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Seasonal dynamics of soil nematode community in an oak-hornbeam wood

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Soil nematodes, community composition, seasonal dynamics, oak-hornbeam forest, Prague

Abstract. Soil nematode community was studied in a deciduous forest in the Natural Protected Area Chuchelský hříb in Prague. The characteristic of the community was studied as follows: species composition, diversity, abundance, trophic structure and seasonal dynamics. The community was characterized by a high number of species (98) but a relatively low mean abundance (3.94 x 10⁴ ind.m⁻²). The most abundant genera were Phasmatodes, Filaricus, Rhabditis and Enterolaimus.

Oak forests or mixed oak forests cover a significant area on the territory of the Czech Republic. Free-living nematodes are an important part of soil fauna in those ecosystems composing diverse and abundant communities. Those communities on the European territory were studied by Sály (1973) in Slovakia, Bassett (1962) in Germany, Wasiłewska (1970, 1971) in Poland or Solovyeva (1986) in the European part of the former Soviet Union. In the Czech Republic, nematodes of an oak forest in South Bohemia were studied by Hánel (1994).

The aim of the present study was to investigate the nematode community of an oak-hornbeam forest near Prague in Central Bohemia, a part of the Natural Protected Area Chuchelský hříb.

MATERIAL AND METHODS

Investigations were carried out in an oak-hornbeam forest (Mélampyro nemorosi Carpinetum) in the Chuchelský hříb near Prague in Central Bohemia, north-west slope, 275 m a.s.l., square code 3952 in the network of squares on the map of the Czech Republic for faunistic research. This locality is a part of the Natural Protected Area.

The soil is mesotrophic brown on silurian rock composed of diabases, limestones and slates. The characteristic of the soil is in Tab. 1.

The climate of the region is characterized by a warm and dry summer, a short winter with a very short duration of snow cover (Quiñ 1971). Mean annual temperature and sum of precipitation in 1990 were 10.7°C and 409 mm, respectively, corresponding values in 1991 were 9.3°C and 409 mm. The seasonal changes of temperature and precipitation are given in Tab. 2.

Soil samples (7 x 7 cm) were taken monthly from September 1990 to August 1991 in 7 replicates down to the depth of 10 cm. Nematodes were isolated from 5g of mixed soil using the modified Baermann funnel method for 24 hours, fixed in FAA and transferred to glycerin (Sály 1983).

The study material consisted of 5,252 nematodes. Individuals were determined to species, specimens in nematode genera were counted. Shannon index of diversity was calculated from genera abundance according to the formula:

* corresponding author
\[ H^+ = \sum_{i=1}^{n} \left[ N_i / N \right] \ln \left[ N_i / N \right] \]

\( N_i \) - abundance of \( i \)-th genus
\( N \) - total abundance
\( n \) - number of genera (Odum 1977)

Table 1: Soil characteristics of locality

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>humus (%)</td>
<td>12.10</td>
<td>8.40</td>
</tr>
<tr>
<td>C (%)</td>
<td>7.01</td>
<td>4.88</td>
</tr>
<tr>
<td>N (%)</td>
<td>0.76</td>
<td>0.27</td>
</tr>
<tr>
<td>C/N</td>
<td>9.22</td>
<td>18.07</td>
</tr>
<tr>
<td>CuO (mg/100g soil)</td>
<td>988.00</td>
<td>151.00</td>
</tr>
<tr>
<td>MgO (mg/100g soil)</td>
<td>19.70</td>
<td>12.90</td>
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<tr>
<td>Fe2O3 (mg/100g soil)</td>
<td>8.90</td>
<td>9.00</td>
</tr>
<tr>
<td>K2O (mg/100g soil)</td>
<td>17.30</td>
<td>9.30</td>
</tr>
<tr>
<td>pH (H2O)</td>
<td>5.33</td>
<td>4.88</td>
</tr>
<tr>
<td>pH (KCl)</td>
<td>4.64</td>
<td>3.94</td>
</tr>
</tbody>
</table>

Table 2: Mean monthly temperatures (°C) and sum of precipitation (mm) from September 1990 to August 1991

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>IX</td>
<td>69</td>
<td>12.9</td>
</tr>
<tr>
<td>X</td>
<td>31</td>
<td>10.5</td>
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<tr>
<td>XI</td>
<td>65</td>
<td>5.2</td>
</tr>
<tr>
<td>XII</td>
<td>59</td>
<td>0.9</td>
</tr>
<tr>
<td>I</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>III</td>
<td>28</td>
<td>6.9</td>
</tr>
<tr>
<td>IV</td>
<td>24</td>
<td>8.5</td>
</tr>
<tr>
<td>V</td>
<td>37</td>
<td>10.9</td>
</tr>
<tr>
<td>VI</td>
<td>90</td>
<td>16.3</td>
</tr>
<tr>
<td>VII</td>
<td>46</td>
<td>20.8</td>
</tr>
<tr>
<td>VIII</td>
<td>56</td>
<td>19.3</td>
</tr>
</tbody>
</table>

The species were divided into five trophic groups: bacterivores, fungivores, facultative plant feeders, plant feeders, omnivores, omnivores (predators). See check list Tab 3. Pearson's correlation coefficients were calculated between temperature abundance and precipitation abundance.

Seasonal changes of the nematode community were evaluated using agglomerative classification of samples, genus abundance transformed by log(x+1), Euclidean distance, Ward's method (Ward 1963). Nematode material is deposited with the authors.

**RESULTS**

A total of 98 species, 64 genera, 32 families and 9 orders of soil nematodes were found in the study plot (Tab 3). Dominant genera were as follows: *Filenchus* \((1.34 \times 10^3 \text{ ind.m}^{-2}, 34.07\%)\), *Plectus* \((0.40 \times 10^3 \text{ ind.m}^{-2}, 10.05\%)\), *Eudorylaimus* \((0.32 \times 10^3 \text{ ind.m}^{-2}, 8.15\%)\), and *Rhabditis* \((0.22 \times 10^3 \text{ ind.m}^{-2}, 5.52\%)\). The population maximum of the genus *Filenchus* was found in October 1990, those of the genus *Plectus* in February 1991, the genus *Eudorylaimus* in December 1990, the genus *Rhabditis* in January 1991. Mean annual value of the Shannon index of diversity was 2.73, monthly values fluctuated from 1.54 to 2.85.

The mean abundance of nematodes was \(3.94 \times 10^3 \text{ ind.m}^{-2}\), its seasonal changes are given in Fig 1. The highest abundance was found in January 1991. Among the trophic groups fungivores
facultative plant feeders were the most abundant nematodes and their seasonal changes were very similar to those of the total nematode community. Microphages had their peak of abundance in January 1991 as well as omnivores and predators (Fig. 1).

The development of nematode community at different sampling months is shown in Fig. 2. The community structure in January 1991 was different from that in the other months, mainly due to the high abundance of the genera *Filenchus*, *Rhabdus*, *Acroboloeides* (Cobb, 1924), *Aporcelaimella* Heyns, 1965 and *Tylencholaimus*. Samples from 1990 were clustered into the group A. There was a high similarity between samples taken in April, May, June and these samples were more similar to the community in February (group B) than to that in March, July and August (group C).

**DISCUSSION**

The oak-hornbeam forest studied was characterized by a high number of nematodes species as well as the oak-dominated forests studied by Bausus (1962), Sály (1973), Solovyeva (1986) and Hánel (1994). The highest values of the Shannon index of diversity were found in August 1991 (2.85), November 1990 (2.82) and in January 1991 (2.80). Similarly, Hánel (1994) found the highest values of the Shannon index in August in an oak forest in South Bohemia. It is interesting, that the lowest abundance of nematodes in the studied forest was in August, whereas on the contrary Hánel (1994) found the peak of abundance in that month.

The abundance of nematodes in oak forests is very variable. Volz (1951) found the maximum abundance of $29.9 \times 10^6$ ind.m$^{-2}$ in an oak-ash forest in Germany, Hánel (1994) found the
minimum value of $0.35 \times 10^4$ ind.m$^{-2}$. The average abundance of nematodes in deciduous forests varies in range of several millions of individuals per m$^2$ (Sohlenius 1980, Wasilewska 1981). In comparison with these data, the abundance of nematodes in the study plot was low. The cause of this phenomenon could consist in dry weather in the year investigated as indicated by negative correlation of nematode abundance either with average month temperatures ($r = -0.587$, n = 12, $P = 0.05$), or with precipitation ($r = -0.424$, n = 12), too. Dry summer was probably responsible for the absence of the peak of abundance in August found by Hánel (1994) in an oak forest in South Bohemia, however, the high Shannon index value of the nematode community remained unaffected by shortage of soil water.
Microbivorous nematodes usually dominate in oak forests. Arpin and Pongé (1986) found almost equal proportion of bacteriophages and mycophageous nematodes in an oak forest in France as well as in the oak-hornbeam forest studied. The genera Filenchus, Eudorylaimus, Plectus and Rhabditis dominated in the forest studied and the same dominants were also ascertained in the oak forest studied by Hánel (1994). In the oak-hornbeam forest in Slovakia Rhabditis was the dominant bacteriophagous genus, Aphelenchus Bastian, 1865 was dominant in the mycophageous (Sály 1973). True phytophagous nematodes had a low abundance in the forest studied and in the forest studied by Hánel (1994), Sály (1973) found a high abundance of the phytophagous species Helicostylenchus multicoenetus (Cobb, 1895). These differences are probably related to a different soil profile and herbaceous undergrowth in the forests compared.

**SUMMARY**

1. A total of 98 species of the soil nematodes were found in the oak-hornbeam forest.
2. The average nematode abundance was $3.94 \times 10^5$ ind. m$^{-2}$. The maximum abundance value was found in January 1991 ($9.03 \times 10^5$ ind. m$^{-2}$), the minimum value was in August 1991 ($0.83 \times 10^5$ ind. m$^{-2}$). The dominant genera were Filenchus, Eudorylaimus, Plectus and Rhabditis.
3. Microbivorous nematodes represented the greater part of the nematode community, the abundance of parasites on higher plants was low.

Table 3. Check-list of nematode species in oak-hornbeam forest, B - bacterivores, P - fungivores, P - plant feeders, O - omnivores, C - carnivores

<table>
<thead>
<tr>
<th>Order</th>
<th>Genus</th>
<th>Species</th>
<th>Reference</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONHYSTERIDA</td>
<td>Monhystera</td>
<td>Bastian, 1865</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td>ARAEOLAIMIDA</td>
<td>Anagelatus</td>
<td>granulosus (Bastian, 1865)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plectus acuminatus</td>
<td>Bastian, 1865</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plectus longicudatus</td>
<td>Bärschli, 1873</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plectus parvus</td>
<td>Bastian, 1865</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plectus rhizophilus</td>
<td>de Man, 1880</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plectus Bastian, 1865 sp.</td>
<td>(B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ceratoplectus armatus</td>
<td>Bärschli, 1873</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tyiocephalus auricularia (Bärschli, 1873)</td>
<td>(B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wilsonema otophorum</td>
<td>de Man, 1880</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylindrolaimus</td>
<td>de Man, 1880 sp.</td>
<td>(B)</td>
</tr>
<tr>
<td>CHROMADORIDA</td>
<td>Chromadorina</td>
<td>Filipjev, 1918</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td>Rhabditida</td>
<td>Metaterephaloides</td>
<td>cranidens de Man, 1880</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teratoccephalus</td>
<td>terrestrialis (Bärschli, 1873)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teratoccephalus</td>
<td>parasutatus Eodebenko, 1975</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acrobeloides</td>
<td>nanus (de Man, 1880)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cephalobus</td>
<td>persimilis Bastian, 1865</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cephalobus</td>
<td>troglophilus Andrássy, 1967</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heptaccephalus</td>
<td>elongatus (de Man, 1880)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Escapabundus</td>
<td>oxyrooides (de Man, 1876)</td>
<td>(B)</td>
<td></td>
</tr>
</tbody>
</table>
23 Eucephalochus striatus Bastian, 1865 (B)
24 Acrobates Linstow, 1877 sp (B)
25 Cervatellus hamatae Thorne, 1937 (B)
26 Panagophorus rigulae (Schneider, 1866) (B)
27 Burialla minugyrae (Bastian, 1873) (B)
28 Rhaditis Dajac, 1845 sp (B)
29 dauer larvae (B)

order APHELENCHIDA
30 Aphelechnodes inae Bastian, 1865 (F)
31 Paraphelenchus parvus parvus (Micoletzky, 1929) (F)
32 Aphelechnodes regisophiler Franklin, 1957 (F)
33 Aphelechnodes parmae (Bastian, 1865) (F)
34 Aphelechnodes Fischer, 1894 sp 1 (F)
35 Aphelechnodes Fischer, 1894 sp 2 (F)
36 Aphelechnodes Fischer, 1894 sp 3 (F)
37 Scutella Fuchs, 1931 sp (C)

order TYLENCHIDA
38 Filenchus vulgaris (Braekel, 1963) (F/P)
39 Filenchus philiformis (Bastian, 1873) (F/P)
40 Filenchus duvae epauir (Andrássy, 1944) (F/P)
41 Filenchus helmei (Szekely, 1959) (F/P)
42 Filenchus minutus (Cobb, 1893) (F/P)
43 Filenchus (Andrássy, 1944) sp 1 (F/P)
44 Filenchus (Andrássy, 1944) sp 2 (F/P)
45 Lagenchus leptosoma (de Man, 1890) (F/P)
46 Tylenchus da nuna Bastian, 1865 (F/P)
47 Tylenchus Bastian, 1865 sp (F/P)
48 Paratylenchus Micoletzky, 1922 sp (P)
49 Gracilus Redi, 1862 sp (P)
50 Mecenchus bryophila (Steener, 1914) (F/P)
51 Mecenchus Andrássy, 1908 sp 1 (P)
52 Diplenchus Philpott, 1880 sp (1)
53 Cylindenchus vonmou (de Man, 1921) (P)
54 Bolechius volutus Lando et Sindhub, 1963 (F/P)
55 Tylenchus hynchus Cobb, 1913 sp (P)
56 Helminthenchus Steener, 1915 sp (P)
57 Rosylenchus Philpott, 1880 sp (P)

order ENOPHIDA
58 Alasoma primitivum de Man, 1880 (B)
59 Alasoma meylia Andrássy, 1901 (B)
60 Alasoma de Man, 1880 (B)
61 Alasoma fulvus de Man, 1879 (B)
62 Prionotobus de Man, 1880 (B)
63 Prionotobus intermedius (Bastian, 1873) (B)
64 Bastiania gracilis de Man, 1896 (B)
65 Triphysa filicumata de Man, 1880 (C)
66 Triphysa gigantea Redi, 1880 (C)
67 Triphysa Bastian, 1865 sp 1 (C)
68 Triphysa Bastian, 1865 sp 2 (C)
69 Tobisch Andrássy, 1929 sp (C)
REFERENCES


Cochlear hair cell population in two primate species
(Cercopithecus aethiops and Macaca arctoides)

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Cochlea, hearing, inner hair cells, primates

Abstract. Basic morphological and morphometrical aspects of the cochlea in two primate species have been studied. Six adult individuals of the Vervet Monkey (Cercopithecus aethiops) and four individuals of the Stump-tailed Macaque (Macaca arctoides) have been involved. Standard paraffin sectioning and surface specimen techniques were used for the assessment. General cochlear morphology is very similar in the two species under study. Numbers and densities of cochlear hair cells are slightly higher in the Macaque than in the Vervet. While the distribution of outer hair cells is also similar in the two species, the inner hair cell distribution differs. However, neither in the Vervet nor in the Macaque the hair cell distribution correlates with the audiogram. Vague correlation between the audiogram and the inner hair cell distribution found in the Vervet cochlea cannot be considered as strong evidence. Hence, the quantitative aspect of the hair cell distribution in the two primate species studied resembles more the situation in man than in non-primates mammals where such correlation has been repeatedly found.

