# ACTA SOCIETATIS ZOOLOGICAE BOHEMICAE

vol. 57

no. 3 - 4

1993 (1994)

ISSN 0862-5247

## CONTENTS

### Articles

# ACTA SOCIETATIS ZOOLOGICAE BOHEMICAE[1)]

*Acta Soc. Zool. Bohem.* Vol. 57, No. 3-4 1994 3 15

ISSN 0862-5247 47678



Published and distributed by Czech Zoological Society. Orders should be sent to the Czech Zoological Society, *Viničná 7, CZ-128 00 Praha 2, Czech Republic. Orders from other countries than Czech Republic should be* placed with Artia, Pegas Press Distributor, Ve Smečkách 30, CZ-111 27 Praha 1, Czech Republic. Printed by BESTIA tel. (02) 311 33 11.

Annual subscription (Volume 57, 1993, 4 issues, 360 pp.):

| | |
|---|---|
| Institutional subscription: | Europe: USD 80.- |
| | Other countries: USD 90.- |
| Private subscription: | Europe: USD 40.- |
| | Other countries: USD 50.- |
| Czech Republic: | Kč 120.- |




1) A continuation of the journal Věstník československé Společnosti zoologické (**Věst. Čs. Spolеč. Zool.**)

*Acta Soc. Zool. Bohem.* **57**: 161-166, 1993 (1994)
ISSN 0862-5247

# *Orientoreicheia* gen. n., and *O. caucasica rousi* subsp. n., new taxa of subtribe Reicheiina from the West Caucasus (Coleoptera: Carabidae: Clivinini)

[1]Petr BULIRSCH & [2]Karel HŮRKA

[1]Wolkerova 18, CZ-410 02 Lovosice, Czech Republic
[2]Department of Zoology, Charles University, Viničná 7, CZ-128 44 Praha 2, Czech Republic

*Received June 21, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Taxonomy, description, redescription, Coleoptera, Carabidae, Reicheiina, *Orientoreicheia* gen. n., *Orientoreicheia caucasica* rousi subsp. n., Palaearctic region**

**Abstract.** *Orientoreicheia* gen. n., type species *Reicheia caucasica* Fleischer and *Orientoreicheia caucasica rousi* subsp. n.are described, illustrated and differentiated from related taxa. *O. caucasica caucasica* (Fleischer) is redescribed. Notes on the taxonomy of the subtribe Reicheiina are given.

Jeannel (1957) revised the genus *Reicheia* Saulcy and the related genera. A subtribe Reicheina Jeannel, 1957 has been established in his monograph for two phyletic lines based on the genera *Reicheia* and *Trilophidius* respectively. The phyletic line of the genus *Reicheia* includes three groups of genera. In the "genres égéidiens" the pronotum is provided with a praebasal groove, the posterior part of pronotal discus is flat and the median line of pronotum is connected with the praebasal groove in the middle. In group called "genres tyrrhéniens" the pronotum lacks the praebasal groove and the posterior part of pronotal discus is globose with an abruptly terminated median line. In addition to these two groups of Mediterranean genera Jeannel also separated the group of "genres africains" with outer elytral striae lost entirely.

Basilewsky (1980) established a new subtribe Reicheiina, for the Jeannel's "série phylétique de *Reicheia*". According to Article 11(f) of the International Code of Zoological Nomenclature (Third Edition) Jeannel (1957) remains the author of the subtribe Reicheiina sensu Basilewsky (1980). Recently some new species and genera of the subtribe have been described. More importantly Basilewsky ( 1980) and Sciaky (1985, 1989) demonstrated that the characters given by Jeannel for the distinction of his three groups of genera are not reliable.

Basilewsky (1980) presumed a very old (possibly Jurassic) origin of the subtribe, due to its present relict, discontinuous range, which includes some parts of the Mediterranean regione and high Afrotropical mountains. Due to their ancient origin the genera of subtribe retained a homogenous general appearance and they are difficult to distinguish.

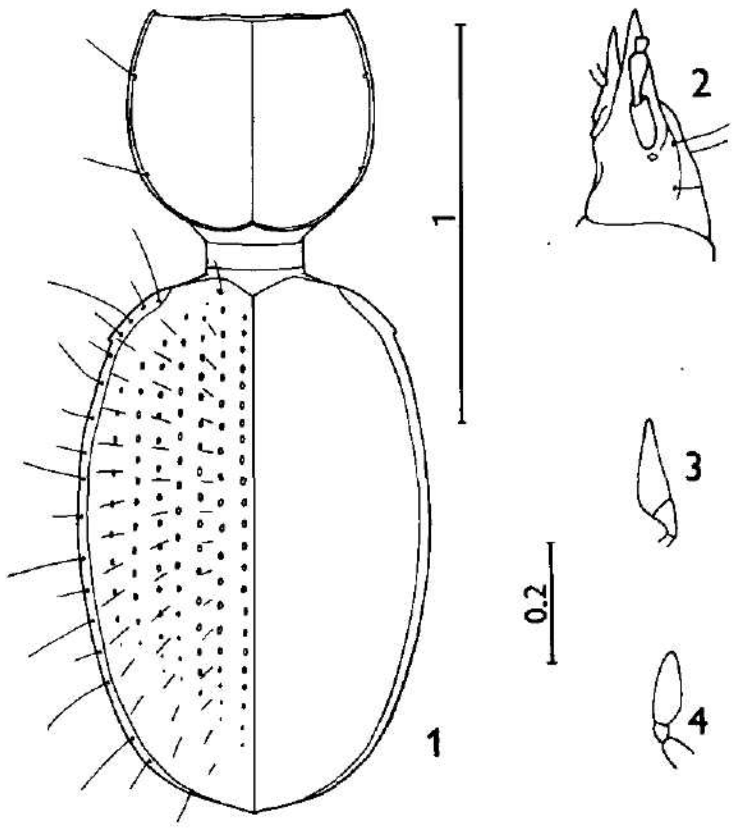
Consequently, it is at present impossible to establish groups of genera characterized by morphological and phyletic features within the subtribe Reicheiina and the same conclusion was reached by Sciaky (1985) .

*Reicheia caucasica* was based on one female described by Fleischer (1921) from the vicinity of Sukhumi (Abkhazia, West Caucasus). Jeannel (1957) classified this taxon as incertae sedis, because he was not able to examine any specimens and the original description is insufficient. Nevertheless, Jeannel included the species in his group of "genres égéidiens". Through the kindness of Dr J. Jelínek (Department of Entomology, National Museum, Praha) we were able to examine the holotype. In addition, we have also studied 39 specimens of *Reicheia caucasica* originating from the collections of P. Bulirsch. R. Rous and B. Zvarič from 7 different localities in the west Caucasus. In our opinion, this species must be classified in a new genus

### *Orientoreicheia* gen. n.

TYPE SPECIES. *Reicheia caucasica* Fleischer, 1921
DESCRIPTION. Body rusty yellow-brown, antennae, mouth parts and legs yellow. Length of body, 2.00-2.55 mm.

Head relatively large, frons with oblique impressions and with a short longitudinal keel between them in some specimens. Eyes strongly reduced, perceptible only as a small, oval unfacetted field (in the original description of *R. caucasica* wrongly "augenlos" = eyes absent) (Fig. 2). Antennae relatively long, second antennomere as long as the third and fourth together, fifth to tenth nearly square( as long as wide), ultimate longer than wide. Ultimate maxillary palpomere long, hatchet-like (Fig. 3).




Figs 1-4. 1 - *Orientoreicheia caucasica rousi* subsp. n., pronotum and elytra; 2 - head, lateral view; 3 - maxillary palpus; 4 - *Reicheidius frondicola* (Reitter), maxillary palpus (after Jeannel, 1957). Scales in mm.

Pronotum subcircular, smooth, microsculpture faint and irregular, lateral border entire, extended from the slightly protruding anterior angle to the connection with the median line at the base of pronotum as a praebasal groove (Fig. 1). Median line becoming slightly deeper anteriorly, markedly so towards the base. Distal tooth of protibia slightly bent outward in dorsal view, distal spur of almost equal length, curved slightly. Ventral little tooth of protibia obtuse, but distinct, dorsal one indistinct, very obtuse.

Elytra globose, almost oval (Fig. 1); base often with distinct granula near parascutellar setiferous puncture. Shoulders rounded but distinct. Lateral margin very wide, extended at base almost to the beginning of the fourth stria. Lateral border of elytra connected with the very distinct basal border in moderate obtuse angle. Elytral striae distinctly punctate and, only at the apex and laterally, are they not impressed clearly, inner striae at base very slightly shortened. First stria entire, second to seventh not visible on the distal third or half of elytra. Intervals almost flat, third, fifth and seventh with a row of setae;one row of longer setae in the lateral margin of the elytra.

Aedeagus as in Figs 5-7 (left lateral view).

DIFFERENTIAL DIAGNOSIS. *Orientoreicheia* gen. n. differs distinctly from *Reicheia* Saulcy, 1862 by the course of the median line of the pronotum. *Reicheia* has a shortened median line and not extending to the praebasal groove, which is interrupted distinctly (Jeannel, 1957) or indistinctly (Sciaky, 1985, 1989) in the baso-medial region of the pronotum. However that of *Orientoreicheia* is connected distinctly with the praebasal groove, which is formed by the elongated lateral borders (Fig. 1). The genus *Reicheidius* Jeannel, 1957, with a single species *R. frondicola* (Reitter, 1881) from southern Dalmatia, is a close relative to the new genus. It differs from *Orientoreicheia* by its greater, partly facetted eyes, the shape of maxillary palps (Fig. 4), the markedly different structure of the median lobe of aedeagus, the different shape of parameres, its less impressed, laterally, and, basally, more shortened elytral striae and by the finer basal border of elytra. The last mentioned is connected with the lateral border at a very obtuse angle; this connection lies (front view) distinctly below the level of basal setiferous punctures. The basal border of the elytra in *Orientoreicheia* is more distinct and connected with the lateral border in moderate obtuse angle; this connection lying almost at the level of the basal setiferous punctures. Three other genera possess a median line of pronotum which is connected with the praebasal groove. *Typhloreicheia* Holdhaus, 1924 includes species without eyes, with much longer elytra which are bordered indistinctly at base. *Reicheadella* Reitter, 1913 differs from the new genus by the presence of two triads of setae along the median line of the pronotum. *Speleodytes* Miller, 1863 differs in its much longer body, longer antennae and longer hind tarsi. The latter two genera have no trace of eyes. *Orientoreicheia* gen. n. is isolated considerably from all the known genera which live more westward, the nearest being from the environs of the Adriatic Sea.

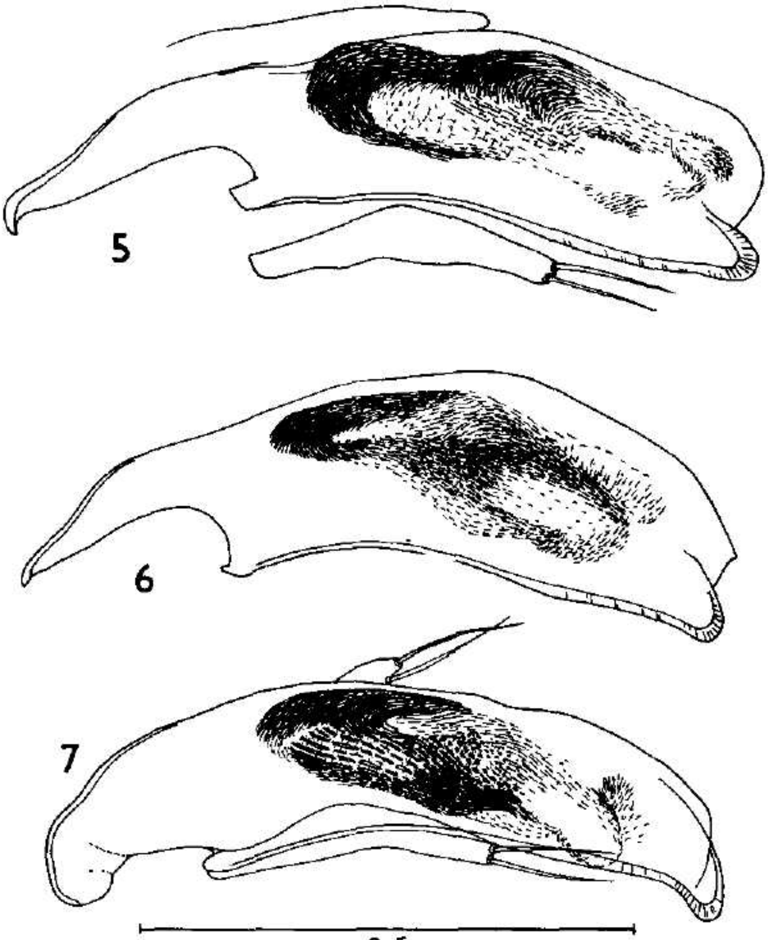
## *Orientoreicheia caucasica caucasica* (Fleischer, 1921)

*Reicheia caucasica* Fleischer, 1921: 145.

HOLOTYPE. Female, Caucasus occ., Abkhasia, Suchum env., Dr. W. Eichler lgt., in Coll. Nat. Mus. Praha.
FURTHER MATERIAL. SU, Abkhasia, Caucasus occ., Gumista vall., 50-200 m, Achadara p. Suchumi, 29.iv., 3.v.1992, P. Bulirsch lgt., in Coll. Bulirsch and Hůrka, 10 spec.; SU, Abkhasia, Caucasus occ., Gumista Fluss, ca. 600 m, vi 1979, R. Rous lgt., in Coll. Bulirsch and Hůrka, 9 spec.; SU, Caucasus occ., Agrba p. Picunda, ca. 10 m, vi 1969, R. Rous lgt., in Coll. Bulirsch and Hůrka, 8 spec.; SU, Caucasus occ., Krasnaja Poljana, vi 1967, R. Rous lgt., in Coll. Bulirsch, 2 spec.; SU, Gruzia, Caucasus occ., Tschipschira Mt., vi. 1979, R. Rous lgt., in Coll. Bulirsch, 1 spec.; SU, Caucasus occ., Gagra env., ca 50 m.,vi. 1971, R. Rous lgt., in Coll. Bulirsch, 2 spec.

Body length - 2.00-2.55 mm, mean of 33 specimens 2.30 mm. Holotype 2.20 mm, Gumista (Rous) 2.00-2.35 mm (mean of 9 spec. 2.22 mm), Gumista (Bulirsch) 2.30-2.40 mm (mean of 10 spec. 2.37 mm), Agrba 2.15-2.35 mm (mean of 8 spec. 2.30 mm), Gagra 2.45 and 2.55 mm, Krasnaja Poljana 2.25 and 2.40 mm, Tschipschira 2.35 mm. Specimens from Gagra are the largest.

Pronotum width/length ratio 1.03-1.08 (mean of 32 spec. 1.05). Elytra length/width ratio 1.46-1.61 (mean of 32 spec 1.54); elytra width/pronotum width ratio 1.32-1.43 (mean of 32 spec. 1.38); elytra length/pronotum length ratio 2.14-2.24 (mean of 32 spec. 2.20).




Figs 5-7. Median lobe and parameres of aedeagus 5,6 - *Orientoreicheia caucasica caucasica* (Fleischer) from Achadara; 7 - *O. caucasica rousi* subsp. n., holotype. Scale in mm.

Both the length and the depth of punctation of the elytral striae vary in specimens from the same population. Nevertheless, the punctation of elytral striae in specimens from the vicinity of the river Gumista are shallower than that in specimens from Agrba.

Aedeagus (13 specimens examined) as in Figs 5 and 6.

DISTRIBUTION. Abkhazia, north west of the river Kelasuri (Bzybskiy khrebet, Gagrinskiy khrebet, coastal region).

### *Orientoreicheia caucasica rousi* subsp. n.

HOLOTYPE. Male, *Caucasus occ., Abkhasia, Jampal vall., Amtkel, 450-700 m, 30.iv.1990, leg. B. Zvarič; in* Coll.P. Bulirsch. PARATYPES. 3 males, 2 females, the same locality, in Coll. National Museum Praha, B. Zvarič (Most) and P. Bulirsch; one female, the same locality, leg. P. Bulirsch, in Coll. P. Bulirsch. All specimens were found in a limited area under dead leaves in the litter of a deciduous wood.

Body length. 2.2-2.4 mm ( mean of 7 spec. 2.3 mm). Pronotum width/length ratio 1.05-1.06 (mean of 7 spec. 1.05). Elytra length/width ratio 1.54-1.61 (mean of 7 spec. 1.57); elytra width/pronotum width ratio 1.35-1.40 (mean of 7 spec. 1.37); elytra length/pronotum length ratio 2.25-2.30 (mean of 7 spec. 2.28).

The length and punctation of elytral striae vary similarly as in the nominotypical subspecies and are similar to that found in specimens from the vicinity of the river Gumista.

Aedeagus (3 specimens examined) as in Fig. 7, its apex bent downward distinctly in lateral view

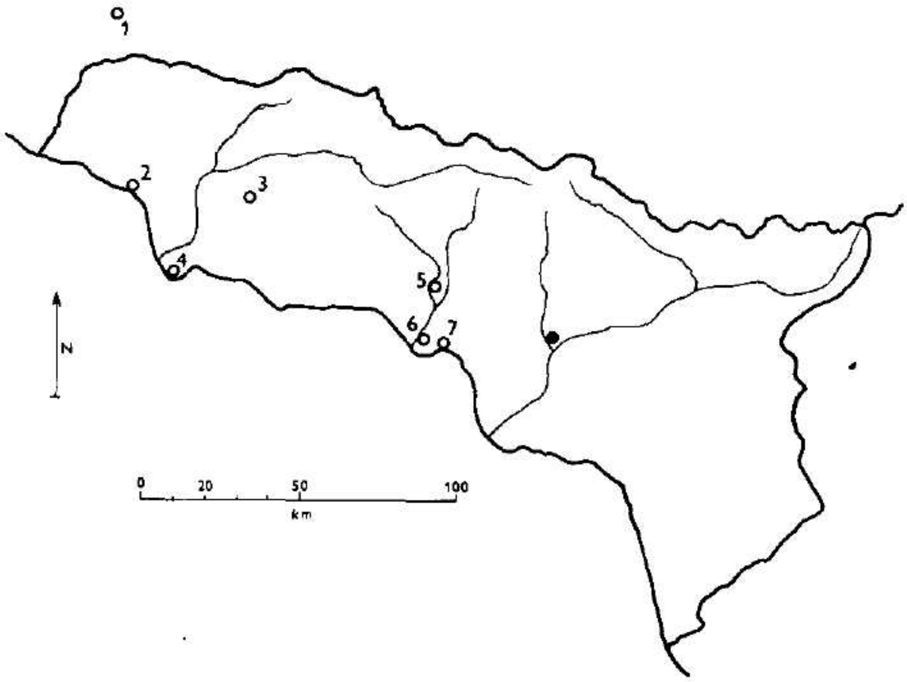



Fig. 8. Map of Abkhazia with the localities of *Orientoreicheia caucasica* (Fleischer) o - *O. c. caucasica*, ● - *O. c. rousi* subsp. n.; 1 - Krasnaya Polyana; 2 - Gagra; 3 - Tschipschira Mt.; 4 - Agrba n. Picunda; 5 - the river Gumista n. Akhalcheni; 6 - Achadara n. Sukhumi; 7 - Sukhumi env. (the holotype).

DISTRIBUTION. Abkhazia, east of the river Kelasuri (Kodorskiy khrebet).

DIFFERENTIAL DIAGNOSIS. *O. caucasica rousi* subsp. n. differs from the nominotypical subspecies mainly in the shape of the apex of aedeagal median lobe bent downward (straight in *O. c. caucasica*) and by relatively longer elytra in the ratio to pronotum, index 2.25-2.30 (aver. 2.28) (2.14-2.24, aver. 2.20 in nominotypical subspecies). This represents the most easterly population of the species (Fig. 8) recorded so far.

DERIVATIO NOMINIS. The new subspecies is dedicated to the collector of much of the material examined of *O. caucasica*, Rudolf Rous, a Czech entomologist.

*Acta Soc. Zool. Bohem.* **57**: 167-172, 1993(1994)
ISSN 0862-5347

# Czech Enchytraeidae (Oligochaeta). IV. Description of *Enchytronia pratensis* sp.n. and a note on *Marionina communis* *)

Josef CHALUPSKÝ jr.

Institute of Soil Biology, Academy of Sciences of the Czech Republic, Na sádkách 7,
CZ-370 05 České Budějovice, Czech Republic

*Received May 3, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Taxonomy, faunistics, Oligochaeta, Enchytraeidae, *Enchytronia pratensis* sp.n., *Marionina communis*, Bohemia**

**Abstract.** *Enchytronia pratensis* sp.n. is described. A species new to the enchytraeid fauna of the Czech Republic, *Marionina communis* Nielsen & Christensen, 1959, is reported. Extended information on enchytraeid taxocenosis of meadow site is supplemented.

Enchytraeids were studied in the soil of a small meadow in the town České Budějovice, South Bohemia. Fifteen enchytraeid species belonging to the genera *Achaeta* Vejdovský, 1878, *Buchholzia* Michaelsen, 1887, *Enchytronia* Nielsen & Christensen, 1959, *Enchytraeus* Henle, 1837, *Fridericia* Michaelsen, 1889 and *Henlea* Michaelsen, 1889 were found. The aim of this paper is to describe a new species of *Enchytronia* recovered in the samples, and to introduce *Marionina communis* Nielsen & Christensen, 1959 which is new to the enchytraeid fauna of the former Czechoslovakia.

## METHODS AND MATERIALS

Six qualitative soil samples with a minimum volume of 1 litre were collected. The soil was sampled to the depth of 10 cm with a metal shovel. The enchytraeids were extracted from the soil by the heated wet funnel method (O'Connor 1955). They were identified live under a light microscope. Some enchytraeids were preserved and stored in 4% formaldehyde, others were stained in borax HCl alcoholic carmine using Mayer's procedure and mounted whole in Canada balsam. Nielsen & Christensen's (1959) conventions are used throughout the descriptions. The drawings are derived from observations of the live animals. Type material is deposited in the author's collection at the Institute of Soil Biology, Academy of Sciences of the Czech Republic.

## RESULTS

The locality was sampled four times: on 11 and 16 February, 1988; 13 December, 1988; and 3 June, 1991. *Buchholzia* sp. dominated the enchytraeid community. One mature and one submature *B. appendiculata* (Buchholz, 1862) were found during the study; all juveniles of *Buchholzia* were assumed to belong to this species. No specimens of *B. appendiculata* were observed in 1991. The reason may have been that a new housing development at the site affected

* Paper is linked with the series of articles on enchytraeids which started under the name "Czechoslovak Enchytraeidae" long before the split of former Czechoslovakia.

## REFERENCES


BASILEWSKY P. 1980: Les Reicheiina de l'Afrique du Sud (Coleoptera: Carabidae). *Entomologia Generalis* **6**: 293-302.

FLEISCHER A. 1921: Ein neuer Euplectes und eine neue Reicheia aus dem Kaukasus. *Wiener Ent. Ztg.* **38**: 145.

JEANNEL R. 1957: Révision des petites Scaritides endogés voisins de Reicheia Saulcy. *Rev. Franc. Entomol.* **24**: 129-212.

SCIAKY R. 1985: Alpiodytes ravizzai n. sp. della Lombardia e osservazioni sulla sistematica della subtribu Reicheiina. *Boll. Soc. Entomol. Ital.* **117**: 76-82.

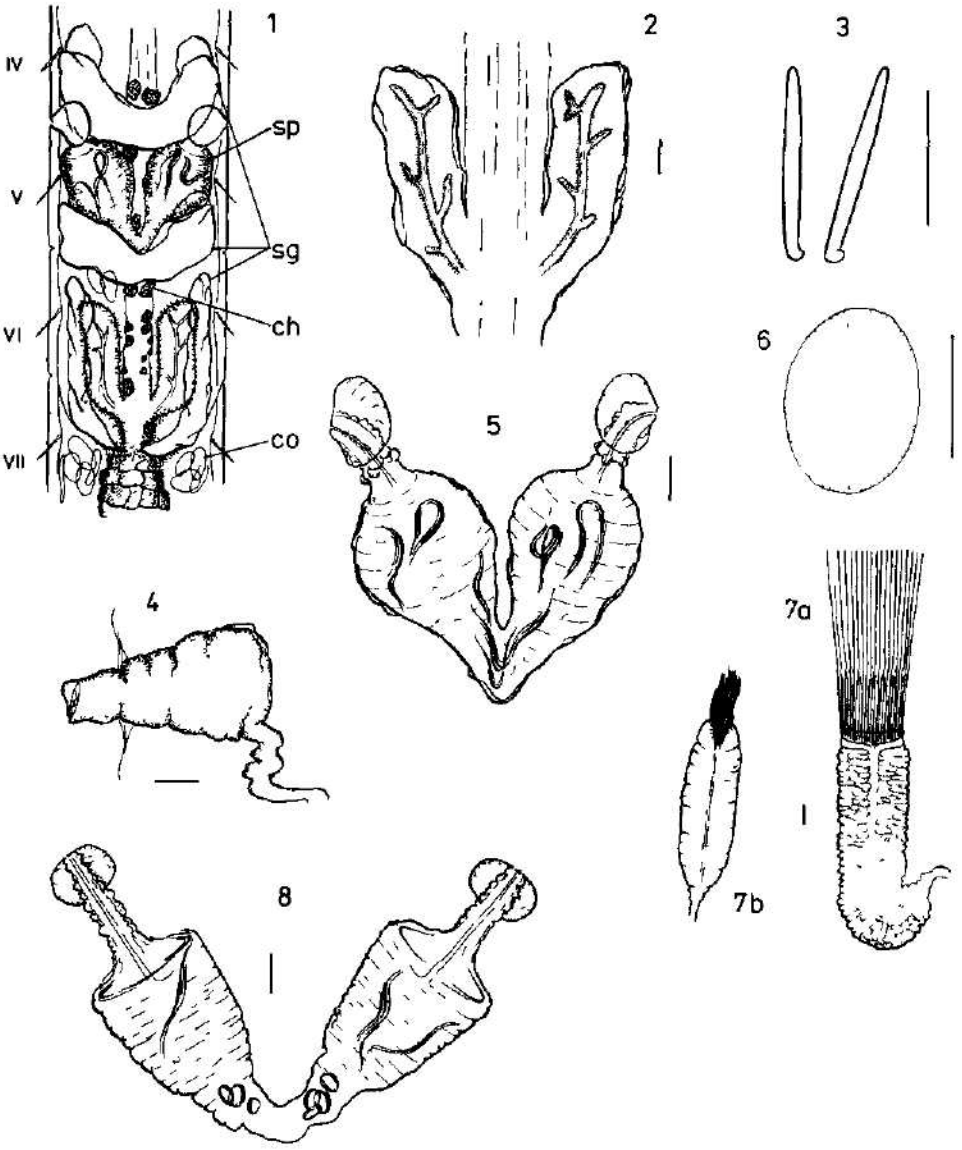
SCIAKY R. 1989: Una nuova specie e un nuovo genere di Reicheiini della penisola Iberica. *Boll. Soc. Entomol. Ital.* **121**: 90-97.

the soil water content, producing drier soil conditions. Other enchytraeid species occurred at the site: *Achaeta eiseni*? Vejdovský, 1878, *Enchytraeus buchholzi* Vejdovský, 1878 s.l., *Enchytronia pratensis* sp.n., *Enchytronia parva*? Nielsen & Christensen, 1959, *Fridericia bisetosa* (Levinsen, 1884), *Fridericia connata* Bretscher, 1902, *Fridericia bulboides* Nielsen & Christensen, 1959, *Fridericia gracilis*? von Bülow, 1957, *Fridericia sylvatica*? Healy, 1975, *Fridericia* sp.A, *Fridericia* sp.B, *Henlea perpusilla* Friend, 1911, *Henlea ventriculosa* (d'Udekem, 1854), and *Marionina communis* Nielsen & Christensen, 1959. In general, the abundance of these species was markedly lower than that of *B. appendiculata*. However, the species of *Achaeta* and *Fridericia* were much more abundant during the last sampling, which indicated a response to an obscure environmental impact on the enchytraeid community.

### *Enchytronia pratensis* **sp.n.** (Figs 1 - 7)

DESCRIPTION. Colour whitish. Live length (3-4) 4.5-5 (5.5) mm; width 150-175 µm (200 µm in clitellar region). Segments (19, 22, 24-27) 28-29 (30). Setal pattern 0,2 - 2 : 2 - 2. Lateral setae absent in VIII-IX. Setae (Fig. 3) with a mild proximal hook; 20-25 µm long in front of clitellum laterally and 28-30 µm long in front of it ventrally; behind the clitellum setal length increasing to 40-43 µm towards the posterior end of the body. Head pore at 0/I. Dorsal pores missing. Clitellum covering XII - 2/5 XIII, elevated outwards, consisting of 18-21 transverse rows of granular and hyaline clitellar cells. Clitellar cells missing in ventral midline between the penial bulbi. The cells are 20 µm high, whereas the underlying epithelial and muscular body wall is 15 µm high. Brain about 120 µm long, length:width ratio 2-2.5:1, its front part with rounded tip, hind margin deeply incised, lateral parts converging anteriorly. Three pairs of septal glands in IV-VI; first and second pair joined dorsally, having ventral lobes; third pair formed by separate, long ventrolateral lobes. Oesophagus with a pair of diverticula in VI (Fig. 2). Each diverticulum communicates with the oesophagus through a narrow channel of a dendritic appearance and with a brush-like border. Chloragogen tissue coloured yellow-brown, cells occurring in IV-VI, densely from VII, almost missing in XI-XII, and again fully developed from XIII onwards. These cells, 30 µm high and 20 µm wide, contain a few oil droplets and lose their well-defined appearance towards the posterior end of the body. Blood colourless, dorsal vessel arising from XIII/XIV. Coelomocytes (Fig. 6) broadly oval, 30 µm long (range 20-38 µm), their cytoplasm finely and regularly grained, rarely with a few less dense areas. Two pairs of nephridia (Fig. 4) anteclitellarly at VII/VIII and VIII/IX; nephridium 95 µm long, anteseptale being 1/4 of postseptale, postseptale with mildly lobed upper margin; efferent duct originating subterminally; interstitial tissue normally developed. Usually six pairs of nephridia behind the clitellum. Spermathecae (Fig. 5) communicating with the exterior laterally at IV/V; ectal openings with a single large gland which is 50 µm wide; ectal ducts 45-55 µm long, irregularly covered by gland-like cells; ampullae club-like, 75-90 µm in diameter, narrowing entally and there coalescing with each other and attached to the oesophagus. In some cases the ampullae appear rough and brownish, having a mosaic structure inside. Sperm pale, arranged in sparse thread-like clusters in ampullar lumen. Seminal vesicles light brown, large, filling (1/2 IX) X-XI (XII). Sperm funnels 100 µm wide when mature (Fig. 7a), length:width ratio 3-3.5:1, collar of the same width as the body of the funnel; sperm stuck on the collar are dark brown, those far from the collar are pale brown. Vasa deferentia 7 µm in diameter, irregularly coiled in loose loops. Penial bulbi 55 (75) µm long, 55 µm wide and high, solid and compact. One mature egg at a time, 350-420 µm long; a few immature eggs in the early stage of development are present at the same time.

HOLOTYPE. Nr. 1988/1 and 10 paratypes in the author's collection are deposited in the Institute of Soil Biology, České Budějovice.




Figs 1 - 7. *Enchytronia pratensis* sp.n 1 - internal anatomy of the anterior body in IV-VII, ch - chloragogen cells, co - coelomocytes, sg - septal glands, sp - spermatheca; 2 - oesophageal diverticula in VI; 3 - setae; 4 - anteclitellar nephridium; 5 - spermathecae, 6 - coelomocyte; 7a - mature sperm funnel; 7b - juvenile sperm funnel. Scale bars = 20 µm.

Fig 8 *Enchytronia annulata* Nielsen & Christensen, 1959, spermathecae; South Bohemia (original drawing). Scale bar = 20 µm.

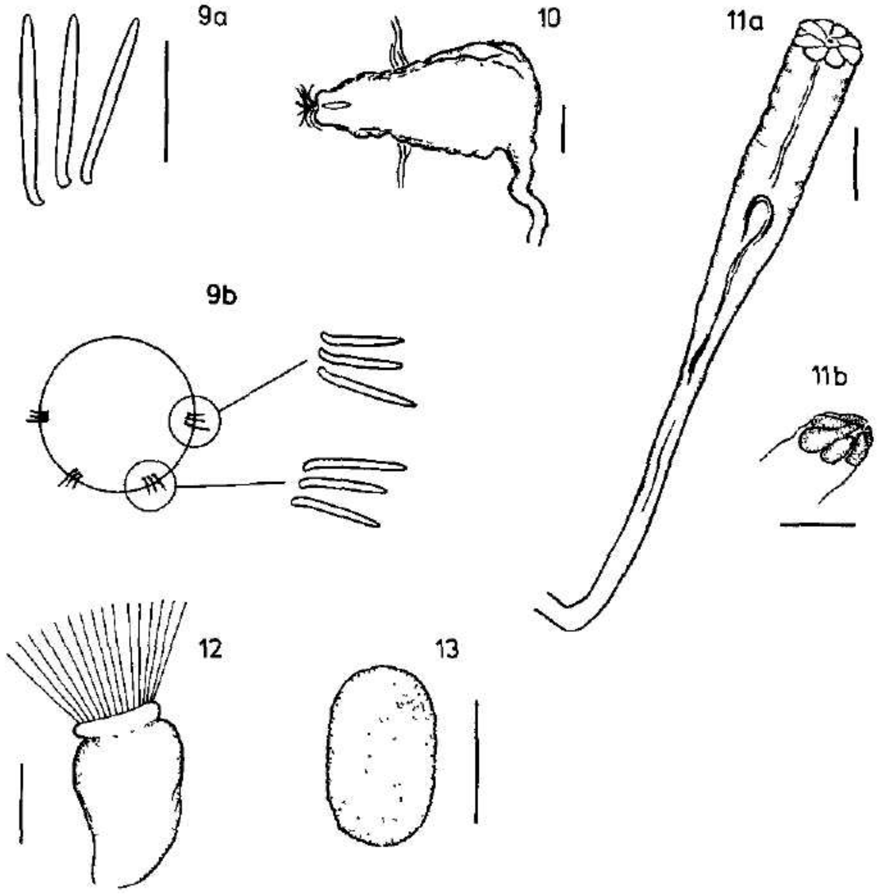
TYPE LOCALITY. Czech Republic, South Bohemia, České Budějovice, 49° 00' 02'' N, 14° 26' 43'' E, little meadow by the road from Vltava housing estate to the village České Vrbné. The site is part of a private garden lying next to a railwayman's old house. Soil at the site is black brown, surface layers with dense grass rootlets, humus form mull.

Sampling occasions: 11 February, 1988: 13 matures; 16th February, 1988: 13 matures; 13 December, 1988: 21 matures and 7 juveniles; 3 June, 1991: 4 matures.

FURTHER LOCALITY. Czech Republic, North Moravia, Jeseníky Mts., Velká kotlina valley, elevation 1425 m, mountain meadow with plant association *Thesio-Nardetum*; 2 July, 1991: 8 matures.

ETYMOLOGY. The species name means "of meadow" in Latin.

COMMENTS. The number of segments varied in the specimens found: one worm with 19, one with 22, one with 24, five with 26, four with 27, nineteen with 28, twelve with 29, and five with 30. Some slight discrepancies compared with the setal pattern mentioned in the description were observed: one animal had 3 setae in one lateral bundle in V; another had 1 seta in one ventral bundle in III; one worm had lateral bundles in XI with 1 and 2 setae respectively; in some




Figs 9 - 13 *Marionina communis* Nielsen & Christensen, 1959 9a - setae; 9b - detailed arrangement of setae in bundles; 10 - anteclitellar nephridium; 11a - spermatheca, 11b - detail of the ectal orifice of spermatheca; 12 - sperm funnel; 13 - coelomocyte. Scale bars = 20 µm.

specimens the setae were occasionally missing from the lateral bundles in II. The setae are oval in cross-section, the transverse axes being 4 µm and 2.5 µm long. The head pore was not observed directly, but its location was inferred from watching outflowing coelomocytes. Cutaneous glands are arranged in about two incomplete transverse rows on each segment. They are inconspicuous if looked side-on, but they can be easily recognized if viewed edge-on. In the latter case they look like small hyaline bodies inserted in the epithelium. The ventrolateral lobes of the third pair of septal glands are 1.5-2-times longer than the length of the oesophageal diverticula. These diverticula are either closely applied to the oesophagus or partly bent outwards; they completely fill the space between the third septal glands. In one individual the diverticula of the oesophagus were found to be poorly developed and the third pair of septal glands was missing. The spermathecae are usually 125-150 µm long depending on the body contraction. The ampullae of the spermathecae resemble those of *E.annulata* Nielsen & Christensen, 1959 (Fig. 8). However, in *E. pratensis* they are typically club-shaped, with rounded margins, whereas in *E. annulata* they are rather cone-shaped with a distinct transition between ectal duct and ampulla. Moreover, in *E. pratensis* the sperm are arranged in relatively long sparse clumps, while in *E. annulata* they form a few small rings close to the ental parts of the spermatheca. The size and structure of the sperm funnel vary. This is likely to reflect the stage of development. Unlike the mature sperm funnel, which is 100 µm wide and with dark brown sperm stuck on the collar, young funnels (Fig. 7b) are 50 µm wide, and have a narrow, high collar with sparse, short and light sperm stuck on the margin.

The new species *Enchytronia pratensis* conforms to the diagnosis of *Enchytronia* Nielsen & Christensen, 1959, extended by Chalupský (1991). It is another species of *Enchytronia* which has well-developed seminal vesicles. Further, it differs from the other *Enchytronia* species known so far by the shape and arrangement of the spermathecae. The closest relative, *Enchytronia annulata*, has no seminal vesicles and the spermathecae are of different appearance.

### *Marionina communis* Nielsen & Christensen, 1959 (Figs 9 - 13)

DESCRIPTION. Normally white. Live length (4) - 5 mm. Segments (25) 26 (27). Setal pattern 3(2) - 2(3)2 : 3 - 2(3)2; lateral bundles present in XII. When three setae are present in a bundle (Fig. 9a), two are short and one is long. The long seta is always the lowest one in the lateral bundles, and the outermost seta of the ventral bundles (Fig. 9b). Setae in II 20 µm long; from III to clitellum the short setae 24-25 µm long, the long seta 28-30 µm; behind the clitellum setae up to 40 µm long. Brain incised on hind margin. Three pairs of septal glands in IV, V and VI, separate dorsally; all pairs with ventral lobes; ventral lobes of the third pair markedly longer than those of the other pairs. Coelomocytes (Fig. 13) oval, with almost parallel lateral margins, 30 µm long (whole range 15-20, 25 and 32 µm), width about half the length. Cytoplasm of coelomocytes regularly finely grained. Nephridia (Fig. 10) in front of clitellum in 4 pairs at VI/VII - IX/X. Spermathecae (Fig. 11a) up to 250 µm long. Ectal ducts, diameter 15-18 µm, make up one fourth of the length of the spermathecae. Glassy bodies (Fig. 11b) in the wall of the ectal duct surround the orifice; the bodies are finely grained, 12 µm long, and are arranged in a rosette. At the transition of the ectal duct and the ental part there is a drop-shaped lumen sparsely filled with pale sperm; the sperm partly enter the ental ducts which coalesce with each other. Seminal vesicles small, containing a few moruloid balls in various stages of spermiogenesis. Sperm funnels (Fig. 12) small, 45 µm long, with length:width ratio 1-1.5:1, truly funnel-shaped, a little curved, with narrow collar. Vasa deferentia narrow, 3.5 µm in diameter. Penial bulb 65 µm long.

COMMENTS. The specimens found largely conform to the diagnosis of Nielsen & Christensen (1959). Czech populations slightly differ in two details. The efferent duct of the anteclitellar nephridia arises postero-ventrally (Nielsen & Christensen: antero-ventrally). In the majority of specimens there were no glands at the ectal orifice hanging into the coelomic cavity. Instead, the hyaline glassy bodies were present inside the wall of the ectal ducts by the ectal openings.

MATERIAL. 11 February, 1988: 3 matures; 16 February, 1988: 3 matures; 13 December, 1988: 1 mature and 2 juveniles.

OTHER LOCALITIES. České Budějovice, oak alley along the pond Černiš, 29 September, 1981: 5 matures. Šumava Mts., grassy clearing near the lake Plešné jezero, 2 September, 1982: 4 matures (soil lgt. M. Tonner). Village Chelčice-Dlouhá ves, meadow, 11 July, 1985: 1 mature. České Budějovice, wet meadow by the pond Nový Vrbenský, 15 February, 1987: 9 matures and 1 juvenile. Krkonoše Mts., mountain meadow with *Viola sudetica* by chalets Zadní Rennerovy boudy, elevation 1300 m, 22 September, 1988: 5 matures and 5 juveniles.

DISTRIBUTION. The Netherlands, Denmark, Norway, Iceland, Sweden (personal observation), Germany, Great Britain, Ireland, Finland, Poland, new to the Czech Republic.

The enchytraeid fauna of the former Czechoslovakia including *Enchytronia pratensis* sp.n. and *Marionina communis* consists of 60 species.


Acknowledgements

I am grateful to Dr Michael A. Learner for his critical comments and linguistic improvements of the manuscript.


## REFERENCES


CHALUPSKÝ J. jr. 1991: Czechoslovak Enchytraeidae (Oligochaeta). III. Description of a new species of Enchytronia and notes on two species of Marionina. *Acta Soc. Zool. Bohemoslov.* **55**: 99 - 113.

NIELSEN C.O. & CHRISTENSEN B. 1959: The Enchytraeidae, critical revision and taxonomy of European species (Studies on Enchytraeidae VII). *Nat. Jutl.* **8-9**: 1 - 160.

O'CONNOR F.B. 1955: Extraction of enchytraeid worms from a coniferous forest soil. *Nature* (Lond.) **175**: 815 - 816.

*Acta Soc. Zool. Bohem.* **57**: 173-182, 1993(1994)
ISSN 0862-5247

# Exploratory behaviour in 12 Palaearctic mice species (Rodentia: Muridae): A comparative study using "free exploration" tests

Daniel FRYNTA

Department of Zoology, Charles University, Viničná 7, CZ-128 44 Praha 2, Czech Republic

*Received September 21, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Exploratory behaviour, commensalism, *Apodemus, Mus, Micromys, Lemniscomys, Acomys***

**Abstract.** Exploratory behaviour of 358 adult mice belonging to the 12 species was recorded during 6-min. free exploration tests. Following mice species were studied: *Apodemus agrarius, A. peninsulae, A. flavicollis, A. sylvaticus, A. microps, A. mystacinus, Mus musculus, Mus domesticus*, F1 hybrids of *M. musculus x M. domesticus, Lemniscomys barbarus, Micromys minutus, Acomys cahirinus.* A considerable interspecific variation was found for most behavioural traits recorded. High level of number of square entries, rearing and time spent in loco-exploratory activity was found in *A. mystacinus;* while low levels were found in *A. agrarius.* Other species showed fairly intermediary values.

## INTRODUCTION

Exploratory behaviour is a novelty seeking activity which has no immediate relationship to needs or to incentive (Barnett & Cowan 1975). It is often believed that exploratory behaviour is under strong selective pressure in natural populations. High levels of exploratory activity were proposed for species with fairly generalist ecological strategy based on behavioural plasticity and learning (Lorenz 1974).

Diverse modifications of classical open-field technique permit quantification of behavioural patterns emitted in standardized novel situation in a fixed short period of time. Amounts of the loco-exploratory activity displayed during the test were traditionally considered to be a measure of exploratory drive. The results of genetical analysis have shown that the behavioural parameters measured by using these simple tests are particularly sensitive to genotype (Abeleen 1970, Garten 1977, DeFries et al. 1978, Schäfer 1982, Vadácz et al. 1983, Ehrman & Parsons 1981). This research was conducted in order to collect comparative data on exploratory behaviour in non-domesticated mice. We selected "free exploration" technique in which a tested animal is allowed to leave its home cage to explore an unfamiliar area. When compared with "forced exploration" technique this procedure seems to be more reliable due to reduction of the manipulation stress and disturbance.

Palaearctic species of the family Muridae are suitable for such a study. Diverse ecological strategies are represented within this group and some species are closely related to each other. Until now, only few studies dealt with these species exploratory behaviour. Free exploration techniques were used for comparison of two species, for example feral and commensal species of house mice *Mus musculus* and *Mus spicilegus* (Meškova et al. 1986), *Acomys cahirinus* and *Mus musculus* (D'Udine & Birke 1975) or for evaluation of the effects of sex and season in *Apodemus sylvaticus* (Lodewijcx 1984 a,b). Other comparative studies in non-domesticated populations are based on "forced exploration" tests (Dojčev 1983, Dojčev & Molle 1983, 1985, Dojčev et al. 1983, Frynta 1992).

## MATERIAL AND METHODS

For this research sexually mature animals both wild and laboratory born were used. Wild caught specimens were captured regularly in summer or autumn to wooden live traps laid in lines spaced 3-4 m. The majority of that animals was probably born in the (late) summer. The age of wild caught commensal House mice was less uniform. Most of wild caught specimens of all genera were maintained in the laboratory throughout the winter and tested during the following spring months from February to May. Laboratory born specimens belonged to the first or second generation derived from the wild populations. The only exception was for those experimental animals of *Lemniscomys barbarus* and *Acomys cahirinus* which originated from the colonies maintained in the laboratory for more generations (see below). The experiments were made during the years 1985-1993.

Fifteen species or populations of mice were tested:

1. *Apodemus agrarius agrarius* (Pallas, 1771) from three localities in Northern Bohemia - Krásná Lípa, Chřibská village (both in district Děčín), vicinity of town Liberec. In total 36 wild caught overwintered animals (22 males and 14 females) were tested.

2. *Apodemus agrarius mantchuricus* Thomas, 1898 from vicinity of the town Vjazemskij (district Chabarovsk) in Russian Far East. 4 wild caught animals (1 male and 3 females) were tested.

3. *Apodemus peninsulae* (Thomas, 1906) from vicinity of the town Vjazemskij (district Chabarovsk) in Russian Far East. In total 16 animals, 5 wild caught animals (3 males and 2 females) and 11 animals (6 males and 5 females) of the first generation born in laboratory were tested.

4. *Apodemus flavicollis* (Melchior, 1834) from several localities in Central Bohemia - Prague, Cerhovice village (district Beroun), Obříství village (district Mělník), etc. In total 19 tests were performed (wild caught animals: 11 males and 4 females; Laboratory born: 1 male and 3 females).

5. *Apodemus sylvaticus* (Linnaeus, 1758) from localities in Central Bohemia - Prague (majority of animals used) and Cerhovice village (district Beroun). In total 77 animals (wild caught: 19 males and 13 females; laboratory born: 23 males and 22 females)

6. *Apodemus microps* Kratochvíl et Rosický, 1952 from Drnholec (district Břeclav) and Vrbovec (district Znojmo) - villages in Southern Moravia. In total 14 animals were tested (13 wild caught: 7 males and 6 females; one laboratory born female).

7. *Apodemus mystacinus* Danford et Alston, 1877 from Breznica village (district Blagoevgrad, Bulgaria). In total 20 wild caught animals (12 males and 8 females) were tested.

8. *Mus macedonicus* Petrov et Ružič, 1985 (= M. abbotti auctorum nec Waterhouse, 1837) from vicinity of village Krumovo (district Jambol, Bulgaria). In total 21 wild caught animals (9 males and 12 females) were tested.

9. *Mus musculus* Linnaeus, 1758 from Prague, Central Bohemia. In total 23 wild caught animals (14 males and 9 females) were tested.

10. *Mus musculus* Linnaeus, 1758 from Reselec village (district Pleven, Bulgaria). In total 26 animals (wild caught: 2 males and 2 females; laboratory born: 13 males and 9 females) were tested.

11. *Mus domesticus* Rutty, 1772 from Easternmost Turkey (towns Dogubayazit and Van; one pair of wild caught animals, 17 males and 15 females of the first generation born in laboratory).

12. Hybrids of *Mus domesticus* (Bansko, Bulgaria) and *Mus musculus* (Reselec, Bulgaria) of F1 generation born in laboratory (12 males and 18 females).

13. *Lemniscomys barbarus* (Linnaeus, 1767) from the laboratory colony originated in Algeria and maintained in captivity for about 4 generations. 12 individuals (6 males and 6 females) were tested.

14. *Micromys minutus* (Pallas 1771) from district Jindřichův Hradec in Southern Bohemia. In total 12 animals (wild caught: 3 males and 1 female; laboratory born: 5 males and 3 females) were tested.

15. *Acomys cahirinus* (Desmarest, 1819) from almost domesticated laboratory colony most probably originated in Israel. 14 specimens (7 males and 7 females) were used.

Groups of captive animals, consisting of one or two pairs and their offsprings, were housed in standard plastic cages (38 x 22 x 22 cm) or in larger glass cages of different size (usually 60 x 50 x 40 cm). The cages were placed in a light controlled room (14L : 10D at the time of testing). Ad libitum water in water bottles and food (DOS2B mouse and rat breeder diet, wheat, etc.) were provided. Each cage contained sawdust bedding, nesting material (cotton-wool or hay) and shelters (tubes 100 mm long, 30 mm in diameter).

The experiments were performed in the glass terrarium (100 x 40 x 40 cm in size) used as "open field". The floor was demarcated into 10 squares of equal dimensions (20 x 20 cm) by painted dark lines. During the testing the field was illuminated by a single 25 W red light bulb suspended approximately 0.5 m above the center of the *open-field. The red light was regulated by using a rheostat to the minimal intensity useful for observation.* The animals were tested during the first half of the dark phase of their light-dark cycle. Each animal received a single 6-min test in open field.

The tests were initiated by placing an animal together with sawdust bedding (about 50 ml) from his real home cage into a small box of red plexiglass (14 x 9 x 9 cm). The doors covering aperture (4 cm in diameter) of the box were closed. The box below called "home" cage was placed at the corner of the "open field". After 5 minutes the *doors were opened (with minimal disturbance) and the latency to leave the home cage was measured. In some* cases when a mouse did not leave the home cage during the first 10 min. after opening the doors the experiment was interrupted. Therefore, the latency values exceeding 600 seconds were replaced by the value 600. Behaviour of an animal was observed and recorded for six minutes after leaving its home cage. The test was divided into 36 periods; each lasted 10 seconds. Number of square entries (below abbreviated and referred as square), rearing (rear) and jumping (jump) were counted. Other behavioural parameters were defined as following:

*Distsq - number of entries in the "distant square", i.e., the square in the corner opposite to the home cage;*

Latdist - latency to the first visit "distant square", i.e., the interval between the first leaving home cage and the first visit in "distant square";

Home - time spent in home cage [s];

Loco - time spent by loco-exploratory activities (gnawing the field, scratching at the floor or walls with the forepaws, climbing, sniffing, jumping, rearing, walking and running about the field) outside the home cage. In *fact it was almost equal to the time spent outside the home cage with the exception of the time spent by grooming* and freezing [s].

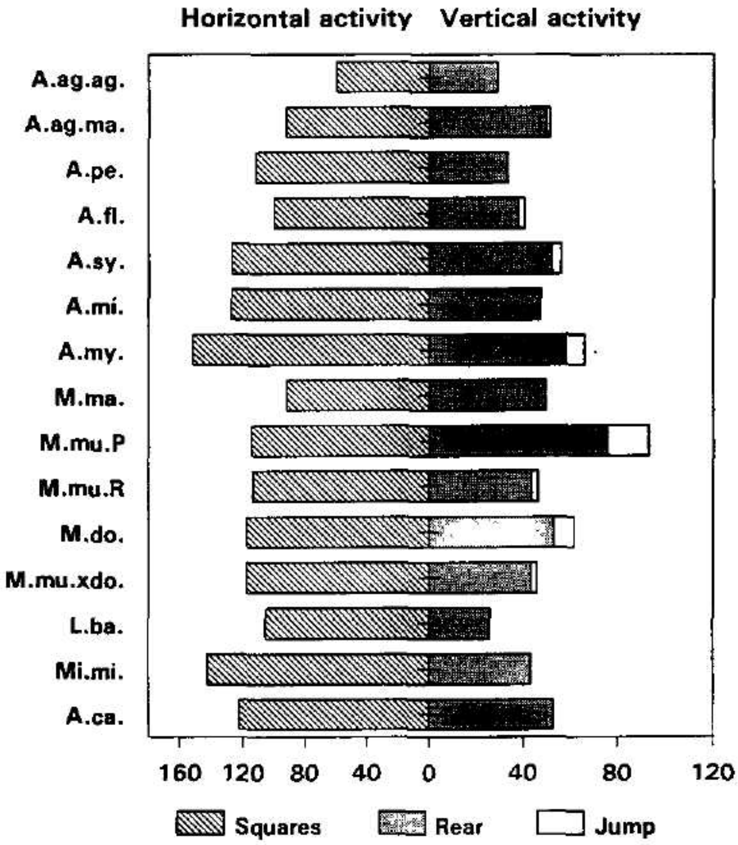



Fig. 1. Means for horizontal (square entries) and vertical (rearing, jumping) activity measures in individual species. Abbreviations are the same as in Tab. 1.

Freeze - time spent by freezing [s]. Only freezing events longer than 10 seconds were recorded;

Groom - time when grooming (all grooming, preening, scratching, licking or biting) of the animal's own body was recorded [s];

Cross - number of crossings the doors connecting the home cage with the "open field";

The number of fecal boli was counted at the end of each test. The floor and walls were thoroughly cleared (washed by using a detergent and 96% ethanol) before the testing of the next animal.

RESULTS

## Intraspecific variation

Sex differences: In order to test differences between the sexes controlled for species two-way analysis of variance was performed for species and sex as factors. Slightly significant influence of sex was found for the time spent by loco-exploratory behaviour only (F=6.17, P=0.013). In 12 of 15 samples (species or populations) under study the mean time spent by loco-exploratory activity was higher in males than that in females. No clear tendency to considerable sexual differences in any other behavioural parameter was found. The corresponding results of ANOVA for these parameters are following: number of square entries F=1.57, P=0.210; rearing F=1.63, P=0.202; distsq F=2.75, P=0.098; crossing F=0.13, P=0.714; time spent in home cage F=3.30, P=0.070, latency (Log-transformed) F=0.04, P=0.829, latdist (Log-transformed) F=0.256, P=0.618; boli F=2.95, P=0.086. Therefore, we pooled the data for males and females in order to broaden samples.

We compared behaviour of laboratory born wood mice (*Apodemus sylvaticus*) with wild born overwintered animals of the same species by using analysis of variance controlled for sex. A significant effect of this factor was found for rearing only (F=6.34, P=0.01). Similar comparisons of wild and laboratory born wood mice (analyses of variance or Kruskal-Wallis tests) performed for all the other behavioural parameters studied did not show any significant result.

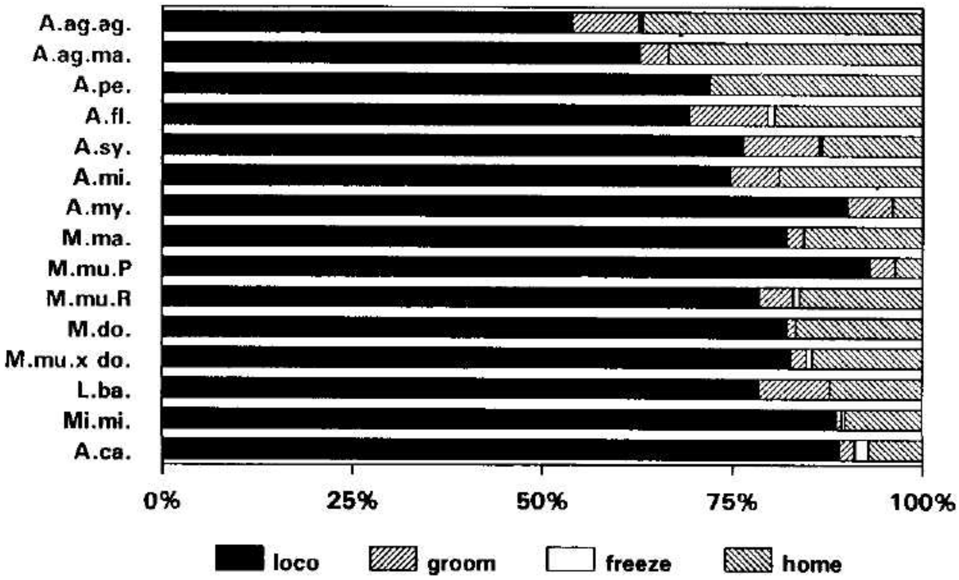



Fig. 2. Mean time spent by loco-exploratory activity (loco), grooming (groom), freezing (freeze) and inside home cage (home). Abbreviations are the same as in Tab. 1.

**Interspecific comparisons**

The mean values and standard errors for each variable and species or population are given in tables 1-3 and Figures 1-2. A considerable interspecific variation was found in the majority of behavioural variables as indicated by the results of non-parametric Kruskal-Wallis statistics ($P<0.0001$). It was less apparent in latency to enter a distant square ($P=0.0039$). The only exception was the non-significant value obtained for freezing ($P=0.1025$).

Also the analysis of variance (described above) revealed highly significant (P) differences among species with respect to the total number of square entries ($F=6.26$), rearing ($F=12.52$), crossing ($F=7.55$), time spent in the home cage ($F=6.89$), time spent by loco-exploratory activity ($F=9.32$). A lot of individual comparisons using Tukey range tests were significant. For example, following comparisons were significant for the number of square entries, rearing, time spent in the home cage and by loco-exploratory activity. A. mystacinus entered significantly more squares than *A. a. agrarius* and *M. macedonicus*. *A. a. agrarius* entered less squares than all the other species under study with the exception of *M. macedonicus, A. a. mantchuricus, A. flavicollis* and *L. barbarus*. Rearing: *L. barbarus* reared less frequently than *M. macedonicus, A. sylvaticus, Ac. cahirinus, M. domesticus, A. mystacinus* and *M. musculus* (Prague), *A. a. agrarius* less than *M. macedonicus, A. sylvaticus, Ac. cahirinus, M. domesticus, A. mystacinus* and *M. musculus* (Prague), *M. musculus* (Prague) more than all the other species under study with the exception of *A. a. mantchuricus*. Home: *A. a. agrarius* spent in the home cage significantly more time than all the other species with the exception of *A. a. mantchuricus, A. peninsulae, A. flavicollis* and *A. microps*. *A. peninsulae* spent in the home cage more time than *A. mystacinus* and the Prague population of *M. musculus*. Loco-exploratory activity. *A. agrarius* spent less time by loco-exploratory than all the other species with the exception of *A. a. mantchuricus* and *A. flavicollis*. *A. mystacinus* spent more time than *A. flavicollis, M. musculus* (Prague) more time than *A. peninsulae, A. flavicollis* and *A. sylvaticus*.

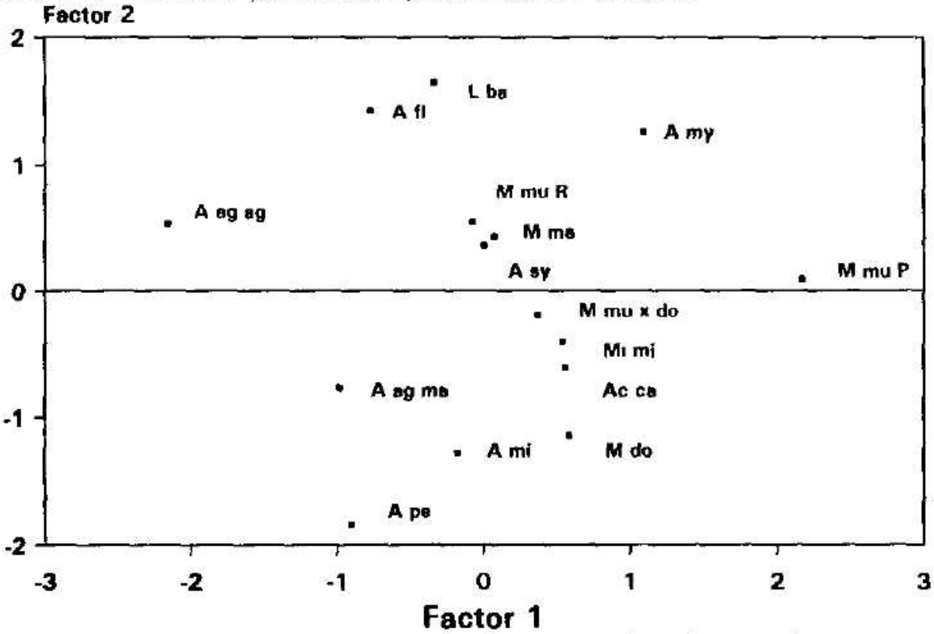



Fig. 3. Results of factor analysis. Scatter-plot of factor scores for individual species. Abbreviations are the same as in Tab. 1.

Iable 1 Means for latency to leave home cage (latency) latency to visit most distant square (latdist), number of boli deposited on the field (boli) and body weight of animals (weight) Both latency measures are LOG-transformed

| | Latency | | | Latdist | | | Boli | | Mean body |
|---|---|---|---|---|---|---|---|---|---|
| Species | n | Mean | S E | n | Mean | S E | Mean | S E | Weight |
| A ag | 36 | 1 13 | 19 | 36 | 2 90 | 06 | 1 11 | 21 | 26 4 |
| A ag ma | 4 | 2 26 | 1 13 | 4 | 2 77 | 43 | 1 50 | 1 19 | 32 9 |
| A pe | 16 | 1 45 | 36 | 16 | 3 70 | 28 | 56 | 27 | 27 6 |
| A fl | 19 | 87 | 20 | 16 | 3 24 | 27 | 1 38 | 52 | 32 0 |
| A sy | 77 | 1 53 | 17 | 68 | 3 03 | 10 | 93 | 18 | 22 5 |
| A mi | 10 | 2 03 | .64 | 14 | 2 42 | 34 | 00 | 00 | 17 0 |
| A my | 20 | 1 35 | 30 | 20 | 2 83 | 21 | 3 00 | 73 | 42 1 |
| M ma | 21 | 73 | 16 | 21 | 3 55 | 12 | 1 86 | 43 | 20 1 |
| M mu P | 23 | 1 16 | 24 | 23 | 3 04 | 18 | 61 | 19 | 19 0 |
| M mu R | 26 | 86 | 17 | 23 | 3 42 | 24 | 83 | 23 | 15 9 |
| M mu x do | 30 | 1 25 | 23 | 21 | 3 35 | 24 | 24 | 17 | 18 0 |
| M do | 34 | 99 | 17 | 34 | 2 99 | 26 | 06 | 04 | 18 6 |
| L ba | 12 | 1 11 | 32 | 12 | 3 05 | 30 | 2 17 | 53 | 51 6 |
| M mi | 12 | 1 72 | 50 | 12 | 2 91 | 27 | 2 08 | 66 | 8 1 |
| A ca | 14 | 98 | 26 | 14 | 2 05 | 26 | 43 | 17 | 45 3 |

Abbreviations A ag = *Apodemus agrarius agrarius* A ag ma = *Apodemus agrarius mantchuricus* A pe = *Apodemus peninsulae*, A fl = *Apodemus flavicollis*, A sy = *Apodemus sylvaticus*, A mi = *Apodemus microps*, A my = *Apodemus mystacinus*, M ma = *Mus macedonicus*, M mu P= *Mus musculus* Prague, M mu R= *Mus musculus* Bulgaria, M mu x do = hybrids of *Mus musculus* and *Mus domesticus*, M do = *Mus domesticus*, L ba = *Lemniscomys barbarus*, M mi = *Micromys minutus*, A ca = *Acomys cahirinus*

The means for each variable and species (population) were treated by using a factor analysis The first factor was highly correlated with the time spent by loco-exploratory activity (0 95), the time spent in the home cage (-0 87), the number of square entries (0 72), rearing (0 70), the number of distant square entries (0 61) and jumping (0 51), while the second factor was correlated with crossings the aperture of the home cage (-0 76), latency to leave the home cage (-0 60), latency to enter a distant square (0 50) and boli (0 46) The scatter-plot of factor scores is given in Figure 3 The marginal position of *Apodemus agrarius* on the left part of the scale according to the first factor is apparent On the other hand *Apodemus mystacinus*, as well as the Prague population of *Mus musculus* were characterized by the highest values of this factor However, great differences between particular populations of commensal mice (*Mus musculus* sensu lato) suggest that the significance of extreme position of the Prague population should not be overestimated Other species displayed fairly intermediary values

## DISCUSSION

Intraspecific variation In a sharp contrast to apparent and highly significant interspecific variation, there were not found considerable sex differences in the majority of behavioural traits displayed during the tests, Also the differences between wild caught and laboratory born wood

Table 2 Mean numbers for square entries (squares), rearing (rear), entries to the most distant square (distsq), *jumping (jump) and crossing the doors of the home cage (cross) Abbreviations are the same as in Tab 1*

| | | Squares | | Rear | | Distsq | | Jump | | Cross | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | n | Mean | S E | Mean | S E | Mean | S E | Mean | S E | Mean | S E |
| A ag | 36 | 59 8 | 5 0 | 29 0 | 2 6 | 4 5 | 4 | 0 | 0 | 7 61 | 63 |
| A ag ma | 4 | 92 8 | 21 2 | 49 5 | 18 1 | 7 3 | 1 7 | 1 5 | 9 | 6 25 | 48 |
| A pe | 16 | 111 9 | 12 0 | 33 4 | 3 6 | 8 7 | 9 | 1 | 1 | 12 81 | 1 77 |
| A fl | 16 | 100 3 | 11 0 | 37 8 | 4 3 | 6 5 | 8 | 2 7 | 1 9 | 5 56 | 88 |
| A sy | 68 | 127 3 | 5 4 | 51 9 | 1 9 | 8 1 | 4 | 4 0 | 1 0 | 7 00 | 51 |
| A mi | 14 | 127 5 | 18 5 | 46 6 | 3 7 | 9 6 | 1 2 | 4 | 4 | 8 14 | 93 |
| A my | 20 | 151 6 | 10 1 | 58 1 | 3 3 | 8 1 | 7 | 7 9 | 1 8 | 5 10 | 88 |
| M ma | 21 | 92 1 | 9 0 | 49 1 | 4 3 | 10 5 | 1 3 | 0 | 0 | 6 57 | 75 |
| M mu P | 23 | 114 7 | 8 4 | 75 6 | 3 3 | 15 0 | 1 4 | 17 4 | 7 8 | 3 04 | 48 |
| M mu R | 23 | 113 4 | 10 1 | 43 7 | 4 1 | 7 6 | 8 | 2 7 | 1 2 | 4 78 | 47 |
| M mu x do | 21 | 117 8 | 11 3 | 43 2 | 3 2 | 10 2 | 1 2 | 2 5 | 1 2 | 3 43 | 45 |
| M do | 34 | 117 5 | 7 5 | 52 9 | 3 2 | 11 0 | 9 | 8 6 | 2 6 | 8 71 | 77 |
| L ba | 12 | 105 2 | 14 9 | 25 6 | 2 9 | 9 5 | 1 2 | 5 | 4 | 4 42 | 70 |
| A ca | 14 | 122 2 | 11 2 | 52 6 | 3 2 | 8 5 | 7 | 1 | 1 | 7 36 | 1 10 |
| M mi | 12 | 142 1 | 12 4 | 43 2 | 4 5 | 9 7 | 2 9 | 2 | 1 | 6 75 | 86 |

Table 3 Mean time spent in home cage (home), by loco- exploratory activity (loco), grooming (groom) and freezing (freeze) Abbreviations are the same as in Tab 1

| | | Home | | Loco | | Groom | | Freeze | |
|---|---|---|---|---|---|---|---|---|---|
| Species | n | Mean | S E | Mean | S E | Mean | S E | Mean | S E |
| A ag | 36 | 132 4 | 15 0 | 194 3 | 11 7 | 31 9 | 8 1 | 1 4 | 1 4 |
| A ag ma | 4 | 120 0 | 57 6 | 226 3 | 51 3 | 13 8 | 12 1 | 0 | 0 |
| A pe | 16 | 100 6 | 21 4 | 258 1 | 16 5 | 1 3 | 6 6 | 0 | 0 |
| A fl | 16 | 70 0 | 22 3 | 249 4 | 18 9 | 37 5 | 12 0 | 3 1 | 2 0 |
| A sy | 68 | 47 6 | 8 2 | 275 1 | 7 7 | 35 9 | 4 4 | 1 3 | 8 |
| A mi | 14 | 67 9 | 17 4 | 268 9 | 15 6 | 23 1 | 6 6 | 0 | 0 |
| A my | 20 | 14 0 | 3 1 | 324 8 | 6 6 | 21 3 | 7 0 | 0 | 0 |
| M ma | 21 | 56 2 | 12 1 | 296 0 | 11 2 | 7 9 | 3 4 | 0 | 0 |
| M mu P | 23 | 12 8 | 6 4 | 335 2 | 7 3 | 12 0 | 4 2 | 0 | 0 |
| M mu R | 23 | 58 0 | 17 6 | 282 8 | 18 0 | 16 1 | 4 3 | 3 0 | 2 3 |
| M mu x do | 21 | 51 9 | 16 7 | 298 1 | 16 0 | 7 1 | 1 2 | 2 9 | 2 4 |
| M do | 34 | 59 7 | 9 7 | 296 2 | 9 5 | 4 1 | 1 2 | 0 | 0 |
| L ba | 12 | 43 8 | 17 2 | 282 5 | 15 6 | 33 8 | 7 0 | 0 | 0 |
| A ca | 14 | 25 6 | 5 9 | 320 4 | 8 4 | 7 6 | 2 8 | 6 4 | 6 4 |
| M mi | 12 | 36 3 | 5 5 | 319 6 | 6 2 | 2 5 | 1 3 | 1 7 | 1 1 |

mice were insignificant in most cases. Similar results were obtained in a comprehensive study conducted in wild caught Wood mouse (*Apodemus sylvaticus*) by Lodewijcx (1984 a,b). The level of the exploratory behaviour in females was stable throughout the year while in males it was higher during the spring-summer period, other effects of sex, sexual activity and partially also of age were not found. However, we can conclude that intraspecific differences seem to be generally smaller than the interspecific ones, the influence of sex, age, tameness and domestication cannot be simply ruled out. Variation due to these factors is often reported in laboratory rodents (Archer 1977, Heth et al. 1987, etc.).

