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THE FLORAL NECTAR PRODUCTION OF THREE *INULA* SPECIES

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We have examined nectar secretion of three *Inula* species (*Inula spiraeifolia* L. , *I. ensifolia* L. , *I. salicina* L.) and we have established that the nectar secretion is periodical. The production maximums appear every two hours to *I. spiraeifolia* and there is a three hours rhythm at *I. salicina*. We have found a forenoon and an afternoon production section at *I. ensifolia*. The three *Inula* species nectar contains three main sugar components: glucose, fructose and sucrose, but their quantity values were different to each other. The nectar of *I. spiraeifolia* is hexose-rich (glucose-dominant), the nectar of *I. ensifolia* is sucrose-rich and the nectar of *I. salicina* is sucrose-dominant. The sexual reproduction was accented at species which are sucrose-rich or sucrose-dominant. The vegetative reproduction seems to be dominant at hexose-rich species.

Key words: Asteraceae, nectar analysis, sugar content, rhythm of nectar production, abiotic factors

INTRODUCTION

We give the nectar secretion of some species of *Inula* genus about which there is very few data or no data at all. Pesti (1980) dealt with the floral nectaries of Asteraceae. The nectar secretion of crops is known among taxa of the family (*Helianthus annuus* L., *Matricaria chamomilla* L.) (McGregor 1976, Máthé 1979, Nikovitz 1983, Frank and Szabó 1989). There are data about wild Asteraceae species, e.g. *Taraxacum officinale* Weber, *Centaurea micranthos* Gmel., *Arctium tomentosum* Mill. (Nikovitz 1983). There were examined taxa of several families referred Asteraceae by Percival (1961), Baker and Baker (1975) and who have done pollination-research on the family (Andersson 1990, 1991, Lack 1976, Kevan et al. 1993, Loertscher et al. 1995).

The purpose of my research was the following:

– determination of floral nectar content,
– determination of daily rhythm of nectar secretion,
– influence of main abiotic factors on the nectar secretion.

MATERIALS AND METHODS

Study sites

The sample area is in South Hungary, in the southern part of the Mecsek Mts, on Tettye Hill. Karstic shrub-forest is typical on the southern slope (*Inulo spiraeifoliae-Quercetum virgilianae*), with species of forest-steppe and steppes such as *Inula spiraeifolia*, *Orchis simia*, and characteristically southern species *Ligustrum vulgare, Berberis vulgaris*, *Lonicera caprifolium*, *Tamus communis*, *Ruscus aculeatus* and *Helleborus odorus* have been found as sub-Mediterranean elements. *Cleistogeni-Festucetum rupicolae* association has been found on the southeastern slope. The species *Festuca rupicola* and *F. valesiaca* are in high constancy. Rare species are: *Pulsatilla grandis*, *Plantago argentea, Ophrys cornuta* (Borhidi 1996). We could find three *Inula* species on the study sites.

Nectar collection and analysis

The sampling of nectar was made in July and August 1997. Nectar samples were taken in every hour, repeatedly from the same flowers, from previously isolated inflorescence, with Whatman no. 1 paper wicks (McKenna and Thomson 1988). The plants were chosen by random which was sampled nectar. We measured the temperature and the relative vapour over 12 hours. Three kinds of sugars were analyzed, sucrose, fructose and glucose (others were not present in the nectar samples!). We has used standards. The obtained nectar was unfastened from Whatman paper. The nectar analysis was carried out by thin layer chromatography (TLC), where the stationary phase was Silica gel 60 F_{524} TLC foils (Merck), with the sample application we used 1 µl Minicaps. The mobile phase was ethyl-acetate : ethanol : 60% acetic acid-water : saturated with boric acid (5:2:1:1), the post-derivatization took place with thymol sulphuric reagent (Grösz and Braunsteiner 1989). After the chemical reaction had been taken place the purple patches were visible on the TLC plates. Area size of patches were measured with densitometer. The different sugars concentration were counted by area size of patches.