INTRODUCTION

Several mammalian species from different taxonomic groups were studied as to the basilar membrane length, width or thickness, number of cochlear hair cells, changes in hair cell density distribution along the spiral organ of the inner ear, etc.

It has been already found that in majority of species studied so far there are conspicuous variations in the densities of hair cells in the cochlea. These variations followed a similar (or even identical) pattern in all individuals of a given species (Ehret & Frankenreiter 1977, Burda & Voldrich 1980, Burda & Ulehléva 1983, Burda 1984, Burda & Voldrich 1984, Burda et al. 1988a, Burda et al. 1988b, Burda et al. 1989 etc.).

Burda & Voldrich (1984) proposed that the above mentioned species-specific variations may be of a great importance for frequency resolution and/or intensity discrimination capabilities, because in number of mammals studied there is a perfect correlation between the functional curve of auditory thresholds (audiogram) and the morphometrical curve of hair cell density distribution (Ehret & Frankenreiter 1977, Burda & Voldrich 1980, Burda & Ulehléva 1983, Burda 1984 etc.).

Controversially, in man, changes of hair cell density distribution along the basilar membrane are small, interindividual variations in hair cell counts are high and do not correlate with the audiometrical curve (Ulehléva & Voldrich 1987).
This controversy provokes several questions about the applicability of various mammalian models for the study of human auditory function. It seems to be a logical consequence that for the purpose of human studies other primate species would be the optimal models. However, apart from man, no other primate species has been studied in detail from this aspect. Even the review article on the comparative cochlear morphology published recently by Nadol (1988) does not contain the basic morphological data on basilar membrane length and width, hair cell numbers and densities etc.

The purpose of this contribution is to fill this gap and bring some new data on the mammalian cochlear morphology and morphometry. In addition, the authors wish to ascertain whether the cochlear hair cell populations of two different species of old world monkeys show any species-specific variations which might be correlated with the audiometrical curve (similarly as in mammals from lower taxonomic groups) or whether the hair cell population resembles the seemingly "unremarkable" quantitative pattern of the human organ of Corti.

MATERIAL AND METHODS

Twelve cochleae of six adult individuals of the Vervet Monkey (Cercopithecus aethiops) and eight cochleae of four adult individuals of the Stumptail Macaque (Macaca arctoides) are involved in this study. All subjects were unanaesthetized control animals from the colony of the Institute of Senso and Vaccines (Praha, Czech Republic).

After sodium pentobarbital euthanasia, the middle ear cavity was exposed by a transtympanic approach and the cochleae were perfused with 10% neutral formaldehyde solution. The temporal bones were then removed and immersed in the fixative. After fixation the temporal bones were rinsed in running tap water, the bone of the osseous capsule was thinned by means of a dentist's drill and the cochlear partition was isolated from the apex up to the hook region under a dissecting microscope. The whole spiral organ was stained in situ with toluidine blue and Ehrlich's haematoxylin. The method is described in detail elsewhere (Olechovská & Volčíčk 1987). The surface specimens of the basilar membrane were mounted in glycerol (see Burá et al. 1989). One cochlea of both species was decalcified by EDTA in toto, embedded in paraffin wax (FLUKA). Midmodular sections were cut at 15 micrometers thickness. To ascertain the mean basilar membrane width five measurements were taken at every half-turn in the horizontal, modular plane.

For quantitative assessment, the organ of Corti was divided into ten segments of equal length in the range of "1" to "10" with subdivisions of "1", with helicotrema being the starting point. All observations and measurements including the sensory stereocilia height assessment were made by light microscopy.

RESULTS

The cochleae of both species studied have 3 and 1/4 turns. The mean total length of the basilar membrane from apex to base including the hook region was 25.88±0.91 mm (N=11) and 23.08±0.91 mm (N=7) in the Vervet and the Macaque respectively (Tab. 1, Tab. 2). The basilar membrane width, measured in each successive half coil ranged from 11.45±3.8 to 31.76±2.22 micrometers in the Vervet and from 11.85±3.61 to 31.38±2.65 micrometers in the Macaque (Fig. 3).

The organ of Corti contained on average 2493±108 inner hair cells (IHC), 9125±397 outer hair cells (OHC) in the Vervet and 2605±198 IHC, 9638±404 OHC in the Macaque. This means that there are on average 96 or 104 IHC and 355 or 384 OHC per one millimeter of the spiral organ of Corti in the Vervet and the Macaque respectively (Tab. 1, Tab. 2).

In both primate species, OHC are arranged, as is usual in mammals, into three rows which tend to be more irregularly arranged at the apex than at the base (Figs 1 and 2)*. OHC which could be classified as belonging to the fourth row were found only exceptionally.

The density of hair cells along the organ of Corti was not uniform. As far as OHC are concerned, their density decreased almost linearly from apex to base (Figs. 4 and 5) correspond-

* The figures 1 and 2 will be found at the end of this issue.
Table 1. Basilar membrane length and hair cell counts in the Vervet Monkey (1 to 6 - numbers of the individuals involved, R, L - right or left ear)

<table>
<thead>
<tr>
<th>Individual / ear</th>
<th>BM Length (mm)</th>
<th>Total HC</th>
<th>Total OHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/L</td>
<td>26.29</td>
<td>2458</td>
<td>9063</td>
</tr>
<tr>
<td>1/R</td>
<td>23.98</td>
<td>2516</td>
<td>9088</td>
</tr>
<tr>
<td>2/L</td>
<td>27.54</td>
<td>2605</td>
<td>9085</td>
</tr>
<tr>
<td>2/R</td>
<td>27.23</td>
<td>2604</td>
<td>9198</td>
</tr>
<tr>
<td>3/L</td>
<td>25.67</td>
<td>2361</td>
<td>8552</td>
</tr>
<tr>
<td>3/R</td>
<td>25.04</td>
<td>2280</td>
<td>8484</td>
</tr>
<tr>
<td>4/L</td>
<td>25.35</td>
<td>2533</td>
<td>9199</td>
</tr>
<tr>
<td>4/R</td>
<td>25.20</td>
<td>2516</td>
<td>9193</td>
</tr>
<tr>
<td>5/L</td>
<td>25.07</td>
<td>2451</td>
<td>9284</td>
</tr>
<tr>
<td>5/R</td>
<td>24.84</td>
<td>2452</td>
<td>9245</td>
</tr>
<tr>
<td>6/R</td>
<td>24.45</td>
<td>2644</td>
<td>10002</td>
</tr>
<tr>
<td>mean</td>
<td>25.88</td>
<td>2493</td>
<td>9125</td>
</tr>
<tr>
<td>Sd</td>
<td>0.91</td>
<td>108.5</td>
<td>396.7</td>
</tr>
</tbody>
</table>

...ding to a continuous widening of the cuticular plates of OHC and flattening of the "W" pattern of the OHC stereocilia formation. On the contrary, in both species under study the density of IHC is apparently different and species specific. In the Vervet Monkey it decreases from the apex reaching its minimum value by the third and fourth segment, then it begins to rise again towards the base (with two cochleas of the animal No 3 being the exception) reaching a plateau of maximum density values from the fifth to the ninth segment. There is a slight depression in the IHC density curve apparent between the sixth and the seventh segment. It is, however, not present in all ears studied. Although the absolute number of IHC within respective segments varied in different individuals, the density distribution curves followed (with one above mentioned exception) a similar trend in all ears examined (Fig. 6). No difference between males and females has been found.

In the stump-tailed Macaque the IHC density decreased steeply within three apical segments from 130-140 IHC/mm to 110 IHC/mm then the curve followed a moderate descending trend finally reaching about 95 IHC/mm at the base (Fig. 7).

Table 2. Basilar membrane length and hair cell counts in the Stump-tailed Macaque (1 to 4 - numbers of the individuals involved, R, L - right or left ear)

<table>
<thead>
<tr>
<th>Individual / ear</th>
<th>BM Length (mm)</th>
<th>Total HC</th>
<th>Total OHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/L</td>
<td>23.99</td>
<td>2538</td>
<td>9006</td>
</tr>
<tr>
<td>1/R</td>
<td>23.92</td>
<td>2517</td>
<td>9123</td>
</tr>
<tr>
<td>2/L</td>
<td>25.38</td>
<td>2752</td>
<td>9690</td>
</tr>
<tr>
<td>2/R</td>
<td>25.09</td>
<td>2828</td>
<td>10005</td>
</tr>
<tr>
<td>3/L</td>
<td>25.24</td>
<td>2690</td>
<td>9885</td>
</tr>
<tr>
<td>3/R</td>
<td>25.76</td>
<td>2233</td>
<td>9864</td>
</tr>
<tr>
<td>4/L</td>
<td>25.59</td>
<td>2579</td>
<td>9894</td>
</tr>
<tr>
<td>4/R</td>
<td>25.08</td>
<td>2605</td>
<td>9838</td>
</tr>
<tr>
<td>mean</td>
<td>25.08</td>
<td>2579</td>
<td>9894</td>
</tr>
<tr>
<td>Sd</td>
<td>0.91</td>
<td>197.8</td>
<td>404.1</td>
</tr>
</tbody>
</table>
Fig. 3. Basilar membrane width.

Fig. 4. Outer hair cell density per mm of the organ of Corti (Vervet Monkey).

Fig. 5. Outer hair cell density per mm of the organ of Corti (Stump-tailed Macaque).
Fig. 6. Inner hair cell density per 1mm of the organ of Corti (Vervet Monkey).
Fig. 7. Inner hair cell density per 1mm of the organ of Corti (Stumptail Macaque).

Fig. 8. Height of longest stereocilia in a given region (Stumptail Macaque - animal No. 3L).
Fig. 9. Average hair cell densities in the two primate species studied (asterisk region corresponds to higher sensitivity for frequencies between 1 and 8kHz as given by Stabbens 1973)
According to pilot measurements performed in one cochlea of the Stumptail Macaque the stereocilia bundle gradually decreased its height from apex to base with only a slight apical difference between four rows of hair cells with the third OHC row having the longest and the IHC having the shortest hairs (Fig. 8).

**DISCUSSION**

Number of cochlear cells in both species under study is 3 and 1/4. It is the maximum length recorded in primates. Similar values are given also for Cebus albifrons, Ateles belzebuth and Papio papio (Werner 1960). The width of the basilar membrane falls within the range known for other primate species which according to Werner (1960) is 105-158 micrometers at the base and 306-432 micrometers at the apex but does not reach the values given for man by Held (1926, quoted by Nador, 1988), i.e. 104-504 micrometers. In comparison with values mentioned by Nador (1988) for several mammalian species including man the longest hairs in the stereociliary tuft at the apical pole of hair cells are higher (longer) in the Stumptail macaque than in rat, guinea pig, cat and even in man. Nevertheless, in the monkey, the stereociliary bundle height increases apicward in a similar manner as in other mammalian species so far studied.

As mentioned already, OHC are distributed very regularly along the organ of Corti similarly in both monkeys. On the contrary, in the Vervet Monkey the density of IHC varies along the organ of Corti in a way which is seemingly different from that of the Stumptail Macaque. As evidenced and discussed in several mammalian species there are some striking correlations between the distribution of hair cells and the curves of auditory (sensitivity and/or resolution) thresholds. In contrast, such a relation does not exist in humans. We have tried to compare the determined morphometrical curve of the hair cell density distribution with the audiometrical pattern for four genera of the subfamily Cercopithecinae, as described by Stubbins (1973).

The only correlation can be found in the region of maximum IHC density in the Vervet which roughly correlates with high sensitivity for frequencies above 1kHz (between segments 6 to 8). We have to point out, however, that the concordance between the distribution of the IHC density and the auditory threshold is not as obvious as in some smaller, subprimate mammals studied from this aspect. The OHC densities in both species and the morphometrical curve of IHC density distribution of the Stumptail Macaque cannot be correlated with the audiogram at all (Fig. 9).

The lack of complete correlation between the hair cell density distribution curve and the audiogram cannot be interpreted as showing that the (inner) hair cells are not involved in frequency discrimination, or that frequency discrimination is poor in the primates under study. Even in those segments where the hair cell density is lowest the actual total number of hair cells in a segment roughly corresponding to a frequency octave vibrating unit is comparatively high due to the longer organ of Corti.

A correlation between the auditory sensitivity for a given frequency region and the number of hair cells, which is a function of the cell density and the length of the corresponding segment, has already been pointed out for several mammalian species especially for those from lower primatological taxa such as rodents or bats (Ehrat & Frankenreiter 1977, Burda & Voldrich 1980, Burda & Uehleke 1983, Bursa 1984, etc.) but was not proved in the present study for two primate species, the Stumptail Macaque and the Vervet Monkey. Topographically related hair cell density distribution is also not known in humans.

It is evident that the relation between the quantitative aspect of the cochlear hair cell population and the functional ability is not clarified enough and still requires further study.
Acknowledgements

We are indebted to Doc Dr F. Veinbäck from BSV Prague, for supplying us with the specimens examined. The technical assistance of Miss Jolana Němcová is also acknowledged.

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BOOK REVIEW


This volume represents a special edition of 'Protoplasma', Vol. 164, 1991. It was compiled by 20 international experts and consists of 13 chapters, which actually present individual scientific reports giving a good number of references to the primary literature. The purpose of report 1 on terminology and nomenclature of the cytoskeletal elements associated with the flagellar/germ apparatus in protists is to establish clear definitions, identify synonyms and indicate homologues. Included are 43 definitions of cytoskeletal elements, for example: peroxisomal structures, fibrillar surface coat, flagellar hairs, transitional region, concentric fibers, basal body, earthworm, microtubular roots, kibernetica, etc. Report 2 deals with tubulin gene families in flagellate/ciliate protists. Report 3 demonstrates the transmembrane signaling as an important component of the function of cilia and flagellar surfaces. Following four reports are dedicated to the flagellar apparatus and swimming patterns of algae, flagellates. In report 8 flagellar and cytoskeletal systems in amoeboid flagellates, Amoebida, Mastigidae and Parabasidae, the so-called Arch-amoebae, are examined. In spite of the lack of mitochondria, the archaebacteria of protists show considerable differences in their organization. This report examines the characters of the flagellar apparatus and its cytoskeleton in archaebacteria to obtain data used for phylogenetic consideration of the three rted groups of flagellates. The data available in report 9 provide support for the hypothesis that flagellates and kinetoplastids are more closely related to each other that they are to other protists. Ultrastructural composition of the motile, feeding, flagellate apparatus, and cytoskeleton are investigated here. In following two reports a comparative overview of the flagellar apparatus and cytoskeleton of dinoflagellates and descriptions of kintoplasts structure of the ciliate protists are given. This two reports deal with ultrastructural aspects of algae and zoosporic fungi.