Intraspecific variation in exploratory behaviour was found also in several studies, which were performed in order to describe changes in behavioural properties of wild populations of voles during the year or their population cycle (Krebs 1970, Jaskin 1980, Turner et al. 1983, Johnston & Gaines 1985, etc.). Interspecific comparisons. Exploratory behaviour depends upon details of testing procedure (illumination, construction of the field etc.). Therefore, we ought to keep in mind, that the results obtained by using different modifications of testing procedure are not fully comparable. Unfortunately, there are available only a few studies that provide data for comparisons of a number of species under identical conditions. All the studies used "forced exploration" techniques. As a part of a program designed to provide systematic comparative behavioural data (Evans et al. 1978, Sloane et al. 1978, Dewsbury et al. 1979, 1980, Baumgardner et al. 1980, Dewsbury 1980, Webster et al. 1981a,b, etc.), "open field" method was introduced by Wilson et al. (1976) as "an analytical tool for assessing species-typical behavioural tendencies in a relatively unstructured situation". They described open-field behaviour in 12 species of rodents and demonstrated obvious interspecific differences. They also found ecological correlates of this behaviour suggesting that open-field behaviour reflects ecological and selective pressures. "Field dwellers" exhibited generally less square entries, "desert dwellers" spent more time by rearing, while "arboreal" species showed the greatest amounts of jumping and loco-exploratory behaviour. These ecological correlates seem to be less clear in larger material, after the adding of other eight species into the comparison (Webster et al. 1979). Similar ecological correlates of open-field behaviour among Palaearctic voles and birch mice were obtained also by Vigorov (1980). It is to be noted here that marked differences in open-field behaviour were found even between sibling species as for example between *Microtus arvalis and M. rossiomeridionalis* (Malygin 1983). Similarly, chromosomal races (species) of *Spalax ehrenbergi* from humid areas displayed more exploratory activity (measured using free exploration technique), than races from dry areas (Heth et al 1987, Nevo 1991).

Frynta (1992) compared the behavioural patterns displayed by seven mice taxa (*Apodemus mystacinus, A. sylvaticus, A. flavicollis, A. microps, A. agrarius, Mus musculus, Mus* sp. from Azerbaidjan and hybrids *M. musculus* x *M. domesticus*) in the open field during 6-min. "forced exploration" tests. Two species, *Apodemus agrarirus* and *A. mystacinus*, showed different patterns of open-field behaviour if compared with other species under study. The former displayed low while the latter high values of square entries, rearing and time spent in activity. Almost the same behavioural patterns are visible from the results of free exploration tests described in the present study.

Our results suggest marked interspecific variation. This evidence may be interpreted on the basis of ecological strategies and adaptation of particular species. As genus *Apodemus* is concerned, both species, which displayed extreme position according to the first factor are specialized. *Apodemus agrarius* is a burrowing species. Its habitat is typically humid, rich and covered with a dense vegetation (Kratochvíl 1977, Böhme 1978). *Apodemus mystacinus* is a Mediterranean species inhabiting extremely dry and rocky habitats (Atallah 1978). Their strategy is obvious also from short vibrissae in *A. agrarius*, which are on the contrary very long in *A. mystacinus* (Kratochvíl 1968).

Within species of the genus *Mus*, the most important ecological distinction is an adaptation to commensalism or feral way of life. Fortunately, regardless to the scarcity of comparative studies using "free exploration" tests in non-domesticated rodents, there are some literary data comparing commensal and feral mice. Mound building mice (*Mus spicilegus*) tested in a large room spent more time inside nest boxes while House mice *M. musculus* displayed more movements along the walls of the field (Meškova et al. 1986). These differences are parallel to those found between *Mus macedonicus* and *Mus musculus*. *M. macedonicus*, a feral species which is closely related to M. hortulanus, jump and rear less frequently and spent more time inside boxes than commensal *M. musculus* when tested preferences for odour marks in a circular arena (Frynta et al. 1992). However, these differences between feral and commensal species of House mice (genus *Mus*) are less obvious in experiments performed in terraria of limited size (Meškova et al. 1986; this study). It is to be remarked here that an emotional reactivity as reflected by plasma corticosteron was found to be higher in feral populations of *M. domesticus* when compared with commensal populations of this species (Ganem 1991 a,b, Ganem et al. 1989). Generally, in agreement with their ecological needs, feral mice seem to be fairly more emotional and less exploratory than their commensal relatives.

It can be concluded that ecological strategy of particular species probably influenced their behaviour in the test. However, a larger sample of comparative data is needed for more precise comparison.

## REFERENCES


ABELEEN J. H. F. 1970: Genetics of rearing behaviour in mice. *Behav. Genet.* **1**: 71-76.

ARCHER J. 1973: Tests for emotionality in rats and mice. A review. *Anim. Behav.* **21**: 205-235.

ATALLAH S. I. 1978: *Mammals of eastern Mediterranean region, their ecology, systematics and zoogeographical relationships. Saugetierk. Mitt.* **26**: 1-50.

BAUMGARDNER D. J., WARD S. E. & DEWSBURY D. A. 1980: Diurnal patterning of eight activities in 14 species of muroid rodents. *Anim. Learn. Behav.* **8**: 322-330.

BIRKE L. A. & D'UDINE B. 1985: Exploratory behavior of two species of murid rodents, Acomys cahirinus and Mus musculus. A comparative study. *Behav. Neur. Biol.* **43**: 143-161.

BOHME W. 1978: Apodemus agrarius Pall., pp. 368-381. In: NIETHAMMER J. & F. KRAPP (eds.): Handbuch der Saugetiere Europas, Band I, Nagetiere 1, Wiesbaden: Verlagsgesellschaft, 476 pp.

DE FRIES J. C., GERVAIS M. C. & THOMAS E. A. 1978: Response to 30 generations of selection for open field activity in laboratory mice. *Behav. Genet.* **8**: 3-13.

DEWSBURY D. A. 1980: Wheel running behavior in 12 species of muroid rodents. *Behav. Processes* **5**: 271-280.

DEWSBURY D. A., LANIER D. L. & MIGLIETTA A. 1978: A laboratory study of climbing behaviour in 11 species of muroid rodents. *Amer. Midl. Nat.* **103**: 66-72.

DOJČEV R. L. 1983: *Exploratory and nonagonistic elements of* Yellow-necked field mouse (Apodemus flavicollis Melch.), Common field mouse (Apodemus sylvaticus L.) and Bank vole (Clethrionomys glareolus Schr.). *God. Sof. Univ. (Biol. Fak.)* **73**: 88-99 (in Bulgarian with a summary in English).

DOJČEV R. L. & MOLLE E. D. 1983: *Searching Activity and Emotional Behaviour of Rodents in the 'Open Field' test.* II. The Common Field Mouse (Apodemus sylvaticus L.). *Ekologija (Sofia)* **12**: 48-53 (in Bulgarian with a summary in English).

DOJČEV R. L. & MOLLE E. D. 1985: Searching Activity and Emotional Behaviour of Rodents in the 'Open Field' test. III. Preliminary ranking differences of the Common field mouse (Apodemus sylvaticus L.). *Ekologija (Sofia)* **15**: 66-72 (in Bulgarian with a summary in English).

DOJČEV R. L., MOLLE E. D. & ATANASOV N. I. 1983: Searching Activity and Emotional Behaviour of Rodents in the 'Open Field' test. I. The Yellow Necked Mouse (Apodemus flavicollis Melch.). *Ekologija (Sofia)* 11: 67-74 (in Bulgarian with a summary in English).

EVANS R. L., KATZ E. M., OLSON N. L. & DEWSBURY D. A. 1978: A comparative study of swimming behavior in eight species of muroid rodents. *Bull. Psychon. Soc.* **11**(3): 168-170.

FRYNTA D. 1992: 'Open field" behaviour in seven mice species (Muridae: Apodemus, Mus), pp. 31-38. In: I. HORAČEK & V. VOHRALIK (eds.): Prague Studies in Mammalogy. Prague: Karolinum - Charles Univ. Press, 245 pp.

FRYNTA D., EXNEROVÁ A., ČIHÁKOVÁ J., KOZLOVÁ P. & ZELINKOVÁ L. 1992: Species discrimination based on olfaction in males of two related mouse species: Mus abbotti and Mus musculus, pp: 49-56. In: I. HORÁČEK & V. VOHRALÍK (eds.): Prague Studies in Mammalogy. Prague: Karolinum - Charles University Press, 245 pp.
GANEM G. 1991a: Commensalisme, fonction corticosurrenalienne et evolution chromosomique chez la souris domestique. Univ. Montpellier II. Ph.D. Thesis, 235 pp.
GANEM G. 1991b: A comparative study of different populations of Mus musculus domesticus: Emotivity as an index of adaptation to commensalism. *Comp. Biochem. Physiol.* ser A **99**: 531-536.
GANEM G., BOISSIN J. & CROSET H. 1989: Étude de la réponse corticosurénalienne a un stress, en relation avec la différentiation chromosomique chez la souris domestique. *C. R. Acad. Sci.* Paris **309**: 735-740.
GARTEN C. T. 1977: Relationships between exploratory behaviour and genetic heterozygosity in the oldfield mouse. *Anim. Behav.* **25**: 328-332.
JASKIN V. A. 1980: Sezonnyje izmenĕnija dvigatĕl'noj aktivnosti ryžich polevok v otkrytom pole [Seasonal changes in locomotor-exploratory activity of Bank voles in the open-field], pp: 92-95. In: Ekologičeskije aspekty povedenija životnych. Sverdlovsk, 110 pp (in Russian).
JOHNSON M. L. & GAINES M. S. 1985: Selective basis for emigration of the prairie vole, Microtus ochrogaster: Open field experiment. *J. Anim. Ecol.* **54**: 399-410.
KRATOCHVÍL J. 1968: Das Vibrisenfeld der europäischen Arten der Gattung Apodemus (Kaup, 1829). *Zool. Listy* **17**: 193-209.
KRATOCHVÍL J. 1977: Die Faktoren, die die Schwankungen der Westgränze des Verbreitungsareals von Apodemus agrarius (Mamm.: Muridae) bedingen. *Věst. Čs. Spol. Zool.* **41**: 253-265.
KREBS C. J. 1970: Microtus population biology: behavioral changes associated with the population cycle in M. ochrogaster and M. pennsylvanicus. *Ecology* **51**: 34-52.
LODEWIJCKX E. 1984a: Seasonal fluctuation in the exploratory behaviour of wild wood mice. *Acta Theriol.* **29**: 273-282.
LODEWIJCKX E. 1984b: The influence of sex, sexual condition on the exploratory behaviour of wild wood mice (Apodemus sylvaticus L.). *Behav. Process.* **9**: 431-444.
LORENZ K. 1974: Vrozené základy chování [Inherited basis of behaviour], pp: 21-100. In: PRIBRAM K.H. (ed.): O biologii učení [The biology of learning]. Praha: Academia (in Czech).
MALYGIN V. M. 1983: Sistematika obyknovennych polevok. [Taxonomy of field voles.]. Moskva: Nauka, 207 pp (in Russian).
MEŠKOVA N. N., KOTENKOVA E. V. & LJALJUCHINA S. I. 1986: Povedenije domovoj (Mus musculus) i kurgančikovoj (Mus hortulanus) myšej pri osvojenii novogo prostranstva. [Behaviour of house mouse and mound-building mouse in the new environment] *Zool. Žurn.* **65**: 123-133 (in Russian with a summary in English).
NEVO E. 1991: Evolutionary theory and processes of active speciation and adaptive radiation in subterranean mole rats, Spalax ehrembergi superspecies, in Israel. *Evol. Biol.* **25**: 1-125.
SCHÄFER M. W. 1982: Analyse des Explorationverhaltens verschiedener Sämme und Generationen der Hausmaus (Mus musculus domesticus, Rutty). II. Vergleichende Betrachtungen der Parental und Filialgenerationen. *Z. Säugetierk.* **47**: 220-230.
SLOANE S. A., SHEA S. L., PROCTER M. M., DEWSBURY D. A. 1978: Visual cliff performance in 10 species of muroid rodents. *Anim. Learn. Behav.* **6**: 244-248.
TURNER B. N. & IVERSON S. L. & SEVERSON K. L. 1983: Seasonal changes in open field behavior in wild male meadow voles (Microtus pennsylvanicus). *Behav. Neural. Biol.* **39**: 60-67.
VADÁCZ C., KOBOR G. & LAJTHA A. 1983: Genetic dissection of a mammalian behaviour pattern. *Anim. Behav.* **31**: 265-270.
VIGOROV J. L. 1980: O vidovich i ekologičeskich različijach orientirovočno-issledovatělskogo povedenija serii form melkich gryzunov, pp: 61-81. In: Ekologičeskije aspekty povedenija životnych. Sverdlovsk, 110 pp.
WEBSTER D. G., LANTHORN T. H., DEWSBURY D. A. & MYER M. E. 1981: Tonic immobility and the dorsal immobility response in twelve species of Muroid rodents. *Behav. Neural. Biol.* **31**: 32-41.
WEBSTER D. G., WILLIAMS M. H., OWENS R. D., GEIGER V. B. & DEWSBURY D. A. 1981: Digging behavior in 12 taxa of muroid rodents. *Anim. Learn. Behav.* **9**: 173-177.
WILSON R. C., VACEK T., LANIER D. L. & DEWSBURY D. A. 1976: Open field behavior in muroid rodents. *Behav. Biol.* **17**: 495-506.

*Acta Soc. Zool. Bohem.* **57**: 183-192, 1993(1994)
ISSN 0862-5247

# Sex ratio in *Apodemus sylvaticus* (Rodentia: Muridae): A comparison of field and laboratory data

Daniel FRYNTA & Marcela ŽIŽKOVÁ

Department of Zoology, Charles University,
Viničná 7, CZ-128 44 Praha 2, Czech Republic

*Received September 24, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Sex ratio, synurbization, *Apodemus sylvaticus***

**Abstract.** The overall sex ratio based on material of 3455 specimens of *Apodemus sylvaticus* snap trapped in 65 localities in the city of Prague was slightly but significantly male biased. The percentage of males was 52.7% in total catch. It was found a considerable variation in sex ratio during the year. The percentage of males was slightly higher during the reproductive season than in autumnal and winter months. The highest proportion of males was recorded at the beginning of breeding season in March (68%, n=79). For the evaluation of juvenile sex ratio we used data from 834 individuals of known sex born in the laboratory. Their total sex ratio was fairly balanced (48.3%) and remained not substantially changed by mortality during adulthood. The effects of mother age, weight and parity on juvenile sex ratio were insignificant. Female biased sex ratio (35%, n=48) found in litters consisting of one or two juveniles most probably can be attributed to mortality in embryos and/or juveniles.

## INTRODUCTION

The sex ratio and its variation during the year belongs to the most important population parameters in small rodents (Bol'šakov & Kubancev 1984). The major aim of this study is to compare data on sex ratio in the Wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758) obtained by snap-trapping in the field with juvenile and adult sex ratios in the laboratory colony. In addition, sex ratio in progeny constitutes an important component of female fitness (cf. Trivers & Willard 1973, Maynard Smith 1980, Schaik & Hrdy 1991, Clutton-Brock 1991, etc.), and therefore, data on sex ratio in individual species may be helpful in testing of predictions of sex ratio theory.

## MATERIAL AND METHODS

The Wood mouse is one of the most widespread rodents in Europe. It seems to be most generalistic species of the subgenus *Sylvaemus*, which is, apparently, an ecological equivalent of North American genus *Peromyscus* (Montgomery 1989b).

### Data from the field

Our material of the Wood mouse was collected in the 65 localities distributed on the territory of the city of Prague (Central Bohemia). Wood mice were captured mostly in snap-traps (10 x 5 cm) of the common type, only small, unimportant proportion was catched in wooden live traps. According to the urbanization gradient, the localities could be sorted into three categories: 1) Parks or cemeteries in the center of the city completely surrounded by built-up areas; 2) Parks, gardens or other man-made green habitats, ruderal sites, etc. on the periphery of the city not completely surrounded by built-up areas; 3) Woods or other seminatural habitats on the outskirts of Prague. After capture, all specimens were dissected and their sex was recorded. For details of methods, localities and population parameters see Frynta et al. (in print), Frynta (1992, 1993), Frynta & Vohralík (1992, in print).

Altogether, 3455 specimens of the Wood mouse captured in the period 1969-1990 were treated, of which 975, 1507, and 973 were collected in the localities of the first, second and third category, respectively.

**Data from the laboratory**

The laboratory colony of *Apodemus sylvaticus* was established from mice captured at several localities in Central Bohemia (mainly in Prague) during the autumn 1987. Groups of captive animals, consisting of one or two pairs and their offsprings, were housed in glass terraria sized from 40 x 30 x 30 cm to 100 x 60 x 40 cm or in standard plastic cages 38 x 22 x 22 cm. Cages were placed in a light controlled room in a long photoperiod (16L : 8D). Ad libitum water in water bottles and food (DOS2B mouse and rat breeder diet) were provided. Each cage contained sawdust, nesting material (hay) and shelters. All the animals were individually marked and their growth and life history was recorded (Žižková 1991, Frynta & Žižková 1992). Therefore, data on parity, body weight and age of each breeding female were available. It is to be noted here that the age was precisely known only for laboratory born females. Wild born females were captured as subadults in autumn. According to our knowledge of reproduction and age structure in Wood mice populations, they were born most probably during the late summer period. Therefore, they were arbitrarily considered to be born in August.

Juvenile Wood mice used in our analysis were of the first-, second- or third- laboratory animals generation. Their sex was identified at various age till weaning during regular inspection of the nests. Altogether, we collected data on the sex in 834 juveniles.

In order to describe sex ratio variation in different age categories of subadult and adult animals, we used data about sex in all animals which survived in our laboratory up to the given age varying within the range from 1 to 16 months. Unfortunately, sex ratios obtained by using this procedure (in the case of laboratory born animals) are affected not only by natural, but also by artificial mortality (e.g. escaped animals or animals used in other experiments, etc.). Therefore, we also computed sex ratios based on life tables from which an artificial mortality was completely subtracted.

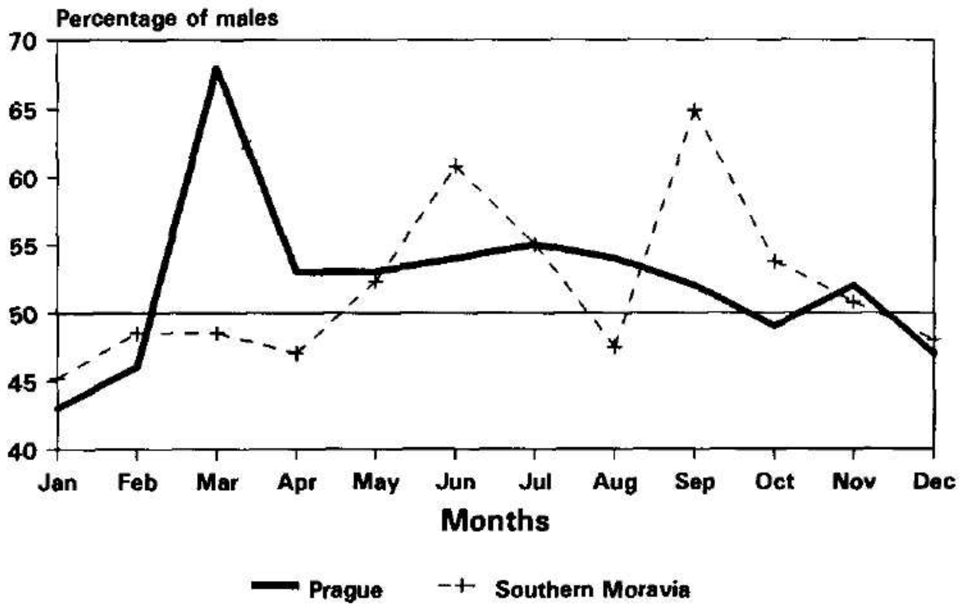



Fig. 1. Variation in the sex ratio during the year. Prague - present study; Southern Moravia - Pelikán 1970.

## RESULTS

*The overall sex ratio in the material captured in Prague was slightly, but significantly male* biased (52.7%, n=3455, $\chi^2$=9.90, P<0.01). A considerable variation of the sex ratio during the year was found (Tab.1, Fig.1). The highest proportion of males was found in March (68%, n=79, $\chi^2$ = 10.6, P<0.01), i.e., at the beginning of reproductive season in this species. Male biased sex ratio occurred throughout the period of intensive reproduction till September and also in November. It was statistically significant for the total material collected during the spring (March-May: 54.6%, n=489, $\chi^2$=6.18, P<0.05) and the summer (June-August: 54.4%, n=1127, $\chi^2$=9.05, P<0.01), but not for the autumn sample (September-November: 51.2%, n=1722, $\chi^2$=0.92). Within the material collected during the winter months, a slight, but an insignificant predominance of females was found (December-February: 45.7%, n=127, $\chi^2$=0.95). No clear trends in sex ratio were found after subdivision of the material according to the degree of urbanization (Tab.2).

The total sex ratio in juveniles born in laboratory was 48.3% (n=834, $\chi^2$=0.94) and remained not substantially changed by mortality during adulthood (Tab.3). After subdivision of the material according to mother age, weight and parity, slightly lower proportions of males were found in primiparous females (45.4%, n=307), in females lighter than 26 grams (45.3%, n=300) as well as in females up to 6 months old (44.3%, n=158). However, these differences were not significant in any case (Tab.4). Testing sex ratio by litter size (Tab.5) revealed an insignificant effect of this factor ($\chi^2$=8.6, d.f.=5). The highest proportion of males was found in the most

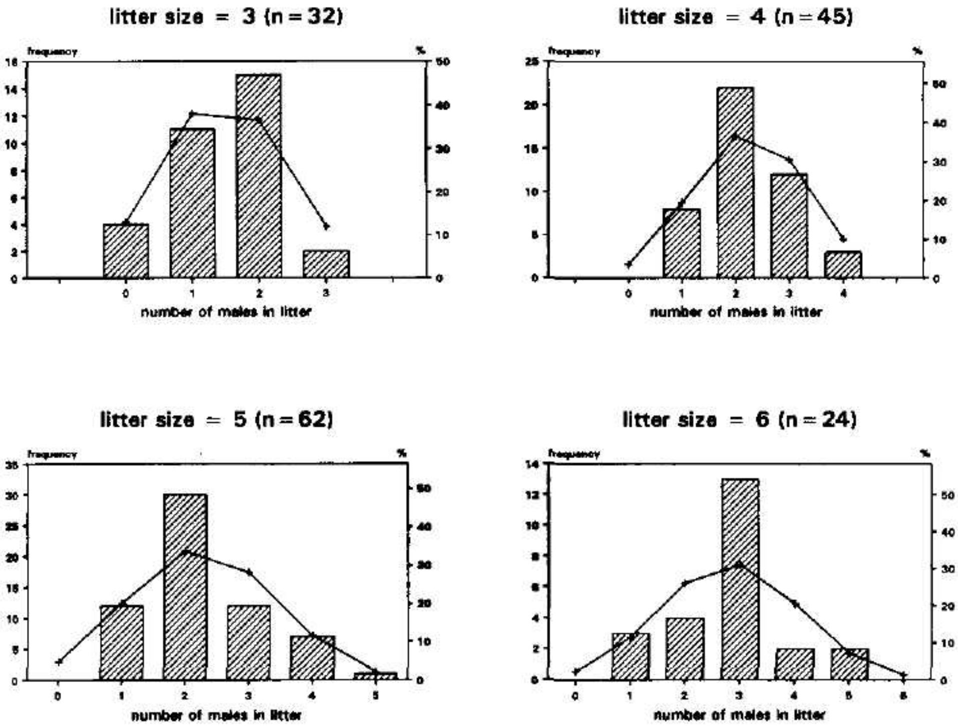



Fig. 2. Distribution of combination of sexes within litters. Lines indicate theoretical predictions based on binomial distribution.

Table 1. Variation in the sex ratio in *Apodemus sylvaticus* during the year. The material snap trapped in the territory of Prague. % - percentage of males (values based on the material less than 50 specimens are given in parentheses)

| Month | n | Males | Females | % | $\chi^2$ | |
|---|---|---|---|---|---|---|
| January | 46 | 20 | 26 | (43) | .78 | n.s. |
| February | 28 | 13 | 15 | (46) | .14 | n.s. |
| March | 79 | 54 | 25 | 68 | 10.64 | P<0.01 |
| April | 129 | 69 | 60 | 53 | .62 | n.s. |
| May | 271 | 144 | 127 | 53 | 1.06 | n.s. |
| June | 289 | 157 | 132 | 54 | 2.16 | n.s. |
| July | 297 | 164 | 133 | 55 | 3.23 | n.s. |
| August | 541 | 293 | 248 | 54 | 3.74 | n.s. |
| September | 569 | 297 | 272 | 52 | 1.09 | n.s. |
| October | 369 | 180 | 189 | 49 | .22 | n.s. |
| November | 784 | 404 | 380 | 52 | .73 | n.s. |
| December | 53 | 25 | 28 | 47 | .16 | n.s. |
| March-May | 489 | 267 | 212 | 54.6 | 6.18 | P<0.05 |
| June-Aug. | 1127 | 614 | 513 | 54.4 | 9.05 | P<0.01 |
| Sept.-Nov. | 1722 | 881 | 841 | 51.2 | .92 | n.s. |
| Dec.-Feb. | 127 | 58 | 69 | 45.7 | .95 | n.s. |
| Total | 3455 | 1820 | 1635 | 52.7 | 9.90 | P<0.01 |

Table 2. Sex ratio in the material of *Apodemus sylvaticus* snap trapped in the territory of Prague divided according to the degree of urbanization. M - males, F - females, % - percentage of males (values based on the material less than 50 specimens are given in parentheses)

| | central parks | | | | peripheral parks | | | | woods | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | n | M | F | % | n | M | F | % | n | M | F | % |
| January | 9 | 3 | 6 | (33) | 24 | 13 | 11 | (54) | 13 | 4 | 9 | 31 |
| February | 4 | 2 | 2 | (50) | 19 | 8 | 11 | (42) | 5 | 3 | 2 | 60 |
| March | 6 | 3 | 3 | (50) | 49 | 36 | 13 | (73) | 24 | 15 | 9 | (63) |
| April | 50 | 29 | 21 | 58 | 56 | 25 | 31 | 45 | 23 | 15 | 8 | (65) |
| May | 62 | 31 | 31 | 50 | 100 | 55 | 45 | 55 | 109 | 58 | 51 | 53 |
| June | 214 | 119 | 95 | 56 | 49 | 26 | 23 | (53) | 26 | 12 | 14 | (46) |
| July | 41 | 19 | 22 | (46) | 196 | 112 | 84 | 57 | 60 | 33 | 27 | 55 |
| August | 179 | 89 | 90 | 50 | 290 | 164 | 126 | 57 | 72 | 40 | 32 | 56 |
| September | 91 | 56 | 35 | 62 | 315 | 159 | 156 | 50 | 163 | 82 | 81 | 50 |
| October | 41 | 20 | 21 | (49) | 208 | 103 | 105 | 50 | 120 | 57 | 63 | 48 |
| November | 278 | 150 | 128 | 54 | 194 | 105 | 89 | 54 | 312 | 149 | 163 | 48 |
| December | - | - | - | - | 7 | 0 | 7 | (0) | 46 | 25 | 21 | 54 |
| Spring | 118 | 63 | 55 | 53.4 | 205 | 116 | 89 | 56.6 | 156 | 88 | 68 | 56.4 |
| Summer | 434 | 227 | 207 | 52.3 | 535 | 302 | 233 | 56.4 | 158 | 85 | 73 | 53.8 |
| Autumn | 410 | 226 | 184 | 55.1 | 717 | 367 | 350 | 51.2 | 595 | 288 | 307 | 48.4 |
| Winter | 13 | 5 | 8 | (38.5) | 50 | 21 | 29 | 42.0 | 64 | 32 | 32 | 50.0 |
| Total | 975 | 521 | 454 | 53.4 | 1507 | 806 | 701 | 53.5 | 973 | 493 | 480 | 50.7 |

Table 3. Sex ratio in the laboratory colony of *Apodemus sylvaticus* and its variation according to the age of animals. Values computed on the basis of life tables in which artificial mortality was excluded are given in parentheses. % – percentage of males

| age | animals born in laboratory | | | wild born | | |
|---|---|---|---|---|---|---|
| [months] | n | males | % | n | males | % |
| 1 | 615 | 305 | 49.6 (50.3) | - | - | - |
| 2 | 513 | 254 | 49.5 (50.0) | - | - | - |
| 3 | 416 | 212 | 51.0 (49.3) | - | - | - |
| 4 | 329 | 166 | 50.5 (49.3) | - | - | - |
| 5 | 272 | 137 | 50.4 (50.4) | - | - | - |
| 6 | 222 | 114 | 51.4 (50.4) | 80 | 45 | 56.3 |
| 7 | 164 | 79 | 48.2 (49.1) | 79 | 44 | 55.7 |
| 8 | 122 | 60 | 49.2 (49.5) | 79 | 44 | 55.7 |
| 9 | 92 | 49 | 53.3 (50.5) | 78 | 43 | 55.1 |
| 10 | 83 | 46 | 55.4 (47.8) | 71 | 40 | 56.3 |
| 11 | 70 | 37 | 52.9 (46.3) | 69 | 39 | 56.5 |
| 12 | 59 | 29 | 49.2 (45.6) | 69 | 39 | 56.5 |
| 13 | 51 | 25 | 49.0 (41.9) | 66 | 38 | 57.6 |
| 14 | 44 | 21 | 47.7 (44.8) | 65 | 37 | 56.9 |
| 15 | 28 | 13 | 46.4 (43.8) | 58 | 31 | 53.4 |
| 16 | 12 | 7 | 58.3 (43.8) | 44 | 24 | 54.5 |

Table 4. Sex ratio variation in relation to maternal age, body weight and parity, in juvenile laboratory born *Apodemus sylvaticus*. % – percentage of males

| | n | males | females | % |
|---|---|---|---|---|
| age of female: | | | | |
| 2 - 6 months | 158 | 70 | 88 | 44.3 |
| 7 - 9 months | 249 | 123 | 126 | 49.4 |
| 10 - 12 months | 268 | 125 | 143 | 46.6 |
| 13 - 18 months | 159 | 85 | 74 | 53.5 |
| ($\chi^2$=3.10, d.f.= 3, n.s) | | | | |
| body weight of female: | | | | |
| 14 g - 25 g | 300 | 136 | 164 | 45.3 |
| 26 g - 30 g | 352 | 176 | 176 | 50.0 |
| 31 g - 40 g | 182 | 91 | 91 | 50.0 |
| ($\chi^2$= 1.67, d.f.= 2, n.s.) | | | | |
| parity: | | | | |
| the first litter | 307 | 137 | 165 | 45.4 |
| the seoond litter | 262 | 132 | 130 | 50.4 |
| the third litter | 162 | 87 | 75 | 53.7 |
| more than third litter | 108 | 47 | 61 | 43.5 |
| ($\chi^2$= 4.45, d.f.= 3, n.s.) | | | | |
| total sex ratio | 834 | 403 | 431 | 48.3 |
| ($\chi^2$= 0.94, d.f.= 1, n.s.) | | | | |

Table 5. Sex ratio in juvenile laboratory born *Apodemus sylvaticus* according to the litter size. % – percentage of males

| Litter size | n | males | females | % | $\chi^2$ | |
|---|---|---|---|---|---|---|
| 1 or 2 | 48 | 17 | 31 | 35.4 | 4.08 | P<0.05 |
| 3 | 96 | 47 | 49 | 49.0 | 0.04 | n.s. |
| 4 | 180 | 100 | 80 | 55.6 | 2.22 | n.s. |
| 5 | 310 | 141 | 169 | 45.5 | 2.52 | n.s. |
| 6 | 144 | 68 | 76 | 47.2 | 0.44 | n.s. |
| 7 | 56 | 30 | 26 | 53.6 | 0.28 | n.s. |
| ($\chi^2$ = 8.60, d.f.=5, n.s.) | | | | | | |

Table 6. Sex ratio distribution within litters in laboratory colony of *Apodemus sylvaticus*

| Litter size | No. of litters | males : females | frequency |
|---|---|---|---|
| 1 | 8 | 1 : 0 | 4 |
| | | 0 : 1 | 4 |
| 2 | 20 | 2 : 0 | 3 |
| | | 1 : 1 | 7 |
| | | 0 : 2 | 10 |
| 3 | 32 | 3 : 0 | 2 |
| | | 2 : 1 | 15 |
| | | 1 : 2 | 11 |
| | | 0 : 3 | 4 |
| 4 | 45 | 4 : 0 | 3 |
| | | 3 : 1 | 12 |
| | | 2 : 2 | 22 |
| | | 1 : 3 | 8 |
| | | 0 : 4 | 0 |
| 5 | 62 | 5 : 0 | 1 |
| | | 4 : 1 | 7 |
| | | 3 : 2 | 12 |
| | | 2 : 3 | 30 |
| | | 1 : 4 | 12 |
| | | 0 : 5 | 0 |
| 6 | 24 | 6 : 0 | 0 |
| | | 5 : 1 | 2 |
| | | 4 : 2 | 2 |
| | | 3 : 3 | 13 |
| | | 2 : 4 | 4 |
| | | 1 : 5 | 3 |
| | | 0 : 6 | 0 |
| 7 | 8 | 6 : 1 | 1 |
| | | 5 : 2 | 3 |
| | | 3 : 4 | 1 |
| | | 2 : 5 | 3 |

Table 7. Sex ratio in samples of *Apodemus sylvaticus* collected in various parts of its distribution area, as reported in the literature.

| Population | n | male % | source |
|---|---|---|---|
| Iberian Peninsula: | | | |
| Montseny, N.E. Spain | 406 | 55.9 | Sans-Coma & Gosalbez (1976) |
| Pyrenees, N.E. Spain | 341 | 56.3 | Sans-Coma & Gosalbez (1976) |
| France: | | | |
| Department Loire, France | 1051 | 58.5 | Saint-Girons (1966) |
| Great Britain and Ireland: | | | |
| Hertsfordshire, England | 1459 | 55.7 | Baker (1930) |
| Wytham Woods, Oxford, England | 906 | 51.2 | Miller (1958), Kikawa (1964) |
| Woodchester Park, England | 1072 | 57.1 | Montgomery (1980) |
| Northern Ireland | 4425 | 57.9 | Montgomery (1989) |
| Skomer Island | 1047 | 58.7 | Jewell (1966) |
| Germany: | | | |
| Berlin, surroundings | 1018 | 56.3 | Stein (1953) |
| Schleswig-Holstein | 625 | 55.4 | Jüdes (1979) |
| Central Europe: | | | |
| Most region, Northern Bohemia | 855 | 49.5 | Bejček (1979) |
| Western Bohemia | 1837 | 54.5 | Hůrka & Němec (1985) |
| Tábor region, Southern Bohemia | 594 | 53.4 | Zbytovský (1989) |
| Prague, Central Bohemia | 3455 | 52.7 | present paper |
| Southern Moravia | 1742 | 52.0 | Pelikán (1970) |
| Stockerau, N.E. Austria | 223 | 57.9 | Steiner (1968) |
| Balkan Peninsula: | | | |
| Rozovata dolina, Bulgaria | 591 | 53.5 | Christov (1974) |
| Bulgaria | 1080 | 54.9 | Straka (1965) |

frequent litter size, i.e., in the litters consisting of 4 individuals (55.6%, n=180). On the other hand, significantly female biased sex ratio was found in the litters consisting of one or two juveniles (35.4%, n=48, $\chi^2$=4.08, P<0.01).

Sex ratio distributions within litters (Tab.6) were compared with expected binomial distribution. A slight tendency to lower variance is obvious from Fig.2. Also chi-square test revealed a significant deviation from binomial distribution in litters consisting of five ($\chi^2$=6.52, n=62, d.f.=2, P=0.038) and six ($\chi^2$=6.15, n=24, d.f.=1, P=0.013) animals. No significant differences were found for litters consisting of four juveniles ($\chi^2$=2.97, n=45, d.f.=1, P=0.084).

## DISCUSSION

As evident from Tab.7, in which survey of literary data is given, a slight predominance of males within samples captured in live or snap traps is a common phenomenon in *Apodemus sylvaticus*. Sex ratios obtained by using these methods are usually biased towards the males also in other *Apodemus* species (Pelikán 1970, Montgomery 1989b). Of course, we have to keep in mind that the seasonal and may be even the annual variation can affect the total values of sex ratio. We found a significant predominance of males in spring and summer periods, i.e., during an intensive breeding season, but not in autumn and winter. This phenomenon may be attributed to seasonal changes in probability of capture associated with breeding. Males have larger home ranges (cf. Montgomery 1989b) and a more intensive exploratory activity (Lodewijckx 1984) during breeding period. On the other hand, it is to be mentioned here, that no clear effect of breeding on sex ratio was reported by Pelikán (1970) in a South Moravian population (Fig.1).

By comparing sex ratio in trappable part of wild population with sex ratio in a laboratory colony of Wood mice, we can assume, that there is a general accordance between these data Both juvenile sex ratio in our material from laboratory conditions and autumnal and winter sex ratios obtained in the field are not significantly deviated from ratio 1 : 1 The same can be concluded also for subadult and adult sex ratios in our laboratory colony However, evaluating these data, we ought to keep in mind a limited number of individuals survived to old age, and therefore, much lower precision of sex ratio estimation in upper age categories

The effects of maternal age, weight, parity and litter size on juvenile sex ratio were repeatedly studied in mammals, but the results of such studies which sometimes contradict each other (Mlíkovsky 1985, 1988, Verme 1983, Gray & Katanbaf 1985, Rawlings & Kessler 1986, Small & Hrdy 1986, etc ) Above mentioned factors showed only an insignificant influence in sex ratios in our material However, on the other hand, the tendency for lower proportion of females in litters produced by younger, smaller and/or primiparous mothers than in older, heavier and/or multiparous ones is in accordance with the sex ratio manipulation theory, predicting that females under good conditions bias investment towards offspring of the sex that most likely benefit from the mother's advantaged situation (i e , towards the males in this case) and vice versa Similarly, we found the highest proportion of males in the litters of medium size, i e , in the litters in which the best rearing conditions are expected

Unfortunately, having no data on sex ratio at the time of birth, we cannot distinguish between the accordance with Trivers & Willard (1973) hypothesis concerning secondary sex ratio and between sex ratio changes due to sex-biased natural mortality or manipulation after birth as expected by Maynard Smith (1980) The frequency of embryonic sets consisting of less than three embryos is extremely low, mostly not exceeding 1% in natural populations of *Apodemus sylvaticus* (Frynta & Vohralík 1993) Therefore, the presence of 28 (i e , 14%) litters of that size in our data from laboratory is most probably a result of natural mortality (embryonic resorption, juvenile mortality) or possible manipulation (infanticide in utero or after birth) Female biased sex ratio in these litters is apparent Similar processes resulting in female bias in small litters produced under stress conditions were described also in other rodents Coypu (Gosling 1986), Wood rat (McClure 1981), etc In contradiction, the results obtained in nutritionally stressed House mice by Cramer (1988) did not show a selective mortality of males

The expected statistical distribution of the sex ratio within litters is binomial one This distribution fits with data of some empirical studies (cf Mlíkovsky 1985) Our results showed a slight tendency towards less variance than that predicted by binomial distribution It is to be mentioned here, that a similar tendency to subnormal dispersion in the distribution of combination of sexes was reported in several studies about pigs, rabbits, mice (cf James 1975) and golden hamsters (Huck et al 1990) However, in the case of the Wood mouse more data are needful for the evaluation of this problem

## REFERENCES


AUSTAD S N & SUNQUIST M E 1986 Sex ratio manipulation in the Common opossum *Nature* **324** 58 60

BAKER J R 1930 The breeding season in the British wild mice *Proc Zool Soc Lond* **1930** 113 127

BEJČEK V 1979 Notes on population dynamics of the Common vole, Microtus arvalis (Pall , 1778) and the Wood mouse (L , 1758), on spoil banks after surface mining of lignite in the Most basin (north western Bohemia) *Lynx* (n s ) **20** 3 24 (in Czech with a summary in English)

BOL'ŠAKOV V N & KUBANCEV B S 1984 Polovaja struktura populjacij mlekopitajuščich i ejo dinamika [Sex structuare in mammalian populations and its dynamics], Moskva Nauka, 233 pp (in Russian)

CHRISTOV L 1974 Insektenfressende Saugern und Nagetiere in dem Rosental Bulgarien *Izv Zool Inst Mus* (Sofia) **39** 29 60

CLUTTON - BROCK T N 1991 The evolution of parental care Princeton Princeton Univ Press, 352 pp

CRAMER K L 1988 Constant sex ratio of progeny in nutritionally stressed wild house mice *Southwest Natur*

33. 255-261.
FRYNTA D. 1992: Reproduction in the Wood mouse (Apodemus sylvaticus) in urban habitats of Prague: I. Males. pp: 39-47. In: HORÁČEK I. & VOHRALÍK V. (eds.): Prague Studies in Mammalogy, Prague: Charles University Press, 245 pp
FRYNTA D. 1993: Body weight structure in the Wood mouse (Apodemus sylvaticus) population in urban habitats of Prague. *Acta Soc. Zool. Bohem.* **57**:91-100.
FRYNTA D. & VOHRALÍK V. 1992: Reproduction in the Wood mouse (Apodemus sylvaticus) in urban habitats of Prague: II. Litter size. *Acta Univ. Carolinae - Biol.* **36**: 325-340.
FRYNTA D. & VOHRALÍK V. (in print): Reproduction in the Wood mouse (Apodemus sylvaticus) in urban habitats of Prague: III. Intensity of reproduction in females. *Acta Soc. Zool. Bohem.*
FRYNTA D., VOHRALÍK V. & ŘEZNÍČEK J. (in print): The distribution of small mammals (Insectivora, Rodentia) in Prague. *Acta Univ. Carolinae - Biol.*
FRYNTA D. & ŽIŽKOVÁ M. 1992: Postnatal growth of Wood mouse (Apodemus sylvaticus) in captivity. pp: 57-69. In. HORÁČEK I. & VOHRALÍK V. (eds.): Prague Studies in Mammalogy. Prague: Charles University Press, 245 pp
GOSLING L. M. 1986: Selective abortions of entire litters in the Coypu: Adaptive control of offspring production in relation to quality and sex. *Amer Natur.* **127**: 772-795.
GRAY E. & KATANBAF M. N. 1985: Sex ratio and distribution of sexes in swine. *J. Heredity* **76**: 36-38.
HUCK U. W., SEGER J. & LISK R. D. 1990: Litter sex ratios in the golden hamster vary with time of mating and litter size and are not binomially distributed. *Behav Ecol. Sociobiol.* **26**: 99-109.
HŮRKA L. & NĚMEC F. 1985: Populationsanalyse der Art Apodemus sylvaticus (Mammalia: Muridae) aus dem Gebiet des Westlichen Teiles der Tschechoslowakei mit Bemerkungen uber ihre Siphonapterofauna. *Folia Mus. Rer. Natur. Bohem. Occid. Zoologica* (Plzeň) **20**: 1-34.
JAMES W. H. 1975: The distribution of the combination of the sexes in mammalian litters. *Genet. Res.* Camb. **26**: 45-53.
JEWELL P. A. 1966: Breeding season and recruitment in some British mammals confined on small islands. *Symp. Zool. Soc Lond.* **15**: 89-116.
JUDES U. 1979: Untersuchungen zur Okologie der Waldmaus (Apodemus sylvaticus Linné, 1758) und der Gelbhalsmaus (Apodemus flavicollis Melchior, 1834) im Raum Kiel (Schleswig-Holstein). I. Populationsdichte, Gewichtsveranderungen, Fortpflantzungs- Jahreszyklus, populationsbiologische Parameter. *Z. Saugetierk.* **44**: 81-95
KIKKAWA J. 1964 Movement, activity and distribution of the small rodents Cl.glareolus and A.sylvaticus in woodland *J. Anim. Ecol.* **33** 259-299.
LODEWIJCKX E. 1984: Seasonal fluctuations in the exploratory behaviour and in the activity of wild wood mice. *Acta Theriol.* **29**: 273-282.
MAYNARD SMITH J. 1980 A new theory of sexual investment. *Behav. Ecol. Sociobiol.* **7**: 247-251
MC CLURE P. A. 1981: Sex-biased litter reduction in food-restricted wood rats (Neotoma floridana). *Science* **211**: 1058-1060.
MILLER R S. 1958: A study of a Wood mouse population in Wytham woods, Berkshire. *J. Mammal.* **39**: 477-493.
MLÍKOVSKÝ J. 1985: Sex ratio distribution in the Siberian tiger Panthera tigris altaica (Mammalia: Felidae). *Z. Saugetierk.* **50**: 47-51.
MLÍKOVSKÝ J 1988: Secondary sex ratio in the Przewalski horse Equus przewalskii (Mammalia: Equidae). *Z Saugetierk.* **53**: 92-101.
MONTGOMERY W. I. 1980: Population structure and dynamics of sympatric Apodemus species (Rodentia: Muridae). *J. Zool. Lond.* **192**: 351-377.
MONTGOMERY W. I. 1989a: Population regulation in the wood mouse, Apodemus sylvaticus. II. Density dependence in spatial distribution and reproduction. *J. Anim. Ecol.* **58**: 477-494.
MONTGOMERY W. I 1989b: *Peromyscus and Apodemus: Patterns of similarity in ecological equivalents. In:* KIRKLAND G I. JR. & J.N. LAYNE (eds.): Advances in the study of Peromyscus (Rodentia). Lubbock: Texas Tech. University Press, 367 pp.
PELIKÁN J. 1970: Sex ratio in three Apodemus species *Zool. Listy* **19**: 23-34.
RAWLINGS R. G. & KESSLER M. J. 1986: Secondary sex ratio variation in the Cayo Santiago Macaque population. *Am J. Primatol.* **10**: 9-23.
SAINT-GIRONS M. C. 1966: Étude du genre Apodemus en France. *Mammalia* **30**: 547-600, 31: 55-100.

SANS-COMA V. & GOSALBEZ J. 1975: Sobre la reproducion de Apodemus sylvaticus L., 1758 en el nordeste iberico. *Misc. Zool.* **3**: 227-233.

SCHAIK C. P. & HRDY S. B. 1991: Intensity of local resource competition shapes the relationship between maternal rank and sex ratios at birth in cercopithecine Primates. *Amer. Natur.* **138**: 1555-1562.

SMALL M. F. & HRDY S. B. 1986: Secondary sex ratios by maternal rank, parity, and age in captive Rhesus macaques (Macaca mulatta). *Am. J. Primatol.* **11**: 359-365.

STEIN G. H. W. 1953: Uber das Zahlenverhaltnis der Geschlechter bei der Feldmaus, Microtus arvalis. *Zool. Jahrb. Syst.* **82**: 137-156.

STEINER H. M. 1968: Untersuchungen uber die Variabilität und Bionomie der Gattung Apodemus(Muridae, Mammalia) der Donau-Auen von Stockerau (Niederösterreich). *Z. Wiss. Zool.* **177**: 1-96.

STRAKA F. 1965: Untersuchungen über die Nahrung und die Vermehrung der Waldmaus (Apodemus sylvaticus) in Bulgarien. *Rast. Nauki*, Sofija, **2**: 153 - 161. (in Bulgarian, with the summary in German).

TRIVERS R. & WILLARD D. E. 1973: Natural selection of parental ability to vary the sex ratio of offspring. *Science* **179**: 90-92.

VERME L. J. 1983: Sex ratio variation in Odocoileus: A critical review. *J. Wildl. Manag.* **47**: 573-582.

ZBYTOVSKÝ P. 1989: Notes to bionomy of breedings of the small mammals in the Tábor region. *Sbor. Jihočes. Muz. Čes. Buděj. Přír. Vědy* **29**: 91-101. (in Czech, with the summary in English).

ŽIŽKOVÁ M. 1991: Růst a rozmnožování *Apodemus sylvaticus* (Muridae) v laboratorních podmínkách. [Growth and reproduction of Wood mouse (Apodemus sylvaticus) in captivity.], Unpubl. M.Sc. Thesis, Prague: Charles University, 151 pp (in Czech).

*Acta Soc. Zool. Bohem.* **57**: 193-195,1993(1994
ISSN 0862-5347

# *Allolobophora moravica*, a new earthworm from the Czech Republic

Václav PIŽL[1] & Lea HOUŠKOVÁ[2]

[1]Institute of Soil Biology, Academy of Sciences of the Czech Republic,
Na sádkách 7, CZ-370 05 České Budějovice, Czech Republic
[2]Department of Environmental Studies, Masaryk University,
Kotlářská 2, CZ-611 37 Brno, Czech Republic

*Received August 23, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Taxonomy, Oligochaeta, Earthworms, *Allolobophora moravica* sp.n., Central Europe**

**Abstract.** A new species of earthworm (Oligochaeta. Lumbricidae) from the riparian forest in South Moravia (Czech Republic) is described: *Allolobophora moravica* sp. n.

## INTRODUCTION

Studies of earthworms in riparious forests of South Moravia, Czech Republic, resulted in the collection of one species of *Allolobophora* Eisen, 1874 that appears to be unlike any previously described members of the genus. In this paper, the description of the new species is given and its taxonomical position is discussed.

## SITE, MATERIAL AND METHODS

Earthworms were sampled in a mixed woodland of maple (*Acer negundo* L.), oak (*Quercus robur* L.), ash (*Fraxinus excelsior* L.) and elder (*Sambucus nigra* L.) near the Pasohlávky village, South Moravia, Czech Republic. The field layer vegetation was dominated by *Urtica dioica* L., *Galium aparine* L., *Impatiens noli-tangere* L., *Aegopodium podagraria* L., *Lamium maculatum* L., *Stachys silvatica* L. and *Chaerophyllum temulum* L. The soil type was modified chernozem. The long-term mean temperature is 9°C, the precipitation 500 mm. The region is prone to drought and temperature extremes and consequently earthworm activity is greatest in the spring and fall.

Table 1. Cumulative totals of earthworm numbers and species representation for four sampling occasions

| Species | Number of individuals | Dominance (%) |
|---|---|---|
| *Allolobophora moravica* sp.n. | 49 | 11.8 |
| *Aporrectodea rosea rosea* (Savigny,1826) | 43 | 10.3 |
| *Dendrobaena octaedra octaedra* (Savigny,1826) | 61 | 14.7 |
| *Fitzingeria platyura platyura* (Fitzinger,1833) | 46 | 11.1 |
| *Lumbricus rubellus rubellus* Hoffmeister,1843 | 92 | 22.1 |
| *Octolasion lacteum* (Örley,1881) | 125 | 30.0 |
| Total | 416 | *100.0* |

Earthworms were extracted using 0.5% formalin or obtained by digging and hand sorting of soil samples (depth 0 - 15 cm), fixed in 4% formalin and stored in a 7% solution of the same fixative. The species we are describing here was collected on the type locality on the following sampling occasions (M - mature, SM - semimature, I - immature specimens): 18 May 1989, 12 M, 2 I, leg. L. Houšková; 31 May 1990, 3 M, 1 I, leg. V. Pižl; 3 June 1990, 5 I, leg. L. Houšková; 16 June 1990, 6 M, 6 SM, 14 I, leg. L. Houšková. Data on the coexisting species are summarized in Table 1.

## DESCRIPTION

*Allolobophora moravica* **sp.n.** (Fig. 1)

EXTERNAL: Length 33 - 48 mm, diameter 1.7 - 2.5 mm, number of segments 95 - 100, weight of fixed specimens 90 - 135 mg. Body cylindrical, somewhat quadrangular posteriorly. Live worms slightly reddish brown with strong anterio-posterior and dorsoventral gradients, clitellum pink;

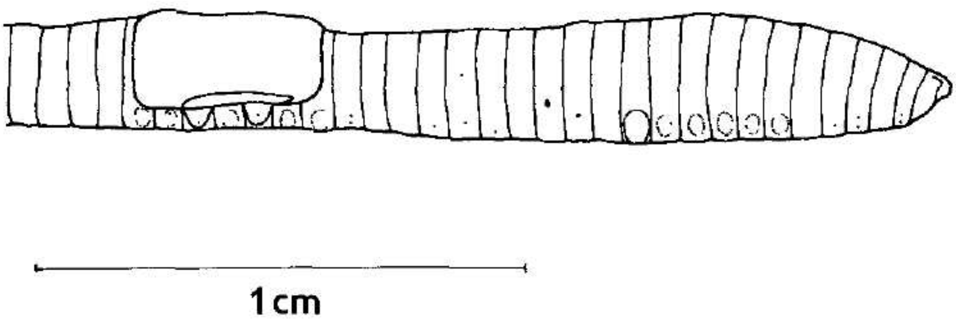



Fig. 1. *Allolobophora moravica* sp. n., anterior part of body (lateral view).

greyish after fixing. Prostomium epilobous (2/3), open. Setae closely paired, relative inter-setae distances on segment 30: aa 11 ab 3, bc 8, cd 2, dd 29. Setae a and b generally on large papillae on 8-12, 23, 24, 26, 28 and 29. Ventral setae of the 12th segment modified into genital setae. *Dorsal pores apparent in postclitellar segments only, in anterior body segments closed.* Nephridial pores irregularly distributed. Male pores in 1/2 15, small, without marked glandular papillae. Female pores in 1/2 14, close to b, with small glandular edge. Clitellum saddle shaped, from (23) 1/n 23 to 28 (1/n 29). Tubercula pubertatis appear on 24 - 27 in form of two linear extensions in the edge of clitellum.

INTERNAL: Musculature of fasciculate type. No septa markedly thickened. Nephridial bladders S-shaped. Morren's glands in 10 and 11, with large dilatation in 10. Crop in 15 and 16, gizzard in 17-18. Typhlosolis from 20/21. Four pairs of seminal vesicles in 9-12. Spermathecae in 9 and 10, large, roundish.

TYPE LOCALITY Czech Republic, South Moravia, 2 km northeast of Pasohlávky village, near the reservoir Nové Mlýny (quadrangle 7065 on the faunistic map of the Czech Republic).

TYPE MATERIAL. Holotype VPC (V Pižl Collection) 241/1, two paratypes VPC 241/2, 3, collected by Václav Pižl on 31 May 1990.

AFFINITY. It is difficult to assign this species to any concrete genus separated from the former *Allolobophora* sensu lato (Bouché, 1972). On the basis of the presence of S-shaped nephridial bladders and two paires of spermathecae, the species might be placed in the genus *Perelia* Easton, 1983 [syn. *Allolobophora (Svetlovia)* Perel, 1976], probably into the *P. tuberosa* (Svetlov, 1924) species group. However, *A. moravica* sp.n. differs in some other characteristics

(no septa thickened, position of Morren's glands, etc.) from all the members of this group, and the area where it was found in seems to be too distant from the range of *Perelia* spp., which are characteristic by the high degree of endemism (Perel, 1979). Hence, we assign it provisionally to *Allolobophora* s. lat. (Bouché, 1972).
ETYMOLOGY. The species is named for Moravia, an area in which it was found.

Acknowledgements

We thank Prof A. Zicsi (Eotvös Lorand University, Budapest) and Dr T. S. Perel (Laboratory of Forest Sciences, Uspenskoye) for their kindness in revising our material and helpfull comments.

## REFERENCES

BOUCHÉ M. B 1972. Lombriciens de France. Ecologie et Systématique. Paris: INRA, 671 pp.

PEREL T. S. 1979. Range and Regularities in the Distribution of Earthworms of the USSR Fauna. Moscow: Nauka, 272 pp. (in Russian, Engl. abstr.)

*Acta Soc. Zool. Bohem.* **57**: 196, 1993 (1994)
ISSN 0862-5247

# BOOK REVIEW

BEHNKE J. M. (editor): **Parasites: Immunity and Pathology. The consequences of Parasitic Infections in Mammals.** London, New York, Philadelphia: Taylor & Francis. 1990, 437 pp. Price (hard cover) Lstg 49.00

The editor is a senior lecturer in zoology at the University of Nottingham, UK. The list of contributors contains 16 acknowledged experts, mostly from Great Britain. As the editor emphasizes in the preface, parasites represent a most diverse group of organisms and reflect the popular life style adopted by living beings. In more recent years parasitology has blossomed as a result of the development of new technologies and as a result of collaborative studies across formally distinct academic disciplines. Designed primarily to interpret interrelationship of parasites, immunity and resultant pathology, this book consist of 19 chapters, each presenting individual scientific communication with a list of comprehensive references.

The introductory chapter is devoted to the coevolution of parasites and hosts when discussing host-parasite arm races - a series of mutual counter-adaptation, advantages and disadvantages of parasitism, and intricately interwoven immunological and pathological aspects of the host-parasite relationship. Two chapters deal with protozoal and helminth antigens and with the antigen uptake, processing and presentation. Another two chapters cover the differentiation of bone marrow cells into effector cells, and humoral and cellular effector immune responses against parasites when discussing the organization of the lymphoid tissue, B and T lymphocytes, natural killer cells, cell-mediated cytotoxicity, granuloma formation and encapsulation. The chapter on genetically determined variation in host response and susceptibility to pathological damage has stressed the complexity of genetic control of both innate and acquired immunity to parasites. As can ba seen from the chapter on protozoan parasites of erythrocytes and macrophages, the diseases that result from this form of parasitism are not yet well understood and leave more questions posed than can been resolved.

Four chapters provide insight into pathology and immunity of parasitic infections. Discussed are cutaneous inflammatory responses to protozoa, nematodes, platyhelminths and arthropods, pulmonary responses, immunological and inflammatory responses in the small intestine associated with helminthic infections an intestinal pathology.

The chapter on acquired immunity and epidemiology focuses on possible ways in which acquired immunity may influence the population dynamics of macroparasite infections, then evaluates the possible consequences of immunity for human helminth infections and their control, and the role of immunity in protozoan epidemiology. The chapter on evasion of host immunity reviews some of the strategies which parasites use to prolong their existence in the host. Described are various host-derived mechanisms, namely various types of unresponsiveness and reduced immunocompetence, and parasite derived mechanisms, namely manipulation of parasite antigens and of the host immune system. The final chapter introduces aspects of vaccination against parasites, namely various types of vaccines, animal models, and vaccination in eradication and control.

This highly informative volume offers a compendium of reviews of parasite induced pathology and relevant host immune responses. How the immune responses are evoked and how they express host-protective resistance at various tissue locations in the mammalian body are considered in some detail. In addition, the pathological sequelae accompanying infections are emphasized. Extensive documentation consits in 19 tables and 137 figures, namely diagrams, schematic drawings, macrophotographs, light and electron microscope pictures. Many objective schematic illustrations presenting parasitological phenomena are structured according to personal conception of individual contributors. This publication provides competent information and will be of interest to final years undergraduates in parasitology and to postgraduate research workers in parasitology, zoology, immunology and pathology.

*Jindřich Jíra*

*Acta Soc. Zool. Bohem.* **57**: 197-201, 1993(1994)
ISSN 0862-5347

# Morphology and life cycles of two new species of *Stenoductus* (Apicomplexa: Cephalina) from the millipede, *Chondromorpha kelaarti* in Kerala, India

P. K. PRASADAN & K. P. JANARDANAN

Parasitology Laboratory, Department of Zoology, University of Calicut, Kerala-673 635, India

*Received June 25, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Taxonomy, morphology, life cycles, new species, Apicomplexa, Cephalina, millipedes, Oriental Region.**

**Abstract.** Morphology and life cycles of 2 new species of cephaline gregarines, *Stenoductus kelaarti* sp. n. and *S. wayanadensis* sp. n. infecting the millipede, *Chondromorpha kelaarti* (Humbert) are described and their affinities with related species discussed.

Thirty-nine species of cephaline gregarines belonging to 8 genera have been reported from Indian millipedes; of these 10 species belonging to *Stenoductus* Ramachandran, 1976 and one belonging to *Stenophora* Labbe, 1899 are from Kerala (Ramachandran 1972; Janardanan & Ramachandran 1979, 1981a,b, 1982a,b, 1983a,b, Janardanan 1987 and Prema & Janardanan 1991). While examining the millipedes of Kerala for their gregarines, we came across 2 species of *Stenoductus* from *Chondromorpha kelaarti* (Humbert) collected from Ezhimala in Cannanore district and Chundale in Wayanad district. These two species are reported here as *Stenoductus kelaarti* sp. n. and *S. wayanadensis* sp. n.

## MATERIAL AND METHODS

*Chondromorpha kelaarti* collected from Ezhimala and Chundale were examined and the different development stages of gregarines recovered were studied following the procedure reported by Janardanan & Ramachandran (1979). Sketches were made with the help of a camera lucida and photographs were taken with a Wild MPS 12 microcamera fitted to a Leitz Diaplan phase-contrast microscope. Measurements are in micrometers and the descriptions are based on a minimum of 20 specimens. Abbreviations used in this paper are: DW – Deutomerite width; PL – Protomerite length; PW – Protomerite width; TL – Total length.

## DESCRIPTION OF SPECIES

### *Stenoductus kelaarti* sp. n.

HOST. *Chondromorpha kelaarti* (Humbert)
SITE. Intestine
LOCALITY. Ezhimala in Cannanore district, Kerala (India)
DATE OF COLLECTION. June to December 1989, 1990
HOLOTYPE. On slide No. G/S-1 deposited in the parasite collections, Parasitology Laboratory, Department of Zoology, University of Calicut, Kerala (India).

Morphology of sporadins (Pl. 1.1; Pl. 2.3)*. Sporadins solitary, milky-white at the end of anterior third and gradually tapering to a round caudad. Protomerite dome-like, with a lens-sha-

* Plates 1-4 will be found at the end of this issue.

ped refractile structure at the apical region; apical papilla and apical pore absent; protomerite epicyte uniformly thick, striated; striations continuous with those on deutomerite; endocyte granular with a granule-free area at the posterior region; septum slightly convex toward protomerite, 1.6 thick; constriction at septum conspicuous. Deutomerite elongate, broader at the end of anterior third and gradually tapering to a round caudad; deutomerite epicyte uniformly thick, striated; endocyte granular. Nucleus round to ovoid; its position variable; endosome single, irregular in outline.

Measurements of sporadins, with mean in parentheses, are noted below:

TL = 160.1 - 264 (180.6); DW = 57.8 - 70.9 (61.5);

PL = 17.3 - 26.4 (20.2); PW = 29.7 - 46.2 (33.9);

Ratios: PL : TL = 1; PW : DW = 1 : 1.8.

Gametocysts and oocysts. Gametocysts (Pl. 1.2; Pl. 2.4,5) spherical, milky-white, opaque; cyst wall single, hyaline, uniformly thick, measured 3.3; line of association clear in newly formed cysts. Fresh cysts measured 75.9 - 82.5 (78.9). Naked, cord-like, mucilagenous sporoduct (Pl. 1.2; Pl. 2.5) extruded through a rupture in the cyst wall. Oocysts were embedded along the whole length of sporoduct. Oocysts (Pl. 1.3; Pl. 2.6) ovoid, with hyaline epispore forming hemispherical polar projections and a conical equatorial ridge. Fresh spores with epispore measured 7.5 by 5.3.