RESULTS

The sugar content of nectar

We managed to demonstrated three sugar type in the examined nectar of *Inula* species: sucrose, fructose and glucose.

The rare specialist (Sr) (Borhidi 1993) *Inula spiraeifolia* gives order with the lowest content of fuctose and sucrose (2.7498 mg/ml, 2.7146 mg/ml) and the highest glucose content. The glucose-dominant is typical in every nectar sample of *I. spiraeifolia*. The glucose content takes part in sugar content is the biggest in the nectar of *I. spiraeifolia* (38.63%). According to Baker-scale (1975) *I. spiraeifolia* nectar is hexose-rich (S/(G+F) = 0.4253) (Fig. 1). Nectar production was less in the beginning of the blooming period, but quality and quantity maximum of nectar production was at bulk blooming to *I. spiraeifolia*. Nectar production decreased in the end of the blooming period (Fig. 5).

In the generalist (G) *I. ensifolia* nectar fructose was the highest (32.89%) and glucose was the lowest content (9.17%) (Table 1). So, the highest value was sucrose content/total sugar content in the nectar of *I. ensifolia* (57.94%) (Fig. 1). Sucrose was the dominant sugar in *I. ensifolia* nectar (Baker-scale: (S/(G+F) = 0.9915, sucrose-rich). The highest sugar content nectar is produced at the main time of the blooming period in the early July. Nectar production decreased in the beginning of the blooming period and at the end of the one, but it does not leave off (Fig. 6).

Table 1
Sugar content (mg/ml) of *Inula* species

		I. spiraeifolia	*I. ensifolia*	*I. salicina*
Fructose	average of the daily total glucose content	2.7146	6.5105	5.8143
	minimum proved fructose content	0.4313	0.404	0.5106
	maximum proved fructose content	3.4959	3.9571	2.894
Glucose	average of the daily total glucose content	3.7459	2.7794	3.3701
	minimum proved glucose content	1.0324	1.2572	0.7668
	maximum proved glucose content	4.6909	3.7434	3.2964
Sucrose	average of the daily total sucrose content	2.7498	9.2109	12.9504
	minimum proved sucrose content	0.4854	0.4126	0.6198
	maximum proved sucrose content	2.3382	9.1499	5.1252

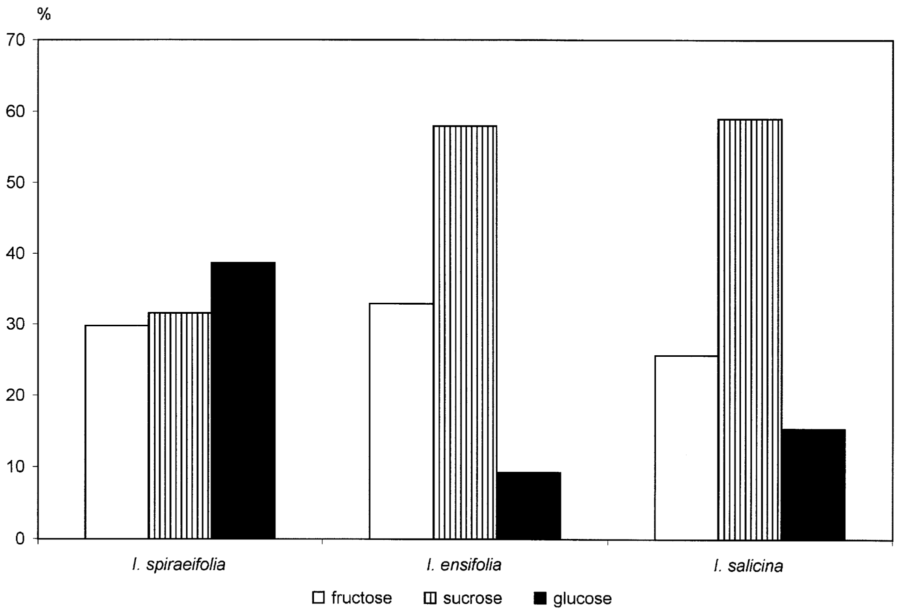

Fig. 1. The percentage divided of sugar components of *Inula* species

In our results sucrose was the highest content in *I. salicina* nectar (22.1348 mg/ml) (Table 1) and sucrose content/total sugar content was 58.98% (Fig. 1). *I. salicina* nectar is sucrose-dominant according to Baker-