The cytoskeleton, the macronuclear network of protein filaments gives the cell strength, rigidity and shape, and is responsible for cell motility and intracellular movements. Several monographs devoted to this cellular organelle have been published recently. This volume provides an up to date synopsis of the flagellar apparatus/cytoskeleton, illustrated by 154 high-quality, for the main part electron micrographs figures. It represents a valuable source of information for scientists who wish to become familiar with the morphology of protists and protozoan parasites.
Chemostat-Turbidostat discontinuum, r-K continuum and population-size regulating mechanism

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Evolution, selection, r-K strategy, turbidostat, chemostat, negative feedback loop, number regulating mechanism, model, efficiency of growth, rate of growth

Abstract. The size stability of natural populations indicates that growth and mortality rates are on average equal. Fine tuning of the two independent processes suggests the existence of a regulating mechanism. Two types of such mechanisms exist. A decrease in the number of organisms can either speed up the growth rate or slow down the mortality rate. The former mechanism (chemostat-like) acts whenever the growth is limited by the concentration of a resource. The latter (turbidostat-like) could be suspected whenever the growth is limited by predators or parasites. Simulation experiments showed that under chemostat-like and turbidostat-like conditions, organisms are selected toward efficiency of growth (gms. of biomass produced/gms. of resource consumed) and rate of growth (gms. of biomass/time), respectively. The existence of two types of selection and the nature of parameters that are selected for, recall old idea of r K strategies. The main difference is that while the old model predicts the existence of r K continuum, this model shows that the two strategies are exclusive.

INTRODUCTION


Currently, r-strategists are considered those organisms that invest their reproductive effort into the production of a great number of offspring. Biological qualities of the offspring, reflected by the chance that individual will survive and reproduce, can be low. On the contrary, the K-strategists invest their reproductive effort into the production of fewer offspring with higher parental investment per capita. Consequently, the chance that an individual will survive and reproduce can be relatively high. The biological properties of r-strategists and K-strategists can also be characterized in concrete terms like body size, generation time, number of reproductive seasons during the lifespan (all lower in r-strategists), or by the effect of the strategy on the properties of the whole population. Populations of r-strategists fluctuate with time. Their size is usually lower than the maximal carrying capacity of the environment. Competition in such populations is low or nonexistent. The individuals are often eliminated from the population randomly, and there is only a low correlation between the biological qualities or the age of individuals and their actual probability of dying. The properties of populations of K-strategists are just the opposite.
**r**-strategy is often considered an adaptation for living in unstable or unpredictable environments, e.g., resource-rich ecosystems in the earlier stages of ecological succession. On the other hand, **K**-strategy is considered the optimal adaptation for living in stable or predictable environments, for old and crowded ecosystems in or near a climax stage.

The idea of **r-K** strategies was introduced by MacArthur. The names **K** and **r** have been derived from names of two parameters in the common form of the logistic equation

\[ \frac{dN}{dt} = rN(1 - N/K) \]

where **r** is the intrinsic growth rate of the population (under optimal conditions) and **K** is the carrying capacity of the environment (the size of population for which \( \frac{dN}{dt} = 0 \)).

The theory in its original formulation (MacArthur 1962), as well as its later development (MacArthur & Wilson 1967), suggests that the existence of two different strategies has something to do with the logistic equation-based model of population growth. As it has already been pointed out (Pianka 1972, Ginzburg 1992), this is not so. In the systems described by the logistic equation, both parameters **r** and **K** are simultaneously under pressure from natural selection. From the equation, it cannot be explained why two distinct ecological strategies, rather than a single mixed one, should exist. Moreover, the logistic equation represents a phenomenological (descriptive) rather than mechanistic model. It is a rearranged second-order polynomial \( \frac{dN}{dt} = aN - bN^2 \). This function fits a S-shaped growth curve usually obtained in experiments, but it does not deal with the actual mechanisms of growth and death in natural populations.

It can be concluded that despite the popularity of the **r-K** idea and despite the evident existence of two distinct ecological strategies, no theoretical model exists so far which could explain the **r-K** dichotomy phenomenon.

The present study attempts to show that the existence of two base types of selection, and consequently two base types of ecological strategies, can be explained by the existence of only two number-regulating mechanisms that can control the growth of a population. Because any population is subjected to one of these two mechanisms, it is also forced to adopt one of two exclusive life strategies.

**RESULTS**

**Model of two types of number-regulating mechanisms**

Despite the existence of temporal fluctuations, the long-term size of a population of different biological species is mostly stable. Such stability implies that natality and mortality rates in natural populations are essentially equal. Such fine tuning of two relatively independent processes in an unpredictable and fluctuating environment is not possible without a negative feedback loop-based number-regulating mechanism.

Basically, there are only two possibilities for the realization of such a mechanism. An increase (decrease) of population number must either induce a decrease (increase) in the natality rate or an increase (decrease) in the mortality rate. Regardless of the type of number-regulating mechanism, a size of the population exists, for which the natality and mortality rates are equal. Under normal conditions this equilibrium point is stable, i.e., after a disturbance the size of the population returns to its original value.

From ecological and evolutionary points of view there is an important difference between these two number-regulating mechanisms. It can be shown that the type of regulation mechanism determines which property of living systems actually contributes to their fitness, i.e., which is subjected to natural selection.

The mortality rate-regulation can be modeled in a laboratory turbidostat (a flow reactor). In this system for continuous cultivation of microorganisms, the population size is regulated by a negative feedback loop between population size (usually monitored by optical density of the
cultivation medium in a tank) and a rate of the pumping of medium through (and consequently a rate of the washing-out of the microorganisms from) the tank. The growth of microbes can be described by a differential equation

\[ \frac{dN}{dt} = N(r - D N) \]

where \( N, r \) and \( r \) are population size, time and growth rate (natality minus natural mortality per capita), respectively, \( D \) is a constant, a technical parameter of the turbidostat, which determines the rate of the pumping of the cultivation medium through the cultivation tank when population size is equal to one.

The second type of number-regulating mechanism operates in a chemostat. This system for continuous cultivation of microorganisms can be realized in any turbidostat by keeping the concentration of some growth factor in the inflow medium at very low limits. Under these conditions the growth of microorganisms and the dynamics of the concentration of the limiting component in the medium (limiting resource) can be described by:

\[ \frac{dN}{dt} = N \left( M(n, R/I) - D N \right) \]
\[ \frac{dS}{dt} = DNS - DNR - N \left( M(n, R/I) \right) \]

where \( R \) and \( S \) are concentrations of the resource in the cultivation tank and in the inflow medium, respectively, \( k \) is the growth efficiency (the number of individuals produced per unit of resource consumed), and \( I \) is the rate of input of resource into one organism under conditions when \( R = 1 \). The meanings of all other symbols are the same as in the previous model. This proposed model differs from common models of the chemostat (Tilman 1982) in two respects: First, the proposed model is universal, it can operate in the chemostat, as well as in the turbidostat mode. Second, the growth of organisms is described by a non-smooth function \( M(n, R/I) \), rather then by a Monod's function \( R/I(R + K) \) (in Monod's function (Monod 1950) the \( K \) is a half-saturation constant, the concentration of resource at which growth rate reaches half its maximal value). The Minimum function is preferred in the present model, because it better reflects the behavior of real organisms. When the concentration of a resource increases the Monod function only asymptotically approaches a theoretical maximal growth rate. For real organisms, however, the maximum growth rate exists, which can be reached under the condition of optimal resource concentration but cannot be exceeded, no matter any further increase in the resource concentration (Pecarinn, 1981).

In the proposed model four types of variables exist: 1) output variables \((N, R)\), 2) technical parameters of the device \((S, D)\), 3) elementary biological parameters of organisms \((r, k)\) and 4) composite parameter of the organisms \((I)\). In contrast to the elementary parameters \( r \) and \( k \), the composite parameter \( I \) cannot be a criterion of fitness. It represents either a physical constant reflecting the coefficient of diffusion of resource particles (Flega 1990), or the result of a physiological regulation that optimizes the rate and efficiency of growth for a current resource concentration (Shmol 1979).

**Competition in turbidostate and chemostatic systems**

To study the competition in the number-regulated populations one must simulate the dynamics of a system of two different species (A and B). Such systems can be described by

\[ \frac{dN_A}{dt} = N_A \left( M(n_A, R/I_k) - D (N_A + N_B) \right) \]
\[ \frac{dN_B}{dt} = N_B \left( M(n_B, R/I_k) - D (N_A + N_B) \right) \]
\[ \frac{dR}{dt} = D (N_A + N_B) S - (D N_A + N_B) R - N_A M(n_A/k_A, R/I) - N_B M(n_B/k_B, R/I) \]

One can analyze the competition of two species that differ in maximal growth rates as well as...
Fig 1. Simulation of the competition of two species, A and B under conditions of different concentrations of resource $J$ in the inflow medium. The simulation was performed using the Bionaval C program (Pozourek, 1992), with parameters: $D=0.00007$, $J=0.00001$, $r_a=0.1$, $r_b=0.15$, $k_a=30$, $k_b=20$, $N_A(0)=50$, $N_B(0)=50$ and $R(0)=300$. Concentration of the resource in the inflow medium ($S$) was 1000, 300 and 533 arbitrary units for Fig. 1a, 1b and 1c, respectively.
In efficiencies of growth it is illustrative to suppose that species A has a higher maximal growth rate and lower efficiency of growth than species B. The result of numeric simulation of competition under conditions of different resource concentrations in the inflow medium is shown in Fig. 1. Evidently three different situations could occur.

1) When the concentration of the resource is low, the growth of both populations is regulated by the chemostatic mechanism. The species with lower efficiency of growth (species A) is completely displaced after an initial period of growth.

2) When the concentration of the resource is sufficiently high, the opposite situation occurs. Both populations are regulated by the turbidostatic mechanism, which results in the displacement of the population with lower maximal growth rate (species B) after the initial period of growth.

3) A range of concentrations of the resource also exists for which the population of species A is regulated by the chemostatic mechanisms while the population of species B is regulated by the turbidostatic mechanism. A long-term coexistence of two populations is then possible. During the period of coexistence, species A is selected toward a higher efficiency of growth while species B toward a higher maximal growth rate. This selection could result either in the switching of the chemostatic regulation of population A to the turbidostatic, or in the switching of the turbidostatic regulation of population B to the chemostatic. After such an event, the second species is quickly displaced.

In summary, the chance of an organism as survival in interspecies competition is determined by two basic biological parameters (the maximal growth rate and the efficiency of the growth) and by the type of number-regulating mechanism in operation. It is also determined by the organism’s capacity to improve these parameters in response to natural selection.

DISCUSSION

Results of our simulation experiments showed that under chemostat-like cultivation conditions, growth efficiency was the critical factor in the fitness of an organism and also a subject of natural selection. Under the turbidostat-like conditions the critical factor was the maximal growth rate.

It seems that in biological systems, even in the laboratory ones, a broad spectrum of properties of the organisms plays an important role in interspecies and intraspecies competition. For example, mutants that can adhere to the walls of the cultivation tank or that can replace part of the resource with another component of the medium will displace their competitors. Such mutations could be considered an improvement of maximal growth rate and an improvement of efficiency of growth in the turbidostat and the chemostat, respectively. Consequently, they will be selected for under both turbidostat-like and chemostat-like conditions. When the same mutation can be interpreted as the improvement of growth rate or growth efficiency according to the type of number-regulating mechanism in operation, the practical meanings of discrimination between the two basic parameters of growth (rate and efficiency) might be questioned.

The reason for such discrimination is that a category of mutations exists for which the improvement of the growth rate can be achieved only at the expense of the growth efficiency (and vice versa). The destiny of these mutations is determined by the type of number-regulating mechanism in operation. The trade-off between efficiency and rate could be a very common phenomenon in biological systems (Shmoll 1979). It means that these mutations can be numerous and their destiny could determine the life strategy of organisms and the character of evolution of the population or of the species.

The present model describes an artificial system for the continual cultivation of microorganisms. The chemostat-like as well as turbidostat-like types of number-regulating mechanisms
operate also in natural ecosystems. The chemostat-like mechanisms operate whenever the growth of population is being limited by an availability of some resource (energy, substance, space). The turbidostat-like mechanisms must be suspected whenever the growth of population is being limited by the activities of predators or parasites.

Real populations are continuously under influence from many factors. Their growth is controlled by the availability of different resources and by the activities of different predators. Their growth should be described by a general expression.

\[ \frac{dN}{dt} = \alpha N^A, N^B, N^C, N^D \]

Here, more than one value of \( N \) can exist for which the \( dN/dt = 0 \). Some of these equilibrium points can be stable, some unstable. The population can move from one equilibrium point to another. At any moment, however, the population can be at only one equilibrium point. For any equilibrium point there are always principal components that are responsible for the return of the population size to the original value after a fluctuation, i.e., for the negative feedback loop. The character of these principal components determines what type of number-regulating mechanism is functioning at any particular equilibrium point.

When we look at the list of properties of \( r \)-strategists and \( K \)-strategists given in the introduction of this essay (Pranska 1978, Parry 1981), we can see that the properties typical for \( r \)-strategists are always more or less tightly connected with maximization of the growth rate, while for \( K \)-strategists with the maximization of the efficiency of growth. It is also evident that \( r \)-strategists are typical inhabitants of resource-rich ecosystems while \( K \)-strategists of crowded ecosystems, where the limitation by the unavailability of some resource can be observed or expected.

This suggests that the \( r \)-strategists and the \( K \)-strategists could in fact be the organisms living under the turbidostat-like and chemostat-like conditions, respectively. The \( r \)-strategists are being selected toward a higher \( r \) (toward maximal growth rate) which forces them to adopt the \( r \)-maximizing strategy. At the same time, the \( K \)-strategists are being selected toward a maximal efficiency of growth (maximal \( K \)) which forces them to adopt the \( K \)-maximizing strategy.

Three differences between \( r \)-\( K \) and \( r \)-\( k \) conceptions should be pointed out:

1) The \( r \)-\( K \) conception predicts that the maximal growth rate and the efficiency of growth are being maximized during evolution in turbidostat and chemostat, respectively.

According to \( r \)-K theory, parameters maximized are growth rate and carrying capacity of environment at the turbidostat and chemostat, respectively. From the results of simulation experiments it is evident, however, that the phenomenologically defined constant \( K \) (see the definition) is being maximized both in the turbidostat and chemostat.

2) Ecologists usually suppose that instead of distinct \( r \) or \( K \) selection, the \( r \)-\( K \) selection continuum normally exists (Pranska, 1978). Our results show that these two types of selection are not only distinct, but also exclusive. The \( r \)-\( K \) continuum, which can be observed in nature, can rather be interpreted as the result of an existence of evolutionary constraints. Nobody doubts that horses will never change into bacteria-like organisms, no matter how strong \( r \)-selection they are being exposed.

