that some of the most damaging insect pests found in its native range do not occur in Europe and Asia (Hanover 1992).

In South Korea, where the largest black locust forests can be found, the leaves are used in fattening of pigs and raising broiler chickens (Keresztesi 1984). In Hungary the trees are used for timber, poles and firewood, the leaves are used for forage, and the flowers are highly valued for their source of nectar and pollen for honeybees (Keresztesi 1980). Besides, flowers can be used also in teas for cough, as well as in syrups, flavouring jams, and in perfumery. The value of honey production is generally enough to pay the cost of establishment of plantations on 30 year rotations (Keresztesi 1988).

The excellent honey flow (on average 1.5 mg nectar and 0.9 mg sugar value) and the great number of trees and flowers make it the most important nectariferous plant in Hungary (Péter and Halmágyi 1959), providing the majority of Hungarian honey (Keresztesi 1977). In the 1960s in the average of six years weight gain from robinia was 31.41 kg, while from other nectar plants only 14.58 kg (Halmágyi and Suhayda 1965a). Therefore honey flow of black locust is essential for Hungarian apiculture, being decisive for the economy of beekeeping (Sajermann 1983). In the land of origin robinia does not yield honey, in Hungary, however, its honey flow is usually balanced and surplus honey can be expected unless late frosts or bad weather at blooming time damage the flowers (Sajermann 1983). Assuming 2 mg nectar yield/flower/day, and an average flowering period of 5.46 days, 176,850 t of nectar or 88,420 t of honey/year were obtainable in Hungary in the 1970s (Keresztesi 1977).

Black locust usually blooms at the middle or end of May in Hungary (**Fig. 2A**). According to the common belief there are usually 40 days between the burst of robinia buds and flower opening (Halmágyi and Suhayda 1965a). In countries to the west and north of Hungary (Germany, Slovakia, Poland), robinia starts blooming later, and the main honey flow is at the beginning or middle of June (Koch 1974).

There is a time shift between the blooming time of robinia trees on the plains and in the mountains of Hungary. In the east robinia starts blooming earlier then in the west, and similarly, southern black locust trees start flowering earlier than the northern ones, therefore the direction of beekeepers' migration is from the south to the north (Halmágyi and Suhayda 1965a; Koch 1974; Sajermann 1983). Migrating makes it possible to exploit two robinia blooms in the same year. However, both blooming periods cannot be fully utilised, only under rare conditions (Halmágyi and Suhayda 1965a). Today the time difference in flowering between the various regions is disappearing, often reduced to a few days, probably due to milder winters and springs. In the 1960s and 1970s robinia honey flow had two distinct peaks in the western part of the country, one between May 24-25 and another between June 5-8, whereas the eastern part could be characterised with a single peak in the second half of May, in the average of 16 years (Koch 1974).

Walkovszky (1998) compared the blooming phenology of black locust in three different time intervals between 1851 and 1994, and noticed a tendency towards earlier flowering, by approximately 3-8 days. This change is related to higher average temperatures in spring.

Robinia flowers (**Fig. 2B**) are the most certain honey source for Hungarian beekeepers (Kardos 1974). However, results may vary from year to year, from region to region and from apiary to apiary, because the microclimate, the strength of the colonies and the load of the bee pasture may be different (Halmágyi and Suhayda 1965a). The proper spring development of the bee colonies is especially important, because they must be ready for honey production already by early or mid May (Sajermann 1983).

Keresztesi (1968) suggested the propagation of generative type, abundantly blooming black locust cultivars that are more valuable for apiculture, e.g. *R. p. decaisneana* that produced the highest amount of nectar compared to other cultivars, and flowers a bit later than common black locust; *R. p.* '*ricsikai*' and *R. p. semperflorens* that flowers throughout the summer; as well as *R. p.* '*zalai*' that flowers later than common black locust, similarly to *Robinia pseudoacacia* x *R. neo-mexicana*, which has also a second blooming period in late July or August.

Robinia honey flow tends to be good if the soil received enough precipitation at the end of the previous year and in spring (Sajermann 1983). The most favourable for robinia honey flow would be moderately humid, overcast and windless weather at the time of bloom, with warm nights (around 15°C) and daytime temperatures above 25°C (Kardos 1974; Sajermann 1983). When temperatures next to the ground are 13-14°C, black locust can already produce nectar, because air temperatures in the canopy are higher due to solar radiation. Cold, northern winds cause nectar production to cease, drying out the flowers. Southern winds, carrying mild, humid air, can be favourable for nectar flow (Józsa 1978).

Honey flow of black locust is influenced already by weather conditions of the previous year. Summer weather affects the number and quality of buds the next year, autumn weather determines if buds can develop sufficiently for withstanding winter frosts. Winter is a critical period, even, slightly cold weather is favourable (Fritsch 1995). Late spring frosts can significantly hinder or even terminate nectar secretion in robinia flowers (Sajermann 1983). However, the most dangerous frosts are those before bud burst, which always corresponds with the bloom of apricot. Frost in this period, following the initiation of sap circulation, can cause real damage, when developing floral buds freeze. Following this period, the sharp decrease in temperature is not so damaging. The second frost damage occurs when the already burst buds or flowers are damaged (Fazekas 1978; Fritsch 1995). Therefore it is important that beekeepers take a look at black locust forests immediately after bud burst. If small racemes can be seen in the buds, good honey flow can be expected. If not, i.e. buds have frozen, secondary buds will burst only after foliation and they will not provide sufficient nectar for bees. If beekeepers check the forest only just before bloom, they will not notice this difference. This

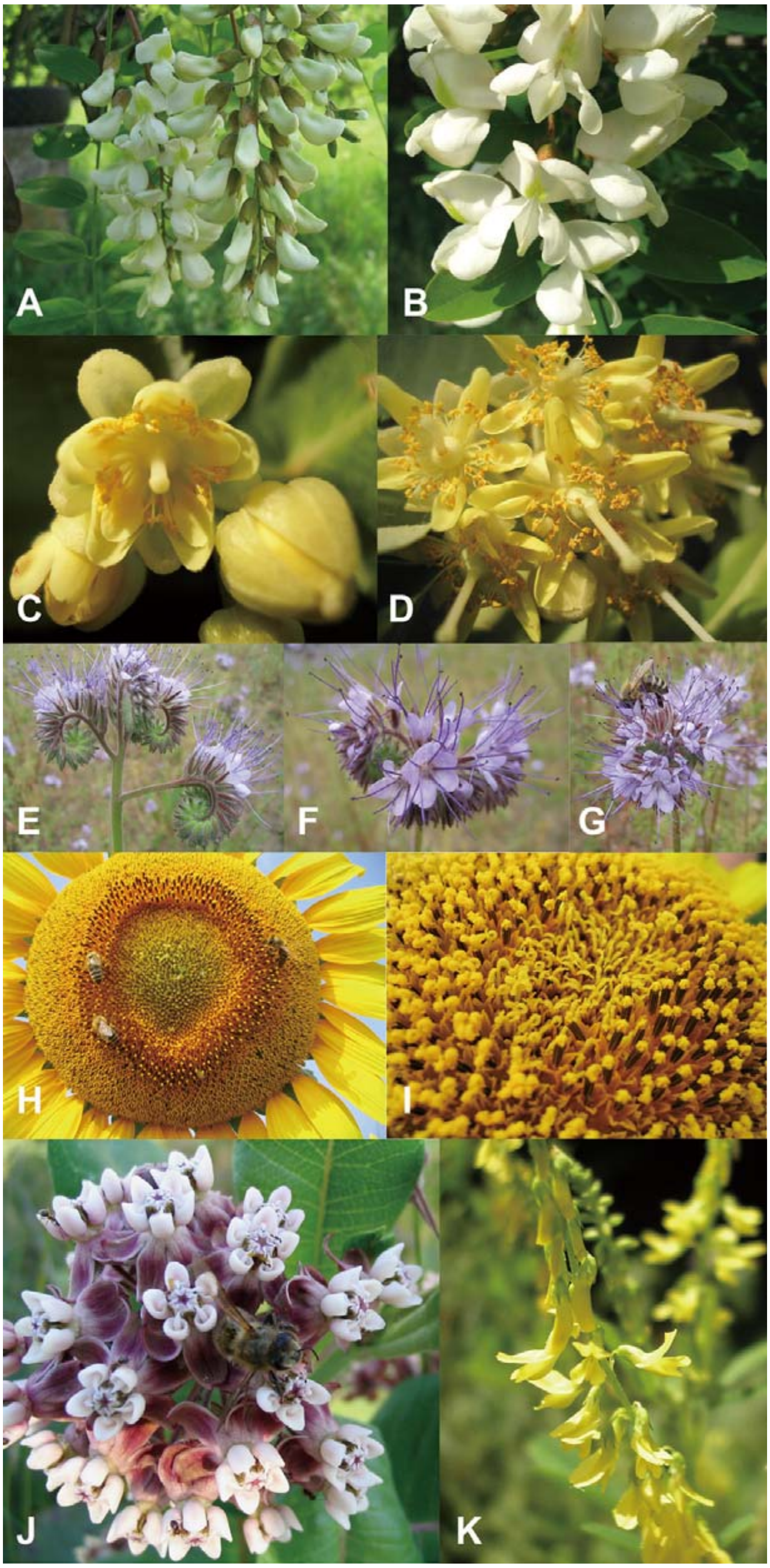

Fig. 1 Flowers of summer bee pasture in Hungary. The most important bee pasture in Hungary is *Robinia pseudoacacia* (**A, B**), with characteristic papilionaceous flower structure (**B**), The nectaries are located on the claws of the sepals in the flowers of *Tilia tomentosa* (**C**), secreting nectar in the old flowers (**D**) as well, The flowers of *Phacelia tanacetifolia* are arranged in scorpioid cymes (**E**), and the stamens are longer than the corolla (**F**), Phacelia flowers emit an overpowering nectar scent that bees cannot resist, visiting the flowers from early morning to late evening (**G**), Sunflower (*Helianthus annuus*) is the second most important bee pasture plant in Hungary (**H**), the disc florets provide both pollen and nectar for honeybees (**I**), The flowers of *Asclepias syriaca* often capture honeybees, because the legs get trapped in the corpusculum of pollinia (**J**), Although the nectar content of a single *Melilotus officinalis* flower is low, the high number of flowers and high sugar contents counterbalance it (**K**).

can be in the background of different honey potential of black locust forests that flower in a seemingly uniform way (Morva 1978). Nectar production of flowers developed from spare buds after the frosts is usually insignificant, depending greatly on temperatures, relative humidity and soil (Józsa 1978). Another damaging factor can be the heavy rains, which is often the case at the flowering of black locust. Rain enhances the aging and destruction of flowers, and thus can cause great damage in just a few days.

Some prerequisites of producing robinia honey can be influenced by the beekeeper, such as preparing the bee colonies for black locust bloom, so that they are not only populous, but also maximally able to collect the nectar. Others are independent from the apiarist: there should be enough robinia flowers, suitable temperature and humidity, stillness of air and mild nights (Fritsch 1995, 2001). Usually the best honey flow is on sandy soil. However, when there was no honey flow on the sandy soils of the Great Plain, the black locust forests of Northern Hungary and Mt. Bakony gave excellent nectar yield (Fazekas 1978).

Good foraging activity cannot be expected under 20°C, even if the weather is neither rainy nor windy (Suhayda 1966). Honeybees can access nectar in robinia flowers only if they force the corolla open, therefore the main collection starts at main bloom and at the beginning of flower wilting. At the two thirds of flowering, weight gain gradually increases day after day, for about 8 days, and in the last third rapidly decreases. Water content of the nectar is great at first; it lasts 7-8 days from the beginning of collecting to ripen the honey to a suitable thickness (Kardos 1974).

According to Halmágyi and Suhayda (1965a), weight gains were around 25-30 kg and 35-40 kg in weaker and better years of the 1960s, respectively. In the second blooming period, in the mountains, the average results varied between 8.82 and 30.37 kg. In a highly successful year, like 1964, among apiaries with 1 colony the 3 best results were 57.20, 61.00 and 86.50 kg, while the best hive weight gains with 2-colony systems were 91.50 and 110.00 kg/hive, achieved by migrating, on 2 robinia blooms (Suhayda 1966). In Sajermann's (1983) experience, daily weight gain could reach 10-15 kg at the main bloom. Mean sugar content in robinia nectar was 34%, and ca. 75% of collected nectar resulted in surplus honey. Nowadays, daily weight gains are lower, in general about 4-5 kg/day.