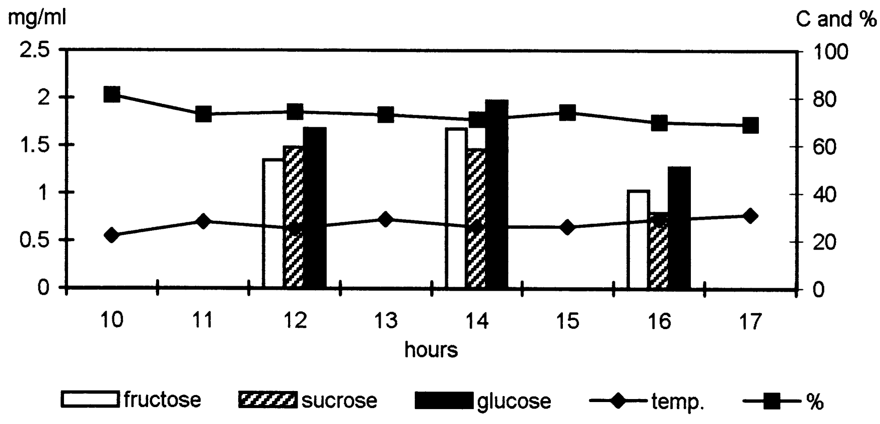

Fig. 2. The sugar content of *Inula spiraeifolia* in dependence of the temperature and the relative vapour

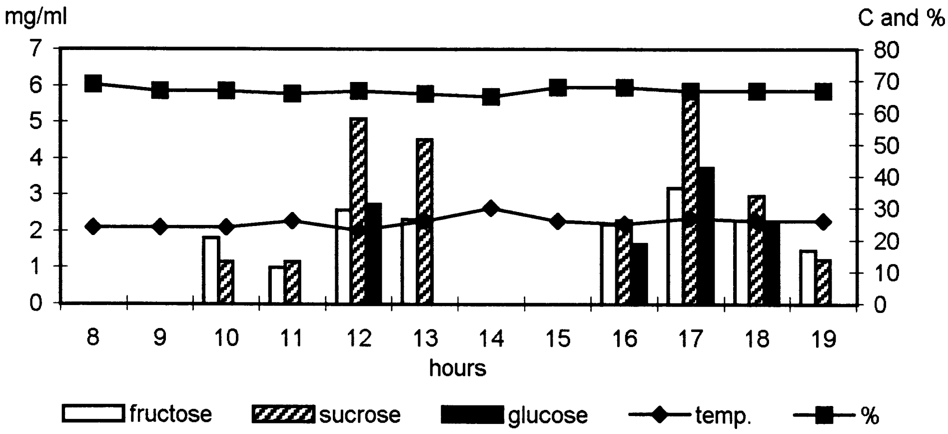

Fig. 3. The sugar content of *Inula ensifolia* in dependence of the temperature and the relative vapour

scale (S/(G+F) = 1.41). Quality of sugars in the nectar samples was the maximum in the early July. Sugar content of nectar was lower in the second part of July but it was similar to whole nectar production of *I. spiraeifolia* (Fig. 7).

The daily rhythm of nectar production

I. spiraeifolia (Sr) flowers produced nectar from 10 am until 4 pm. We demonstrated production maximums at 10 am, 12 pm, 2 pm and 4 pm.