Biology. Gametocysts kept in moist chamber developed and extruded spores in 72 hours. After 36 h of incubation, a clear zone, without inclusions, differentiated below the cyst wall. Oocysts aggregated at the central dense area. The central dense mass then raised at one point into a protuberance which slowly became more and more pronounced until its tip finally broke through the hyaline cyst wall and extruded out as a cord-like, mucilagenous sporoduct. The sporoduct disintegrated by absorbing moisture and set the spores free.

Midgut fluid of the millipede activated the sporozoites in 5 to 6 minutes. A wriggling movement was observed inside the spore and the sporozoites came out in 9 to 10 min., one after the other, and continued to move actively in the midgut fluid. The sporozoites penetrate the midgut epithelial cells and develop into trophozoites.

The intracellular trophozoite (Pl. 1.4; Pl. 2.1) observed was aseptate, ovoid, 4.9 by 3.3, stainable with hematoxylin, but for a halo of unstained host cell region around; its nucleus was central. The smallest lumen trophozoite (Pl. 1.5) measured 28 by 14. The largest observed trophozoite (Pl. 1.6; Pl. 2.2) measured 161.7 in length; its protomerite dome-shaped, with a lens-like refractile structure at its apex; deuteromerite maximally wide at the end of anterior third, tapering gradually to the posterior and ending in a slightly broader, bulb-like caudad. With further growth the lumen trophozoites became sporadins.

### *Stenoductus wayanadensis* sp. n.

HOST. *Chondromorpha kelaarti* (Humbert)

SITE Intestine

LOCALITY. Chundale in Wayanad district, Kerala (India)

DATE OF COLLECTION. June to December 1989 and 1990

HOLOTYPE. On slide No. G/S-2 deposited in the parasite collections, Parasitology Laboratory, Department of Zoology, University of Calicut, Kerala (India).

Morphology of sporadins (Pl. 3.1). Sporadins tadpole-like, elongate, laterally curved. Protomerite rectangular to hemispherical, wider than long; apical papilla and apical pore absent; protomerite epicyte uniformly thick, striated, striations continuous with those on deuteromerite; endocyte granular; septum convex toward deuteromerite. Deuteromerite elongate, narrow behind septum, maximally dilated behind the anterior third, then narrows to become a uniformly cylindrical, laterally curved and round ended posterior half; epicyte uniformly thick, hyaline, striated; endocyte granular. Nucleus ovoid, feebly visible in fresh sporonts; endosome single, round, with a number of granules.

Measurements of sporadins, with mean in parentheses, are noted below:
TL = 305.3 - 480.2 (343.1); DW = 46.2 - 84.2 (61.4);
PL = 14.9 - 29.7 (22.1); PW = 21.5 - 33 (27.2).
Ratios: PL : TL = 1 : 15.5; PW : DW = 1 : 2.3.

Gametocysts and oocysts. Gametocysts (Pl. 3.2,3; Pl. 4.4,5) spherical, opaque, milky-white; cyst wall single, hyaline, measured 3.3 - 4.9. Line of association clearly visible in early gametocysts. Fresh cysts measured 108.9 - 125.4. Sporoduct elongate, almost cylindrical, with maximum width at the base and round, disc-like structure at the distal end. The duct lumen 11.5 - 21.4 in diameter. Oocysts (Pl. 3.4; Pl. 4.6) ovoid, with hyaline epispore forming pointed polar projections; equatorial ridge absent. Fresh oocysts with epispore measured 15 by 3.8.

Biology. Gametocysts maintained in moist chamber developed spores in 4 days. Line of association disappeared in 18 to 20 h of incubation. After 24 h, a clear zone differentiated at the periphery below cyst wall. After 36 h, a small circular depression appeared on the cyst surface indicating the base of the sporoduct. From this depression, a tube-like sporoduct began to develop toward the centre (Pl. 3.2; Pl. 4.4) and continued to grow till 72 hours. On the 4th day the sporoduct evaginated through the depression on the cyst wall, and released oocysts in a mucilagenous cord through the duct lumen. The cord disintegrated and set the spores free after a few minutes of exposure to moisture.

The liberation of sporozoites was induced by placing fresh spores in the host's midgut fluid, which activated the sporozoites in 45 seconds. The sporozoites emerged through one pole of the spore after 50 sec of exposure. The sporozoites penetrate the midgut epithelial cells and develop into trophozoites.

The intracellular trophozoites observed (Pl. 3.5; Pl. 4.1) were ovoid, aseptate, measured 7.8 - 8.4 by 4.5 - 6.6. They stained deeply with hematoxylin, but the surrounding region of the host cell remained unstained. Smallest lumen trophozoite (Fig. 3.6) measuring 23.1 by 14.8 was found attached to the midgut epithelial cell through a knob-like, 2.5 long epimerite. Its protomerite measured 5 8 and deuteromerite 14.8. With further growth in size the trophozoites (Pl. 4.2,3) become worm-like and laterally curved. A trophozoite of 265.6 by 29 7 size (Pl. 3.7) had and '8'-shaped epimerite measuring 18.2 by 15.7; its protomerite measured 18.2 by 21.4, and deuteromerite 229.9 by 29.7. Largest trophozoite observed (Pl. 3.8) measured 292.9 by 33; its bulbous epimerite measured 14 by 13.2; hemispherical protomerite, 16.5 by 21 5 and elongate laterally curved deuteromerite 262.4 by 28.1. In trophozoites of this size the anterior third was highly flexible. Trophozoites of larger size discarded their epimerites and remained free in the midgut lumen. The deuteromerite of these trophozoites exhibited progressive enlargement at the middle third, and finally assumed the characteristic tadpole-like form of sporadins. A late trophozoite measuring 305.3 by 51.2 (Pl. 3.9) almost resembled a young sporadin; its protomerite measured 13.2 by 23.9 and deuteromerite 292.1 by 51.2

## DISCUSSION AND SYSTEMATIC POSITION

Characters of the present gregarines such as solitary sporadins without epimerites, nuclei without myonemes, extrusion of spores through a tubular or cord-like, naked sporoduct and ovoid spores with hyaline epispore justify their position in the genus *Stenoductus* Ramachandran, 1976 of the family Monoductidae Ray & Chakravarty, 1933.

*Stenoductus kelaarti* sp. n. This gregarine from *Chondromorpha kelaarti* shows superficial resemblance to *S. polydesmi* Janardanan & Ramachandran, 1983 infecting *Polydesmus* sp. But it is different from *S. polydesmi* in measurements and ratios, and in having (1) dome-shaped protomerite with lens-like refractile structure at the apical region, (2) deuteromerite with maximum width at the end of anterior third, (3) endosome with irregular outline, (4) naked and cord-like sporoduct and (5) spores with epispore forming hemispherical polar projections and a conical equatorial ridge. Based on these, the present gregarine is considered to be a new species and is reported here as *Stenoductus kelaarti* sp. n., after its host.

*Stenoductus wayanadensis* sp. n. The present species of *Stenoductus* superficially resembles *S. chondromorphi* Janardanan & Ramachandran, 1981 from *Chondromorpha kelaarti* in Cannanore. But a comparison of characters shows that it differs from *S. chondromorphi* in having (1) monomorphic sporadins, (2) rectangular to hemispherical protomerite, (3) sporoduct with a disc-like structure at its tip, (4) ovoid spores with hyaline epispore forming pointed polar projections, (5) spores released in a mucilagenous cord through the duct lumen, (6) trophozoites with epimerites and (7) measurements and ratios which are different. Besides, the host of the present species belongs to a different geographical locality. The present gregarine is hence a distinct species, and is reported here as *Stenoductus wayanadensis* sp. n.

Gasc & Ormieres (1977) described the life cycle of a new species of *Stenophora: S. oxydesmi* from the millipede *Oxydesmus granulosus*. In this species the gametocyst dehiscence is caused by a central pseudocyst. The oocysts, with loose epispore, escape from the gametocyst through a point of lesser resistance, and are agglomerated to form a thick strand with the ejected pseudocyst. This strand disintegrated very quickly. It is obvious from the description and figures that the gametocyst dehiscence and the structure of spores do not agree with that of *Stenophora* in which the gametocysts dehisce by simple rupture, releasing spores singly. Further, the spores are without any epispore (Watson-Kamm 1922, Chakravarty 1959, Levine 1982). As these characters of *S. oxydesmi* are identical with those of the genus *Stenoductus* Ramachandran, 1976 (emend Janardanan & Ramachandran, 1979) it is shifted from the genus *Stenophora* Labbe, 1899 to *Stenoductus* Ramachandran, 1976. Therefore, a new taxonomic status, *Stenoductus oxydesmi* (Gasc & Ormieres) comb. n. is proposed for this gregarine species.

### Acknowledgements

The authors express their sincere thanks to Prof J. M. Demange of the Natural History Museum, Paris for taxonomic identification of the millipede. One of the authors (P.K.P.) is thankful to C.S.I.R., New Delhi for financial assistance.

### REFERENCES

CHAKRAVARTY M. 1959: Systematic position of some genera and classification of the suborder Cephalina Delage and Herouard. *Proc. Zool. Soc.* **12**: 71-81.

GASC C. & ORMIERES R. 1977: Stenophora oxydesmi n. sp. eugregarine parasite d' Oxydesmus granulosus Pa. de Beauv. (Myriapoda, Polydesmidae) du Dahomey. *Cah. Orstom, Ser. Biol.* **12**: 25-28.

JANARDANAN K. P. 1987: Stenoductus ktenostrepti n. sp. (Apicomplexa: Cephalina) from the millipede, Ktenostreptus calcaratus Demange. *Arch. Protistenk.* **133**: 295-299.

JANARDANAN K. P. & RAMACHANDRAN P. 1979: Observations on a new species of cephaline gregarine from the millipede, Carlogonus palamtus Demange, 1977. *Zool. Anz.* **203**: 392-400.

JANARDANAN K. P. & RAMACHANDRAN P. 1981a: Stenoductus chondromorphi sp. n. (Sporozoa: Cephalina) from the polydesmoid millipede, Chondromorpha kelaarti (Humbert). *Acta Protozool.* **20**: 411-419.

JANARDANAN K. P. & RAMACHANDRAN P. 1981b: On a new cephaline gregarine Stenoductus xenoboli n. sp. (Protozoa: Cephalina) from the gut of the millipedes, Xenobolus acuticonus Attems and Aulacobolus graveleyi Silvestri. *Proc. Ind. Acad. Parasitol.* **2**: 57-61.

JANARDANAN K. P. & RAMACHANDRAN P. 1982a: Observations on Stenoductus organognathi sp. nov. (Cephalina: Monoductidae) from the millipedes, Organognathus janardanani Demange and Frageostreptus

hyatti Démange collected from Kerala, India. *Riv. Parasitol.* **43**: 293-299.
JANARDANAN K. P. & RAMACHANDRAN P. 1982b: Studies on a new cephaline gregarine Stenoductus trigoniuli sp. n with a note on its cytopathology *Arch. Protistenk.* **125**. 249-256.
JANARDANAN K. P. & RAMACHANDRAN P. 1983a: On a new septate gregarine, Stenoductus polydesmi sp n. (Sporozoa Cephalina) from the millipede Polydesmus sp. with observations on host-specifity of gregarines infecting millipedes in Kerala, India. *Acta Protozool* **28**: 87-94.
JANARDANAN K. P & RAMACHANDRAN P. 1983b: Observations on 2 new species of cephaline gregarines (Protozoa: Sporozoa) of the genus Stenoductus Ramachandran, 1976 from Sphaerotherid millipedes in Kerala, India. *Arch Protistenk.* **127**: 405-412.
LEVINE N D. 1982: Apicomplexa. In Synopsis and Classification of Living Organisms PARKER S. P. (ed.) New York: McGraw-Hill Book Company, pp.: 571-587.
PREMA S & JANARDANAN K. P. 1991: Life history of Stenoductus kalorthomorphae, a new cephaline gregarine (Apicomplexa: Sporozoa) from the millipede, Kalorthomorpha sp. *Bioved* **2**: 43-46.
RAMACHANDRAN P. 1972. A new species of cephaline gregarine (Protozoa: Sporozoa) from Kerala, India. *J Zool Soc. India* **24**: 149-153.
WATSON-KAMM M. W. 1922. Studies on gregarines II Synopsis of the polycystid gregarines of the world, excluding those from the Myriapoda, Orthoptera and Coleoptera. Ill. Biol Monogr. 7: 1-104.

*Acta Soc. Zool. Bohem.* **57**: 202, 1993 (1994)
ISSN 0862-5247

# BOOK REVIEW

FRANCIONE G. L. & CHARLTON ANNA E: **Vivisection and Dissection in the Classroom: A Guide to Conscientious Objection.** The American Anti-Vivisection Society, Jenkintown, USA. 136 pages, ISBN 1-881699-00-5 (pbk).

The animal rights movements and anti-vivisection activism is becoming more and more prominent in the world. Especially in the United States of America where organisations as People for the Ethical Treatment of Animals, The Human Society of the United States and The American Anti-Vivisection Society exist. Lawyers Gary L. Francione and Anna E. Charleton from Rutgers Animal Rights Clinic wrote for all students who do not wish to vivisect, kill and dissect nonhuman animals a guide to resisting and using legal possibilities in their fight with school authorities in the USA. There are chapters on students rights and the first amendment of freedom of religion, relevant doctrines of federal law and other state law doctrine that may support and selected arguments and responses. The book is accompanied by appendices with a list of selected cases, sample legal pleading and recommendation and report of American Bar Association, Young Lawyers Division (YLD), Committee of Animal Protection Law.

All those seeking information of this type will be very satisfied. Those expecting that they could get information about nonanimal and animal alternatives will be disappointed. In a short chapter devoted to this theme the problem is discussed a new only from a legislative point of view.

*Josef Chalupský*

*Acta Soc. Zool. Bohem.* **57**: 203-210, 1993(1994)
ISSN 0862-5347

# Seven new species of *Leistus* from China (Coleoptera: Carabidae: Nebriinae)

Riccardo SCIAKY

Via Fiamma 133, I-20129 Milano, Italy

*Received March 25, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Taxonomy, new species, Coleoptera, Carabidae, *Leistus*, Eastern Palearctics**

**Abstract.** In this study seven new species of *Leistus (Evanoleistus)* from China are described and compared with those already known from that region. *L. perraulti* sp. n., *L. pavesii* sp. n., *L. cylindricus* sp. n., *L. sichuanus* sp. n., and *L. saueri* sp. n. are from the region of Sichuan, *L. bohemorum* sp. n. from Gansu and *L. farkaci* sp. n. is the first species known from the region of Qinghai.

Studying material of Carabidae from China (regions of Sichuan, Gansu and Qinghai) I found seven species of *Leistus* Fröhlich belonging to the subgenus *Evanoleistus* Jedlička that did not correspond to any of the species previously known. A thorough examination of the literature, possible thanks to the recent works by G.-G. Perrault, lead me to ascertain that I was in front of undescribed species belonging to the same group of most of the species described by Tschitschérine in 1903, but certainly different from all of them. With this note I will describe the new species and expose the differences from the nearest ones; moreover I will give some data on two other species from China up to now insufficiently known.

In the description of the new species I have used some indexes; here follows their list and the abbreviations used in the text.

antennal index: antennal segment 5/antennal segment 3 = IA
pronotal index: width/length of pronotum = IPw/l
pronotal index: maximum width of pronotum/basal width of pronotum = IPm/b
elytral-pronotal index: width of elytra (taken together)/width of pronotum = IE/P
elytral index: length/width of elytra = IEl/w

## *Leistus (Evanoleistus) perraulti* sp. n.

DIAGNOSIS. A *Leistus (Evanoleistus)* of 8.6 mm, dark reddish-brown with paler appendages. Pronotum weakly transverse, sensibly restricted and sinuate towards the base; elytra narrow, oval, with shoulders very obliquous, widest in the apical half. Aedeagus with apex short and pointed downward.

TYPE LOCALITY. China, N Sichuan, Zhangla 4700 m.

TYPE SERIES. Holotypus, male, 9-11.VII.1991, in collection Sciaky.

DERIVATIO NOMINIS. I am happy to dedicate this species to Dr Georges Perrault from Paris, who has, in several contributions, completely revised the systematics of the difficult genus *Leistus*.

DESCRIPTION. Size mm 8.6; the whole body dark reddish-brown with pale appendages. Habitus as in Fig. 1*. Microsculpture strong on head and pronotum, weaker on elytra.

Head big, inpunctate, not very convex, little narrower than pronotum; eyes not very big and convex. Mandibles very wide and relatively short, with faint external sinuation. Temporae long

* The figures 1-17 will be found at the end of this issue.

and obliquous, collar constriction well marked dorsally Gular setae brought by a transversal carina IA = 1 36

Pronotum small, weakly transverse, the sides almost regularly rounded in the anterior half, very weakly sinuated towards the base Guter ill-defined, in the anterior portion almost obsolete, then narrow until the hind angles Disc weakly convex, median line well marked, anterior margin strongly projecting onward at middle, unbordered, preapical area densely punctate, fore angles not prominent Prebasal sulcus well-defined, basal area completely punctate, basal angles almost right Posterior seta absent IPw/l = 1 22, IPm/b = 1 65 Legs very long, fore tarsi of male quite strongly dilated

Elytra long and narrow, with striae deep, all distinct and strongly punctate, intervals convex Third interval with two points adjoining the third stria Shoulders obliquous, basal margin perpendicular to suture, forming a curve with lateral margin Maximum width at two thirds of length, apex rather rounded IE/P = 1 45, IEl/w = 1 68

Abdominal segments with one couple of setae each in the male Female unknown

Genitalia Aedeagus with apex short, pointed, with no particular characteristics (Fig 10)

AFFINITIES Following Tschitschérine's table (1903) this species would be situated near *L gracilentus* Tschitscherine, 1903, but the new species has narrower elytra and effaced shoulders

*Leistus (Evanoleistus) pavesii* **sp. n**

DIAGNOSIS A *Leistus (Evanoleistus)* of 9 8 mm, completely brownish Pronotum weakly transverse, sensibly restricted towards the base, elytra wide, oval, with shoulders very obliquous, widest in the apical half Aedeagus with apex very long, regularly arcuate (Fig 11)

TYPE LOCALITY China, N Sichuan Shuasingsi 3800 m

TYPE SERIES Holotypus male 4 VII 1991 in collection Sciaky 1 paratype female with the same data as holotypus in coll Pavesi

DERIVATIO NOMINIS This species is named after my dear colleague and friend Maurizio Pavesi, from Milan, student of Carabidae

DESCRIPTION Size mm 9 8, the whole body dark reddish brown with reddish appendages Habitus as in Fig 2 Microsculpture strong on head and pronotum, less strong on elytra

Head big impunctate not very convex little narrower than pronotum eyes big and convex Mandibles very wide and long, with faint external sinuation Temporae long and obliquous, collar constriction well marked dorsally Gular setae brought by a transversal carina IA = 1 45

Pronotum small, weakly transverse, the sides almost regularly rounded in the anterior half, then abruptly converging behind towards the basal angles Gutter deep, well defined, punctate, relatively large in its whole length Disc almost flat, median line well marked, anterior margin almost rectilinear, unbordered, preapical area densely punctate, fore angles not prominent Prebasal sulcus well-defined, basal area completely punctate, basal angles obtuse Posterior seta absent IPw/l = 1 23, IPm/b = 1 92 Legs very long, fore tarsi of male quite strongly dilated

Elytra long and wide, weakly convex, with striae deep, all distinct and strongly punctate; intervals convex Third interval with two points adjoining the third stria Shoulder well marked, basal margin perpendicular to suture, forming a curve with lateral margin Maximum width little before middle of length, apex rather rounded IE/P = 1 50, IEl/w = 1 61

Abdominal segments with one couple of setae each in the male, two couples in the pygidium of the female

Genitalia Aedeagus with apex very long and curved downward pointed at tip (Fig 11)

AFFINITIES Also this species would be situated, like the preceding one, near *L gracilentus* Tschitscherine, 1903 and *L gracillimus* Tschitscherine, 1903, but in *L pavesii* sp n the elytra are much wider, the colour is reddish-brown and the sixth stria reaches the base of elytra

### *Leistus (Evanoleistus) cylindricus* sp. n.

DIAGNOSIS A *Leistus (Evanoleistus)* of 8 9-9 2 mm, completely piceous, with a very smooth appearance due to the almost complete lack of microsculpture Very peculiar within the genus for the total lack of pronotal and elytral gutter and the striae indicated only by big, deep points Aedeagus with apex long, with two small carinae on the superior side, near the apex (Fig 12)
TYPE LOCALITY China, N Sichuan, Zhangla 4200 m
TYPE SERIES Holotypus, male 24 VII 1991, in collection Sciaky 3 Paratypi, both the sexes with the same data as holotypus in coll Pavesi
DERIVATIO NOMINIS The name alludes to the peculiar shape of the body of this species
DESCRIPTION Size mm 8 9-9 2, body and legs piceous, antennae reddish-brown Habitus as in Fig 3 Microsculpture almost absent from head, pronotum and elytra, that appear absolutely smooth and shining

Head big, inpunctate, convex, nearly as wide as pronotum, eyes big and convex Mandibles very wide and relatively short, with strong external sinuation Temporae long and obliquous, collar constriction well marked dorsally Gular setae brought by a transversal carina IA = 1 33

Pronotum very small, weakly transverse, the sides almost regularly rounded in their whole length The lateral margins are completely convex, leaving no gutter at all, as can be observed, for instance, in genus *Dyschirius* Bonelli Disc very strongly convex, median line little distinct, anterior margin projecting onward, unbordered, preapical area densely punctate, fore angles not prominent Prebasal sulcus well-defined, basal area completely punctate, basal angles obtuse Posterior seta absent IPw/l = 1 17, IPm/b = 1 91 Legs very long, fore tarsi of male weakly dilated

Elytra long and very convex, almost cylindrical, striae all distinct, made by deep, spaced points, but striae 3-8 vanished in the distal portion, intervals convex, absolutely smooth Third interval with two points in the middle of interval's width Like in the pronotum, the lateral margins are completely convex, leaving no gutter at all Shoulders completely rounded, the basal margin strongly obliquous, forming a curve with the lateral one Maximum width just after the middle of length, apex rather rounded IE/P = 1 47, IEl/w = 1 58
Abdominal segments with one couple of setae each in the male, two couples in the pygidium of female

Genitalia Aedeagus with apex long, bent downward, superiorly carenated (Fig 12)
AFFINITIES This species is unique within the genus in the total lack of pronotal and elytral gutter; both pronotum and elytra have the upper surface that continues to the epipleura in a smooth curve, without a change of convexity

### *Leistus (Evanoleistus) sichuanus* sp. n

DIAGNOSIS A *Leistus (Evanoleistus)* of 8 9 mm, completely piceous
TYPE LOCALITY China W Sichuan Zhi Long (Shou Ji)
TYPE SERIES Holotypus female, 3 8 VIII 1992, in collection Sciaky
DERIVATIO NOMINIS This species is named after the region of China where it has been found
DESCRIPTION Size mm 8 9, body and appendages piceous Habitus as in Fig 4 Microsculpture very weak on head, pronotum and elytra, that appear smooth and shining

Head big, inpunctate, convex, much narrower than pronotum, eyes big and convex Mandibles very wide and relatively short, with faint external sinuation Temporae long and obliquous, collar constriction well marked dorsally Gular setae brought by a transversal carina IA = 1 44

Pronotum wide, strongly transverse, the sides almost regularly rounded in the anterior half, then abruptly parallel in the basal portion. Gutter wide, sparsely punctate, reflexed in the middle. Disc weakly convex, median line well distinct, anterior margin almost straight, unbordered, preapical area densely punctate, fore angles not prominent. Prebasal sulcus well-defined, basal area completely punctate, basal angles right. Posterior seta absent. IPw/l = 1.43, IPm/b = 1.93. Legs shorter than in all the other species known to me from China.

Elytra long and strongly convex, with striae 1-5 distinct and punctate, 6 very weakly impressed, the next completely effaced; interval convex, smooth. Third interval with four points almost in the middle of the interval's width. Shoulder well marked, basal margin perpendicular to suture, forming a curve with lateral margin. Gutter narrow. Maximum width almost at the middle of length, apex rather rounded. IE/P = 1.24, IEl/w = 1.69.

Abdominal segments with one couple of setae each, the pygidium with two couples in the female. Male unknown.

Genitalia. Male unknown.

AFFINITIES. The shape of the pronotum of this species strongly reminds that of *L. reflexus* Semenov, from which it is distinct in the more convex elytra, with narrow gutter. The convex structure of the elytra, on the other hand, reminds that of *L. cylindricus* sp. n., but the shape of the pronotum is completely different.

*Leistus (Evanoleistus) farkaci* **sp. n.**

DIAGNOSIS. A *Leistus (Evanoleistus)* of 6.9-7.8 mm, completely dark reddish-brown. Pronotum weakly transverse, strongly restricted towards base; elytra narrow, oval, with shoulder strongly obliquous, widest in the apical half. Aedeagus with apex long, shovel-shaped (Fig. 13).

TYPE LOCALITY. China, Qinghai, 30 Km S of Huizu, M. Daban 3600 m.

TYPE SERIES. Holotypus, male, 1-3.VII.1992, in collection Museo Civico di Storia Naturale, Milan. Paratypes 2,4 males and females with the same data as holotypus, in coll. Bulirsch, Dacarta, Dvořák, Farkač, Hůrka, Pavesi and Sciaky.

DERIVATIO NOMINIS. This species is named after my colleague and friend Jan Farkač, renamed carabidologist from Prague.

DESCRIPTION. Size mm 6.9-7.8; body dark reddish-brown, appendages reddish-brown. Habitus as in Fig. 4. Microsculpture strong on head and pronotum, weaker on elytra.

Head big, inpunctate, not very convex, hardly narrower than pronotum; eyes big and convex. Mandibles very wide but rather short, with faint external sinuation. Temporae long and obliquous, collar constriction well marked dorsally. Gular setae brought by a transversal carina. IA - 1.50.

Pronotum small, weakly transverse, the sides regularly rounded in the anterior half, then sinuate towards the base. Gutter well-defined, sparsely punctate, relatively large along its whole length. Disc rather flat, median line well marked, anterior margin almost rectilinear, unbordered, preapical area densely punctate, fore angles weakly prominent. Prebasal sulcus well-defined, basal area completely punctate, basal angles obtuse, subrounded at the tip. Posterior seta absent. IPw/l = 1.25, IPm/b = 1.81. Legs relatively short, fore tarsi of male strongly dilated.

Elytra long and wide, with striae weakly punctate; intervals convex. Third interval with no points. Shoulders well marked, basal margin perpendicular to suture, forming a curve with lateral margin. Maximum width little after middle of length, apex rounded. IE/P = 1.45, IEl/w = 1.65.

Abdominal segments with one couple of setae each in the male; two couples in the pygidium of female.

Genitalia. Aedeagus with apex long, parallel, then bent downwards (Fig. 13).

AFFINITIES. It is not easy to place this species, the first known from the region of Qinghai, among the others known from China. Its position looks quite isolated: its size is smaller than in any other Eastern *Leistus* and it has no special characters (e.g. abbreviated elytral striae as in *L. nubicola* Semenov, multiple pronotal setae as in *L. crenifer* Tschitschérine and *L. nubicola* or lack of pronotal and elytral gutter as in *L. cylindricus* sp. n.). *L. farkaci* sp. n. seems relatively primitive, maybe the species most similar to the common ancestor of all the extant species.

*Leistus (Evanoleistus) crenifer* Tschitschérine, 1903

This species was known only upon the two type-specimens originally described by Tschitschérine (1903). I have examined several specimens from Sichuan, Jiuzhagou, 30 km W of Nanping. This station is close to its type-locality (Sichuan, Ta-Tsao-Pin), and the specimens examined correspond very well to the original description. I can therefore give here a photograph of its habitus (Fig. 6) and a drawing of its aedeagus (Fig. 14). The aedeagus is long, with the apex almost rectilinear and pointed downwards.

AFFINITIES. This species is quite isolated within the genus in the peculiar structure of the pronotal seta, that is inserted in the lateral margin of pronotum instead than in the gutter. I know very few instances of such a type of insertion in the family Carabidae, but all the other characters are typical of the *Leistus* of this region.

*Leistus (Evanoleistus) reflexus* Semenov, 1889

This species was known only upon the single type-specimen originally described by Semenov (1889) and later redescribed by Tschitschérine (1903). I have examined a series of specimens from Gansu, between Xiahe and Heznojhen, a station close to its type-locality (Gansu, monastery Dzhoni), which correspond very well to the original description and to Tschitschérine's redescription of this species. I can therefore give a photograph of its habitus (Fig. 7) and a drawing of its aedeagus (Fig. 15). The aedeagus is short, shoe-shaped, with the apex pointed downwards.

AFFINITIES. I include with doubt this species in the subgenus *Evanoleistus*, as the shape of aedeagus is different from that typical of the subgenus and seems to approach the shape typical of *Leistus* s. str. Anyway, the resemblance to the other species here described is so marked that I do not want to isolate it, only species of *Leistus* s. str. in a geographical area occupied only by the subgenera *Evanoleistus* and *Neoleistus* Erwin.

*Leistus (Evanoleistus) bohemorum* **sp. n.**

DIAGNOSIS. A *Leistus (Evanoleistus)* of 9.8-10.1 mm, piceous. Pronotum strongly transverse, markedly restricted towards base, hind angles right; elytra wide, oval, with shoulders strongly obliquous, widest in the basal half. Aedeagus with apex long, parallel, then abruptly bent downwards (Fig. 16).

TYPE LOCALITY. China, Gansu, Golo Shan, Wen Xian.

TYPE SERIES. Holotypus, male, VII.1992, in collection Sciaky. 1 Paratypus, female, in coll. Pavesi.

DERIVATIO NOMINIS. I am glad to dedicate this species to all the Czech entomologists, who have brought so many new species to knowledge with their entomological explorations of far-away countries.

DESCRIPTION. Size mm 9.8-10.1; body and appendages piceous, only antennae (from antennomere 2) tarsi and buccal parts paler. Habitus as in Fig. 8. Microsculpture strong on head and elytra, almost absent on pronotum.

Head big, sparsely punctate and wrinkled, not very convex, much narrower than pronotum, sparsely punctate near the eyes; eyes big and convex. Mandibles very wide but rather short, with faint external sinuation. Temporae long and obliquous, collar constriction well marked dorsally. Gular setae brought by a transversal carina. IA = 1.63.

Pronotum wide, strongly transverse, the sides rounded in the anterior half, then strongly sinuate before the basal angles. Gutter wide, punctate, reflexed in the middle. Disc very flat, sparsely punctate; median line well marked, anterior margin almost rectilinear, unbordered, preapical area densely punctate, fore angles prominent. Prebasal sulcus well-defined, basal area completely punctate, basal angles acute. Posterior seta absent. IPw/l = 1.47, IPm/b = 1.96. Legs quite long, fore tarsi of male rather strongly dilated.

Elytra wide and weakly convex, with striae deep and strongly punctate; intervals convex. Third interval with four points adjoining the third stria. Shoulder well marked, basal margin perpendicular to suture, forming a curve with lateral margin. Maximum width little before middle of length, apex rather rounded. IE/P = 1.24, IEl/w = 1.52.

Abdominal segments with one couple of setae each; two couples in the pygidium of female.

Genitalia. Aedeagus with apex long, parallel, then abruptly bent downwards and with dorsal apophysis continuing the aedegal tube and partially covering the ostium (Fig. 16).

AFFINITIES. This species has two dorsal apophysis partially covering the ostium, a character that seems to approach it to the subgenus *Neoleistus*. In spite of it, I prefer to include it in *Evanoleistus*; anyway, it is well distinct from all other species through the very large and wide pronotum, more strongly transverse than in any other species known from China up to day.

The palearctic species of *Neoleistus* have recently been revised by Perrault (1991) and seem to possess one (*L. angulicollis* Fairmaire, 1886) or two (*L. niger* Gebler, 1847) such apophysis. On the other hand, Perrault (1985b) described *Leistus (Evanoleistus) negrei* from Nepal with the same type of apophysis, but judging it so evidently related to the other species of the group that it would be wrong to give it a different subgeneric position. For the same reason I prefer to include the two species here described in *Evanoleistus*, until further studies will point out the opportunity of separating them. Anyway, I keep some doubts on the value of *Neoleistus*, as several Chinese *Leistus* seem to possess one or two rudimental dorsal apophysis, and also a species of *Leistus* s. str. from Russian Far East (*L. janae* Farkač & Plutenko, 1992) has them. Maybe the name *Neoleistus* should be reserved to the American species, while the Eastern palearctic ones should be included all together in *Evanoleistus*, no matter how developed are the dorsal apophysis.

*Leistus (Evanoleistus) saueri* **sp. n.**

DIAGNOSIS. A *Leistus (Evanoleistus)* of 10.8-11.2 mm, piceous. Pronotum strongly transverse, strongly restricted but not sinuate towards base; elytra narrow, oval, with shoulders strongly obliquous, widest almost at the middle of length. Aedeagus with apex rather short, pointed downward (Fig. 17).

TYPE LOCALITY. China, W Sichuan, Mugezo Lake, 4000 m.

TYPE SERIES. Holotypus, male, 16 VII 1992, in coll. Sciaky. 1 Paratypus, female in coll. Pavesi.

DERIVATIO NOMINIS. This species is named after my friend Roman Sauer, renamed coleopterologist from Prague.

DESCRIPTION. Size mm 10.8-11.2; body blackish, iridescent on elytra, appendages dark reddish-brown, antennae (from antennomere 2) tarsi and buccal parts paler. Habitus as in Fig. 9. Microsculpture strong on head, pronotum and elytra.

Head big, inpunctate, not very convex, much narrower than pronotum; eyes big and convex. Mandibles very wide but rather short, with faint external sinuation. Temporae long and obliquous, collar constriction well marked dorsally Gular setae brought by a transversal carina IA = 1 54

Pronotum big, transverse, the sides almost regularly rounded in the anterior half, rectilinearly converging towards the basal angles, not sinuate Gutter well-defined, sparsely punctate, relatively large along its whole length Disc very flat, median line well marked, anterior margin almost rectilinear, unbordered, preapical area densely punctate, fore angles weakly prominent Prebasal sulcus well-defined, basal area completely punctate, basal angles obtuse Posterior seta absent IPw/l = 1 38, IPm/b = 2 00 Legs relatively long, fore tarsi of male strongly dilated

Elytra long and narrow, with striae deep and strongly punctate; intervals convex Third interval with four points adjoining the third stria Shoulders well marked, basal margin perpendicular to suture, forming a curve with lateral margin Maximum width little before middle of length, apex rather rounded IE/P = 1 30, IEl/w = 1 69

Abdominal segments with one couple of setae each, two couples on the pygidium of female

Genitalia Aedeagus with apex quite short, pointed and with two dorsal apophysis on the two sides of the ostium (Fig 17)

AFFINITIES Also this species has two dorsal apophysis partially covering the ostium, a character similar to that typical of the subgenus *Neoleistus* For the same reasons mentioned above (see the description of *L bohemorum* sp n ) I prefer to maintain it in the subgenus *Evanoleistus*

## SYSTEMATIC OBSERVATION

The seven species here described belong to the same group that should also include *L reflexus* Semenov, *L cycloderus* Tschitscherine, *L crenifer* Tschitscherine, *L nubicola* Tschitscherine, *L gracilicollis* Tschitscherine, and *L gracillimus* Tschitscherine Judging from the shape of the aedeagus, they must be ranged in the subgenus *Evanoleistus*, even though some of them (*L bohemorum* sp n , *L saueri* sp n and *L reflexus* sp n ) show some characters that should be typical of the subgenus *Neoleistus* Within this subgenus, they seem to approach the group of *L nepalensis* Jedlička (Perrault 1985b), as they are all species living at high elevations, wingless and almost always black or brown, without metallic hues

Among the other species of *Leistus* known from China, there are *L angulicollis* Fairmaire and *L shenseensis* Perrault belonging to the subgenus *Neoleistus* and *L yunnanus* Banninger belonging to the species-group of *L crassus* Bates of the subgenus *Evanoleistus*

At the moment I do not want to try a synthesis, as I am sure that many more species from the regions of Sichuan, Gansu, Xizang and Qinghai remain to be discovered, but I feel confident that a general work on the Chinese *Leistus* will require in future a thorough reexamination of all the subgenera and will most probably lead to their redefinition


### Acknowledgement

I would like to express my sincere thanks to my friends Jan Farkač and Roman Sauer (Prague) and Maurizio Pavesi and Stefano Zoia (Milan) for variously helping or encouraging me while I was writing this work


## REFERENCES


FARKAČ J & PLUTENKO A 1992 New Leistus s str from eastern Asia (Coleoptera, Carabidae) *Acta Soc Zool Bohemoslov* **56** 161 162

PERRAULT G -G 1985a Le genre Leistus Froehlig (Coleoptera Carabidae Nebriini) VI Le sous genre Evanoleistus Jedlicka (1) *Bull Mens Soc Linn Lyon* **54** 13 24

PERRAULT G G 1985b Le genre Leistus Froehlig (Coleoptera Carabidae Nebriini) VII Le sous-genre Evanoleistus Jedlicka (2) le groupe L nepalensis Jedlicka *Bull Mens Soc Linn Lyon* **54** 36-51

PERRAULT G.-G. 1986: Le genre Leistus Froehlig (Coleoptera - Carabidae - Nebriini). VIII: Sous-genre Leistus s. str. (1). Groupes d'especes et biogéographie. *Bull. Mens. Soc. Linn. Lyon* **55**: 50-65.
PERRAULT G.-G. 1988: Le genre Leistus Froehlig (Coleoptera - Carabidae - Nebriini). VIII: Sous-genre Leistus s. str. (2). Les especes asiatiques. *Bull. Mens. Soc. Linn. Lyon* **57**: 44-56.
PERRAULT G.-G. 1991: Le genre Leistus Froehlig (Coleoptera - Carabidae - Nebriini). XII. Le sous-genre Neoleistus Erwin: Le groupe de L. niger Gebler. *Bull. Mens. Soc. Linn. Lyon* **60**: 14-19.
SEMENOV A. 1889: Diagnoses coleopterorum novorum ex Asia centrali et orientali. *Horae Soc. Entomol. Ross.* **23**: 348-403.
TSCHITSCHÉRINE T. 1903: Les Leistus de l'intérieur de la Chine. *Horae Soc. Entomol. Ross.* **36**: 22-37.

*Acta Soc. Zool.Bohem.***57**: 211-293, 1993(1994)
ISSN 0862-5247

# The zoogeography of gall midges (Diptera: Cecidomyiidae) of the Czech Republic I. Evaluation of faunistic researches in the 1855-1990 period

Marcela SKUHRAVÁ

Bítovská 1227/9, CZ-140 00 Praha 4-Michle, Czech Republic

*Received May 17, 1993; accepted October 14, 1993*
*Published March 15, 1994*

**Zoogeography, faunistics, Diptera, Cecidomyiidae, horizontal and vertical occurrence, frequency groups, long-term changes, population dynamics; threatened, extinct, endangered, vulnerable species; Czech Republic.**

**Abstract.** Fauna of the family Cecidomyiidae, including 500 species, is evaluated from the zoogeographical point of view based on data about occurrence gathered by earlier authors and on data obtained during systematic faunistic investigations at 670 localities throughout the territory of the Czech Republic. One to 77 species have been recorded at individual localities. On average, 26 species have been found per locality. Average number of species falls with increasing elevation. Based on horizontal occurrence, all species are divided into six frequency groups by using the first six members of the geometrical progression with quotient 2 and coefficient a, accompanied with verbal denomination: I. species occurring solitarily, II. scarcely, III. moderately, IV.considerably, V.abundantly, VI.commonly. Based on vertical occurrence, thirteen types of similar vertical occurrence schemes are recognized. About 210 species belong to planare, 460 to colline, 290 to submountain, 122 to mountain, and 26 to sub-Alpine species (sensu lato). Based on analysis of long-term changes in population dynamics, gall midges are divided into six groups, viz. species with increasing, stable and decreasing population density, disappearing species and disappeared species and species insufficiently known. 64 species (12%) are threatened species of which 32 (7%) are extinct, 16 (3%) are endangered and 16 (3%) are vulnerable species.The horizontal and vertical occurrence of 230 gall midge species is demonstrated in maps and graphs.

This paper is dedicated to the memory of my university teacher, Prof Dr Julius Komárek (1892-1955), who as the first turned my attention to the study of this remarkable insect group - gall midges, Cecidomyiidae.

CONTENTS

## INTRODUCTION

The relatively small territory of the Czech Republic spreads over 79,000 square km in the middle of Europe and is inhabited by a rich fauna of the family Cecidomyiidae including about 500 gall midge species. Many data about occurrence which have been gathered by research workers since 1855 up to the present facilitate the analysis and evaluation of the gall midge fauna from the zoogeographical point of view. On the other hand, the territory of the Czech Republic is suitable for such studies - it comprises areas ranging from lowlands in elevation of about 100 meters up to mountains in elevation of 1600 m a.s.l. Although large areas of original forest have been cleared for cultivation and for timber, forests still cover about one-third of the country. Many plant species growing in forests, on meadows, in fields, along the rivers, brooks and around the ponds are host species for many gall midges.

The family Cecidomyiidae includes small flies the body of which varies from 0.5-8 mm in length. As adults, they live only several hours but as larvae they develop for several weeks, months, or one or two years. On the basis of larval feeding habits, gall midges may be divided into three biological groups. Phytophagous larvae feed upon plants and some of them cause galls on plant organs. Zoophagous larvae feed upon other small animals, especially insects and mites, and may be used for biological control. Mycophagous larvae feed upon fungi. In addition to these groups, there are gall midge species known and described only from the adults stage whose biology is at present completely unknown and these are called free-living species (Skuhravá, Skuhravý & Brewer 1984).

From about 500 gall midge species inhabiting the territory of the Czech Republic, 460 species (93%) are phytophagous, 16 species (3%) are zoophagous, 5 species (1%) are mycophagous and the biology of 16 species (3%) is unknown. All these species are the subject of the zoo-

*geographical analysis in this paper A review of all gall midge species forming the fauna of the* Czech Republic, including the zoogeographical diagnoses, will be given in the second part of the present study

## HISTORY

The study of phytophagous gall midge species has a long tradition in the territory of the Czech Republic Peculiar and curious deformations, the galls on various plants shrubs and trees already attracted the attention of research workers in the second half of the 19th century

Kirchner (1855, 1856) was the first who published a list of gall making insects from our territory He collected more than 100 galls in the vicinity of the towns of České Budějovice and Kaplice in southern Bohemia and described their forms He mentioned 18 galls of gall midges, most of which he designated only as "*Cecidomyia*" These gall midges were described and named later Amerling (1859) reported the occurrence of *Asynapta lugubris* which he reared from *Prunus spinosa* (correctly *Asphondylia pruniperda*)

In the 19th century the Czech Lands, Bohemia and Moravia, were the components of the Austro-Hungarian Empire Several excellent Austrian entomologists collected galls at Znojmo in southern Moravia, described several new gall midge species and contributed to the development of gall midge studies in our country Thomas (1878) recorded the occurrence of galls of *Cecidomyia persicariae* (correctly *Dasineura bistortae*) at the peak part of the Krkonoše Mts Handlirsch (1885) described a gall midge species, *Cecidomyia braueri*, from the locality "Frain bei Znaim" (= Vranov near Znojmo) Wachtl (1883) described four gall midges the galls of which were found near Znojmo, viz *Cecidomyia moraviae* in 1883 *Clinorrhyncha millefolii* in 1884, *Cecidomyia potentillae* and *C trachelii* in 1885 Mik (1885) reported the occurrence of galls of *Dasineura capsulae* found in the environs of Znojmo by Wachtl Hieronymus (1890) mentioned the occurrence of several gall midge species in the territory of Bohemia and Moravia

At the end of the 19th century the Czech entomologist Kowarz (1894) summarized knowledge dealing with insects in his Catalogus insectorum faunae bohemicae He introduced here 18 gall midge species assigned to 7 genera (without further data)

In the 20th century research workers paid attention to the occurrence of galls caused by various insects including gall midges For the increasing cecidological studies in all European countries there was the very important two volume edition of Houard (1908 1909) containing keys for determination of gall makers based on their host plant species Brehm (1905) found in the environs of Elbogen (now Loket) in western Bohemia 12 gall midge galls Some of them are the first findings in the territory of Bohemia Dittrich and Schmidt (1910) mentioned the occurrence of *Mayetiola poae* in the Jeseníky Mts

Vimmer (1905-1937) who was concerned mainly in the studies of morphology and anatomy of many species, genera and families of Diptera, extended knowledge of gall midges in his fourteen papers by describing seven new species the galls of which had been found and adults reared by Baudyš, viz *Rhopalomyia pseudofoliorum R simulans R baudysi R flavipalpis, Asphondylia baudysi, A moraviae* and *Dasineura armoraciae* Unfortunatelly, all type specimens of gall midges from Vimmer's collection have been lost Two Moravian phytopathologists, Prof Bayer and Prof Baudyš, contributed significantly to the cecidological studies in Bohemia and Moravia Bayer (1910 1946) published in his seven papers many data about the occurrence of galls caused by various animals, so called 'zoocecidia' He summarized data in a review of galls found in Bohemia (Bayer 1910) and in Moravia (Bayer 1914) The excellent German research worker Rubsaamen (1914) named one of the gall midge genera in honour of Bayer's contribution to gall midge advancement as *Bayeria*, with the type-species *B erysimi* the galls of which were found by Bayer in Brno environs The fundamental contribution to the gall midge studies in the Czech Republic is due to Baudyš (1912-1969) who, during nearly sixty years, published more than fifty papers dealing with galls and gathered much data about the occurrence of gall midges in the territory of Bohemia and Moravia

Two German entomologists, Mohn (1966-1971) and Ertel (1975) described several new species of gall midges based on larvae obtained from dry material from Baudyš's collection of galls

Several research workers studied gall midges from the point of view of their economic importance in agriculture and forestry Čermík (1925 1940) in his fourteen contributions reported about plant diseases and deformations including galls of gall midges, which occurred in his time on plants in the surroundings of the town Olomouc in northern Moravia Pfeffer (1937) drew attention to the new insect pest which developed in fir cones, viz *Resseliella piceae* in southern Bohemia Čermík (1943 1952) was occupied with insect pests developing in seeds of forest trees, especially with the gall midge *Resseliella piceae*. Data about the occurrence of gall midges damaging lucerne are given by Šedivý (1970). Příhoda(1972) reported the occurrence of a new pest on needles of coniferous trees in Bohemia. Křístek et al. (1976) studied insect pests of cones and seed of *Larix decidua*, and provided data about the occurrence of gall midges developing in larch cones in the Czech Republic. Gall midges as members of insect community developing in edafon of a spruce monoculture in southern Moravia are recorded in the paper of Vaňhara (1992). Informations on the occurrence and economic importance of gall midges collected in the territory of the Czech Republic during the first half of the 20th century are evaluated in the book by Skuhravá & Skuhravý (1960).

Skuhravá (1957-1982) published in fifteen contributions the results of the planned, systematic faunistic research of phytophagous gall midges which had been carried out at about 700 localities spread throughout the territory of the Czech Republic. All these data of many earlier and present authors relate to the occurrence or importance of gall midge species and do not examine the relationship between species and the area which they occupy in large territories. Skuhravá (1982) showed the possibility of using the faunal data for zoogeographical studies, elaborated the method of zoogeographical analysis (Skuhravá 1987) and used it to the evaluation of gall midge fauna inhabiting the territory of Slovakia (Skuhravá 1991).

## STUDY AREA

The Czech Republic, a newly independent country constituted at the beginning of 1993, occupying an area of about 79,000 square km extends through middle Europe and is situated between 12$^0$ 05'-19$^0$E longitude and between 48$^0$06' - 51$^0$03' N latitude. It comprises three historic lands - Bohemia, Moravia (often called the Czech Lands) and Silesia.

The territory of the Czech Republic is formed by the Bohemian Massif (Český masiv) which consists of a large elevated basin (the Bohemian Plateau, or (Česká tabule) encircled by mountain ranges that occasionally reach heights exceeding 900 meters above see level. The Vltava (Moldau) and the Labe (Elbe) rivers form the main drainage system, flowing northward through Germany to the North Sea, the Odra (Oder) River to the Baltic Sea and the Morava River flows south into the Dunaj River (Danube) and to the Black Sea.

In the middle of the territory are lowlands, then the elevation gradually increases to the south-west, north-west and north-east up to boundary mountains, viz. the Šumava Mts., Český les Mts., Krkonoše Mts., Orlické hory Mts., Hrubý Jeseník Mts. and Moravskoslezské Beskydy Mts. To the south-east the territory of the Czech Republic inclines down to the Pannonian lowlands. The mean elevation of the territory of the Czech Republic is about 450 m a.s.l. The lowlands (100-200 meters) occupy about 10%, hilly countries (200-500 meters) about 56%, highlands (500-1000 meters) about 32% and mountains (over 1000 meters) only about 2% of the whole territory.

The highest point of the Czech Republic is 1602 m a.s.l. at the mountain Sněžka in the Krkonoše Mts., and the lowest point is 116 m a.s.l. at the river Labe near Hřensko in northern Bohemia where the Labe River enters Germany. The climate is mixed and it is on the dividing line between the Atlantic climate occurring in western Europe and the continental climate of eastern Europe. It is characterized by an annual mean air temperature at Praha 9,2°C, at Brno 8,4°C, and average annual precipitation at Praha 478 mm, at Brno 522 mm. In the long-term (1901-1950), July is the warmest, January the coldest month.

From the phytogeographical point of view, Dostál (1966) divided the territory of the Czech Republic into three regions, viz. the Hercynicum (Central-European forest flora), the Pannonicum (Central European and south-east European thermophilous flora) and the Carpaticum occidentale with three subregions, viz. the subregion of the Moravian pre-Carpathian flora, the subregion of Silesian lowlands and the subregion of Beskyd Mts. In 1987 research workers of the Institute of Botany in Průhonice elaborated and published a map "Regionálně fytogeografické členění ČSR" (Regional-Phytogeographical outline of the ČSR, 1987) in which the territory of the Czech Republic is divided into three phytogeographical areas: the thermophyticum, the mesophyticum and the oreophyticum. About 3,000 plant species belonging to the Angiospermae (Monocotyledones and Dicotyledones) grow naturally in various plant communities, the composition of which changes with rising altitude from lowlands to mountain. From the zoogeographical point of view, the territory of the Czech Republic is ranged in the classification system of biogeographical provinces of the world (Udvardy 1975) to the western half of the Palaearctic Region (or realm) from which the greater part belongs to the middle European forest Province and the smaller part lying in the south-eastern part of the Czech Republic to the Pannonian Province.This is in accordance with the earlier division of Mařan (1958) who gave, with the exception of the above mentioned units, two subprovinces, viz. the sub-province of the middle-Bohemian lowlands and hilly countries, and the sub-province of the so-called Varrissian Mts, i e the boundary mountains

MATERIAL AND METHODS

The collection of about 500 gall midge species which has been found since 1855 up to the present in the territory of Bohemia and Moravia, forming now the Czech Republic, is the fundamental material for this zoogeographical study There are evaluated 30,000 data about the occurrence of gall midge species of which 12,000 have been gathered by earlier research workers and the rest by the present author Earlier research workers carried out investigations of the occurrence of gall-making animals mainly incidentally They collected galls in localities where they lived or worked, or during various trips

At the beginning of our studies we provided a plan of systematic investigations of the gall midge fauna of the Czech Republic the territory of which we divided into several parts Localities in which we intended to collect gall midge galls were placed throughout the whole territory using the map with Ehrendorfer's network, as far as possible one locality in each square (See Fig 1)

The occurrence and distribution of gall midge species at these localities have been investigated by means of an uniform method by collecting galls on host plant species at each locality and by slowly walking through variuos biotopes in the course of one or two hours, searching and collecting galls on plants, or plants inhabited by mites and aphids, or rusts in which larvae of gall midges may develop All findings were recorded, including the occurrence of the most common species Results of such a method are comparable

Gall midges inhabiting the territory of the Czech Republic are evaluated from two points of view, viz. from the geographic and from the zoological points of view From the geographic point there is presented the horizontal occurrence by various numbers of gall midge species which occur at individual localities in the whole territory, and the vertical occurrence is shown by the average numbers of gall midge species which occur in the rising altitudinal zones

On the other hand, the gall midge fauna is also evaluated from the point of view of frequency of species in investigated localities Each species is evaluated for occurrence and distribution in the territory in the past and in the present, which shows its long-term changes in population dynamics and also its ability to live in various altitudinal zones and various altitudinal ranges Demands of majority of the gall midge species are illustrated using maps of their horizontal occurrence and graphs of their vertical occurrence

These maps and graphs, together with analyses of the occurrence of gall midge species in the successive altitudinal zones by 100 metres, make it possible to assign each gall midge species to one of the altitudinal groups

For the elaboration of graphs, the corresponding elevations of each locality were determined from the Atlas of Czechoslovak Socialistic Republic (1966), or in the Statistic Lexicon of Municipalities of the ČSSR (1976) Nomenclature of host plant species is based on Ehrendorfer (1973), nomenclature of gall midge species on Skuhrava (1986)

RESULTS

## Diversity

The diversity of gall midge species at localities in the territory of the Czech Republic ascertained during our faunistic investigations is shown in Fig 2 where numbers of species per locality are indicated by circles of various size At individual localities, up to 77 gall midge species have been recorded during one excursion lasting one to two hours Only one gall midge species was found at the peak part of the mountain Kokrháč, 1443 m a s l in the Krkonoše Mts. in eastern Bohemia, and at Šerák, 1351 m a s l in the Hrubý Jeseník Mts in northern Moravia.

Two to ten gall midge species were found at 110 localities, eleven to twenty species at 150 localities; twenty to thirty species at 160 localities; thirty to fourty species at 130 localities; fourty to fifty species at 90 localities, fifty to sixty species at 26 localities, and more than sixty species, the highest numbers, were found at three localities in eastern Bohemia, viz 62 species at Doudleby nad Orlicí, 281 m a s l ; 73 species at Rybná nad Zdobnicí, 405 m a s l., and even 77 gall midge species at the locality Spy near Nove Město nad Metuji, 324 m a s l

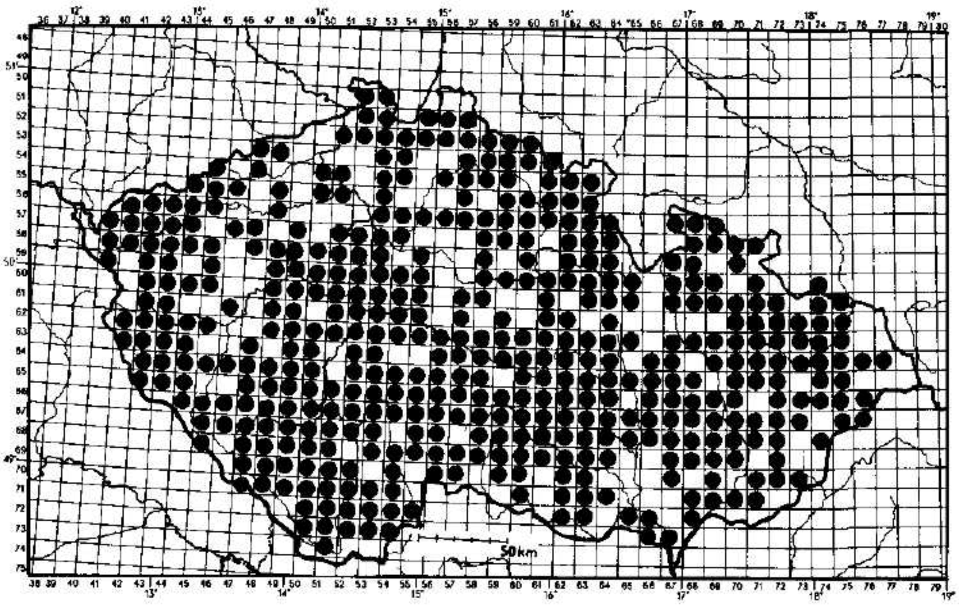



Fig.1. Czech Republic where a planned systematic faunistic investigation was carried out in the period of 1957-1982. The territory is divided by means of Ehrendorfer's network into small oblongs of a size 11 x 12 km. Black circles show localities where gall midge galls were collected.

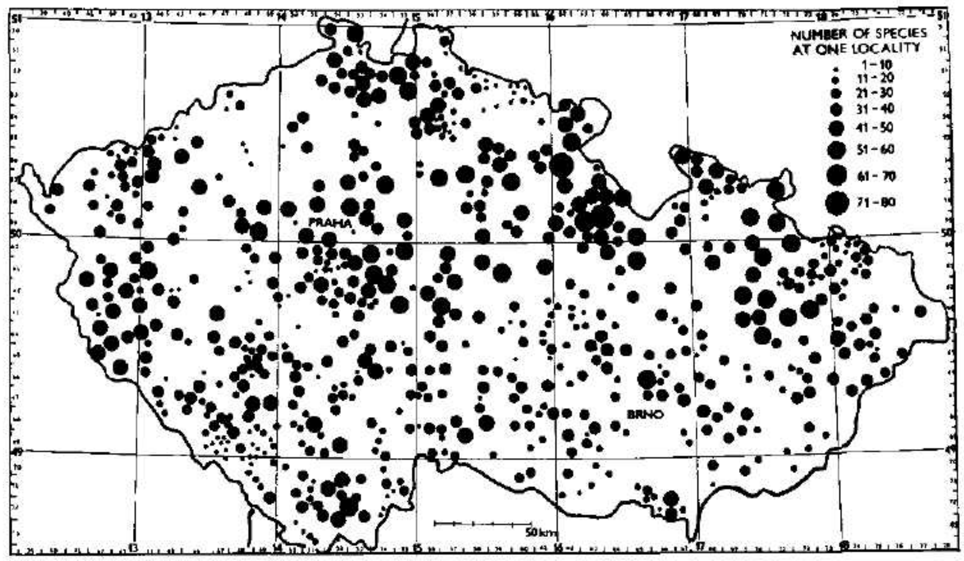



Fig.2. The territory of the Czech Republic with black circles of various size showing various numbers of gall midge species at localieies.

On average, 26 gall midge species have been found per locality in the territory of the Czech Republic which is more than in the territory of Slovakia, where it was 19,5 species (Skuhravá 1991).The average numbers of gall midge species differs in particular regions of the Czech Republic: the highest number, 38 species were found in northern Moravia (Skuhravá 1964) and in eastern Bohemia (Skuhravá 1980); 37 species in the Český les Mts. in western Bohemia (Skuhravá 1973); 30 species in middle Bohemia (Skuhravá 1979); 29 species in the Novohradské Hory Mts. in southern Bohemia (Skuhravá 1971); 28 species in the area of Křivoklátsko in middle Bohemia (Skuhravá 1975); 26 species in the Jihočeské pánve (Southern Bohemian Basin) (Skuhravá 1974): 25 species in north-eastern and south-western Moravia (Skuhravá 1980); 24 species in the Oderské vrchy Hills in northern Moravia (Skuhravá 1959 ); 23 species in the Bohemian-Moravian Uplands (Skuhravá 1980); 22 species in the Český ráj (Bohemian Paradise) at the boundary line of middle and eastern Bohemia (Skuhravá 1977); 18 species in the Šumava Mts. (Skuhravá 1972); 14 species in the area of Hlučínsko in northern Moravia (Skuhravá 1957); and only 8 species on the average in localities in the Krkonoše Mts.(Skuhravá 1961).

The diversity of gall midge species is dependent on the diversity and richness of vegetation which includes host plant species for the gall midges. The changing composition of vegetation the species of which at present have decreased significantly, with many plant species disappearing, or quite disappeared from our country, influences the number of gall midge species. The diversity of gall midges at localities in the Czech Republic which were higher at the beginning of our investigations in several areas, fluctuated and changed during thirty years and at present shows the successive decreasing trend. Many gall midge species, which were abundant in the past, are rare at present and several species quite disappeared from our landscape (see chapter: Threatened gall midge species).

**Horizontal occurrence**

The horizontal occurrence of gall midge species that is their occurrence on large, extensive territory of the whole Czech Republic where investigations were carried out on 670 localities. Based on horizontal occurrence given by number of localities at which the particular species have been found, where one locality is considered as one finding, it is possible to divide all gall midge species recorded in the territory of the Czech Republic into six frequency groups by using the first six members of the geometrical progression with quotient 2 and coefficient "a":
$a.2^0 + a.2^1 + a.2^2 + a.2^3 + a.2^4 + a.2^5 = 63.a$ (=a sum).

The value of this coefficient may be determined from a sum of the geometrical progression. In the case of 670 localities which have been investigated in the territory of the Czech Republic, 63 a = 670, and a = 10,6. Each of the six members of this geometrical progression defines one frequency group. After the substitution, the geometrical progression has these values:
10,6 + 21,2 + 42,4 + 84,8 + 169,6 + 339,2

The frequency groups are then derived, adapted and it is possible to describe each of these frequency groups in words:

| Frequency group: | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Number of localities: | 1-10 | 11-32 | 33-74 | 75-160 | 161-330 | 331-670 |
| Verbal enomination: | solitary | carce | moderate | considerable | abundant | common |

The ranging of gall midge species in particular frequency groups refers to the time and area in which the investigations are carried out. The population dynamics of gall midges, as with other insects, change in long-term periods and the local abundance varies under the influence of abiotic and biotic factors. Many gall midge species which occurred abundantly in the past, quite disappeared from our country. On the other hand, some gall midge species which were very rare in the past, rose abruptly up to pest status, as was the case of *Haplodiplosis marginata*.

Under the following frequency groups there are given the numbers of gall midge species and percentage parts which they occupy from all gall midge species recorded in the Czech Republic and, as examples, the gall midge species developing on trees and shrubs and some interesting species developing on herbaceous plants. Frequency group I includes species occurring solitarily which were found at 1 - 10 localities. It involves 154 gall midge species (45%). The following species developing on trees are representatives: gall midge species limited to *Quercus cerris*, viz. *Janetia cerris, J. homocera, J. nervicola, Dryomyia circinans, Contarinia subulifex* and *Contarinia quercicola; Asynapta strobi* and *Dasineura abietiperda* developing on *Picea excelsa; Paradiplosis abietis* on *Abies alba; Phegobia fagicola* on *Fagus sylvatica; Dasineura berberidis* on *Berberis vulgaris; Sackenomyia reaumurii (Phlyctidobia solmsii)* on *Viburnum lantana*. On herbaceous plants: *Acodiplosis inulae* on *Inula britannica; Macrolabis orobi* on *Orobus vernus; Rhopalomyia tubifex* on *Artemisia campestris; Dasineura daphnes* on *Daphne cneorum; Dasineura phyteumatis* on *Phyteuma orbiculare; Dasineura armoraciae* on *Armoracia rusticana*. Some of them belong to disappearing species.

Frequency group II includes species occurring scarcely which have been found at 11 - 32 localities. In this group there belong 69 gall midge species (20%). As typical species developing on trees may be designated: *Contarinia baeri* on *Pinus sylvestris; Taxomyia taxi* on *Taxus baccata; Oligotrophus juniperinus* on *Juniperus communis; Massalongia rubra* on *Betula pendula; Placochela ligustri* on *Ligustrum vulgare; Craneiobia corni* on *Cornus sanguinea*. On herbaceous plants: *Rhopalomyia tanaceticola* on *Tanacetum vulgare; Rhopalomyia millefolii* on *Achillea millefolium; Contarinia melanocera* on *Genista tinctoria; Asphondylia baudysi* on *Coronilla varia; Asphondylia sarothamni* on *Sarothamnus scoparius; Asphondylia verbasci* on *Verbascum nigrum*.

Frequency group III includes species of moderate occurrence which were found at 33 - 74 localities. It includes 48 gall midge species (14%). Typical species developing on trees: *Thecodiplosis brachyntera* on *Pinus sylvestris; Contarinia fagi* on *Fagus sylvatica; Dasineura acrophila* on *Fraxinus excelsior; Aschistonyx carpinicolus, Contarinia carpini* and *Dasineura ruebsaameni* on *Carpinus betulus; Janetiella lemei* on *Ulmus; Contarinia tiliarum* on *Tilia; Anisostephus betulinus* on *Betula; Asphondylia pruniperda* on *Prunus spinosa; Placochela nigripes* on *Sambucus nigra*. On *herbaceous plants: Cystiphora sanguinea* on *Hieracium pilosella; Dasineura affinis* on *Viola reichenbachiana; Mayetiola poae* on *Poa nemoralis; Dasineura potentillae* on *Potentilla argentea; Dasineura ranunculi* on *Ranunculus acris*.

Frequency group IV includes species of considerable occurrence which have been found at 75 - 160 localities. In this group there are 41 gall midge species (12 %). Species developing on trees: *Dasineura kellneri (D. laricis)* on *Larix decidua; Macrodiplosis volvens* on *Quercus robur; Hartigiola annulipes* on *Fagus sylvatica; Dasineura irregularis (D. acercrispans), Drisina glutinosa* and *Harrisomyia vitrina* on *Acer pseudoplatanus; Dasineura fraxini* on *Fraxinus excelsior; Zygiobia carpini* on *Carpinus betulus; Physemocecis ulmi* on *Ulmus; Dasineura tiliae (D. tiliamvolvens)* and *Didymomyia tiliacea* on *Tilia; Semudobia betulae* on *Betula; Dasineura clavifex* and *D. salicis* on *Salix; Harmandia tremulae* and *Contarinia petioli* on *Populus tremula; Mikomya coryli* on *Corylus avellana; Contarinia sorbi* on *Sorbus aucuparia*. On *herbaceous plants: Contarinia aequalis* on *Senecio nemorensis* ssp. *Fuchsii; Rhopalomyia foliorum* on *Artemisia vulgaris; Contarinia loti* on *Lotus corniculatus; Contarinia craccae* on *Vicia cracca; Rondaniola bursaria* on *Glechoma hederacea; Wachtliella persicariae* on *Polygonum amphibium*.

Frequency group V includes species of abundant occurrence which have been found at 161 - 330 localities. In this group there are 27 gall midge species (8 %). Typical species developing on trees: *Macrodiplosis dryobia* and *Contarinia quercina* on *Quercus robur* and *Q. petraea; Mikio-*

*la fagi* on *Fagus sylvatica; Dasineura fraxinea* on *Fraxinus excelsior; Dasineura tortilis (D alni)* on *Alnus glutinosa* and *A. incana; Dasineura thomasiana* and *Physemocecis hartigi* on *Tilia cordata* and *T. platyphyllos; Plemeliella betulicola* on *Betula pendula* and *B. pubescens; Dasineura crataegi* on *Crataegus oxyacantha; Dasineura rosaria, D. terminalis* and *Iteomyia capreae* on various *Salix*-species; *Harmandia cavernosa, H. globuli* and *H. populi* on *Populus tremula; Wachtliella rosarum* on *Rosa canina; Dasineura plicatrix* and *Lasioptera rubi* on various *Rubus*-species. On herbaceous plants: *Spurgia (Bayeria) capitigena* on *Euphorbia cyparissias; Kiefferia pericarpiicola* on various species of the family Apiaceae; *Cystiphora taraxaci* on *Taraxacum officinale; Macrolabis heraclei* on *Heracleum sphondylium; Dasineura viciae* on *Vicia sepium* and other *Vicia*-species; *Dasineura trifolii* on *Trifolium repens*.