Robinia honey is the latest crystallizing among honeys. It remains fluid for 3-4 years, has a mild flavour, and its colour varies from pale yellow to greenish yellow (Sajermann 1983; Keresztesi 1988; Halmágyi 2001). It is similar to milkweed honey, but the latter is slightly darker and more acidic (Szél *et al*. 2002; Kasper-Szél *et al*. 2003). According to their investigations, fructose to glucose ratio was higher in robinia honey, and turanose content was outstandingly high. Both diastase and invertase enzyme activity was significantly lower in robinia honey compared to milkweed honey, in accordance with another Hungarian and a Spanish study, which also showed low invertase activity in false acacia honey (Serra Bonvehí *et al*. 2000). Széles *et al*. (2006) studied the nutritional properties and quality parameters of Hungarian honeys. They also found that diastase activity is reduced in acacia honey compared to the values measured in other Hungarian honeys, ranging from 10 to 35.

Pacs and Halmágyi (1994) summarised the honey flow results of black locust between 1984 and 1993. They observed that honey flow began 5-6 days earlier than in the previous 2 decades, which may be related to hotter springs. They already called the attention to the significant black locust plantations being established in the Mediterranean region, as well as in Middle Asia and the Far East, forecasting that robinia honey will be produced throughout Eurasia, and the importance of Hungarian robinia honey will decrease.

Robinia honey produced in Hungary has an important role on the international honey market, considering both quantity and quality. But, Hungary is not the only vendor of this kind of honey, so it is necessary to elaborate an efficient marketing strategy. For example, Romania is also present on the market with a significant amount of robinia honey with similar quality. The structure of honey export in Romania is similar to that in Hungary, which can be explained by the similar composition of bee pastures. The number of bee colonies in Romania approaches that of Hungary, but their bee pasture is much larger. Yearly honey production of Romania is estimated 16-19,000 tons, out of which about 50% is robinia honey. Therefore, they also offer a significant amount of good quality robinia honey for export, and can also have a decisive role on the international robinia honey sales market. Among other countries producing robinia honey, e.g. France, Italy and Slovakia can be mentioned (2,000-2,500; 1,500-2,000 and 800-1,000 t/year, respectively). From the estimated robinia honey production in Europe, about 40-50% (80%, according to Takács 2005) is produced in Hungary, depending on the season. Thus, although our role is important, it is not exclusive. Another problem can be the market loss, e.g. in 2004 the export to Germany was reduced by 47.3% in Hungary, but only by 10.4% in Romania (MMCsEE 2005).

Besides Europe, only China produces robinia honey, however its quality is so low that it cannot be sold on the EU market, except when improved with e.g. Hungarian robinia honey. The amount of robinia honey produced in Hungary and China cannot exceed 25,000 tons even in good seasons. However, about 40-50,000 tons of so-called robinia honey are sold in the EU, suggesting that real robinia honey is mixed with other light coloured honeys or manipulated in other ways. It results in the situation that although consumers can hardly find real robinia honey, Hungarian beekeepers cannot sell their high quality robinia honey even at a low price (Takács 2005).

Tilia (lime) species, *Tiliaceae*

Lime trees (*Tilia* spp.) bloom in June, with an overpowering scent, giving high honey flow only in favourably hot and humid weather. ***Tilia cordata*** **Mill. (small-leaved lime)** is a forest species, blooming in the second half of June, 8-10 days after black locust, simultaneously with sweet chestnut, for 10-12 days, ensuring high honey flow in favourable weather. The somewhat later blooming ***Tilia tomentosa*** **Moench (silver lime)** is also a good nectar plant. It is followed by ***Tilia platyphyllos*** **Scop (large-leaved lime)**, planted in parks and alleys, providing ample pollen source, but little nectar. Lime trees on the whole can ensure good honey flow for 3-4 weeks (Sas 1956c; Győr 2001).

Gulyás (unpublished) described the pit-nectaries of limes that are located on the claws of the sepals (**Fig. 2C**), which are ovoid, ca. 5 mm long and greyish green from short trichomes. The nectaries comprise subepidermal small-celled glandular tissue and multicellular glandular trichomes, occurring between epidermal cells. At the claws, trichomes can be found in a furrow-like hollow. From the claw towards the sepal blade the surface of the nectary gradually flattens.

The nectar flow of limes is uneven (**Fig. 2D**). According to Faluba (1957), in order to achieve high honey flow, besides the optimal high temperatures and relative humidity, enough precipitation is also necessary for the soil from July to September the previous year. However, Marton (1960) claimed that honey flow is influenced rather by the precipitation in the month preceding black locust bloom. Soil is an important factor in the honey flow of lime. In general, limes produce little if any honey on sandy soils, while compact soils with medium moisture content, usually rich in nutrients, have a positive effect on nectar flow (Halmágyi 1975).

Sas (1956c) observed that limes usually secrete copious nectar only in early morning hours, until 8.00-10.00 h. According to Örösi (1968) the nectar gland is secreting during the whole day, but most nectar is produced from midnight to 6.00 h. Accordingly, honeybees collect the most nectar in the early morning hours. Depleted nectar is substituted only partially during the day. Our experience confirmed that nectar collecting is the most intensive in the morning, starting at 6.00-7.00 h. In the hottest noon hours, nectar secretion ceases and honeybees are accordingly less active.

In Hungary, Péter studied the nectar production of lime trees. Sugar value was 0.55, 1.79 and 0.55 mg at *T. cordata*, *T. platyphyllos* and *T. tomentosa*, respectively (Halmágyi 1975), compared to 0.15-3.00 mg, 0.54-3.26 mg, 0.63-3.38 mg measured in various other countries. Honey potential is 90-1,000, 250-800 and 560-1,200 kg/ha, respectively (Crane *et al*. 1984).

The apicultural significance of lime almost equals that of black locust in Zselic (South-Transdanubia). Lime honey can be sold and exported at a good price, and bees can develop on it well. In good years it can reach 50-80% of the mean honey flow of black locust. Silver lime is native to the Zselic, however, this valuable bee pasture is disappearing, since the aspects of nature conservation are largely ignored. Similarly to other *Tilia* species, hot, rainy and humid weather is desirable during flowering for good honey flow of silver lime. The amount of precipitation is decisive in nectar flow, about 90 mm rain is desirable, and mean temperatures of 18-19°C are the most advantageous. In the average of 3 months the most favourable are temperatures around 20°C and about 200 mm precipitation. In a study of 4 years (1998-2001), honey yield ranged from 2 to 17 kg/colony, and in a longer interval (1950-2005), from 2.5 to 22 kg (Győr 2001, 2005).

It is difficult to extract pure lime honey, which has a characteristic, pleasant scent and flavour (Halmágyi 1991). Its colour is darker than robinia honey, ranging from pale yellow to amber. The unifloral honey is slightly bitterish, and granulates relatively slowly. Its beneficial effect is well-known for colds, sore throat and coughs, and it is also suggested against nervousness and insomnia (http://www.magyarmez.hu/mezfajtak.html).

Castanea sativa **Mill.,** ***Fagaceae*** **(sweet chestnut)**

Sweet chestnut is a fruit tree of hills and mountains, preferring mild climate, but can tolerate frosts. It is distributed from South Europe and North Africa to the Caucasus; its northernmost occurrence is in the Carpathian basin and the Rhine-region. The tree prefers deep, loose soils that are not calcareous, but also develops well on clay sandy soil or weakly compact soils. In Hungary there are three main regions where sweet chestnut can be found: 1. Nagymaros and vicinity 2. Western Hungary 3. Southern Transdanubia (Hazslinszky 1955a; Halmágyi 1966).

The fruits are among the most nutritious ones, and the tree can be a significant bee-pasture, where a large number of trees is present. Sweet chestnut provides ample pollen, and some of the beekeepers consider it mainly as a pollen source, but the staminate flowers produce nectar as well. In Hungary it blooms in late May, June or early July, for 3-4 weeks, which further enhances its significance, because it covers the interval between black locust and annual hedge-nettle (*Stachys annua*) that is otherwise a poor honeyflow period (Hazslinszky 1955a; Sas 1956c; Halmágyi 1966; Szilva 1969).

The inflorescence is composed either of male or female flowers, or staminate and pistillate flowers occur together (Halmágyi 1966). Only the male flowers produce nectar (Szilva 1969) that is secreted on the surface of the disc (lobed protuberances) located at the base of filaments in staminate flowers (Hazslinszky 1955a; Halmágyi 1966). Although only a tiny amount of nectar is produced in a single flower, the overall nectar production of sweet chestnut is significant due to the huge number of flowers in the inflorescence (Hazslinszky 1955a). Thus it can be a good nectar plant, however, nectar flow is largely influenced by weather. Nectar production starts at approximately 20°C and in sunny weather lasts only until morning dew has dried up. If overcast, in high relative humidity and at 22-28°C, it gives a significant nectar secretion and honey flow. Rain is very harmful to flowers and it washes the nectar out of them (Varga 1955; Sas 1956c). There are nectaries also on the bracts of the pistillate flowers, but honeybees do not collect nectar from these (Halmágyi 1966).

Gulácsy (1975) investigated the nectar production of sweet chestnut in Hungary, in sunny weather, before the drying up of dew. She found that daily nectar weight was above 1 mg/flower, higher than previously reported abroad (0.02-0.09 mg/flower) by Kuliev (1952), but average sugar content was similar in the two studies (21.8% and 22.0%, respectively), ranging from 17.8% to 32.0%, and sugar value was between 0.3-0.5 mg (Gulácsy 1975). The highest colony weight gain reported by Halmágyi (1966) was 8.3 kg. Counting 100 trees/ha, 54.4 kg nectar is produced, which corresponds to 27.20 kg honey, and 11.98 kg pure sugar (Kuliev 1952).

Sweet chestnut honey is golden yellow to yellowish brown in colour, with a strong, characteristic aminoid scent, reminding of chestnut flowers, slightly bitter, granulating relatively late. Its diastase content is usually high. According to pollen analysis, samples often contain as much as 90-100 % sweet chestnut pollen (Hazslinszky 1955a; Örösi 1962). Due to the bitterish taste several people dislike pure chestnut honey (Örösi 1962). Aldrovandi (1961) claimed that Italian chestnut honey was different, with a dark brown colour and crystallizing quickly. The difference can probably be explained by the mixing of honey dew in the Italian honey (Halmágyi 1966). Although quite wide-spread in Hungary, the area covered by sweet chestnut is much greater in other countries, consequently there are more data from abroad. Chestnut honey is popular in Switzerland, France, Italy, Spain, Germany, Austria, the countries of the former Soviet Union and Yugoslavia (Halmágyi 1966). From sweet chestnut, bees can collect also honey dew (Fossel 1958).

Phacelia tanacetifolia **Benth.,** ***Hydrophyllaceae*** **(lacy or tansy phacelia)**

Phacelia tanacetifolia Benth. and *Ph. congesta* Hook. are annuals belonging to the *Hydrophyllaceae* family, originating from California and Texas, respectively, introduced to Europe in the early 19th century (Pellett 1923; Tutin 1992; Kirk 2005). They can be sown periodically during the entire summer, until as late as mid July and thus provide an excellent nectar source continuously (Koltay 1959; Simon 2004). The so-called after-seed phacelia (sown at the end of May) provides a high quality bee pasture from mid-August to late September (Nagy 2002a). Under continental conditions in Hungary it can flower longer than under dry conditions in the Mediterranean, where it flowers only from April to July (Petanidou 2003). Similarly to the UK (Williams and Christian 1991), in Hungary it can be sown even in mid-July, and in this case *Phacelia* flowers from late September until killed by frosts.

It is listed among the world's top twenty honey plants (Crane *et al*. 1984), and has been widely used for nectar under suitable climates in Europe, e.g. in countries of the former USSR, as well as Northern and Eastern European countries. It is suitable for extending summer bee pasture with its long blooming period of 5-6 or even 8 weeks (Williams and Christian 1991), filling the nectar gap between robinia and sunflower, when few other melliferous plants are available, always providing fresh nectar, ensuring good brood and supporting the autumn development of colonies. To avoid simultaneous bloom with black locust, it should be sown in the second half of March (Beretvás 1953). It should be sown periodically, in order to ensure bee-pasture continuously (Nagy 2002b). From the time of sowing, it flowers 6-8 weeks later, and provides valuable bee pasture for as long as 2 months (Péter 1975c). In favourable weather it can give surplus honey, as well (Beretvás 1953; Koltay 1959; Moldvay 1959; Kégi 1960; Dögei 1987). It protects against soil erosion, and can be used also as fodder or soil improver, but the latter uses are not so significant in Hungary as in the case of papilionaceous plants. Its further advantage is that it has a better frost endurance than black locust and can also tolerate drought. It does not require special soil conditions, but does best on medium-compact soils and humus rich sandy soil (Beretvás 1953; Kégi 1960; Nagy 2002c; Kirk 2005).