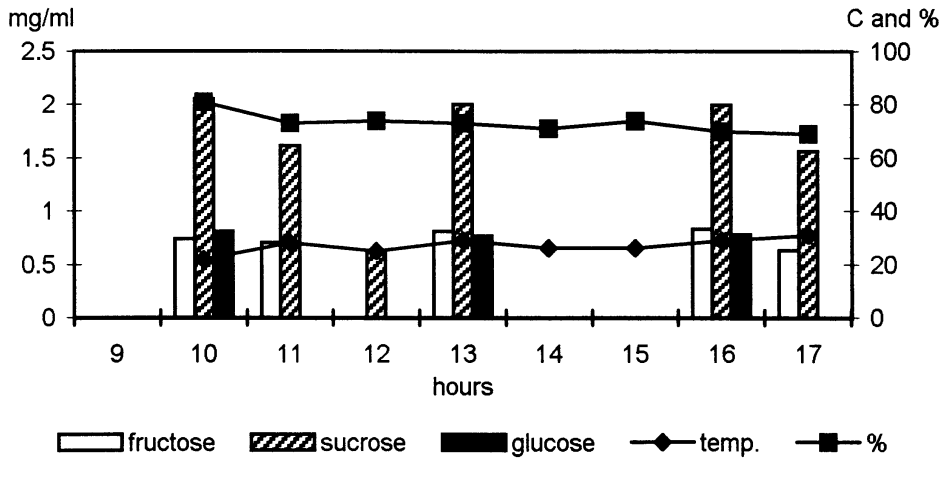

Fig. 4. The sugar content of *Inula salicina* in dependence of the temperature and the relative vapour

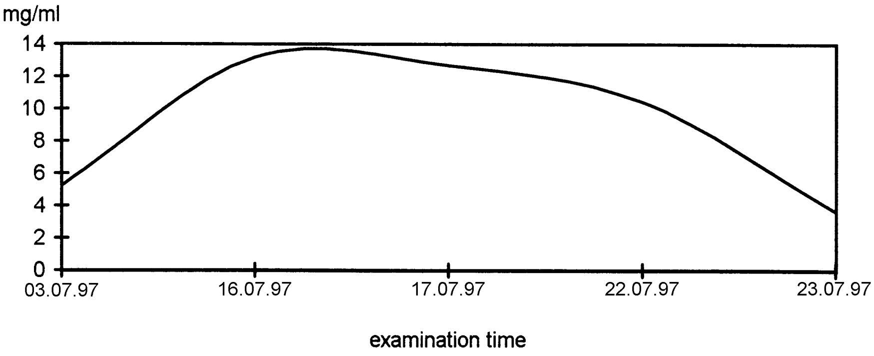

Fig. 5. The total sugar content of *Inula spiraeifolia* at the examination time

Thus, the production maximums appeared every two hours to *I. spiraeifolia* (Fig. 2). Nectar production was stoppage or there is a little producing among the nectar production maximums.

I. salicina (G) nectar production was at 10 am, 1 pm, 4 pm or 11 am, 2 pm, 5 pm. Thus, the production maximums appeared every three hours to *I. salicina*. There is a little producing among the nectar production maximums (Fig. 4).

I. ensifolia (G) nectar production showed maximums between 10–12 am and between 16–17. Hence, we have found a forenoon and an afternoon production section at *I. ensifolia* (Fig. 3).