3) The \( r \)-\( K \) theory is based on empirical data only. There is no theoretical model that could explain the existence of these two types of selection. On the other hand, \( r \)-\( k \) conception, which explains the same empirical data, was deduced from a mechanistic model of population growth.

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BOOK REVIEW


The leading author is Clinical Professor of Medicine and Tropical Medicine at the University of California, San Francisco. Unfortunately, the second author deceased in 1984. The third author is Professor of Parasitology at the Oklahoma State University, Tulsa.

The previous editions of this book appeared in print in 1986, 1969, 1971, 1976, and in 1986. As indicated in the preface, the major changes in the present edition are a number of new life cycle drawings, additional illustrations for and rearrangements of the chapters on techniques, the addition of a number of new figures throughout the book, and a new chapter on the parasitic diseases associated with immune deficiencies. The volume is concluded with a comprehensive list of up-to-date references. Individual parasitic diseases are presented according to following scheme: morphology and biology of the causative agent, symptoms, pathogenesis, epidemiology, prevention, and treatment.

Chapter 1 contains the introduction to parasitology and basic information in the field. Chapter 2 provides insights into the phenomena of parasitism and host relations. Chapters 3-5 are concerned with protozoa parasites. Lumen- dwelling (intestinal) protozoa are represented by the dysentery amoebae and other species of the genus Entamoeba, including the commensals. Listed here are representatives of the opportunistic free-living genera Acanthamoeba and Naegleri. In contrast, the ciliates and apicomplexans, including the sporozoa, metazoa, cryptosporidia, and mactropoidea discuss bolus. Following chapters are dedicated to malarial plasmodia, leishmania, toxoplasma, and to other blood and tissue-dwelling (protozoan) protozoa.

Chapters 6-9 comprise helminths as endoparasites in humans. The nematodes are represented by the great intestinal fluke Fasciolopsis buski, by echinococcus, heterophyidae, by liver flukes, blood flukes (schistosomes), and by different species of lung flukes belonging to the genus Paragonimus. Uncommon trematode parasites as species of Alona and Nanophryus salmincola are also looked at here. The cestodes found in humans include the broad (filarial) tapeworm, the pork and beef tapeworms, the agents of schistosomiasis, and other tapeworms found in humans (genus Diphyllobothrium and Hymenolepis). Further on intestinal, blood, and tissue nematodes that cause visceral infections, helminthiasis, volvulosis, and gastrointestinal and genitourinary infections, and some uncommon tissue nematodes as Encephalitozoon spp. and Bayliscasparis procyonis are looked at.

Chapter 10 concentrates on arthropods and human disease. Recorded are the mite, the hair follicle mite, mites of nonhuman hosts that cause irritating dermatitis and allergy, human flea, fly larvae that cause myiasis, and cheng ho. Descriptions of parasitoses, arthropod and arthropod vectors follow.

Chapter 11 focuses on parasitic infections in immunocompromised hosts. Listed here are organisms of uncertain immunologic status (Plasmodium ovale, Plasmodium vivax), particular species of sarcosoma, ascarids, and mucosal spores (Encephalitozoon hellem, Enterocythozoon hellem), and particular species of helminths and arthropods. Chapter 12 summarizes signs and symptoms of parasitic disease, and chapter 13 discusses pseudoparasites and pitfalls.

Chapters 14-16 deal with procedures described for parasite identification and laboratory confirmation of parasitic infections: when discussing examination of stool specimens, examination of blood, other body fluids and tissues, symptom and urine, and immunodiagnostic methods. Given here are detailed prescriptions for fixatives and preservation solutions, stains and media for culturing protozoan parasites.

The text is extensively augmented by 259 figures composed of line drawings and photographs. They constitute individual life history stages of protozoan and helminthic parasites, arthropods of medical importance, biological cycles, electron micrographs, virosequences, pathological changes in organs and tissues, medical imaging.

(to be continued on p. 104)
Small mammals (Insectivora, Rodentia) in the city of Prague: distributional patterns

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Abstract Based on material consisting of 9765 specimens collected in 105 localities, we analyzed present distribution of 11 small mammal species in the territory of Prague. This material included original as well as literary data (published papers, unpublished final reports of inventory research in natural reserves, diploma theses, etc.) from the period 1960–1990. According to their distribution pattern, the species can be divided into following two groups: 1) Crocidura sylvestris, Apodemus sylvaticus, Mus musculus and Microtus arvalis are widely distributed in the whole territory, including the city centre. These species are able to penetrate through built-up areas. M. musculus is the only true commensal species inhabiting buildings throughout the year. C. sylvestris is an outdoor species with the exception of cold winter months in which part of its population is concentrated indoor. A. sylvaticus and M. arvalis are not directly associated with human settlements, although the former species was found as winter immigrant into buildings. A. sylvaticus colonized almost all parks and other green areas in the city and became the most abundant species. Urban populations of both C. sylvestris and A. sylvaticus may probably gain owing to the absence of their potential competitors. Microtus arvalis is dependent upon presence of grassy plots. 2) Other species could be arranged into following groups according to their decreasing ability to penetrate into the centre of the city: a) Sorex araneus, b) Clethrionomys glareolus, c) Apodemus flavicollis, d) Sorex minutus, Neremys fodiens and Microtus minutus. Absence of these species in suitable habitats in the parks and cemeteries surrounded by built-up areas should be attributed to island effects. Pitymys subterraneus is distributed in the southeastern part of the Prague territory only, because a local limit of its range in Central Bohemia passes just through Prague area.

INTRODUCTION

Animal populations living in large urban agglomerations may serve as proper model in ecological studies (Klausnitzer 1987).

So far, little attention was devoted there to small mammals other than rats and house mice.

In Europe, certain data on their distribution and ecology are available from, e.g., Manchester (Yalden 1980), Oxford (Dickman 1987), Duklan & Doncaster 1986), Leipzig (Klenke 1986), Berlin (Elvers & Elvers 1984), Warsaw (see below), Wroclaw (Chudoba et al. 1961), Košice (Mošnýk 1985), Piotava (Gavrilienko 1970), etc. Unfortunately, only few of these studies are based on numerous material. This fact was in most cases caused by frequent disturbance of traps by humans, forcing researchers to limit samples or to use alternative methods (Dickman 1986). The most comprehensive data were collected by Polish authors who systematically studied synurbanization processes in Apodemus agrarius in Warsaw (Andrzejewski et al. 1978, Babinska-Werka 1981, Babinska-Werka & Gabarczyk 1981, Babinska-Werka et al. 1979, 1981, Gabczynska et al. 1987, Glwicz 1980a,b, Gosczynski 1979, Sikorski 1982a,b).
There are also papers dealing with ecology of small mammals in urban agglomerations in Central Asia (Alimu-Aa: Stogov 1988), Japan (Takatsu 1976), and North America (Syracuse: VanDuffel & Rowe 1986).

In the Czech Republic the occurrence of small mammals has been studied in the towns: České Budějovice (Vlček 1979, Vlček & Kohn 1986), Brno (Pelšík et al. 1980, 1983) and Liberec (Horová 1987).

In Prague, the systematic study of small mammal fauna started in the 1970s. Several papers about occurrence of small mammals in some parts of Prague have been published (Hodková 1981, Hanžal 1982, Korblová 1985b, Anděravá 1987a,b, Vohralík & Reháková 1985, Frynta & Vohralík 1991), single records are to be found also in publications by Grundová (1962), Vlasák (1969) or in theses by Trpáč (1964) and Šmelíka (1969), but most of the data remained unpublished. Reviews of the then available knowledge were repeatedly given by Hanžal (1975, 1976, 1983, 1985).

Recently, attention was also paid to the reproduction and population structure in Crocidura suaveolens (Vohralík 1988) and Apodemus sylvaticus (Frynta 1992, 1993, Frynta & Vohralík 1992, 1994, Frynta & Žížková 1994).

The major aims of the present study are as follows:

1) Hitherto, a great number of records concerning the distribution of small mammals in the city of Prague have been accumulated. Despite their potential value, most of them remained just in field notebooks, some are available in unpublished theses or have been published in obscure journals. Therefore, we attempted to arrange all these scattered records into a single data set useful for further analysis.

2) A second aim is concerned with basic analysis of the distribution pattern in individual species. It is based on the evaluation of both the resulting distribution pattern and the situation in individual localities. This approach is suitable for solving the following topics: a) To classify the species according to their ability to penetrate into urban environment; b) To ascertain the species which have successfully colonised urban environment (indirect evidence for synurbanization processes); c) To disclose the cases in which the species in a locality isolated by built up areas is absent, in spite of the presence of an apparently suitable habitat (indirect evidence for island effects).

A quantitative analysis of presented data will be given later.

MATERIAL AND METHODS

We attempted to collect all the available records on the distribution of small mammals in the territory of Prague starting from the 1960s until the year 1990. Our attention was restricted to species which could be studied using snap-traps of common size (10 x 5 cm). Distribution of larger, fossorial and/or arboreal species as Arvicola terrestris, Talpa europaea, Ochotona, Muscardinus avellanarius, Rattus norvegicus, etc., will be elaborated separately.

Most of the records is based on material collected by the first two authors (D.F., V.V.) and their colleagues and students from the Department of Zoology, Charles University, Prague. Some of the records were published (Vohralík & Reháková 1985, Korblová 1985b, Vohralík, Frynta & Vohralík 1992) or are available in unpublished theses (Chloupek 1989, Fránek et al. 1989, Frynta 1982, Červenová 1989, Korblová 1985, Korblová 1989, Zemanová 1986).

These data were complemented by an extensive inventory research in Natural Reserves in 1986-1989, which was supported financially by the Prague Centre of State Conservation Care and Nature Protection and organized by the last author (J.R.). Results of this research are given in a series of unpublished reports (Anděřavá 1986, 1989, Anděravá 1987, Horáček & Horák 1988, Horáček et al. 1987, Hynková 1987, 1988, Janěcká 1988, Rezníček 1988, Šimček 1987, 1988a,b, Šimek & Malina 1987, Švecová 1988, Švecová 1988b, 1989). Faunistic records concerned with the period 1960-1990 contained in the literature were used also. Data obtained by raptor and/or owl pellet analysis were omitted because of the facts that the birds of prey are able freely cross the barriers of mammal migration and their foraging ranges can largely exceed the scale used in our mapping.
Altogether, we collected records of 9765 specimens belonging to 11 species (see below under Survey of the Material). Almost all this material, regardless of its origin, was collected using small trap-traps (10 x 5 cm) of various types for the Department of Zoology, Charles University, Prague. Only small, transplantable parts of mammals were collected in wooden live traps. These animals were immediately released or maintained in captivity. In several cases the findings of dead animals or nests records (in Mororcan nurseries only) were also included.

In a total, data on the distribution of small mammals in 105 localities were evaluated. These localities are distributed on the whole territory of the city of Prague (Fig. 1). In two localities (No. 4 Bohunice housing estate, No. 46 Rejzrovy sad), no animals were obtained in spite of trapping efforts exceeding 200 trap-nights.

Most of animals were captured in green areas, e.g. parks, gardens, woods, cemeteries, natural sites, etc. Some of these plots (parks or cemeteries) situated in the center of the city were almost completely surrounded by built up areas (localities Nos. 44, 46, 47, 49, 54, 88, 89, 91, 92, 94, 95). On the other hand, some other localities (woods, reserves) on the outskirts of Prague consisted of rather seminatural habitats (above all localities Nos. 1, 3, 10, 13, 15, 16, 17, 18, 23, 24, 25, 26, 28, 30, 32, 33, 34, 35, 38, 39, 46, 67, 70, 72, 89, 84, 90, 104) or predominantly (Nos. 6, 22, 27, 37, 54, 75, 85, 104) or partly (Nos. 5, 9) inside buildings.

In the distributional maps (Figs 2-12) we accepted even a single record as an evidence of presence of the species. Absence of the individual species was recorded in such localities only in which sufficient sample was available. As sufficient we considered samples either consisting of more than 75 specimens of small mammals (localities Nos. 5, 9, 12, 13, 15, 16, 18, 19, 23, 26, 28, 31, 32, 34, 35, 36, 38, 40, 47, 48, 54, 64, 65, 66, 70, 73, 78, 83, 84, 86, 88, 96, 98, 102, 105) or obtained using trapping effort of more than 1000 trap-nights (Nos. 3, 17, 44, 49, 94). Altogether, 48 localities were involved.

**Survey of the Material.**

In the following survey the individual specimens are arranged in their systematic order.

*Sorex araneus* Linnaeus, 1766


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Fig. 1 Map of Prague with survey of localities where small mammals were collected. For locality names see under "Survey of the material"

Soren minnus Linnaeus, 1766

Neomys fodiens  Pennant, 1771


Note: After finishing of the manuscript an additional record became available, that should not be omitted, i.e., 18. Satalická bukánice and Vranovský park, Sept 1992, (Chálek 1994)

Cricetinae: sauvolepis (Pallas, 1821)

Cicinnomys glareolus (Schreber, 1780)


*Micronus arvalis* (Pallas, 1779)

*Pitymys subterraneus* (de Selys-Longchamps, 1839)


*Apodemus sylvaticus* (Linnaeus, 1758)


Fig. 2. Distribution of *Sorex araneus* in Prague. Explanations: Dark rings - localities in which the species was recorded. Open rings - localities from which sufficient sample (sample containing of more than 75 small mammal specimens or that obtained after trapping effort exceeding 1000 trap nights) is available, but the species was not recorded.
Fig. 3. Distribution of Sorex in Prag. For explanation see Fig. 2.
Fig. 5. Distribution of Crocidura suaveolens in Prague. For explanation see Fig. 2.
Apodemus flavicollis (Melchior, 1836)


Fig. 6 Distribution of Clethrionomys glareolus in Prague. For explanation see Fig. 2.
Fig. 7. Distribution of Microtus arvalis in Prague. For explanation see Fig. 2.
Micromys minutus (Pallas, 1771)


Mus musculus Linnaeus, 1758

RESULTS AND DISCUSSION

Theoretical considerations

According to the theory of island biogeography (Mac Arthur & Wilson 1967, Simberloff 1976) the species richness should be usually lowered in islands. This phenomenon may be caused both by increased extinction rates in islands of small size and by decreased immigration rate caused by isolation. The smaller the island or the greater its distance from the mainland, the lower the number of animal species found there. This concept can be fruitfully applied also to parks isolated by built-up areas (Klauerter 1987).

In general, following major factors could limit considerably the small mammal distribution in the city:

1. Low immigration rate. Absence of the species should be expected in localities situated in the centre of the town or in those surrounded by compact built up areas.

2. High extinction rate. Absence of the species should be expected in localities of small size irrespective to their location. Owing to the fact that extinction rate is negatively correlated with population size, the lower the dominance of particular species the higher extinction rate could be expected.

3. Presence or absence of specific habitat required by specialized species. The species is absent in localities with lack of suitable habitat irrespective of their location.

Of course, the time factor, i.e., the duration of present situation and what preceded it, should be taken into account in every particular case.

