Nectar plants and larval food-plants of the genus *Glossotrophia* (Geometridae, Sterrhinae): studies on pollen grains attached to museum specimens

Axel Hausmann[1] & Stefan Dötterl[2]

[1] Zoologische Staatssammlung München, Münchhausenstr. 21, D-81247 München, Germany; e-mail: Axel.Hausmann@zsm.mwn.de
[2] Lehrstuhl Pflanzensystematik, Universität Bayreuth, Universitätsstrasse 30, D-95440 Bayreuth, Germany, e-mail: Stefan.Doetterl@uni-bayreuth.de

Abstract. 544 specimens of the Geometrid moth genus *Glossotrophia*, belonging to nine species, were examined under the stereomicroscope searching for attached pollen grains. Pollen was found on 105 specimens (8 species). In addition we identified pollen grains of further 39 specimens under the scanning electron microscope. Pollen grains attached to the tip of the abdomina of nine females strongly indicate egg deposition at or in those flowers (mainly Caryophyllaceae). Pollen grains attached to the proboscis or neighbouring structures, most frequently found in the subgenus *Glossotrophia*, and here preferably in females, are suggestive of nectar plant use. The subgenus *Glossotrophia* turned out to be almost exclusively specialised on Caryophyllaceae nectar plants (mainly *Silene, Dianthus*), whereas the other subgenera utilize a wider spectrum of nectar sources. This finding does well correspond to the known spectra of larval host-plants. A strong positive correlation was found between length of proboscis, preference for Caryophyllaceae, and frequency of pollen grain attachment. Collectively, these results demonstrate that the analysis of pollen loads in museum specimens (though sometimes being very old) may provide valuable data on host use patterns through time and space.

Key words. Geometridae, Sterrhinae, *Glossotrophia*, pollen load, museum specimens, nectar sources, host plants, Caryophyllaceae

Introduction

Pollen loads have previously been studied in different groups of animals, such as mammals (Goldingay et al. 1991; Hacket & Goldingay 2001), birds (Hopper 1980; Wooller et al. 1983; Borgella et al. 2001), bees (Bernhardt & Walker 1984; Westrich & Schmidt 1987; Camillo & Garofalo 1989; Abrol 1990; Nazarov 1995; Müller 1996; Nazarov & Gerlach 1997), flies (Krannitz & Maun 1991; Kearns 1992), butterflies (Cruden & Hermann-Parker 1979; Hawkeswood 1985; Tobar et al. 2001) and moths (Esche 1992; Gregg 1993; Nazarov & Efetov 1993). This is an indirect method to get information on nectar-plant relationships of the studied specimens. Pollen load can be used as a marker for migration (Gregg 1993) or for determination of the extent of host-plant specialisation (Westrich & Schmidt 1987; Müller 1996). Further it was used to determine the role of specific animals as pollinators of particular plant species (Hopper 1980; Goldingay et al. 1991; Hacket & Goldingay 2001) and to discover food sources and food niche overlap among sympatric species (Camillo & Garofalo 1989; Esche 1992). We here study pollen loads of the taxonomically difficult genus *Glossotrophia*. Identification and systematics of this genus were subject of various previous papers (Hausmann 1992, 1993a, b, 1994, 1996). Some taxa of this genus have a very long proboscis. The length of the proboscis is about 10–13mm in subgenus *Glossotrophia*, 7–10mm in subgenus *Libanonia*, 4–6mm in subgenus *Parenzanella*, and only 3–4mm in subgenus *Microglossotrophia* (Hausmann 1993b).

The long proboscis of the nominotypical subgenus *Glossotrophia* is unique in Geometridae and inspired Prout (1913) to base the scientific name on this feature. The curved proboscis externally projects from the pupa and is much longer than the whole pupa (Hausmann 2001, text fig. 113). As until now nothing is known about nectar plant interactions of the adult moths and data on larval host-plant relationships are scarce (Tab. 2), we aimed to analyse pollen loads attached to different body parts of the different sexes and taxa of *Glossotrophia* in order to obtain more information on food-plants. Using museum specimens, we show that analysis of pollen loads in museum specimens (though sometimes being very old) may provide valuable indicators of host use patterns through time and space.

Material and Methods

Light microscopy. 544 specimens of the collection material of the genus *Glossotrophia* in the Zoologische Staatssammlung München (ZSM) (Tab. 2) were examined under a stereomicroscope in order to determine a statistical pattern about the frequency of pollen loads in the genus *Glossotrophia*. In a standardised way we examined each specimen for 30sec. All details, such as label data, sex, position of pollen grains and if possible pollen type were noted (special labels were attached to specimens with pollen grains). Reared specimens were excluded from the study. If long series were available, representative random samples from selected localities were examined. Real frequency of pollen grain attachment is underestimated, since (1) some pollen grains have surely been overlooked given the limited time of examination, (2) doubtful observations of grains were scored as negative findings, (3) during collecting usually the more beautiful and thus younger specimens are chosen, which may not had visited flowers, (4) possibly some reared specimens, that are not labelled as such, were included in the study and (5) some specimens could have lost the pollen grains after collecting.