The inflorescences develop at the shoot apexes, each consisting of scorpioid cymes (**Fig. 2E**), and flowers open in acropetal sequence (Williams 1997). The flowers of *Ph. tanacetifolia* are gamosepalous, the light or dark blue corolla forms a 4-5 mm long tube, widening at the apical part. The stamens are longer than the corolla (**Fig. 2F**), while the style is somewhat shorter than the stamens. The nectary is located around the base of the ovary, and the secreted nectar accumulates at the bottom of the corolla tube (Kégi 1960; Williams 1997; Nagy 2002a). In *Ph. congesta* the stamens are only slightly longer than the corolla tube (Simon 2004).

Dögei (1987) claims that phacelia does not require bee pollination, but it provides an excellent honey source. On the other hand, Nagy (2002a) emphasizes the esssential role of honeybees in fertilisation of the plant. In the absence of bees, seed production is dramatically lower. Both honeybees and bumblebees forage on the flowers from early July until late October in Great-Britain (Williams and Christian 1991), somewhat later than in Hungary. The great advantage of phacelia is that it provides food for bees even under extreme conditions, such as dry, hot as well as wet and cool weather. It emits such an overpowering nectar scent that bees cannot resist, and visit the flowers from early morning to late evening in great numbers (**Fig. 2G**), collecting both nectar and pollen (Nagy 2002a), even in great heat (Nagy 1964). Similarly, in the UK bee foraging commenced as early as 05.00 h to 07.00 h and ceased at 19.00 to 21.00 h GMT (Williams and Christian 1991). The best nectar flow was measured at or above 30°C in Hungary (Beretvás 1953). Flower age was found to be an important correlate of secretion rate in a study conducted in southern UK: 4 h- and 7 h-old flowers had higher secretion rates than older and younger flowers (Williams 1997). Bee visitation of phacelia in Hungary also depends on the blooming intensity of black locust and lime (Nagy 2002c). According to Kulcsár (1960), the nectar production of phacelia is 40% of that in black locust, and provides good bee-pasture for 6-8 bee colonies/ha, but Nagy (2002b) stated that for a hectare it is worth planning 8-10 bee colonies to achieve higher fertilisation rates. Depending on the time of sowing and weather, phacelia may still bloom in November, and Nagy (1964) observed honeybees even then in sunny weather, and claimed that temperatures below 0°C do not harm the nectar production of phacelia (Nagy 1964). However, Péter (1991a) could not measure any nectar below 10°C, concluding that this is the lower limit of nectar production. He determined the optimum temperature for nectar production at 23-24°C, with 60-70% relative humidity.

According to Nagy (2002c), the honey potential ranges from 60 to 360 kg/ha, depending on the season and weather conditions, but Örösi (1968) claimed that honey potential could reach even 300-1000 kg/ha. The odour of phacelia honey is not so intensive as that of the nectar, it has a delicate aroma, its colour is amber or sometimes light green. In the 1980s it became more significant in Hungary, was produced in greater amounts, and was listed among unifloral honeys. It is not advisable to mix phacelia honey with robinia honey, despite their apparent similarity, because phacelia honey granulates quickly and its pollen shape is very different from that of robinia, bearing six long furrows as viewed under the light microscope (Lukács 1988; Kirk 2005).

The popularity of phacelia has been growing throughout Hungary since 2000, because the market position of cereals and corn, traditionally cultivated on large areas, is becoming inestimable. Other factors in its increasing popularity are that its growing expenses are low, it can be cultivated with great certainty and has no special requirements (Nagy 2002c). Phacelia has no pathogens and pests, so only little herbicide is used for weed control. Therefore it is spreading in bio-agriculture as a soil-disinfecter and green manure. It can substitute for other good melliferous plants, if their nectar yield is not satisfactory, mainly due to weather conditions (Nagy 2002a). A further advantage of phacelia is that it can be sown during the period of cereal harvest, which is traditionally in late June, early July in Hungary. Thus phacelia can have a dual role, supplying forage for bees and serving a useful agronomic purpose by the capture of nitrogen and covering the soil protecting it from erosive forces (Williams and Christian 1991).

Brassica nigra (L.) Koch*, Sinapis alba* L., *Brassicaceae* (black and white mustard)

From the cultivated mustards, *Sinapis alba* L. and *Brassica nigra* (L.) Koch. are the most well-known in Hungary. Koppán (1979) observed good honeybee visitation on the flowers of black mustard; most of them collected pollen and nectar together. Extractable honey amounted to 7-8 kg. Molnár (1981) claimed that *S. alba* is a reasonably good nectar plant, which blooms at the end of May or mid June, ensuring ample pollen and sometimes surplus honey, as well. However, Hungarian beekeepers rarely introduce bee colonies to mustard plots, since it is wiser to utilise the whole of black locust bloom. Mustard honey is darker yellow compared to oilseed rape honey, but crystallizes similarly quickly.

Similarly to other *Brassica* species, the lateral nectaries of brown mustard (*B. juncea*) and white mustard (*S. alba*) produced more nectar than the median ones in a study conducted in Poland. Nectar secretion started at loose bud and peaked during anther dehiscence. One hundred flowers of a brown mustard cv. 'Malopolska' and a white mustard cv. 'Borowska' secreted 28.4 mg and 24.9 mg nectar sugar, respectively (Masierowska 2003).

Elaeagnus angustifolia L., *Elaeagnaceae* (Russian olive)

Russian olive can be found from South Europe to Mongolia. It probably arrived in Hungary in the Turkish times (16th century) and became wide-spread especially on the Great Plain. It is able to live on alkaline and sandy soil, too, and can tolerate air pollution. It requires abundant light and high temperatures, but it is frost-hardy in Hungary. Due to the nitrogen-fixing bacteria on its roots, it can improve soil nitrogen supply (Halmágyi 1970).

Russian olive is the best nectar plant of Hungarian alkaline soils, bearing staminate, pistillate and hermaphrodite flowers that emit a strong, overpowering scent. The nectar gland is situated around the base of the more or less developed pistil, being bigger in pistillate and hermaphrodite flowers than in staminate ones (Gulyás 1984c; Halmágyi 1991).

It blooms at the end of May and June, usually with and after black locust; therefore it is suitable for filling the aestival nectar gap (Merényi Maczejka 1958; Gulyás 1984c). Besides the excellent honey flow (Dóka 1968), the tree provides pollen, as well (Koltay 1953). Although sugar values are quite low, honeybees visit flowers from morning to evening, even if bloom overlaps with that of black locust; therefore it is suitable for extending intensive foraging activity and for improving the taste of robinia honey (Halmágyi 1970; Gulyás 1984c). A further advantage is that spring frosts do not damage the flowers (Dóka 1968). However, if the beekeeper wants to produce pure robinia honey, he must take care to avoid places where Russian olive can be found in the vicinity, because it can easily pollute and discolour robinia honey with its pollen.

According to the investigations of Halmágyi (1970), nectar sugar value varied between 0.024-0.088 mg and 0.005-0.056 mg in 1966 and 1969, respectively. Gulyás (1984c) measured 0.06-3.00 mg nectar/flower, with 8.7-69.0% sugar content. According to him sugar values can be slightly higher, ranging from 0.02 to 0.44 mg. Besides fructose, glucose and sucrose, maltose can also be detected in the nectar. Morning dew and moist hot weather can increase nectar production. However, in some flowers no nectar is produced at all (Gulyás 1984c). In 2007 we experienced that although the scented flowers predicted a good honey flow first, honeybees could visit them only for two days, because nectar secretion ceased due to dry, hot weather.

Pure honey can rarely be extracted from Russian olive flowers alone; it is used rather for brood rearing in the well-developed colonies. The honey is light yellow, its scent is the same as that of the flowers (Halmágyi 1970; Gulyás

1984c).

Onobrychis viciifolia Scop., *Fabaceae* (sainfoin)

Sainfoin is a perennial fodder plant that can be grown also in soils that are not good enough for alfalfa and red clover (Jávorka *et al*. 1955). It grows excellently on calcareous soils that are common in Hungary, tolerates cold and drought; therefore, greater attention should be paid to it both as fodder and bee pasture (Dóka 1968; Szalay 1993a).

Sainfoin is entomophilous, allogamous (Jávorka *et al*. 1955), and flowers from late May until late August, later than alfalfa (Halmágyi and Suhayda 1966b; Szalay 1993a), thus the beginning of bloom overlaps with black locust bloom. Although it flowers 3 times a year, only the first 2 blooms give good nectar yield (Molnár 1981). Honeybees can utilize the second bloom, following the first mowing, particularly well (Szilva 1968b). Nectar is secreted around the short peduncle below the ovary (Szilva 1968b), and it is easily accessible on both sides of the free standing stamens (Jávorka *et al*. 1955). Sainfoin attracts honeybees better than alfalfa (Szalay 1993a), and provides better foraging activity than clovers; a weight gain of 5-7 kg is frequent (Jávorka *et al*. 1955; Szilva 1968b). According to Crane *et al*. (1984) honey potential was 4-20 kg/ha, in practice the honey yield was usually 9-20 kg/ha. Ruff (2002) claimed, however that honey potential can reach even 100 kg/ha. The sugar content of nectar is 45% in general, the sugar value is 0.24 mg (Ruff 2002). Although sugar values are small, several flowers open at the same time (Molnár 1981), thus it is worth keeping bees there (Szilva 1968b).

The pale yellow, crystal clear honey has a pleasant odour, in contrast with the mildly unpleasant smell of the flowers, and crystallizes slowly, with a pleasant creamy consistency (Örösi 1962; Szilva 1968b; Ruff 2002). The moisture content is 17%. Sainfoin honey is suitable for mixing with other honeys because of its light colour (Szalay 1993a).

SUMMER BEE PASTURE

Trifolium (clover) species, *Fabaceae*

Clover species are important melliferous plants that had been known as weeds before, and later have become crop plants in Hungary (Koltay 1953). These fodders are important for apiculture only if left for seed production (Halmágyi and Suhayda 1966b). The most important nectar-yielding clovers in order of bloom time are the following: *T. incarnatum* (crimson clover), *T. repens* (white clover) and *T. pratense* (red clover) (Koltay 1953). Sugar values in clovers range from about 0.1 to 0.3 mg, similarly to sugar values of mahonia in weaker years (Halmágyi 1967).

***Trifolium incarnatum* L. (crimson clover)** is an annual, overwintering fodder species (Péter 1991a). It flowers from April to July, before or together with black locust (Sas 1956a; Szilva 1968b; Molnár 1981). Honeybees frequently visit the flowers, providing both pollen and nectar that can be reached easily, because the length of the flower tube is 5.5-6.0 mm (Szilva 1968b; Molnár 1981). Nectar flow is usually moderate (Sas 1956a). For good nectar flow somewhat calcareous soils are desirable (Molnár 1981). In the Transdanubian region, Farkas (1986) observed that crimson clover attracted bees better than oilseed rape or even black locust.

***Trifolium repens* L. (white clover)** is an entomophilous, self-sterile perennial grassland species, not so often cultivated as red clover, but frequently occurring wild. Honeybees can easily reach the nectar, because flower tubes are the shortest in this clover species. The bees readily collect pollen, as well. White clover flowers from May or June until late autumn. Sometimes a few kg foraging activity is possible, but nectar flow is usually enough only for balance (Halmágyi and Suhayda 1966b; Szilva 1968b).

***Trifolium pratense* L. (red clover)** is an important perennial rough fodder and soil improver, grown mainly in the cooler, wetter regions, and occurring also wild. Flowers from June until August (Halmágyi and Suhayda 1966b; Dóka 1968; Szilva 1968b), often together with black locust, but in cases preceding it, honeybees often visit red clover flowers. It can provide bee pasture for a long time if left for seed. The second bloom in the middle of July can be utilised better (Réger 1956; Dóka 1968).

Honeybees can collect pollen from the flowers (Szilva 1968b) and their pollinating work is of high importance for seed yield, because red clover is an entomophilous, allogamous species, similarly to white clover (Halmágyi and Suhayda 1966b). However, in the case of red clover the significance of honeybees as pollinators is smaller than that of bumblebees (*Bombus* spp.), whose proboscis is longer (Péter 1975c). Red clover can be an excellent nectar plant, the flowers may produce nectar abundantly, depending on soil and weather conditions, as well as cultivar characteristics (Halmágyi and Suhayda 1966b; Nikovitz 1985). However, its apicultural value is questionable, because nectar is located deep in the flower, being difficult to access by honeybees. Therefore bees frequently do not visit the deep flowers of red clover (Domonkos 1955; Halmágyi and Suhayda 1966b). Since the mean length of proboscis in Hungarian honeybees is 6.5 mm, nectar is available for them only in cultivars where the flower tube is short (up to 8.0-10.5 mm according to Smaragdova 1954). In long-tube flowers, bees can reach the nectar only if its level rises high enough, thanks to favourable soil and climate conditions (Domonkos 1955; Szilva 1968b; Nikovitz 1985). Also, in some cases intensive bee visitation can be observed mainly on the drooping flower heads, since in this position nectar gets closer to the flower opening (Domonkos 1955).