All the above-discussed factors acting simultaneously are responsible for the distribution of urban population. There are apparent differences among individual species as well as towns. For example, pattern and size of an area (VanOort & Rowe 1986) and habitat type (Dickman 1987) were identified to be the most important factor affecting mammal species richness in Sydney, U.S.A. and in Oxford, respectively. Shelters were found to be the most important for A. agrarius in Warsaw (Babinska-Werka et al. 1979), etc.
Fig. 9. Distribution of *Apodemus sylvaticus* in Prague. For explanation see Fig. 2.

Comments to individual species

*Sorex araneus* (Fig. 2)

The Common shrew is present in almost all green areas (52 localities), with the exception of several localities in the centre of Prague (Nos. 49 Vítkov, 47 Strašnice - Židovské hřbitovy, 54 Botanical garden & Albertov, 44 Havlíčkův sad, 88 Petrín, 94 Letenské sady). Suitable habitats for populations of *S. araneus* are apparently in at least two of these localities (Strašnice - Židovské hřbitovy, Petrín). Absence of this species should be attributed to isolation of these localities by built-up or other unsuitable areas.

*Sorex minutus* (Fig. 3)

The Lesser shrew was found in 17 localities distributed on the outskirts of Prague only. Its occurrence is typical for certain seminatural habitats as woods and alluvial habitats along streams. However, its habitat requirements seem to be more specific than those of the previous species. In view of the fact that *S. minutus* was not found in Satalická Bažantnice and Vinořský park (locality No. 13) during an extensive research by Čítulová, who in 1987-1994 collected there 2549 small mammals (Čítulová 1989, 1994), the record of this species reported from there by Smrček (1988) seems to be problematic.
Neomys fodiens (Fig. 4)

Records of the Water shrew (16 localities) are confined to peripheral parts of Prague only, where it seems to be fairly common if suitable habitats along streams are available.

Crocidura suaveolens (Fig. 5)

The Lesser White-toothed shrew was found in 50 localities including several in the very centre of Prague. In the center, among localities from which sufficient material was available it was not found only in two (Nos. 44 and 54). On the other hand, absence of this species in samples obtained in larger forest complexes on the periphery of the city is a regular phenomenon, which is in accordance with the general ecological strategy of this species. In Central Europe, C. suaveolens prefers warm sunny habitats as shabby hales and slopes, vineyards, ruderal sites etc., or even buildings (Anděra & Šťánska 1984). In Prague, it seems to be an outdoor dweller, with the exception of cold winter months in which part of its population is concentrated indoor. C. suaveolens is the only shrew inhabiting isolated parks and other green areas in the centre of the city. Therefore, its urban populations may probably profit from the absence of their potential competitors.
Clethrionomys glareolus (Fig. 6)

The Bank vole was recorded in 39 localities situated exclusively on the Prague periphery. It was not found in any of ten localities in the central part of the city, from which sufficient sample were available. In at least four of them (Nos. 47, 49, 88, 96) there are extensive plots of habitats suitable for this species. Owing to the fact that C. glareolus is bound to the presence of trees and shrubs, its immigration through built up or open areas without vegetation cover is strongly limited. Moreover, the probability of stochastic extinction in isolated populations of small size is multiplied by periodical fluctuations in population size that are characteristic for this species. Having in mind these facts we can conclude that the present absence of C. glareolus in green areas of central Prague is most probably a result of island effects.

Microtus arvalis (Fig. 7)

The Common vole is confined to areas covered with grass and therefore it is not directly associated with human settlements. However, it was found in most of the Prague territory (48 localities) including some larger, but isolated, parks in the city centre. In contrast to the above vole, Clethrionomys glareolus, it is evident, that in Prague the Common vole possesses ability to penetrate through built up areas.
Pitymys subterraneus (Fig. 8)

The Pine vole occurs in southeast parts of Prague territory only. It was found in eight localities there. However, it has to be remarked here that in spite of the considerable effort, the species have not been found neither in areas adjacent in north and west to Prague (data by V. V.). Therefore, the unusual distribution pattern of P. subterraneus in Prague may be ascribed to a local fault of the range of this species.

Apodemus sylvaticus (Fig. 9)

The Wood mouse was recorded in 77 localities. It was present in all the samples of sufficient size. Although it is regular winter immigrant into buildings, the Wood mouse is a species not directly associated with human settlements. It has colonized almost all parks and other green areas in the city, becoming a dominant species in localities of this type (Frynta 1982). Urban populations of A. sylvaticus may probably gain owing to the absence of their potential competitor, A. flavicollis. Population structure and reproduction in A. sylvaticus along the urbanization gradient in Prague were described by Frynta (1992, 1993), Frynta & Voltračová (1992, 1994) and Frynta & Žižková (1994).

Successful colonization of urban habitats by this species is common in Europe. This phenomenon is not surprising in context of the fact that A. sylvaticus as species showing wide ecological valency is known from various habitats including the extreme ones (Bejček 1983, 1988).
was reported as a dominant species in parks and other green areas of a number of European cities, e.g. Manchester (Yalden 1980), Oxford (Dickman 1987, Dickman & Doncaster 1986), České Budějovice (Vlček 1979, Vlček & Kohn 1986) and Brno (Pelikán et al. 1980, 1983). However, this dominance occurs only in absence of A. agrarius. In towns within the distribution range of A. agrarius (Kračovský et al. 1976), this species occupies the niche of the dominant urban dweller and, therefore, the abundance of A. sylvaticus is much lower, probably as a result of their mutual competition. This pattern was reported from Berlin (Elvers & Elvers 1984), Leipzig (Krönke 1986), Warsaw (Andrzejewski et al. 1978, Babinska-Werka 1979), Wroclaw (Chudoba et al. 1961), Piotrow (Gavrilenco 1970), Liberec (Horová 1987), Kolín (Mošanský 1985). The only exception of this rule is the city of Alma-Ata, Kazakhstan, where Wood mouse is more abundant than A. agrarius (Stogov 1988). However, the taxonomic position of Wood mouse populations from this region, traditionally considered to be A. sylvaticus is doubtful (Mežičný & Zykov 1991).

Also in other parts of Palaeartic region, urban niche is occupied by related forms of Apodemus (Russian Far East: A. agrarius manchuricus, Kostenko 1984, Japan: A. speciosus, Takatsu 1976), or in North America by species of the genus Peromyscus (Syracuse: VanDruiff & Rowe 1986), which represent an ecological equivalent of Apodemus in America (Montgomery 1989).

*Apodemus flavicollis* (Fig. 10)

The Yellow-necked mouse was recorded in 26 localities. Its distribution, restricted to forest stands on the periphery of Prague, reminds to that of *C. glareolus*, however, it is distinctly more limited. The causes of its absence in some parks and forests are unclear. It can be attributed to island effects as well as to possible competition with *A. sylvaticus.*

**NOTE:** The discrimination between *A. sylvaticus* and *A. flavicollis* was made according to the hind foot length, coloration, and if necessary also according to the upper molar length. Due to relatively great size differences between these two species in Prague, it seems that only a small, unimportant fraction of animals should be determined erroneously.

*Microtus minutus* (Fig. 11)

Harvest mouse is the most rarely collected species. It was recorded from 8 localities only. We suppose this species to be actually more common, its limited presence in our material may be probably caused by its low trapability in the commonly used snap traps. According to available records, the species seems to be absent in central parts of the city.

*Mus musculus* (Fig. 12)

House mouse is the only true commensal species inhabiting buildings throughout the year. It was recorded from 40 localities distributed in the whole territory of Prague. Being restricted to human settlements, this species is lacking in numerous samples collected in natural habitats. Its occurrence in such places, far from any building, which was found in several cases should be attributed to capture of dispersing animals. In the Czech Republic, stable outdoor populations of the House mouse are reported from Southern Moravia only (Pelikán 1974).

**NOTE:** Regardless to the presence of contact zone between *Mus musculus* and *Mus domesticus,* most of the Czech territory is inhabited by the species *M. musculus.* According to phenotypic signs (coloration, tail length etc.), it is evident that the Prague population belongs also to this species. It is to be noted here, that mice derived from wild populations in Prague were repeatedly used in genetic research (Forejt & Iványi 1974, Forejt et al. 1988, Micková & Iványi 1976, 171
Dehmull et al. 1988, Reic et al. 1990, Forejt et al. 1991) and even introgressed strains were established (Pavlíková & Forejt 1987). All the above results obtained using biochemical and genetic methods confirm that Prague population belongs without doubts to M. musculus. On the other hand, occurrence of escaped laboratory mice found in at least two localities (No.5 Zoo Park, No.54 Botanical Garden & Albertov) may result in local introgression into wild population.

Concluding remarks

According to the pattern of their distribution in Prague, treated species can be divided into following two groups:

1) *Cricetulus sacculus*, *Apodemus Sylvaticus*, *Mus musculus* and *Microtus arvalis* are widely distributed in the whole Prague territory including the central part.

2) Other species could be sorted into following order according to their decreasing ability to penetrate to the centre of the city: a) *Sorex araneus*, b) *Clethrionomys glareolus*, c) *Apodemus flavicollis*, d) *Sorex minutus*, *Neomys fodiens* and *Micromys minutus*. The Pine vole, *Primys subterraneus* cannot be included into this evaluation, because as evident, a local limit of its distribution passes just through the Prague area.

While the presence or absence of species of the former category in a particular locality seems to be almost fully determined by the presence or absence of suitable habitats, it is apparently not the case in species of the latter category. In parks and cemeteries situated near the city centre they were frequently found to be absent even in places, which evidently were suitable from the point of view of their typical ecological requirements. Consequently, their absence in these localities surrounded by built up areas should be attributed to island effects. Among most conspicuous examples belong, e.g., the absence of both *Clethrionomys glareolus* and *Apodemus flavicollis* in the locality No 96 (Strumovka) as well as absence of *Sorex araneus*, *C. glareolus* and *A. flavicollis* in localities Nos 88 (Petřín) and 47 (Strážnice - Židovské hřbitovy).

However, it has to be remarked here that in many cases the possibility, that absence of the species is caused by habitat selection cannot be simply ruled out. It could be expected especially in species possessing more specific habitat requirements as are, e.g., *Neomys fodiens*, *Micromys minutus* and possibly also *Sorex minutus*.

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Composition and seasonal changes of soil nematode community in a Central European oak forest

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Soil nematodes, community composition, seasonal changes, oak forest, South Bohemia

Abstract. The structure and dynamics of soil nematode community were studied at 60-70 years old oak forest in South Bohemia in 1986-1987. A total of 104 species was found. Rhabditis marasmi group, Acrobeloides nanus and Filenchus minutus were the most abundant nematodes. The mean abundance of the total community was 1.27 x 10^6 ind m^-2, the mean biomass 1.59 g m^-2. Bacteriophages, mycoplastas and omniphages dominated in the abundance, omniphages and bacteriophages in the biomass.

Free-living and parasitic nematodes are an important group of invertebrates in terrestrial ecosystems. Soil nematodes in woodland sites reach abundance ranging from 2.55 to 29.800 x 10^6 ind m^-2 and biomass from 75 to 15.200 mg fw m^-2 (Sohlenius 1988). Majority of nematodes in forest ecosystems belongs to bacteriophagous animals, omniphagous and predaceous species have the greatest biomass (Waskowska 1979). Proportion of mycoplastas and phytophagous nematodes to the total nematode abundance is variable.

Ecological studies on nematodes in forest ecosystems often deal with functional (trophic) groups of nematodes and interactions between genera or species with respect to their life strategies were paid less attention. The aim of this study was to analyse composition and seasonal changes of a nematode community in a Central European oak forest with a view to particular species and genera and their biology.

MATERIAL AND METHODS

Investigations were carried out in an oak forest (60-70 years old) in South Bohemia near Netolice village, 49°04'N, 14°11'E, 486 m a.s.l., square code 6051 in the network of squares on the map of the Czech Republic for faunistic research. Long-term mean annual air temperature in the region is 7.3°C, precipitation 602 mm. The seasonal changes of air temperature and precipitation in 1986-1987 are given in Fig.1. The dominant tree was Quercus robur L., accompanied by sparse Tilia cordata Mill., Fraxinus excelsior L., Picea abies (L.) Karst., Acer pseudoplatanus L. and Fagus sylvatica L. The constant species in the undergrowth were Oxalis acetosella L., Sativica europaea L., Viola reichenbachiana Jord., Veronica chamaedrys L. Soil type is a light loam cambisol, 10.2% clay (pHc), 40.0% sand (10-250 µ, wet wt.), The values of pHH2O (soil:H2O = 1:5) in litter, humus layer, and B-horizon were 5.4, 5.2, and 4.9, respectively. Mean organic carbon (Corg) content was about 5% in 0-5 cm and 2% in 5-10 cm.

Soil samples were taken in approximately monthly intervals in January-December 1986 and in April-December 1987 using a cylindrical corer with an area of 1 cm^2 (inner diameter 1.2 cm) in 10 replicates to the depth of 10 cm. Soil samples were divided into 0-5 cm and 5-10 cm subsamples. Nematodes were isolated from the soil by means of the modified Baermann funnel method for 24 hrs. Animals were fixed by hot FAA, temporary and
Table 1: Mean abundance (x10^4 ind m⁻²) of soil nematodes in oak forest, bold - cecoton species (C50-100%)