Frequency group VI includes species of common occurrence which have been found at more than 331 localities. In this group there are only six species (2 %), of which only one develops on a tree and five on herbaceous plants. They are the following species: galls of *Dasineura populeti* formed by marginal leaf rolls on *Populus tremula* were found at 333 localities; flower bud galls of *Schizomyia galiorum* at 351 localities and stem galls of *Geocrypta galii* at 406 localities; both species on *Galium mollugo* and other *Galium-species*; leaf bud galls of *Dasineura hyperici* on *Hypericum perforatum* at 422 localities; leaf galls of *Dasineura urticae* on *Urtica dioica* at 430 localities, and galls of *Jaapiella veronicae* on vegetative tops of *Veronica chamaedrys* at 501 localities.

For zoogeographical considerations, frequency groups III up to VI are very useful as they include species that are abundant to common: more date ensures more correct zoogeographical conclusions.

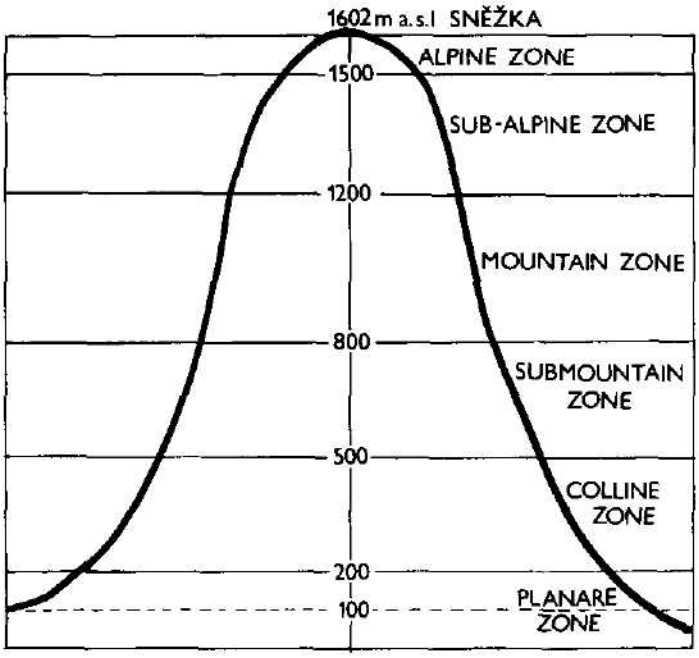



Fig.3. Scheme of the altitudinal zonation of the territory of the Czech Republic demonstrated on the Sněžka mountain, 1602 m a.s.l., in the Krkonoše Mts.

### Vertical occurrence

The composition of vegetation, which included host plant species for phytophagous gall midges, changes with rising altitude from lowlands to mountain. For that reason the occurrence of gall midge species is analyzed here from the point of view of relations of gall midge species to altitudinal zones. The basis of this analysis is the altitudinal zonation of the vegetation in the High Tatra Mountains given in the Atlas of ČSSR (1966) with the characteristics of planare, colline, submountain, mountain and sub-Alpine zones which is adapted for the Krkonoše Mountains (Fig. 3).

In the Czech Republic the mountain zone extends in elevation 800-1200 m and the sub-Alpine zone begins over 1200 m a.s.l. and extends up to the peak of the mountain Sněžka, 1602 m a.s.l., the highest point od the Czech Republic. The localities at which we investigated the gall midge fauna were placed in successive altitudinal zones from lowlands up to mountain as equally as it was possible.

The vertical occurrence of gall midges in the territory of the Czech Republic is shown by the average number of gall midge species recorded at localities in separate successive altitudinal zones by 100 metres (Fig.4). Their vertical occurrence falls with increasing elevation. On average, 30 gall midge species have been found at one locality in the planare zone (100 - 200 m) where investigations have been carried out at 18 localities. In the colline zone (200 - 500) where investigations were carried out at 424 localities, the average number is also 30 species. The highest average number, 32 gall midge species, was ascertained here in the altitudinal zone

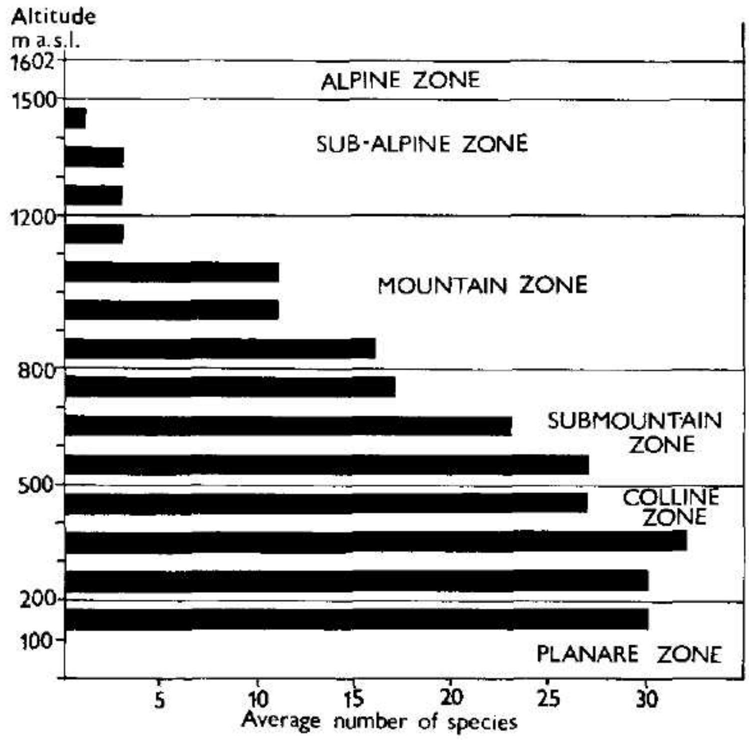



Fig.4. The falling average number of gall midge species with rising elevation given in 100 meters spans in the altitudinal zones of the Czech Republic from the planare zone where, on average, 30 species have been recorded, up to the sub-Alpine zone where only 3 species have been found.

between 300 - 400 m. The average number of gall midge species begins to fall in the submountain zone (500 - 800 m) where 183 localities have been examined and where the average number is 22 species. The average numbers in belts of 100 m are: 27, 23 and 17 species. The greatest decline is between the submountain and mountain zone and in the lower part of the mountain zone.

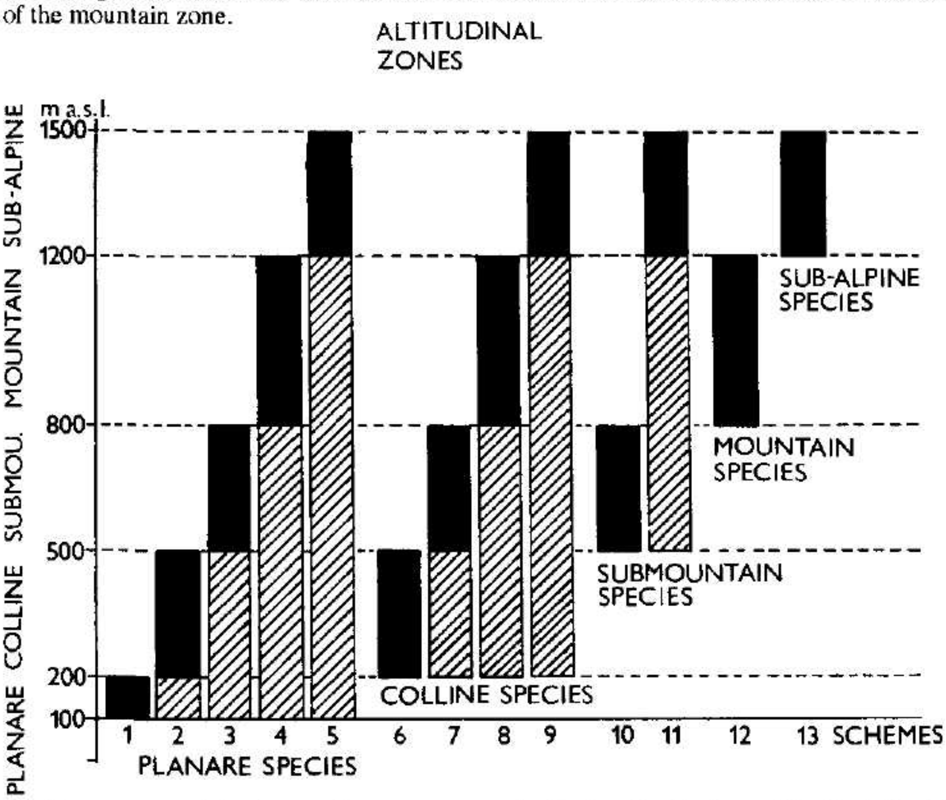



Fig. 5 Thirteen types of similar vertical occurrence recognized in the gall midge fauna of the Czech Republic. 1-5 planare species; 6-9 colline species; 10-11 submountain species; 12 mountain species; 13 sub-Alpine species. Black parts of columns indicate the highest altitudinal zone into which the particular gall midge species reaches from lower lying zones; the diagonal shading of columns shows the lowest level from which particular species occur (detailed explanation in text).

In the mountain zone (800 - 1200 m) investigations were carried out at 38 localities and on average 10 species have been recorded. The average number in belts of 100 m are ; 16, 11, 11, and 3 species. In the sub-Alpine zone (1200 - 1500 m), searched at 5 localities, there occur only two or three gall midge species.

The maximum occurrence of a particular species in a particular altitudinal zone agrees with its ecological potency. Such gall midge species may be named after this altitudinal zone. They are planare, colline, submountain, mountain and sub-Alpine gall midge species. Few gall midge species are restricted to the narrow span of one zone (monozonal species), mostly they occur in two (oligozonal species), three or four altitudinal zones (polyzonal species).

Based on analyses of about 500 gall midge species in the Czech Republic, the occurrence of each of them shows certain regularities which may be demonstrated on graphs of vertical occurrence, above all of most common gall midge species (see Fig.46). Their occurrence begins

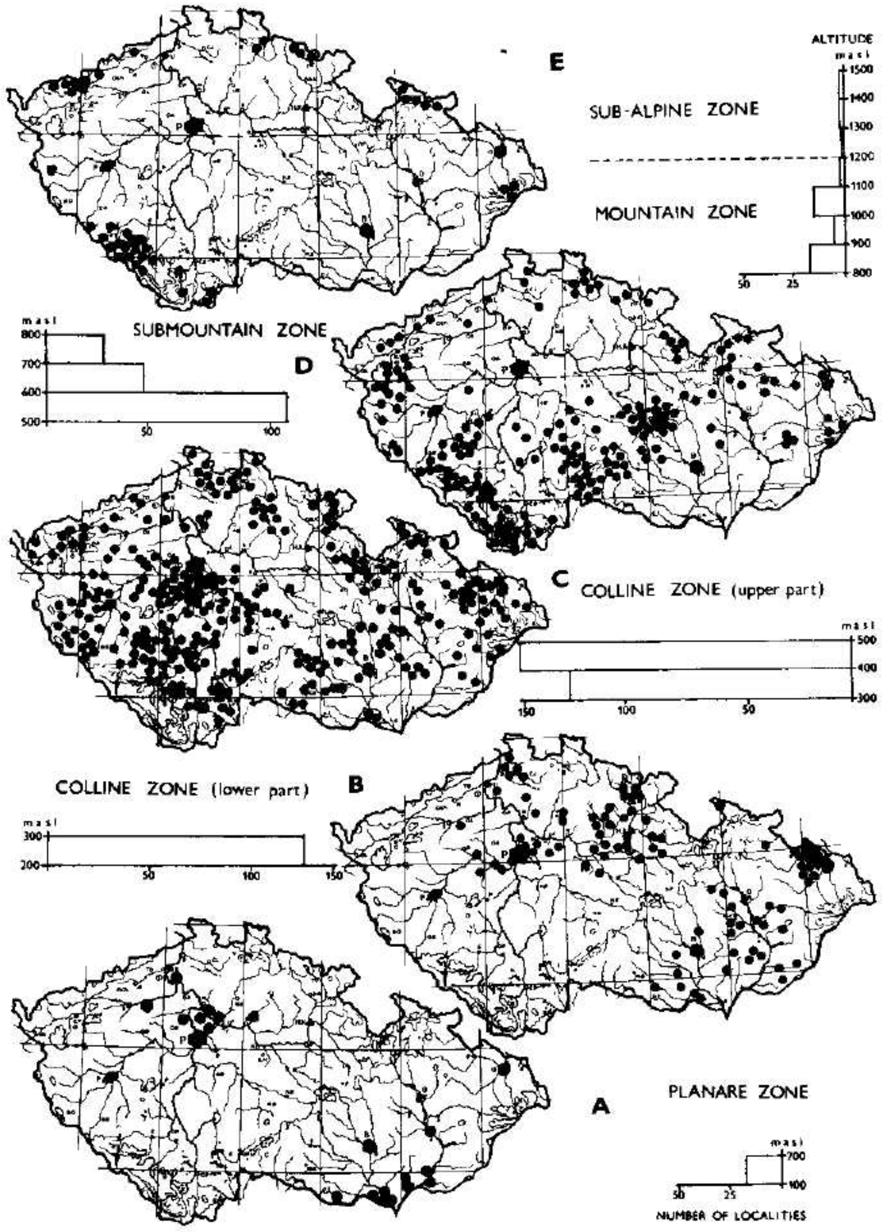



Fig.6. Five maps of the territory of the Czech Republic showing the dislocation of examined localities and their number (in graphs) in particular zones: A planare zone, investigated at 18 localities; B colline zone (lower part), at 124 localities; C colline zone (upper part), at 300 localities; D submountain zone, at 183 localities; E mountain zone, at 38 localities, and sub-Alpine zone, at 5 localities.

at one, two or several localities in the lower part of the altitudinal zones, the maximum occurrence is usually in the middle part and the occurrence is finished at one, two or several localities of the upper altitudinal zone

Such manners, or manifestation of existence of gall midge species dealing with its occurrence in particular landscape which is noted for altitudinal zonation, may be designated as similar vertical occurrence scheme (outline, type, pattern) In the fauna of gall midges inhabiting the territory of the Czech Republic, there were recognized thirteen types of similar altitudinal (vertical) occurrence schemes which are treated in the next chapters (see Fig 5)

To facilitate the evaluation, all examined localities in the territory of the Czech Republic were divided into five maps showing the distribution of localities in particular altitudinal zones which are accompanied with corresponding graphs showing their vertical occurrence (see Fig 6)

### *1. Planare gall midge species* (Fig 7)

The planare zone occupies lowlands from sea level up to elevations of 200 or 300 m a s l In the Czech Republic that is from 116 m a s l , the lowest point at the level of the river Labe near Děčín in the northern Bohemia, up to 200 meters This territory, today almost completely cultivated, was originally covered mainly with formations of floodplain forest Today large parts are occupied by crop lands and settlements

In the planare zone, the gall midges were collected in 18 localities lying in the middle part of Bohemia and in the southern part of Moravia (see Fig 6 A) Together with the findings of earlier authors, in the planare zone there were found 210 gall midge species, i e 42 % of all ascertained species in the Czech Republic Larvae of all these species develop on host plant species indigenous in this zone and may be, therefore, designated as planare species sensu lato

Only a small part of them is restricted to the planare zone; most of them penetrate into the colline zone, and some of them reach up into the higher lying altitudinal zones up to sub-Alpine zone All these gall midge species occurring in the planare zone may be ranged based on similar vertical occurrence schemes into five groups (see Fig 5 1-5)

1 species occurring in narrow elevation spread of the planare zone between 100 200 (300) meters They are planare species sensu stricto
2 species occurring in slightly wider elevation spread inhabiting both planare and colline zones and reaching at most up to 500 meters They will be treated in the chapter about colline gall midge species
3 species the occurrence of which begins in planare zone which penetrate through colline zone to the submountain zone they will be discussed under submountain species
4 species the occurrence of which begins in the planare zone which penetrate through colline and submountain zones and reach the mountain zone They will be analyzed under mountain species
5 species the occurrence of which begins in the planare zone which penetrate through colline, submountain and mountain zones and reach the sub Alpine zone They will be treated under sub Alpine species

Planare gall midge species (sensu stricto)

Only 14 species, i e about 7 % of all gall midge species found in the planare zone, belong in this group, occurring in the narrow elevation spread between 100 - 200 meters Two of them, viz *Contarinia subulifex* and *Contarinia quercicola*, are in their larval development restricted to tree host plant species, the oak *Quercus cerris*, causing galls on leaves and leaf buds Other gall midge species live in the larval stage on various organs of herbaceous host plant species, some of them causing galls of various types

Larvae of *Microlasioptera flexuosa* develop inside the non-flowering stems of *Phragmites australis* without the reed showing any signs of attack Larvae of *Dicerura iridis* live in groups under the leaf sheats of *Iris pseudocarus* and larvae of *Planetella subterranea* under the leaf

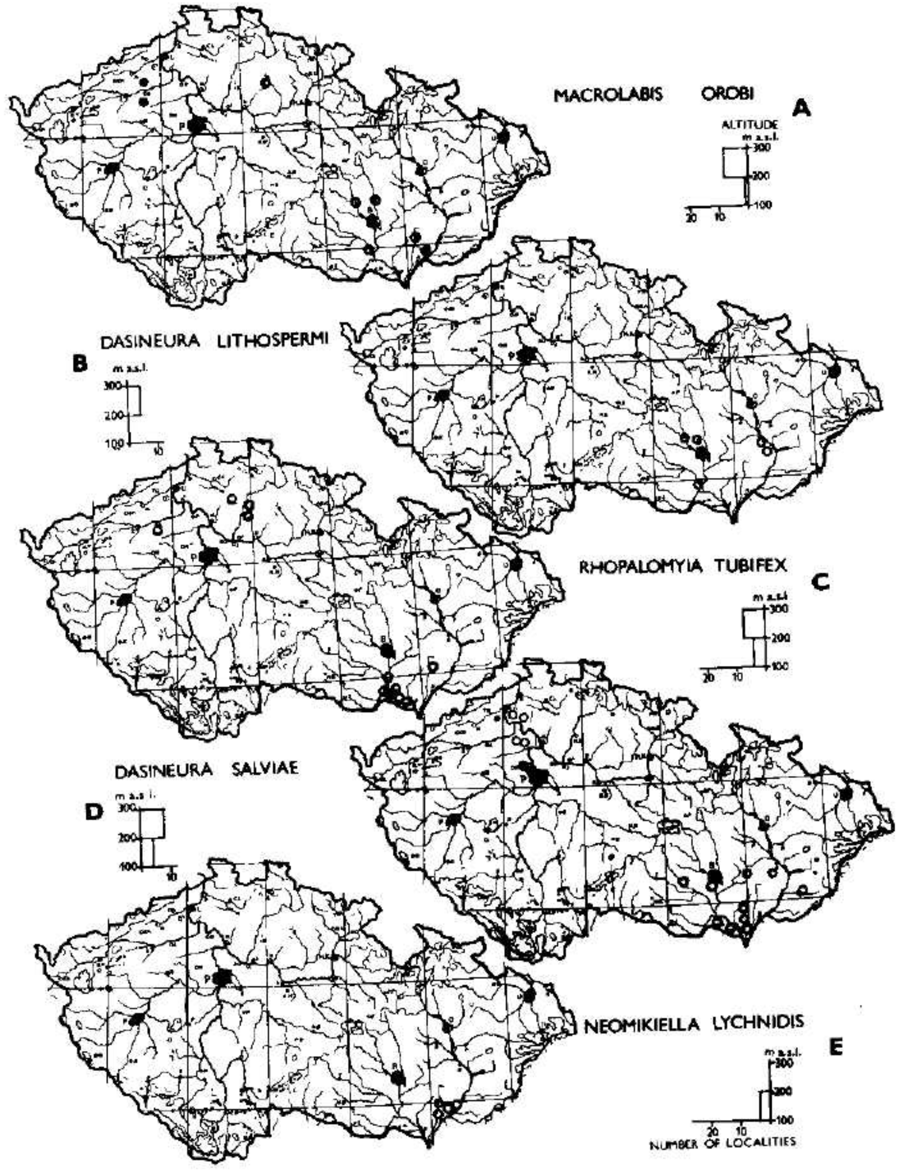



Fig. 7. Planare gall midge species inhabiting the lower part of the colline zone: A *Macrolabis orobi* on *Lathyrus vernus*; B *Dasineura lithospermi* on *Lithospermum officinale*; C *Rhopalomyia tubifex* on *Artemisia campestris*; D *Dasineura salviae* on *Salvia pratensis* and *S. nemorosa*; E *Neomikiella lychnidis* on *Melandrium album*.- Note. In all maps white circles indicate findings of earlier authors referring to the first half of the 20th century and black circles findings of Skuhravá referring to the second half of the 20th century.

sheaths of *Carex* sp. Larvae of ***Contarinia lentis*** destoy flower buds of ***Lens nigricans*** and in south-western Slovakia they cause loss of lentil seeds. Larvae of ***Dasineura*** alyssi form stem galls on ***Alyssum alyssoides***. Larvae of ***Neomikiella lychnidis*** cause large ***conspicuous*** white galls on ***Melandrium album***. Larvae of ***Rhopalomyia cristaegalli*** develop in flower bud galls of ***Rhinanthus minor***. Larvae of ***Rhopalomyia baudysi, R. flavipalpis, R. pseudofoliorum*** and ***R. tubifex*** develop in various types of galls on several species of the genus ***Artemisia***. Larvae of ***Resseliella dizygomyzae*** live in the channels inside the shoots of basket willow, ***Salix viminalis*** (Urban & Skuhravá 1982).

Several gall midge species inhabit a little broader elevation spread being found up to 300 meters. Larvae of ***Macrolabis orobi*** live in rolled margins of ***Lathyrus vernus***. Larvae of ***Dasineura lithospermi*** cause rosette leaf galls on ***Lithospermum officinale***. Larvae of ***Rhopalomyia tubifex*** produce tubular galls at the growing tip of ***Artemisia campestris***. Larvae of ***Dasineura salviae*** change into galls the flower buds of ***Salvia pratensis*** and ***S. nemorosa.***

### *2. Colline gall midge species* (Figs 8 - 15*)

The colline zone occupies hilly countries spread between 200 - 500 m a.s.l. which were originally overgrown with oak forest with predominant trees of ***Quercus robur, Q. petraea, Carpinus betulus*** and ***Fraxinus excelsior***.

In the colline zone the composition of the gall midge fauna was investigated together in 424 localities spread over the whole territory of the Czech Republic from which 124 localities belonged to elevation spread between 200 - 300 m, 138 localities between 300 - 400 m and 162 localities between 400 - 500 meters (see Fig. 6 B,C).

In the colline zone there have been found 460 species of gall midges, i.e. 92 % of all gall midge species recorded from the territory of the Czech Republic. They may be called colline gall midge species sensu lato. The occurrence of most of them, including 264 species, begins at elevations over 200 meters. They occur only in the colline zone, or penetrate higher altitudinal zones. The occurrence of the remainder, including 196 species, begins in one, two or several localities of the planare zone at elevations under 200 meters. These species are spread in the colline zone up to its upper boundary, or overcome it and penetrate higher altitudinal zones. Based on the similar vertical occurrence schemes, all these gall midge species may be ranged in eight groups: the first up to the fourth include species the occurrence of which begins in the colline zone (Fig. 5: 6-9), and the fifth up to the eight those the occurrence of which begins in the planare zone (Fig. 5: 2-5).

1. species occurring only in the colline zone at elevations between 200 - 500 meters (colline species sensu stricto)
2. species inhabiting the colline zone and reaching the submountain zone. They will be treated under submountain species
3. species the occurrence of which begins in the colline zone which penetrate through the submountain zone to the mountain zone, they will be discussed under mountain species
4. species penetrating from the colline zone through submountain and mountain zones to the sub-Alpine zone. They will be treated under sub-Alpine species
5. species their occurrence begins in the planare zone and is finished here in colline zone, they will be discussed in this chapter
6. species coming from the planare zone, penetrating up to submountain zone: they will be discussed under submountain species
7. species coming from the planare zone penetrating up to the mountain zone, they will be treated under mountain species
8. species coming from the planare zone, penetrating through colline, submountain and mountain zones up to the sub-Alpine zone, they will be discussed under sub-Alpine species

---

* Figs 8-52 see pages 237-281

Colline gall midge species (sensu stricto)

In the rather narrow elevation range between 200 - 500 meters which forms the colline zone 124 species of gall midges occur, i.e. 47 % of all species living in this zone. The majority of them, about 100 species, are phytophagous, with larvae developing in various organs of host plant species - on herbaceous plants, shrubs and trees. Only a small part - 10 species - are zoophagous, with larvae attacking other small animals, viz. mites, aphids, psyllids or other gall midges. The rest are species the biology of which is unknown.

Many phytophagous gall midge species which occurred abundantly in the past, almost disappeared from our landscape, maybe in connection with large changes during the second half of the 20th century. For example: *Hybolasioptera cerealis*, larvae of which develop in depressions on stem of *Secale cereale* and various grasses; *Dasineura lotharingiae*, larvae of which cause galls on flower buds of *Cerastium glomeratum; Rhopalomyia baccarum*, which produces berry-shaped galls on stems of *Artemisia vulgaris; Dasineura bupleuri*, which develop in galls on growing tips of *Bupleurum falcatum*, and *Bayeria thymicola*, larvae of which cause rosette galls on *Thymus serpyllum* (Fig.8).

On the other hand, *Contarinia solani*, larvae of which induce galls on flower buds of *Solanum dulcamara*, is an increasingly abundant species. Galls of *Macrolabis holosteae* at the growing top of *Stellaria holostea* may be easy overlooked, whereas galls of *Dasineura stellariae* on the same host plant species are conspicuous, ovoid in the shape and brown coloured. *D. stellariae* is also a disappearing species. *Dasineura loewii* deforming flower buds of *Euphorbia sequierana*, and *Dasineura lamiicola*, larvae of which develop in axillar or terminal bud galls on *Lamium maculatum*, may also be species that have disappeared (Fig.9).

More than 20 phytophagous species develop on various trees growing in this zone. *Atrichosema aceris* causes swellings of petioles on *Acer campestre*. Larvae of *Contarinia acerplicans* live in folded leaves of *Acer pseudoplatanus*. Both species are very rare. Larvae of *Apiomyia bergenstammi* damage young branches of *Pyrus communis*. Larvae of *Contarinia rhamni* develop inside swollen deformed buds of *Frangula alnus*. Larvae of *Contarinia pruniflorum* develop in flowers of *Prunus spinosa* and larvae of *Contarinia rubicola* in swollen unopened flower buds of *Rubus caesius*. Larvae of *Dasineura tetensi* live inside deformed young leaves of *Ribes nigrum*, larvae of *Contarinia ribis* in swollen unopened flower buds of *Ribes uva-crispa*. Five gall midge species develop in damaged organs of various species of the genus *Salix*, viz. *Dasineura albipennis, D. nielseni, D. pseudococcus, D. purpureaperda* and *D. triandraperda*. Larvae of *Dasineura xylostei* produce leaf galls on *Lonicera xylosteum*. Larvae of *Xylodiplosis nigritarsis* develop inside xylem vessels in fresh cut wood of *Quercus robur*. Larvae of *Janetiella siskyiou* damage seeds of *Chamaecyparis lawsoniana*. Larvae of *Paradiplosis abietis* cause galls in needles of *Abies alba* (see Fig.15.E) and larvae of *Taxomyia taxi* develop in rosette galls on the shoots of *Taxus baccata* (see Fig.15.D).

Species inhabiting elevation range 100-500 meters (Figs 10-15)

In this group belong about 60 species the occurrence of which begins at one, two or several localities in the planare zone. In the colline zone they reach their maximum occurrence and they do not extend to elevation of 500 meters. From the point of view of their frequency, many species occur at more than 10 localities and belong to moderate occurring species.

The majority of gall midge species develop in the larval stage on herbaceous host plant species and only 14 species are restricted to trees.Of the gall midge larvae that are associated with herbaceous plant species, there are four very interesting species of the genus *Asphondylia*, viz. *A. baudysi* developing in deformed pods of *Coronilla varia; A. ononidis*, larvae of which develop in leaf bud galls on *Ononis spinosa*; *A. cytisi* living in buds of *Cytisus austriacus*;

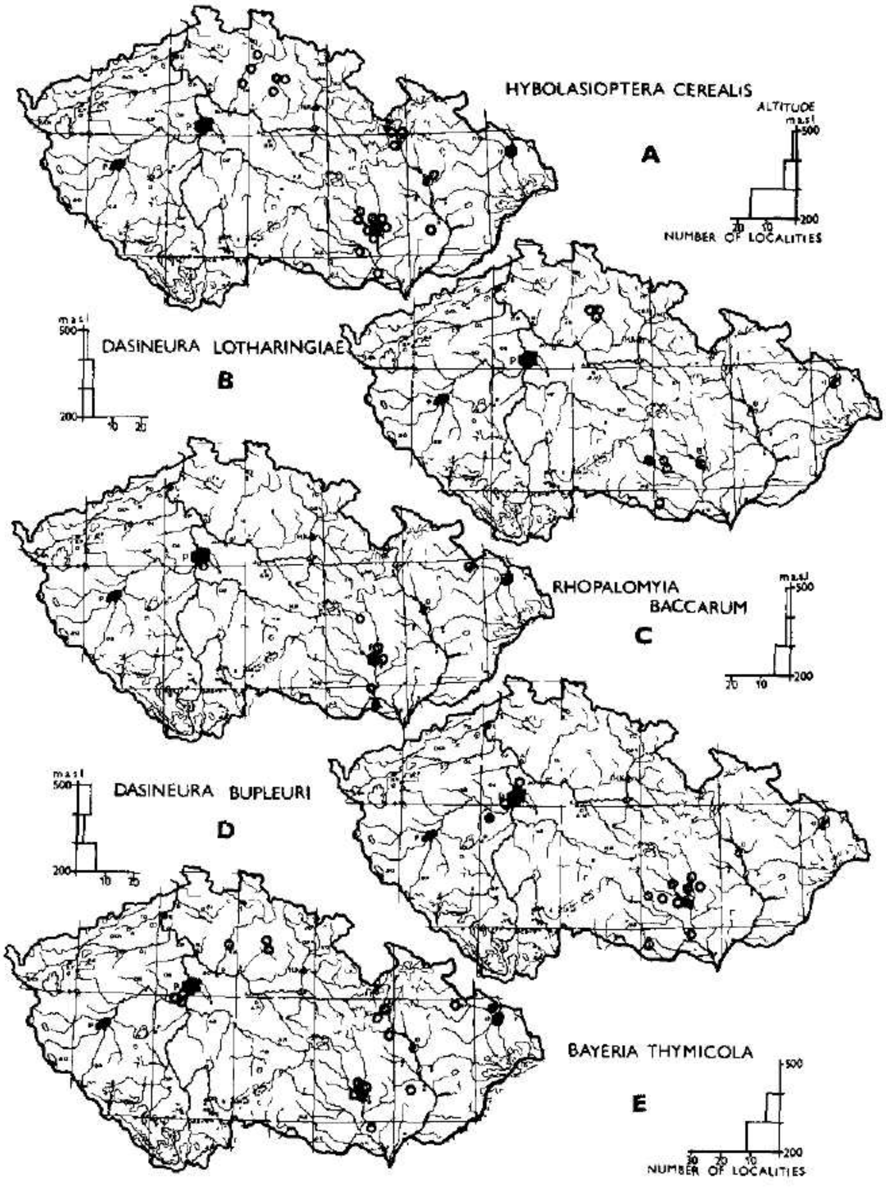



Fig 8. Colline gall midge species: A *Hybolasioptera cerealis* on *Agropyron repens* and other species; B *Dasineura lotharingiae* on *Cerastium glomeratum* and other species; C *Rhopalomyia baccarum* on *Artemisia vulgaris* and *A. scoparia*; D *Dasineura bupleuri* on *Bupleurum falcatum*; E *Bayeria thymicola* on *Thymus serpyllum*.

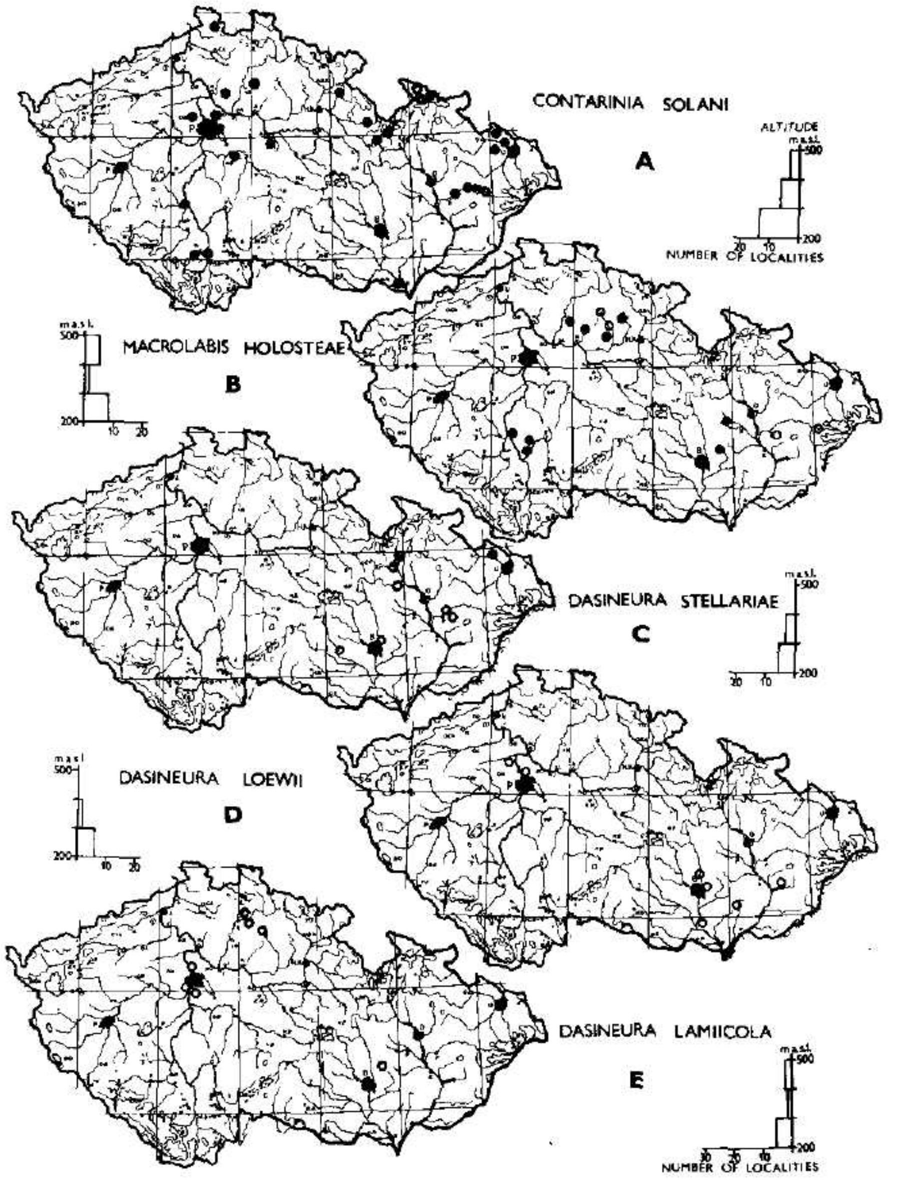



Fig.9. Colline gall midge species: A *Contarinia solani* on *Solanum dulcamara*; B *Macrolabis holosteae* and C *Dasineura stellariae* on *Stellaria holostea*; D *Dasineura loewii* on *Euphorbia seguierana*; E *Dasineura lamiicola* on *Lamium maculatum*.

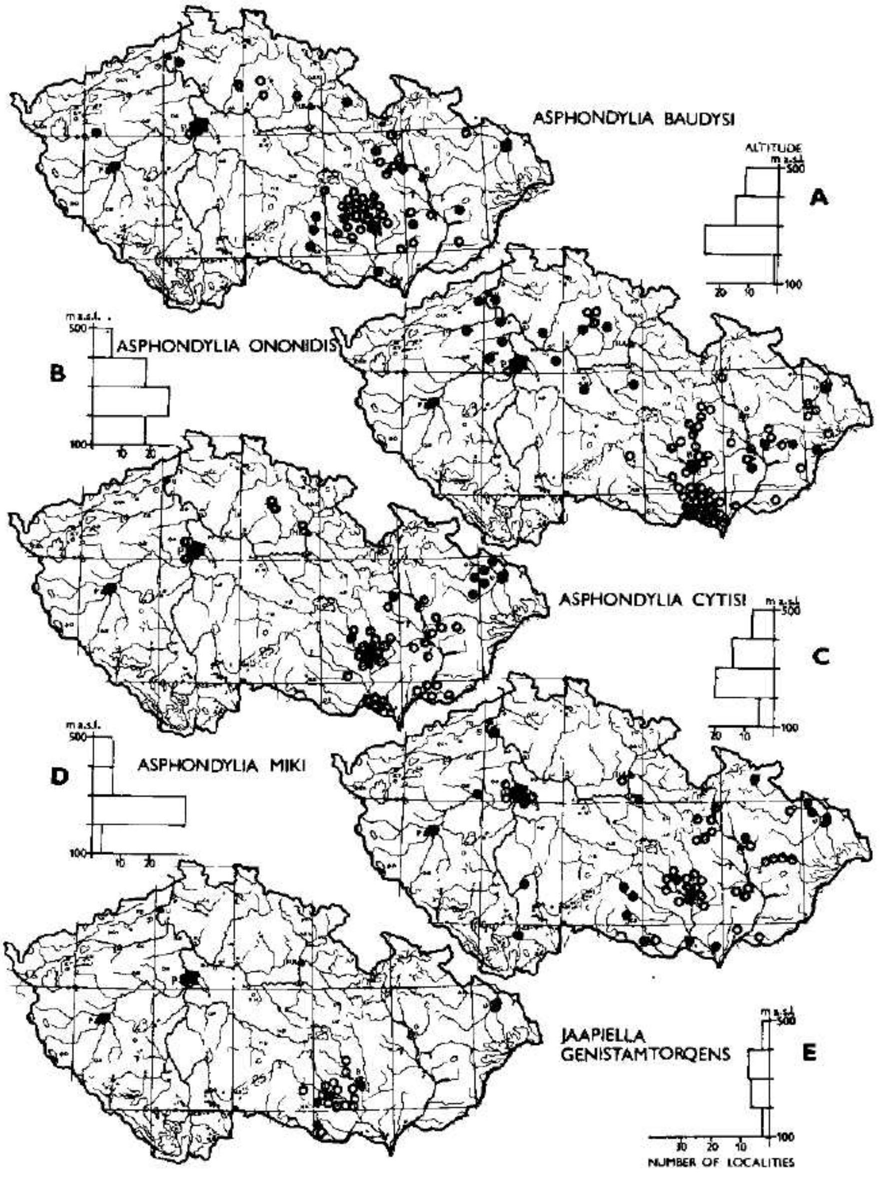



Fig. 10. Planare and colline gall midge species: A *Asphondylia baudysi* on *Coronilla varia*; B *Asphondylia ononidis* on *Ononis spinosa*; C *Asphondylia cytisi* on *Cytisus austriacus*; D *Asphondylia miki* on *Medicago sativa*; E *Jaapiella genistamtorquens* on *Genista pilosa*.

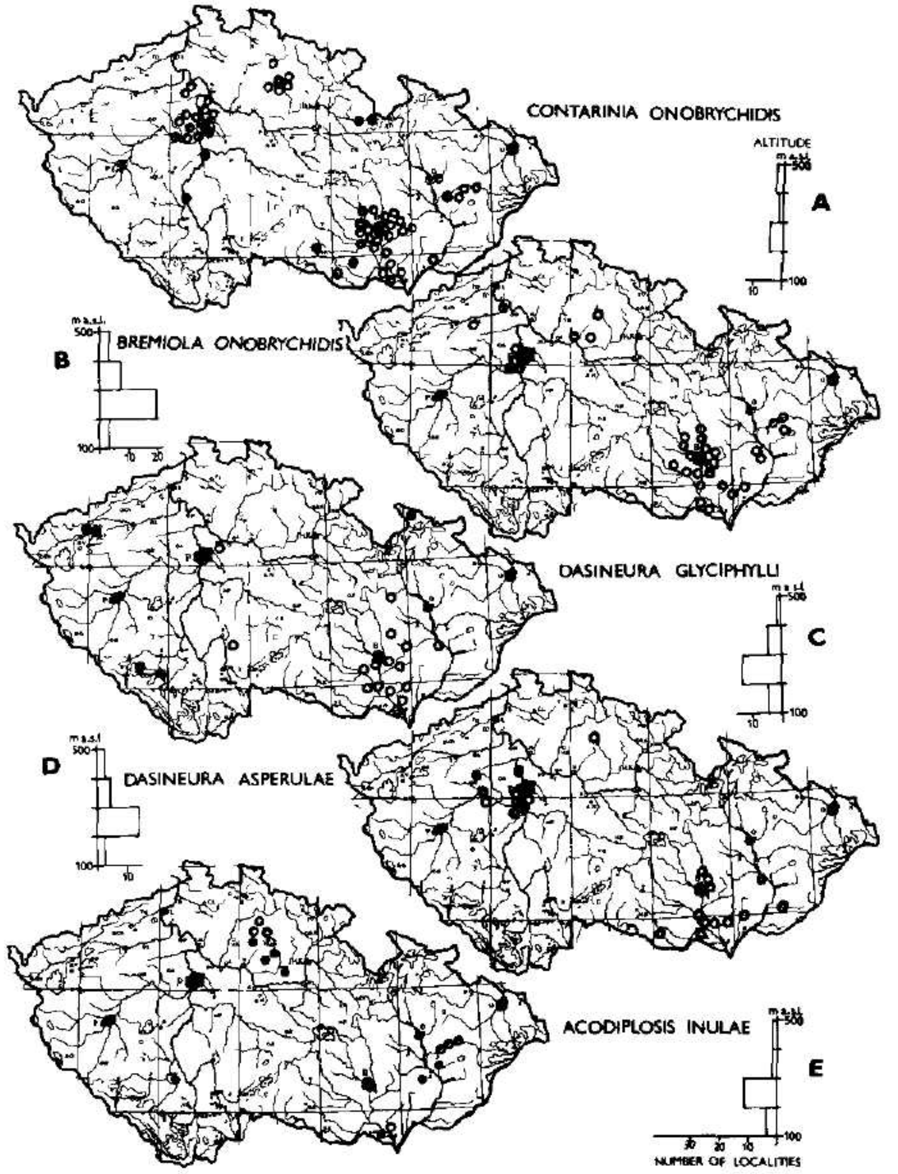



Fig.11. Colline gall midge species: A *Contarinia onobrychidis* and B *Bremiola onobrychidis* on *Onobrychis viciifolia*; C *Dasineura glyciphylli* on *Astragalus glycyphyllos*; D *Dasineura asperulae* on *Asperula tinctoria* and *A. cynanchica*; E *Acodiplosis inulae* on *Inula britannica* and *I. ensifolia*.

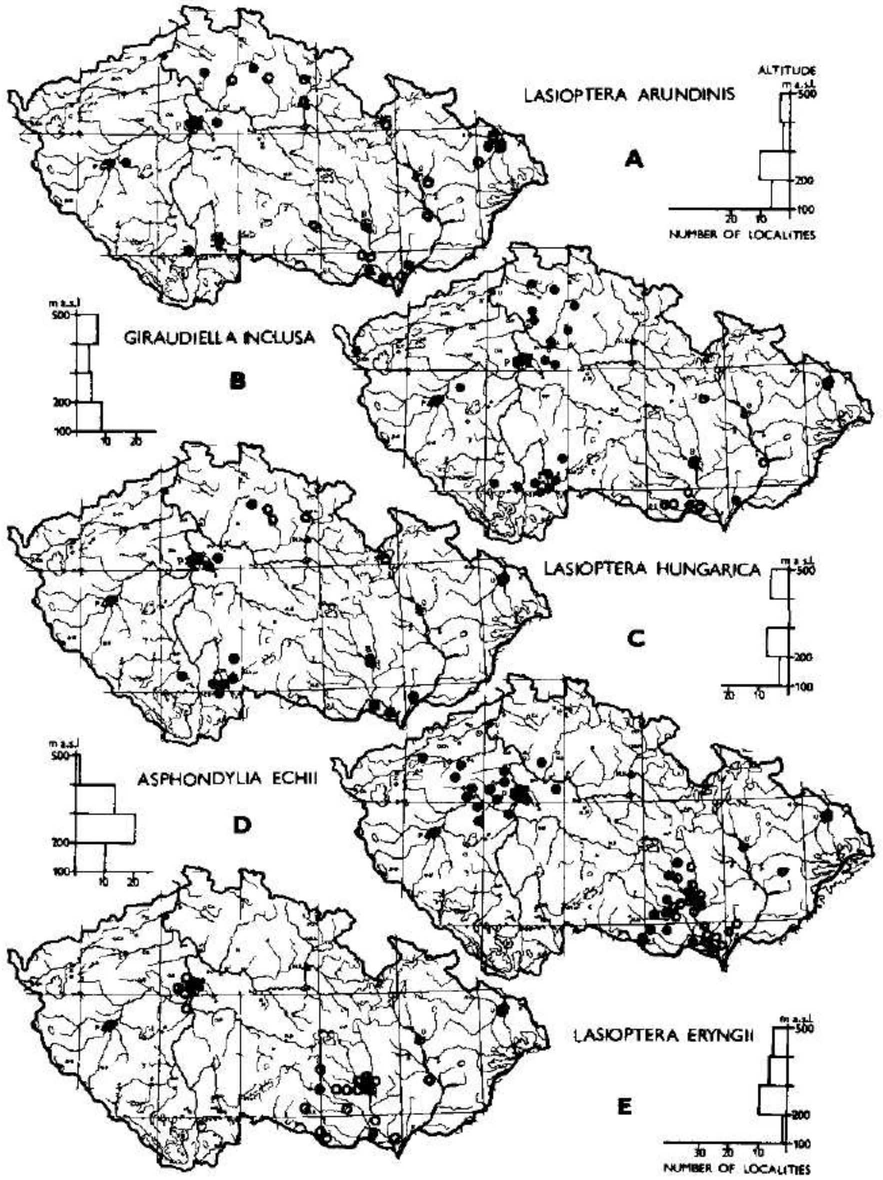



Fig 12 Planare and colline gall midge species A *Lasioptera arundinis*, B *Giraudiella inclusa*, C *Lasioptera hungarica*, all on *Phragmites australis*, D *Asphondylia echii* on *Echium vulgare*, D *Lasioptera eryngii* on *Eryngium campestre*

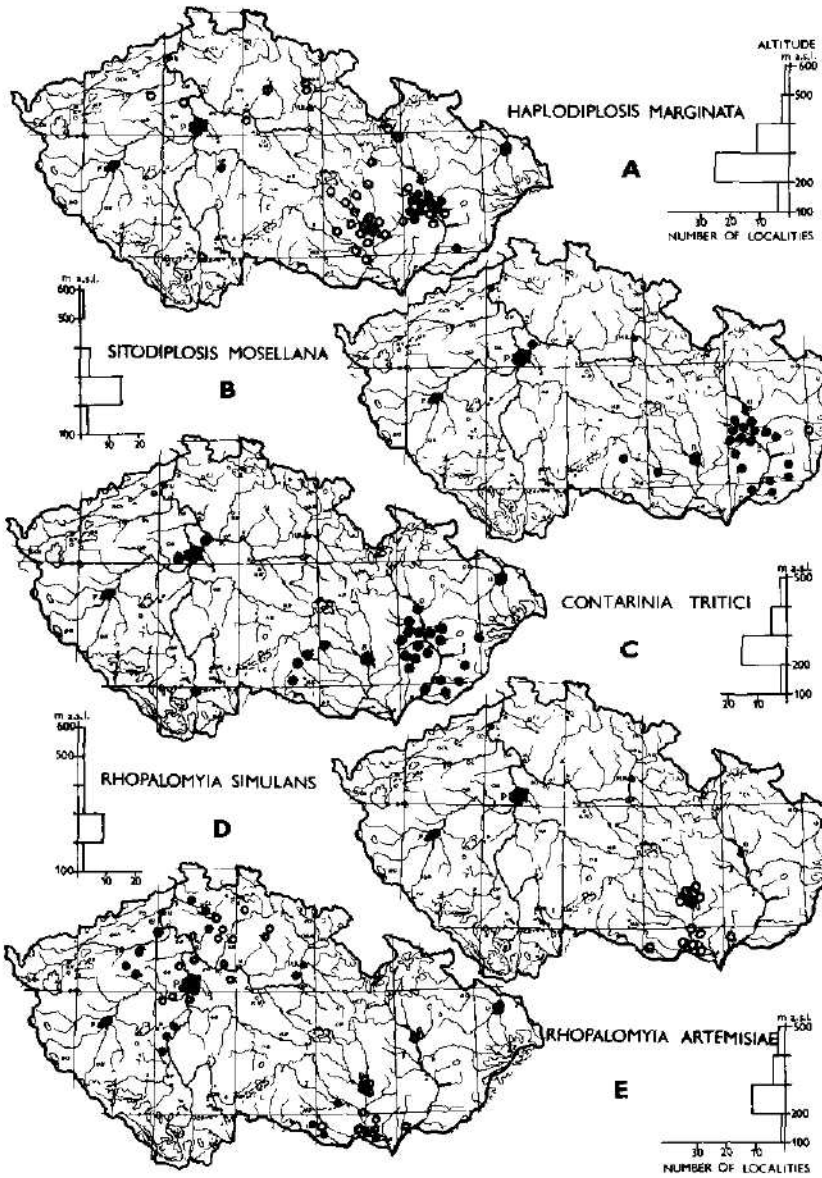



Fig. 13. Planare and colline gall midge species: A *Haplodiplosis marginata* on *Agropyron repens*, *Hordeum sativum* and *Triticum vulgare*; B *Sitodiplosis mosellana*, C *Contarinia tritici*, both on *Triticum vulgare*; D *Rhopalomyia simulans*, E *Rhopalomyia artemisiae*, both on *Artemisia campestris*.

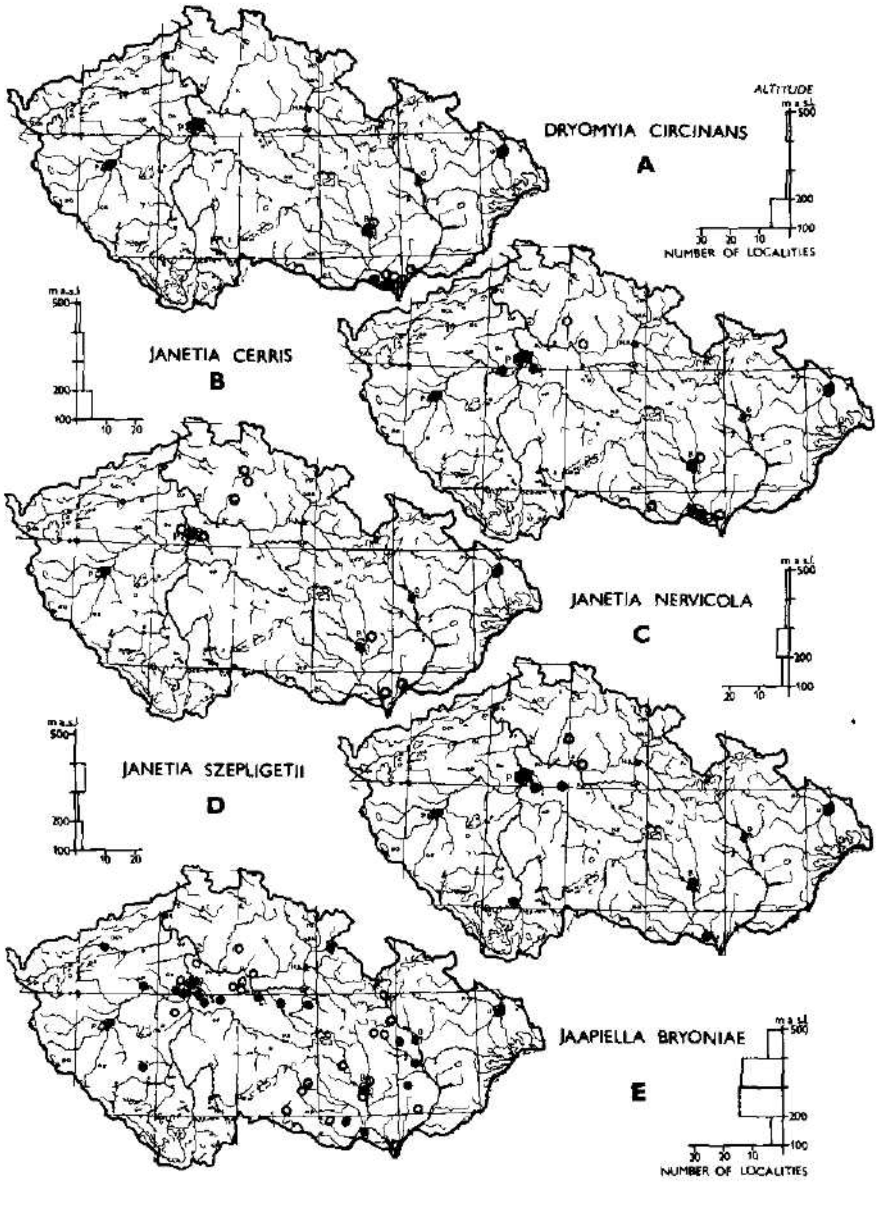



Fig 14 Planare and colline gall midge species A *Dryomyia circinans*, B *Janetia cerris*, C *Janetia nervicola*, D *Janetia szepligetii*, all on *Quercus cerris*, E *Jaapiella bryoniae* on *Bryonia alba*

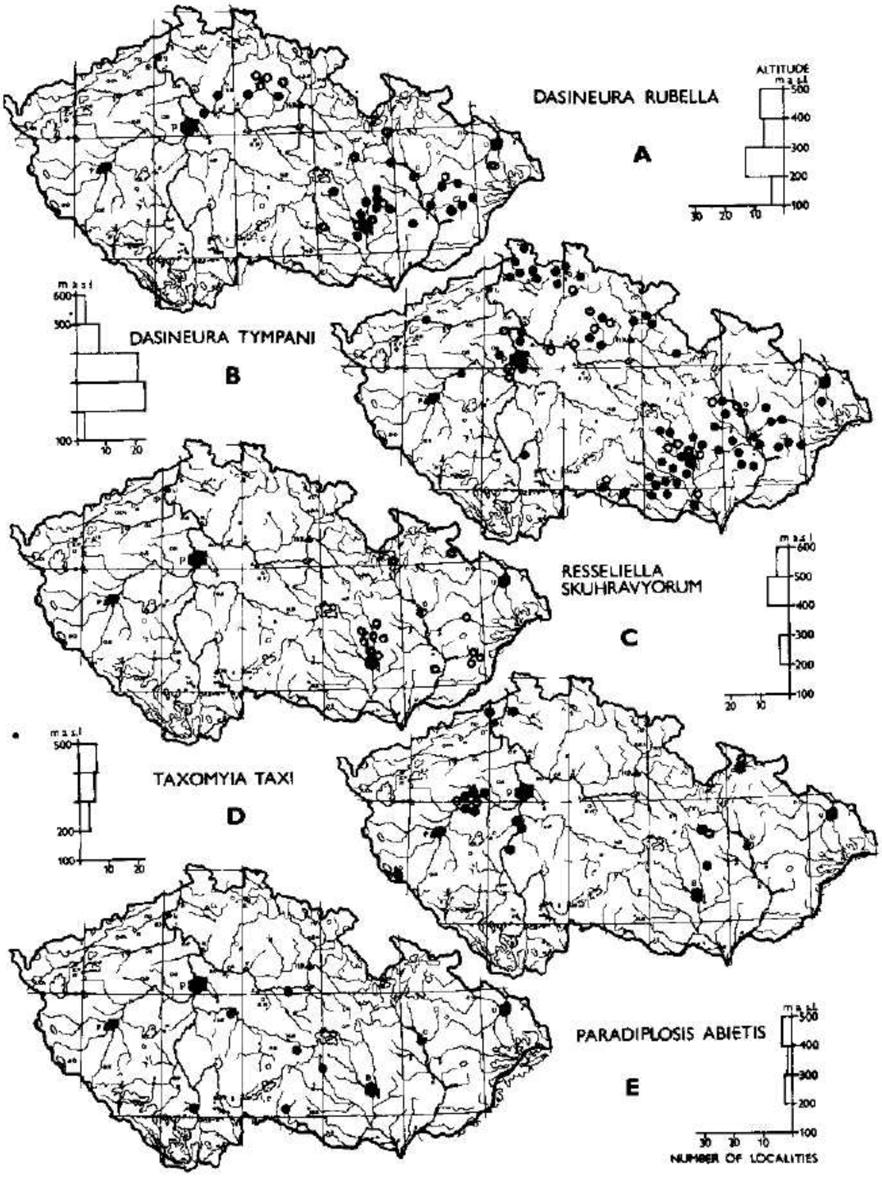



Fig 15 Planare and colline gall midge species: A *Dasineura rubella*, B *Dasineura tympani*, both on *Acer campestre*, C *Resseliella skuhravyorum* on *Larix decidua*, D *Taxomyia taxi* on *Taxus baccata*; E *Paradiplosis abietis* on *Abies alba*

*A. muki*, larvae of which induce galls on pods of *Medicago sativa*. Larvae of *Jaapiella genistamtorquens* live in rosette galls on growing tips of *Genista pilosa* (Fig.10). Several species which develop on other host plants belong to disappearing species, viz. *Contarinia onobrychidis* and *Bremiola onobrychidis*, larvae of which cause galls on flower buds and leaflets of *Onobrychis viciifolia; Dasineura glyciphylli* causing folded leaflets on *Astragalus glycyphyllos* and *Acodiplosis inulae*, larvae of which produce ovoid galls on stems of *Inula britannica* (Fig.11).

Three species developing inside stems of *Phragmites australis*, viz. *Giraudiella inclusa, Lasioptera arundinis* and *L. hungarica*, occur scattered at locatilies lying along rivers, brooks and in stands around ponds. Larvae of *Giraudiella inclusa* form corn-like galls on the inner side of reed stem, larvae of *Lasioptera arundinis* cause thickening and shortening of lateral shoots and larvae of *L. hungarica* live inside the cavity of reeds without any sign of attack (Skuhravá & Skuhravý 1981, 1992).

The gall midge *Lasioptera eryngii*, larvae of which cause conspicuous large swellings on stems of *Eryngium campestre*, belong to a disappearing species. At the beginning of the 20th century it was found at several localities in middle Bohemia near Praha. During our intensive faunistic investigations in 1955-1980 period this species was not found, it disappeared from this area. At present it occurs rarely in the southern part of Moravia. Flower bud galls of *Asphondylia echii* on *Echium vulgare* which disappeared from southern part of Moravia, were found at localities lying in middle Bohemia (Fig.12).

Three gall midge species larvae of which develop on cereal crops, from time to time cause serious damage. Larvae of *Haplodiplosis marginata (H. equestris)* produce saddle-shaped galls on stems of *Triticum vulgare* and *Hordeum sativum*, larvae of *Contarinia tritici* and *Sitodiplosis mosellana* develop in the spikeletts. *Rhopalomyia simulans*, the species described by Vimmer (1924) from Moravia, has not been found since 1926 up to the present. *Rhopalomyia artemisiae* shows a similar tendency to disappear. Twenty years ago this species occurred abundantly in middle Bohemia but at present it is very difficult to find galls in this area (Fig.13).

On trees a few species develop in the colline zone up to the upper limit, but many species extend over this line.Only in the colline zone there occur six species developing in the larval stage in galls of various types on leaves of *Quercus cerris*, viz. *Dryomyia circinans, Janetia cerris, J. homocera, J. nervicola, J. pustularis*, and *J. szepligetii*. These south-European species extend into the area of southern Moravia, their northern boundary of distribution area (Fig.14).

Two gall midge species develop on leaves of *Acer campestre*. Larvae of *Dasineura rubella* attack young opening leaves whereas larvae of *Dasineura tympani* live in parenchymatous galls on the leaves. Larvae of *Resseliella skuhravyorum* developing in cones of *Larix decidua* were found during intensive studies (Křístek et al.1976) mainly in the territory of southern Moravia. Rosette galls of *Taxus baccata* caused by larvae of *Taxomyia taxi* occur only in localities where the host plant species is indigenous (not cultivated). The gall midge *Paradiplosis abietis*, larvae of which cause galls on needles of *Abies alba*, is a disappearing species (Fig.15).

### *3. Submountain gall midge species* (figs 16-31)

The submountain zone includes uplands between 500 to 800 m a.s.l.It is characterized by broadleaved forests and fields of resisting crop plants such as oats and potatoes. It was originally covered with oak-fir forests which are now mostly converted into spruce monocultures.

In the submountain zone gall midges were examined together in 183 localities from which 108 localities lie in elevation ranges between 500-600 meters, 48 localities between 600-700 meters and 27 localities between 700-800 meters (see Fig.6.D).

In the submountain zone 290 gall midge species have been found, i.e. 58% of all gall midge species recorded in the territory of the Czech Republic. They may be designated submountain gall midges sensu lato. The majority of them are species extending here from the lower altitudinal zones: 137 gall midge species extend up to here from the planare zone and 139 species from the colline zone. Some of both types of gall midge species finish their occurrence in this zone and do not cross the boundary of 800 meters, but another part of them overcome it and reach up to the mountain and sub-Alpine zones.

The submountain gall midge species may be ranged, based on similar vertical occurrence schemes (see Fig.5), into eight groups, as follows:

1. species occurring only in the submountain zone in the elevation range between 500-800 meters (submountain species sensu stricto); they will be discussed in this chapter.
2. species the occurrence of which begins here in the submountain zone and reaches up to the sub-Alpine zone; they will be treated under sub-Alpine species.
3. species extending here from the planare zone the occurrence of which is finished here; they will be discussed in this chapter.
4. species extending here from the planare zone and penetrating to the mountain zone; they will be discussed under mountain species.
5. species extending here from the planare zone and penetrating up to the sub-Alpine zone; they will be treated under sub-Alpine species.
6. species extending here from the colline zone the occurrence of which is finished here in the submountain zone; they will be discussed in this chapter.
7. species extending here from the colline zone and penetrating to the mountain zone; they will be treated under mountain species.
8. species extending here from the colline zone, penetrating the mountain zone and reaching up to the sub-Alpine zone; they will be discussed under sub-Alpine species.

*Submountain species sensu stricto*

Only 13 gall midge species occur in the elevation range between 500-800 meters. All of them are rare species being found only at one, two or three localities. Four of them belong to zoophagous species, viz. ***Lestodiplosis longifilis, L. raphani, L. trifolii*** and ***Trisopsis acicularis***, larvae of which are predators attacking and sucking small gall midge larvae moving in the soil. Nine species have phytophagous larvae which cause galls on various host plant species.

***Dasineura berberidis***, larvae of which cause leaf galls on ***Berberis vulgaris***, and ***Wachtliella ericina***, larvae of which live in rosette galls on ***Erica herbacea***, reach the southern part of Bohemia, their northern boundary of distribution in south-western Europe. Galls on the leaves of ***Quercus*** robur are caused by larvae of ***Polystepha quercus***. Larvae of ***Resseliella theobaldi*** live under the bark of ***Rubus idaeus***. Subterranean galls on ***Chrysanthemum leucanthemum*** are produced by larvae of ***Rhopalomyia hypogaea***. In the inflorescences of ***Festuca rubra*** live larvae of ***Contarinia festucae*** and ***Dasineura festucae***. Larvae of ***Contarinia asclepiadis*** develop in slightly swollen seed follicles of ***Cynanchum vincetoxicum***, and larvae of ***Contarinia hyperici*** gall unopened flower buds of ***Hypericum perforatum***.

Species inhabiting elevation range 100-800 meters

In the large elevation range between 100-800 meters 74 gall midge species occur. Their occurrence begins in one, two or several localities in the planare zone, then they reach maximum occurrence in the colline zone and penetrate successively to higher elevations of the submountain zone. The occurrence of these species is finished at most at the elevation of 800 meters. They may be designated as colline and submountain species.

About thirty gall midge species are associated with host plant trees, and more than forty species develop on herbaceous host plant species, causing galls of various type on plant organs.

a) Gall midges on trees (Figs 16-20)

Larvae of *Craneiobia corni* cause galls on leaves of Dogwood, *Cornus sanguinea*. Larvae of *Placochela ligustri* develop in flower buds of *Ligustrum vulgare*. *Sackenomyia reaumurii (Phlyctidobia solmsi)* cause pustule galls on leaves of *Viburnum lantana*. All these species occur in the colline zone, exceed only a little the lower line of the submountain zone and their occurrence is finished in the elevation range between 500-600 meters. *Sackenomyia reaumurii* and *Craneiobia corni* belong to disappearing species, whereas *Placochela ligustri* to progressive species, the occurrence of which is more abundant at present than it was in the past (Fig.16).

Four gall midge species are associated in their development with hornbeam, *Carpinus betulus*, causing galls of various types on its leaves. They are the following species, viz. *Contarinia carpini*, larvae cause folded parts between two lateral veins; *Dasineura ruebsaameni*, larvae in parenchymous leaf galls; *Zygiobia carpini*, larvae in swellings along the median veins; *Aschistonyx carpinicolus*, larvae in irregularly deformed young leaves. All species have their maximum occurrence in the colline zone and penetrate up to the lower part of submountain zone (Fig.17). Gall midge species *Dasineura mali*, larvae of which live in rolled leaf margins of maple, *Malus sylvetris*, *Dasineura pyri*, larvae of which develop in similar galls on pear, *Pyrus communis*, and *Contarinia pyrivora*, the pest of pear fruits, exceed the elevation of 600 meters. *Dasineura crataegi*, larvae of which develop in rosette galls of hawthorn, *Crataegus oxyacantha*, penetrates even to the elevation of 848 meters at the peak part of the Přimda Mountain in the Český les Mts.(Fig.18).