Crane *et al*. (1984) found 0.08-0.90 mg nectar in a flower and sugar concentration ranged from 17 to 60%. Péter (1971a) measured 0.21-0.74 mg nectar/flower with 10.0-48.5% sugar content and 0.04-0.23 mg sugar value. Cultivars with sugar values exceeding 0.1 mg are considered as suitable nectar sources (Nikovitz 1985). Comparing the nectar production of several legume crops in Canada, Szabo and Najda (1985) found *T. pratense* the best nectar producer (9.6 μl/inflorescence), with the highest sugar concentration (64.8%), and the largest estimated sugar yield (883 kg/ha).

Excessive rainfall is unfavourable for the nectar flow of red clover, and bees do not collect nectar if sugar contents are low due to the diluting effect of rain. According to Réger (1956) and Halmágyi and Suhayda (1966b) for good nectar flow medium moist hard ground and silent, hot and humid weather is optimal, with temperatures of 28-32°C. Péter (1985) determined the minimum temperature for nectar production below 13°C, the maximum above 30°C, and the optimum, where the best sugar values can be reached, between 24-25°C. The optimal relative humidity is 60-80%. Red clover can add to the completion of winter honey and sometimes provides surplus honey, as well. However, colonies usually reach only a balance from red clover; a weight gain of 3-5 kg can be considered as good. There is no foraging activity in cool or extremely dry weather (Réger 1956; Halmágyi and Suhayda 1966b). Honey is crystalline or pale yellow and crystallizes to a medium degree (Szilva 1968b).

***Trifolium hybridum* L. (hybrid clover, Swedish clover)** is a biennial or perennial fodder, originating from Sweden, growing on medium compact or compact clay soils. Similarly to red clover, it flowers from June to August. It is entomophilous, allogamous, like the previously mentioned clover species, and honeybees readily visit the flowers for nectar and pollen (Péter 1991a). According to Nyárády (1958), nectar concentration ranges from 26.5 to 46.5%, averaging 39.0%, and the honey potential is 100-120 kg/ha.

Belonging to the end of summer bee pasture, ***T. arvense* L. (rabbitfoot clover)**, growing mainly on drier sandy soils, is the latest blooming among clovers. If occurring in masses, it can provide some nectar and pollen for honeybees (Sas

1956d).

Helianthus annuus L., *Asteraceae* (sunflower)

Sunflower is the second most important bee pasture plant in Hungary (**Fig. 2H**). It is primarily used in the oil industry, due to its outstanding sowing area, but its apicultural value is significant, too (Farkas 1983; Péter 1991a), which can be explained by its extended flowering period – starting at the end of June or beginning of July, depending on the time of sowing – and the large area (531,000 ha in 2006) where it provides pollen and nectar for honeybees (**Fig. 2I**) (Nyárády 1958). Sunflower is grown in all counties of Hungary, however, its distribution is not even, therefore beekeepers have to migrate in order to reach a better honey yield. At present a large scale of hybrids is available; more than 40 are commonly grown, and the 10 leading hybrids occupy three quarters of the sowing area (Zsombik 2006), thus beekeepers can expect extractable honey mainly from these hybrids.

Opinions about the apicultural value of sunflower varied until the 1970s, because of its uneven honey flow and also because nectar gathering honeybees tend to keep their bodies free from spiny sunflower pollen, so their hair becomes worn down and they soon become ”black” (Ruff 1991). The cultivar shift began from 1977, and by 1980 almost 50% of them was replaced by hybrids. The currently grown hybrids ensure higher nectar production than the earlier cultivated traditional cultivars (Ruff 1991; Péter 1981).

Little information is available about the apicultural value of sunflower under the present conditions of intensive cultivation. The honey production of hybrids can be very different and fluctuating, depending on various soil and climatic conditions, and it may vary even within the same cultivar or hybrid (Suhayda 1997), which can be explained by the highly different ecological adaptability and agrotechnical requirements of hybrids.

Sunflower is an entomophilous plant, thus its fertilisation is greatly enhanced by the pollinating activity of insects, especially honeybees (Péter 1991a). Honeybee pollination helps to increase yield significantly (Benedek *et al*. 1974; Farkas 1983), thus agricultural producers are interested in beekeepers' introducing colonies to sunflower plantations. However, in Hungary it is not usual to pay for honeybee pollination.

The nectar production of sunflower can be influenced not only by the genetic background of the cultivar or hybrid (Péter 1975c; Lajkó 2002), but also by climatic conditions (Halmágyi and Suhayda 1963b; Péter 1975c; Pesti 1980; Zajácz *et al*. 2002). The amount and sugar content of the secreted nectar depends mainly on temperature and relative humidity (Pesti 1980). Besides the weather, the nutritive and moisture content of soil can also influence nectar production and sugar concentration of hybrids, which may change not only between growing areas, but also within a hybrid (Szalai-Mátray *et al*. 2001; Zajácz *et al*. 2002). If the moisture content of the soil is sufficient, there is nectar production even on heat days (Zajácz *et al*. 2002).

Several researchers dealt with the honey flow of sunflower in Hungary, and some of them (Miskolci 1948; Péter 1991b) stated that sunflower is an inconsistent nectar plant. The first Hungarian nectar studies on sunflower were done by Halmágyi and Suhayda (1963b). They measured 0.388-0.487 mg/flower nectar weight, 51.3-53.6% sugar content, and sugar value ranged between 0.207-0.212 mg. Their results called attention to the effect of soil on nectar production. The sugar value of the Hungarian cv. 'Kisvárdai' was 0.331, 0.385 and 0.483 mg on sandy, clay and marshy soil, respectively. Örösi (1968) considered sunflower an excellent nectar source, that was significant only in areas where it was cultivated on a large scale. Frank and Kurnik (1970) found that the sugar value of 'Kisvárdai' was 0.135 mg on clay, which is lower than in previous studies.

In the investigation of Pesti (1976), the sugar value of a disc floret was 0.222 mg, and the highest nectar production was measured at 9.00 h, with 0.570 mg/flower. Nectar production was 0.23-0.59 mg/flower in sunflowers studied by Péter (1981) at 19-25ºC and 64-84% relative humidity, mean sugar content was 39.51% and sugar value ranged between 0.10-0.28 mg. He emphasized the positive effect of artificial fertilizers on nectar production. In the case of nitrogen treatment he measured more, but thinner nectar, and the sugar value remained constant. When treating with phosphorus, nectar sugar content increased by 36.7%. No quantitative or qualitative positive change could be observed in the case of potassium treatment. A significant increase could be achieved, however, by applying NPK together, which increased nectar sugar content by 50%.

According to the study of Nikovitz *et al*. (1984), sugar value was the highest in 'IH–81','IH–51' and 'Luciole' (0.170, 0.148 and 0.133 mg, respectively) from the studied hybrids. Mészáros and Gulyás (1994) measured 0.05-0.26 mg nectar production on compact soil in 1993. Mean sugar content was about 25.0% in the average of 16 studied hybrids. Honey flow values of hybrids 'Aréna' and 'Pixel' were considered excellent by Albrecht and Szalai-Mátray (1998), their sugar value being 0.12 and 0.13 mg, respectively.

The hybrid 'Denver' was classified as weak, 'Dogo', 'Rigasol' and 'Natil' as medium, 'EX 399', 'U 55', 'Sonrisa','Resia','Pixel','S 277' and 'Aréna' as good and 'Beni', 'Viki' and 'Alexandra' as excellent nectar plants by Lajkó (2002). In his earlier study, Lajkó (2001) measured 1.5-2.3 mg average nectar production of 20 disc florets on compact soil.

Nectar production on various soil types was investigated by Bujáki and Horváth (2001). Sugar content was regularly higher than average on compact soil, whereas lower than average on sandy soil. Sugar value was 52 μg/floret based on the results of both soil types. Highest sugar value was measured in hybrid 'Resia', whereas the lowest in 'Iregi HNK 173'. Nectar sugar content was higher than average in hybrids 'Aréna','Sonrisa','Florakisz' and 'S-277'.

Recently the lack or fluctuation of nectar production in sunflower has been reported, which might be explained by the extremities of weather (Szentpáli 2002). The lowest amount of sunflower honey was produced in 2000. Szalai-Mátray *et al*. (2001) investigated the nectar production of 16 sunflower hybrids. Sugar value ranged between 0.032-0.095 mg, the highest values were measured in 'Aréna', 'Larisol' and 'Fantasol', while the lowest in 'Florix', 'Flores' and 'KWS Helia 04'.

Higher average nectar production (0.232, 0.147 mg/floret) and sugar value (0.111, 0.080 mg) were measured on sandy soil with humus compared to clay soil, respectively (Szentes 2003a, 2003b). The reason for this was the larger amount of precipitation during the growing season on sandy soil. This study draws attention to the significant influence of agronomic and habitat conditions and other abiotic factors – mainly the weather – on the nectar and sugar production of hybrids. At the same time, sunflower honey production was larger on clay soil, with an average of 16-18 kg/colony. In accordance with Szentes (2003b), the results of Zajácz *et al*. (2004) confirmed that sunflower produces nectar also on sandy soil, if there is enough precipitation at the right time.

Honeybees visit the flowers in the hottest noon hours, as well, provided that soil moisture and thus nectar production are sufficient (Zajácz *et al*. 2005, 2006a). Morva (1977) observed that the best honey flow can be measured at above 30ºC, below this temperature there is hardly any nectar in sunflower florets, and below 25ºC hive weight decreases.

In sunflower hybrids studied between 2002-2005, nectar production ranged between 0.082-0.353 mg in a disc floret, and sugar content was 36.8-58.7% (Zajácz *et al*. 2006b). Under the given agro-ecological circumstances, 'NK Brio', 'Jazzy' and 'Aréna PR' hybrids gave the best results in the study area, while 'Pedro PR' and 'NK Dolbi' provided less sufficient bee pastures (Zajácz 2006).

The amount of extractable sunflower honey can vary on a broad scale. According to Örösi (1968) it can reach 10-12 kg in a good season, while Morva (1977) measured 19 kg total weight gain. Gulyás (1981) measured 4.9 kg as the highest daily weight gain from sunflower in 1980, and the total amount of extracted honey was 32 kg. Suhayda (1997) claimed that the amount of extractable honey was 25 kg from 'Viki','Astill'and 'Kamill', and 18.4 kg from 'Andrea'.

Sunflower honey amounts to 15-21% of the total yearly production in Hungary (approximately 20,000 t). In 2000 and 2001 it came to the 3^{rd}-4^{th} position only, because of the significant decrease in its sowing area. Sunflower honey has a characteristic flavour, pleasant aroma and scent, and it crystallizes quickly. Its colour ranges from golden yellow to orange, depending on the amount of flavonoids. Its pH is acidic (pH 3.6-4.5), its water content is 17-19%. HMF value after extraction is 0.1-0.2 mg %, slightly increasing afterwards. The ratio of sunflower pollen is usually 35-40%. Diastase activity is medium, but it has to be at least 10.9. The sucrose content of good sunflower honey does not exceed 5-7% (http://www.pointernet.pds.hu/honey/AMC-prosp/AMC-mez.html#Napraforgóméz). In a study of Széles *et al*. (2006), pH was 3.14, acidity 1.535 cm^3, HMF 0.24 mg/100g, diastase activity 13.3, water content 20.7% and sugar content 79.3% in a sunflower honey sample bought from a Hungarian beekeeper.

Asclepias syriaca L., *Asclepiadaceae* (milkweed)

The genus *Asclepias* includes several species, originating from North America, all of them good melliferous plants (Suhayda 1963). *A. syriaca* was introduced to Europe as an ornamental in 1629 (Sajermann 1988), and was first found in Hungary in 1736 (Szalóky 2004). Later on its cultivation came to an end, but these stands served as the starting points of invasion. Now it grows wild, as a perennial weed occurring mainly on sandy soil in Hungary (Sajermann 1988), growing in masses on the previously cultivated areas of the Great Hungarian plain (Fehér 2006) and certain areas of Transdanubia (Ruff 2001), and it is especially frequent in county Bács-Kiskun. It can be easily propagated mainly from the rhizome. Furthermore, it is highly resistant to cultivation and herbicides, consequently it is spreading quickly, which is also enhanced by toxic substances in the bitter latex that prevent animals from feeding on it. It can be harmful for arable lands, vineyards and forest plantations, because of its effective propagation strategy. The root extract inhibits the development of cereals and competing weed species with its toxic substances, but also its shading effect is significant (Fele 2000; Szalóky 2004). Because of its aggressive spread as an invasive weed species, some efforts have been made recently to decrease the stands of milkweed in Hungary.