SEM studies: 39 further specimens where pollen was visible under the stereomicroscope were chosen for detailed examination and identification of the pollen grains (these specimens are not included in the frequency analysis). All pollen grains were studied if there were just a few; otherwise we examined a random sample. The air-dried pollen grains from the moths were taken up on double faced adhesive tape, sputtered with gold and studied under a scanning electron microscope (Philips XL 30 ESEM) at 20 kV. We used the works of Punt (1976), Punt et al. (1981), Punt & Clarke (1980, 1981, 1984), and Punt & Hoen (1995) to identify pollen grains.

Statistical analysis: To analyse the data we employed a Chi^2-test (Rohlf and Sokal 1995; Sokal and Rohlf 1995). If the expected value for at least one cell was equal to or smaller than 5 we carried out Fisher's exact test instead.

Results

We studied under the SEM more than 250 pollen grains attached to 39 specimens belonging to 10 *Glossotrophia* taxa (6 species; Tab. 1). More than 60% of these grains could be identified as Caryophyllaceae pollen. The subgenus *Glossotrophia* exhibited

the highest specialisation to plants of this plant family: 5 of the 6 examined taxa had exclusively Caryophyllaceae pollen grains, mostly from *Silene* or *Dianthus* (Figs. 2a, b). The only exception was *Glossotrophia diffinaria* where, in addition to *Silene* pollen, grains from *Linum catharticum* (Fig. 2c), cf. *Polygonum* and an unknown pollen grain were found. In contrast, examination of taxa from the subgenera *Libanonia* and *Parenzanella* revealed pollen types from a diverse spectrum of plant families. On one female (specimen Nr. 14b, Tab. 1) we found Caryophyllaceae pollen grains on the last segment of the abdomen.

105 specimens with pollen grains were found among 544 examined specimens studied under the stereomicroscope (Tab. 3). Though it was not possible to identify the plant species or families under the stereomicroscope, most of the pollen grains (>70%) seemed to correspond well to the Caryophyllaceae pollen grains as examined under the SEM.

We found pollen in all subgenera and on most studied taxa (Tab. 3). Especially in the subgenus *Glossotrophia* ($Chi^2_{df=1}$=6.36; p=0.012) pollen occurred more frequently on females than on males. No pollen grains could be found on males of the subgenus *Microglossotrophia*. In the remaining three subgenera, 6–21% of the males carried pollen grains (difference between these three subgenera not significant: $Chi^2_{df=2}$=3.35; p=0.19). In females there were big differences with regard to pollen load at subgeneric level ($Chi^2_{df=3}$=19.8; p<0.001). Females of the subgenus *Glossotrophia* had an exceptionally high load (pollen grains on 35% of the studied specimens).

In all subgenera most pollen was found attached to head parts (Tab. 4). 86–100% of the pollen-positive specimens in the different subgenera had pollen grains at least on one of the head parts. When looking only at the head, the most important structure for pollen load in all subgenera, except for *Parenzanella*, was the proboscis. In the subgenus *Glossotrophia*, for example, we found 70% of the 'head-positive' specimens carrying pollen on the proboscis, in *Parenzanella* only 38% ($Chi^2_{df=1}$=6.76; p<0.01). In the latter subgenus, the most important structure of the head for pollen load was the eye.

Comparing the sexes with respect to pollen attachment to different body parts there are barely differences with one exception: In 15% of the cases pollen could be found on the tip of abdomen on females, but pollen grains were never attached to the tip of abdomen on males (Fig. 1).

Discussion

Most species of the *Silene vulgaris* and *S. dioica*-groups are considered 'good' nectar plants for nocturnal moths. They produce a lot of nectar in the late afternoon or evening until midnight (Witt et al. 1999). Pollen grains attached to eyes, palpi, frons or proboscis of various *Glossotrophia* species may be interpreted as strong indication of nectaring at *Silene* species, as does the frequent presence of pollen grains at the underside of wings (mainly at the basis). In 105 of 544 examined specimens (19%) pollen grains were found, almost all of them attached to the mouthparts or