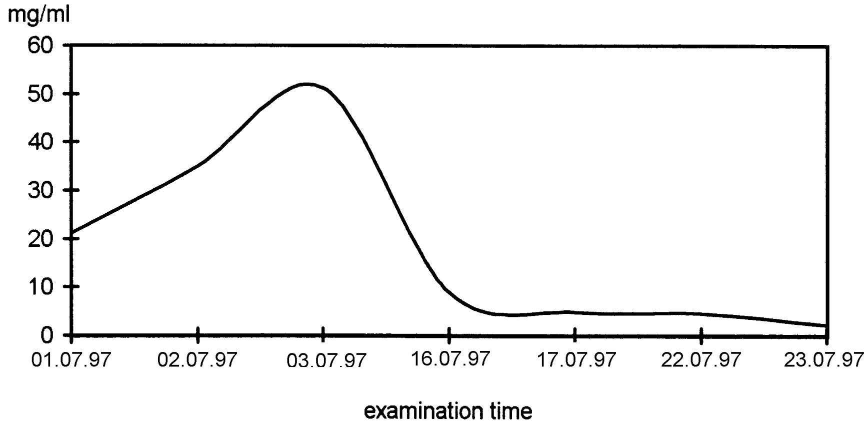

Fig. 6. The total sugar content of *Inula ensifolia* at the examination time

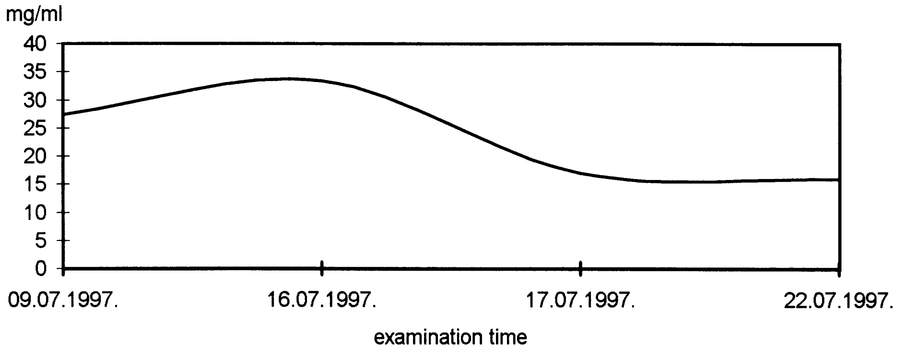

Fig. 7. The total sugar content of *Inula salicina* at the examination time

The influence of the main abiotic factors to the nectar production

We measured the temperature and the relative vapour over 12 hours parallel with the nectar sampling. The correlation among the sugar content of nectar samples, temperature and relative vapour was tested by a correlation analysis.

According to our results the nectar production no correlated with temperature over the day (*I. spiraeifolia*: $r = -0.54413$, $p < 0.05$; *I. salicina*: $r = -0.41652$, $p < 0.05$; *I. ensifolia*: $r = 0.222056$, $p < 0.05$). We found a weak connection between nectar production and relative vapour to two species (*I. salicina*: $r = -0.6454$, $p < 0.05$; *I. ensifolia*: $r = -0.74679$, $p < 0.05$) and was not correlation between two factors to *I. spiraeifolia* ($r = 0.2730$, $p < 0.05$).

DISCUSSION

Three sugars occurred in the nectar of three *Inula* species: sucrose, fructose and glucose. *I. spiraeifolia* nectar is hexose-rich (glucose), *I. ensifolia* and *I. salicina* nectar is sucrose as dominant sugar. This is inconsistent with statement that in the long-tubular flowers occurs mostly sucrose-dominant nectar (Percival 1961).

The average of total sugar content is least in *I. spiraeifolia* nectar (9.2103 mg/ml), but maximum sugar content is maintained over blooming period. The average of total sugar content is the highest in *I. salicina* and *I. ensifolia* nectar (22.1348 mg/ml; 18.5008 mg/ml) which was experienced only during the main blooming period. Nectar production is over blooming period but sugar content is less before and after main blooming period. In this way, *I. salicina* and *I. ensifolia* assure sweeter nectar for visiting of insects.

According to most of literature nectar producing plants have a nectar production maximum in the morning (Nikovitz 1983, Pesti 1980), but nectar production of the examined species is rhythmical. The production maximums appeared every two hours to *I. spiraeifolia*, every three hours to *I. salicina*. We found a forenoon and an afternoon production section at *I. ensifolia*. Neither before 8 am nor after 6 pm was sugar content in the nectar samples. In this way, probably three *Inula* species have no nectar production at night, but three species assure food to visitors the whole day.

According to correlation analysis the temperature and relative vapour has no direct influence on nectar production. The rhythm of nectar production probably is endogenous rhythm and typical of species.

Thus, it may be presumable that reproduction of the generalist *I. ensifolia* and *I. salicina* have bigger role to the insects than to the rare specialist *I. spiraeifolia*. The vegetative reproduction is probable in case of *I. spiraeifolia*.

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