Five gall midge species develop in the larval stage on oaks, *Quercus robur* and *Q. petraea*, occurring abundantly in the colline zone, having there maximum occurrence and penetrating to the submountain zone, nearly up to its boundary at an elevation of 800 meters. *Arnoldiola libera*, larvae of which cause leaf galls exceed this line; leaf galls of *Macrodiplosis dryobia* and *M. volvens*, and bud galls of *Contarinia quercina* were found just short of this line. All these gall midges, with the exception of *Polystepha malpighii*, belong to progressive species, the abundance of which shows a tendency to increse (Fig.19).

Larvae of two species induce galls on the leaves of various elms, viz. *Ulmus minor*, *U. glabra* and *U. laevis*. Larvae of *Janetiella lemeei* cause small rounded swellings on the veins; larvae of *Physemocecis ulmi* develop in small circular pustules. Both elm gall midge species occur scattered in the planare zone and have their maximum in the colline zone. *Janetiella lemeei* reaches up nearly to the boundary of the submountain zone, at the hill Třemešný vrch, 794 m a.s.l. in middle Bohemia, and *Physemocecis ulmi* exceeds this line, being found at an elevation of 850 m a.s.l. at the saddle Libínské sedlo in the Šumava Mts.

The blackhorn, *Prunus spinosa*, a common shrub growing in planare and colline zones, is the host plant of five gall midge species.The occurrence of two of them, *Contarinia pruniflorum* and *Dichodiplosis langeni* ends in the colline zone. Three species extend into the colline zone and rise up to the submountain zone. *Dasineura tortrix*, larvae of which damage terminal leaves, have been found at an elevation of 674 m a.s.l. at Hořice in southern Bohemia and bud galls of *Asphondylia pruniperda* and leaf pouch galls of *Putoniella pruni* nearly reach the limit of the submountain zone at an elevation of 784 m a.s.l. at Slavkovský Chlumek, the Nature Reserve in the Šumava Mts. (Fig.20).

b) Gall midges on herbaceous plants (Figs 21-31)

From more than forty species of this group the gall midges causing galls on *Medicago sativa* are typical, viz. *Dasineura medicaginis*, *Contarinia medicaginis* and *Jaapiella medicaginis*. The local abundance of these species changes in long-term cycles. In the period of their outbreaks they are considered to be pests of alfalfa, causing loss of seed (*Contarinia medicaginis*), or loss of green matter (*Dasineura medicaginis* and *Jaapiella medicaginis*). Similar galls are caused on *Medicago lupulina* by *Dasineura lupulinae* and *Jaapiella lupulinae* but these species are not so abundant as the previous species and do not have any economic importance (Fig.21).

Two gall midge species produce galls on *Glechoma hederacea: Rondaniola bursaria*, cylindrical leaf galls, and *Dasineura glechomae*, terminal leaf bud galls. Both species penetrate up to the upper line of the submountain zone. *Diodaulus traili*, larvae of which produce flower bud galls on *Pimpinella saxifraga*, is a disappearing species, and *Neomikiella beckiana*, causing galls on *Inula conyza*, and *Asphondylia verbasci*, forming flower bud galls on *Verbascum lychnitis*, are colline species inhabiting an elevation range of 198-510 meters. The annual isotherm of $10^0$C forms in southern Moravia the northern boundary of the abundant occurrence of *A. verbasci* in Europe (Fig.22).

Five colline species exceed the upper boundary of the colline zone and penetrate up to an elevation of 600 meters. Larvae of *Asphondylia melanopus* cause galls on pods of *Lotus corniculatus*, larvae of *Asphondylia menthae* live in flower bud galls of *Mentha arvensis*, larvae of *Bayeria salicariae* develop in axillary leaf buds on *Lythrum salicaria*. Larvae of *Loewiola centaureae* cause pustule galls on leaves of *Centaurea scabiosa* and *C. jacea*. Larvae of *Dasineura sisymbrii* form spongy galls on stems of *Rorippa amphibia* and other species (Fig.23).

Several species penetrate into the middle part of the submountain zone. These are the following species: Larvae of *Macrolabis ruebsaameni* develop in terminal galls of *Prunella vulgaris*. Larvae of *Jaapiella floriperda* live in swollen unopened flower buds of *Silene vulgaris*. Larvae of *Contarinia nasturtii* develop in galls of *Nasturtium palustre* and of other host plant species and may be pests of vegetable crops. Larvae of *Lasioptera carophila* cause swellings at the point of insertion of the umbellules in inflorescences of *Pimpinella saxifraga*. Larvae of *Wachtliella persicariae* develop in swollen rolled leaf margins of *Polygonum amphibium* (Fig. 24).

Gall midge *Bayeria erysimi*, larvae of which cause stem swellings of *Erysimum virgatum*, quite disappeared from the territory and since 1963 has not been found here. It is probably an extinct species. Larvae of *Spurgia (Bayeria) capitigena* produce rounded terminal galls on tips of *Euphorbia cyparissias*. They are very abundant in warmer localities. Larvae of *Macrolabis lamii* develop in terminal leaf bud galls on *Lamium album*. Larvae of *Rhopalomyia foliorum* cause small ovoid galls on the leaves of *Artemisia vulgaris*. Larvae of *Dasineura aparines* produce large galls on stems of *Galium aparine* (Fig.25).

Larvae of *Dasineura brassicae* live in swollen and prematurely ripening siliquas of *Brassica napus* and *B. oleracea* and may injure these vegetable crops. *Dasineura similis*, larvae of which produce galls on *Veronica scutellata, V. anagallis* and *V. beccabunga*, is probably an extinct species. Galls of *Contarinia scrophulariae*, larvae of which live in flower bud galls of *Scrophularia nodosa*, occur at scattered localities. Larvae of *Dasineura bayeri* cause galls on the vegetative tips of *Sisymbrium loeselii*. Larvae of *Jaapiella moraviae* live in swollen unopened flower buds of *Lychnis viscaria*. Since 1966 galls of this species have not been found. It is probably an extinct species (Fig.26). The following gall midge species reach from the planare zone to the upper limit of the submountain zone:

*Lasioptera calamagrostidis*, larvae of which live under the leaf sheaths of *Calamagrostis epigeios; Contarinia barbichi* causing galls on leaf buds of *Lotus corniculatus; Tricholaba trifolii*, larvae of which live in folded leaflets of *Trifolium pratense*. Of the gall midge species larvae of which develop on *Tanacetum vulgare, Ozirhincus tanaceti* occurs throughout the territory, whereas *Rhopalomyia tanaceticola*, causing conspicuous large galls on various parts of the host plant, occurs in the northern part of Bohemia and the north-eastern part of Moravia (Fig.27).

Larvae of several gall midge species develop in galls of various shape on stems and leaves of

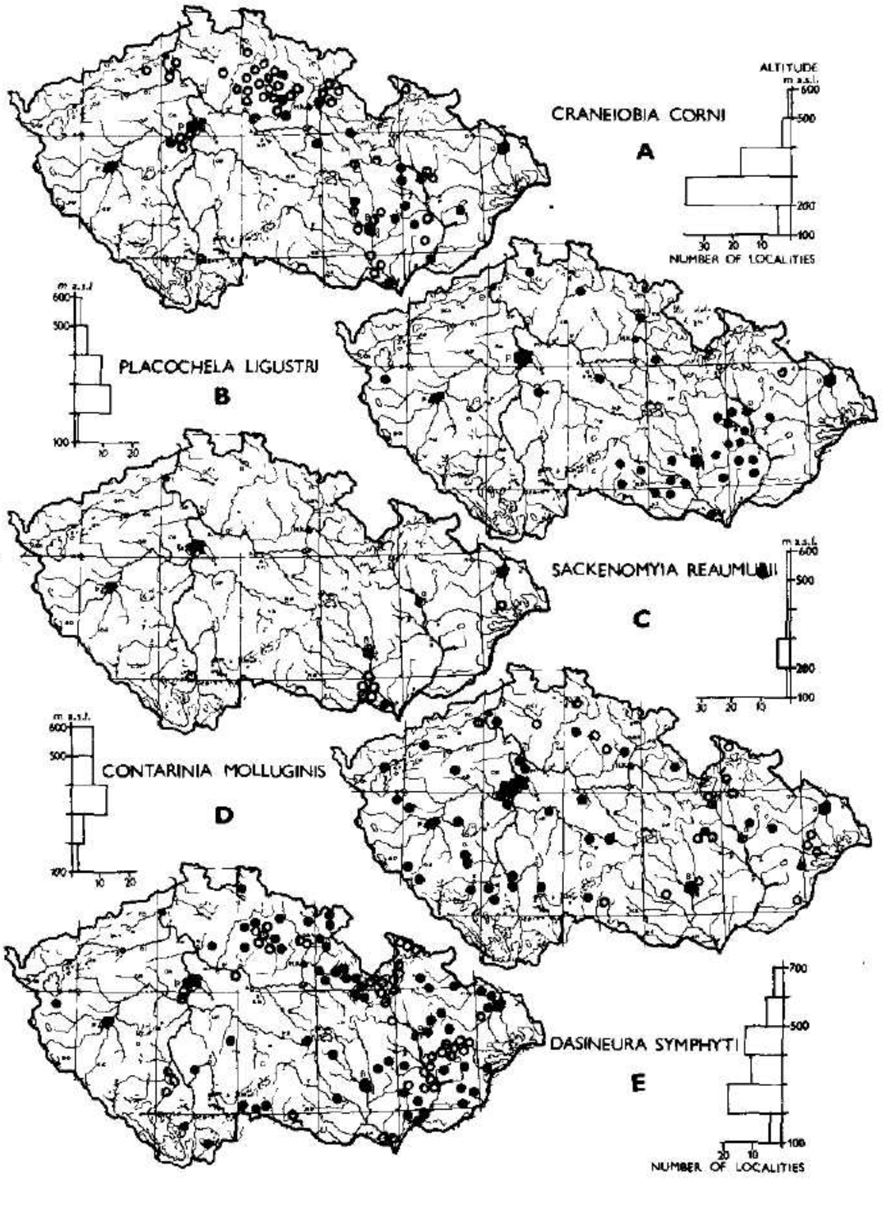



Fig. 16. Gall midge species extending to the submountain zone: A *Craneiobia corni* on *Cornus sanguinea*; B *Placochela ligustri* on *Ligustrum vulgare*; C *Sackenomyia reaumurii* on *Viburnum lantana*; D *Contarinia molluginis* on *Galium mollugo*; E *Dasineura symphyti* on *Symphytum officinale*.

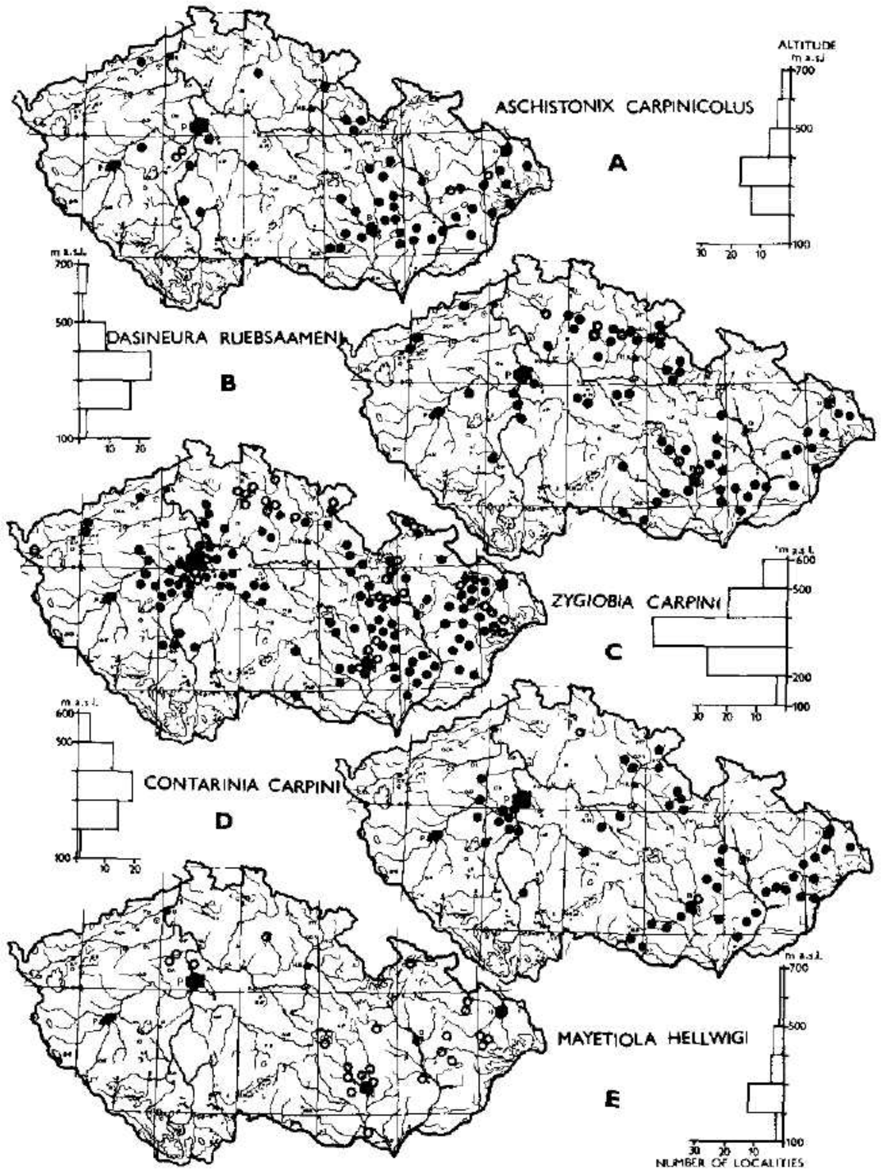



Fig.17. Gall midge species extending to the submountain zone: A *Aschistonyx carpinicolus*; B *Dasineura ruebsaameni*; C *Zygiobia carpini*; D *Contarinia carpini*; all on *Carpinus betulus*; E *Mayetiola hellwigi* on *Brachypodium sylvaticum* and *B. pinnatum*.

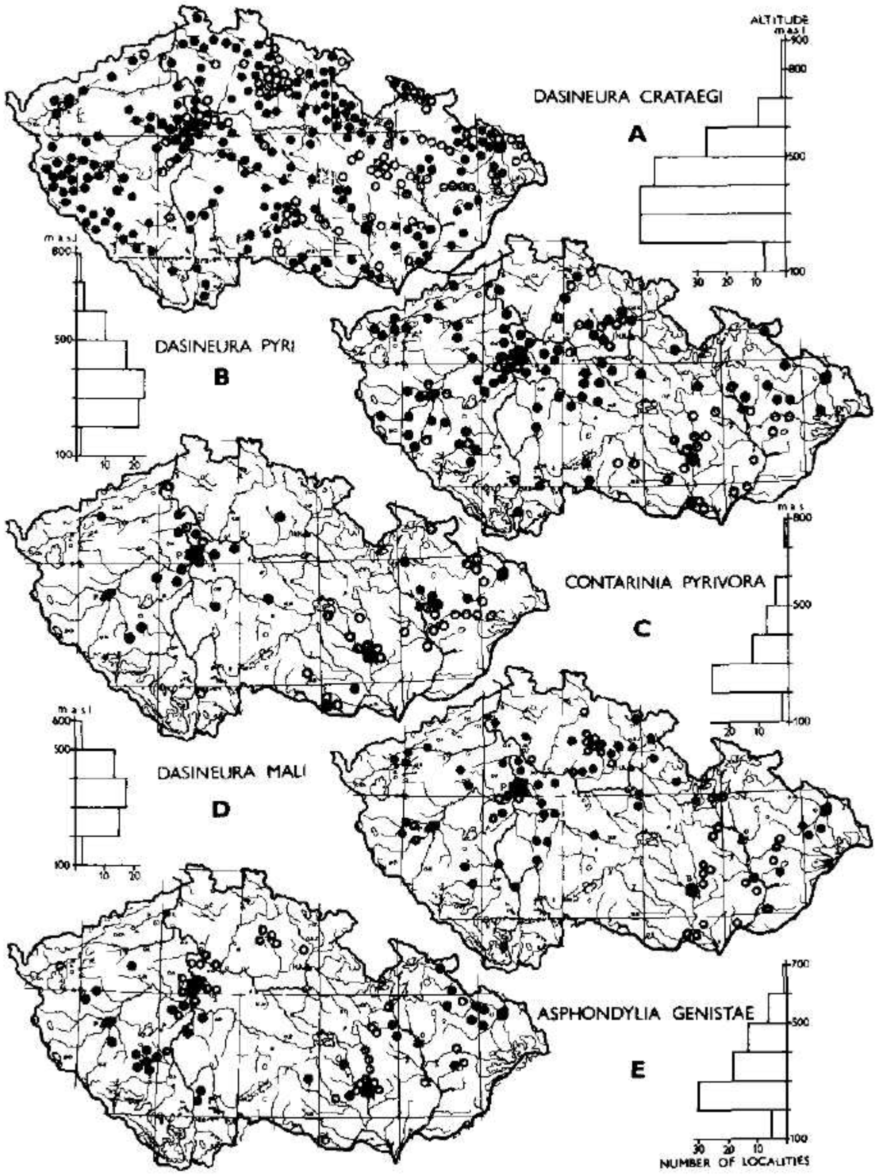



Fig 18 Gall midge species extending to the submountain zone A *Dasineura crataegi* on *Crataegus oxyacantha*, B *Dasineura pyri*, C *Contarinia pyrivora*, both on *Pyrus communis*, D *Dasineura mali* on *Malus sylvetris*, E *Asphondylia genistae* on *Genista germanica* and *G tinctoria*

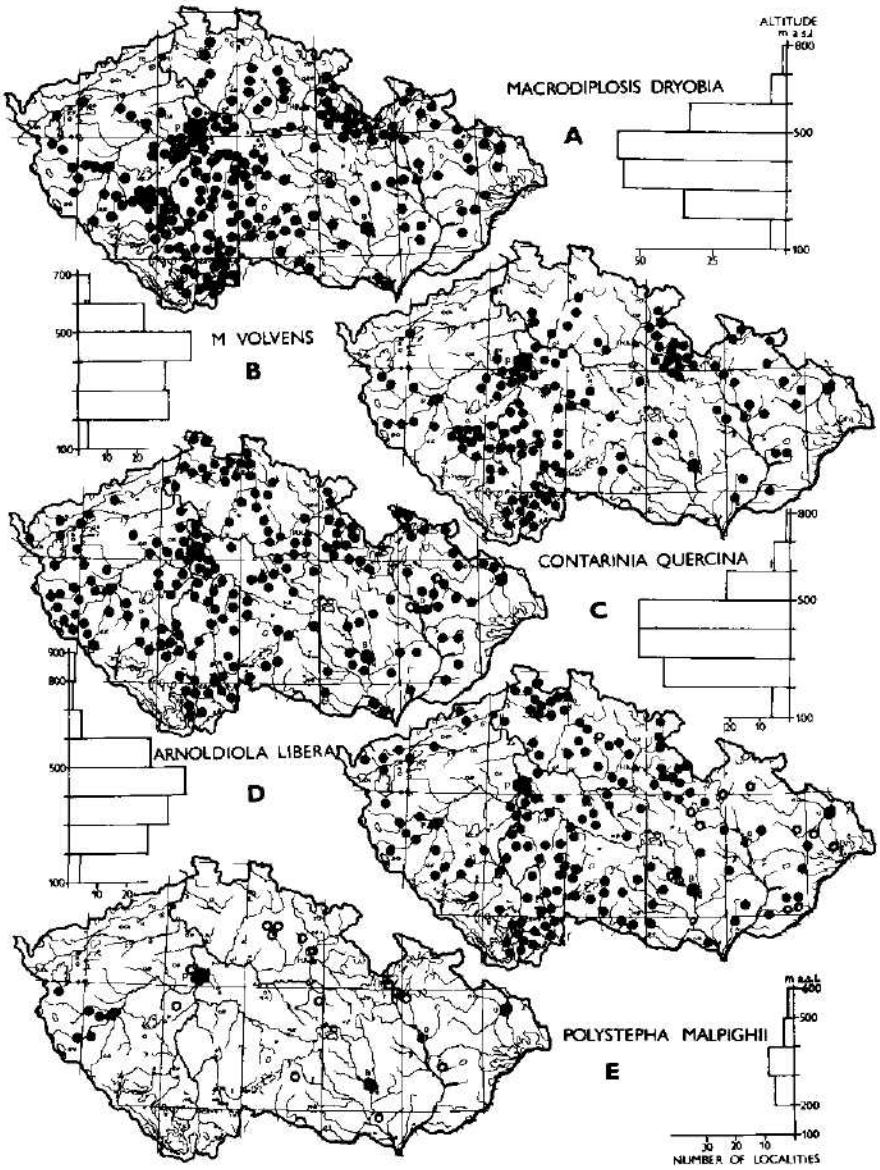



Fig 19 Gall midge species developing on *Quercus robur* and *Q. petraea* extending to the submountain zone A *Macrodiplosis dryobia*, B *Macrodiplosis volvens*, C *Contarinia quercina*, D *Arnoldiola libera*; E *Polystepha malpighii*

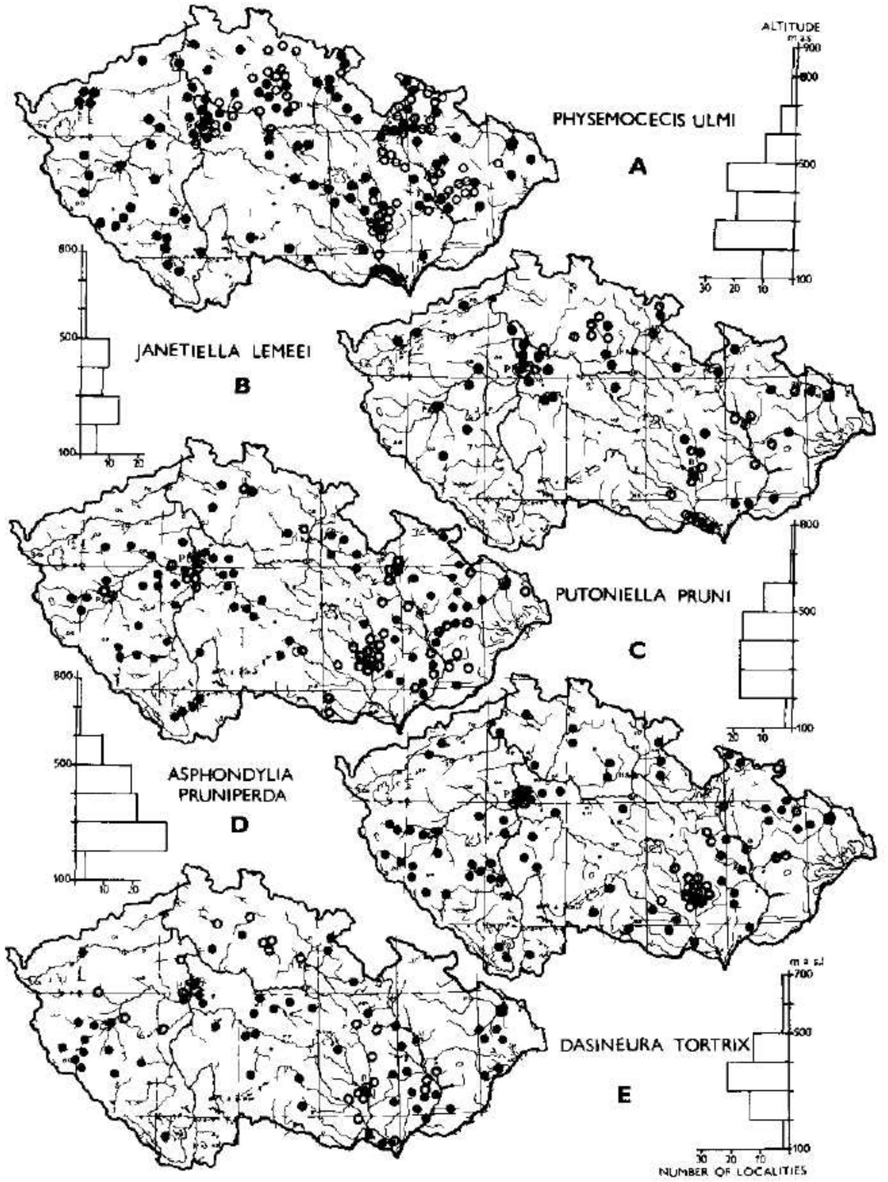



Fig 20 Gall midge species extending to the submountain and lower part of the mountain zones A *Physemocecis ulmi*, B *Janetiella lemeei*, both on *Ulmus minor*, *U glabra* and *U laevis*, C *Putoniella pruni*, D *Asphondylia pruniperda*, E *Dasineura tortrix*, all on *Prunus spinosa*

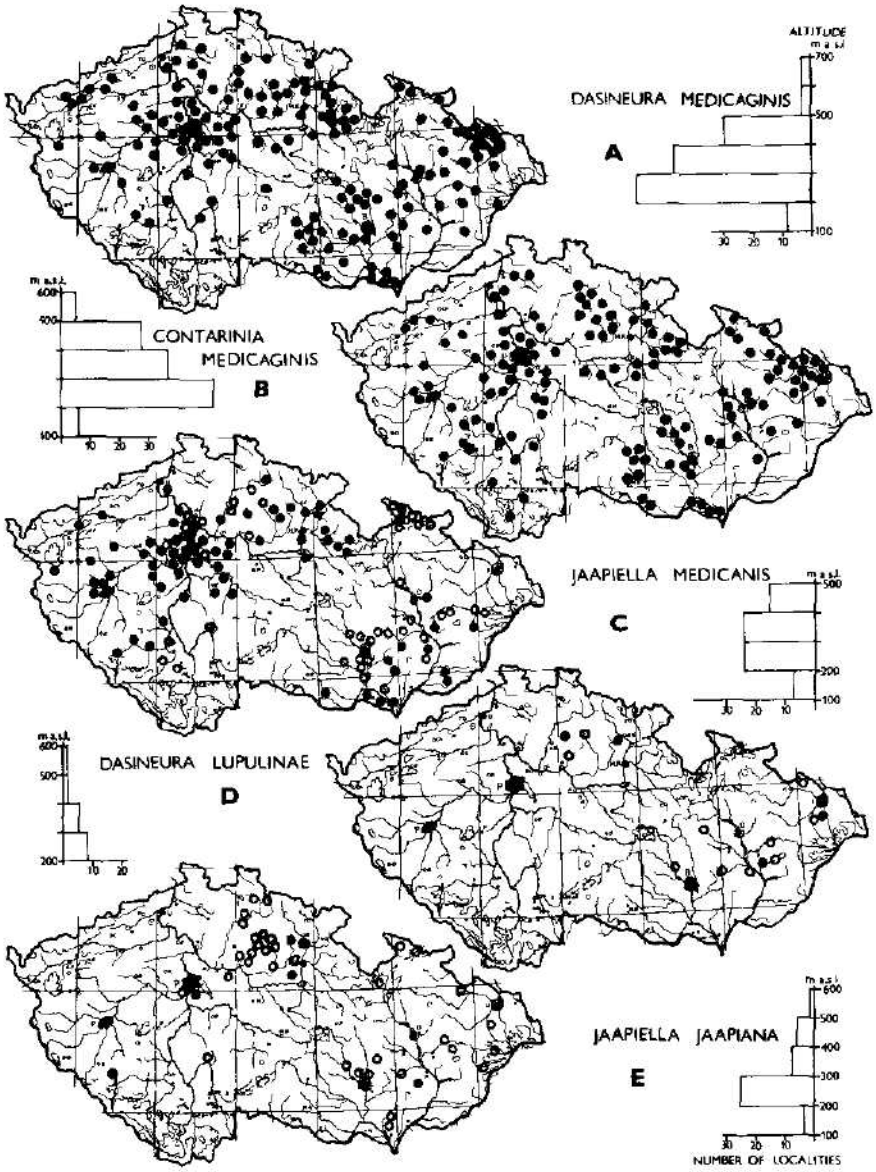



Fig 21 Gall midge species reaching the lower part of the submountain zone A *Dasineura medicaginis*, B *Contarinia medicaginis*, C *Jaapiella medicaginis* all on *Medicago sativa*, D *Dasineura lupulinae*, E *Jaapiella jaapiana*, both on *Medicago lupulina*

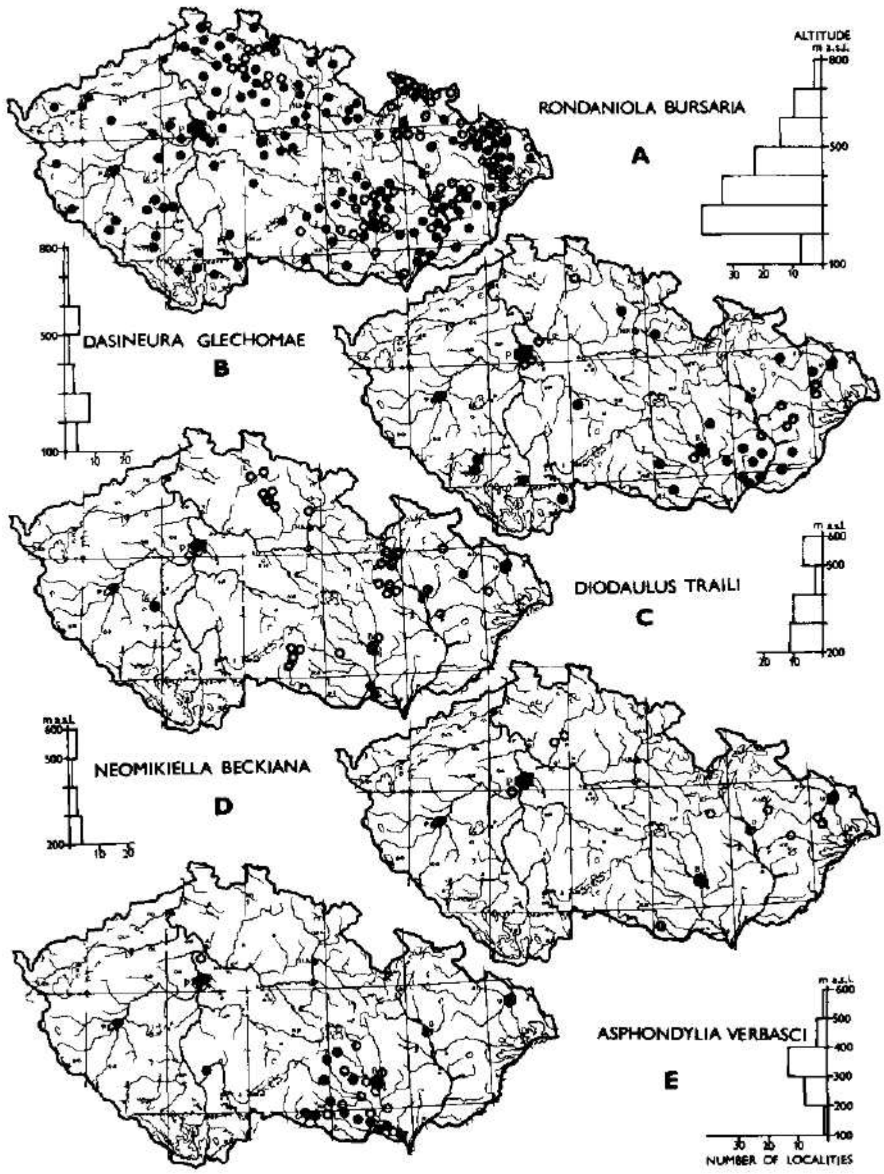



Fig 22 Gall midge species reaching the submountain zone A *Rondaniola bursaria*, B *Dasineura glechomae*, both on *Glechoma hederacea*, C *Diodaulus traili* on *Pimpinella saxifraga*, D *Neomikiella beckiana* on *Inula conyza*, E *Asphondylia verbasci* on *Verbascum lychnitis*

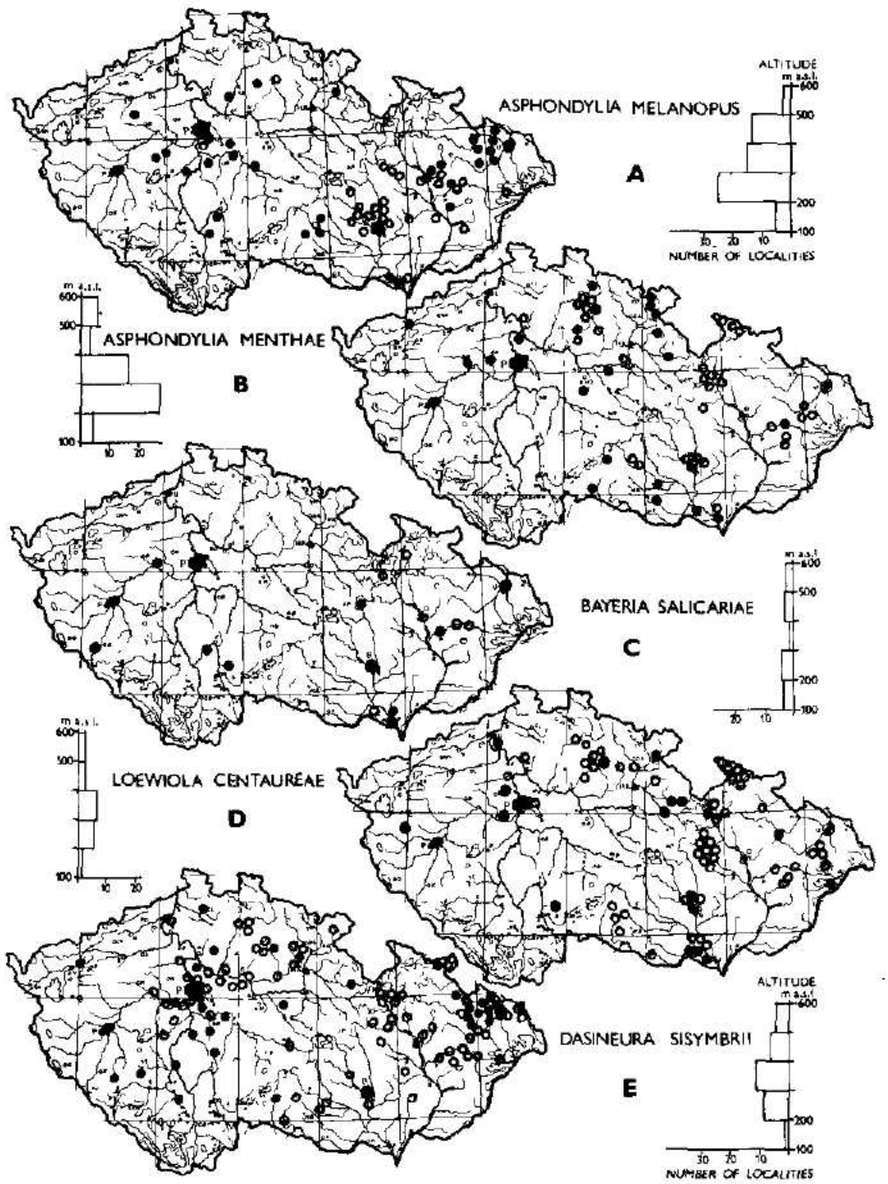



*Fig.23.* Gall midge species reaching up to the submountain zone: A *Asphondylia melanopus* on *Lotus corniculatus*; B *Asphondylia menthae* on *Mentha arvensis*; C *Bayeria salicariae* on *Lythrum salicaria*; D *Loewiola centaureae* on *Centaurea scabiosa* and *C. jacea*; E *Dasineura sisymbrii* on *Rorippa amphibia* and other species of Brassicaceae.

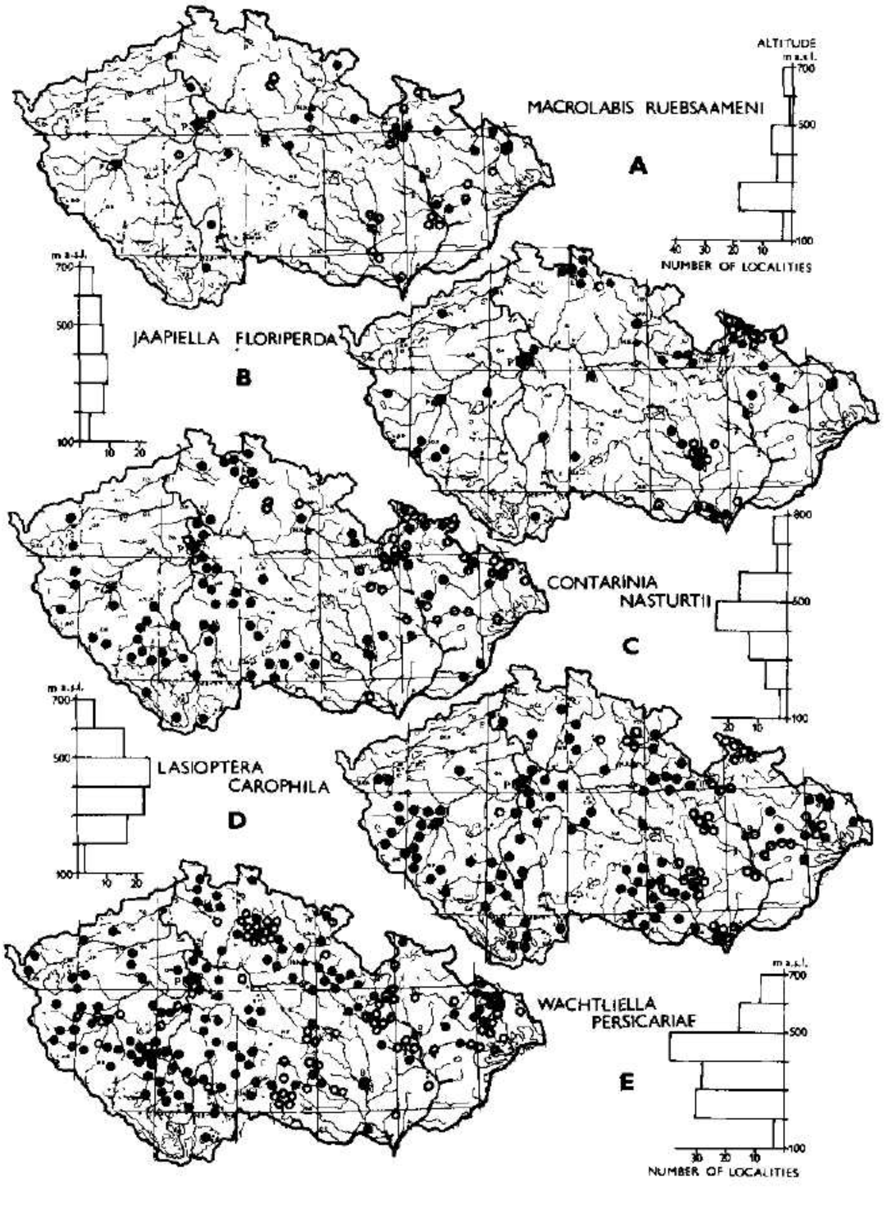



Fig.24. Gall midge species reaching the submountain zone: A *Macrolabis ruebsaameni* on *Prunella vulgaris*; B *Jaapiella floriperda* on *Silene vulgaris*; C *Contarinia nasturtii* on *Nasturtium palustre* and other species of Brassicaceae; D *Lasioptera carophila* on *Pimpinella saxifraga*; E *Wachtliella persicariae* on *Polygonum amphibium*.

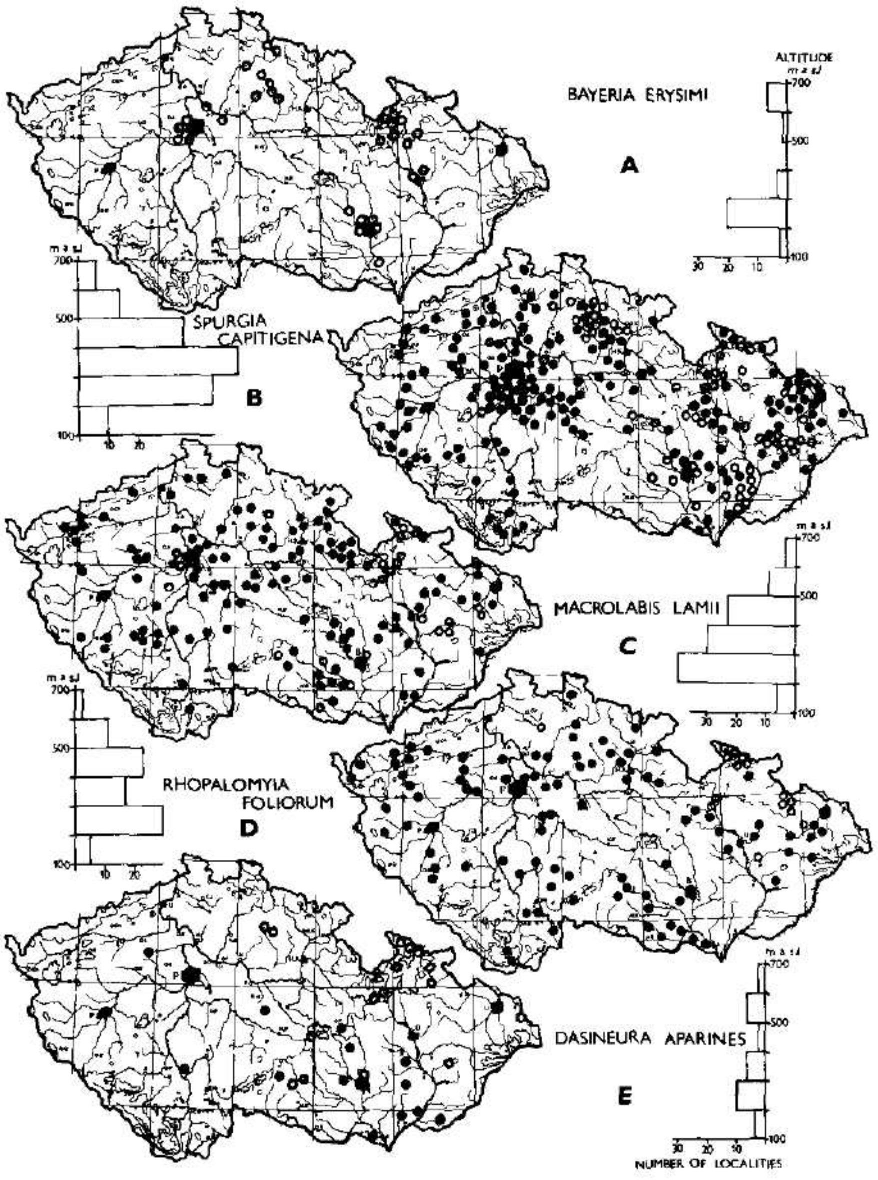



Fig 25 Gall midge species reaching the submountain zone A *Bayeria erysimi* on *Erysimum virgatum*, B *Spurgia (Bayeria) capitigena* on *Euphorbia cyparissias*, C *Macrolabis lamii* on *Lamium album*, D *Rhopalomyia foliorum* on *Artemisia vulgaris*, E *Dasineura aparines* on *Galium aparine*

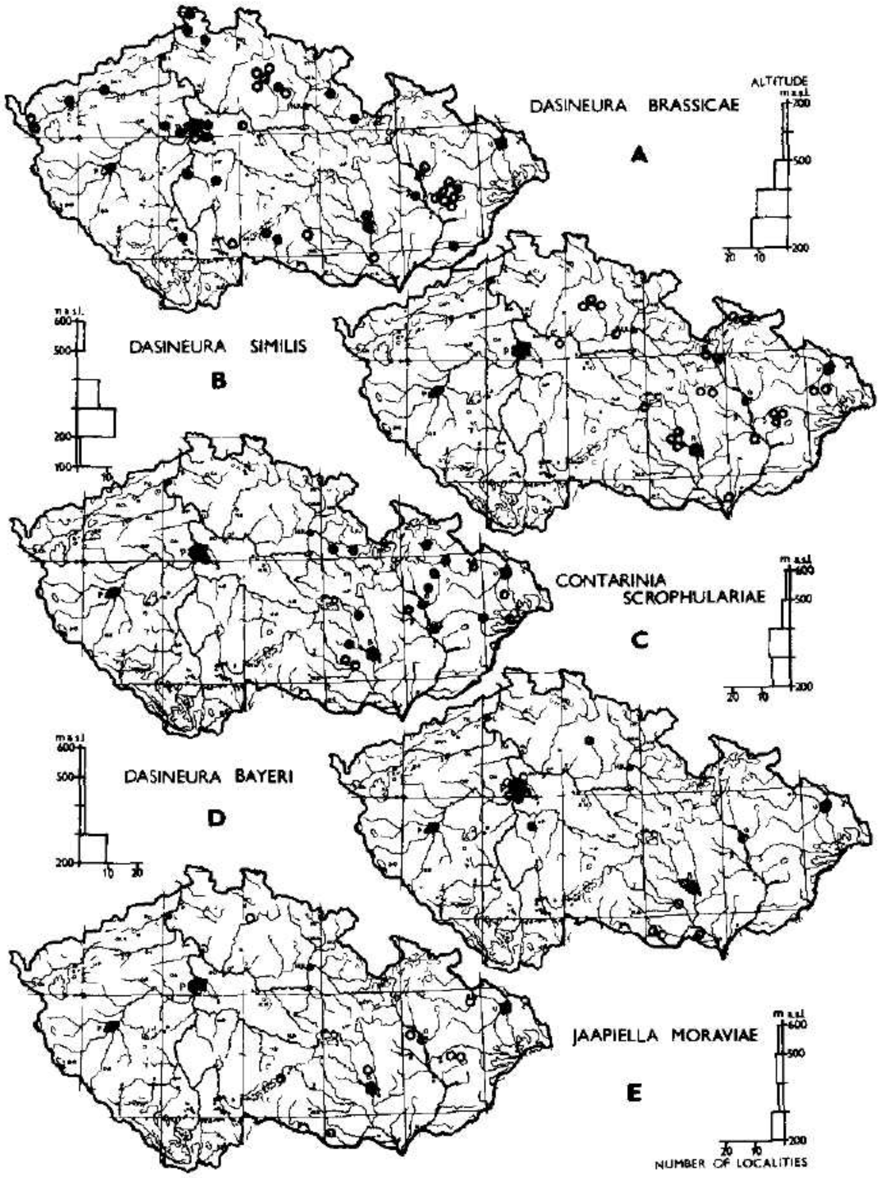



Fig.26. Gall midge species reaching the submountain zone: A *Dasineura brassicae* on *Brassica napus*; B *Dasineura similis* on *Veronica scutellata*; C *Contarinia scrophulariae* on *Scrophularia nodosa*; D *Dasineura bayeri* on *Sisymbrium loeselii*; E *Jaapiella moraviae* on *Lychnis viscaria*.

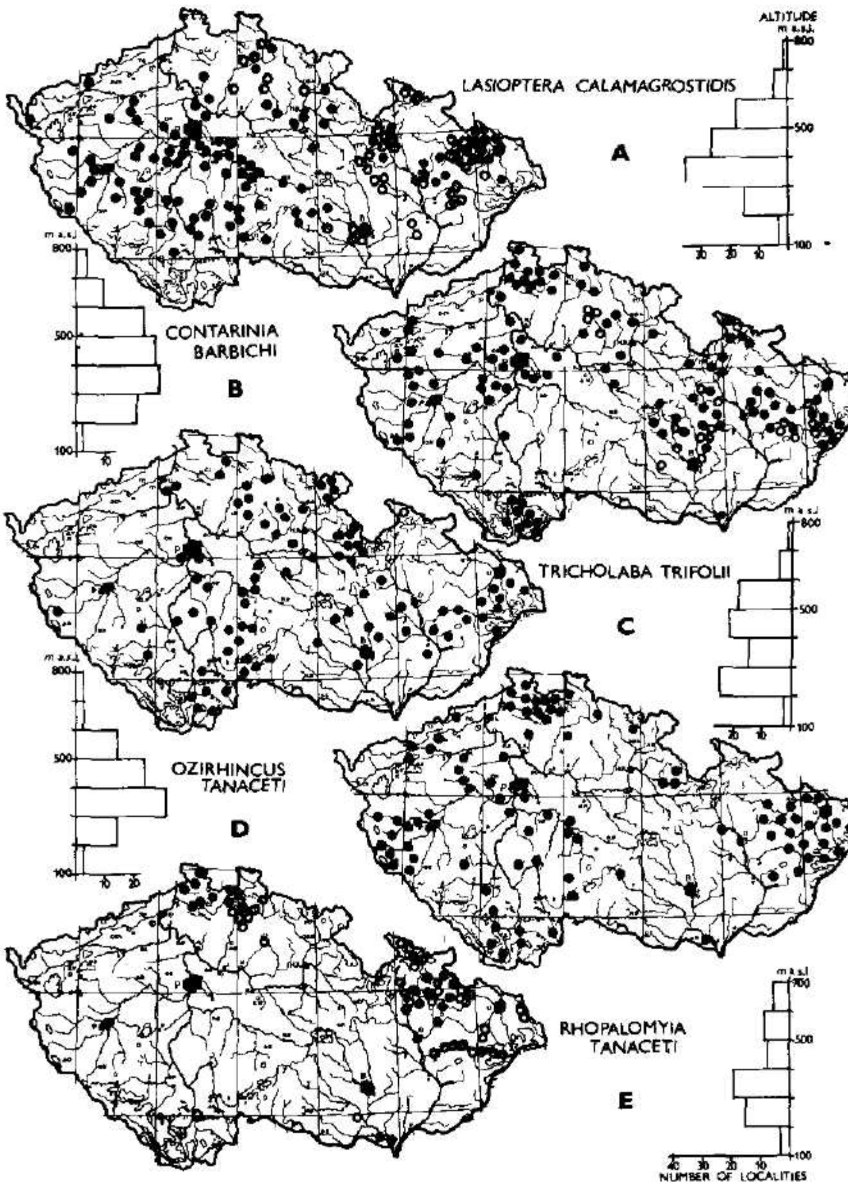



Fig.27. Gall midge species reaching the submountain zone: A *Lasioptera calamagrostidis* on *Calamagrostis epigeios*; B *Contarinia barbichi* on *Lotus corniculatus*; C *Tricholaba trifolii* on *Trifolium pratense*; D *Ozirhincus tanaceti*, E *Rhopalomyia tanaceticola*, both on *Tanacetum vulgare*.

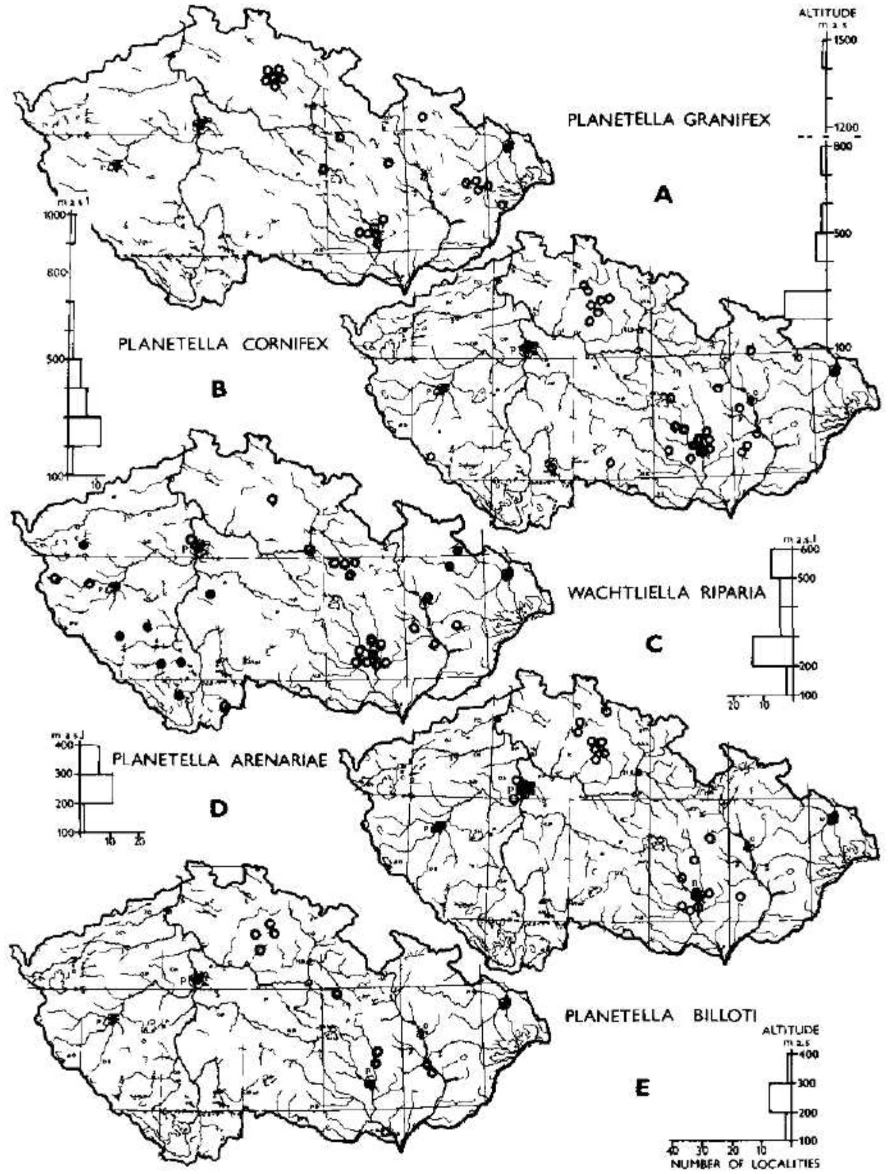



Fig 28 Gall midge species developing on *Carex* species reaching the sub-Alpine zone A *Planetella granifex* on *C echinata*, B *Planetella cornifex* on *C pallescens* and *C elata*, C *Wachtliella riparia* on *C riparia* and *C muricata*, D *Planetella arenariae* on *C arenaria*, E *Planetella billoti* on *C davalliana*

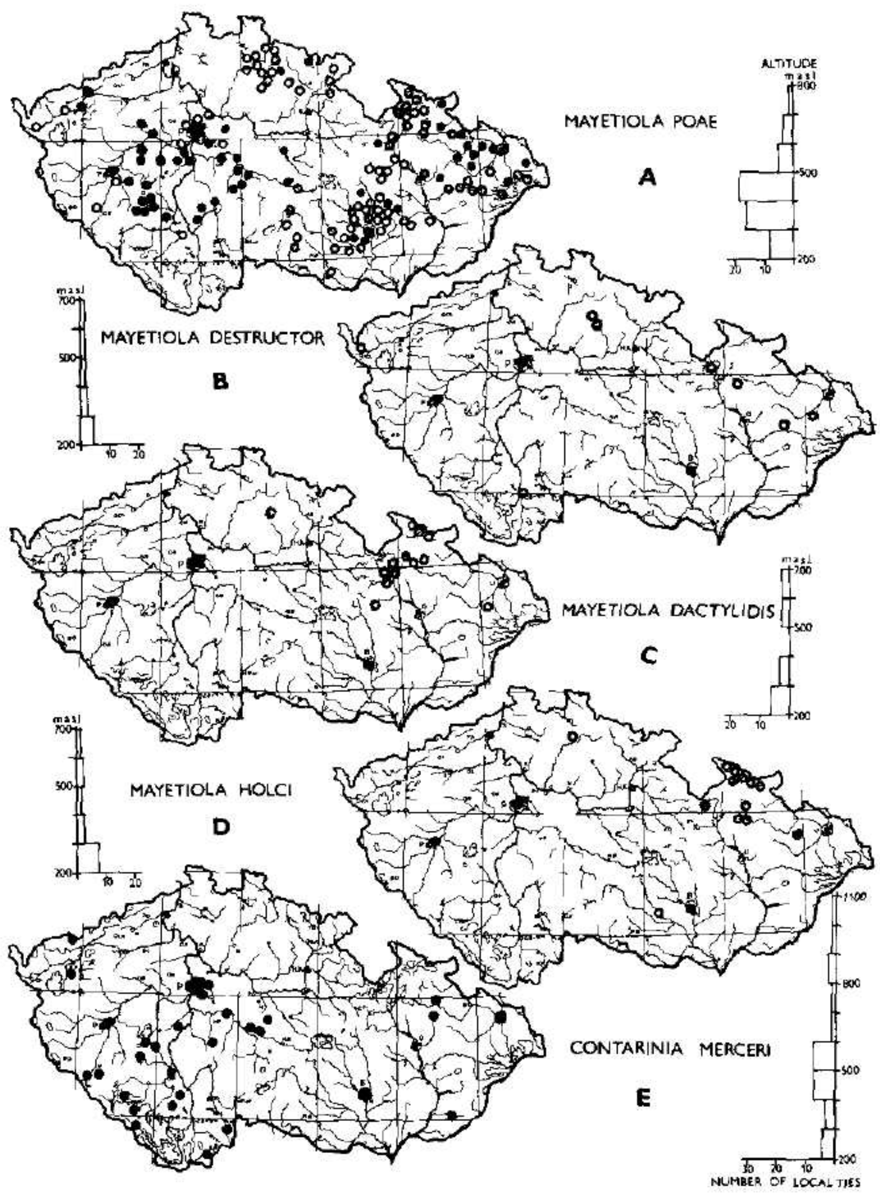



Fig 29 Gall midge species developing on species of the family Poaceae reaching the mountain zone A *Mayetiola poae* on *Poa nemoralis* B *Mayetiola destructor* on *Agropyron repens Phleum pratense* and *Triticum vulgare*, C *Mayetiola dactylidis* on *Dactylis glomerata*, D *Mayetiola holci* on *Holcus mollis* and *H lanatus*, E *Contarinia merceri* on *Alopecurus pratensis*

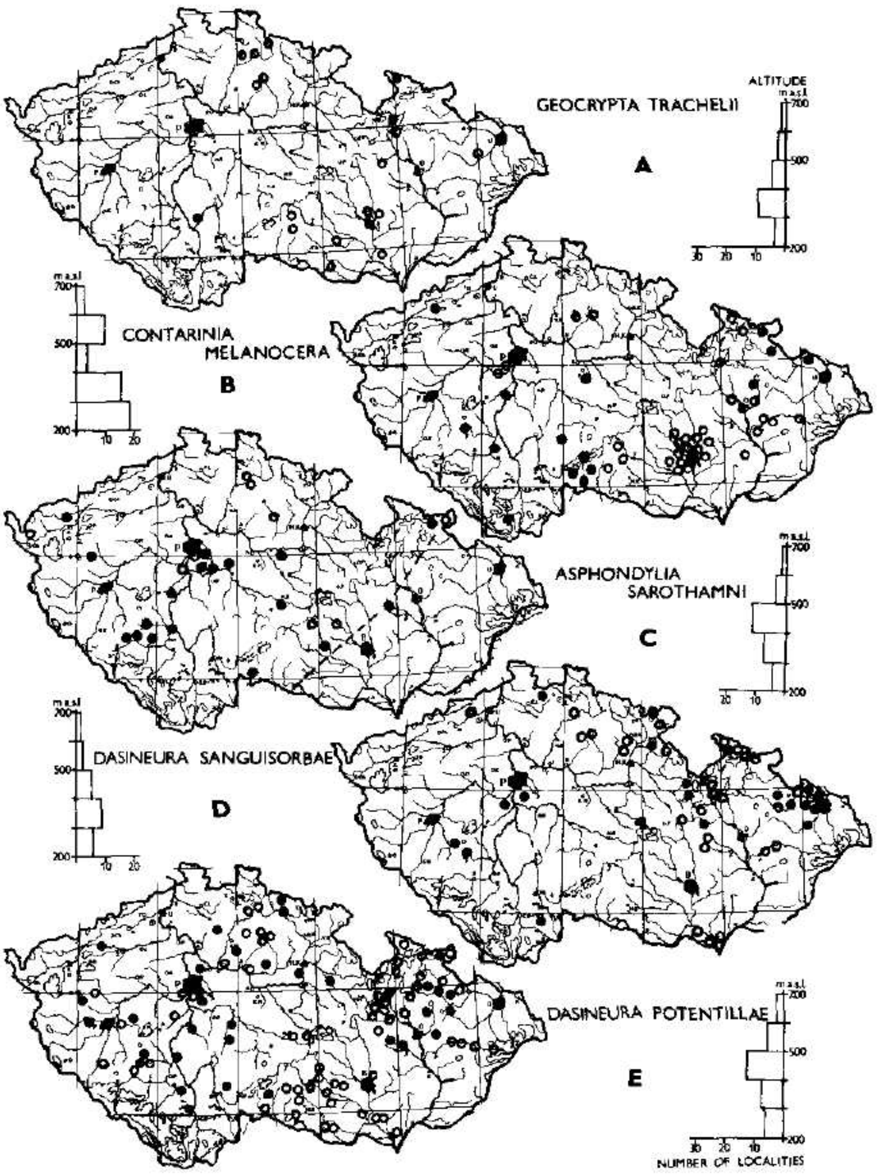



Fig 30 Gall midge species reaching the submountain zone A *Geocrypta trachelii* on *Campanula rotundifolia*, B *Contarinia melanocera* on *Genista tinctoria*, C *Asphondylia sarothamni* on *Sarothamnus scoparius*, D *Dasineura sanguisorbae* on *Sanguisorba officinalis*, E *Dasineura potentillae* on *Potentilla argentea*

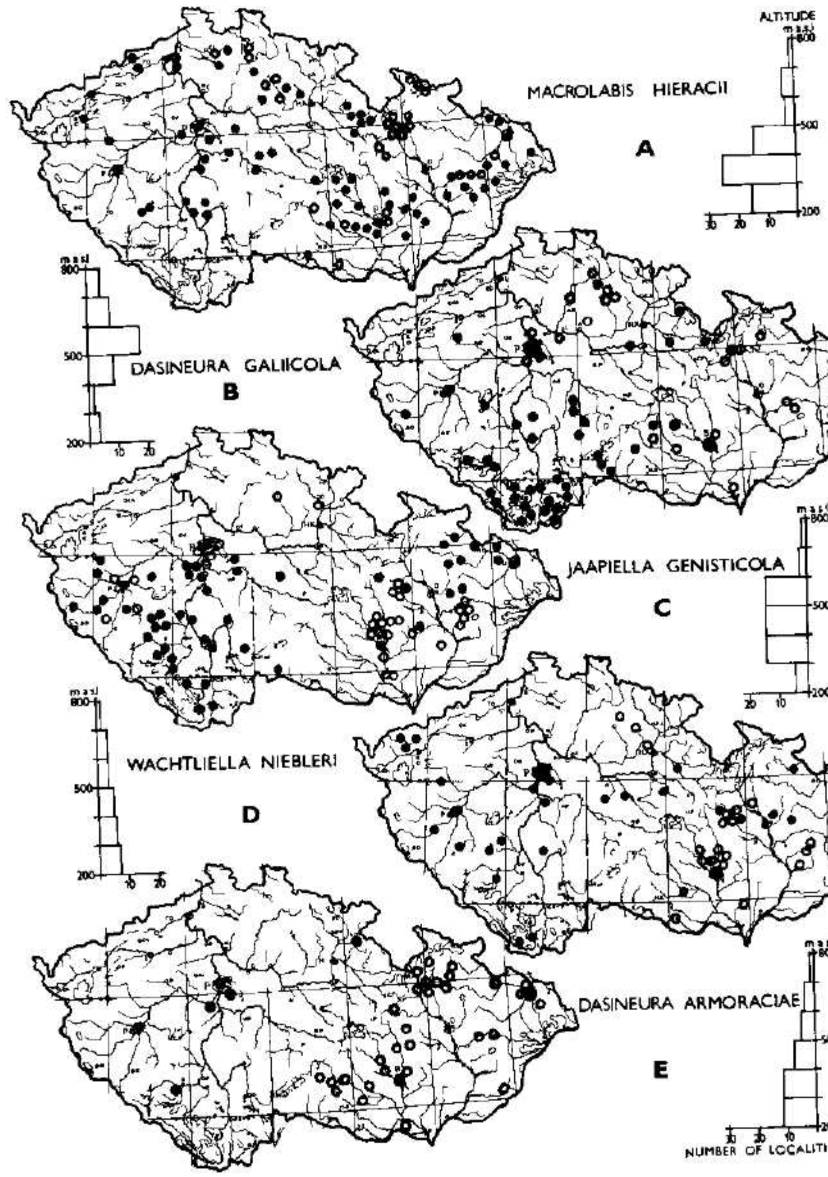



Fig 31 Gall midge species reaching the submountain zone A *Macrolabis hieracii* on *Hieracium sylvaticum*, B *Dasineura galiicola* on *Galium uliginosum*, C *Jaapiella genisticola* on *Genista tinctoria*, D *Wachtliella niebleri* on *Cytisus nigricans*, E *Dasineura armoraciae* on *Armoracia rusticana*

many species of the genus *Carex*. Two species, *Planetella arenariae* and *P. billoti*, occur only in the colline zone; galls of *Planetella cornifex* were found from the planare zone up to 1030 meters and galls of *Planetella granifex* even at an elevation of 1464 meters at Vysoká hole in the Hrubý Jeseník Mts. All gall midge species developing on *Carex* host plants belong to disappearing species. Larvae of *Wachtliella riparia* develop in swollen and deformed fruits of *Carex riparia* and *C. muricata* and were actually found at several localities in the colline zone (Fig.28).

Several gall midge species develop on various species of the family Poaceae. Larvae of *Mayetiola poae* produce swellings above nodes of *Poa nemoralis* and reach up to 800 m a.s.l. at Pustevny on the Radhošť mountain in the Moravskoslezské Beskydy Mts. Larvae of *Mayetiola destructor* cause swellings on the lower part of stems of weed grasses, viz. *Agropyron repens* and *Phleum pratense*. If they attack cereals, viz. *Triticum vulgare* and other cereals in large numbers, they may be pests. Larvae of *Mayetiola dactylidis* develop in depressions on stems of *Dactylis glomerata*. They have been found at localities in northern Moravia and at one locality in Bohemia. Galls of *Mayetiola holci* on *Holcus mollis* and *H. lanatus* have been found in similar parts of Moravia and Bohemia. Larvae of *Contarinia merceri* develop in inflorescences of *Alopecurus pratensis*. They occur from the colline zone up to the mountain zone at 1025 m a.s.l. at Boží Dar in Krušné hory Mts.(Fig.29).

Larvae of *Geocrypta trachelii* cause onion-shaped bud galls on *Campanula rotundifolia*. Larvae of *Contarinia melanocera* produce globular fleshy swellings on twigs of *Genista tinctoria*. It seems to be a disappearing species. Larvae of *Asphondylia sarothamni* develop in swollen pods and in buds of *Sarothamnus scoparius*. This is a sub-Atlantic species which reaches the eastern boundary of its distribution area in the territory of Moravia along the line connecting localities: Osoblaha (in the north) - Stínava - Studenec - Landštejn (in the south). To the east of this line, no galls of *A. sarothamni* have been found. Larvae of *Dasineura sanguisorbae* live in pod-like folded leaflets of *Sanguisorba officinalis*. Larvae of *Dasineura potentillae* gall flower buds of *Potentilla argentea* (Fig.30).