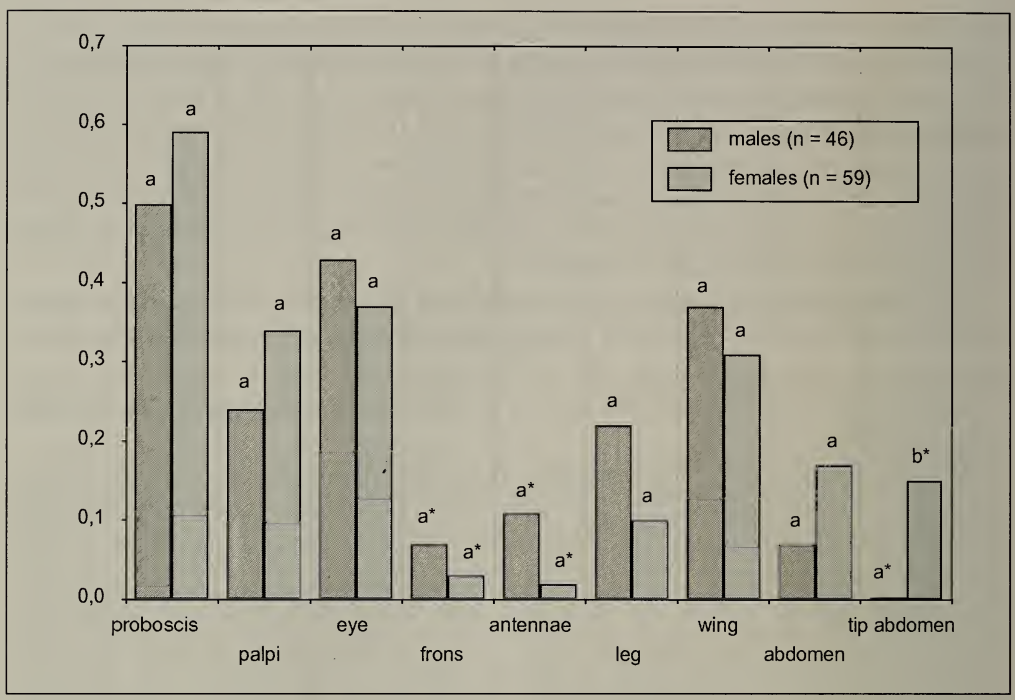

Fig. 1: Sex-specific attachment of pollen grains to various body parts of *Glossotrophia* moths in relation to specimens with pollen grains (results from stereo microscope examination). Bars with the same letters are not significantly different ($p < 0.05$). Comparisons were made only within single body parts (*: Fisher's exact test).

close to them, and most of the pollen grains apparently belonged to the family Caryophyllaceae. Thus pollen grains attached to collection specimens revealed that Caryophyllaceae are important as food source for Geometrid moths of the genus *Glossotrophia*. The authors have no explication for the extraordinarily high frequency of pollen grains at the eyes of *G. asellaria* (subgenus *Parenzanella*), though pollen frequency was low at the proboscis of this species (Tab. 4).

The following conclusions are drawn from our studies:

(1) Species of the subgenus *Glossotrophia* seem to feed nearly exclusively on nectar from Caryophyllaceae, mainly *Silene* and *Dianthus*. Only the Turkish *G. diffinaria* was recorded also on Linaceae, and probably Polygonaceae. One attached Orchidaceae pollinarium was observed in *G. confinaria prouti* (Fig. 2d). The other subgenera had a much wider spectrum of nectar-plants (Tab. 1).

(2) Overall females bear pollen grains more often than males. This difference was pronounced in the subgenus *Glossotrophia*, but absent in *Libanonia, Parenzanella* and *Microglossotrophia*. Our findings might indicate that females visit flowers more often than males. Since in other moths adult feeding affects the size or number of offspring produced by a female (e.g. Boggs 1987; Stevens et al. 2002), also *Glossotrophia* females might be in greater need of carbohydrate intake.

(3) Attachment of pollen grains at the last segment(s) of female abdomen (as found in 9 females) may be interpreted as strong indication of egg deposition into the calyx