<table>
<thead>
<tr>
<th>Order</th>
<th>Species</th>
<th>1986</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONHYSTERIDA</td>
<td><em>Eunonchyla vulgaris</em> (de Man, 1880)</td>
<td>5.8</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td><em>Eumonchylids</em> sp., <em>E. florincola</em></td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>Geomonhystera vulgaris</em> (Buchholz, 1873)</td>
<td>6.1</td>
<td>0.4</td>
</tr>
<tr>
<td>ARAEOLOMIDA</td>
<td><em>Cylindrolaimus bambus</em> Andrássy, 1908</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td><em>Anguillimicrorhabditis</em> (Buchholz, 1885)</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>Plectus acuminatus</em> Bastian, 1865</td>
<td>36.1</td>
<td>123.3</td>
</tr>
<tr>
<td></td>
<td><em>Plectus crassipes</em> Bastian, 1865</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>Plectus decipiens</em> Andrássy, 1908</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td><em>Plectus geophila</em> de Man, 1889</td>
<td>1.0</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td><em>Plectus loesi</em> Dittmar, 1873</td>
<td>17.0</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td><em>Plectus paras</em>* Bastian, 1865</td>
<td>14.0</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td><em>Plectus rigidus</em> de Man, 1889</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><em>Plectus nanulus</em> Maleczek, 1915</td>
<td>2.5</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td><em>Plectus nitidus</em> Andrássy, 1908</td>
<td>36.8</td>
<td>142.9</td>
</tr>
<tr>
<td></td>
<td><em>Plectus sieboldii</em> Muir &amp; Coomans, 1978</td>
<td>1.3</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>*Plectus Bastian, 1865 sp 1</td>
<td>1.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>*Plectus Bastian, 1865 sp 2</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><em>Ceratopharyngidae</em> (Truskova, 1976)</td>
<td>0.1</td>
<td>0.1</td>
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<tr>
<td></td>
<td><em>Ceratopharyngidae</em> (Buchholz, 1873)</td>
<td>10.0</td>
<td>0.4</td>
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<tr>
<td></td>
<td><em>Veronicellina</em> sp.<em>de Man, 1889</em></td>
<td>5.5</td>
<td>-</td>
</tr>
<tr>
<td>TTRATOCEPHALIDA</td>
<td><em>Mesodiaryphaloides crassipes</em> (de Man, 1880)</td>
<td>3.1</td>
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</tr>
<tr>
<td></td>
<td><em>Teratocephaloides costatus</em> Andrássy, 1908</td>
<td>-</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td><em>Teratocephaloides linearis</em> Anderson, 1969</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td><em>Teratocephaloides paraherakia</em> Ersévenko, 1973</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td><em>Teratocephaloides terminus</em> Andrássy, 1958</td>
<td>0.2</td>
<td>-</td>
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<tr>
<td></td>
<td><em>Teratocephaloides terrestris</em> (Buchholz, 1873)</td>
<td>0.9</td>
<td>1.6</td>
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<tr>
<td>RHADITIDA</td>
<td><em>Heterocephalobus elongatus</em> (de Man, 1880)</td>
<td>21.6</td>
<td>28.1</td>
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<td></td>
<td><em>Heterocephalobus londi</em> Andrássy, 1908</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><em>Cephalobus perigynus</em> Bastian, 1865</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td><em>Cephalobus troglobus</em> Andrássy, 1967</td>
<td>0.2</td>
<td>24.8</td>
</tr>
<tr>
<td></td>
<td><em>Eucytheridus ovata</em> (de Man, 1876)</td>
<td>0.7</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td><em>Enchytrans stramine</em> (Buchholz, 1865)</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><em>Acrobeloides nanus</em> (de Man, 1889)</td>
<td>7.2</td>
<td>75.8</td>
</tr>
<tr>
<td></td>
<td><em>Acrobeloides</em> (Cobb, 1924) sp</td>
<td>2.1</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td><em>Cerielloides</em> Thorson, 1937 sp</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>Chilopiace</em> Theyme, 1937 sp</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>Panagrellus rugosus</em> (Stenner, 1866)</td>
<td>5.6</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td><em>Bursaphelenchus</em> (Buchholz, 1873)</td>
<td>6.9</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td><em>Rhodoctena maupasi</em> Seurat in Maupas, 1919</td>
<td>125.1</td>
<td>353.9</td>
</tr>
<tr>
<td></td>
<td><em>Bursaphelenchus</em> vivus* Theyme, 1905</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td><em>Bursaphelenchus</em> vivus* Theyme, 1905</td>
<td>4.6</td>
<td>67.0</td>
</tr>
</tbody>
</table>
order DIPLOGASTERIDA
43 *Diplogaster* Schultze in Carus, 1857 sp.

order APHELENCHIDA
44 *Aphelegaster* avaculis Bastian, 1885 0.5 -
45 *Paraplelegaster pseudoparvulus* (Mecolesky, 1922) - 0.1
46 *Aphelechacides zaprophilus* Frankhu, 1957 24.7 68
47 *Aphelechacides subparvulus* Sanwal, 1961 16.3 42.6
48 *Aphelechacides punius* (Thorne, 1929)
49 *Aphelechacides Fischer, 1894 sp -
50 *Aphelechacides maculatus* Meyl, 1953 9.4 7.5

order TYLECHIDA
51 *Filenchus decipiens* (Andrassy, 1954) 19.8 11.0
52 *Filenchus helaeae* (Szegyegi, 1969) 30.3 19.2
53 *Filenchus minutus* (Coch, 1893) 53.9 75.4
54 *Filenchus polyplatus* (Steiner et Albin, 1946) 0.7 0.9
55 *Filenchus* (Andrassy, 1954) sp 8.8 3.4
56 *Agienchus agricola* (de Man, 1884) 0.1 -
57 *Caelenchus costatus* (de Man, 1921) 1.7 -
58 *Malenchus acutus* Andrassy, 1968 1.8 -
59 *Melenchus bryophilus* (Steiner, 1914) 1.8 21.1
60 *Leenchus leptotoma* (de Man, 1880) - 3.5
61 *Cephalenchus megacephalus* Goodin, 1962 2.8 1.1
62 *Biplechus dubius* (Butschl, 1873) 0.2 -
63 *Helocenchus pseudolabis* (Steiner, 1914) 1.1 -
64 *Royleenchus fischeri* Saw, 1965 0.3 -
65 *Pratylenchus rematus* Loof, 1960 0.1 -
66 *Paraplenchus projectus* Jenkins, 1956 0.2 -
67 *Noneschus nematolaimos* (Taylor, 1936) 2.3 -
68 *Drylenchus* (Falgey, 1936) sp 1 32.8 108.5
69 *Drylenchus* (Falgey, 1936) sp 2 0.1 -

order ENOPLIDA
70 *Bastina coccidea* de Man, 1876 0.9 2.2
71 *Phomodelias delachus* de Man, 1980 1.0 -
72 *Prunodelias intermedius* (Butschl, 1873) 14.9 9.1
73 *Tryonella affine* de Man, 1980 0.1 -
74 *Lopeda filicata* de Man, 1880 1.9 3.1
75 *Alamus molyt Andrassy, 1961 -
76 *Alamus parvus* Thorne, 1939 6.8 4.7
77 *Alamus primitiva* de Man, 1880 -
78 *Alamus de Man, 1880 sp -
79 *Paraplechus delaconis* (de Man, 1876) 0.2 -
80 *Amphidolias pseudolobanianus* Alten, 1953 - 0.1

order MONONCHIDA
81 *Clarkenchus papillatus* (Bastian, 1865) 9.2 10.1
82 *Conchasparus* (de Man, 1880) 0.9 -
83 *Protomichilus punctatus* (Cobb, 1917) 24.7 22.1

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permanent mounts were made by the glycerol-ethanol method (Šály 1983). All nematodes in samples were counted and identified simultaneously.

The biomass was estimated for 50 adult specimens of each species (excluding those with low abundance) according to Andrási (1956). The biomass of juveniles was calculated as a half of the adult value (Šály 1973).

Diversity was evaluated using the number of species and the index of species diversity $H'$ (Shannon) according to Shannon & Weaver (1949). Species having their constancy C50-100% represented the characteristic species combination of community. Nematodes were divided into trophic (ecological) groups as follows: bacteriophages, mycrophages, phytophages, omnivores, predators, total nematodes, and others.

Table 2. Mean characteristics of soil nematode community in oak forest, A - abundance ($10^5 ind. m^{-2}$), B - biomass (mg m$^{-2}$), $H'$ - index of diversity, CL - confidence limits ($P=0.05$)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bacteriophages</td>
<td>467</td>
<td>234</td>
<td>950</td>
<td>714</td>
</tr>
<tr>
<td>Mycrophages</td>
<td>288</td>
<td>17</td>
<td>301</td>
<td>19</td>
</tr>
<tr>
<td>Phytophages</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>+</td>
</tr>
<tr>
<td>Omnivores</td>
<td>221</td>
<td>1195</td>
<td>227</td>
<td>787</td>
</tr>
<tr>
<td>Predators</td>
<td>37</td>
<td>123</td>
<td>36</td>
<td>97</td>
</tr>
<tr>
<td>total nematodes</td>
<td>1023</td>
<td>1571</td>
<td>1515</td>
<td>1617</td>
</tr>
<tr>
<td>CL</td>
<td>4410</td>
<td>4500</td>
<td>4500</td>
<td>±590</td>
</tr>
<tr>
<td>% of adults</td>
<td>28.2</td>
<td>22.6</td>
<td>±10</td>
<td>±20</td>
</tr>
<tr>
<td>number of species</td>
<td>92</td>
<td>76</td>
<td>±10</td>
<td>±15</td>
</tr>
<tr>
<td>$H'$</td>
<td>3.39</td>
<td>2.96</td>
<td>±0.5</td>
<td>±0.5</td>
</tr>
</tbody>
</table>
(species 1-43, 70-72, 75-80 in Tab.1), mycophages (i.e. fungal + facultative plant feeders) (44-55, 58-60, 68, 69), phytophages (56, 57, 61-67), omnivores (87-104), predators (73, 74, 81-86). Pearson correlation coefficients ($r_p$) were calculated between the nematode abundance and soil moisture or temperature, Spearman rank correlation coefficients ($r_s$) were calculated between the abundance and air temperature or precipitation. Dendrograms were produced for genera presence (Euclidean similarity) and for log($x$+1) genus abundance (cosometric similarity) by Euclidean distance and Ward's clustering algorithm, program CLUSTAN (Wishart 1981). The total material studied was about 22,000 individuals. Nematode material is deposited with the author in the Institute of Soil Biology AS CR.

![Graph image](image)

**Fig. 1.** Seasonal changes of air temperature and precipitation.

**RESULTS**

A total of 104 species of nematodes were found in the soil of the oak forest. Three species, *Rhabditis maupasi*, *Acrrobolodes nana* and *Filenchus minutus*, dominated in both years. *Aporcelaimelus obscurus* and *Melencchus bryophilus* + *octarayensis* were dominant in 1986, while *Plectus acuminatus*, *Plectus silvicola*, *Ditylenchus* spp. and *Mezodorylaimus basilini* dominated in 1987. There were 15 species in the characteristic species combination of the community in 1986 and 16 species in 1987 (Tab.1). The highest biomass was established for the species
A. obscurus, Eudorylaenus cortesi, P. silticicus, P. uncinatus, Prionchulus punctatus and M. bastioni. The mean value of the index of species diversity H' was higher in 1986 (3.39) than in 1987 (2.96).

The mean abundance of nematode community in 1986 and in 1987 was 1.02 ± 0.41 x 10^6 ind. m^-2 and 1.52 ± 0.64 x 10^6 ind. m^-2, respectively (Tab.2). In both years, the peak of abundance (0-10 cm) was found in August. High population densities of nematodes were also observed in January 1986 and in November 1986. In 1987, the highest abundance was found in April (Fig.2). In the soil layer of 5-10 cm, the seasonal changes of nematode abundance showed two peaks in

![Graph showing seasonal changes of abundance and biomass of nematodes.](image)

Fig. 2. Seasonal changes of abundance (white bars) and biomass (black bars) of nematodes. Upper part of the white bars is the abundance in the soil layer of 0-5 cm, under part in the layer of 5-10 cm. Absissa – confidence limits (P = 0.05).

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both years (Fig.2). The abundance in this soil layer depended upon air temperature in the period June - December ($r_s 1986 = +0.89, n=7; r_s 1987 = +0.66, n=6$). The seasonal changes of abundance in the soil layer of 0-5 cm in 1987 was correlated with the soil moisture ($r_p = +0.70, n=8$).

The majority of nematodes preferred the upper parts of the soil horizon including leaf litter. In 1986 and 1987, 73.8% and 86.0% of nematode specimens were found in the layer of 0-5 cm, respectively.

The mean biomass of nematodes in 1986 and in 1987 was $1.57 \pm 0.45$ g.m$^{-2}$ and $1.62 \pm 0.59$ g.m$^{-2}$, respectively. In the first year the peaks of biomass coincided with the peaks of abundance,

Fig. 3. Seasonal changes of abundance of ecological groups in nematode community.
A. bacteriophages - solid line, mycophages - broken line, phytophages - dotted line
B. omnivores - solid line, predators - broken line.
in the second year, conspicuous maximum of biomass was observed in April (Fig. 2). The mean individual biomass of nematode specimen was significantly lower in 1987 (1.15 ± 0.19 µg) than in 1986 (1.70 ± 0.24 µg). The mean specimen biomass did not decrease under 1 µg in 1986, but in August 1987 it was only 0.60 µg. This decline probably reflected generally lower biomass of nematode specimen in 1987 compared with its value in 1986; a high abundance of nematodes in 1987 was caused by the population increase of smaller species and juveniles. The adult specimens represented 28% (21% - 38%) of nematode community in 1986 and 23% (13% - 28%) in 1987.

Three ecological groups dominated in 1986 and in 1987: bacteriophages (46% and 63% of the total abundance, respectively), mycophages (28% and 20%) and omnivores (21% and 15%). Omnivores represented 76% of nematode biomass in 1986 and 49% in 1987. The biomass of bacteriophages was 15% in 1986 and 44% in 1987 (Tab. 2). Seasonal changes of nematode trophic groups are shown in Fig. 3. Fluctuations in abundance of bacteriophagous
nematodes were similar to those of the total nematode community in both years. Three peaks of mycorrhizal nematodes was found in 1986, one peak in 1987. High population densities of mycorrhizal nematodes appeared in January, August and November 1986, but in 1987 abundance of omniphages fluctuated and no distinct maxima or minima were observed.

Three bacteriophagous genera were dominant in 1986 and 1987 as follows: *Plectus* (12% and 21% of the total nematode abundance), *Acrobelaides* (7% and 5%), and *Rhadinus Dujardin*, 1845 (12% and 23%, respectively). The genus *Plectus* had three peaks of abundance in 1986 (January, August, November-December), but in 1987 its abundance decreased from April to December. Similar changes were observed in the abundance of the genus *Rhadinus*. The abundance peaks of the genus *Acrobelaides* was found in August in both years and in January 1986.

Among mycorrhizal genera, the genus *Filenchus* was dominant in both years 1986 and 1987 (11% and 7% of the total nematode abundance, respectively). The genus *Maenischius Andrassy*, 1968 dominated (9%) in 1986, and the genus *Dylenties* (7%) in 1986. The highest abundance of the genus *Filenchus* was in January 1986 and in August (both years). The genus *Maenischius* reached the maximum abundance in January 1986, the genus *Dylenties* in April 1987, and the genus *Apheinichoschides* in August 1987.

Omniphagous genera *Aporcelaimellus Heyns*, 1965 and *Eudorylaimus* dominated in 1986 (7% and 6% of the total nematode abundance, respectively). The genus *Mesodorylaimus Andrassy*, 1959 was dominant in 1987 (6%).

**DISCUSSION**

The nematode community in the oak forest studied was characterized by a high number of species. For example, Soloyevyva (1986) found 43 - 118 species of nematodes in oak (or mixed oak) forests in the European part of the former USSR, Arpin (1975) determined 22 species in France, and Basins (1962) and Volz (1951) gave data concerning 75 and 50 species in oak forests in Germany. Bartovisov & Hamel (1994) determined 98 species in an oak-hornbeam wood in Central Bohemia. Relatively low number of nematode species (50) in the oak-hornbeam forest was found by Savy (1973, 1975) in Slovakia.

The abundance of nematodes in oak-dominated forests usually varies from 1 to 5 million individuals per m² (Arpin 1975, Arpin & Pouge 1986, Soloyevyva 1986), and the mean abundance in the oak forest studied is in accordance with those data. Very high abundance (29.8 x 10⁶ ind/m²) in an oak-ash forest in Germany was found by Volz (1951). The data on nematode biomass in oak forests are scarce. Savy (1975) give values from 3.95 to 13.45 g/m². Volz (1951) found 15.2 g/m². Comparing available information, the biomass of nematodes in the oak forest studied was relatively low.