The plant may flower from June to August in Hungary, with its main bloom after that of black locust (Suhayda 1963; Ruff 2001). In our experience of recent years, flowering finishes earlier, by the beginning of July, especially after a mild winter, like in 2007, when the plants flowered only from early June to late June. A single flower lasts for 3-5 days, but the whole patch of plants can attract honeybees for about a month continuously. Honeybees collect only nectar from the flowers (Fele 2000), visiting them from early morning to late evening. We observed honeybees on the flowers as early as 5.00 h, but in general they started nectar collection at 6.00 h, and finished at 19.00 h or 20.00 h.

An important drawback of milkweed is that it can capture honeybees due to its special flower structure (**Fig. 2J**). The legs of visiting insects get caught in the corpusculum of pollinia. Honeybees transfer the pollinia to the next flower and normally get rid of them or, alternatively they carry the pollen to the hive. Sometimes, however, bees cannot get free and perish on the flower. The degree of bee deaths varies (Suhayda 1963; Fele 2000; Ruff 2001), but there are several beekeepers who dislike milkweed because of this phenomenon.

The nectaries are the walls of the stigmatic chamber (Stadler 1886), and there is an effective capillary connection from the stigmatic chamber to the cuculli, which act as nectar reservoirs (Galil and Zeroni 1965; Kevan *et al*. 1989). According to Kevan *et al*. (1989) nectar has two functions in *A. syriaca*: in the stigmatic chamber it has the direct role in pollen germination and in the cuculli it has an indirect role through pollinator feeding.

In Hungary, honey flow is good especially on sandy soil, where hive weight increase can be 11-14 kg (Suhayda 1963), but also as high as 15-25 kg/colony foraging activity can be reached. Fehér (2006) claims that milkweed has substituted spurge in the bee pasture, but its honey flow is more secure than that of the latter species. On the other hand, Ruff (2001) and Nagy (2002) found the honey flow of milkweed rather inconsistent, but it can be excellent in certain seasons.

For nectar production hot weather (30-34°C) is favourable, when secreted nectar is very concentrated. Highest daily weight gains were measured at the middle of bloom, on the hottest (28-32°C) days (Sajermann 1988; Fele 2000). Some beekeepers observed that nectar flow was weak in hot weather with no precipitation, and best results were achieved in rainy, hot weather (Sajermann 1988). Others claimed that rain or cool weather ceased honey flow and wind made the nectar more concentrated (Fele 2000). Southwick (1983) observed that the highest rate of nectar secretion occurred between 20.00 h and 08.00 h, when evaporation is minimal and nectar sugar concentration falls below 30%. Otherwise, it is highly concentrated, with concentration values above 40%. According to Zsidei (1993) flowers produce 3.0-5.0 mg nectar/day, with 30-50% sugar content. A bee colony can collect 15-20 kg honey during the flowering period of milkweed, and honey potential is 500-600 kg/ha. In sunny weather, at 23-24ºC, Péter (1991b) measured 60-65% sugar content, and sugar value ranged from 2.0 to 2.5 mg/flower/day.

Orosz-Kovács (pers. comm.) confirmed that nectar secretion took place from evening to morning, filling each nectary in the flowers. In early July of 1988, at 6.00 h nectar amounts ranged from 0.4 to 1.9 μl in individual nectaries (5 nectaries/flower), with refraction values between 17-20%. Lower nectar amounts were measured in the balloon stage than in the open flowers. The low sugar content can be explained with high relative humidity (85% at 26ºC). Daily nectar volume/flower was 8.6-10.2 μl, with 18-23% sugar content.

In our experience, 4-5 years ago daily foraging activity reached 3-4 kg/colony, but in the last few years honey yield varied to a great extent. In 2006 on an overcrowded milkweed plot (several thousand colonies/ha), a maximum of 1.0-1.5 kg honey yield/day could be achieved. However, other beekeepers had very good results the same year, with 25-26 kg honey/colony during bloom time. In 2007, nectar flow of milkweed was low in the whole country, and little if any honey could be extracted. The lack of nectar may be attributed to the exceptionally hot weather, with temperatures of 35-40ºC, which caused the wilting and drying of flowers, despite abundant rain at the time of flowering.

The unifloral honey is light yellow or greenish-yellow, very similar to robinia honey, aromatic, with a characteristic pleasant scent that is kept by the honey for months. It granulates slowly, starting with delicate crystals (Sajermann 1988; Fele 2000; Ruff 2001; Fehér 2006). In comparative studies of milkweed and robinia honeys (Szél *et al*. 2002; Kasper-Szél *et al*. 2003) milkweed honeys proved to be of darker colour and more acidic. Both diastase and invertase enzyme activity was significantly higher in milkweed honeys, while fructose to glucose ratio was higher in robinia honey. There was also a significant difference between the di- and trisaccharide content of the two unifloral honeys, maltose and turanose content was outstandingly high in milkweed and robinia honey, respectively.

Cucurbita **and** ***Cucumis*** **spp.,** ***Cucurbitaceae*** **(squashes, cucumbers and melons)**

Koltay (1953) and Sas (1956c) mention *Cucumis* and *Cucurbita* species among the most important nectar-yielding crop plants, some of which have been grown in Hungary since the end of the 16th century (Bartók and Gulyás 1995). They flower after black locust and last almost until the frosts. Their apicultural significance is increased by the fact that the main bloom is in mid-summer, a period with otherwise poor honey flow (Kiss 1956). According to Molnár (1981) cucurbits flower from June to September and produce a lot of nectar and pollen.

Both *Cucurbita* and *Cucumis* spp. are insect-pollinated, allogamous (Kiss 1956; Halmágyi and Suhayda 1965b). In order to reach a good yield the pollination activity of the bees is essential. On the other hand, nectar and pollen yield of squash flowers is of high value for honeybees (Kiss 1956). The number of male flowers is higher compared to females in both genera. According to Halmágyi and Suhayda (1965b), pistillate flowers have smaller apicultural significance, because nectar is produced in fewer flowers and with lower amounts than in staminate ones. Even in the male flowers only a third or half of them contain nectar, which tends to be highly concentrated.

The structure of *Cucurbita* flowers is favourable for honeybees: petals serve as a landing place for them, the corolla tube is spacious, and the openings of the nectar chambers are usually big enough to make them accessible for bees (Szalay 1989). The nectar glands are well-developed, with three tips and three hollows (Örösi 1962) and thanks to their significant size (2.5-5.5 mm in diameter) they can produce enough nectar for filling the honey sac of a few workers (Szalay 1989, 2004). In the pistillate flowers the nectary is located on the top of the ovary, thus honeybees can reach the nectar easily. In staminate flowers the nectar gland is hidden below the dome of the connate filaments, and thus nectar is also hidden to a certain degree (Örösi 1962; Halmágyi and Suhayda 1965b). The degree of connation is a cultivar characteristic. If stamens are highly connate, honeybees cannot access nectar, however good the nectar flow is (Halmágyi and Suhayda 1965b; Szilva 1968a).

The apicultural evaluation of *Cucurbita* spp. varies in the literature. Halmágyi and Suhayda (1965b) stated that varieties of *C. pepo* L. are important for apiculture in Hungary, since they are cultivated crop plants. However, the number of flowers per unit area is much less than in other nectar plants in main bloom, therefore foraging activity is moderate. According to Szalay (2004) this disadvantage can be decreased by a special growing method. Since pollen production is abundant, Halmágyi and Suhayda (1965b) claimed that squashes can be rather counted on as pollen sources. Örösi (1968) confirmed that pollen collecting is also important besides nectar. Others (Sanduleac 1959; Linsley 1960), however, claim that bees can collect pollen from the flowers only with great difficulty.

Opinions vary also concerning nectar flow. According to Kiss (1956) the nectar yield of squashes is voluminous, providing a good bee pasture even in big drought. Thanks to the good honey flow, bee colonies become strong and they can also reserve pollen for winter and the coming spring (Kiss 1956). According to Crane *et al*. (1984) it is excellent, while others classify it as a weak nectar source. Szalay (2004) also measured a wide range of nectar data in Hungary, depending on growing conditions, weather, time of day and degree of reabsorption. He also observed that staminate flowers produce somewhat less and more diluted nectar, contrary to the observations of Halmágyi and Suhayda (1965b). His results are in accordance with the findings of Nepi *et al*. (1996, 2001), who claimed that both male and female flowers of *C. pepo* are extremely rewarding compared with most bee-pollinated flowers, producing 22-40 mg sugar/flower in the 6 h of anthesis. They found that female flowers produced significantly more nectar sugar than did males, mainly because of a higher concentration of sugars in nectar (440 vs. 325 mg/ml), and thus were more attractive for honeybees. Similarly, Ashworth and Galetto (2002) reported threefold higher nectar sugar production in female flowers of *C. maxima* Duch. ssp. *andreana*.

Cucurbit flowers are open from early morning (6.00 h) to the noon hours, parallel to the first active period of honeybees. In the lack of odour they attract the bees with their size and conspicuous colour. However, some cucurbit flowers also have a pleasant scent. Nectar secretion starts already in the bud stage and it continues also in darkness, so it is possible that the nectar cup is dry in the evening, but it is already full of nectar the next morning. The peak of nectar secretion can be observed at 10.00-11.00 h (Szalay 1989, 2004). In the case of plants with a long growing season, nectar yield was the largest in July-August (Szalay 2004).

Cucurbita pepo **var.** ***oblonga*** flowers from July until September. In sunny, warm places where relative humidity is high, nectar is produced abundantly, whereas in cool, shady places nectar production decreases. Honeybees forage mainly on pollen, but generally collect the nectar, too (Szilva 1968a).

Investigating different varieties of *Cucurbita* species, Halmágyi and Suhayda (1965b) found that summer squashes (*C. pepo* varieties) were the most frequently visited by honeybees, probably due to the fact that they had several flowers in close vicinity and nectar was easily available. The nectar weight varied between 4.0-18.3 mg and 8.8-24.1 mg, with 42.2-50.2% and 19.6-54.0% sugar content, and 3.6-8.5 mg and 4.1-6.8 mg sugar value in the cultivar with no runners and with runners, respectively.

According to the investigations of Szalay (1989), the cultivar 'white with no runners' produced the most nectar during main bloom, at the middle of August, and smaller amounts were measured at the beginning and end of bloom.

From the varieties of ***C. maxima***, the highest nectar weight and sugar value were measured in cv. 'Chile', but its filaments were connate to such a degree that honeybees could not access the nectar in male flowers. Cultivars 'Szegedi óriásbogyó' and 'Toursi recézett' also had high nectar weights and sugar contents and bees could access the nectar (Halmágyi and Suhayda 1965b). Szalay (1989, 2004) confirmed that the cultivated varieties of *C. maxima* are mostly good nectar plants, providing a continuous nectar source for honeybees for 2-4 months, whereas *C. moschata* (Duch ex Lam.) Duch ex Poiret is a weak nectar plant.

Since floral nectar production of cucurbits has previously been studied mainly in the Northern areas of Hungary (see above), although they are light and heat-requiring plants, Bartók and Gulyás (1995) decided to investigate their nectar production in the hotter southern part (Szeged) and found that nectar production was higher here than in the cooler northern region. According to their measurements, each marrow cultivar is an excellent melliferous plant, producing large amounts of nectar. They also found that in general, staminate flowers produce more nectar, confirming earlier observations of Halmágyi and Suhayda (1965b). The best nectar producer was *C. pepo*, the maximum nectar amount secreted by its flowers reached 450 mg, which, taking into consideration all nectariferous plants in the world, is exceeded only by the nectar production of the orchid *Coryanthes*. Excellent nectar production can be related to the size of the nectary, because from Hungarian melliferous plants, *C. pepo* possesses the largest nectar glands, its diameter reaching 1.5 cm. In pistillate flowers, the size of the stigma (being a gland itself) is inversely proportionate with the size of the nectar gland. Thus, e.g. in the pistillate flowers of calabash (*Lagenaria vulgaris* Ser.) there is no nectary, because the diameter of the stigma can exceed 1 cm (Bartók and Gulyás 1995).

In the nectar four sugar components could be detected: fructose, α- and β-glucose and sucrose. An interesting observation was that when the first fruit started to develop on a given plant, sucrose could no longer be detected in the nectar, suggesting that sucrose was utilized in fruit development. This was confirmed by an experiment when all developing pistillate flowers were removed from a plant, and consequently sucrose was present in the floral nectar throughout the summer. In the nectar of staminate flowers, potassium- and iron content exceeded that of pistillate flowers (Bartók and Gulyás 1995).

According to Bartók and Gulyás (1995), it is worth introducing bee colonies to *C. pepo* fields. A 10-20 ha area can ensure only the daily needs of a bee colony, and extractable surplus honey cannot be expected (Bartók and Gulyás 1995). Ludányi (1995) also confirmed that pure marrow honey can be extracted only exceptionally, because sunflower flowers at the same time. The honey is golden yellow or yellowish brown, with a pleasant flavour and a faint taste of pumpkin-seed oil. It crystallizes slowly, and despite the formation of large crystals, the honey remains soft.