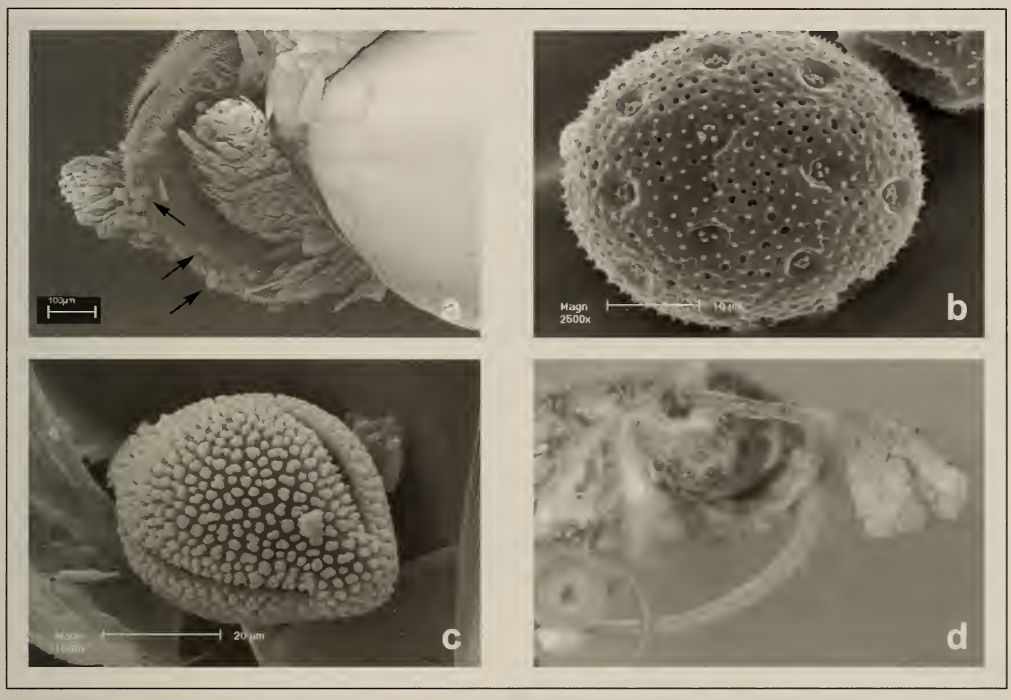

Fig. 2: Pollen found at different *Glossotrophia* taxa. (**a**) Caryophyllaceae pollen attached to head parts of *Glossotrophia confinaria*, (**b**) Pollen grain of the *Silene dioica*-group, (**c**) Pollen grain of *Linum catharticum*, (**d**) Pollinium of *Platanthera* (Orchidaceae) attached to head of *Glossotrophia confinaria prouti* (northern Italy).

of the flower. No males were found with pollen grains at the tip of the abdomen. In one female of *Glossotrophia confinaria prouti* (specimen Nr. 14, Tab. 1) eight Caryophyllaceae pollen grains were identified under the SEM. Caryophyllaceae as larval host-plants are already known for this species (Tab. 2). Similarly pollen grains at the tip of female abdomen have been observed under the stereo microscope in nine further females belonging to *G. confinaria*, *G. diffinaria, G. alba, G. mentzeri* and *G. rufomixtaria* (all subgenus *Glossotrophia*). Pollen grains could be identified in additional studies under the SEM as 'Caryophyllaceae'.

(4) Known larval host-plants for the subgenus *Glossotrophia* are largely restricted to the Caryophyllaceae genus *Silene*. The Spanish *G. rufomixtaria* was recorded also on *Gypsophila* and, reputedly, on *Dianthus* (references in Tab. 2). Thus, larval host-plants do well correspond to the preferred adult nectar sources (Tab. 2) in this subgenus. This may indicate a narrow niche of the adult moths, i.e. nectaring, mating and oviposition would all occur close to host-plants. In the monobasic subgenus *Parenzanella* (including only *G. (P.) asellaria*), however, larval host-plants of many other families (Zygophyllaceae, Scrophulariaceae, Lamiaceae; Brassicaceae) are recorded (Hausmann in press). Similarly, a much wider spectrum of nectar sources was observed than in the subgenus *Glossotrophia*.

(5) Length of proboscis is about 10–13mm in subgenus *Glossotrophia*, 7–10mm in subgenus *Libanonia*, 4–6mm in subgenus *Parenzanella*, and only 3–4mm in sub-

genus *Microglossotrophia* (Hausmann 1993b). Thus, length of proboscis reveals to be strongly correlated to frequency of pollen grain attachment to proboscis and palpi (Tabs. 2, 4). While this frequency is 21.6% in *Glossotrophia*, the subgenus with the longest proboscis, it is only 1.6% in *Microglossotrophia*, the subgenus with the shortest proboscis, and about 6% in *Libanonia* and *Parenzanella*, the subgenera with medium sized probosci. These differences are significant ($Chi^2_{df=3}=33.3$; $p<0.001$). Taking into consideration the results discussed under (1), correlation results also between length of proboscis and Caryophyllaceae as nectar source. Analyzing the SEM results, Caryophyllaceae pollen was found on 25 of in total 28 studied specimens of *Glossotrophia*, the subgenus with the longest proboscis, while Caryophyllaceae pollen was only found on 4 of in total 11 studied specimens of subgenera with shorter probosci (difference significant in Fisher's exact test; $p=0.002$).

Acknowledgements

We are grateful to Ulrich Meve, Georg Acker and Rita Grotjahn for their introduction and supervision on the scanning electron microscope, and to Konrad Fiedler for valuable discussions about the manuscript and the statistical analyses. We thank Wim Punt for help on identification of some pollen grains. Günter Gerlach (Botanical Garden Munich) kindly helped with the identification of an Orchidaceae pollinium.

References

Abrol, D. P. 1990. Studies on the pollen loads and pollination efficiency of some bees. – Journal of Animal Morphology & Physiology **37**: 147–150.

Bernhardt, P. & K. Walker 1984. Bee foraging on 3 sympatric species of australian *Acacia*. – International Journal of Entomology **26**: 322–330.

Boggs, C. L. 1987. Ecology of nectar and pollen feeding in Lepidoptera. Pp. 369–391 *in*: F. Slansky Jr. & J. G. Rodriguez (eds.), Nutritional ecology of insects, mites, spiders, and related invertebrates – current issues. – John Wiley & Sons, New York.

Borgella, R. J., A. A. Snow & T. A. Gavin 2001. Species richness and pollen loads of hummingbirds using forest fragments in southern Costa Rica. – Biotropica **33**: 90–109.

Camillo, E. & C. A. Garofalo 1989. Analysis of the niche of two sympatric species of *Bombus* (Hymenoptera, Apidae) in southeastern Brazil. – Journal of Tropical Ecology **5**: 81–92.