Larvae of *Macrolabis hieracii* develop in deformations at the top of the stem of *Hieracium sylvaticum*. Larvae of *Dasineura galiicola* form artichoke-shaped galls on *Galium uliginosum*. It seems to be an increasing species. Larvae of *Jaapiella genisticola* produce galls on growing tips of *Genista tinctoria*. This species disappeared from the territory of southern Moravia and has not been found in the area north of Praha. Larvae of *Wachtliella niebleri* live in folded leaflets of *Cytisus nigricans*. This species disappeared from the territory of southern Moravia. Larvae of *Dasineura armoraciae* gall flower buds of *Armoracia rusticana*. In the past it was abundant in the territory of Moravia, but now it seems that it has disappeared from this area (Fig.31).

### *4. Mountain gall midge species* (Figs 32-48)

The mountain zone includes uplands, hill-sides of higher mountains and highlands spread above 800 m a.s.l. up to the upper forest boundary which goes in the Czech Republic to an elevation of about 1200 m a.s.l. The surface of this zone was primarily overgrown with beech forests which were mainly converted into spruce monocultures. The composition of plant and animal communities changes quickly with rising elevation. In the mountain zone gall midges were investigated during our faunistic researches at 38 localities: 17 localities at elevations between 800-900 meters, 5 localities between 900-1000 meters, 14 localities between 1000-1100 meters and two localities between 1100-1200 meters (see Fig.6.E). Also earlier research workers, viz. Vimmer, Bayer and Baudyš, collected galls at the peak parts of several mountains lying in this zone. In the mountain zone 122 gall midge species have been found, i.e. 25% of all gall midge species recorded in the territory of the Czech Republic. They may be called mountain species sensu lato. The majority of them, including 119 species, penetrate here from the lower lying altitudinal zones, from the planare and the colline zones. Gall midges which occur in the mountain zone may be classified on similar vertical occurrence schemes (see Fig. 5) into five groups, as follows:

1. species occurring only in the elevation range of the mountain zone between 800-1200 meters; they are mountain species sensu stricto.
2. species extending here from the planare zone, the occurrence of which ends here in the mountain zone.
3. species extending here from the planare zone penetrating up to the sub-Alpine zone; they will be discussed under sub-Alpine species.
4. species extending here from the colline zone, the occurrence of which ends here in the mountain zone.
5. species extending here from the colline zone, penetrating up to the sub-Alpine zone; they will be treated under sub-Alpine species.

Mountain species sensu stricto

Only three gall midge species occur in the mountain zone in the elevation range of 800-1200 meters. They are the following species: *Contarinia crispans* and *Contarinia valerianae*, larvae of which form galls on leaves and flower buds of *Valeriana officinalis*. They were found in the Česnekový důl valley on the hill-side of the Praděd mountain in the Hrubý Jeseník Mts.at an elevation of about 1200 meters. The third species is *Dasineura filipendulae*, larvae of which develop in deformed flower buds of *Filipendula vulgaris*, having been found at the peak part of the hill Vsacký Cáb in the Vsetínské vrchy Hills at an elevation of 842 m a.s.l.

Species inhabiting the elevation range 100-1200 and 200-1200 meters (Figs 32-48)

In this group, which is composed from two sub-groups, belong 119 gall midge species of which 63 extend here from the planare zone and 56 from the colline zone. Twenty of these species, have a scattered distribution in the mountain zone and extend into the sub-Alpine zone. All gall midge species including in both sub-groups will be discussed here together because it is very difficult to separate them naturally. More than forty species are limited in their larval development to trees and shrubs and more then seventy species develop on herbaceous plants.

a) Gall midges on trees (Figs 32-40)

Three gall midges develop on hazel, *Corylus avellana*. The rare species, *Contarinia cybelae*, larvae of which produce leaf folds, inhabit several localities of the colline zone. Swollen catkins attacked by *Contarinia coryli* may be found up to an elevation of 660 meters and the gall midge species *Mikomya coryli*, larvae of which develop in circular hollows on the lower surface of the leaves, extend into the mountain zone up to Lipka, 881 m a.s.l. in southern Bohemia.

In the galls formed by swollen unopened flower buds of common elder, *Sambucus nigra*, there live three gall midge species, viz. *Placochela nigripes, Contarinia sambuci* and *Arnoldiola sambuci*. All these species are scattered in the colline zone and penetrate the submountain zone where their occurrence ends. *Contarinia baeri*, larvae of which cause the bending of needle pairs of *Pinus nigra*, penetrates into the mountain zone up to Lipka, 881 m a.s.l. in southern Bohemia (Skuhravý 1971, 1990) (Fig.32).

Two species of lime, *Tilia cordata* and *T. platyphyllos*, are the host plants for five gall midge species. They occur in the planare zone scattered, in the colline zone abundantly having here their maximum occurrence. The occurrence of three species ends just below the upper limit line of the submountain zone. *Contarinia tiliarum*, larvae of which cause rounded galls on flower stalks, leaf petioles and the extremities of young twigs, reaches up to 750 meters and the occurrence of *Dasineura tiliae*, larvae of which live in upward rolled swollen leaf margins, and of *Didymomyia tiliacea*, developing in woody leaf galls, ends at an elevation of 770 meters. Two lime gall midge species,*Physemocecis hartigi* and *Dasineura thomasiana*, penetrate into the mountain zone: *P. hartigi* up to Lipka, 881 m a.s.l. in the Šumava Mts. and *D. thomasiana* up to Kraví hora, 955 m a.s.l. in the Novohradské hory Mts. (Fig 33)

Of the four gall midge species which are restricted to the juniper, *Juniperus communis*, viz. *Oligotrophus juniperinus, O. panteli, O. schmidti* and *Schmidtiella gemmarum*, only *Oligotrophus juniperinus* extends to the mountain zone and occurs abundantly at an elevation of 1003 m a.s.l. at Kubova Huť in the Šumava Mts. Two gall midge species develop on larch, *Larix decidua*. Larvae of *Resseliella skuhravyorum* occur in the colline zone and bud galls of *Dasineura kellneri (D. laricis)* were found from the planare zone up to the mountain zone at an elevation of 1070 m a.s.l. at Pláně in the Šumava Mts.

The maple, *Acer pseudoplatanus*, is the host plant for four species of gall midegs, larvae of which cause galls on leaves, viz. *Contarinia acerplicans* that occurs only in the colline zone, *Dasineura irregularis (D. acercrispans), Harrisomyia vitrina* and *Drisina glutinosa*. These occur from the planare zone up to the mountain zone and their galls were found at an elevation of 1070 m a.s.l. at Pláně in the Šumava Mts. (Fig.34)

Five gall midge species develop in the larval stage on ash, *Fraxinus excelsior*. *Contarinia marchali* occurs rarely in the colline zone, *Clinodiplosis botularia*, an inquiline species, penetrates to the submountain zone and three gall midge species, viz. *Dasineura acrophila, D. fraxini* and *D. fraxinea*, the galls of which are most abundant, reach the mountain zone up to the peak part of Boubín, 1120 m a.s.l. in the Šumava Mts.

Of two gall midge species which cause galls on various species of *Rubus*, viz. *Lasioptera rubi*, larvae of which develop in stem swellings, and *Dasineura plicatrix*, developing in contorted and twisted leaves, *L. rubi* extends to an elevation of 1084 m a.s.l. at Kleť and galls of *D. plicatrix* were found at Hojsova Stráž,890 m a.s.l., both in the Šumava Mts. (Fig 35)

On aspen, *Populus tremula*, eleven gall midge species are known to occur in the Czech Republic. Two are inquilines and nine species develop in the larval stage on leaves, causing galls of various shapes. Six of them extend to the mountain zone and were found at elevations of 1065 m a.s.l. at Javorník, and at 1070 m a.s.l. at Planě, both in the Šumava Mts., and at 1000 m a.s.l. at Rýchory in the Krkonoše Mts. (Fig. 36).

Two gall midge species develop in galls on mountain-ash, *Sorbus aucuparia*. Larvae of *Contarinia sorbi*, developing in folded leaflets, occur from the colline to the mountain zone up to an elevation of 1065 m a.s.l. at Javorník in the Šumava Mts., whereas *Contarinia floriperda*, causing flower bud galls, extends to the sub-Alpine zone.

Only one gall-making species develops on alder, *Alnus glutinosa* and *A. incana*. Larvae of *Dasineura tortilis (D. alni)* live in folded and swollen leaves. Galls occur abundantly from the planare to the mountain zone up to 1070 m a.s.l. at Pláně in the Šumava Mts. Also the gall midge *Wachtliella rosarum*, larvae of which live in folded leaflets of *Rosa canina* and other species, occurs abundantly from the planare to the mountain zone extending to 906 m a.s.l. at Mářský vrch near Prachatice in southern Bohemia (Fig. 37)

Six gall midge species are limited in their larval development to birch, *Betula pendula* and *B. pubescens*. Three species of the genus *Semudobia*, viz. *S. betulae, S. tarda* and *S. skuhravae* develop in female catkins, whereas *Anisostephus betulinus, Plemeliella betulicola* and *Massalongia rubra* cause galls of various shapes on leaves. Galls of *Plemeliella betulicola* occur up to an elevation of 1070 m a.s.l. at Pláně, galls of *Semudobia betulae* were found at 1065 m a.s.l. at Javorník, both in Šumava Mts., galls of *Massalongia rubra* at an elevation of 955 m a.s.l. at the Kraví hora mountain in the Novohradské hory Mts. (Fig. 38).

More than twenty gall midge species develop in galls on various organs on many species of willows, *Salix* spp. Galls on leaves, buds, catkins, twigs or other damaged organs of willows occur from the planare up to the sub-Alpine zone. The occurrence of most gall midge species ends in the submountain zone, as shown by *Dasineura marginemtorquens*, larvae of which cause leaf margin rolls on *Salix viminalis* (see Fig 38 E). Several species extend up to the mountain zone and they were found at the peak parts of several mountains; *Dasineura clavifex* at Javorník, 1065 m a.s.l. in the Šumava Mts., *D. saliciperda* and *D. iteobia* at Žalý, 1036 m a.s.l. in the Krkonoše Mts., *D. salicis* at Šerlich, 1018 m a.s.l. in the Orlické hory Mts., *D. auritae* at Velký Polom, 1060 m a.s.l. in the Hrubý Jeseník Mts. (see Fig.40.E). Two willow gall midge species, viz. *Iteomyia capreae* and *Dasineura rosaria*, reach up to the sub-Alpine zone (Fig.39).

The beech, *Fagus sylvatica*, is the dominant species in plant associations of the mountain zone, forming the forest stands here. Four gall midge species develop, causing galls of various shapes on leaves and leaf buds. The occurrence of all begins in the colline zone. They are spread abundantly in the submountain zone and their occurrence ends in the mountain zone at the peak part of Boubín, 1120 m a.s.l. in the Šumava Mts. (Fig. 40).

b) Gall midges on herbaceous plants (Figs 41 - 48)

Several of about seventy gall midge species developing on herbaceous host plants reach to or a little over the upper limit of the submountain zone and some gall midge species exceed this line and penetrate to the higher elevations of the mountain zone. Galls of *Macrolabis podagrariae* on leaflets of *Aegopodium podagraria* were found on the hill-side of the Krušné hory Mts. at Kovářská, 820 m a.s.l. Swollen leaflets of *Pimpinella saxifraga*, caused by larvae of *Jaapiella hedickei*, at the hill Mářský vrch, 906 m a.s.l. in the Šumava Mts. Galls formed by larvae of *Dasineura affinis* on leaf margins of *Viola reichenbachiana* were found at an elevation of 955 m a.s.l. at Kraví hora in the Novohradské hory Mts. Two gall midge species, viz. *Dasineura ranunculi*, larvae of which cause cornet-shaped rolled leaves of *Ranunculus acris*, and *Janetiella thymi*, producing galls at the growing tips of *Thymus serpyllum*, occur up to an elevation of 770 m a.s.l. at Rejvíz in the Hrubý Jeseník Mts. (Fig. 41).

The following gall midge species occur from the planare zone up to the lower part of the mountain zone.Pustule galls on leaves of *Sonchus arvensis* caused by larvae of *Cystiphora sonchi* were found up to an evevation of 890 m a.s.l. at Hojsova Stráž in the Šumava Mts. *C. sonchi* seems to be a decreasing species; in the past it was more abundant than it is at present. Swollen and crumpled leaves of *Geum urbanum* produced by larvae of *Contarinia gei* occur from the planare zone up to an elevation of 880 m a.s.l. at Lipka in the Šumava Mts. *Dasineura violae*, larvae of which live in rosette leaf galls of *Viola tricolor* ssp. *arvensis*, is also a decreasing species. Galls of *D. violae* occur up to an elevation of 820 m a.s.l. at Kovářská in the Krušné hory Mts.; flower bud galls of *Gephyraulus raphanistri* on *Raphanus raphanistrum* up to an elevation of 848 m a.s.l. at Přimda in the Český les Mts. *Wachtliella stachydis*, larvae of which live in swollen deformed leaf and flower buds of *Stachys sylvatica*, is a decreasing species and it occurs at present scattered and in smaller areas of Moravia than it was in the past. The galls were recorded at Vsacký Cáb, 842 m a.s.l. in the Vsetínské vrchy Hills (Fig. 42). The following gall midge species occur from the colline zone to the lower part of the mountain zone. Flower bud galls of *Contarinia lysimachiae* on *Lysimachia vulgaris* were found up to Mariánská, 860 m a.s.l. in the Krušné hory Mts. Pod-like folded leaves of *Lathyrus pratensis* caused by larvae of *Dasineura lathyri* were found at Libínské sedlo, 850 m a.s.l. in the Šumava Mts. Galls of three gall midge species were found at Kovářská, 820 m a.s.l. in the Krušné hory Mts., viz. *Asphondylia lathyri*, larvae of which induce galls on the pods of *Lathyrus pratensis, Dasineura myosotidis*, larvae of which live in swollen unopened flower buds of *Myosotis palustris*, and *Rhopalomyia ptarmicae*, larvae of which develop in deformed flower heads of *Achillea ptarmica*. Galls of this last species have not been found in the territory of Moravia (Fig. 43).

Several gall midge species occur from the planare zone up to the middle part of the mountain zone. Two gall midge species reach up to Pláně, 1070 m a.s.l. in the Šumava Mts., viz. *Dasineura trifolii*, larvae of which form galls from folded leaflets of *Trifolium repens*, and *Dasineura lathyricola*, larvae of which live between two discoloured stipules of *Lathyrus pratensis*. Galls of two other species have been found at Javorník, 1065 m a.s.l. in the Šumava

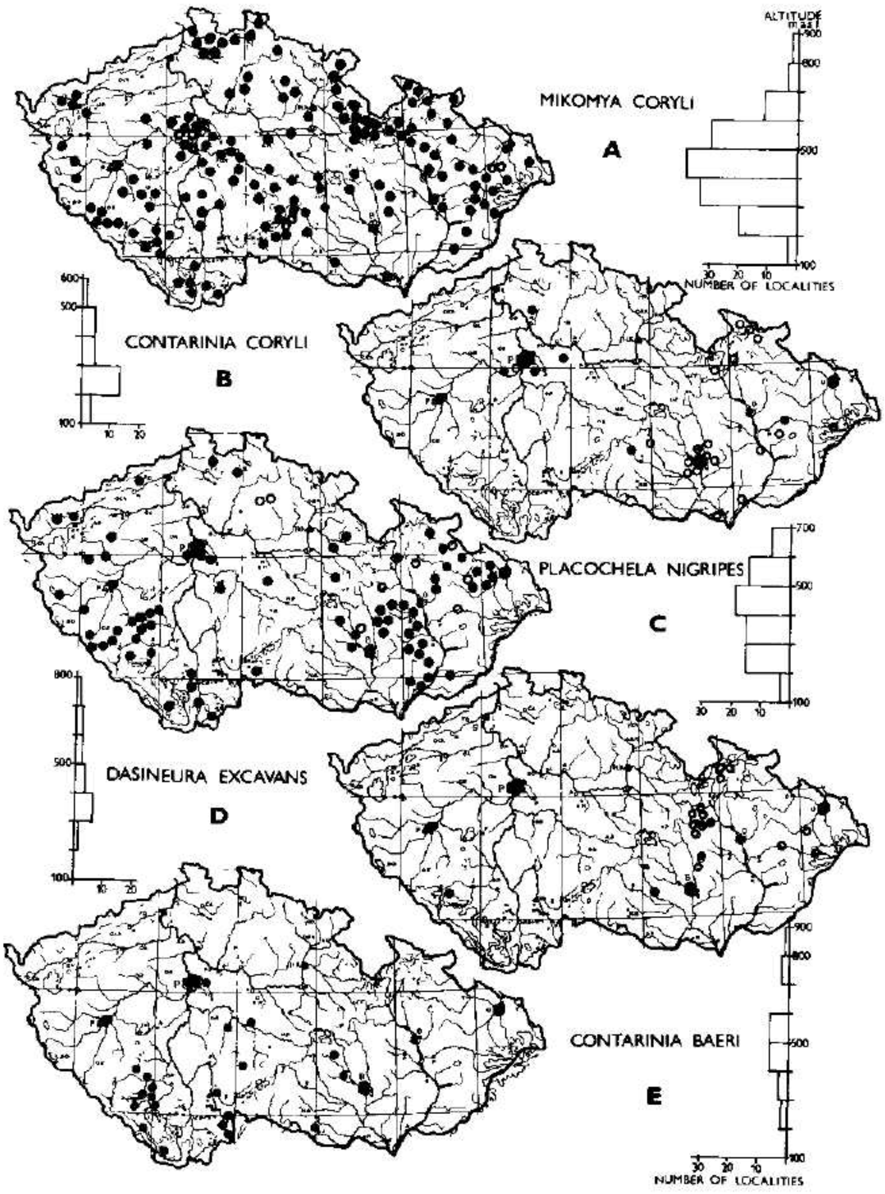



Fig.32. Gall midge species reaching the submountain zone and mountain zone: A *Mikomya coryli*; B *Contarinia coryli*, both on *Corylus avellana*; *Placochela nigripes* on *Sambucus nigra*; D *Dasineura excavans* on *Lonicara xylosteum*; E *Contarinia baeri* on *Pinus sylvestris*.

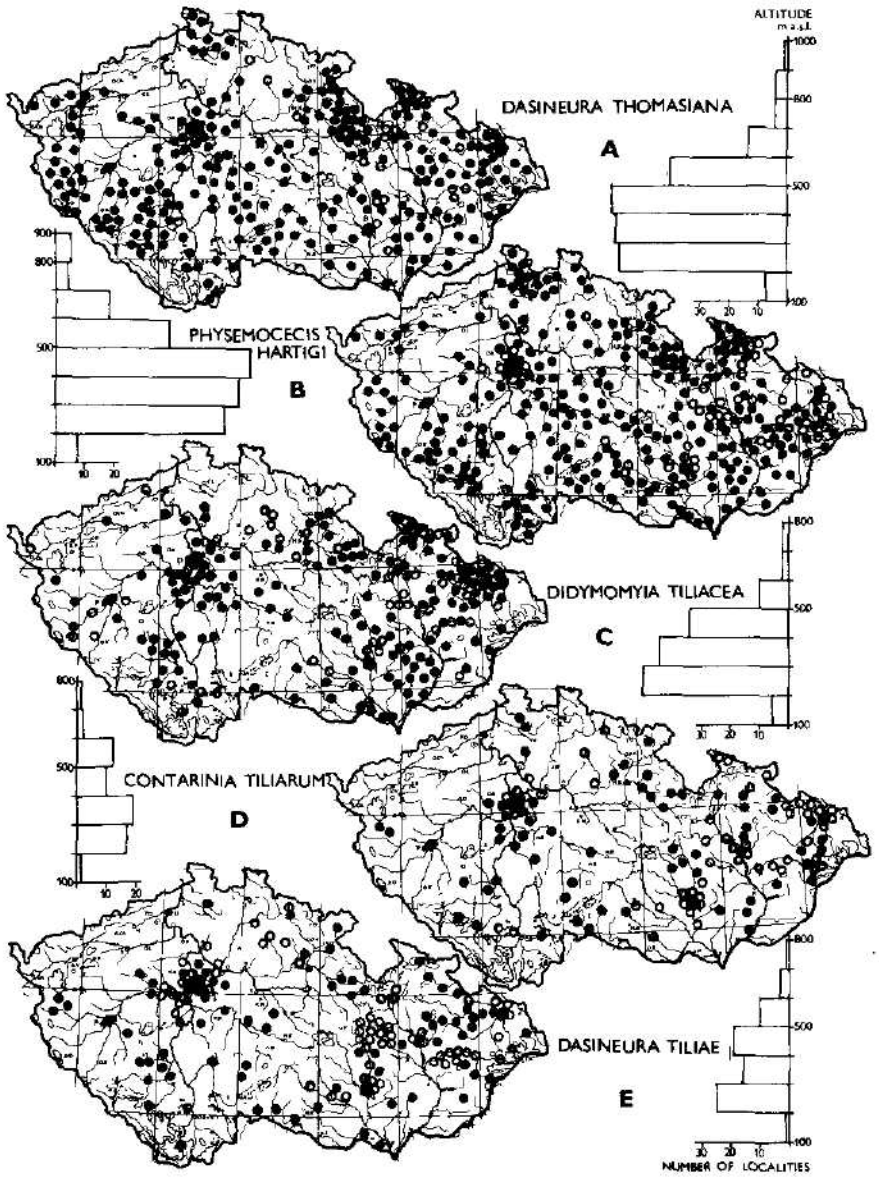



Fig.33. Gall midge species developing on *Tilia platyphyllos* and *T. cordata* reaching the submountain and mountain zones: A *Dasineura thomasiana*; B *Physemocecis hartigi*; C *Didymomyia tiliacea*; D *Dasineura tiliae*; E *Contarinia tiliarum*.

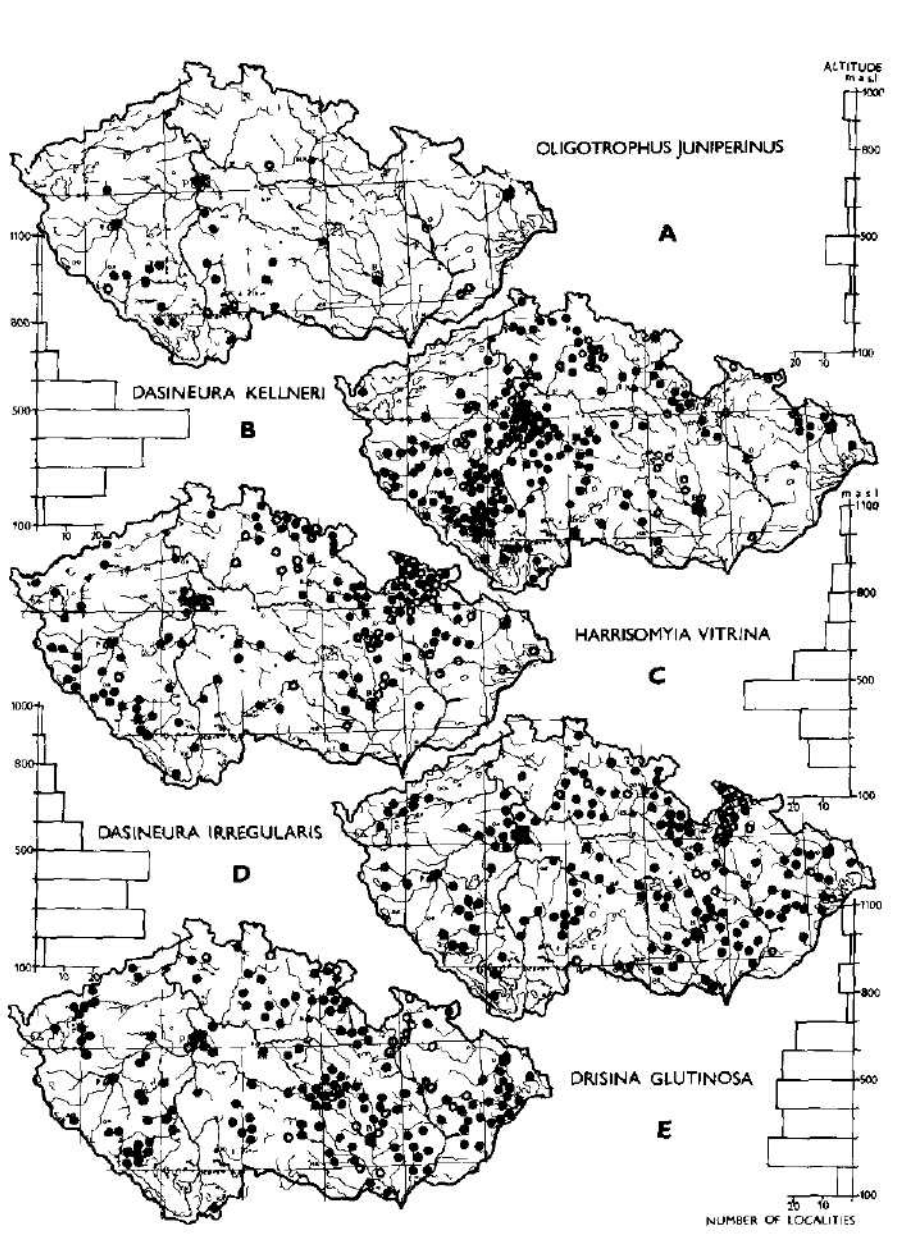



Fig 34 Gall midge species reaching the mountain zone A *Oligotrophus juniperinus* on *Juniperus communis*, B *Dasineura kellneri* on *Larix decidua*, C *Harrisomyia vitrina*, D *Dasineura irregularis*, E *Drisina glutinosa*, all on *Acer pseudoplatanus*

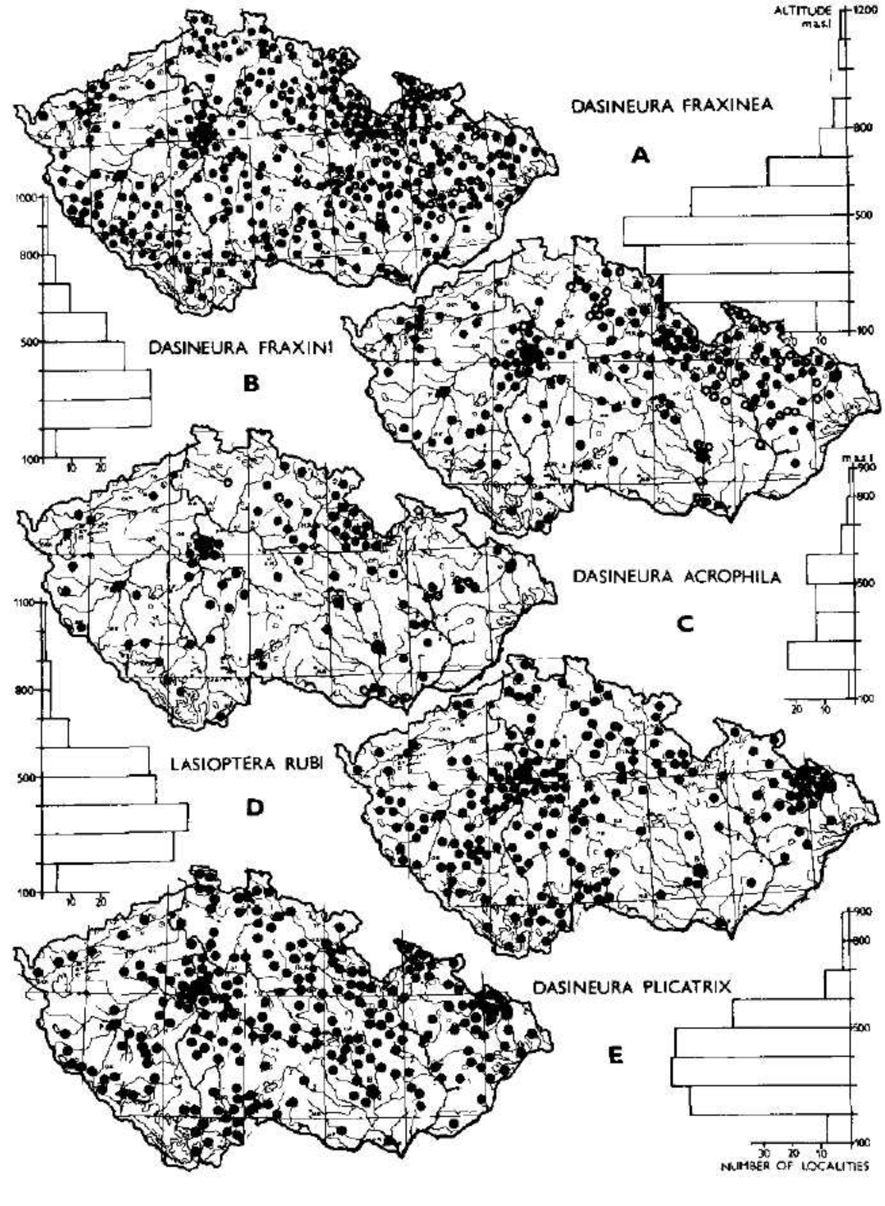



Fig.35. Gall midge species reaching the mountain zone: A *Dasineura fraxinea*, B *Dasineura fraxini*, C *Dasineura acrophila*, all on *Fraxinus excelsior*; D *Lasioptera rubi* on *Rubus idaeus* and other species; E *Dasineura plicatrix* on *Rubus caesius* and other species.

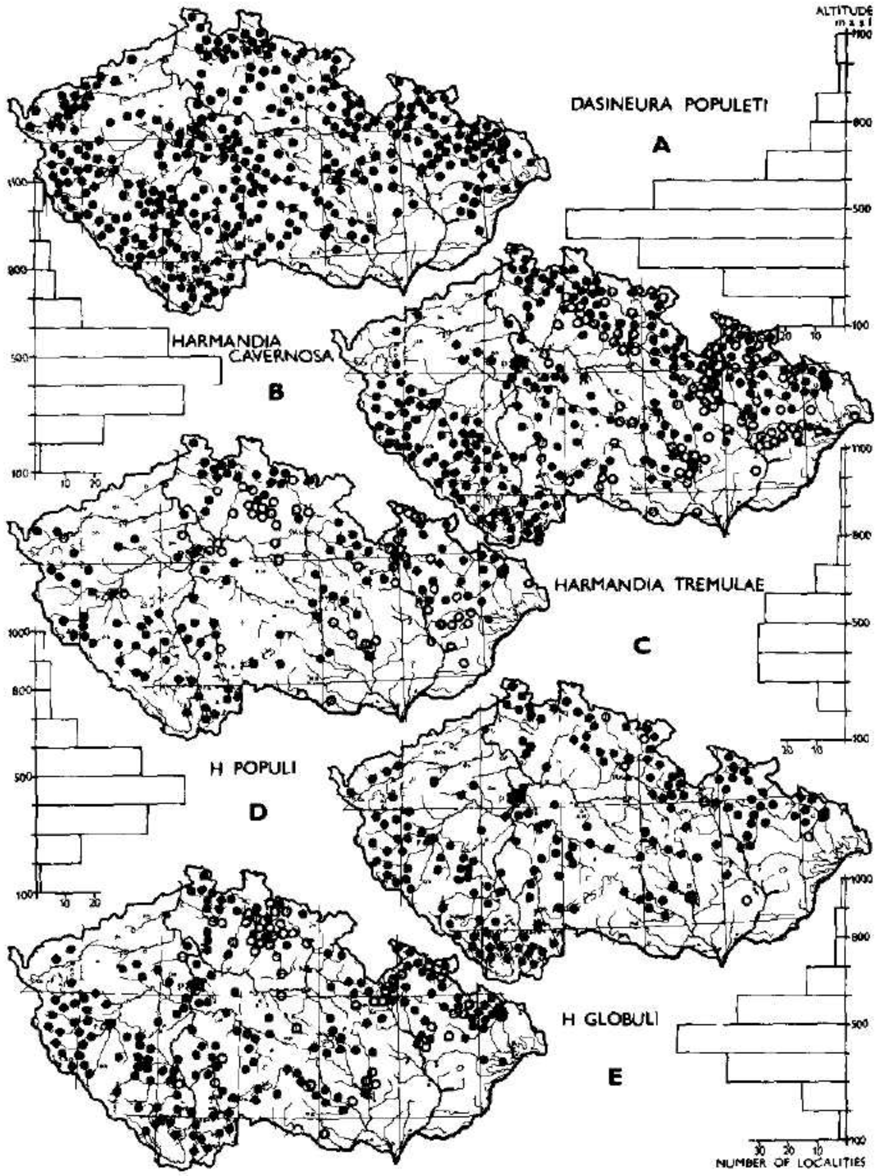



Fig.36. Gall midge species developing on *Populus tremula* reaching the mountain zone: A *Dasineura populeti*; B *Harmandia cavernosa*, C *Harmandia tremulae*; D *Harmandia populi*; E *Harmandia globuli*.

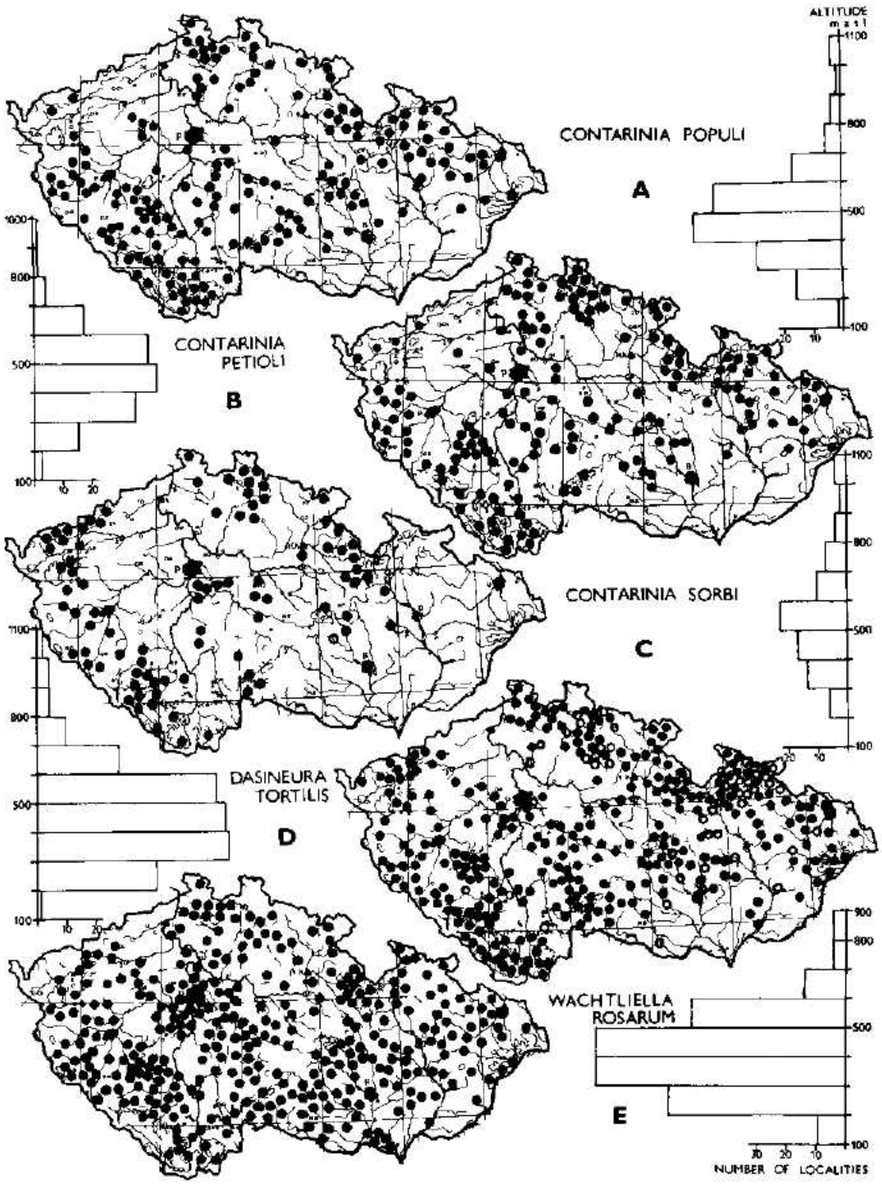



Fig 37 Gall midge species reaching the mountain zone A *Contarinia populi*, B *Contarinia petioli*, both on *Populus tremula*, C *Contarinia sorbi* on *Sorbus aucuparia*, D *Dasineura tortilis* on *Alnus glutinosa* and *A incana*, E *Wachtliella rosarum* on *Rosa canina*

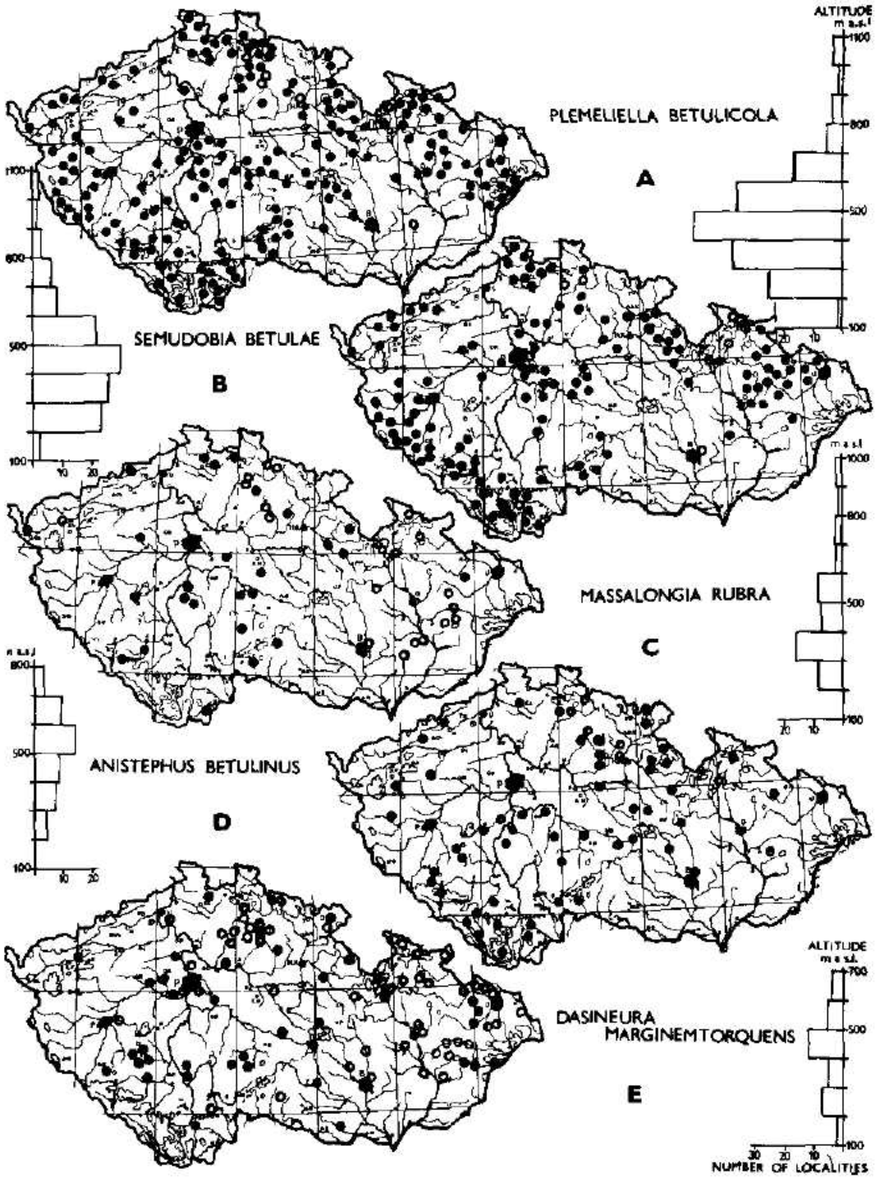



Fig 38. Gall midge species reaching the mountain zone: A *Plemeliella betulicola*; B *Semudobia betulae*; C *Massalongia rubra*, D *Anisostephus betulinus*; all on *Betula pendula* and *B. pubescens*; E *Dasineura marginemtorquens* on *Salix viminalis*.

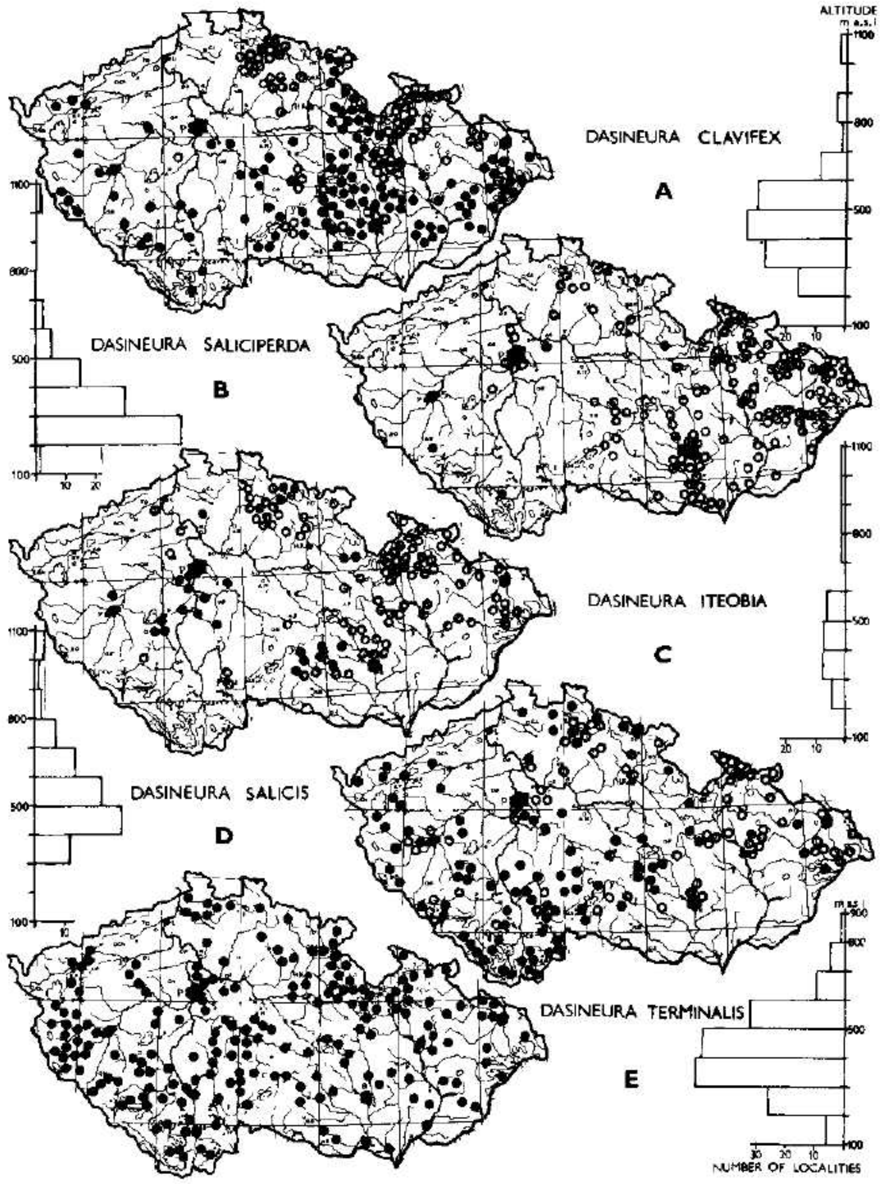



Fig.39. Gall midge species developing on various *Salix*-species and reaching the mountain zone: A *Dasineura clavifex* on *Salix aurita*, *S. caprea* and *S. cinerea*; B *Dasineura saliciperda* on *Salix alba* and *S. fragilis*; C *Dasineura iteobia* on *Salix caprea*; D *Dasineura salicis* on *Salix cinerea*, *S. aurita* and *S. caprea*; E *Dasineura terminalis* on *Salix fragilis*.

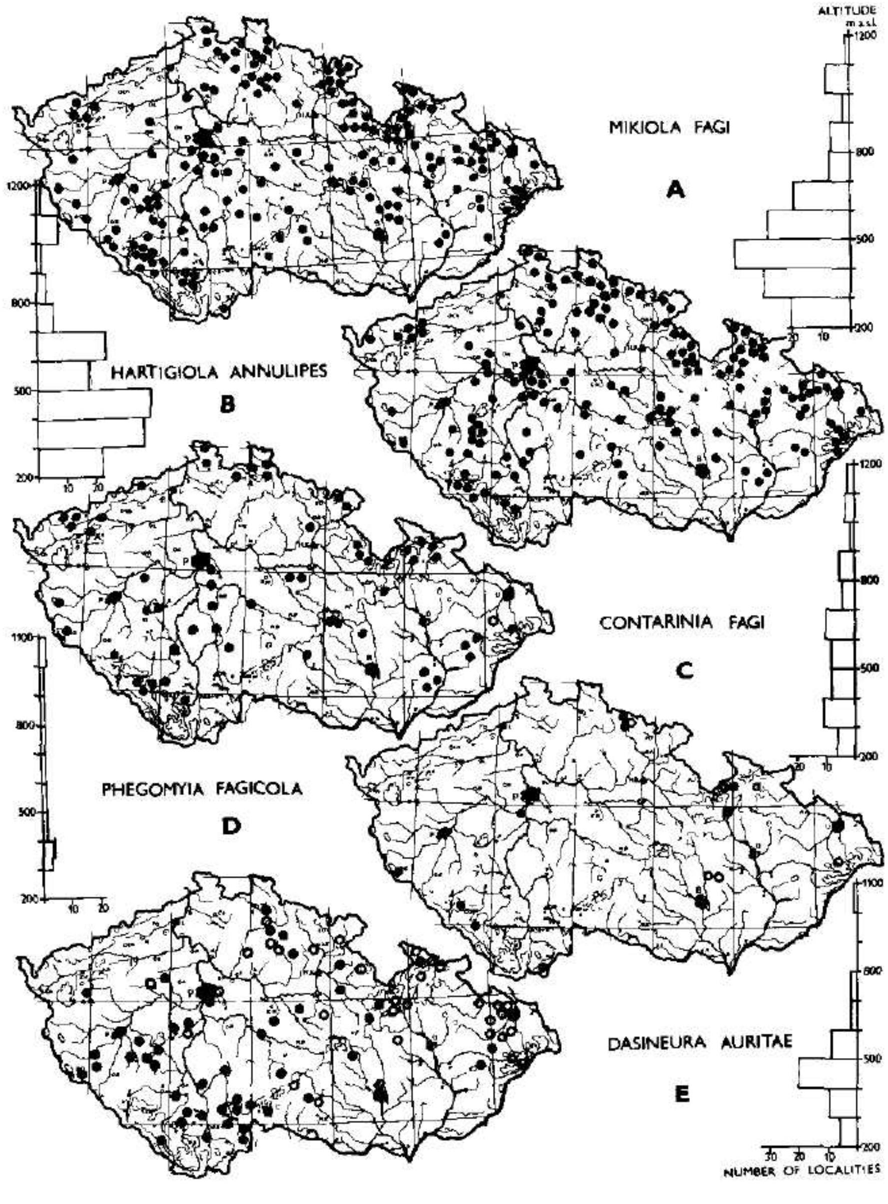



Fig. 40. Gall midge species reaching the mountain zone: A *Mikiola fagi*, B *Hartigiola annulipes*, C *Contarinia fagi*, D *Phegomyia fagicola*, all on *Fagus sylvatica*; E *Dasineura auritae* on *Salix aurita*.

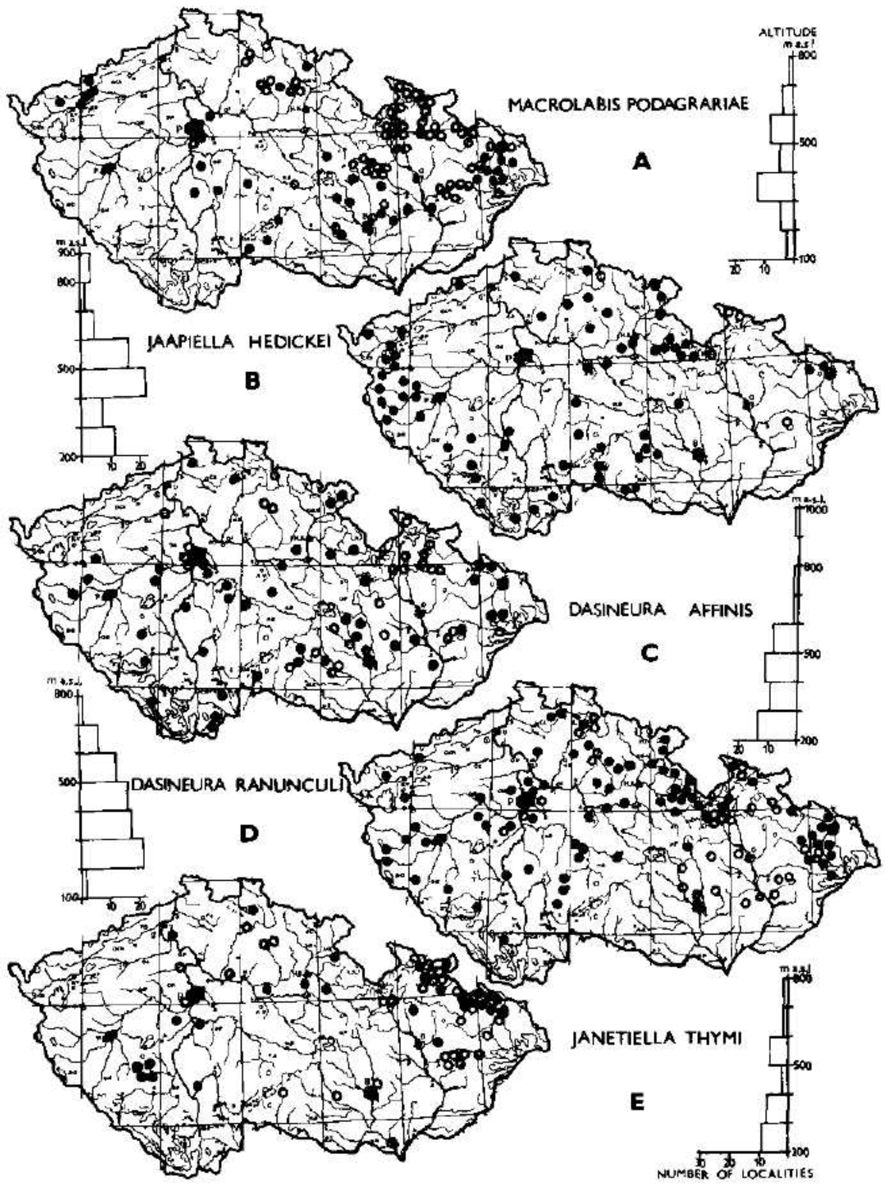



Fig.41 Gall midge species reaching the mountain zone: A *Macrolabis podagraria* on *Aegopodium podagraria*; B *Jaapiella hedickei* on *Pimpinella saxifraga*, C *Dasineura affinis* on *Viola reichenbachiana*, D *Dasineura ranunculi* on *Ranunculus acris*; E *Janetiella thymi* on *Thymus serpyllum*.

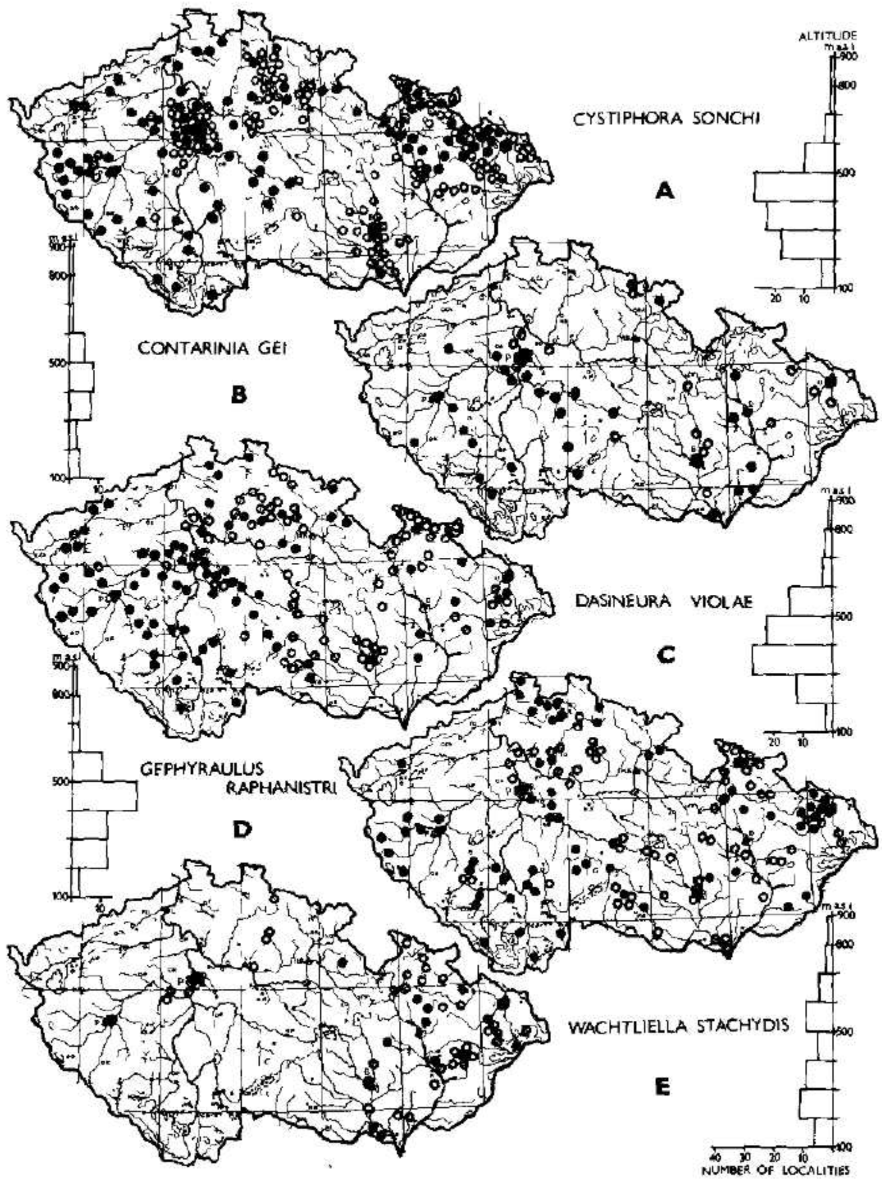



Fig. 42. Gall midge species reaching the lower part of the mountain zone: A *Cystiphora sonchi* on *Sonchus arvensis*; B *Contarinia gei* on *Geum urbanum*; C *Dasineura violae* on *Viola tricolor* ssp. *arvensis*; D *Gephyraulus raphanistri* on *Raphanus raphanistrum*; E *Wachtliella stachydis* on *Stachys sylvatica*.

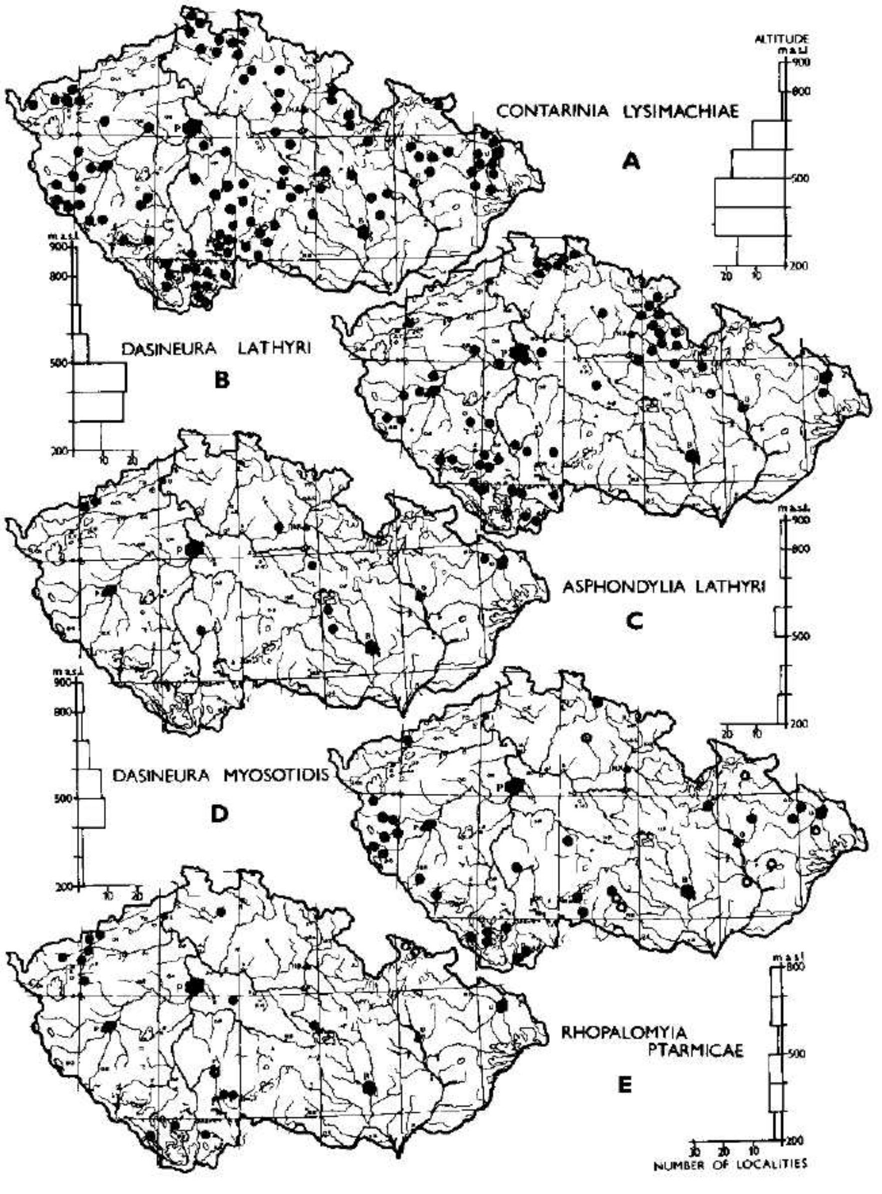



Fig 43 Gall midge species reaching the lower part of mountain zone A *Contarinia lysimachiae* on *Lysimachia vulgaris*, B *Dasineura lathyri*, C *Asphondylia lathyri*, both on *Lathyrus pratensis*, D *Dasineura myosotidis* on *Myosotis palustris*, E *Rhopalomyia ptarmicae* on *Achillea ptarmica*

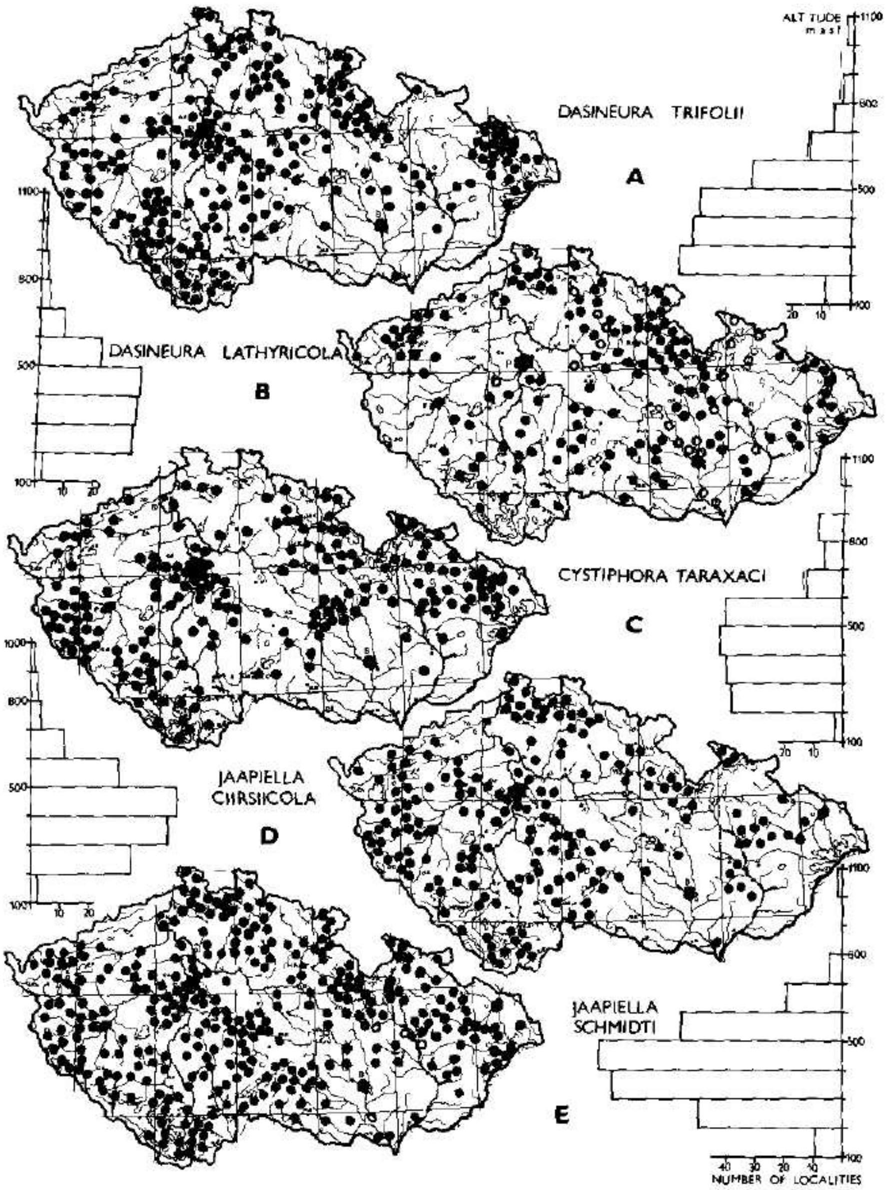



Fig 44 Gall midge species reaching the mountain zone A *Dasineura trifolii* on *Trifolium repens*, B *Dasineura lathyricola* on *Lathyrus pratensis*, C *Cystiphora taraxaci* on *Taraxacum officinale*, D *Jaapiella cirsiicola* on *Cirsium arvense*, E *Jaapiella schmidti* on *Plantago lanceolata*

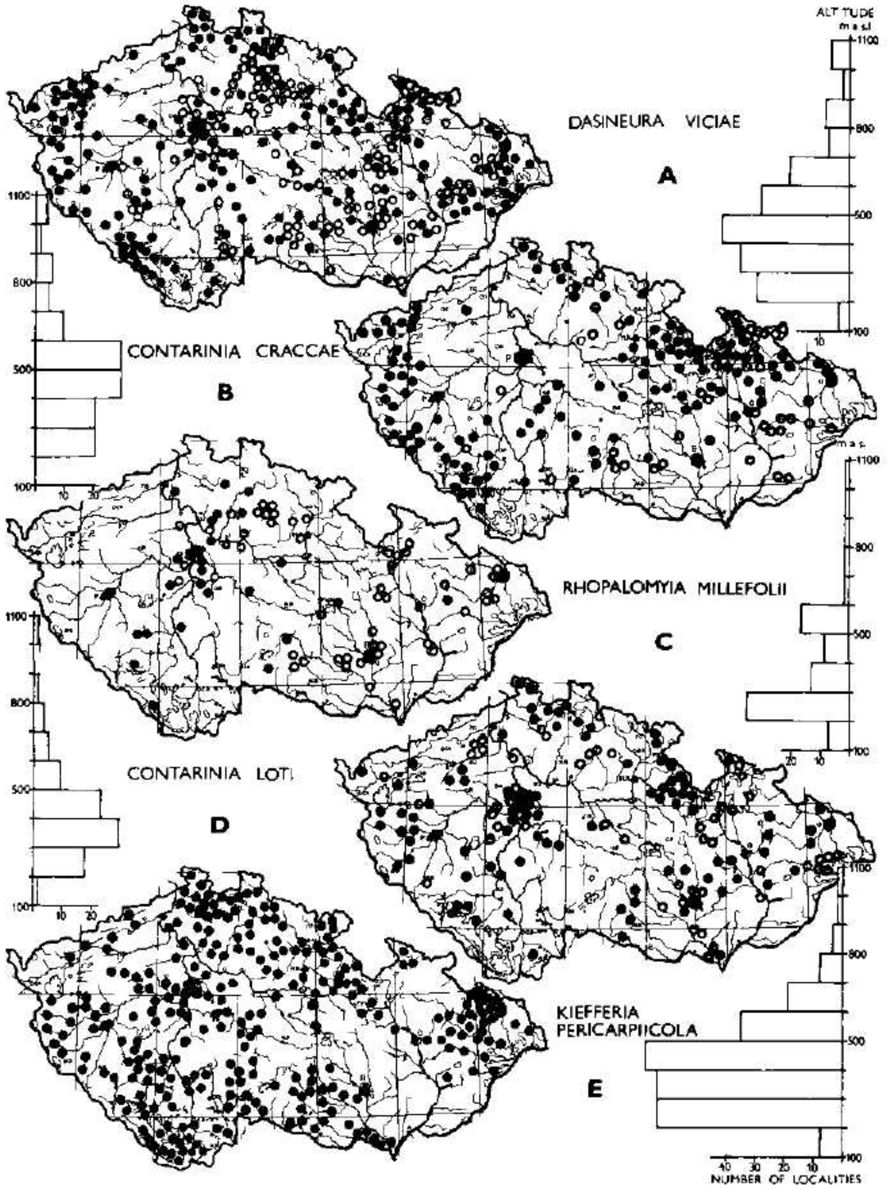



Fig 45 Gall midge species reaching the mountain zone A *Dasineura viciae* on *Vicia sepium* and other species B *Contarinia craccae* on *Vicia cracca*, C *Rhopalomyia millefolii* on *Achillea millefolium* D *Contarinia loti* on *Lotus corniculatus*; E *Kiefferia pericarpiicola* on *Pimpinella saxifraga* and other species of the family Apiaceae