Extrafloral nectaries also occur in squashes, but they are not significant for apiculture because of their small size (Halmágyi and Suhayda 1965b; Szilva 1968a).

In the pistillate flower of ***Cucumis*** the nectar gland is collar-like. In the staminate flower it covers the bottom of the receptacle and the lobed protuberance. Honeybees can easily access nectar. Cucumber flowers also yield abundant pollen, but not as much as squash flowers (Halmágyi and Suhayda 1965b). The honey flow of *Cucumis* was much lower than that of *Cucurbita* species, and its nectar production was uneven, with few flowers containing nectar at all. Sugar value of cultivars varied between 0.407-3.097 mg (Halmágyi and Suhayda 1965b).

Cucumis melo **L. (muskmelon, honeydew, sugar melon, cantaloupe)** provides nectar and pollen, and honeybees collect both. In the female flowers, the nectary has evolved from the degenerated stamens, in the male flowers from the rudimentary pistil (Szilva 1968a).

In ***Cucumis sativus*** **L. (cucumber)** the number of male flowers is about twice as high as that of female ones. Plants flower from June until September and produce abundant pollen. Nectar flow is uneven, strongly influenced by weather. The honey is dark yellow or brown, tastes like cucumber and crystallizes quickly (Szilva 1968a).

In ***Citrullus lanatus*** **(Thunbg.) Mats et Nak. (watermelon)** nectar accumulates around the base of the stamens in male flowers, and around the base of the stigma in the female flowers. The flowers open from July for 55-60 days continuously. Honeybees readily visit the flowers for nectar, but also collect pollen. Pure honey is not known (Szilva 1968a).

Lotus corniculatus L., *Fabaceae* (bird's foot trefoil)

Bird's foot trefoil is a perennial legume, used as fodder, native to temperate regions of America and Asia. In Hungary it occurs wild on roadsides, pastures and meadows, but it is also cultivated (Péter 1961). Earlier it was considered as a weed, but later on it became one of the most important nectar-yielding crop plants (Koltay 1953), illustrated by the fact that there was a 10-fold increase in its sown area from 1951 to 1961 (Péter 1961). It can be cultivated successfully on acidic soils with poor drainage and ventilation that are not suitable either for alfalfa or red clover (Péter 1991b).

Bird's foot trefoil flowers from May until September. The nectary is located under the ovary, and nectar accumulates in the stamen tube (Szilva 1968b). Honeybees can reach nectar easily and readily visit the flowers, collecting both nectar and pollen, thereby contributing to fertilisation. For apiculture the fields sown for seed are valuable (Péter 1961; Szilva 1968b), because the crop flowers in summer when few nectar sources are available, and it enhances the development of colonies and helps establishing the winter nest (Sztrancsik 1961).

Bird's foot trefoil can be an excellent bee pasture, depending on the weather. Warm, humid and windless weather are favourable for nectar secretion (Péter 1961). Honey flow is enhanced by abundant precipitation and temperatures above 25-28°C (Sztrancsik 1961). Péter (1961, 1971b) measured similar daily nectar weights (0.22-0.61 mg and 0.32-0.48 mg, dry matter content (18.0-50.2% and 20.88-42.74%), and sugar values (0.13 and 0.10-0.15 mg) in 1961 and 1971, respectively. During his 1961 measurements, daily honey flow reached 1.0-2.3 kg in warm weather. Sztrancsik (1961) found that the net weight gain per family was 0.95 kg in the average of 3 years, and honey potential was 20.25 kg/ha. According to Nyárády (1958), however, honey potential can be even twice as much, 50 kg/ha under climatic conditions in Hungary. Its pure honey is not known (Szilva 1968b).

In comparison, in Canada Murrell *et al.* (1982) measured 2.33-5.07 μl nectar/umbel (the mean number of florets/umbel was around 3), concluding that there was a twofold varietal range in nectar yield per umbel and an even larger difference in potential yield per plant. In the USA, DeGrandi-Hoffman and Collison (1982) studied the nectar production of six cultivars, and measured lower values than Murrell *et al.* (1982), corresponding better to those measured earlier in Hungary: florets contained 0.16-0.28 μl nectar, with sugar concentrations ranging from 13.1% to 19.5% (0.03-0.07 mg sugar/floret).

Based on the long-lasting bloom, satisfactory nectar weight and sugar value, bird's foot trefoil could be recommended for the improvement of summer bee pasture. It could not fully substitute annual hedgenettle, but belongs to useful summer nectariferous plants by all means (Péter 1961), and it would be worth keeping bees next to bird's foot trefoil plots (Sztrancsik 1961). Unfortunately, however, as it can be obvious also from the lack of recent literature on *L. corniculatus*, today bird's foot trefoil is hardly known among Hungarian beekeepers.

Ailanthus altissima (Mill.) Swingle [syn. *A. glandulosa* Desf.], *Simaroubaceae* (Chinese Sumach, tree of heaven)

Tree of heaven originates from China, and has been planted as an ornamental in parks and gardens, and also in forest stands on the plains in Hungary (Simon 2004). Being a good nectar and pollen source, Koltay (1953) listed tree of heaven among trees that should be planted in shelter forest belts. Dóka (1968) claimed that Hungarian beekeepers would have no bee pasture problems after black locust bloom, if tree of heaven were similarly wide-spread. However, it is considered as a weed tree in forestry, because it outplaces more valuable trees (Sajermann 1996), being an aggressive "polluting" species that easily goes wild (Simon 2004). It has no special soil requirement (Dóka 1968), but it is more sensitive to early spring frosts than black locust (Sajermann 1996).

According to Dóka (1968) the tree flowers after Russian olive, but before lime trees. Sas (1956c) and Merényi Maczejka (1958) observed that it flowers ca. 2 weeks after black locust, for 10-14 days. Sajermann (1996) claimed that blooming starts already during the main bloom of black locust, and may last for 2-3 weeks, sometimes only 1-2 weeks. Honeybees visit the scented flowers in great numbers, mainly in early morning and afternoon, which suggests that nectar production is lower in the hottest noon hours. Better honey flow was experienced in drier years (Sajermann 1996).

According to Örösi (1962), it is an excellent melliferous plant, but in Sajermann's (1996) experience, a good honey flow cannot be expected each year, only if weather is favourable. In his opinion, on the whole it is worth planting, because it can ensure continuous honey flow after black locust. Although the tree has an unpleasant odour, the light-coloured, greenish honey is aromatic, with a pleasant, intensive muscat odour (Dóka 1968; Hábi 1970; Sajermann 1996). If it is mixed with robinia honey, the quality of the latter can be improved (Sajermann 1996).

Extrafloral nectaries are also significant nectar sources in ailanthus. According to Gulyás (1964) they are located on the leaf margin, while Sajermann (1996) observed them at the leaf base. Bory and Clair-Maczulajtys (1990) gave a detailed description on the position, anatomy and cytology of the foliar nectaries, drawing our attention to variations in the morphology and physiology of extrafloral glands depending on the phenological stage and reproductive state of the tree. Stalked nectaries, with an apical pore, appear on the first leaves, at the base of the petiole. The completely developed pinnated leaves bear nectaries on the abaxial surface of the lamina, each leaflet averaging five nectaries situated at the tip of the secondary vein. The nectar is extruded from the pore which is located at the top of the gland. The different types of extrafloral nectaries show a great homogeneity as regards their histology and cytology, each consisting of an epidermis covered with thick cuticle, glandular tissue, transition zone and a belt of tannin-containing cells. The secretory tissue is supplied by both phloem and xylem. Despite these similarities, the composition of the extrafloral nectar varies according to the type of the nectary (Bory and Clair-Maczulajtys 1986). According to Örösi (1962) nectar is secreted by young leaves in the morning hours. On the contrary, Sajermann (1996) observed that secreting leaves were old, which he explained by everyday rains. Honeybees collected nectar from extrafloral nectaries for 1-2 hours in the morning, and an even shorter period in the afternoon.

Evodia (evodia) species, *Rutaceae*

About 50 *Evodia* species live in East Asia, Polynesia and Australia, and about 20 originate from China (Lengyel 1943; Vicze and Túrmezei 1965). Several *Evodia* species have naturalized in Hungary, e.g. *E. hupehensis* Dode., *E. daniellii* Benn Hemsl., *E. henryi* Dode. and *E. officinalis* Dode. (Péter 1974a). Since they originate from subtropic and tropic areas, they are frost sensitive (Lengyel 1943; Szibele 1991), but frost sensitivity decreases with the aging and strengthening of trees (Suhayda 1991). Sas (1974) claimed that only May frosts can damage young shoots, but this does not affect blooming, either. Also, the cold sensitivity varies from species to species. Taking this into consideration *E. hupehensis* and *E. daniellii* were suggested for European, and thus Hungarian climates, for improving the bee pasture (Suhayda 1991).

Evodia trees grow fast and flower already at the age of 5-6 (Lengyel 1943), from the end of June until the beginning of August (Kiss 1963; Sas 1974). They are important for apiculture not only because they are excellent nectar sources, but also because they flower at a time when other nectar plants are scarce and there is hardly any foraging activity (Kiss 1963; Szibele 1991). Kiss (1963) and Sas (1974) observed that honeybees visited the flowers in great numbers from morning to late evening, especially when temperatures were above 20°C, and collected significant amounts of nectar and pollen. Szibele (1991) counted 15-20 honeybees on a single inflorescence at the same time. They could always find nectar in the flowers.

E. henryi flowers in the second half of June, *E. daniellii* from late June, but mainly in July and *E. hupehensis* in late July, but mainly in August, and sometimes early September. By planting the three species mixed, continuous bee pasture can be established from June to end of August (Vicze and Túrmezei 1965; Túrmezei 1967). Furthermore, trees do not flower at the same time even within a species (Szibele 1991). *E. daniellii* and *E. hupehensis* can be propagated quickly, and the young trees are not so frost-sensitive as those of *Hovenia*. On the other hand, *Evodia* species require much light and cannot tolerate alkaline or too compact soils with high moisture level (Vicze and Túrmezei 1965). With other *Evodia* species (e.g. *E. bodinieri, E. officinalis*, *E. rutecarpa*) the blooming period could be further extended (Vicze and Túrmezei 1965). Bloom time of evodias is usually 3-4 weeks. Within the same inflorescence, male flowers are present in higher numbers compared to females. First the staminate flowers open for a short time, followed by pistillate flowers that start opening only after the staminate ones have wilted (Túrmezei 1967).

Péter *et al*. (1966) studied the nectar production of *Evodia* species in North-West Hungary, and found that mean sugar content was 44.2-64.3% and sugar values ranged from 0.43 to 1.00 mg, while Halmágyi measured 0.199 mg mean nectar weight, 64.9% mean sugar content and 0.132 mg mean sugar value in Gödöllő (central Hungary). According to these data nectar production of evodias was lower than that of black locust (Halmágyi 1975).

In summary, an increased planting of *Evodia* species would be desirable (Vicze 1986), because they are highly suitable for improving the end of summer bee pasture (Péter 1974a), and ***Evodia*** could even replace the disappeared annual hedgenettle (Suhayda 1968a). Their propagation would be desirable because of their long-lasting bloom, abundant nectar production and the easy accessibility of nectar (Kiss 1963).

In the name of ***E. hupehensis*** **Dode. (hupeh evodia)** evodia refers to the sweet scent of nectar ('euodia' = sweet-smelling), and 'hupehensis' to its place of origin (the province Hupeh in Eastern China) (Sas 1974). The tree prefers nutrient rich, medium compact clay soil or better sandy soils. It can moderately tolerate drought, but then its nectar production decreases. Hupeh evodia requires lot of light, is sensitive to frosts, but tolerates polluted air. The tree flowers at an early age (3-5 years), for almost two months. In South Hungary it produces nectar for a long period, from mid July to mid August (Beliczay 1998). An older tree can offer 200,000 flowers for the bees. Freshly opened flowers open fully at 8.00 h and bees start to visit the flowers in great numbers. Bee visitation decreases a bit at noon, but increases again in the afternoon until evening (Túrmezei 1967). In comparison, flowers of hupeh evodia are visited by honeybees in even greater numbers than those of other evodias (Sas 1974). Bees collect both nectar and pollen. Besides honeybees, bumblebees and flies also use the flowers for foraging (Péter 1974a). Where planted as an ornamental, the high number of bees may be disturbing for local residents (Beliczay 1998).