Cruden, R. W. & S. M. Hermann-Parker 1979. Butterfly pollination of *Caesalpinia pulcherrima* with observations on a psychrophilous syndrome. – Journal of Ecology **67**: 155–168.

Esche, T. 1992. Konkurrieren Nachtschmetterlinge um Blüten? — Dissertation, Albert-Ludwig-Universität Freiburg. 194 pp.

Forster, W. & T. A. Wohlfahrt 1981. Die Schmetterlinge Mitteleuropas, Band **5** (Spanner). – Franckh'sche Verlagsbuchhandlung, Stuttgart. 312 pp.

Goldingay, R. L., S. M. Carthew & R. J. Whelan 1991. The importance of non-flying mammals in pollination. – Oikos **61**: 79–87.

Gregg, P. C. 1993. Pollen as a marker for migration of *Helicoverpa armigera* and *Helicoverpa punctigera* (Lepidoptera: Noctuidae) from western Queensland. – Australian Journal of Ecology **18**: 209–219.

Hackett, D. J. & R. L. Goldingay 2001. Pollination of *Banksia* spp. by non-flying mammals in north-eastern New South Wales. – Australian Journal of Botany **49**: 637–644.

Hausmann, A. 1992. Nachtrag zur Geometridenfauna Jordaniens (Lepidoptera, Geometridae). – Nachrichtenblatt bayerischer Entomologen **41**: 98–100.

Hausmann, A. 1993a. Der Aussagewert struktureller Unterschiede des 8. Sternits. Beitrag zur Systematik der italienischen Vertreter der Gattung *Glossotrophia* Prout, 1913 (Lepidoptera, Geometridae). – Atalanta **24**: 265–297.

Hausmann, A. 1993b. Zweiter Beitrag zur Taxonomie und Systematik der Gattung *Glossotrophia* Prout, 1913 (Lepidoptera: Geometridae, Sterrhinae). – Mitteilungen der Münchner Entomologischen Gesellschaft **83**: 77–107.

Hausmann, A. 1994. Dritter Beitrag zur Revision der Gattung *Glossotrophia* Prout, 1913 nebst Beschreibung zweier neuer Gattungen (Lepidoptera: Geometridae, Sterrhinae). – Nota lepidopterologica **17**: 195–211.

Hausmann, A. 1996. Zwei neue Geometridenarten aus Vorderasien (Insecta, Lepidoptera, Geometridae). – Spixiana **Suppl. 22**: 3–10.

Hausmann, A. 2001. Introduction. Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae, Geometrinae. 282 pp. – *In*: A. Hausmann (ed.), The Geometrid Moths of Europe **1**. – Apollo Books, Stenstrup.

Hausmann, A., in press. Sterrhinae. 600 pp. – *In*: A. Hausmann (ed.), The Geometrid Moths of Europe **2**, – Apollo Books, Stenstrup.

Hawkeswood, T. J. 1985. The role of butterflies as pollinators of *Acacia bidwillii* (Mimosaceae) at Townsville, northern Queensland. – Australian Journal of Botany **33**: 167–174.

Hopper, S. D. 1980. Bird and mammal pollen vectors in *Banksia* communities at Cheyne Beach western Australia. – Australian Journal of Botany **28**: 61–76.

Kearns, C. A. 1992. Anthophilous fly distribution across an elevation gradient. – American Midland Naturalist **127**: 172–182.

Krannitz, P. G. & M. A. Maun 1991. Insect visitors to the guelder rose *Viburnum opulus* var. *opulus* (Caprifoliaceae) in London, Ontario. – Canadian Field Naturalist **105**: 13–17.

Millière, P. 1871. Catalogue raisonné des Lépidoptères des Alpes-Maritimes 2. – Memoires Societe Scientifice Naturaliste **1873**: 1–135.

Müller, A. 1996. Host-plant specialization in western palearctic anthidiine bees (Hymenoptera: Apoidea: Megachilidae). – Ecology Monographs **66**: 235–257.

Nazarov, V. V. 1995. Pollination of *Steveniella satyrioides* (Orchidaceae) by wasps (Hymenoptera, Vespoidea) in the Crimea. – Lindleyana **10**: 109–114.

Nazarov, V. V. & K. A. Efetov, 1993. On the role of the Crimean Zygaenidae (Lepidoptera) in pollination of *Anacamptis pyramidalis* (Orchidaceae). – Zoological Journal **72**: 54–67.

Nazarov, V. V. & G. Gerlach 1997. The potential seed productivity of orchid flowers and peculiarities of their pollination systems. – Lindleyana **12**: 188–204.

Punt, W. (ed.) 1976. The northwest European pollen flora, **I**. – Elsevier, Amsterdam. 145 pp.

Punt, W. & G. C. S. Clarke (eds.), 1980. The northwest European pollen flora, **II**. – Elsevier, Amsterdam. 265 pp.

Punt, W. & G. C. S. Clarke (eds.) 1981. The northwest Ruropean pollen flora, **III**. – Elsevier, Amsterdam. 138 pp.

Punt, W. & G. C. S. Clarke (eds.) 1984. The northwest Europcan pollen flora, **IV**. – Elsevier, Amsterdam. 369 pp.