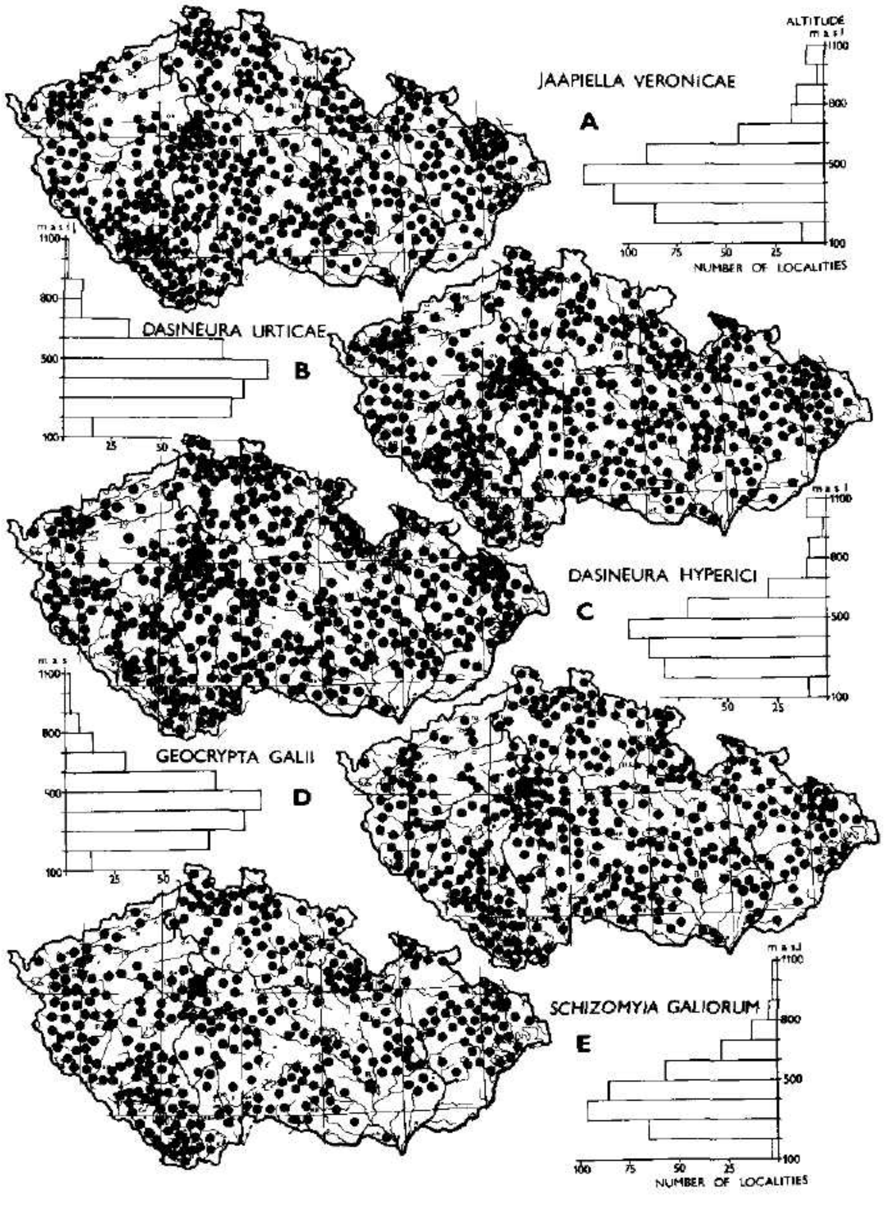



Fig.46 The most common gall midge species extending from the planare zone up to the mountain zone: A *Jaapiella veronicae* on *Veronica chamaedrys*; B *Dasineura urticae* on *Urtica dioica*, C *Dasineura hyperici* on *Hypericum perforatum*; D *Geocrypta galii*, E *Schizomyia galiorum*, both on *Galium mollugo* and other species

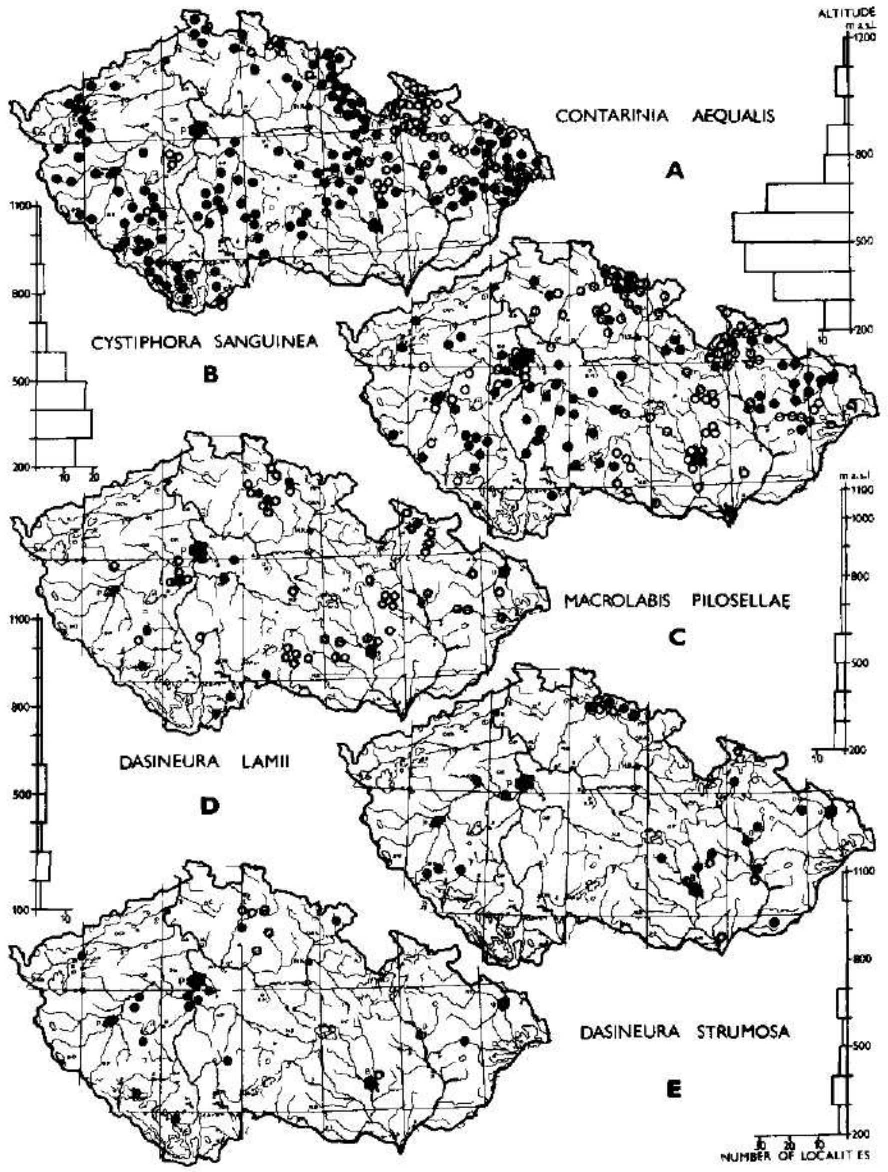



Fig 47 Gall midge species reaching the mountain zone A *Contarinia aequalis* on *Senecio nemorensis* ssp *Fuchsii*, B *Cystiphora sanguinea* on *Hieracium pilosella* and *H sylvaticum*, C *Macrolabis pilosellae* on *Hieracium pilosella*, D *Dasineura lamii* on *Lamium maculatum*, E *Dasineura strumosa* on *Lamium galeobdolon*

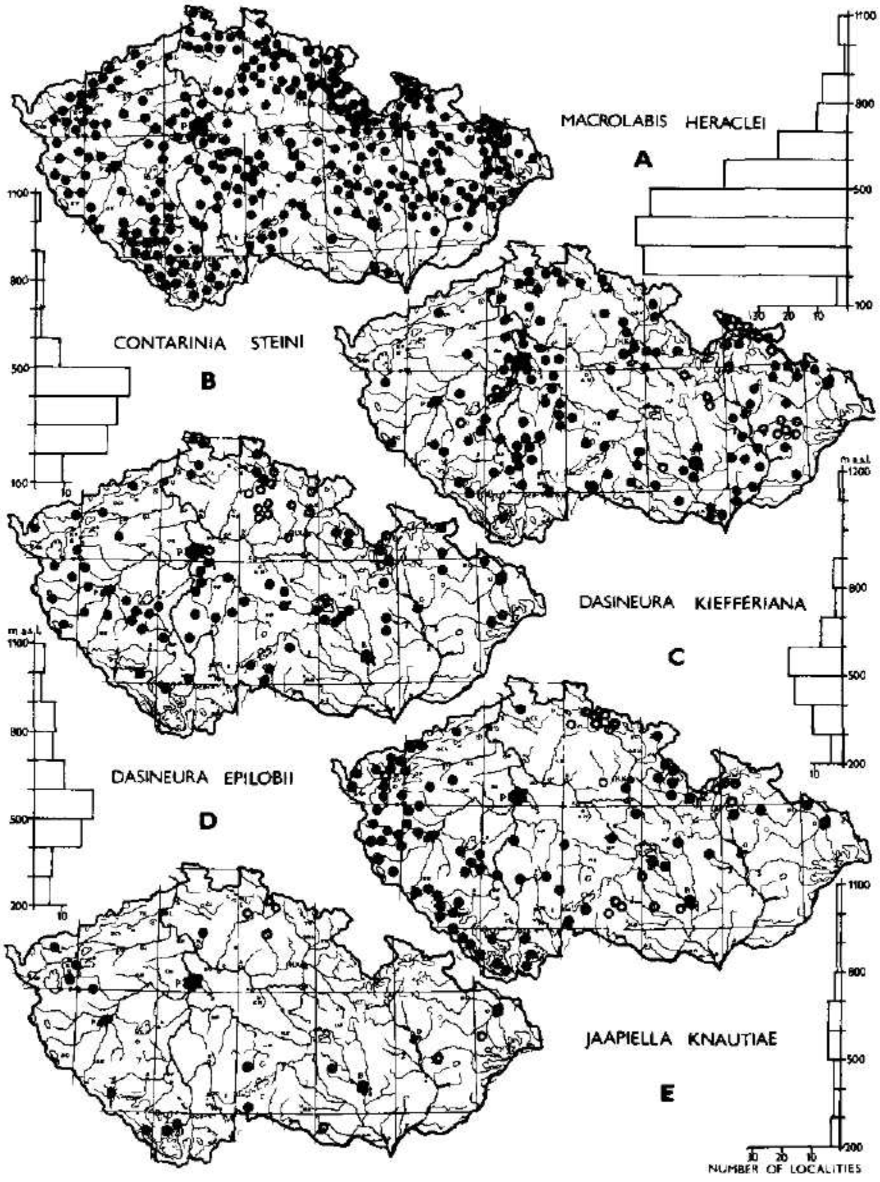



Fig.48. Gall midge species reaching the mountain zone: A *Macrolabis heraclei* on *Heracleum sphondylium*; B *Contarinia steini* on *Melandrium album*; C *Dasineura kiefferiana*, D *Dasineura epilobii*, both on *Epilobium angustifolium*; E *Jaapiella knautiae* on *Knautia arvensis*.

Mts , viz *Cystiphora taraxaci*, larvae of which cause pustule leaf galls on *Taraxacum officinale*, and *Jaapiella schmidti*, larvae of which live in the seed capsules of *Plantago lanceolata* Larvae of *Jaapiella cirsiicola* living in flower heads of *Cirsium arvense* were found at an elevation of 1000 m a s l at Zlata Studně in the Šumava Mts (Fig 44)

Two gall midge species developing on *Vicia*, viz *Dasineura viciae* on leaflets of *Vicia sepium* and *Contarinia craccae* on flower buds of *Vicia cracca*, seem to have retreated from the lowlands to the mountains Galls of *D viciae* were found at Pláně, 1070 m a s l and galls of *C craccae* at Horska Kvilda, 1070 m a s l , both in the Šumava Mts Galls of three other gall midge species occur at an elevation of 1065 m a s l at Javorník in the Šumava Mts , viz *Rhopalomyia millefolii*, larvae of which cause conspicuous galls on *Achillea millefolium*, the species which almost disappeared from the territory of Moravia, *Contarinia loti*, larvae of which gall the flower buds of *Lotus corniculatus*, *Kiefferia pericarpiicola (K pimpinellae)* larvae of which develop in swollen fruits of *Pimpinella saxifraga* and other closely related species from the family Apiaceae This is an abundant species the galls of which are conspicuous on all host plant species (Fig 45)

Five gall midge species which are most common and are placed in frequency group VI, develop in galls on commonly occurring plants Larvae of *Jaapiella veronicae* cause galls at the growing tips of *Veronica chamaedrys* larvae of *Dasineura urticae* live in leaf galls on *Urtica dioica*, larvae of *Dasineura hyperici* induce galls on *Hypericum perforatum*, larvae of *Geocrypta galii* produce stem galls on *Galium mollugo* and larvae of *Schizomyia galiorum* develop in flower bud galls of the same host plant All these species occur in the peak part of the Šumava Mts at Kleť, 1084 m a s l , at Javorník, 1065 m a s l and at Planě, 1070 m a s l (Fig 46)

Larvae of *Contarinia aequalis* form axillar or terminal leaf bud galls on *Senecio nemorensis* ssp *fuchsii*, which is a dominant species of the mountain plant associations Galls of *C aequalis* occur from the colline to the mountain zone up to the peak part of Boubin, 1120 m a s l in the Šumava Mts It seems to be an increasing species Galls of two gall midge species were found at Žaly, 1036 m a s l in the Krkonoše Mts , viz pustule leaf galls of *Cystiphora sanguinea* on *Hieracium pilosella* and flower bud galls of *Dasineura lamii* on *Lamium maculatum*, whereas leaf bud galls of *Macrolabis pilosellae* on *Hieracium pilosella* and underground bud galls of *Dasineura strumosa (D galeobdolontis)* on *Lamium galeobdolon* were found at Javorník, 1065 m a s l in the Šumava Mts (Fig 47)

The abundant species *Macrolabis heraclei (M corrugans)*, larvae of which gall the young leaves of *Heracleum sphondylium*, occurs abundantly from the planare zone up to the mountain zone and its galls were collected at an elevation of 1070 m a s l at Planě in the Šumava Mts Unopened flower buds of *Melandrium album* inhabited by larvae of *Contarinia steini* were found at the peak part of Boubin, 1120 m a s l in the Šumava Mts Of two species limited in their development to *Epilobium angustifolium*, the rolled leaf margins caused by larvae of *Dasineura kiefferiana* were found at Radhošť, 1129 m a s l in the Moravskoslezske Beskydy Mts and flower bud galls induced by larvae of *Dasineura epilobii* were found at Javorník, 1065 m a s l in the Šumava Mts Button-shaped galls at the growing tip of *Knautia arvensis*, caused by larvae of *Jaapiella knautiae*, occur at the peak part of the Kleť mountain, 1084 m a s l in the Šumava Mts (Fig 48)

### *5. Sub-Alpine gall midge species* (Figs 49 - 52)

The sub-Alpine zone is designated the area spread over the boundary of continuous forest, called also the forest line, timber line, or tree limit, at elevations between 1200 and 1300 meters, extending to an elevation of 1602 meters, at the peak of Sněžka, the highest point of the Czech Republic There is barren country covered with grasses, with small shrubs such *Vaccinium myrtillus, V uliginosum, V vitis-idaea, Salix herbacea* and with sparse vegetation This zone is characterized by dwarf pines, *Pinus mugo*.

In the sub-Alpine zone gall midge species were collected during our faunistic investigations in five localities, viz. in the Krušné hory Mts. on the peak part of mount Klínovec, 1244 m a.s.l.; in the Krkonoše Mts. at Zlaté Návrší, 1300 m a.s.l. and at Kokrháč, 1443 m a.s.l.; in the Hrubý Jeseník Mts. at Šerák, 1351 m a.s.l. and at Keprník, 1423 m a.s.l. (see Fig.6.E). Baudyš, Bayer, Vimmer and Seidel, searched and collected galls at several localities in the sub-Alpine zone: in the Krkonoše Mts. at the peak part of Vysoké Kolo, 1503 m a.s.l., Kotel, 1435 m a.s.l., Pančická louka, 1400 m a.s.l., Kotelní jámy, 1300 m a.s.l.; in the Hrubý Jeseník Mts. at several localities in the peak part and the hill-side of Praděd, 1491 m a.s.l. and at Vysoká hole, 1464 m a.s.l.; in the Moravskoslezské Beskydy at the peak part of Lysá hora, 1323 m a.s.l.; at Kralický Sněžník, 1423 m a.s.l. and also in the Šumava Mts. at Jezerní Stěna, 1343 m a.s.l.

In the rough climatic conditions of the sub-Alpine zone 26 gall midge species have been found, i.e. about 5% of all species recorded in the territory of the Czech Republic. They may be designated as sub-Alpine species sensu lato. Galls of four species were collected only in the elevation range of the sub-Alpine zone and may be designated as sub-Alpine species sensu stricto. Twenty two gall midge species occur here in the sub-Alpine zone scattered on the peak parts of the highest mountains of the Czech Republic. The majority of them occur abundantly in the lower altitudinal zones, where these species have their maximum occurrence, and enter into the sub-Alpine zone only solitarily and have been found here only at one or two localities, seldom at several contiguous localities at elevations above 1200 meters.

In the sub-Alpine zone, in the elevation range between 1200-1300 meters, there have been found only two gall midge species, between 1300-1400 meters seven gall midge species and between 1400-1500 meters even 16 gall midge species; each of them has been found only at one locality in the sub-Alpine zone.

All gall midge species occurring in the sub-Alpine zone may be classified on the basis of similar vertical occurrence schemes (see Fig.5) into four groups, as follows:

1. species occurring only in the sub-Alpine zone; they are sub-Alpine species sensu stricto.
2. species extending here from the submountain zone.
3. species extending here from the planare zone, which occur in colline, submountain and mountain zones.
4. species extending here from the colline zone which occur in submountain and mountain zones.

Sub-Alpine species sensu stricto

Four gall midge species have been found only in the sub-Alpine zone. Larvae of *Brachydiplosis caricum* living under the leaf sheaths of *Carex* sp. have been found at Vysoké Kolo, 1503 m a.s.l. in the Krkonoše Mts. Galls of *Contarinia helianthemi*, produced by larvae on vegetative tips of *Helianthemum nummularium*, were found at Vysoká hole, 1464 m a.s.l. in the Hrubý Jeseník Mts. On the sub-Alpine meadow at Pančická louka, at an elevation of about 1400 m a.s.l. there have been found galls of *Dasineura vitisidaea*, caused by its larvae at the tips of shoots of *Vaccinium vitis-idaea*. Galls of *Contarinia crispans* formed by deformed thickened leaves of *Valeriana officinalis* were found at an elevation of 1200 m a.s.l. in the valley of Česnekový důl on the hill-side of the Praděd mountain in the Hrubý Jeseník Mts.

Species extending to the sub-Alpine zone from lower lying altitudinal zones

Two gall midge species, viz. *Contarinia aconitifloris* and *Dasineura bistortae*, reach up to the sub-Alpine zone from the submountain zone. Larvae of *Contarinia aconitifloris* live inside swollen unopened flower buds of *Aconitum lycoctonum* and *A. napellus* and prevent development of seeds. These galls have been found only in two localities at an elevation of 709 m a.s.l. at Jelení Žleb near Karlov pod Pradědem in the Hrubý Jeseník Mts. and at an elevation of 1435 m a.s.l. in the Kotelní Jámy in the Krkonoše Mts. (see Fig. 52).

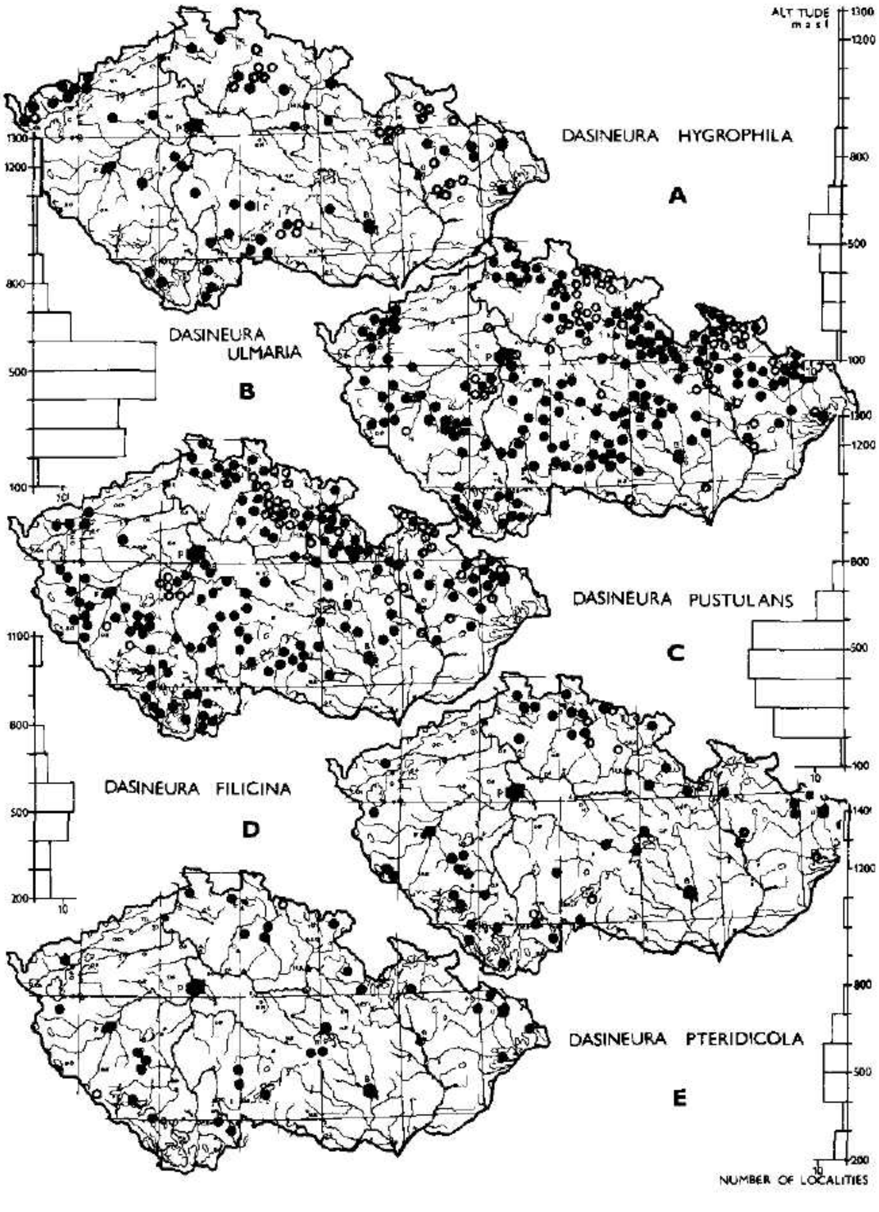



Fig 49 Gall midge species reaching the sub Alpine zone A *Dasineura hygrophila* on *Galium palustre*, B *Dasineura ulmaria* C *Dasineura pustulans*, both on *Filipendula ulmaria*, *Dasineura filicina*, E *Dasineura pteridicola*, both on *Pteridium aquilinum*

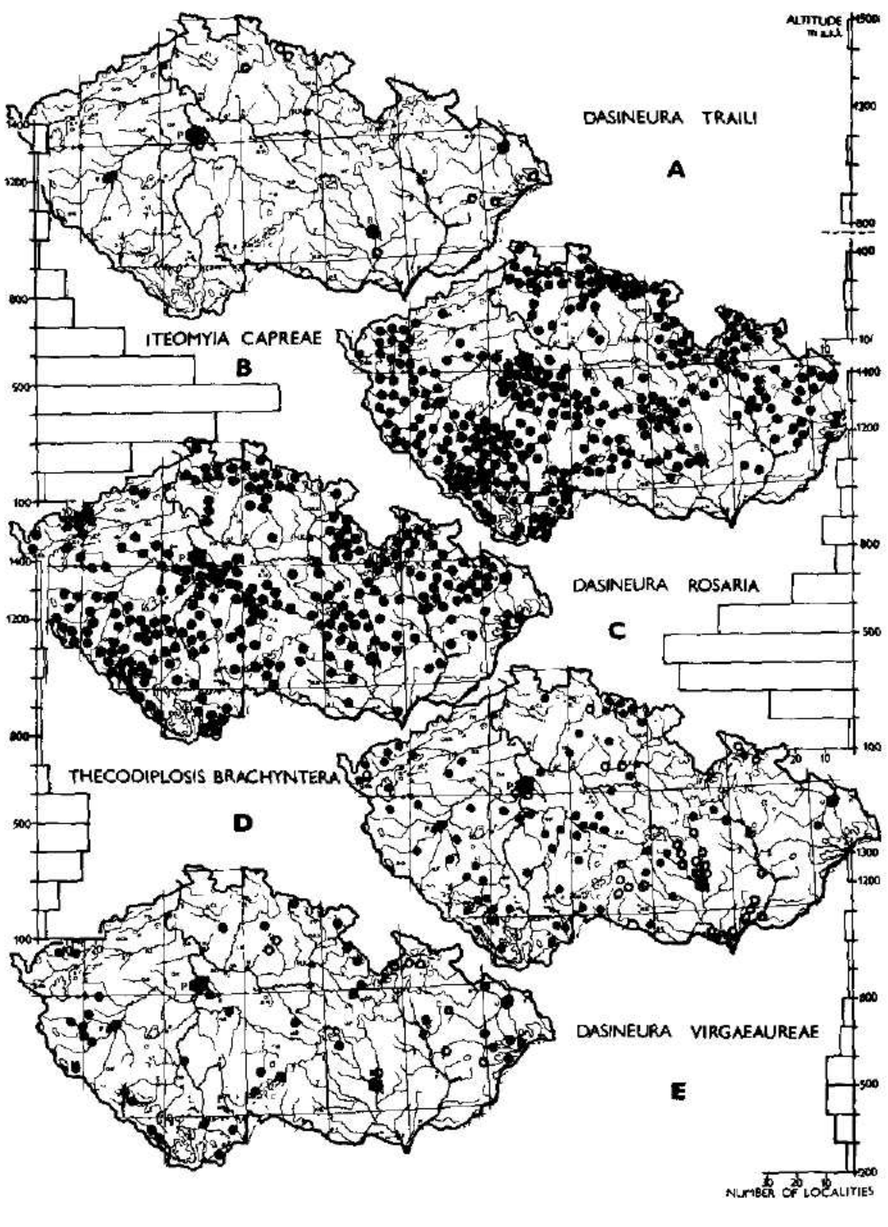



Fig.50. Gall midge species extending from lower lying localities to the sub-Alpine zone: A *Dasineura traili* on *Ranunculus acris*; B *Iteomyia capreae* on *Salix caprea* and *S. aurita*; C *Dasineura rosaria* on *Salix alba* and *S. cinerea*; D *Thecodiplosis brachyntera* on *Pinus sylvestris* and *P. mugo*; E *Dasineura virgaeaureae* on *Solidago virgaurea*.

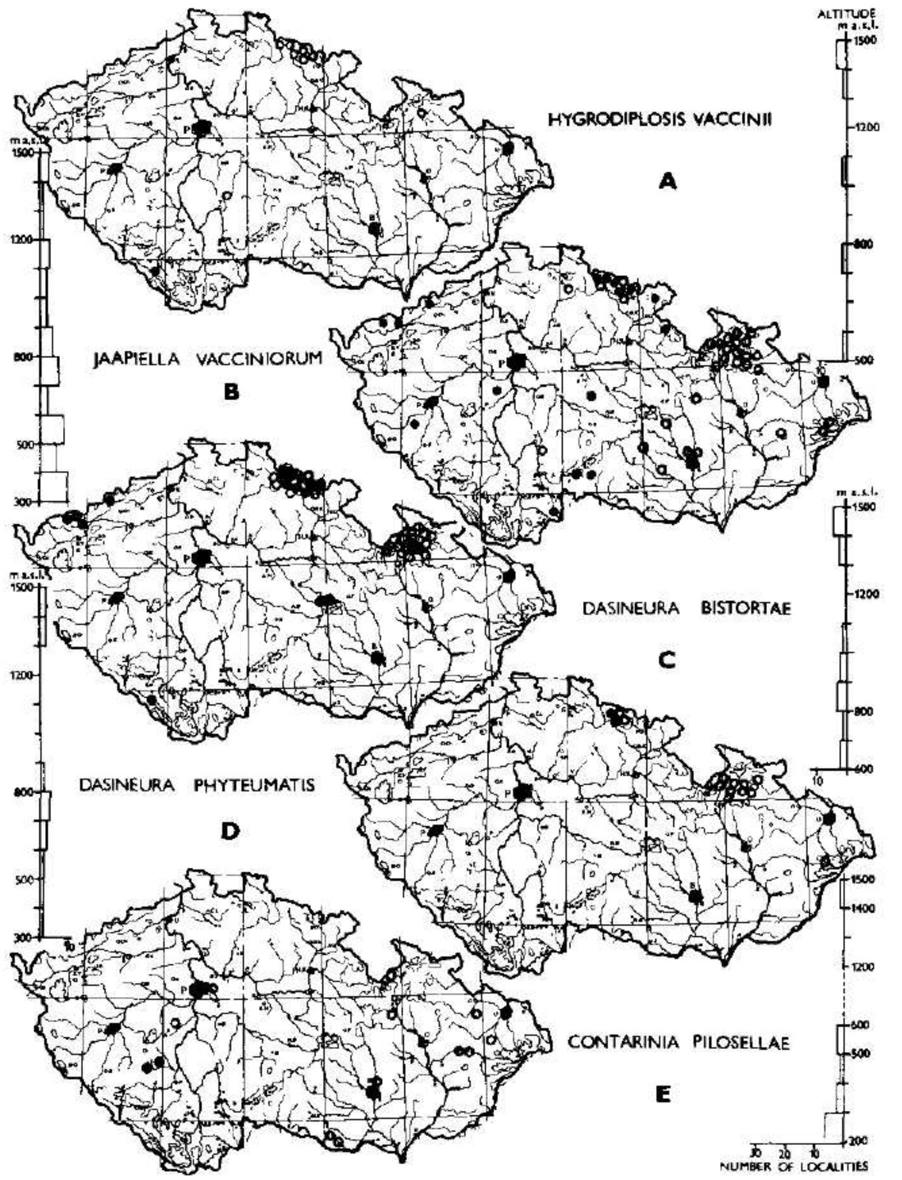



Fig.51. Gall midge species extending from lower lying localities to the sub-Alpine zone: A *Hygrodiplosis vaccinii* on *Vaccinium uliginosum*; B *Jaapiella vacciniorum* on *Vaccinium myrtillus*; C *Dasineura bistortae* on *Polygonum bistorta*; D *Dasineura phyteumatis* on *Phyteuma orbiculare* and *P. spicatum*; E *Contarinia pilosellae* on *Hieracium pilosella*.

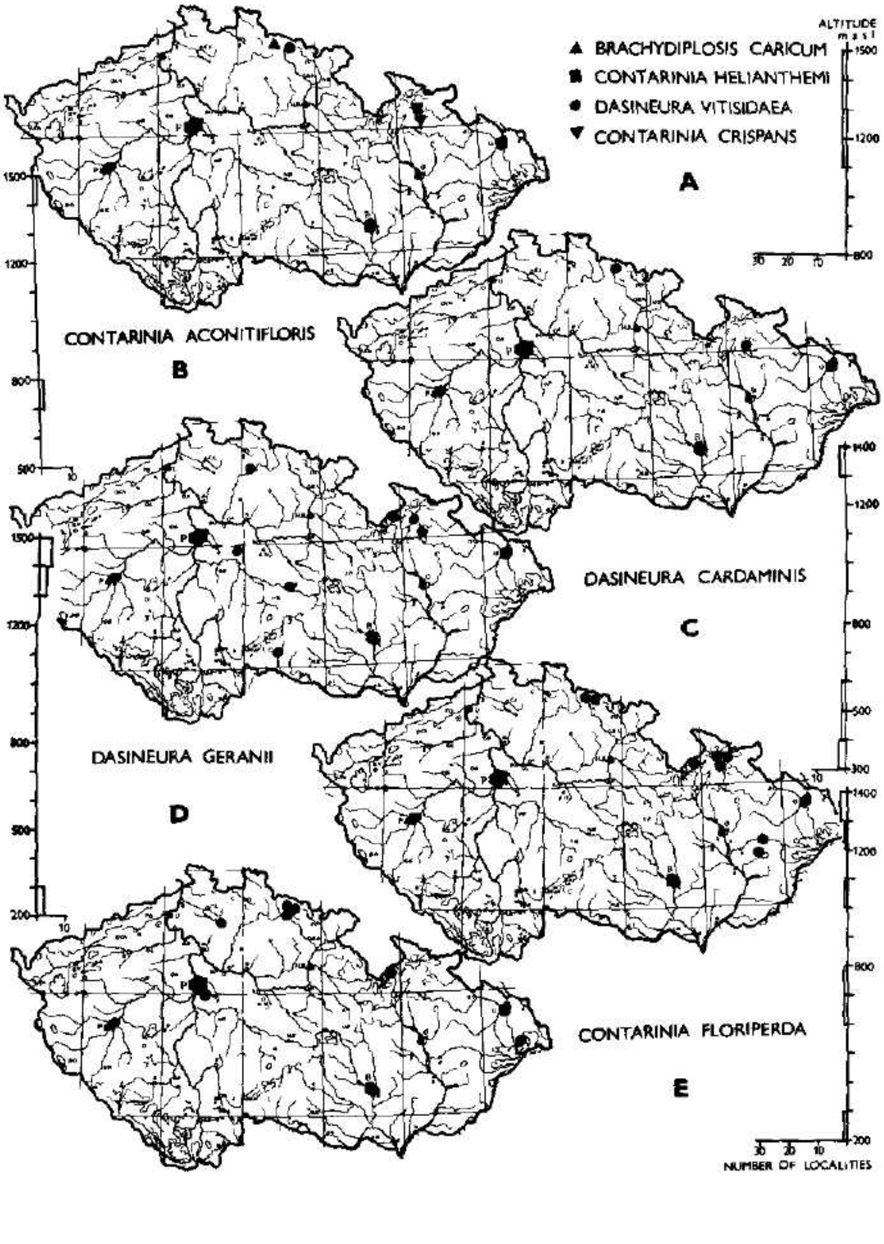



Fig.52. Sub-Alpine gall midge species: A *Brachydiplosis caricum* on *Carex* sp., *Contarinia helianthemi* on *Helianthemum nummularium*, *Dasineura vitisidaea* on *Vaccinium vitis-idaea* and *Contarinia crispans* on *Valeriana officinalis*. Gall midge species penetrating in sub-Alpine zone from lower lying localities: B *Contarinia aconitifloris* on *Aconitum lycoctonum* and *A. napellus*; C *Dasineura cardaminis* on *Cardamine pratensis*; D *Dasineura geranii* on *Geranium sanguineum*; E *Contarinia floriperda* on *Sorbus aucuparia*.

Larvae of *Dasineura bistortae* produce galls on the leaves of *Polygonum bistorta* which are formed by loosely rolled leaf margins. These galls have been found at more than forty localities at an elevation range from 670 m a.s.l. at Kameničky in the Bohemian-Moravian Uplands up to 1491 m a.s.l. at the peak part of the Praděd mountain in the Hrubý Jeseník Mts. At the lower situated localities, this species occur in cold and damp localities, mainly nearby to peat-bogs, sometimes together with pustule galls of an undescribed gall midge species (see Fig. 51). Twenty gall midge species extend into the sub-Alpine zone from lower lying altitudinal zones where they have their maximum occurrence areas. Ten of them occur scattered in the planare zone, the occurrence of other species begins in one, two or several localities in the colline zone. Five species cause galls on trees, four species develop in galls on small shrubs and larvae of eleven species live in various organs of herbaceous plant species, forming galls.

The following species develop on trees and extend up to an elevation of 1400 meters: *Thecodiplosis brachyntera*, larvae of which induce shortening and swelling of the needle pairs of *Pinus mugo*, and *Contarinia floriperda*, larvae of which live in unopened flower buds of *Sorbus aucuparia*. Galls of both these species were found at the sub-Alpine meadow Pančická louka, 1400 m a.s.l. in the Krkonoše Mts. Two species, larvae of which cause galls on various species of *Salix*, viz. *Dasineura rosaria* (terminal leaf bud galls) and *Iteomyia capreae* (small globular leaf galls) were found at the peak part of Šerák, 1351 m a.s.l. in the Hrubý Jeseník Mts. Galls of *Dasineura periclymeni* on leaves of *Lonicera periclymenum* were found at Lysá hora, 1323 m a.s.l. in the Moravskoslezské Beskydy Mts. Four gall midge species, larvae of which develop in galls on small shrubs, extend upwards nearly to the upper limit of the sub-Alpine zone: galls of *Jaapiella vacciniorum* were found at the peak part of Praděd, 1491 m a.s.l. in the Hrubý Jeseník Mts., terminal leaf galls of *Contarinia helianthemi* developing on *Helianthemum nummularium* at Vysoká hole, 1464 m a.s.l. in the Hrubý Jeseník Mts., galls of *Hygrodiplosis vaccinii* on *Vaccinium uliginosum* in the peak part of Kotel, 1435 m a.s.l. in the Krkonoše Mts. and galls of *Dasineura vitisidaeae* on *Vaccinium vitisidaea* at Pančická louka, 1400 m a.s.l. in the Krkonoše Mts.

Eleven gall midge species larvae of which cause galls on herbaceous plants, extend from the lower lying altitudinal zones up to the boundary of the submountain zone. They are the following species: *Dasineura hygrophila*, larvae of which cause galls on the growing tips of *Galium palustre; Dasineura ulmaria* and *D. pustulans* causing galls on the leaves of *Filipendula ulmaria; Dasineura pteridicola* and *D. filicina* developing in galls on the leaves of *Pteridium aquilinum*. Larvae of *Dasineura traili* develop in swollen unopened flower buds of *Ranunculus acris*. Galls on growing tips of *Solidago virgaurea* produce larvae of *Dasineura virgaeaureae*. In deformed flower buds of *Phyteuma orbiculare* and *P. spicatum* there develop larvae of *Dasineura phyteumatis*. Larvae of *Contarinia pilosellae* cause galls on flower buds of *Hieracium pilosella*, larvae of *Dasineura cardaminis* on *Cardamine pratensis*, larvae of *Dasineura geranii* in flower buds of *Geranium sylvaticum*.

**Long term changes in population dynamics**

Long-term changes in population dynamics may be shown in changes of population density of gall midge species during the 20th century. These changes are evaluated by a comparison of data about their occurrence in the first half of the 20th century that had been gathered by earlier authors, viz. Bayer who published his zoocecidological papers about distribution of galls in the years 1910-1946, Černík (1925-1940) and Baudyš (1912-1969), with data about occurrence in the second half of the 20th century, which have been obtained during faunistic investigations by Skuhravá (1957-1982).

The comparison of data about occurrence of a particular gall midge species in the first half of the 20th century with data of its occurrence in the second half is shown in maps using the white circles for findings of earlier authors and black circles for findings of Skuhravá (Figs 7-52).

For such comparison, the most suitable are those gall midge species which are not rare but which occur moderately to abundantly in examined territory being ranged in frequency groups II to VI. In the gall midge fauna of the Czech Republic there have been recognized six groups of species noted for their particular population density character, viz. species with increasing, stable and decreasing population density, disappearing and disappeared species and, finally, species which are insufficiently known.

1. Species with increasing density

There are gall midge species whose population density rose during the second half of 20th century in comparison with population density in the past. In this group there belong more than 100 gall midge species (20%). About one half of them develop on trees. For example, ***Mikiola fagi*** causing galls on ***Fagus sylvatica***, is characterized by numbers of findings 100/161. The first number indicates number of localities at which this species was found in the past, the second number means the number of localities at present (see Fig.40.A). Gall midge species ***Wachtliella rosarum*** developing in galls on leaflets of ***Rosa canina*** is characterized by numbers of findings 190/317 (see Fig. 37.E); ***Macrodiplosis dryobia*** inducing galls on leaf margins of ***Quercus robur*** and ***Q. petraea*** by numbers of findings 100/183 (see Fig.19.A); ***Dasineura tortilis*** living in leaf galls on ***Alnus glutinosa*** and ***A. incana*** by numbers of findings 60/284 (see Fig.37.D).

For several gall midge species the increasing population density change abruptly into outbreaks, as happened, for example, with ***Thecodiplosis brachyntera*** which develops in galls on ***Pinus sylvestris*** and ***P. mugo*** and is characterized by numbers of findings 30/67 (see Fig.50.D). Outbreaks of this species are described by Skuhravý (1991). Similarly it was with two gall midge species which develop in galls on the leaves of ***Acer pseudoplatanus***, viz. ***Harrisomyia vitrina***, characterized by numbers of findings 60/109 (see Fig.34.C), and ***Drisina glutinosa*** by numbers of findings 26/142 (see Fig.34.E), the outbreaks of which were described by Skuhravá & Skuhravý (1986).

Increasing population density has been recorded also by several gall midges developing on herbaceous plants, for example by ***Contarinia aequalis*** causing galls on ***Senecio nemorensis*** ssp. ***Fuchsii*** which is characterized by numbers of findings 70/160 (see Fig.47.A), and by ***Jaapiella veronicae*** developing in galls on ***Veronica chamaedrys*** with numbers of findings 190/501 (see Fig.46.A). ***Contarinia tritici*** (2/23) and ***Sitodiplosis mosellana*** (1/20), two gall midge species injurious to cereals, appeared abruptly in the second half of the 20th century, as it is shown in Fig.13.B,C. Outbreaks of these species in Europe were described by Skuhravá et al.(1984).

2. Species with stable (constant) density

There are gall midge species whose population density at present is approximately on the same level as it was in the past. They may be denominated as stable or constant species. About 15 gall midge species (3%) show nearly the same population density at present as in the past. From the species developing on trees there are, for example, ***Dasineura salicis***, characterized by numbers of findings 100/92 (see Fig.39.D), and ***Iteomyia capreae*** by numbers of findings 270/297 (see Fig.50.B), both developing on various species of ***Salix***; ***Massalongia rubra*** on ***Betula pubescens*** by numbers of findings 20/26 (see Fig.38.C); ***Putoniella pruni*** on ***Prunus spinosa*** by numbers of findings 60/67 (see Fig.20.C).

From gall midges developing on herbaceous host plant species there are, for example, ***Asphondylia melanopus*** causing galls on ***Lotus corniculatus*** and characterized by numbers of findings 30/30 (see Fig.23.A); ***Asphondylia echii*** on ***Echium vulgare*** by numbers of findings

20/24 (see Fig.12.D); *Asphondylia verbasci* on *Verbascum nigrum* by numbers of findings 12/14 (see Fig.22.E); *Contarinia medicaginis*, the pest of *Medicago sativa*, by numbers of findings 120/129 (see Fig.21.B); *Wachtliella persicariae* on *Polygonum amphibium* by numbers of findings 100/121 (see Fig.24.E).

3. Species with decreasing density

There are gall midge species which were abundant in the past and their population density sank moderately and successively during the second half of the 20th century. They may be called regressive or decreasing species. In this group there belong about 60 gall midge species (12%). For example, *Craneiobia corni* developing in leaf galls on *Cornus sanguinea* is characterized by numbers of findings 50/16 (see Fig.16.A); *Lasioptera rubi* causing stem galls on *Rubus idaeus* by numbers of findings 280/204 (see Fig.35.D). Several gall midge species developing on various *Salix*-species belong also in this group, of these mainly *Dasineura rosaria* is characterized by numbers of findings 400/251 (see Fig.50.C) and *Dasineura marginemtorquens* by numbers of findings 100/30 (see Fig.38.E).

From species developing on herbaceous plants there are, for example, *Mayetiola poae* developing in stem galls of *Poa nemoralis* and characterized by numbers of findings 100/45 (see Fig.29.A); *Rhopalomyia artemisiae* causing large rounded galls on *Artemisia campestris* by numbers of findings 30/18 (see Fig.13.E); *Contarinia melanocera* inducing stem galls on *Genista tinctoria* by numbers of findings 34/15 (see Fig.30.B); *Dasineura sisymbrii* making spongy stem galls on *Rorippa amphibia* by numbers of findings 123/30 (see Fig.23.E); *Loewiola centaureae* causing pustule leaf galls on *Centaurea scabiosa* and *C. jacea* by numbers of findings 92/16 (see Fig.23.D); and several species of the genus *Asphondylia*, viz. *A. baudysi* developing in pod galls of *Coronilla varia* is characterized by numbers of findings 40/11; *Asphondylia cytisi* on *Cytisus austriacus* by numbers of findings 40/6; *Asphondylia miki* causing pod galls on *Medicago sativa* by numbers of findings 40/17 (see Fig.10.A,C,D).

*Dasineura medicaginis*, formerly a serious pest of *Medicago sativa* which occurred injuriously in the period 1965-1970 and its numbers of findings is 300/153, is not abundant at present and its numbers are reduced to a low level (see Fig.21.A).

Some gall midge species of this group which are rare at present and are known only from a few localities may be designated, based on IUCN definitions of threatened species categories, as vulnerable species. See Table 3.

4. Disappearing species

Disappearing species are those which occur abundantly in the first half of the 20th century and the population density of which fell significantly during the second half of the 20th century and at present are known from one, two or several (few) localities, and their numbers have been reduced to a critical level. All these species may be ranged, based on IUCN definitions of threatened species categories, to endangered species. In this group there belong 16 gall midge species (3%). For example, *Sackenomyia reaumurii (Phlyctidobia solmsii)* developing in pustule leaf galls on *Viburnum lantana* is characterized by numbers of findings 7/1 (see Fig.16.C); *Lasioptera eryngii* causing stem galls on *Eryngium campestre* is characterized by numbers of findings 19/2 (see Fig.12.E); *Bayeria thymicola* inducing bud leaf galls on *Thymus serpyllum* is characterized by numbers of findings 14/1 (see Fig.8.E); *Dasineura saxifragae* developing in flower bud galls of *Saxifraga granulata* is characterized by numbers of findings 5/1 and *Dasineura daphnes* causing galls on *Daphne cneorum* is characterized by numbers of findings 3/2. See Table 2.

Table 1 Extinct gall midge species (disappeared species) with number of localities at which they were found in the past

| | | | |
|---|---|---|---|
| *Bayeria erysimi* | 33 | *Neomikiella beckiana* | 9 |
| *Bremiola onobrychidis* | 32 | *- lychnidis* | 4 |
| *Contarinia coryni* | 2 | *Planetella arenariae* | 18 |
| *- pastinaceae* | 10 | *billotii* | 10 |
| *Dasineura cardaminicola* | 2 | *- caricis* | 3/1 |
| *- cardaminis* | 6 | *- cornifex* | 25 |
| *- fructum* | 3 | *- fischeri* | 10 |
| *- lamiicola* | 7 | *frireni* | 12 |
| *- lithospermi* | 5 | *- gallarum* | 6 |
| *- loewii* | 7 | *granifex* | 20 |
| *- pierrei* | 16 | *kneuckeri* | 3 |
| *- sampaina* | 2 | *- rosenhaueri* | 1 |
| *similis* | 22 | *subterranea* | 10 |
| *Hybolasioptera cerealis* | 23 | *- tuberifica* | 6 |
| *Jaapiella cucubali* | 3 | *- tumorifica* | 2 |
| *-moraviae* | 8 | *Rhopalomyia simulans* | 11 |

Table 2 Endangered gall midge species (disappearing species) with number of localities at which they were found in the past (first number) and at present (second number)

| | | | |
|---|---|---|---|
| *Bayeria thymicola* | 14/1 | *Geocrypta trachelii* | 16/3 |
| *Dasineura bupleuri* | 10/1 | *Hygrodiplosis vaccinii* | 5/1 |
| *- daphnes* | 3/2 | *Jaapiella genistamtorquens* | 14/3 |
| *- glyciphylli* | 19/5 | *Lasioptera eryngii* | 19/2 |
| *lotharingiae* | 6/1 | *Macrolabis orobi* | 6/2 |
| *- phyteumatis* | 12/2 | *Rhopalomyia baccarum* 6/1 | |
| *- salviae* | 14/2 | *- tubifex* | 10/1 |
| *- saxifragae* | 5/1 | *Sackenomyia reaumurii* | 7/1 |

Table 3 Vulnerable gall midge species (species with decreasing density) with number of localities at which they were found in the past (first number) and at present (second number)

| | | | |
|---|---|---|---|
| *Asphondylia baudysi* | 40/11 | *- armoraciae* | 21/1 |
| *- cytisi* | 40/6 | *- lupulinae* | 11/4 |
| *- ononidis* | 2/17 | *- traili* | 24/4 |
| *Contarinia coryli* | 19/6 | *Jaapiella jaapiana* | 34/6 |
| *- melanocera* | 34/15 | *Lasioptera arundinis* | 13/10 |
| *- onobrychidis* | 60/7 | *Loewiola centaureae* | 92/16 |
| *Craneiobia corni* | 50/16 | *Macrolabis pilosellae* | 53/13 |
| *Dasineura asperulae* | 21/1 | *Rhopalomyia millefolii* | 60/22 |

## 5 Disappeared species

Disappeared species are those which occurred in the first half of the 20th century and the occurrence of which was not documented (confirmed) during the second half of the 20th century. Such species, based on IUCN categories of threatened species, may be denominated as extinct although it is possible that small populations of such species could survive in hidden places in nature and may be rediscovered in the future. In this group there may be range 32 gall midge species (7%). Above all, ***Bayeria erysimi*** developing in stem swellings of ***Erysimum virgatum*** which is characterized by numbers of finding 32/0 (see Fig 25 A); ***Bremiola onobrychidis*** developing in leaflet galls of ***Onobrychis viciifolia*** by numbers of findings 32/0 (see Fig.10.B); *Hybolasioptera cerealis* living on stems of various grasses by number of findings 23/0; and all thirteen species of the genus *Planetella* developing in galls on various *Carex*-species (see Fig.27.D and Fig.28.A,B,E). See Table 1.

6. Species insufficiently known
In this group are ranged gall midge species the occurrence of which is known based only on very few data. Most of them belong in frequency group I (see page 218). More than one half of the gall midge species known to occur in the territory of the Czech Republic belong here - about 270 species (55%). For lack of informations it is not possible to place them in one of the above mentioned groups.

**Threatened gall midge species**

Based on evaluation of long-term changes in population dynamics of the gall midge fauna in the territory of the Czech Republic during the 20th century, 64 species (13%) may be designated as threatened in the terms of the International Union for Conservation of Nature and Natural Resources (IUCN) and may be placed into its three categories indicating the degree of threat, viz. extinct, endangered and vulnerable species.

1. Extinct species
Based on the IUCN definition of this category, these are "species not definitely located in the wild during the past 50 years". As regards gall midges, 32 species (7%) which occurred here at the beginning of the 20th century, quite disappeared from the territory of the Czech Republic. They are examined in the chapter "Disappeared species" and listed in the Table 1.

2. Endangered species
Based on the IUCN definition of this category, these are "species in danger of extinction whose survival is unlikely if causal factors continue operating". The population density of 16 gall midge species (3%) fell drastically during the second half of the 20th century. They are classed as disappearing species, being known only from one, two or three localities at present. They are examined in the chapter "Disappeared species" and listed in the Table 2.

3. Vulnerable species
Based on the IUCN definition of this category, these are "species believed likely to move into the "Endangered" category in the near future if the causal factors continue operating". As regards gall midges, 16 species (3%) which were abundant in the past show decreasing population density trends and at present are found only on a few localities. They are examined in the chapter "Species with decreasing density" and listed in the Table 3.

## SUMMARY

The rich fauna of the family Cecidomyiidae, including 500 species inhabiting the relatively small territory of the Czech Republic of 79,000 square km in the middle Europe, is evaluated from the zoogeographical point of view based on data about occurrence gathered by earlier authors and data obtained during systematic faunistic investigations at about 670 localities spread throughout the territory of the Czech Republic from the lowlands at an elevation of 100 m a.s.l. up to mountains at an elevation of 1500 m a.s.l. in the Krkonoše Mts. There are evaluated 30,000 records about the occurrence of gall midge species of which 12,000 have been gathered by earlier authors.

One to 77 gall midge species have been recorded at individual localities during one

excursion lasting one to two hours. Only one species was found at the mountain Kokrháč, 1443 m a.s.l. in the Krkonoše Mts., and at Šerák, 1351 m a.s.l. in the Hrubý Jeseník Mts. The highest number (77 species) were found at Spy near Nové Město nad Metují, 324 m a.s.l. in eastern Bohemia. On average, 26 species have been found per locality which is more than in the territory of Slovakia where it was 19.5 species (Skuhravá 1991). The average numbers of species differ in particular regions of the Czech Republic and fall with increasing elevation.

Based on horizontal occurrence, given by numbers of findings where one locality is considered as one finding, all gall midge species are divided into six frequency groups by using the first six members of the geometrical progression with quotient 2 and coefficient "a", accompanied with verbal denomination: I. species occurring solitarily found at 1-10 localities: 154 species (45%); II. species occurring scarcely found at 11-32 localities: 69 species (20%); III. species of moderate occurrence found at 33-74 localities: 48 species (14%); IV. species of considerable occurrence found at 75-160 localities: 41 species (12%); V. species of abundant occurrence found at 161-330 localities: 27 species (8%); VI. species of common occurrence found at more than 331 localities: 6 species. They are the following species: ***Dasineura populeti*** (found at 333 localities), ***Schizomyia galiorum*** (351 localities), ***Geocrypta galii*** (406 localities), ***Dasineura hyperici*** (422 localities), ***D. urticae*** (430 localities), and ***Jaapiella veronicae*** (501 localities).

Based on vertical occurrence, thirteen types of similar vertical occurrence have been recognized in the gall midge fauna of the Czech Republic (Fig.5). About 210 species (42%) belong to planare species (sensu lato) of which 14 are planare species sensu stricto, occurring only in the planare zone, and remaining species penetrate in higher lying altitudinal zones (Fig.5:1-5). 460 species (92%) are colline species (sensu lato) of which 124 are colline species sensu stricto, occurring only in the colline zone, and remaining species occur in broader altitudinal range (Fig.5:6-9). 290 species (58%) belong to submountain species (sensu lato) of which 13 are submountain species sensu stricto, inhabiting only the submountain zone, and remaining species occur in broader altitudinal range (Fig.5:10-11). 122 species (25%) are mountain species (sensu lato) of which only three are mountain species sensu stricto and remaining species occur in broader altitudinal range (Fig.5:12). Only 26 species (5%) may be designated as sub-Alpine species (sensu lato) of which four are sub-Alpine species sensu stricto occurring only in the sub-Alpine zone and remaining species penetrate here from lower lying altitudinal zones (Fig.5:13).

The horizontal and vertical occurrence of 230 gall midge species is demonstrated in maps and graphs. Some of these species may be used for determination of sub-provinces of zoogeographical districts in the Czech Republic.

Based on analysis of long-term changes in population dynamics, it is possible to divide gall midge fauna of the Czech Republic into six groups: 1. species with increasing density: 160 species (20%); 2. species with stable density: 15 species (3%); 3. species with decreasing density: 60 species (12%); 4. disappearing species: 16 species (3%); 5. disappeared species: 32 species (7%); 6. species insufficiently known: 270 species (55%).

Based on IUCN categories, 64 gall midge species (13%) may be classed as threatened species: 32 species (7%) to extinct, 16 species (3%) to endangered and 16 species (3%) to vulnerable species (see Tables 1-3).

*Acknowledgements*

I thank Dr K. M. Harris, International Institute of Entomology, London, for his advice and for critical reading and comments to the manuscript.

I thank my colleagues Assist Prof Dr Bohdan Křísa, Charles University, Praha, and Dr Štěpán Husák, Institut of Botany, Průhonice, for their many years' cooperation in determination and verification of the host plants of gall midges.

I express my thanks to my husband Dr Václav Skuhravý, without whose help I could not carry out these extensive investigations, and also to our children, Ing Pavel Skuhravý and Dr Ivana Vaněčková-Skuhravá who helped us to collect gall midge galls during our excursions in the course of summer holidays.

## REFERENCES

AMERLING C. 1859: Über Asynapta lugubris auf Pflaumenbäumen. *Lotos* **9**: 60-63; 140-142.

Atlas of the Czechoslovak Socialistic Republic. Praha: Ústřední Správa Geodézie a Kartografie & ČSAV (in Czech, Engl. abstr.).

BAUDYŠ E. 1912: Für Böhmen neue Gallen *Sbor. Kl. Přírod. Praha* **8** 1-16 (in Czech, Germ. abstr.).

BAUDYŠ E. 1914: [Contribution to the distribution of galls in Moravia ]. *Čas. Čes. Spol. Entomol.* **11**: 12-16 (in Czech).

BAUDYŠ E. 1916a: Neue Gallen und Gallenwirte aus Bohmen. *Soc. Entomol. Stuttgart* **31**: 45-49.

BAUDYŠ E. 1916b: Ein Beitrag zur Verbreitung der Gallen in Bohmen. *Verh. Zool. Bot. Ges. Wien* **66**: 49-136.

BAUDYŠ E. 1916c: [The galls new to Bohemia]. *Čas. Čes. Spol. Entomol.* **13**: 1-10 (in Czech)

BAUDYŠ E. 1917a: [The galls new to Bohemia II ] *Čas. Čes. Spol. Entomol.* **14**. 14-38 (in Czech).

BAUDYŠ E. 1917b: Neue Gallenwirte aus Bohmen II. *Soc. Entomol Stuttgart* **32**: 43-45.

BAUDYŠ E 1918 [The galls new to Bohemia III ].*Čas Čes Spol. Entomol.* **15**. 42-52. (in Czech).

BAUDYŠ E. 1920-1921: [Contribution to the zoocecidiological investigation of Moravia]. *Čas. Mor Musea* **17-19**: 530-568 (in Czech).

BAUDYŠ E. 1923a: Les zoocecidies nouvelles pour la Boheme IV. *Čas. Čs. Spol. Entomol.* **20**: 56-67; 90-105 (in Czech, with a French title).

BAUDYŠ E. 1923b: Recherches sur les zoocecidies de la Moraviae. Seconde communication. *Sbor. Kl. Přírod. Brno* **5**: 37-55 (in Czech with a French title).

BAUDYŠ E. 1924: [Recherches sur les zoocecidies de Moraviae. Troisieme communication] *Práce Mor. Přírod Spol* **1**. 1-28 (in Czech).

BAUDYŠ E. 1925. [Recherches sur les zoocecidies de Moraviae et de Silesiae. Quatrieme communication]. *Sbor. Kl Přírod. Brno* **7**: 1-87 (in Czech).

BAUDYŠ E. 1926a [Recherches sur les zoocecidies de Moraviae et de Silesiae. Cinquieme communication]. *Sbor. Vys Šk. Zeměd. Brno* **1926** 1-48 (in Czech).

BAUDYŠ E. 1926b: [The second contribution to the distribution of galls in Bohemia]. *Sbor. Vys. Šk. Zeměd. Brno* **1926**: 1-105 (in Czech).

BAUDYŠ E. 1939. [The third contribution to the distribution of galls in Bohemia] *Acta Entomol. Mus. Nat.Pragae* **17** 71-80 (in Czech)

BAUDYŠ E. 1940: [The sixth contribution to the zoocecidiological investigation of Moravia and Silesia]. *Entomol Listy Brno* **3**: 107-116 (in Czech).

BAUDYŠ E 1944: Ein Beitrag zur Verbreitung der Zoocecidien in der Umgebung von Welichowky. *Acta Entomol. Mus Nat Pragae* **21-22**(1943-44): 127-138 (in Czech, Germ abstr.).

BAUDYŠ E. 1946: Fourth contribution to the knowledge of plant galls in Bohemia. *Acta Entomol. Mus. Nat. Pragae* **24**: 175-208 in Czech, Engl. abstr.).

BAUDYŠ E. 1947: The sixth contribution to the zoocecidiological investigation of Moravia and Silesia. *Sbor. Vys. Šk. Zeměd. Brno* **1947**: 1-55 (in Czech, Engl abstr ).

BAUDYŠ E 1948: The seventh contribution to the zoocecidiological investigation of Moravia and Silesia. *Sbor. Vys. Šk. Zeměd.Brno* **1948**: 1-64 (in Czech, Engl. abstr.).

BAUDYŠ E. 1953: The zoocecidia (galls) of basket willows in Moravia. *Sbor Vys.Šk.Zeměd. Brno* **1953**: 1-28 (in Czech, Engl. abstr.).

BAUDYŠ E 1954a: Die Gallen aus dem Gebiete Schlesiens und den anliegenden Teilen Mahrens. Praha Stát. Pedag. Nakl , 288 pp (in Czech, Germ. abstr ).

BAUDYŠ E 1954b: Ein Beitrag zur Verbreitung der Zoocecidien im Gebiete des Reichensteiner Gebirges. *Přír. Sbor. Ostr. Kr.* **15**: 125-135 (in Czech, Germ. abstr.).

BAUDYŠ E 1959. [The second contribution to the distribution of galls in the Rychlebské hory]. Rychlebské Hory Sborník Prací o Přírodních Poměrech, Ostrava: 208-241 (in Czech).

BAUDYŠ E. 1960a: [Zoocecidia of Kotouč Mt. and its environs I]. *Přír. Čas. Slezský* **21**: 397-414 (in Czech)

BAUDYŠ E 1960b [Zoocecidia of Kotouč Mt. and its environs II] *Přír. Čas. Slezský* **21**: 565-581 (in Czech).

BAUDYŠ E. 1961a: Contribution cécidiologique a la recherche scientifique dans la region de Jeseníky et Beskydy.*Přír. Čas.Slezský* **22**: 57-64 (in Czech, French abstr.).
BAUDYŠ E. 1961b: Les zoocécidies des environs d'Opava I. *Přír. Čas. Slezský* **22**: 199-216 (in Czech, French abstr.).
BAUDYŠ E. 1962a: Les zoocécidies des environs d'Osoblaha. *Přír Čas. Slezský* **23**: 73-84 (in Czech, French abstr.).
BAUDYŠ E. 1962b: Beitrag zur Verbreitung der Gallen (Zoocecidien) im Gebiete von Olomouc. *Věst. Vlastivěd. Mus. Olomouc* **5**: 81-195 (in Czech, Germ. abstr.).
BAUDYŠ E. 1963a: Koniferengallen in Mähren. *Sbor. Vys. Šk. Zeměd. Brno C* **1963**: 81-89 (in Czech, Germ. abstr.).
BAUDYŠ E. 1963b: [Zoocecidia in the ferns in Moravia]. *Zpr. Obl. Mus. JV Moravy Gottwaldov* **1963**: 93 (in Czech).
BAUDYŠ E. 1963c: [Zoocecidiological supplements from Moravia]. *Zpr. Obl. Muz. JV Moravy Gottwaldov* **1963**: 94 (in Czech).
BAUDYŠ E. 1963d: Ein Beitrag zur Zoocecidienverbreitung im Ostböhmischen Kreis. *Acta Mus. Reginaehrad. ser. A* **5**: 113-141 (in Czech, Germ. abstr.).
BAUDYŠ E. 1964a: Zoocecidien der Umgebung der Stadt Opava II. *Acta Mus. Siles. Opava, ser. A* **13**: 17-40 (in Czech, Germ. abstr )
BAUDYŠ E. 1964b: Gallen auf Eschen und Ulmen in Mähren. *Sbor. Vys. Šk. Zeměd. Brno, C*: 43-54 (in Czech, Germ. abstr.).
BAUDYŠ E. 1964c: Beitrag zur Verbreitung von Zoocecidien auf Gräsern in Mähren. *Sbor. Vys. Šk. Zeměd. Brno, s.A* **1964**: 217-224 (in Czech, Germ abstr ).
BAUDYŠ E. 1964d: Ergänzung zur Verbreitung von Zoocecidien auf Gräsern in Mähren. *Sbor. Vys. Šk. Zeměd.,s.A* **1964**: 733-741 (in Czech, Germ. abstr.).
BAUDYŠ E. 1964e: Zur Verbreitung der Zoocecidien in Südostmähren. *Zpr.Obl. Muz. JV Moravy Gottwaldov* **1964**: 67-71 (in Czech, Germ. abstr.).
BAUDYŠ E. 1964f: Zweiter Beitrag zur Verbreitung der Zoocecidien im Kreis Ost-böhmen. *Acta Mus. Reginaehrad. s.A* **4**:163-220 (in Czech, Germ. abstr.).
BAUDYŠ E. 1965a: Supplement to the distribution of galls in pea plants in Moravia. *Sbor. Kl. Přírod. Brno* **1965**: 3-12 (in Czech, Germ. abstr.).
BAUDYŠ E. 1965b: [To the distribution of galls in the mint plants from South-East-Moravia]. *Zpr. Obl. Mus. JV Moravy Gottwaldov* **1965**: 108-111 (in Czech).
BAUDYŠ E. 1965c: Beitrag zum Cecidienvorkommen in der Umgebung von Osoblaha II. *Acta Mus. Silesiae ser.A* **14**: 141-152 (in Czech, Germ. abstr.).
BAUDYŠ E. 1965d: Zur Verbreitung der Zoocecidien auf den Futterpflanzen der Familie Schmetterlingsblütter. *Sbor. Vys. Šk. Zeměd. Brno, A* **1965**: 513-523 (in Czech, French abstr.).
BAUDYŠ E. 1966a: Beitrag zur Verbreitung der Zoocecidien in Gebiet Jihlava. Studie z Vysočiny, *Přír. Vědy Jihlava* **1966**: 3-21 (in Czech, Germ. abstr.).
BAUDYŠ E. 1966b: Gallen an Knöterichgewachsen, Nelkengewachsen, unsw. *Zprávy Obl. Mus. JV Moravy Gottwaldov* **1966**: 19-24 (in Czech, Germ. abstr.).
BAUDYŠ E. 1966c: Contribution a l'existence des zoocécides sur les cultures fruitieres en Moravie. *Sbor. Vys. Šk. Zeměd. Brno ser. A* **No.538**: 365-378 (in Czech, French and Germ. abstr.).
BAUDYŠ E. 1967a: Die Gallen von Opava and Umgebung III. *Acta Mus. Siles. s.A.* **14**: 7-12 (in Czech, Germ. abstr.).
BAUDYŠ E. 1967b: [Zoocecidiological fragment from southern Moravia]. *Zprávy Oblast. Muz. Gottwaldov* **1967**: 37-43 (in Czech).
BAUDYŠ E. 1967c: Dritter Beitrag zur Verbreitung der Zoocecidien im ostböhmischen Kreis. *Acta Mus. Reginaehrad. s.A* **8**: 71-86 (in Czech, Germ. abstr.).
BAUDYŠ E. 1967d: Zur Verbreitung der Gallen auf Pappel und Espe in Mähren. *Sbor. Vys. Šk. Zeměd. Brno, s.C,* **34**: 153-164 (in Czech, Germ. abstr.).
BAUDYŠ E. 1968: Dipterocecidien des Rychleber Gebirges. *Zprávy Čsl. Spol. Entomol. Praha* **4**: 51-55 (in Czech, Germ. abstr.).
BAUDYŠ E. 1969: Dritte Ergänzung zur Verbreitung der Zoocecidien in dem Reichensteinergebirge (Rychlebské hory). *Acta Mus. Siles., s.A.* **18**: 163-174 (in Czech, Germ. abstr.).