Túrmezei (1967) observed that the life span of individual male flowers is only one day. He recorded that, on the whole, male flowers bloomed for 18 days, followed by an 11-day-long blooming period of female flowers; thus the tree was in bloom for 29 days altogether. In the morning hours he measured 0.95-1.30 mg nectar in staminate flowers and 0.07 mg/flower in pistillate flowers (this value, however is based on data of a single day, and much higher values could be predicted for female flowers, too, because honeybees frequented them just like male flowers). Péter measured slightly higher nectar weights: 1.57 and 1.20 mg in two different locations in 1960 (Túrmezei 1967). In a later study of 4 years in North-West Hungary he concluded that mean nectar weight/flower was around 0.5 mg with 37.12-52.54% sugar content and sugar value varied between 0.21-0.33 mg (Péter 1974a).

Melilotus (melilot or sweetclover) species, *Fabaceae*

Melilotus officinalis **(L.) Pall. (yellow sweetclover)** and ***Melilotus albus*** **Desr. (white sweetclover or melilot)** are biennial plants that had been known as weeds before, but have become crop plants (Koltay 1953; Király 1994) in Europe, then were introduced to the US. They are used as fodder, soil improver and green manure, and are considered to be drought-tolerant due to their deep-reaching root system (Koltay 1954). Melilots require cross pollination; pollen transfer is mediated by honeybees and other insects, thus increasing seed yield (Péter 1975c).

White sweetclover is an excellent melliferous plant, whose value is increased by its flowering time from mid May or June to late autumn (Sas 1956c; Szilva 1968b), often blooming for six weeks (Péter 1991a), filling the summer nectar gap (Király 1994). In Hungary both annual and biennial varieties have been grown, but the cultivation of the biennial, overwintering variety is preferred. It can be utilized only as a fodder plant in the first year (Király 1994), and flowers only in the second season, from late May until early August (Halmágyi and Suhayda 1966b). For apiculture only the plots left for seed are valuable (Péter 1975c). White melilot can be successfully cultivated on poor calcareous and sandy soils, and also on soils that are lacking in nutrients (Péter 1991a). Melilots are among the most important melliferous plants in North America, where the cultivated annual variety known as Hubam-clover was developed. In the USA it is grown on several hundred thousand hectares, and it belongs to the main honey flow (Király 1994), being as important as black locust in Hungary (Koltay 1954; Szilva 1968b). Also in France, melilots are leading nectar plants besides black locust, phacelia and lavender. The EU supports leaving fields fallow and sowing with soil-improving cultures, such as melilots (Nagy 2002). A high priority area is the cultivation of white melilot, as well as phacelia, both of which can be grown with low cultivation costs and production risk, growing well even on low quality soils (Király 1994), without using chemicals and fertilisers. Furthermore, they have a soil-disinfecting, soil-loosening effect and nitrogen-fixing capacity (Mariák 2003). In Hungary more attention should be paid to white melilot, especially in improving summer bee pasture as an excellent nectar plant (Király 1994).

In *M. albus*, nectar glands are located at the base of the ovary, and honeybees can easily suck the nectar out of the short, 4-mm-long flower tubes. Foraging activity above 10 kg is not rare. It is worth introducing honeybee colonies to bigger plots (Szilva 1968b). The sugar value in white melilot flowers is 0.04 mg, and the honey potential is 250-500 kg/ha (Örösi 1968). It is supposed to be drought-tolerant at the time of bloom (Péter 1991a; Király 1994), secreting nectar also in dry, hot weather (Szilva 1968b). However, according to the observations of Pintér (1953) it can keep good nectar producing capacity only between certain limits. Nectar yield can be reduced by strong wind, enhancing the evaporation of nectar and at the same time keeping the bees from flying out, as well as by unfavourable soil types. The honey is light-coloured, crystalline, with a pleasant flavour, with a tinge of vanilla and it crystallizes quickly (Szilva 1968b).

Yellow sweetclover flowers from May until September. Honeybees frequently visit the tiny flowers (**Fig. 2K**) that do not contain much nectar, but in sunny weather the sugar content is above 70%, and sugar value approaches 0.20 mg. It can serve as a daily food source for bees (Péter 1974b).

According to our experience in county Bács-Kiskun (central Hungary) yellow melilot flowers simultaneously with milkweed. If there is good nectar flow in milkweed, honeybees prefer that to melilot, but in the lack of nectar in milkweed, they visit melilot flowers. The orange colour melilot pollen is also highly attractive for honeybees, and they collect it readily, and even more so, because they cannot collect any from milkweed, although it is very important for them for brood rearing.

Vicia (vetch) species, *Fabaceae*

Vicia villosa and *V. pannonica* belong to melliferous crop plants that had been known as weeds before (Koltay 1953). *V. villosa* is considered to be a moderate or good nectar source, whereas *V. pannonica* is a weak nectar plant (Lengyel 1943; Halmágyi and Suhayda 1962b, 1963c).

V. villosa **Roth. (hairy vetch)** was originally spread in South-East Europe and the Mediterranean. In Hungary it is an important fodder plant and soil improver (green manure) (Szilva 1968b). It is widespread in dry grasslands and stubbles as a weed (Halmágyi and Suhayda 1966b), prefers compact soils, but succeeds in any well-drained, even low productivity soils, such as poor sandy soil (Péter 1991a). It is grown mostly with rye as support plant (http://www.date.hu/szervez/nyiregyh/nemesit/szoszosb.htm). These plants flower immediately after robinia, from late May until early August or even September (Halmágyi and Suhayda 1966b; Szilva 1968b). It is worth introducing colonies to well-developed hairy vetch stands, but only stands left for seed are important for apiculture (Szilva 1968b) and mainly the nectar, because pollen production is not significant, compared to nectar yield (Örösi 1962; Halmágyi and Suhayda 1963c, 1966b). Honeybees readily visit the flowers for nectar and pollen (Nyárády 1958; Szilva 1968b) and their pollinating activity increases the seed yield of this allogamous annual plant (Halmágyi and Suhayda 1966b; Szilva 1968b). Örösi (1962) observed that honeybees can access nectar in the normal way or through a hole made by bumblebees.

There is no significant nectar production at the beginning and end of bloom. Hairy vetch can tolerate dry, hot weather relatively well, and moderate, constant wind does not reduce nectar production, either, because nectar can be found quite deep and therefore protected in the flower. Strong wind decreases the number of flowers with nectar and it becomes concentrated, while in humid weather it is diluted. The honey flow is uneven, but it can be good in favourable weather, when it is sufficiently hot, with maximum temperatures above 20°C and high relative humidity, e.g. following rain. In such weather the amount or sugar content of nectar is not necessarily higher, but nectar can be found in a significantly higher number of flowers. In dry, windy and cool weather, however, the majority (half or two thirds) of flowers does not offer any nectar or its amount is much less. Most nectar was measured in flowers just before wilting and also in better developed inflorescences. Its sugar value varied between 0.087-0.201 and 0.047-0.282 mg in 1961 and 1962, respectively (Halmágyi and Suhayda 1962b). Although sugar values are not high, it is counterbalanced by the great number of flowers and inflorescences, therefore it is worth migrating on it. Péter (1971a) measured 0.62-1.65 mg nectar in flowers on sunny days, and 1.42-2.57 mg on rainy days, sugar content was 27.88-35,60% and 18.21-32,00%, respectively, and sugar value ranged from 0.17 to 0.57 mg. In hot sunny weather hairy vetch can yield surplus honey, however, in years with changeable, rainy weather no good results can be expected (Péter 1975d). Daily foraging activity of 1-3 kg is frequent, but also 12 kg is possible, and weight gain varies between 5-15 kg. Its honey is crystalline, white, pale amber or greenish yellow, with a pleasant, mild flavour (Halmágyi and Suhayda 1962b, 1963c, 1966b; Szilva 1968b).

Besides intrafloral nectaries, the plant also possesses extrafloral ones on the stipules at the base of the petiole, but the nectar production of the latter ones is not significant. In 3 years of study, no nectar drops and collecting honeybees could be observed on the extrafloral glands, even at the time when floral nectaries provided abundant nectar (Lengyel 1943; Nyárády 1958; Örösi 1962; Halmágyi and Suhayda 1962b, 1963c; Gulyás 1964; Szilva 1968b).

Vicia pannonica **Cr. (Hungarian vetch)** is an annual crop that requires better, eutrophic soil compared to hairy vetch. It flowers also for 2-3 weeks but it is considered a weak nectar plant. Still, honeybees visit the flowers for pollen and nectar. Dry, hot, as well as cool weather is unfavourable for nectar production. A plant bears relatively few flowers, and the majority of these does not produce nectar. Even in favourable weather only half of the flowers contained any nectar on 2-3 sampling days, when sugar value reached or exceeded that of hairy vetch, however, honeybees rather visited the flowers of the latter one. They can collect nectar from the flowers of Hungarian vetch only with difficulty (Halmágyi and Suhayda 1963c), because they can reach it only if bumblebees have pierced them before. However, honeybees could easily collect nectar from the extrafloral glands that are frequently present on stipules (Lengyel 1943; Nyárády 1958; Örösi 1962). In three years of study nectar could be measured in one year only, on 3 stipules altogether, in average 0.33 mg/stipule, and they were instead visited by ants (Halmágyi and Suhayda 1963c).

V. faba **L. (broad bean)** flowers in June and July. It is mainly self-pollinated, but the odour of the flowers and food attracts the bees, thus foreign pollination may also occur. Honeybees frequently visit broad bean flowers, since they can collect both nectar and pollen (Nyárády 1958; Vicze 1987). Nectar glands can be found inside and outside the flower, at the top of the rachis and on the stipule (Péter 1975c). Lengyel (1943) observed that honeybees can access the flowers only if bumblebees have pierced them previously, similarly to other vetches. However, Nikovitz *et al.* (1985) stated that although the corolla tube is quite long, honeybees can reach the nectar with their proboscis. According to their measurements, cv. 'Lippói' produced only 0.2 mg diluted nectar, in accordance with earlier observations about moderate honey flow Örösi (1962).

The nectary structure of *Vicia* species was described in detail by Davis *et al.* (1988), Davis and Gunning 1991, 1992) and Stpiczynska (1995). From nine *Vicia* species two had small, almost flat nectaries (*V. tetrasperma*, *V. hirsuta*), while the others possessed much better developed glands. The nectaries of five *Vicia* species had convexities with the shape of a protuberance, a half-ring or a half-ring with a ligulate outgrowth, with secretory stomata on the top. The intrafloral gland of *V. villosa* and *V. angustifolia* belong to the latter type, while that of *V. sepium* is completely convex, annular, with a ligulate outgrowth, contrasting the earlier observations of Gulyás and Kincsek (1982), who described the glands of these three vetches as epimorphic, flat nectaries. Nectary stomata are supposed to have a passive, non-regulatory function during nectar secretion, due to the loss of guard-cell movement (Davis *et al.* 1988; Davis and Gunning 1992). In the flowers of *V. faba* total nectar sugar production was positively correlated with the percentage of modified stomata on the extreme tip of the nectary projections (Davis and Gunning 1991).

Stachys annua L., *Lamiaceae* (annual hedgenettle, woundwort)

Woundwort is an annual, excellent melliferous plant, widespread in Europe and South-West Asia. Except for extremely acid and loose sandy soils it occurs everywhere, but grows best on compact calcareous soils (Halmágyi and Suhayda 1966c). Despite its uneven nectar flow, in the 1950s annual hedgenettle used to be the second best nectar plant in Hungary after robinia. It grew on arable fields, mainly in stubble-fields, especially on loose, warm clay and loess soils (Hazslinszky 1955b). In the 1960s it was still the most important nectar plant among weeds (Halmágyi and Suhayda 1966c). Transition to large-scale agriculture in the 1950s and '60s, however did not favour annual hedgenettle, and consequently its apicultural significance was decreasing. Outstanding results like 20-30 years ago were rare in the 1960s. However, it was still significant for apiculture, because the species flowered in the period when there were hardly any other significant nectariferous plants (Halmágyi and Suhayda 1966c). By the 1970s annual hedgenettle almost disappeared from the fields, due to stubble-stripping, but mainly to preemergent weed-killers (Csörgő 1977; Székelyhidi 1978). In the 1990s both factors were falling to the background, thus creating a more favourable environment for hedgenettle, which has also been used as a medicinal plant (Szalay 1993b). On the southern part of the Great Hungarian Plain annual hedgenettle is gaining space again (Nagy 2002). Torma *et al.* (2006) also found that *S. annua* appeared among the characteristic weeds of maize plots.

Annual hedgenettle flowers from early June to late September, or even October in favourable weather, usually for 1.5-2 months. The main blooming period is in July (Sas 1956c, 1956e; Újvárosi 1957; Halmágyi and Suhayda 1966c). The apicultural significance is not only in producing more honey, but it can also ensure the strengthening of colonies and safe wintering, and consequently strong colonies the next spring (Hazslinszky 1955b).