Punt, W. & P. P. Hoen 1995. Caryophyllaceae. – Review of Palaeobotany and Palynology **88**: 83–272.

Prout, L. B. 1912–1916. Die spannerartigen Nachtfalter. – *In*: A. Seitz (ed.), Die Großschmetterlinge der Erde **4**. – Verlag A. Kernen, Stuttgart.

Prout, L. B. 1934–1935, additions 1938. Brephinae, Oenochrominae, Hemitheinae, Sterrhinae, Larentiinae. – *In*: A. Seitz (ed.), Die Großschmetterlinge der Erde, Suppl. **4**. – Verlag A. Kernen, Stuttgart.

Rohlf, F. J. & R. R. Sokal 1995. Statistical tables. – W. H. Freeman and Company, New York. 199 pp.

Sokal, R. R. & F. J. Rohlf 1995. Biometry. – W. H. Freeman and Company, New York. 887 pp.

Stevens, P., Froud, K. & Jamieson, L., 2002. Effects of adult feeding on longevity and fecundity of *Ctenopseustis obliquana* (Lepidoptera: Tortricidae). – New Zealand Journal of Crop and Horticultural Science **30**: 229–234.

Tobar, L. D., C. J. O. Rangel & C. M. Andrade G. 2001. Las cargas polinicas en las mariposas (Lepidoptera: Rophaloccra) de la parte alta de la cuenca del Rio Roble-Quindio-Colombia. – Caldasia **23**: 549–557.

Westrich, P. & K. Schmidt 1987. Pollen analysis an auxiliary tool to study the collecting behavior of wild bees (Hymenoptera: Apoidea). – Apidologie **18**: 199–214.

Witt, T., A. Jürgens, R. Geyer & G. Gottsberger 1999. Nectar dynamics and sugar composition in flowers of *Silene* and *Saponaria* species (Caryophyllaceae). – Plant Biology **1**: 334–345.

Wooller, R. D., E. M. Russell, M. B. Renfree & P. A. Towers 1983. A comparison of seasonal changes in the pollen loads of nectarivorous marsupials and birds. – Australian Wildlife Research **10**: 311–318.

Tab. 1. Examined taxa, number of observed pollen grains, body parts, where grains were attached to, and identification of pollen types using a SEM.

Specimen Nr.	Sex	Number of pollen grains	Pollen grains attached to	Pollen type
Glossotrophia (Glossotrophia) confinaria confinaria				
1	f	2	leg	*Silene vulgaris*-type
2	m	3	proboscis, palpi, eye	*Dianthus*
3	m	3	wing	*Silene vulgaris*-type
4	m	1	proboscis	*Silene vulgaris*-type
5	m	4	proboscis	*Silene dioica*-group
6	f	4	eye	Caryophyllaceae
7	m	4	wing	Caryophyllaceae
8	m	9	proboscis, palpi	*Silene dioica*-group
9	m	1	proboscis	*Silene dioica*-group
Glossotrophia (Glossotrophia) confinaria prouti				
10	f	6	proboscis, leg	*Dianthus*
11	f	10	proboscis, eye	4 x *Silene dioica*-group, 6 x *Dianthus*
12	m	22	proboscis	*Dianthus*
13	m	2	proboscis	Caryophyllaceae
14a	f	11	proboscis	*Dianthus*
14b	f	8	tip of abdomen	Caryophyllaceae
Glossotrophia (Glossotrophia) confinaria scoblei				
15	m	6	wing	Caryophyllaceae
Glossotrophia (Glossotrophia) diffinaria				
16	f	3	proboscis	1 x cf. *Polygonum*, 1 x *Silene dioica* group, 1 x *Silene vulgaris*-type
17	f	10	proboscis, palpi	9 x *Silene vulgaris*-type, 1 x unidentified (not Caryophyllaceae)
18	f	4	proboscis	*Linum catharticum*
19	f	9	proboscis	*Linum catharticum*
20	f	6	proboscis, wing	*Linum catharticum*
Glossotrophia (Glossotrophia) alba alba				
21	f	6	proboscis	Caryophyllaceae
22	f	3	proboscis, eye	*Silene dioica*-group
23	f	2	wing	*Silene vulgaris*-type
24	f	2	proboscis	*Silene vulgaris*-type
Glossotrophia (Glossotrophia) rufomixtaria				
25	m	6	proboscis	3 x *Dianthus*, 3 x Caryophyllaceae
26	f	2	proboscis, eye	*Silene dioica*-group
27	m	1	proboscis	*Silene dioica*-group
28	m	8	proboscis	Caryophyllaceae
Glossotrophia (Libanonia) semitata taurica				
29	f	5	proboscis	4 x Caryophyllaceae, 1 x *Linum catharticum*
30	f	12	proboscis	cf. *Polygonum*
Glossotrophia (Libanonia) semitata ariana				
31	f	7	proboscis	cf. *Polemonium*
32	f	13	proboscis	*Syringa*
33	m	4	proboscis	Caryophyllaceae
34	f	10	proboscis	*Silene dioica*-group
35	m	14	proboscis	12 x cf. *Polemonium*, 2 x unknown (not Caryophyllaceae)
Glossotrophia (Parenzanella) asellaria isabellaria				
36	f	13	proboscis	cf. *Polemonium*
37	f	10	proboscis	cf. *Polemonium*
Glossotrophia (Parenzanella) asellaria dentatolineata				
38	f	1	proboscis	Caryophyllaceae
39	f	7	wing	*Syringa*