BAUDYŠ E. & VIMMER A. 1919-1920: [About galls and gall-forming insects in the Czech segges]. *Čas. Čes. Společ. Entomol.* **16**: 40-60, 17: 45-59 (in Czech).

BAYER E. 1910a: Les zoocécidies de la Boheme *Marcellia* 9: 64-104; 127-158.

BAYER E. 1910b: Ein Beitrag zur Kenntnis der Weidengallen. *Hedwigia* **49**: 392-395.

BAYER E. 1912 [Contribution to the knowledge of Czech galls] *Sbor. Kl. Přírod. Praha* **1911**. 5-43 (in Czech).

BAYER E. 1914: [Moravian galls]. Zprávy Komm. Pro Přírod. Prozk. Moravy, *Odd. Zool Brno No* **15** 1-182 (in Czech)

BAYER E. 1917: [Gall-forming Cecidomyiidae in Central European Carex spp.]. *Čas Čes. Společ. Entomol.* **14**. 75-92 (in Czech).

BAYER E. 1920 [Synopsis of the Central-European galls with regard to the Czech countries]. *Čas. Mor Mus.* **16**. 64-85; 17-19: 15-168; 469-529 (in Czech).

BAYER E 1946: [The galls of the Olomouc district in Jos Otruba's collections 1944]. *Věst. Čs. Zool. Společ.* **10**: 81-89 (in Czech)

BREHM V. 1905: Zoocecidien, gesammelt in den Jahren 1903 und 1904 in der Umgebung von Elbogen (Bohmen). *Marcellia* **4**: 182-183.

ČERMÁK K. 1943. Zwei Tannensamen zerstorende Fliegen - Lonchaea viridana Meig. und Resseliella piceae Seitner - in Bohmen und Mahren. *Lesnická Práce* **22**: 105-107 (in Czech, Germ. summ ).

ČERMÁK K. 1952: Insect pests attacking the seeds of our main forest trees. *Práce Výzk. Úst Lesn.* **1**: 5-87 (in Czech, Engl. abstr )

ČERNÍK F L. 1925: [Plant diseases and deformations occurring on plants of the flora of Olomouc] *Čas. Vlasten. Spol. Mus. Olomouc* **36**. 124-149 (in Czech).

ČERNÍK F L. 1927: [Plant diseases and deformations occurring on plants of the flora of Olomouc]. *Čas. Vlasten. Spol. Mus. Olomouc* **38**: 14-21 (in Czech)

ČERNÍK L.F. 1931. Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora III. *Verh. Naturf Ver. Brunn* **52** 148-164.

ČERNÍK L F. 1932: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora IV. *Verh. Naturf. Ver Brunn* **63**. 51-74.

ČERNÍK L.F. 1933: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora. V. Teil *Verh. Naturf Ver. Brunn* **64** 56-76.

ČERNÍK L F. 1934: Krankheiten und teratologische Missbildungen an Pflanzen der Olmutzer Flora. VI. Teil. *Verh Naturf Ver Brunn* **65**: 81-103

ČERNÍK L F. 1935: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora. VII. Teil *Verh. Naturf Ver. Brunn* **66**: 29-60

ČERNÍK L.F 1936: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora. VIII. Teil. *Verh. Naturf. Ver Brunn* **67**. 18-50

ČERNÍK F.L. 1937. Krankheiten und teratologische Missbildungen an Pflanzen der Olmutzer Flora. IX. Teil. *Verh Naturf Ver. Brunn* **68**: 49-78.

ČERNÍK F.L. 1938a: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora. X. Teil. *Verh. Naturf Ver. Brunn* **69**: 91-122

ČERNÍK F.L. 1938b [Phytopathological reports on plants of the Olomouc environs] *Čas. Vlasten Spol. Mus. Olomouc* **51**: 144-153 (in Czech)

ČERNÍK F.L. 1939a: Krankheiten und teratologische Missbildungen an Pflanzen der Olmutzer Flora. XI. Teil. *Verh. Naturf. Ver Brunn* **70**: 52-80.

ČERNÍK F.L 1939b: [Phytopathological reports on plants of the Olomouc environs] *Čas. Vlast. Spol. Mus. Olomouc* **52**: 164-174 (in Czech).

ČERNÍK F.L. 1940a: [Phytopathological reports on plants of the Olomouc environs]. *Čas. Vlast Spol. Mus. Olomouc* **53**: 156-175 (in Czech).

ČERNÍK F L. 1940b Krankheiten und teratologische Missbildungen an Pflanzen der Olmutzer Flora. XII. Teil. *Verh. Naturf. Ver Brunn* **71**: 56-88.

ČERNÍK F.L. 1941-43: Krankheiten und teratologische Missbildungen an Pflanzen der Olmützer Flora. XIII.-XV Teil *Verh Naturf Ver Brunn* **72** (1941): 3-39; **73** (1942): 3-51; **74** (1943): 3-45.

DITTRICH R & SCHMIDT H. 1910: Nachtrag zu dem Verzeichnisse der schlesischen Gallen I. Jahres-Ber. Schles. Ges. Vaterl Cult Breslau, *Zool -Bot Sect.* **87**: 79-105.

DOSTÁL J. 1966: Phytopathological regionalisation. In: *Atlas of Czechoslovak Socialistic Republik:* 23 (in Czech, Engl abstr ).

EHRENDORFER F 1973 Liste der Gefässpflanzen Mitteleuropas Stuttgart Fischer Verlag, 318 pp
ERTEL M 1975 Untersuchungen zur Larvensystematik der Gattung Mayetiola (Cecidomyiidae, Diptera) *Stuttg Beitr Naturk S.A* **Nr. 267** 1-64
HANDLIRSCH A 1885 Zwei neue Dipteren *Verh Zool Bot Ges Wien* **34** (1884) 135 142
HAVELKA J & SKUHRAVA M 1984 Faunistic records from Czechoslovakia Diptera Cecidomyiidae *Acta Entomol Bohemoslov* **81** 395
HIERONYMUS G 1890 Beitrage zur Kenntniss der europaischen Zoocecidien und zur Verbreitung derselben *Jahres-Ber Schles Ges Vaterl Cult Breslau* **68** 49-272
HOUARD C 1908-1909 Les zoocecidies des plantes d'Europe et du Bassin de la Méditerranee Two Volumes Paris A Hermann et fils, 1247 pp
KIRCHNER L A 1855 Die Gallenwüchse des Budweiser Kreises, nebst nomineller Angabe der Gallenerzeuger und deren Schmarotzer *Lotos* **5** 127-137, 157-161, 202-205, 236-244
KIRCHNER L 1856 Die Harzgallen der Nadelholzer um Kaplitz *Lotos* **6** 9-12
KOWARZ F 1894 Catalogus insectorum faunae bohemicae II Fliegen (Diptera) Bohmens Prag Verlag der Physiokratischen Gesellschaft 42 pp
KŘÍSTEK J, SKRZYPCZYNSKA M & VRANA J 1976 The insect pests attacking the ripening cones and seeds of European larch in Southern Moravia *Acta Univ Agric Brno S C (Fac Silv)* **45** 149-161
MAŘAN J 1958 [A zoogeographical outline of the Czechoslovak fauna] *Sbor Čs Spol Zeměp* **63** 89-110 (in Czech, Engl abstr)
MIK J 1885 Über Zoocecidien auf Taxus baccata und Euphorbia cyparissias L *Wien Entomol Ztg* **4** 65 66
MOHN E 1966 1971 Cecidomyiidae (Itonididae) In LINDNER E (ed) Die Fliegen der Palaearktischen Region Stuttgart E Schweizerbartische Verlagshandlung, 248 pp
PFEFFER A 1937 An interesting pest of fir-cones *Čas Čs Společ Entomol* **34** 50 (in Czech, Engl abstr)
PŘÍHODA A 1972 A new pest of fir needles *Lesnicka Prace* **51** 237-239 (in Czech, Engl abstr)
[Regional Phytogeographical outline of the ČSR] (The map), 1987, Praha Academia (in Czech)
RUBSAAMEN E H 1914 Cecidomyidenstudien III *Marcellia* **13** 88-114
SEIDEL J 1957 Pflanzengallen und Blattminen aus dem Gebiete des Glatzer Schneeberges *Přír Sbor Ostrav Kr* **18** 248-270
SKUHRAVA M 1957 Gallmucken des Gebietes von Hlučín (Itonididae, Diptera) *Přír Sbor Ostrav Kr* **18** 83-94 (in Czech, Germ abstr)
SKUHRAVÁ M 1959 Gallmücken des Oder Gebirges I (Itonididae, Diptera) *Přír Čas Slezsky* **20** 28-48 (in Czech, Germ abstr)
SKUHRAVA M 1961a Gallmucken des Riesengebirges *Acta Mus Reginaehrad Pard* **3** 147-154 (in Czech, Germ abstr)
SKUHRAVA M 1961a. Geographische Verbreitung einiger Gallmucken in Nordwestmahren (Diptera, Itonididae) *Čas Čs Společ Entomol* **58** 184-192
SKUHRAVA M 1964 Gallmucken der Gebirge Hruby Jeseník, Rychlebske hory und Oderské vrchy II(Itonididae, Diptera) *Acta Mus Siles ser.A* **13** 165-182 (in Czech, Germ abstr)
SKUHRAVA M 1971 Die Gallmucken des Gebietes Novohradske hory (Diptera Cecidomyiidae) *Sbor Jihočes Mus Česke Budějovice* **11**, Suppl. 69 75 (in Czech, Germ abstr)
SKUHRAVA M 1972 Die Gallmucken des Šumava Gebirges (Cecidomyiidae, Diptera) *Sbor Jihočes Muz České Budějovice* **12**, Suppl. 2 119-139 (in Czech, Germ abstr)
SKUHRAVA M 1973a. Die Gallmucken (Cecidomyiidae, Diptera) des Gebirges und des Gebirgsvorlandes Česky les *Přírod Čas Jihočes Česke Budějovice* **13** 9-23 (in Czech, Germ abstr)
SKUHRAVA M 1973b Monographie der Gallmuckengattung Clinodiplosis Kieffer, 1894 (Cecidomyiidae, Diptera) *Studie ČSAV* **17** 1-80
SKUHRAVA M 1974 Die Gallmucken der Sudbohmischen Becken (Cecidomyiidae, Diptera) *Acta Sci Nat Mus Bohem Merid Česke Budějovice* **14** 43-59 (in Czech, with Germ abstr)
SKUHRAVA M 1975 Die Gallmücken des Gebietes Křivoklát (Cecidomyiidae, Diptera) *Boh Centr Praha* **4** 84-95 (in Czech, Germ abstr)
SKUHRAVA M 1977 Die Gallmücken des Gebietes Česky raj (Böhmisches Paradies) (Cecidomyiidae, Diptera) *Boh Centr Praha* **6** 143-158 (in Czech, Germ abstr)
SKUHRAVA M 1978. Chorologie und Okologie einiger Gallmuckenarten (Cecidomyiidae, Diptera) pp 303-309 In ORSZAGH I (ed) Dipterologica Bohemoslovaca I Bratislava Veda, 360

SKUHRAVÁ M. 1979: Die Gallmucken Mittelbohmens (Cecidomyiidae, Diptera). *Boh. Centr. Praha* **8**: 125-165 (in Czech, Germ. abstr.).
SKUHRAVÁ M. 1980a. Die Gallmucken Ostbohmens (Cecidomyiidae, Diptera) *Práce, Studie, Přír., Pardubice* **12**: 87-109 (in Czech, Germ. abstr.).
SKUHRAVÁ M. 1980b: Verbreitungsareal einiger europaischer Gallmuckenarten (Diptera, Cecidomyiidae). *Acta Univ. Carol., Biol.* **1977**: 403-416.
SKUHRAVÁ M. 1980c: Die Gallmucken der Bohmisch-Mahrischen Anhohe (Cecidomyiidae, Diptera). *Acta Sci. Nat. Mus. Occ. Třebíč* **11**: 17-46 (in Czech, Germ. abstr.).
SKUHRAVÁ M. 1981: Die Gallmucken von Nordost- und Sudostmahren (Cecidomyiidae, Diptera). *Čas. Slez. Muz. Opava ser.A* **30**. 17-44 (in Czech, Germ abstr.).
SKUHRAVÁ M. 1982a: Die Gallmucken der Nord- und Nordwestbohmens (Cecidomyiidae, Diptera). *Sbor. Severočes. Muz.,Ser. Nat. Liberec* **12**: 120-144 (in Czech, Germ. abstr.).
SKUHRAVÁ M. 1982b: Phytophage Gallmucken als Modellobject für planmassige faunistische Forschung. *Zprávy Čs. Zool. Společ.* **17-18**: 35-56 (in Czech, Germ. abstr.).
SKUHRAVÁ M. 1982c: Montane und alpine Gallmuckenarten (Cecidomyiidae, Diptera) der Tschechoslowakei. *Acta Mus. Reginaehrad. (A) Suppl.* **(1980)**. 109-110
SKUHRAVÁ M. 1982d: The use of faunal data in zoogeographic studies *Folia Fac. Sci. Nat. Univ. Purk. Brun 23, Biol.* **74**. 127-131.
SKUHRAVÁ M 1986· Family Cecidomyiidae. In: Catalogue of the Palaearctic Diptera, Vol. 4. Budapest & Amsterdam. 72-297 pp.
SKUHRAVÁ M 1987a: Analysis of areas of distribution of some Palaearctic gall midge species (Cecidomyiidae, Diptera). *Cecidologia Internationale* **8**: 1-48.
SKUHRAVÁ M. 1987b: Cecidomyiidae. In: Check List of Czechoslovak Insects II. *Acta Faun. Entomol. Mus. Nat. Pragae* **18**: 69-81. Skuhravá M. 1989: Taxonomic changes and records in Palaearctic Cecidomyiidae (Diptera). *Acta Entomol. Bohemoslov.* **86**: 202-233.
SKUHRAVÁ M 1991. Gallmucken der Slowakei (Cecidomyiidae, Diptera). VI. Die Zoogeographie der Gallmucken. *Zbor. Slov. Nár. Múz., Prír. Vedy, Bratislava* **37**: 85-178.
SKUHRAVÁ M. & SKUHRAVÝ V. 1960 [Gall Midges]. Praha: ČSAZV + SZN, 271 pp. (in Czech, Germ. summ.).
SKUHRAVÁ M. & SKUHRAVÝ V 1981: Die Gallmucken (Cecidomyiidae, Diptera) des Schilfes (Phragmites communis Trin ). *Studie ČSAV*, **1981** (3), 152 pp.
SKUHRAVÁ M. & SKUHRAVÝ V. 1986. Outbreak of two gall midges, Harrisomyia n.gen. vitrina (Kieffer) and Drisina glutinosa Giard (Cecidomyiidae, Diptera) on maple, Acer pseudoplatanus L. in Czechoslovakia. *Ztschr. Angew. Entomol.* **101** 256-274
SKUHRAVÁ M & SKUHRAVÝ V. 1992: Biology of gall midges on common reed in Czechoslovakia. pp.196-207 In: SHORTHOUSE J.D. & ROHFRITSCH O Biology of Insect Induced Galls. New York, Oxford: Oxford Univ. Press, 280 pp.
SKUHRAVÁ M , SKUHRAVÝ V. & BREWER J. W. 1984a: Biology of Gall Midges. pp 169-222. In: ANANTHAKRISHNAN T N. (Ed.): Biology of Gall Insects. New Delhi, Bombay, Calcutta. Oxford + IBH Publ Co., 362 pp.
SKUHRAVÁ M., SKUHRAVÝ V. & BREWER J. W. 1984b The distribution and long-term changes in population dynamics of gall midges (Cecidomyiidae, Diptera) on cereals in Europe. *Cecidologia Internationale* **5**: 1-5.
SKUHRAVÝ V. 1971: Die Gallmucke Contarinia baeri (Prell) - ein Schadling der Weisskiefer (Pinus silvestris L.). *Anz. Schädlingsk. Pflsch.***44**: 49-56.
SKUHRAVÝ V 1990: The gall midge Contarinia baeri (Prell) (Dipt., Cecidomyiidae) on the Scotch pine Pinus sylvestris L. *J. Appl. Entomol* **110**: 449-453.
SKUHRAVÝ V 1991: The needle-shortening gall midge Thecodiplosis brachyntera (Schwagr.) on the genus Pinus Rozpr. ČSAV, Ř. Mat. A Přír. Věd, Nr. 10, Praha: Academia; 104 pp
[Statistical Lexicon of Municipalities in the ČSSR in 1974]. Praha, 1976, 860 pp. (in Czech).
ŠEDIVÝ J. 1970: Occurrence of lucerne gall midge (Dasyneura ignorata Wachtl) in the years 1966-1968. *Ochrana Rostlin* **6**: 95-102
THOMAS F. 1878. Uber 42 neue Pflanzengallen. *Z. Ges Naturw.* **51**: 703-708.
UDVARDY M. D. 1975· A classification of the biogeographical provinces of the world. IUCN Occassional Paper

No 18, Switzerland, 48 pp
URBAN J & SKUHRAVÁ M 1982 Gall midge Resseliella dizygomyzae (Barnes, 1933) (Cecidomyiidae, Diptera) on basket willow (Salix viminalis L ) in Czechoslovakia. *Lesnictví* **28** 927-939 (in Czech, Engl , Germ and French abstr )
VAŇHARA J 1992 *Insect community of edaphon of a spruce monoculture in the Drahanská Upland* 169-174 In KLIMO E & MARŠALEK J (eds) Manmade Spruce Ecosystem Structure, Functions, Production, Processes Report from Project Rajec Brno, 178 pp
VIMMER A 1905 [Supplements to the Kowarz's list of Bohemian Diptera] *Čas Čes Společ Entomol* **2** 102-105 (in Czech)
VIMMER A 1909 [Liste des Insectes dipteres de la Bohemiae] *Čas Čes Společ Entomol* **6** 37-49 (in Czech)
VIMMER A 1913 [List of Bohemian Diptera] Entomol Příručky, 8 Praha, 99 pp (in Czech)
VIMMER A 1924 [Gall midges from galls on Artemisia campestris L ] *Čas Čsl Společ Entomol* **21** 58-61 (in Czech)
VIMMER A 1925 [Larven und Puppen der zweiflügeligen Insecten Mitteleuropas mit besonderer Berücksichtigung der Kulturpflanzenschadlinge] Praha Unie, 348 pp (in Czech)
VIMMER A 1928a [On a new species of the genus Asphondylia H.Lw ,(Cecidomyidae, Diptera)] *Čas Čsl Společ Entomol* **25** 52-55 (in Czech)
VIMMER A 1928b Monographie der Gattung Rhopalomyia in der Tschechoslowakei (Diptera, Cecidomyidae) *Acta Entomol Mus Nat Pragae* **6** 49-66 (in Czech, Germ abstr )
VIMMER A 1931 [The genera of Diptera in Czechoslovakia] Praha, 379 pp (in Czech)
VIMMER A 1935 [Czechoslovakian Cecidomyidae which Dr Baudyš bred from galls] *Acta Entomol Mus Nat Pragae* **13** 13-24 (in Czech)
VIMMER A 1936a [Czechoslovak Cecidomyidae which Dr Baudyš bred from galls II part Diplosaria] *Acta Entomol Mus Nat Pragae* **14** 167-178 (in Czech)
VIMMER A 1936b [Dasineura armoraciae n sp (Diptera, Cecidomyidae)] *Čas Čsl Společ Entomol* **33** 134-135 (in Czech, diagnosis in Latin)
VIMMER A 1937a [Asphondylia Baudysi n sp (Cecidomyidae, Diptera)] *Čas Čsl Společ Entomol* **34** 107-108 (in Czech, diagnosis in Latin)
VIMMER A 1937b [Czechoslovak Cecidomyidae bred from galls by Dr Baudyš III Diplosaria - Asphondylaria] *Acta Entomol Mus Nat Pragae* **15** 5-16 (in Czech)
WACHTL F A 1883 Einige neue europaische Gallmucken (Cecidomyiden) *Zentbl Ges Forstw* **9** 476-478
WACHTL F A 1884 Eine neue und eine verkannte Cecidomyide *Wien Entomol Ztg* **3** 161-166
WACHTL F A 1885 Zwei neue europaische Cecidomyiden Ein Beitrag zur Kenntniss der Gallen erzeugenden Insecten *Wien Entomol Ztg* **4** 193-196
WACHTL F A 1886 Uber Gallmucken *Wien Entomol Ztg* **5** 209-210
WACHTL F A 1887 Zwei neue Gallmucken und ihre Gallen *Wien Entomol Ztg* **6** 289-292

*Acta Soc Zool Bohem* **57** 294, 1993 (1994)
ISSN 0862-5247

# BOOK REVIEW

HARRISON F W & RUPPERT E E (editors) **Microscopic Anatomy of Invertebrates. Volume 4. Aschelminthes.** New York, Chichester, Brisbane, Toronto, Singapore Wiley-Liss, a John Wiley & Sons Publication, XIV + 424 pages 180 x 255 mm Price hardcover US Dollars 150 00 ISBN 0-471-56103-7

This volume is the fourth representative of a series of encyclopaedic monographs published in 15 volumes under editionship of F W Harrison The treatise begins with protozoan protists (for review see Acta Societatis Zoologicae Bohemoslovacae, 56 156, 1992) As the editor emphasizes in the preface to the treatise, the body of each chapter is devoted to microscopic anatomy, particularly to cellular studies at the ultrastructural level This volume is organized into 10 chapters compiled by 12 university experts Six of them are Americans, the others are from Denmark France, Germany and Canada Each chapter concludes with an extensive list of literature cited

Chapter 1 (E E Ruppert, Clemson, SC) is intended to give an "Introduction to the Aschelminth Phyla A Consideration of Mesoderm Body Cavities, and Cuticle " As stated here, it is difficult to offer a positive definition of an aschelminth (Greek askos – bag, cavity) Aschelminth animals are impressive because of their diversity of unconventional body organization The application of electron microscopy to aschelminths has substantially increased knowledge of the organisation of each phylum and has led to new insights into the mutual affinities of these animals The two cardinal characteristics of Aschelminths are a pseudocoel and an extracellular cuticle These two hallmarks are examined in following paragraphs nature of mesoderm and coelomate design, embryonic and adult compartments in animals, body cavities in Aschelminthes, cuticles in Aschelminthes Chapter 2 (V Lammert, Gottingen) deals with the Gnathostomulida, a group of marine animals with a slender, worm-like habitus Chapter 3 (E E Ruppert) is devoted to the Gastrotricha, the small, strap- or tenpinshaped acoelomate worms, flattened ventrally and arched dorsally, most adults do not exceed 1 mm in length Chapter 4 (K A Wright, Toronto), focuses on Nematoda, tapering cylindrical, clearbodied, pseudocoelome worms Species vary greatly in size The phylum is divided into two orders the Secernentea and Adenophorea Both groups include important parasites of plants, animals and man Selective survey of the comparative structure of nematodes is illustrated in following paragraphs the body wall, growth and molting, the digestive system, the nervous system, the excretory (osmoregulatory) system, connective tissue and pseudocoelom Chapter 5 (J Bresciani, Copenhagen) covers the phylum Nematomorpha, with superficially resemble the Nematoda and were for a long time confused with them They are long and slender animals, the largest of them can be 1 m long or more Representatives of the order Gordioidea known as horsehair worms or hair worms in fresh water and damp soil in temperate and tropical regions of the world Their larvae are obligate parasites in a variety of aquatic and terrestrial arthropods Gordian worms were recovered also from fish, birds, and mammals, including man In chapter 6 (P Clement, Lyon, E Wurdak, Collegeville, MN) Rotifera or Rotatoria are looked at, microscopis aquatic animals swiming with the aid of locomotory cilia, constitute and important part of the plancton of fresh and brackish waters A few species are marine Acanthocephala, thorny headed worms are discussed in chapter 7 (T T Dunagan, D M Miller, both Carbondale, IL) They are parasitic worms living in the small intestine of vertebrates, varying in lenth from less than 2 mm to more than 60 cm Examined here are their external and gross anatomy, tegumental organization, lemnisci, muscle, lacunar system, excretory system, reproduction, and nervous system Last three chapters cover the Priapulida (V Storch, Heidelberg), Loricifera (R M Kristensen, Copenhagen), and Kinorhyncha (R M Kristensen, Copenhagen, R P Higgins, Washington, DC) All three groups constitute phyla of small free living invertebrates, the loriciferans being the most recent animal group to be discovered (1983) Last pages represent taxonomic and subjective indexes

This volume contains 576 figures arranged in a similar way as in the previous volume 3 Both volumes provide a specific and exhaustive coverage of microscopic anatomy of helminths and related groups

*Jindřich Jíra*

*Acta Soc Zool Bohem* **57** 295-297, 1993(1994)
ISSN 0862-5247

# *Leiodes graefi* sp.n. from Montenegro (Coleoptera: Leiodidae)

Zdeněk ŠVEC

Žerotínova 47, CZ-130 00 Praha 3, Czech Republic

*Received December 15, 1992, accepted May 20, 1993*
*Published March 15, 1994*

**Taxonomy, new species, key, Coleoptera, Leiodidae, *Leiodes*, Montenegro**

**Abstract.** *Leiodes graefi* sp n from Montenegro is decribed and distinguished from similar *L badia* (Sturm) Related Palaearctic species are keyed

## INTRODUCTION

Through the favour of Mr Hans Graf (Solingen, Federal Republic Germany) I had a possibility to study an interesting *Leiodes* species collected in Montenegro Mr Graf noticed the species is different from well known *L badia* (Sturm) The species is hitherto unknown to science It belongs to the species characterised by high ecked mesosternal carina and it is described below From all others related Palaearctic species this new species can be distinguished by the characters used in the following key.

1 Basis of pronotum straight, hind angles not pull out backward Beetles with membraneous wings 2
- Basis of pronotum sagged, hind angles pull out backward Species without membraneous wings *Leiodes discontignyi* (Bris ), *rosai* Daff , *ampla* (Rtt ), *rectangula* (Rtt ), *imeritina* (Rtt ), *nitidula* (Er ), *javorniki* (Hlis ) and *nitida* (Rtt.) All mentioned species are well defined by Daffner, 1982

2 Elytra with strong oblique strigosites connecting rows of punctures 3
- Elytra without any oblique strigosites 5

3 Last antennal segment distinctly narrower than the provious one Antennal club allways lightly coloured 1 5 2 5 mm Western, southern, southern central Europe, N Africa *L flavicornis* (Brisout)
- Last antennal segment a little narrower than the previous one Antennal club usually dark 4

4 Last antennal segment a little longer than wide Parameres distally tapered 1 8-2 5 mm Western, southern and central Europe *L strigipenne* Daffner
- Last antennal segment about a half as long as wide Para-meres expanded distally 1 5-2 3 mm Europe *L gyllenhalli* Stephens

5 Second to fourth elytral rows of punctures curved distintly toward sides at their midlenght Tip of aedeagus with wide notch 3 0-3 5 mm Western, central and southern Europe L nigrita (Schmidt)
All elytral rows of punctures run straight Tip of aedeagus pointed 6

6 Pronotum distinctly punctate 7
- Pronotum very finely and scarcely punctate 9

7 Spaces between elytral rows strongly and very distinctly punctate Last antennal segment distinctly narrower than the previous one 1 7-2 3 mm Canary Isl *L oceanica* (Wollaston)
- Spaces between elytral rows very finely and rarely pun-ctate Last antennal segment a little narrower than the previous one 8

8 Punctures of elytral rows fine and closely standing, antennal club dark Parameres distinctly shorter than median lobe 1 8-2 5 mm Central, south-eastern and eastern Europe *L carpathica* (Ganglbauer)

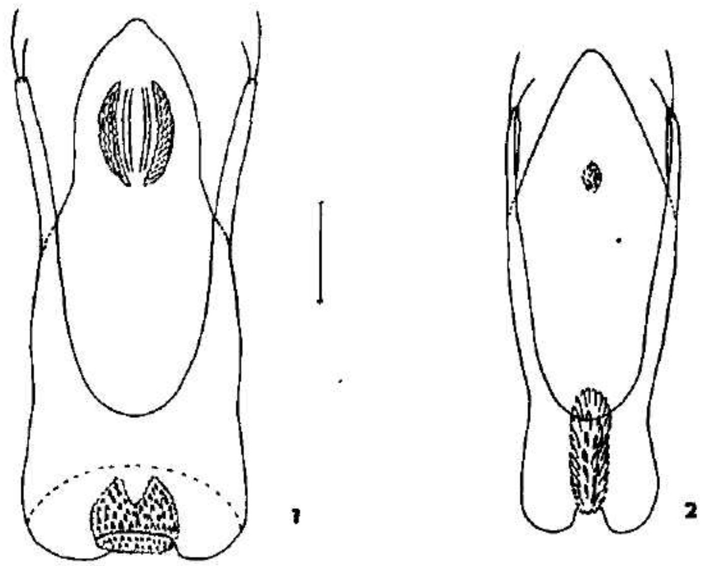
- Punctures of elytral rows fine and scarcely standing, antennal club lightly coloured. 1.8-2.5 mm. Eastern central, eastern Europe, Asia Minor, Middle Asia, Siberia . . . . . . . . . . . . . . . . . *L. subtilis* (Reitter)

9 Short antennae reach about to midlength of pronotum . . . . . . . . . . . . . . . . . . . . . . . . . . . 10

- Long antennae reach nearly to basis of pronotum. 1.7-2.5 mm. Southern France, Corsica . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. castanescens* (Fairmaire)

10 Very fine punctures of discal rows become much stronger and much more distinct laterally. Sides of median lobe concave before tip (Fig.1). 1.7-2.2 mm. Montenegro . . . . . . . . . . . . . . . . . . . *L. graefi* sp.n.

- Discal and lateral rows of punctures very similar, in their size, strong, distinct. Sides of median lobe straightly tapered to tip (Fig.2). 1.5-2.5 mm. N. Africa, Europe, Caucasus, Siberia . . . . . *L. badia* (Sturm)




Figs 1-2. Aedeagus dorsally: 1 - *Leiodes graefi* sp.n.; 2 - *L. badia* (Sturm). Scale 0.1 mm.

## *Leiodes graefi* sp.n.

TYPE MATERIAL: Holotype: male, Montenegro, 10.vi.1984, Ulcinj, H.Gräf legit; paratypes: male, 2 females, the same data; 4 males, 3 females, the same data but 24.vi.1982; 2 males, 2 females, Montenegro, vi.1982, Hladil legit. HOLOTYPE, 1 male and 2 females paratypes deposited in author's collection, 1 male, 1 female paratypes depos. in coll. H.Gräf (Solingen, Germany), 5 males 4 females paratypes deposited in coll. J.Cooter (Hereford, England).

Reddish-yellow to dark-brown coloured, pronotum and elytral sutura darker in some of the paratypes. Legs, antennae and mouth yellow-reddish. Coxae and metasternum darker. Length of body 1.7-2.2 mm, in holotype length of body 2.1 mm, head 0.2 mm, pronotum 0.4 mm, elytra 1.5 mm, antenna 0.5 mm, width of head 0.6 mm, pronotum 1.2 mm, elytra 1.2 mm. Height of pronotum 0.7 mm, elytra 0.8 mm.

Head. Finely but distinctly punctate, punctures spaced by 2-5 their diameter. Vertex with 4 large punctures. Last antennal segment distinctly narrower than the previous one. Antennae laying backward over reache the midlength of pronotum.

Pronotum. Much more finely and scarcely punctate than the head. Punctures small, superficial, separated by 4-10 their diameters. Some larger ones interposed before basis. With traces of micro-reticulation in holotype. Hind angles broadly rounded. The largest width of pronotum at the basis.

Elytra. Rows of punctures distinct but very fine at disc, spaced by 1-3 their diameter. Lateral rows with distinctly coarse punctures. Intervals with very rare, small and superficial punctures, some larger punctures interposed in odd intervals. These punctures smaller than ones in rows.

Legs. Anterior tibiae as twice as wide distally than at basis. First to fourth basal segments slightly expanded, hind tibiae simply curved in male.

Metasternum. Laterally nearly smooth with some rare small punctures. Finely and densely punctured and haired in the middle. With micro-reticulation at lateral part distally.

Aedeagus. Sides of median lobe concave before the tip. Endophallic structures as in Fig.1.

DIFFERENTIAL DIAGNOSIS. Leiodes graefi sp.n. differs from the very similar *L. badia* (Sturm) by much smaller and finer punctures of the rows at the elytral disc. Sides of median lobe are concave before the tip in *L. graefi* (Fig. 1) while the same one in *L. badia* is simply tapered distally (Fig. 2).

DERIVATIO NOMINIS. Dedicated to collector, entomologist and my friend Mr Hans Gräf from Solingen, Federal Republic Germany.

Acknowledgement

I wish to thank to my friend Jan Růžička, entomologist from Prague, for his irreplaceble help with my work.

## REFERENCES

DAFFNER H. 1983: Revision of the Palaearctic species of the Tribus Leiodini Leach (Coleoptera, Leiodidae). *Folia Entomol. Hung.* **44** (2): 9-163 (in German, English abstr.).

*Acta Soc Zool Bohem* **57** 298-299, 1993 (1994)
ISSN 0862-5247

# BOOK REVIEW

ECKERT J , KUTZER E , ROMMEL M , BURGER H -J & KORTING W **Veterinarmedizinische Parasitologie. Begrunded von J. Boch und R. Supperer. Fourth totally revised and essentially extended edition.** Berlin und Hamburg Paul Parey Verlag 1992, XXII + 905 pages 160 x 240 mm Price hardcover DM 158 00 ISBN 3-489-52916-2

Both founders of this renowned textbook of veterinary parasitology, distinguished professors Josef Boch (Munich) and Rudolf Supperer (Vienna) have given the continuation in tradition in charge of other German speaking authors from Zurich, Vienna, Hannover and Giessen First edition in 1971 (for review see Journal of Hygiene, Epidemiology, Microbiology and Immunology, 17 36, 1973) contained a total of 408 pages, the second and third edition followed in 1977 and 1983 (for review see Folia Parasitologica, 31 363-364, 1984 Thus, since the first edition, the volume has been doubled

The volume is divided into two parts Opening chapter introduces some important definitions and abbreviations of various social and scientific organizations, chemotherapy and control, diagnostics, and parasitological and epidemiological terms General part contains eight chapters First, various forms of symbiosis, mutualism, commensalism and parasitism are discussed The chapter on systematics and taxonomy provides insights into protozoan phyla, namely the Sarcomastigophora, Apicomplexa, Microspora, Myxozoa and Ciliophora Metazoan parasites include the phylum Plathelmintha (platyhelminths or flatworms) introducing the class Trematodea (=Trematoda) with subclasses Apidogastria, Monogenia and Digenia The class Cestodea (=Cestoda, tapeworms) includes the subclasses Cestodaria and Eucestodia The phylum Nematoda (=Nemata, roundworms) followed by Acanthocephala (thorny headed worms), Annelida (jointed worms), Pentastomida (tongue worms) and Arthropoda conclude this chapter The authors introduce here their own modification of the zoological nomenclature with followings endings -a for the phylum, subphylum or superclass, ea- for the class, ia for the subclass, -idea for the superorder, -ida for the order, -ina for the suborder, -oidea for the superfamily, idae for the family, inae for the subfamily The chapter dealing with the host-parasite interrelationships examines environmental problems, host specificity and resistance, and immunity The chapter on principles of pathogenesis is concerned various mechanism of harmful effects and pathological changes associated with protozoic and metazoic parasites The chapter on techniques needed to identify parasites describes basic laboratory procedures in veterinary parasitology, namely the staining of blood films and examination of faecal specimen for the presence of protozoans, methods for culturing, etc Helminthological methods cover the collection, sending and disposal of specimens, various coprological procedures, parasitological dissection, demonstration of helminths in soil, dry mud and in grass samples, and fixation and preservation of helminths This section also covers arachno-entomological techniques for the collection, dissection, preparation and cultivation of parasitic mites, ticks and insects Following chapters concern the epidemiology/epizootiology, principles of parasite control, and ecological importance of permanent stages

The special, most extensive part (733 pages) including 10 chapters is devoted to parasitic diseases in ruminants, solid hoofed animals, swine, dog and cat, rabbit, fowl, game animals, hedgehog, fishes and honey-bee Parasitic infections include protozoans (covered by M Rommel), helminths (covered by J Eckert and H-J Burger), and atrhropods (covered by E Kutzer) E Kutzer reviewed also the parasites of game animals, hedgehog and honey bee W Korting treated the fishes With parasitic infections in individual groups of animal hosts described are the pathogenic parasites life cycles, frequency and geographical distribution, pathogenesis and pathology, immunity, epidemiology/epizootiology, diagnosis, and prophylactic and therapeutic measures The concluding is intended to give an overview of antiparasitic drugs and agents arranged into two appendices In appendix 1 the antiparasitica are listed alphabetically according to particular groups of animals Generic and proprietary names of drugs are given here together with names of corresponding manufacturers Appendix 2 introduces a list of drugs arranged alike according to proprietary names

The arrangement of parasite groups or species considering the groups or species of hosts proved useful in previous editions. Hence, information on parasite species having a wide range of hosts may be located under several headings. For example, *Toxoplasma gondii* is discussed in 12 chapters, *Trichinella spiralis* is characterized in 9 chapters. Most important hosts are provided with most detailed descriptions of their parasites. The number of parasite species presented here is impressive. For exmaple, listed here are: 90 species of *Eimeria*, 22 species of *Sarcocystis*, 10 species of *Capillaria*, 10 species of *Onchocerca*, etc. Over past decade still more advances have been made in many important fields of parasitology. New parasite species have been recognized. *Neospora caninum* is a newly described (1988) cyst-forming coccidian of dog. It can cause necrotizing encephalitis and myositis. Canine neosporosis has been previously misdiagnosed as toxoplasmosis. Actual public health problems presents cryptosporidiosis in ruminants and in other mammals and man. The genus *Trichinella* has been subdivided into several species/subspecies: *spiralis, nativa, nelsoni, pseudospiralis* (most recently *T. britoni*). Surveys of *Echinococcus granulosus* revealed that within this species several "strains" (or subspecies ?) emerged which show different morphological, biochemical, biological features and different infectiousness for final and intermediary host. Most recently a strain af camel origin has been recognized.

Many parasitic infections in animals are transmissible to man as zoonoses. Therefore, this textbook may be of considerable interest both to veterinary practitioners and life scientifists, and to medical professionals, particularly to parasitologists, epidemiologists and hygienists engaged in teaching or research. Apart from a currently known diseases as toxoplasmosis, cryptosporidiosis, hydatidosis, cysticercosis, toxocarosis and others, there is an information on parasitic zoonoses which occur in man sporadically, and which are actually registered in the International Nomenclature od Diseases, such as babesiosis, sarcocystosis, heterophyasis, dicrocoeliasis, echinostomiasis, coenurosis, gongylonemiasis, capillariasis, oesophagostomiasis, gnathostomiasis, thelaziasis, etc. The names of parasitic diseases introduced in this volume correspond with names recommended by the World Associacion for the Advancement of Veterinary Parasitology.

The treatise on particular groups of parasites and parasitic diseases concludes with an extensive list of literature cited. In preparing this volume the authors have made use of hundreds of journals, reviews and books. This latest edition focuses mostly on recent references and together with previous editions constitutes a valuable source to parasitological literature. The volume is extensively augmented by 254 high quality figures composed of schematic line drawings, photographs of parasites and their developmental and life history stages, full page plates presenting coccidian oocyst and helminth ova, pathomorphological changes in organs and tissues, clinical aspects and laboratory procedures. In addition, there are essential data condensed into 68 tabular reviews providing information on systematics and taxonomy, resistance of permanent stages of protozoans and helminths to various temperatures, morphological and biological characteristics in eimerians and in *Cystoisospora* species, keys for identification of histozoic and intestinal helminths, filarial worms, routes of *Toxocara canis* infections, effects of antiparasitic drugs, etc.

Based on the tradition of more than 20 years and reflecting personal experience of a team of leading experts, this volume represents a readable, well referenced, illustrated and produced, and throughout updated textbook of veterinary parasitology.

*Jindřich Jíra*

# PRAGUE STUDIES IN MAMMALOGY

***Collection of papers dedicated to Prof. Dr. Vladimír Hanák on occasion of his 60th birthday***

*Edited by*
Ivan Horáček & Vladimír Vohralík

Karolinum - Charles University Press
Praha 1992

245 + xxi pp.
30 contributions by 47 authors (from 10 countries)
including subject index and bibliographies

Key words: Mammalia (Inusectivora, Chiroptera, Rodentia, Carnivora, Perissodactyla, Artiodactyla): distribution, systematics, ecology, behaviour

The publication is available at price of 25,- DM
(or an equivalent in an other currency) from:

The Secretary,
Department of Zoology
Charles University
Viničná 7
CZ-128 44 Praha 2

PRASADAN P. K. & JANARDANAN K. P. : Morphology and life cycles of two new species of *Stenoductus* (Apicomplexa: Cephalina) from the millipede, *Chondromorpha kelaarti* in Kerala, India

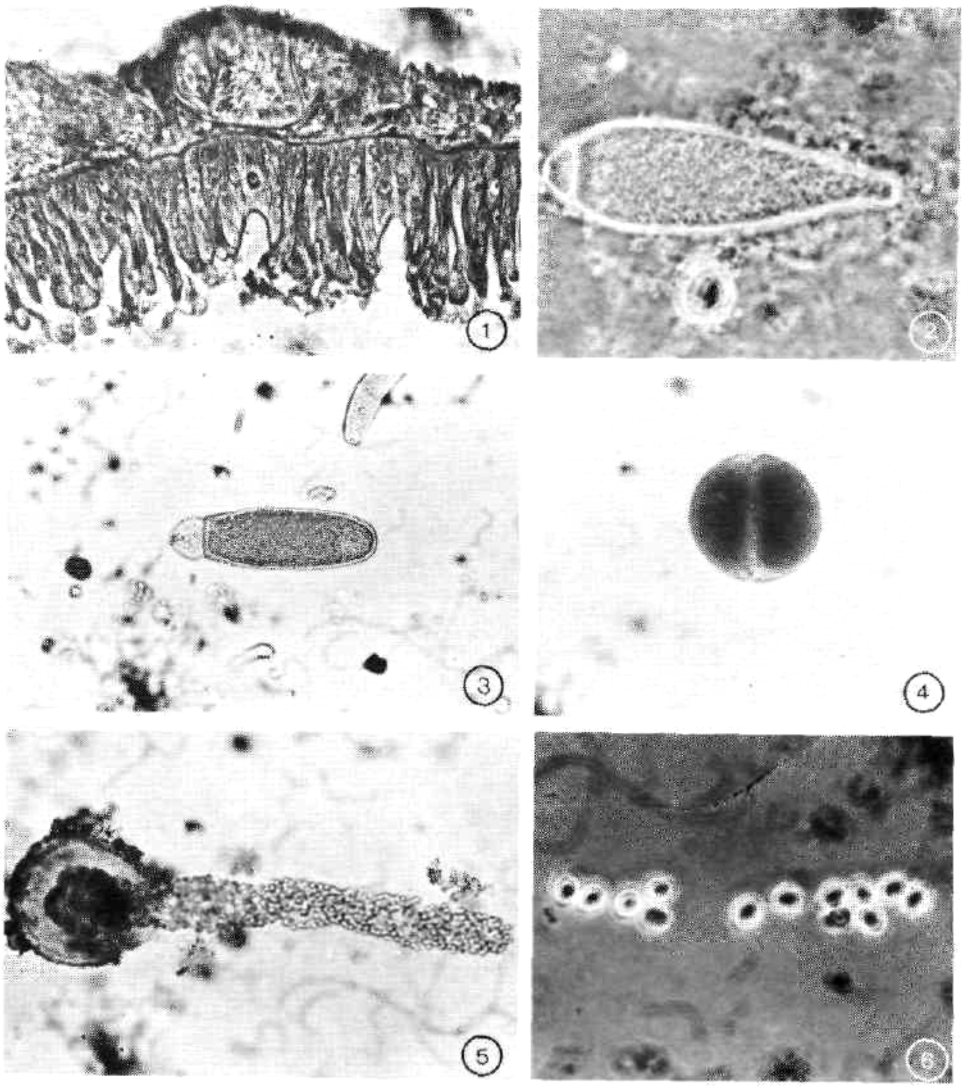



Plate 1. *Stenoductus kelaarti* sp. n. (1 - Sporadin; 2 - Gametocyst with sporoduct; 3 - Spore; 4 - Midgut epithelial cells showing an intracellular aseptate trophozoite; 5,6 - Lumen trophozoites).

PRASADAN P. K. & JANARDANAN K. P. : Morphology and life cycles of two new species of *Stenoductus* (Apicomplexa: Cephalina) from the millipede, *Chondromorpha kelaarti* in Kerala, India

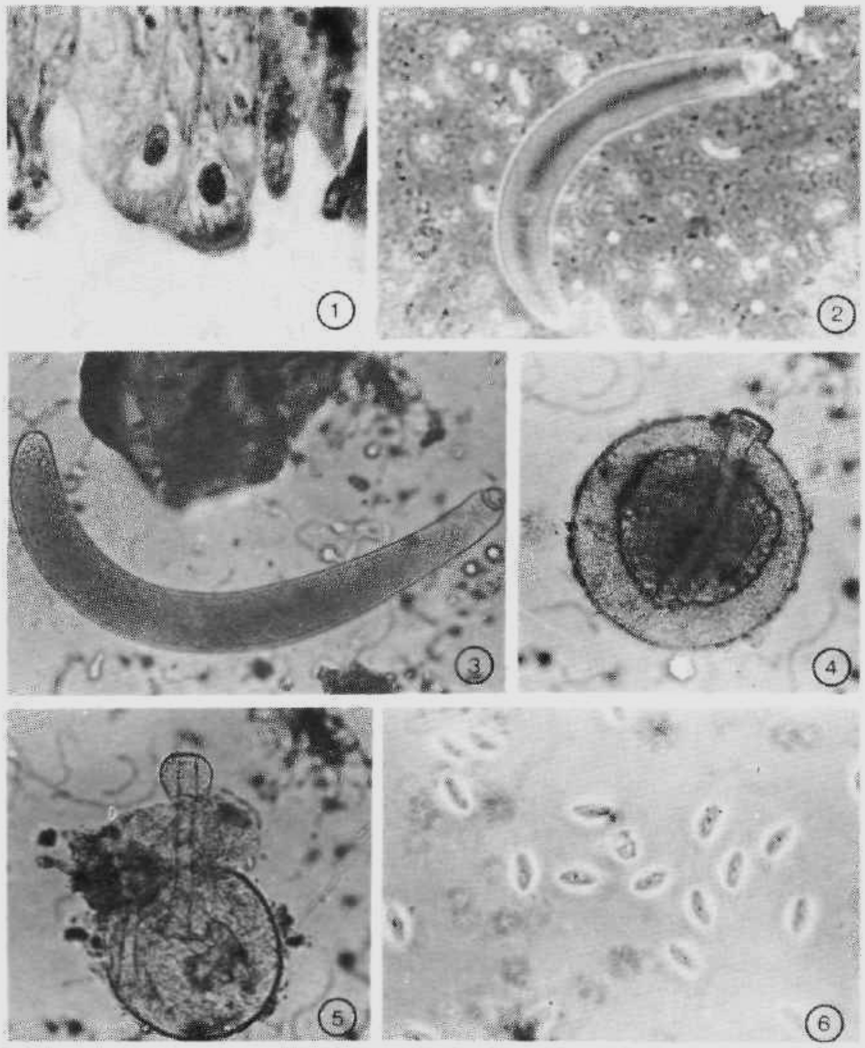



Plate 2. *Stenoductus kelaarti* sp. n. (1 - Midgut epithelial cells showing an intracellular aseptate trophozoite x 610; 2 - Trophozoite x 370; 3 - Sporadin x 160; 4 - Gametocyst x 265; 5 - Gametocyst with sporoduct x 265; 6 - Spores x 890).

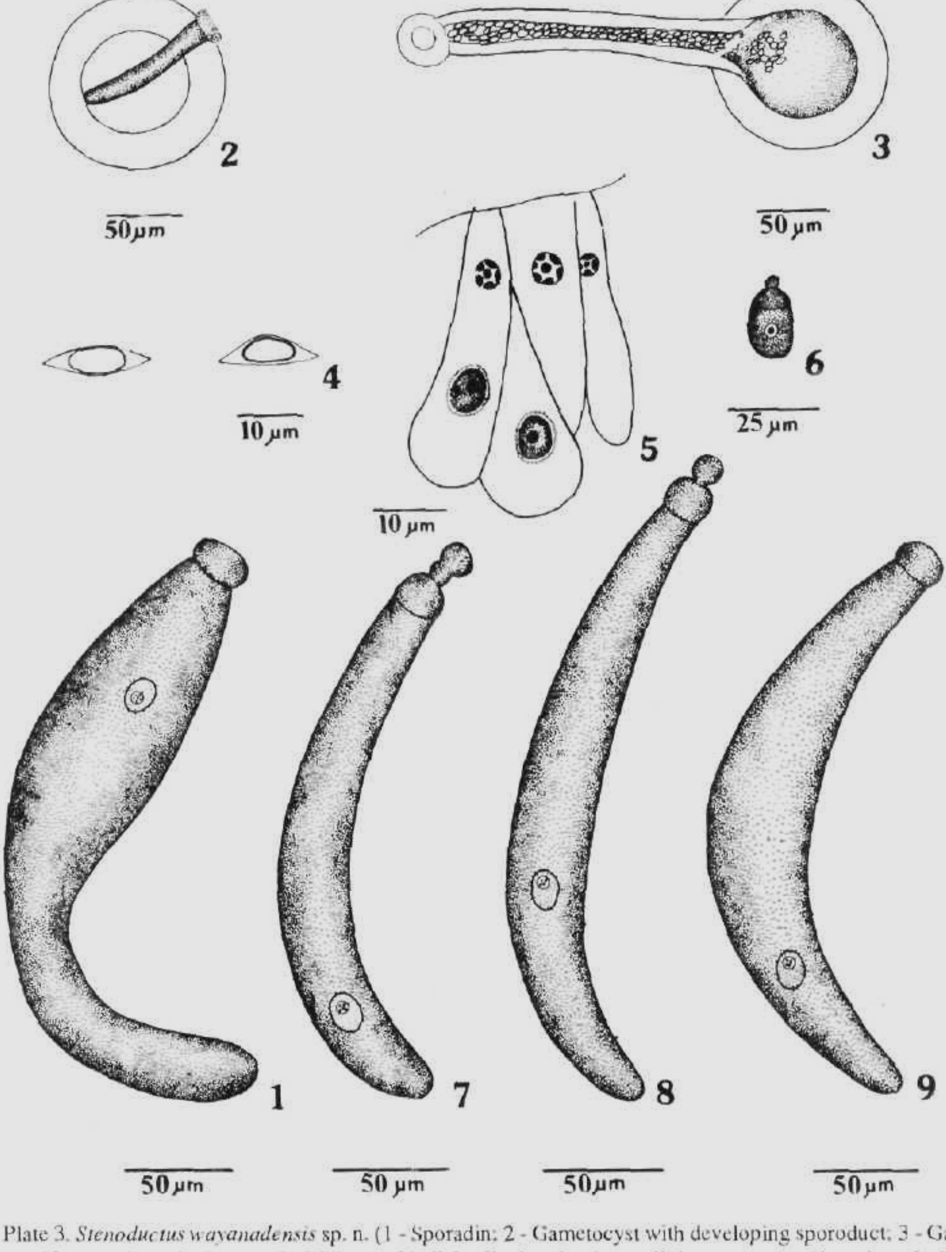



Plate 3. *Stenoductus wayanadensis* sp. n. (1 - Sporadin; 2 - Gametocyst with developing sporoduct; 3 - Gametocyst with sporoduct; 4 - Spores; 5 - Midgut epithelial cells showing intracellular aseptate trophozoites; 6 - Early trophozoite; 7 - Trophozoite with '8'-shaped epimerite; 8 - Trophozoite with bulbous epimerite; 9 - Late trophozoite).

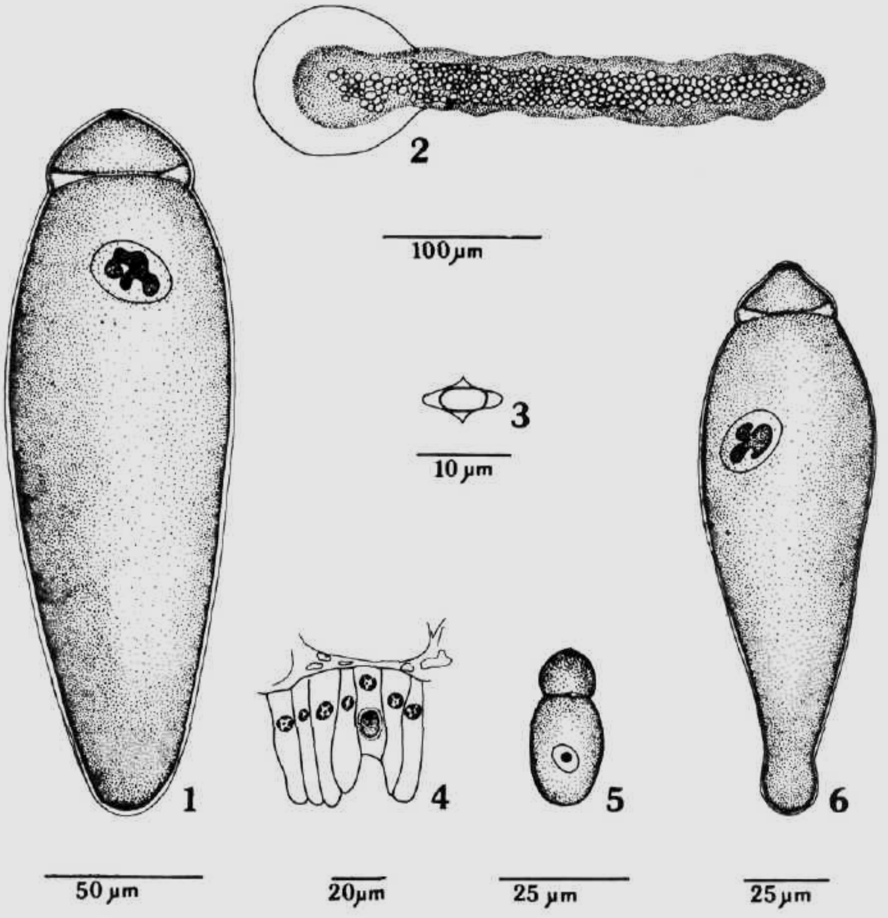
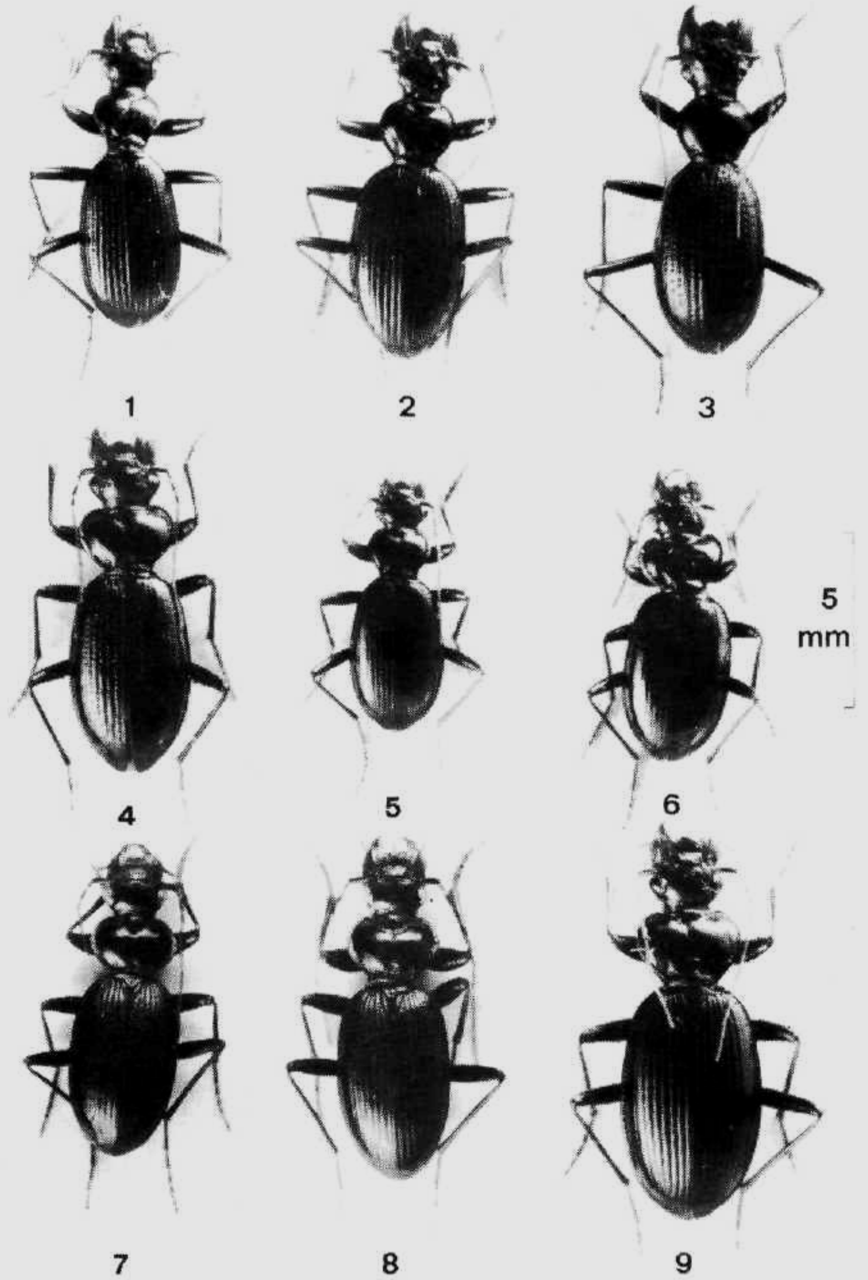
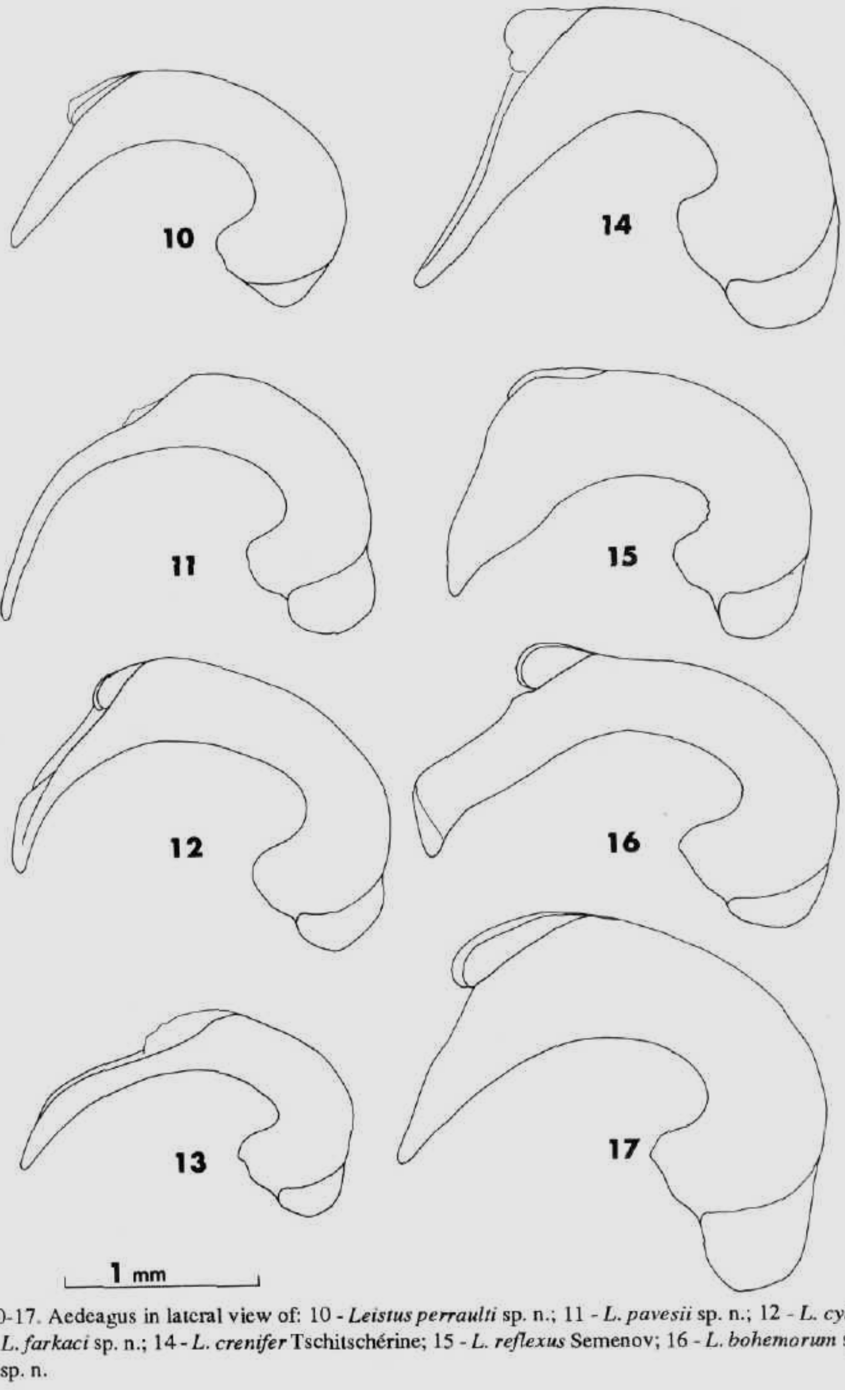



Plate 4. *Stenoductus wayanadensis* sp. n. (1 - Midgut epithelial cells showing intracellular aseptate trophozoite x 890; 2,3 - Trophozoites x 530; 4 - Gametocyst with developing sporoduct x 370; 5 - Gametocyst with sporoduct x 370; 6 - Spores x 890).




Figs 1-9. Habitus of 1 - *Leistus perraulti* sp. n., holotypus, male; 2 - *L. pavesii* sp. n., holotypus, male; 3 - *L. cylindricus* sp. n., holotypus, male; 4 - *L. sichuanus* sp. n., holotypus, female; 5 - *L. farkaci* sp. n., holotypus, male; 6 - *L. crenifer* Tschitschérine; 7 - *L. reflexus* Semenov; 8 - - *L. bohemorum* sp. n., holotypus, male; 9 - *L. saueri* sp. n., paratypus, female.




Figr 10-17. Aedeagus in lateral view of: 10 - *Leistus perraulti* sp. n.; 11 - *L. pavesii* sp. n.; 12 - *L. cylindricus* sp. n.; 13 - *L. farkaci* sp. n.; 14 - *L. crenifer* Tschitschérine; 15 - *L. reflexus* Semenov; 16 - *L. bohemorum* sp. n.; 17 - *L. saueri* sp. n.

## INSTRUCTIONS TO AUTHORS

*Acta Societatis Zoologicae Bohemicae* publishes in English, original papers on general, applied and systematic zoology, biographies and book reviews. Papers by members of the Czech Zoological Society are prefered. It is understood that manuscript submitted are not offered to any other journal for prior or simultaneously publication.

Authors of taxonomic papers must respect the articles of the International Code of Zoological Nomenclature (Third Edition, 1985) and to observe its recommendations. The manuscript, including footnotes, references and tables, must be typed with double spacing (30 lines per page) on side A4 paper (210 mm x 297 mm), in duplicate, and should be not longer than 30 pages. Pages must be numbered throughout the manuscript. Final version (corrected as requested by referees and language reviewer) is preferably accepted on an IBM PC-compatible 5.25" or 3.5" diskette.

Heading: Title of the paper, full name(s) of author(s), place of work with full address - each on separate line.

Key words: Select a set (one or two lines) of key words (index terms). The set should be complete (i.e. words from the title should be repeated if considered index terms).

Abstract summarizing concisely the contents of the paper and indicating the relevance of the work, should not exceed 20 type-written lines.

References: within the text - Dryden (1968), (Lattin 1967), Kumari & Nair (1967), Tamiro et al. (1970), the full citation should be given in the list of references. Under the References authors should be cited in full followed by abbreviations of periodicals in accordance with The World List of Scientific Periodicals, 4th edition, Butterworths, London (1964-1965). The number is to be given (in parentheses) only when individual numbers are paginated independently (see example b). References to papers published in languages other than the major ones, or printed in characters other than Latin, should content English translation, with an appropriate note at the end (see example e, f).

Examples:

(a) Dryden G.L. 1968: Growth and development of Suncus murinus on Guam. J. Mammal. 49: 51-62.

(b) Lönnberg E. & Gustavson C. 1937: Contribution to the life-history of the striped wrasse. Ark. Zool. 29(7): 1-16.

(c) Lattin G. de 1967: Grundriss der Zoogeographie. Jena: Fischer Verlag, 602 pp.

(d) Makin D. 1987: The status of bats in Israel. pp: 403-408. In: Hanák V., Horáček I. & Gaisler J. (eds.): European bat research. Praha: Charles Univ. Press, 718 pp.

(e) Schornikov E. I. 1969: A new family of Ostracoda from the supralitoral zone of Kuril islands. Zool. Zhurnal 48: 494-498 (in Russian, Engl. abstr.).

(f) Lekeš V. 1993: [Macrolepidoptera in middle Polabí lowland]. Polabská Příroda 4: 19-20 (in Czech).

Illustrations and their caption or legends must form a separate unit. Clear technically perfect line drawing and photographs (black-white, glossy) are accepted. The original drawing and photographs (one set) should not be more than twice as large as when printed and preferably into blocks or plates so that the blocks of drawings or photographs may be uniformly reproduced over the page with the journal. Legends to the illustrations should be supplied on a separate sheet of paper. References to illustrations and tables in the text: Fig. 1; Figs 1-2; Plate 1, Fig.1 (for photographic plates); Table 1.

Tables including headings and explanations should be on separate sheets of paper, numbered consequently with Arabic numerals.

Marking in the manuscript (in light pencil, not in ink or type written). In the text: Latin names of taxa up to generic level - with wavy underlining (italics). In the References: names of periodicals (not the Latin names of taxa) with wavy underlining.

Proofs will be sent to the authors. One hundred reprints are supplied free of charge. Manuscripts of published papers and originals of illustrations are not returned unless return requested.

Address of the editorial office: Acta Soc. Zool. Bohem., Dr David Král, Viničná 7, CZ-128 00 Praha 2, Czech Republic