The nectariferous tissue is located at the base of the pistil, secreting the nectar to the bottom of the corolla tube (Péter 1973). The honey flow of annual hedgenettle is excellent in favourable weather, but it is strongly influenced by the composition and moisture content of the soil, as well as by temperature and relative humidity (Sas 1956e). Following a rainy period in early summer, it yields ample nectar in hot summers (30-35°C day temperatures and dewy nights). The main two reasons for the lack of honey flow are excessive summer precipitation and cold soil, as well as low air temperatures. Flowers can produce nectar if temperatures are above 16-18°C and relative humidity is above 50-60%. If any of these conditions is not met, nectar secretion will cease or decrease to a degree that bees will not be able to reach the tiny nectar drop at the bottom of the flower (Hazslinszky 1955b; Koltay 1955; Nyárády 1958; Halmágyi and Suhayda 1966c; Péter 1973).

Its honey yield/colony could reach 50-100 kg in the 1950s (Hazslinszky 1955b), but in the 1960s, 17.8 and 19.5 kg were among the higher results, and the best foraging activity recorded in 10 years was 22.7 kg (Halmágyi and Suhayda 1966c). Péter (1973) measured 0.556 mg nectar/flower with 33.14% sugar content, and sugar value was 0.184 mg in the average of 3 years. The honey of annual hedgenettle is crystalline or pale yellow (Örösi 1962).

END OF SUMMER BEE PASTURE

Solidago (goldenrod) species, *Asteraceae*

Goldenrod species are native to North America, all of them known as good melliferous plants. In 1963 Suhayda suggested planting goldenrods in Hungary, claiming that they can be significant for apiculture only if occurring in great numbers. By the end of the 1970s, *Solidago* species were already spread on the banks of the river Drava (Székelyhidi 1978). Today they are considered as dangerous invasive species that are common along roads and riverbanks. Although their further spread is undesirable from ecological and nature conservation aspects, they are valuable plants both for apiculture and as medicinal plants. The shoots of various goldenrod species are collected at the beginning of flowering as herbs with a diuretic and anti-inflammatory effect.

In the case of *Solidago gigantea* Ait. (giant goldenrod) and *S. canadensis* L. (Canadian goldenrod) the first occasions of going wild in Hungary can be dated to the mid 19th century. Today giant goldenrod is common in Transdanubia, whereas Canadian goldenrod can be observed mainly around larger Transdanubian cities and the capital, Budapest. The blooming period lasts from mid July to October. Giant goldenrod prefers habitats close to natural, mainly on wet, sometimes compact grounds, whereas Canadian goldenrod occurs on looser, quickly warming soils (Péter 1974b; Szalóky 2004). Their pollen serves as a food source not only for honeybees, but other insects as well, and these also contribute to the spread of goldenrods. The ample pollen is very important for overwintering honeybees as a winter food source. Another factor in their quick spread is that the specialist phytophagous insects that feed on *Solidago* species in North America, are missing in Europe (Szalóky 2004).

In Hungary *Solidago* species provide the best honey flow on moist, compact soil, but honeybees readily visit the flowers everywhere all day long (Suhayda 1963). Goldenrods are good nectar producers under suitable conditions and honeybees can easily reach nectar in the flowers. Besides bees, flies can also be observed on the flowers, sucking nectar (Székelyhidi 1978). Goldenrod secretes nectar periodically (Bede Fazekas 1973). The plant is the most sensitive to soil moisture and air temperatures, requiring 25-26°C for good nectar flow, producing the highest nectar amounts at temperatures around 30°C. If these requirements are met, it is a reliable melliferous plant that can ensure huge foraging activity (Suhayda 1963; Székelyhidi 1978), providing overwintering honey, and usually surplus honey, too. In the average of 4 years, honey yield per colony was 8-10 kg (Bede Fazekas 1973), but according to Suhayda (1963) hive weight increase ranges from 11 to 16 kg.

S. gigantea flowers contain 0.26-0.38 mg nectar under optimal conditions, but in other cases there is no measurable amount of nectar in the flowers. Sugar content usually remains below 30% and sugar value is generally well below 1 mg. Beekeepers must take its uneven nectar production into consideration: in certain years it ensures overwintering food for colonies, in others they perish during goldenrod bloom (Péter 1974b, 1975b).

Goldenrod honey is among the unifloral Hungarian honeys that have been accepted and acknowledged in the EU (Szalay 2006). However, goldenrod honey can vary to a great extent, because it also contains the honey of several other wild flowers that bloom at the same time and habitat (Vicze 2006). The honey is dark brown, with a strong scent and pleasant, spicy flavour, granulating quickly (http://www.magyarmez.hu/mezfajtak.html).

Sophora japonica L., *Fabaceae* (Japanese pagodatree, scholar tree)

Japanese pagodatree originates from the Far East. In Hungary it flowers in late July and early August, thus could ensure continuity in bee pasture after the bloom of black locust and lime trees (Sas 1956e; Merényi Maczejka 1958; Visy 1964). Besides being a pollen and nectar source for honeybees (Koltay 1953), it also provides a high quantity of wood, and can be planted as an ornamental. The tree can tolerate weaker, even alkaline soils; it is drought-resistant and prefers hot weather (Szőcs 1974).

There is a great number of flowers on a tree, visited by large numbers of bees, most intensively in the morning and early afternoon (Suhayda 1968b; Buchinger 1969). Honeybees can often be observed also on flowers that are below the tree, collecting nectar. There are 50-100 flowers in an inflorescence, opening at different times in the interval of 3-6 days. Two peaks could be observed in honeybee visitation: at 11.00 h and 16.00 h. Air temperature and humidity strongly influences the number of bees visiting the trees, as well as sunshine. The nectar gland is located at the base of the flower, next to the pistil. Its honey can hardly be obtained purely, it usually mixes with the nectar of other plants (Visy 1964). Its honey is dark yellow, in sunshine looks olive-green and granulates quickly (Szőcs 1974).

At the end of the 1960s, at the time of bloom several authors observed "walking" honeybees under the tree that were not able to fly and also dead bees. The proboscis of dead bees was thrust out. The nectar and probably also the pollen of pagoda trees was supposed to contain some kind of toxic material that could cause the death of honeybees and brood (Buchinger 1969; Kangyal 1969). On the other hand, in different years and places, Kangyal (1969) observed several honeybees visiting the flowers of pagoda trees, and all of them remained healthy while collecting a lot of nectar and pollen. Zsigmond (1969) also claimed that if the flowers of Japanese pagodatree were in fact toxic, death of honeybees would be experienced at all times and places, but this is not the case. Szőcs *et al.* (1969) stated that honeybees became strengthened on the flowers of pagoda trees, and sometimes surplus honey was gained, too. According to him 3-4 dead bees per square meter corresponds to the natural death rate of honeybees.

Gontarski (1949) experimented with the honey, nectar and pollen of *Sophora*. Bees did not die or become paralysed from either of them. They were neither dazed when closed together with inflorescences of pagoda trees. He discovered that honeybees became the victims of the bee-beetle (*Philantus triangulum*). This wasp paralyses the bees with its sting, and afterwards pushes the nectar out of the bee, or carries the victim into its nest. A single female may kill 400-1000 honeybees. This view could be supported also by the fact that honeybees under pagoda trees seem to be dead, but they stay alive for a while, though paralysed (Gontarski 1949). Szőcs *et al*. (1969) also believed that bee-beetles (*Philantus* sp.) can be responsible for pulling out the proboscis of honeybees.

Besides *S. japonica*, three related species are known as good nectar plants: *S. microphylla*, *S. secundiflora* and *S. tomentosa*. The nectar of *S. secundiflora* was suspected to be toxic for honeybees, but no trustworthy observation or experiment was carried out to prove it. *S. microphylla* was also supposed to daze honeybees, which could be in the background of the mysterious bee deaths (Szőcs *et al*. 1969).

Fagopyrum esculentum Moench, *Polygonaceae* (buckwheat)

Buckwheat is an annual crop that has been cultivated for centuries in Asia, North America and Europe for human and cattle consumption. Originating from Asia, it spread in Eastern-Europe with the mediation of Mongols and Turks, and then also in Western Europe. It was a well-known cereal in the Middle Ages (Sághi 2002), and it was still grown in Hungary at the turn of the 19th century, in southern Transdanubia and Northern Hungary (Bálint 1998). Later it fell into oblivion, not only because of a change in diet, but also due to the lack of improvement in contrast to other cereals (Sághi 2002).

However, with the spreading of bio-foods, buckwheat has been re-discovered in western Europe, as part of a natural diet. Today there is an increasing demand for buckwheat, and it can be marketed well in the EU. It has become popular, thanks to its advantegous physiological and medicinal effects. Its biomass can be used as fodder, too. It can be cultivated easily, and does not need any herbicide treatment, because it is able to suppress weeds. The plant has a short growing season, with high heat requirement, thus it is suitable as after-seed (Bálint 1998). Being frost-sensitive, it can be sown from mid-May. It can be cultivated on any soil, except for extreme soil conditions (Péter 1991a). Depending on the time of sowing, in Hungary it flowers from the end of June to end of September (Szilva 1968b; Sághi 2002), generally for 4 weeks, out of which 3 weeks are the period of intensive nectar secretion. Honeybees visit the flowers only in the morning (Péter 1991a), unless it is cool and cloudy or rainy, when they visit the flowers all day long (Ember 1955). The yield of buckwheat can be significantly (by as much as 500-1000 kg/ha) increased by bee-pollination, since it is self-incompatible (Szilva 1968b; Sághi 2002).

The flowers form a corymb (Bálint 1998; Sághi 2002). Buckwheat is distylous, pin flowers develop long styles that project 2-3 mm above the anthers, while thrum flowers present short styles reaching about the level of the middle of the filaments of the stamens (Cawoy *et al*. 2006). The orange nectaries appear at the base of the stamens, in the form of swellings. Honeybees can easily suck the nectar out of the 5-mm-long flower tubes (Szilva 1968b).

Buckwheat can be an excellent melliferous plant, its abundant nectar production and long blooming period make it a popular bee pasture (Bálint 1998; Sághi 2002). However, it is known for its uneven nectar flow (Szilva 1968b), being good only under optimal environmental conditions, when it is grown on compact soil, the end of summer is rainy and cool (rains every 3-4 days), and day temperatures do not exceed 25°C. It cannot tolerate hot weather and drought (Sas 1956d), because its roots are close to the soil surface, and in the absence of rain it does not yield any nectar, even if nights are cool. Honey yield is ca. 0.5 kg/day, so it is worth introducing honeybee colonies to buckwheat (Ember 1955).

Cawoy *et al*. (2006) observed in Belgium that thrum flowers produced larger and fewer pollen grains and secreted more nectar, with a higher proportion of sucrose, than pin flowers. Higher nectar production of thrum flowers was recorded only during the first 5 weeks after plants started to flower. Thereafter, nectar production decreased, and differences between the two morphs were no longer statistically significant. Nectar contained sucrose, glucose and fructose, and was hexose dominant. Total sugar concentrations were similar in the two morphs, but sucrose concentration was significantly higher in the nectar of thrum flowers. The sucrose/ hexose ratio, considered a good estimator of insect attractiveness, was higher for thrum plants. In the field, thrum flowers were preferentially visited by honeybees, they spent more time per flower and visited more flowers per inflorescence on thrum than on pin plants, particularly in the morning. Honeybee foraging activity was apparently correlated with nectar production, which was higher in thrum flowers and increased during the course of a plant's life, culminating at full blooming.

In Hungary buckwheat can give 100-200 kg/ha honey (Sághi 2002). Its honey is reddish brown or dark brown, with a distinct scent, pleasant for some people, unpleasant for others, therefore it is rather used for baking (Ember 1955; Szilva 1968b). Although its organoleptic properties are different from the products that are known for Hungarian honey consumers, any amount of buckwheat honey can be sold to France. It has been proved that its effective substances can be found in the honey, as well, therefore it is especially sought after in cardiotherapy. Besides buckwheat honey, the pollen is also important as an export product (Sághi 2002).

CONCLUDING REMARKS AND NEED FOR FURTHER RESEARCH

As it could be obvious throughout the text, most of the available literature on Hungarian bee-pasture is out of date, with the exception of a few important melliferous crop plants, such as oilseed rape and sunflower, as well as fruit trees. There is very limited information available about the nectar production of some plants that are becoming important as sources of valuable unifloral honeys, such as lavanders and sages. New investigations on the nectar and honey production of Hungarian nectar plants under the present ecological conditions would be absolutely necessary, also in the case of better known crops, because new cultivars are being introduced, and their nectar producing capacity or honey potential is not yet known. Another important issue is that the nectar producing ability of crop plants should be taken into consideration in cultivar breeding. More attention should be paid to the needs of apiculture in agricultural practice, both in terms of making melliferous plants available as bee-pasture, and applying the proper chemicals at the proper time in order to avoid bee deaths. If various segments of agriculture can co-operate with each other, both cross pollination needs of several crops can be ensured, and high quality honey production can be maintained in Hungary.

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