Tab. 2. Studied material with results from the analysis of pollen loads; * selection of specimens randomly, focussing on 2-3 regions, but omitting selection of reared specimens; ** apparently no Caryophyllaceae pollen

Taxon	total specimens present at ZSM (approx.)	number of randomly selected (*)specimens for stereo microscope studies	origin	specimens with attached pollen in binocular studies	specimens with attached pollen in SEM studies	specimens with attached pollen: collecting date (months from I-XII)	specimens with attached pollen: altitude (m above sea-level)	length of proboscis (mm)	nectar plant families	larval food plant families
G. (Glossotrophia) confinaria confinaria (Herrich-Schäffer, 1847)	400	73	SE France (Hautes Alpes), N Italy (Lake Garda), W Macedonia (Lake Ochrid)	20	9	late V –early IX	200–800	10–13	Caryophyllaceae [1]	Caryophyllaceae [5]
G. (Glossotrophia) confinaria prouti Hausmann, 1993	200	38	N Italy, Val Venosta	7	5	late VI – early IX	300–400	10–13	Caryophyllaceae, Orchidaceae [1]	Caryophyllaceae [1,6]
G. (Glossotrophia) confinaria scoblei Hausmann, 1993	10	10	N Sicily	7	1	mid-VI – late VII	700–1200	10–13	Caryophyllaceae [1]	-
G. (Glossotrophia) diffinaria Prout, 1913	60	29	Turkey	20	5	mid-VI – early VIII	600–1700	10–13	Caryophyllaceae, Linaceae, ?Polygonaceae [1]	-
G. (Glossotrophia) alba alba Hausmann, 1993	40	30	C Italy	8	4	early VI – mid-VIII	100–1600	10–13	Caryophyllaceae [1]	-
G. (Glossotrophia) alba brunellii Hausmann, 1993	200	29	S Italy	-	-	-	-	10–13	-	Caryophyllaceae [2]
G. (Glossotrophia) mentzeri Hausmann, 1993	30	19	Crete	5	-	mid-V – late VII	550–1100	10–13	-	Caryophyllaceae [1]
G. (Glossotrophia) rufomixtaria (de Graslin, 1863)	60	40	S France, Spain	7	4	mid-VI – late VII; lat IX	0–1000	10–13	Caryophyllaceae [1]	Caryophyllaceae [1,2,5]
G. (Libanonia) semitata taurica Wehrli, 1930	100	32	S Turkey	6	2	mid-IV – late VI, early IX	400–1000	7–10	Caryophyllaceae, Linaceae, ?Polygonaceae [1]	-
G. (Libanonia) semitata ariana Ebert, 1965	300	31	E Aphganistan, Turkmenistan	1	5	early V – alte VI; early IX – mid-X	1100–1800	7–10	Polemoniaceae, Oleaceae, Caryophyllaceae [1]	-
G. (Parenzanella) asellaria asellaria (Herrich-Schäffer, 1847)	14	14	Corsica, Sardinia	4 **	-	early VI – mid-VI	400–800	4–6	-	-
G. (Parenzanella) asellaria romanaria (Millière, 1869)	15	15	C Italy	4 **	-	early IV; mid-VIII – mid-IX	0–100	4–6	-	Scrophulariaceae [2,5]
G. (Parenzanella) asellaria isabellaria (Millière, 1868)	80	42	N and E Spain	6	2	late IV – late V; mid-VII – early X	0–1100	4–6	? Polemoniaceae [1]	Brassicaceae [2,4]
G. (Parenzanella) asellaria dentatolineata Wehrli, 1926	25	20	S Spain	2	2	mid-VI – mid-VII	600–2000	4–6	Oleaceae, Caryophyllaceae [1]	-
G. (Parenzanella) asellaria lenzi Hausmann, 1993	20	17	Morocco	3	-	mid-IV; early VII	1000	4–6	-	-
G. (Parenzanella) asellaria gerstbergeri Hausmann, 1993	25	25	Canary islands	-	-	-	-	4–6	-	Zygophyllaceae [2]
G. (Parenzanella) asellaria tripolitana Turati, 1929	30	19	SE Algeria, Libya	4	-	late V – early VI	0–300	4–6	-	Zygophyllaceae, Scrophulariaceae, Lamiaceae [2,3]
G. (Microglossotrophia) alfierii Wiltshire, 1949	200	31	SW Saudi Arabia; Yemen	1	-	early IV	700	3–4	-	-
G. (Microglossotrophia) gracilis Brandt, 1941	500	30	Oman	-	-	-	-	3–4	-	-

[1]: results from present studies (Hausmann & Dötterl); [2]: Hausmann (2004); [3]: Prout (1935); [4]: Millière (1871); [5]: Prout (1935); [6]: Forster & Wohlfahrt (1981);

Tab. 3. Frequency of pollen grains attached to *Glossotrophia* specimens (selected taxa) after examination under a stereomicroscope.