The seasonal changes of nematode abundance in forests are often characterized by two peaks (e.g., Savy 1980). The seasonal curve of abundance changes in the oak forest studied can be divided into two periods. In the first period (May-October) there was the peak of abundance in August in both years. The second period (November-April) was marked by nematode population maxima in January 1986 or in April 1987. An explanation of these changes can be given as follows. In relatively mild winter (January 1986; sufficient precipitation and accumulation of leaf litter in autumn 1985), certain nematode populations (*Plectus*, *Rhadinus*, *Acrobelaides*, *Apheinichoschides*, *Filenchus*, *Maenischius*) reached their peaks in early winter. If low temperature occurred (January 1987), the development of nematodes was probably retarded and nematodes (mainly *Plectus* and *Rhadinus*) realized their population maxima in early spring. The abundance peak in August was limited neither moisture nor temperature. Consequently, the seasonal changes of nematode community in the forest studied can be viewed in terms of "two-peak seasonal dynamics", but with a time-changeable increase of nematode abundance in the cold period of the
year, in lower altitudes the development of nematode population in oak forests can be limited by water shortage during summer (Bartošová & Hášel 1994).

The genera *Plectus*, *Rhabditis* and *Acrobeloides* were most important bacterivorous nematodes, but these taxa differ in their life-history strategies. The generation time of the species in the family Rhabditidae is a few days at room temperature (Sohlenius 1968). Cephalobidae develop from egg to egg in 1-2 weeks (Sohlenius 1973), and the species of the family Plectidae complete their life cycle in more than 2 weeks (Oversvaag Nielsen 1949, Yeates 1972, Maggenti 1961). Rhabditidae (all species are hermaphroditic) survive unfavourable life conditions in the stage of non-feeding but motile "dancer larvae" (Golden & Riddle 1984), Plectidae (mostly parthenogenetic females) probably in eggs protected by cuticle with spines. The response of *Rhabditis* to an increase in bacterial populations consists in recovery from dancer larva stage, that of *Plectus* probably in egg-hatching. The ubiquitous genus *Acrobeloides* has short generation time and is parthenogenetic.

The second most abundant group of nematodes were mycoprophages (or myco-phytophages). The abundance of the genus *Aphelenchoidea* was relatively low although this genus was abundant in oak forests in Germany (Bassus 1962). Many species of the genus *Aphelenchoidea* feed upon mycorrhizal fungi (Riffie 1970) and they can complete their life cycle in a few days. The mycoprophagous genus *Aphelenchus* Bastian, 1865 was almost absent at the stand in the present study whereas it was dominant in an oak-hornbeam forest in Slovakia (Sály 1973).

The species of the family Tylenchidae are abundant in oak forests, however, their feeding habits are insufficiently known (Yeates et al. 1993) in their comprehensive study on nematode food preferences considered Tylenchidae to be mainly plant feeders. On the other hand, Wood (1973) cultivated *Tylenchus* Bastian, 1865 spp. on fungi and Magnussen (1983) observed and documented feeding *Tylenchus* and *Malenchus* upon mycorrhizal fungi. The abundance of plant feeding Tylenchidae species (e.g., *Aphelenchus agricola*, *Cephalobus costatus*, *Cephalobus megacephalus*) was very low (Tab. 1), whereas the species of the genera *Malenchus* and *Malenchus* belonged to dominant nematodes. Very likely, the majority of nematodes in the family Tylenchidae fed on fungi. Parasites on higher plants (Dolichogenidae, Hoplolaimidae, Pratylenchidae, Paratylenchidae and Caonematidae) represented negligible part of nematodes populations in the forest studied. Low population densities of mycoparasites was also found in an oak-hornbeam wood in Central Bohemia (Bartošová & Hášel 1994). In contrast to our data, Sály (1973) found great population densities of mycoparasites in an hornbeam-oak forest in Slovakia (Arpa & Ponge 1986) in Quercus petraea and Quercus sessiliflora woods in France.

Some nematodes in the order Dorylaimida (comphagous in this study) can be mycophagous, too. The species of the genus *Dolichoenchis* de Man, 1876 were cultivated on fungi (Wood 1973, Magnussen 1983). According to Yeates (1973) the genus *Aporcelaimella* can feed upon autotrophous microflora. The genus *Mesodorylaimus* could also be mycophagous as it occurred in high densities in leaf litter of the forest studied. The species of order Dorylaimida are K-strategists or persisters (Bongers 1990) while mycophagous nematodes in the orders *Aphelenchida* and *Tylenchida* belong to r- or r/K strategists (or colonisers with C/P value about 2). It is evident that fungi and bacteria in the forest studied could be controlled by nematodes with different ways of life. As in populations of bacterivorous nematodes competition between mycophagous species for food can be expected, however, there is little information on their interactions in field conditions.

Sohlenius (1985) studied influence of climatic conditions on nematode coexistence in coniferous forest soil (Central Sweden) in laboratory experiment and found that the competitive ability of the different species changes with moisture and temperature. Some genera (*Rhabditis* *Aphelenchoidea*) increased their population densities at low 2-5°C temperatures. Many species
are adapted to low temperatures, for example the nematodes of the family Plectidae are abundant in polar regions (Proctor 1984). In the oak forest studied, great population densities of the genera Plectus, Acrobeles, Robditus, Aphelechidaes, Filenchus and Malenchus were found in winter as well as in summer.

Precipitation, soil moisture and temperature were probably important factors influencing nematode community development, however the seasonal changes of abundance cannot be explained by soil microclimate only. The summer abundance peaks were found in August, nevertheless, high precipitation and air temperature above 10°C were in May, June and July, too. Nematode "peak assemblages" in summer (August 1986 and 1987) were similar to those in winter (January 1987) and in spring (April 1987) (Fig. 4A). High abundance of microbivorous nematodes indicated that development of soil and litter microflora could trigger off the development of eggs or dauer stages of many species. Activity of plant roots probably influenced soil microflora and indirectly the populations of various nematodes. Carnivorous mononchid nematodes, predacious microarthropods, tardigrades and nematophagous fungi can also significantly influence population densities of microbivorous species (Small 1987, Karg 1983, Norstream 1984). Very likely, seasonal changes in population densities of nematode species in the oak forest studied resulted from biological interactions in soil and, to a less extent, from moisture-temperature fluctuations.

SUMMARY

1. The species composition of the trophic structure and seasonal changes of soil nematode community were studied at 60-70 year old oak forest in South Bohemia in 1986-1987.
2. A total of 104 species were found, Rhoditus managis group, Acrobeles nasus, Jlenchus minutus were dominant nematodes in both years. Aporcelaimellus obscures and Malenchus hyophilis and acurvesens dominated in 1986 while Plectus acuminatus, Plectus silvanus, Diytenuis spp and Mesodorylaimus castanicolor in 1987.
3. The mean nematode abundance was 1.27 x 10⁶ ind m⁻², the proportion of adult specimens was about 25%. Seasonal changes of nematode community was marked by two population maxima. The abundance peak in August was found in both years, other peaks were observed in January 1986 and in April 1987. The mean biomass of nematode community was 1.59 g m⁻².
4. Bacteriophages were the most abundant trophic group of nematodes followed by mycophages and omnophages. The abundance of parasites on higher plants was very low.

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Scaphiostena gen. n. and descriptions of two new species of the family Mordelliidae from Oriental region (Coleoptera: Mordelliidae)

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Taxonomy. Ophthaimocnala stradi sp. n., Scaphiostena schwendingeri gen. n. and sp. n., key, Oriental region

Abstract. New monotypic Oriental genus Scaphiostena gen. n. with type species Scaphiostena schwendingeri sp. n. as well as Ophthaimocnala stradi sp. n. from Thailand are described

INTRODUCTION

In the present paper the description of a new genus and species Scaphiostena schwendingeri gen. n. and sp. n. are given. This species with remarkable morphology was collected by a Swiss entomologist, Mr P. Schwendinger, into pitfall traps in the extreme climatic conditions of cold, rainy and misty mountain forests of Don Inthanon in northern Thailand. The other species described below belongs to the genus Ophthaimocnala Ernsch hitherto known as a monotypic genus from tropical Africa. The discovery of the second species from Oriental region is therefore very important.

Ophthaimocnala stradi sp. n.

Completely red-brown. Pubescence golden-brown with silvery reflection on elytra. Body rather convex and parallel sided with short and broadly conical pygidium (Fig. 1).

Head broadly convex, rather large, only slightly narrower than pronotum, prolonged anteriorly. Width length ratio as 6:8:5.6. Eyes very large, pubescent, almost round, corrugated near insertions of antennae, particular facets medium sized. Gales rather short, yellow-brown, on the tip with corose outgrowths which form a very blunt point. Maxillary palps with segments 2 and 3 of equal width, terminal segment elongate subelliptic, inner angle situated at its middle length. (Fig. 2). Antennae rather long, with four basal segments equally broad, segment 1 by one third longer than 2, segment 3 only slightly shorter than 2 and equal to 4; segment 5 somewhat wider and by two thirds longer than 4, segments from the fifth one onwards becoming gradually narrower and 13 times (segment 5) to 17 times (segment 10) longer than wide, terminal segment oblong oval, 2.5 times longer than wide and by one fourth longer than the penultimate (Fig. 3).

Pronotum flatly convex, much wider than long (width length ratio as 8:2:5:5), with only moderate collar-like projection anteriorly. Posterior lobe little vaulted. Sides in lateral view lightly emarginate, posterior angles moderately obtuse, rounded. Surface of pronotum finely and densely punctate.
Figs 1-9. *Ophthalmoconala arnaldi* sp. n. (holotype, male): 1 - general view; 2 - maxillary palpus; 3 - antenna; 4 - anterior tibia and tarsus; 5 - hind tibia and tarsus; 6 - left and right paramere; 7 - phallobase; 8 - penis; 9 - 8th internal sternite. Scale: a - 6, b - 2, c - 1, d - 7, e - 4, f - 6, g - 9.

Scutellum small, broadly triangular.

Elytra convex, in anterior half parallel-sided, twice as long as their combined width, with dense and rather coarse rasp-like punctures.

Pygidium broadly conical, a little more than twice as long as hypopygium, and reaching only one fourth of the length of elytra.

Anterior tibiae quite straight, without a calf-like swelling and longer hairs. Anterior tarsus distinctly shorter than tibia, segment 4 deeply emarginate, by half shorter than the terminal segment, with onychium on its central side (Fig. 4). Mesotibia distinctly longer than tarsus.
Metanha (Fig. 5) with one very oblique and long apical ridge (running from apical margin to the two thirds of the tibia length) and one distinct dorsal ridge. The first segment of posterior tarsus with two oblique ridges, following segments without ridges. Outer terminal spur reaching one third of the length of inner one.

Male genitalia as figured (Figs 6, 7, 8).

Length from the tips of mandibles to that of elytra 4.4 mm, to the tip of pygidium 5.2 mm.


NAME DERIVATION. The new species is dedicated to my friend Jan Strnad, Prague.

DIFFERENTIAL DIAGNOSIS. Ophthalmoconala strinadi sp. n. is the second species of a hitherto monotypic genus, proposed originally for O. castanea Ermisch, 1968 from tropical Africa (Ermisch 1968). The two species are very similar and differ especially by the body form, which is stouter, with elytra only twice as long as wide in O. strinadi sp. n., but markedly more slender, with elytra 2.2 times longer than wide, in O. castanea Antennae in O. strinadi sp. n. are comparatively longer, almost twice as long as the head, whilst only 1.4 times longer than the head in O. castanea. Unfortunately, male genitalia of O. castanea are not figured in the original description.

Scaphiostena gen. n.

Body (Fig. 10) short with rounded sides, large head and extremely long pygidium. Further very conspicuous and important characters are, small, coarsely faceted and pubescent eyes, very long antennae, terminal segment of maxillary palps secundiform (Fig. 14), penultimate segment of anterior and intermediate tarsi deeply bilobed, elytra very short, and broadly truncate at the apex, mesepisterna (Fig. 12) very short, short, but very oblique ridges on metabasit and on three segments of posterior tarsus.

The emarginate penultimate segment of anterior and intermediate tarsus as well as very broad pronotum (width/length as 6/4) suggest the close relationship of the new genus to the genera Dellamora Normand and Pseudodellamora Ermisch from the western Palaearctic. The genera can be distinguished according to the following key (according to Ermisch, 1950, modified). The form of the terminal segment of maxillary palps and the coarsely faceted pubescent eyes in Scaphiostena gen. n. resemble also those of the genera Glyphostena Ermisch and Neomordellista Ermisch, but the new genus may be easily distinguished from the latter genera by the form of elytra, pygidium and mesepisterna. The basic form of male genitalia (Fig. 11) does not differ, in fact, from that of Mordellista Costa.

TYPE SPECIES. Scaphiostena schwendingeri sp. n.

Incorporation of Scaphiostena gen. n. into the modified key to genera by Ermisch (1950):

74(75) Terminal segment of maxillary palps in male more or less not shaped like in Mordellista Ermisch. Metabasit besides one apical ridge with two more lateral ridges. Metabasit with only one terminal spur. Elytes finely faceted and pubescent. W. Mediterranean. Cyprus

Dellamora Normand

191
Terminal segment of maxillary palpus in both sexes secundiform. Metastigma with two terminal spurs.

(a) Elytra parallel sided, 2.4 - 2.5 times longer than their combined width, at the apex elongate, rounded. Metastigma almost straight; Pygidium usually long, twice as long as hypopygium and reaching about one-fifth of the length of elytra. Metatibia with only one lateral ridge. Eyes finely faceted and pubescent. W. Mediterranean, Caucasus.

*Psedapelma* Emsh.

(b) Elytra broad with acute sides, only 1.4 times longer than their combined width, broadly truncate at the apex. Metastigma strongly curved inwards. Pygidium extremely long, nearly four times as long as hypopygium and reaching three-fourths of the length of elytra. Metatibia, apart from one apical ridge, with 2 - 3 very oblique lateral ridges. Eyes very small, coarsely faceted and pubescent. Thailand.

*Scaphiostena* gen. n.

76(73) Continued (see Emsh 1950)

**Scaphoidea schwendingeri sp. n.**

Completely, yellow-brown. Strongly convex and rounded with extremely developed pygidium. Pubescence sparse, bright golden yellow.

Head strongly convex, comparatively large, only slightly narrower than pronotum. Width: length as 7:6:6.5. Anterior portion of head capsule not prolonged anteriorly, clypeus as well as labrum very broad; labrum moreover extremely short. Eyes very small, oblong oval, without depression at the insertions of antennae (Fig. 13), finely faceted and pubescent (number of facets, due to the reduced eye size, very low). Entire posterior and lower margin of eye bordered, temples indistinct. Second segment of maxillary palpus in male elongate-clavate, only slightly wider than the third one; terminal segment broadly secundiform, inner angle situated at its middle length (Fig. 14). Terminal segment in female only a little narrower. Antennae (Fig. 15) very long, equal in both sexes. Segment 2 as long as, but distinctly narrower than 1; 3 by one fourth shorter and a little narrower than 2; 4 as wide as, but by one third longer than 3; 5 more than three times longer than wide and by nearly fifth longer than 4; segments 5 onwards gradually slightly abbreviated; segment 10 only twice as long as wide, terminal segment oblong oval, 2.6 times longer than wide and by one fourth longer than the penultimate. Ratio of the lengths of antennal segments as 10:9:12:15:13:13:12:12:12:12:16.