Taxon	total examined		with pollen grains	
	males	females	males	females
Glossotrophia (*Glossotrophia*) *confinaria confinaria*	41	32	8 (20%)	12 (38%)
Glossotrophia (*Glossotrophia*) *confinaria prouti*	22	16	2 (9%)	5 (31%)
Glossotrophia (*Glossotrophia*) *confinaria scoblei*	6	4	5 (83%)	2 (50%)
Glossotrophia (*Glossotrophia*) *diffinaria*	14	15	9 (64%)	11 (73%)
Glossotrophia (*Glossotrophia*) *alba alba*	15	15	1 (7%)	7 (47%)
Glossotrophia (*Glossotrophia*) *alba brunellii*	15	14	0 (0%)	0 (0%)
Glossotrophia (*Glossotrophia*) *mentzeri*	15	4	4 (27%)	1 (25%)
Glossotrophia (*Glossotrophia*) *rufomixtaria*	14	26	1 (7%)	6 (23%)
Glossotrophia (*Libanonia*) *semitata taurica*	16	16	2 (13%)	4 (25%)
Glossotrophia (*Libanonia*) *semitata ariana*	15	16	0 (0%)	1 (6%)
Glossotrophia (*Parenzanella*) *asellaria asellaria*	13	1	3 (23%)	1 (100%)
Glossotrophia (*Parenzanella*) *asellaria romanaria*	10	5	3 (30%)	1 (20%)
Glossotrophia (*Parenzanella*) *asellaria isabellaria*	27	15	4 (15%)	2 (13%)
Glossotrophia (*Parenzanella*) *asellaria dentatolineata*	12	8	2 (17%)	0 (0%)
Glossotrophia (*Parenzanella*) *asellaria lenzi*	11	6	0 (0%)	3 (50%)
Glossotrophia (*Parenzanella*) *asellaria gerstbergeri*	14	11	0 (0%)	0 (0%)
Glossotrophia (*Parenzanella*) *asellaria tripolitana*	9	10	2 (22%)	2 (20%)
Glossotrophia (*Microglossotrophia*) *alfierii*	15	16	0 (0%)	1 (6%)
Glossotrophia (*Microglossotrophia*) *gracilis*	12	18	0 (0%)	0 (0%)
subgenus *Glossotrophia* (total)	142	126	30 (21%)	44 (35%)
subgenus *Libanonia* (total)	31	32	2 (6%)	5 (15%)
subgenus *Parenzanella* (total)	96	56	14 (15%)	9 (16%)
subgenus *Microglossotrophia* (total)	27	34	0 (0%)	1 (3%)
TOTAL	296	248	46 (16%)	59 (24%)

Tab. 4. Attachment of pollen grains to various body parts of the moths (results from stereo microscope examination; compare Tab. 3); **ab**: absolute numbers (multiple entries possible); pp: frequency of occurrence in relation to specimens with pollen grains; **pt**: frequency of occurrence in relation to total number of examined specimens; **S**: total numbers of examined specimens; n: specimens with pollen grains.

subgenus	*Glossotrophia*			*Libanonia*			*Parenzanella*			*Microglossotrophia*			total		
body part	**ab**	pp	pt	**ab**	pp	pt	**ab**	pp	pt	**ab**	pp	pt	**ab**	pp	pt
proboscis	**45**	0.61	0.17	**4**	0.57	0.06	**8**	0.35	0.05	**1**	1.00	0.02	**58**	0.55	0.11
palpi	**28**	0.38	0.10	**1**	0.14	0.02	**2**	0.09	0.01	**-**	-	-	**31**	0.30	0.06
eye	**25**	0.34	0.09	**3**	0.43	0.05	**14**	0.61	0.09	**-**	-	-	**42**	0.40	0.08
frons	**4**	0.05	0.01	**-**	-	-	**1**	0.04	0.01	**-**	-	-	**5**	0.05	0.01
antennae	**5**	0.07	0.02	**-**	-	-	**1**	0.04	0.01	**-**	-	-	**6**	0.06	0.01
legs/thorax	**15**	0.20	0.06	**-**	-	-	**1**	0.04	0.01	**-**	-	-	**16**	0.15	0.03
wings	**28**	0.38	0.10	**3**	0.43	0.05	**4**	0.17	0.03	**-**	-	-	**35**	0.33	0.06
abdomen	**11**	0.15	0.04	**-**	-	-	**2**	0.09	0.01	**-**	-	-	**13**	0.12	0.02
tip of abdomen	**8**	0.11	0.03	**-**	-	-	**-**	-	-	**-**	-	-	**8**	0.08	0.01
n	**74**			**7**			**23**			**1**			**105**		
_	**268**			**63**			**152**			**61**			**544**		