Pronotum flatly convex, transverse (width to length as 6:4), without the collar-like anterior prolongation; posterior lobe actually indistinct. Sides in lateral view (quite) straight, posterior angles obtuse, rounded.

Scutellum very small, broadly triangular, under normal conditions completely concealed by pronotum.

Elytra short and broad, moderately extending behind humera, only twice as long as their combined width. Apex of elytra broadly truncate, as broad as the elytral base (Fig. 11).

Pygidium more than three times longer than hypopygium, reaching one third of the total body length and two thirds of the length of elytra.

Anterior tibia in male gently curved upwards, without swelling on inner side and without longer hairs. The fourth segment of anterior and intermediate tarsi encurvate to about two thirds of its length, with anteriorly truncate onychium on ventral side. Metatibia, apart from apical ridge, with 2-3 very oblique lateral ridges (the uppermost ridge mostly rudimentary). First segment of posterior tarsus with 2-3 oblique ridges, second and third segments with 2 ridges each. Outer terminal spur of metatibia reaching two thirds of the length of the inner one. Membranous (Fig. 12) very short, only half longer than wide, with quite straight lateral margin, only slightly projecting between elytra and pronotum.

Male genitalia as figured (Figs 16, 17).

**Type Material.** Holotype, male, Thailand, prov. Chiang Mai, Doi Inthanon, 2500 m, 16-18.4.1987, leg. P. Schwendinger. Allotype, female, the same data. Paratypes: 1 male, the same data as holotype; 1 male, 1 female, ditto, but 18.4-23.8.1987, 2 females (1 spec. without head and pronotum), ditto, but 17.7.1986 - 16.2.1987. Deposited in Museum d'Histoire naturelle, Genève, two paratypes in my collection.

According to collector (personal communication by Dr. L. Lobl) all species were captured into pitfall traps with the Formalin fixative, in which they have been accumulated during a very long period of time (see above data).

**Name Derivation.** The new species is dedicated to the collector.

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techniques (X-rays, CT scans, sonograms, electrocardiograms), charts of geographic distribution of important parasitic diseases, and some laboratory procedures. Moreover, there are 11 full-page colour plates presenting the trophozoites and cysts of intestinal protozoa, malarial parasites in thin and thick blood films, and eggs of various intestinal helminths. In addition, there are 9 tables and many unnumbered reviews providing summarized information on protozoan and helminthic infections, and diseases transmitted by arthropods. Further on, presented are identification keys and characteristics, differential diagnosis, and suggested drug regimens. There is hardly any essential new information omitted in this volume. Based on tradition of 34 years and seven editions, this volume represents a readable, thoroughly updated, originally illustrated, and well-referenced textbook.

(continuation from p. 150)
Isometrus zideki sp. n. from Malaysia and Indonesia, and a taxonomic position of Isometrus formosus, I. tiurstoni and I. sankariensis (Arachnida: Scorpiones: Buthidae)

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Abstract Isometrus (Reddyanus) zideki sp. n. is described from Malaysia and Indonesia (Kalimantan). Taxonomic position of Isometrus formosus Pocock, I. tiurstoni Pocock, and I. sankariensis Tikader & Batuwidae is discussed. Isometrus formosus is placed in the nomenklaturotypic subgenus Isometrus Hampson, 1907 and Pocock on the basis of distribution of pedipalp trochanters. The validity of the subgenus Isometrus and Reddyanus Vachon is affirmed, whereas the subgenus Clomacryptes Tikader & Batuwidae is considered to be a synonymy to the nomenklaturotypic subgenus. The type and only known species of the latter subgenus I. sankariensis is transferred in the subgenus Isometrus. A check list of all species of the genus Isometrus is included.

Isometrus (Reddyanus) zideki sp. n. (Figs 1, 3, 9-12)

Type material Holotype. Male, labelled Malaysia, Cameron Highlands, 1992 (collectors unknown), in the author's collection. Paratypes. One male (nos 1) and nine females (nos 2-10) labelled Malaysia, Cameron Highlands, 1992 (nos 2-3) and 1994 (nos 4-10) (collection anonymous), one female (no. 11) labelled Indonesia, Kalimantan, Nanga Ptnch, Pontan, leg. J.A. Schneider 26 VII 1993. One male No. 3 is deposited in the Department of Invertebrate Zoology, National Museum (Natural History), Prague. All other paratypes are in the author's collection.

Type locality A forest species occurring under tree bark.

Derivation of name Named after Jiří Zidek, a Czech palaeontologist and zoologist at the New Mexico Tech University, Socorro, USA.

Description The total length is 32.0 and 29.2 mm in the males and 25.7-30.2 mm in the females. Measurement of the carapace, telson, segments of the metasoma and segments of pedipalps, and numbers of pectinal teeth are given in Table 1. There are 11 and 12 pectinal teeth in the males and 10-12 in the females. For the position and distribution of trochanters on the pedipalps see Figs 1-3. The base color is yellow to reddish brown with numerous black spots over the entire body. On the chelicerae the black pigment forms an irregular lattice. The carapace, legs, femur and patella of the pedipalps are spotted. The carapace has a well-defined black spot around the median eyes, and the mesosoma bears three longitudinal stripes that, however, may not be well developed or readily apparent. The tarsus is darker than the manus, which is yellow to light reddish brown with minute black spots chiefly on the external surface. In the females the base color of the first three metasomal segments is yellow, and that of the last two segments and the telson is reddish brown to black. The posterior halves of the first four metasomal segments
Table 1. Measurements in millimeters of the species described. The column denoted "Pectinal teeth" contains numbers of both left and right teeth separated by a colon.

<table>
<thead>
<tr>
<th>Species</th>
<th>Isometrus(R.) zideki sp. n. holotype male</th>
<th>Isometrus(R.) zideki sp. n. paratype No. 2 Female</th>
</tr>
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<tbody>
<tr>
<td><strong>Total</strong></td>
<td>length 32</td>
<td>length 28</td>
</tr>
<tr>
<td><strong>Campax</strong></td>
<td>length 3.5</td>
<td>length 3.2</td>
</tr>
<tr>
<td></td>
<td>width 3.7</td>
<td>width 3.5</td>
</tr>
<tr>
<td><strong>Metasoma</strong></td>
<td>length 21.2</td>
<td>length 16.6</td>
</tr>
<tr>
<td>segment I</td>
<td>length 2.4</td>
<td>length 1.8</td>
</tr>
<tr>
<td></td>
<td>width 1.5</td>
<td>width 1.3</td>
</tr>
<tr>
<td></td>
<td>length 3.1</td>
<td>length 2.3</td>
</tr>
<tr>
<td></td>
<td>width 1.5</td>
<td>width 1.3</td>
</tr>
<tr>
<td></td>
<td>length 3.4</td>
<td>length 2.6</td>
</tr>
<tr>
<td></td>
<td>width 1.4</td>
<td>width 1.2</td>
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<tr>
<td></td>
<td>length 4.0</td>
<td>length 3.0</td>
</tr>
<tr>
<td></td>
<td>width 1.4</td>
<td>width 1.1</td>
</tr>
<tr>
<td></td>
<td>length 4.9</td>
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</tr>
<tr>
<td></td>
<td>width 1.5</td>
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<tr>
<td><strong>Telson</strong></td>
<td>length 3.4</td>
<td>length 3.0</td>
</tr>
<tr>
<td><strong>Pedipalp</strong></td>
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<td>length 2.7</td>
</tr>
<tr>
<td>femur</td>
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<td>width 1.0</td>
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<tr>
<td>patella</td>
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<td>length 3.4</td>
</tr>
<tr>
<td></td>
<td>width 1.5</td>
<td>width 1.4</td>
</tr>
<tr>
<td>tibia</td>
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<td>length 0.4</td>
</tr>
<tr>
<td></td>
<td>width 0.4</td>
<td>width 0.5</td>
</tr>
<tr>
<td>tarsus</td>
<td>length 3.5</td>
<td>length 2.4</td>
</tr>
<tr>
<td></td>
<td>width 1.9</td>
<td>width 1.2</td>
</tr>
<tr>
<td>finger I</td>
<td>length 3.5</td>
<td>length 3.2</td>
</tr>
<tr>
<td><strong>Pectinal teeth</strong></td>
<td>11.1</td>
<td>10.1</td>
</tr>
</tbody>
</table>

are spotted and darker, and the fifth segment is entirely black. In the males the metasoma is less spotted. The first three segments are yellow with but a few spots, the fourth segment is reddish brown to black, the fifth segments is black, and the telson is again reddish brown to black.

**Affinities.** The species is characterized by distribution of trichobothria on the pedipalps (Figs 1-3), only two rows of granules on the subacicular tooth of the telson (Figs 9, 11), very thin metasoma in both sexes (Table 1), a well-developed median keel on the underside of the fifth metasomal segment, and two well-developed parallel keels on the undersides of third and fourth metasomal segments (Figs 10, 12). The space between these two keels contains a row of irregularly dispersed granules of uneven size, which are much less numerous in the males than in the females.

Geographically, the nearest species of *Isometrus* is *I. formosus* Pocock, 1893 from Java. This species has not yet been placed into any subgenus. According to opinion of the author of this paper *I. formosus* is a member of the nomenotypic subgenus (see below). In this subgenus belongs also *I. (L.) maculatus* (De Geer, 1778), which has so far been the only species known from Malaysia and Kalimantan. In contrast, *Isometrus zideki* sp. n. belongs in the subgenus *Reddyanus* Vachon, 1972 (Vachon 1972, 1976 1982 and 1982) and appears to be most closely related to *I. (R.) hemi* Vachon, 1976 from New Caledonia, which has similar proportions and also bears only two rows of granules on the subacicular tooth of the telson. This character differentiates these two species very well from the majority of other species of the subgenus *Reddyanus*. *I. (R.) zideki* sp. n. differs from *I. (R.) hemi* in having 10-12 pectinal teeth (12-13 in *I. hemi*) and a pronounced median keel on the underside of the fifth metasomal segment in both sexes (Figs 10,
Discussion. Twelve species of scorpions belonging to five families are known to occur in Kahl-
natan. They are *Isometrus* (*Reddyanus*) zideki sp. n., *Isometrus* (*Isometrus*) maculatus (De-
Geer, 1778), *Lycias shelfordi* (Borelli, 1904) and *Lycias hosei* (Pocock, 1890) of the family
Buthidae, *Heterometrus* (*Heterometrus*) longimanus (Herbst, 1800) of the family Scorpioidae.

Figs 1-3. *Isometrus* (*Reddyanus*) zideki sp. n. (Paratype No. 2). Fig. 1. Tibia. Fig. 2. Patella. Fig. 3. Patella
and femur. Denoted is position of trichobothrium e1 in the holotype (male). The second male (Paratype No. 1)
has trichobothrium e1 situated between d4 and d5, but closer to d5 than in the female. In Fig. 1, the first capital
letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of
pedipalp. Explanations: First letters: d, dorsal; e, external l, internal. Second, or second plus third letters: b, basal,
ab, suprabasal, m, medial, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same
classification. Designation and description of trichobothria according to Vachon (1973).
Liocheles australasiae (Fabricius, 1775) (Vachon & Lourenco 1985) and Liocheles waigleni (Gervais, 1844) of the family Ischmiridae (Koch 1977), Chaerillus celebensis Pocock, 1893, Chaerillus variegatus Simon, 1877, Chaerillus chapmani Vachon & Lourenco, 1985 (Vachon & Lourenco 1985) and Chaerillus laevimanus Pocock, 1899 (Pocock 1899) of the family Chaeriliidae, and Parascorpioidea montana Banks, 1928 of the family Vaefovidae (Francke 1976).

Figs 4-6. Isometrus (Isometrus) formosus Pocock, 1893. Fig. 4. Tibial. Fig. 5. Patella. Fig. 6. Telson. In Fig. 4, the first capital letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of pedipalp. Explanations: First letter: d, doral; c, external. Second, or second plus third letters: b, basal; sb, suprabasal; m, medial; st, subterminal; t, terminal. Numbers distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1973).

Isometrus (Isometrus) formosus Pocock, 1893 comb. n. (Figs 4-6)


COMMENTS. The total length is 52.3 mm, of which the metasoma amounts to 34 mm. The distribution of the trichobothria on the pedipalps corresponds precisely to that given for the subgenus Isometrus by Vachon (1972, 1982). This species is very well characterized also by a pronounced subacicular lobe-like tooth (Fig. 6) with three rows of granules.

DISCUSSION. Kraepelin (1899) and Vachon (1972, 1976) listed this species only from Java and Sumatra, but Takashima (1948, 1950) found in the Tokyo Science Museum a male from Manokwari, New Guinea. According to Koch (1977) the New Guinea record is disputable, however, because the specimen may in reality belong to *I. melanodactylus* (C. L. Koch, 1867). Takashima (1950) characterized *I. formosus* by 10-13 (usually 11) pectinal teeth, whereas *I. melanodactylus* has 10-17 pectinal teeth (Koch 1977) and the specimen of *I. formosus* examined in this study has 14 pectinal teeth.

Figs 7-8. *Isometrus (Isometrus) sanctaeaccess*(Tikader & Bautista, 1983). Fig. 7. Tibia, Fig. 8. Femur. In Fig. 7, the first capital letters denote trichobothria situated on the manus; the first lower case ones, those situated on the fixed finger of pedipalp. Explanations: First letter: d, dorsal; e, external. Second, or second plus third letter: a, basal, b, submedian, t, subterminal; c, terminal. Numbers distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1973).
Isometrus (Isometrus) thurstoni Pocock, 1893

Isometrus (Isometrus) thurstoni Pocock, 1893: 293; Knaepelin, 1899: 67.


COMMENTS. The total length is 45.2 mm, of which the metastoma amounts to 27.3 mm. There are 16 pectinal teeth. Subgeneric characters entirely agree with those of the type subgenus Isometrus (Vachon 1972, 1982).

DISCUSSION. Vachon (1982) placed this species in the subgenus Isometrus, but Tikader & Bastawade (1983) transferred it into the subgenus Reddyanus. A revision of subgeneric characters listed and discussed by Vachon (1972, 1982) reaffirms the placement of this species in the subgenus Isometrus.

Figs 9-12. Isometrus (Reddyanus) zideki sp. n. Fig. 9 male (Holotypus), lateral view of telson and fifth and fourth segments of the metastoma. Fig. 10 male (Holotypus), ventral view of telson and fifth and fourth segments of the metastoma. Fig. 11 female (Paratypes No. 2), lateral view of telson and fifth and fourth segments of the metastoma. Fig. 12 female (Paratypes No. 2), ventral view of telson and fifth and fourth segments of the metastoma.
Isometrus (Isometrus) sankaranensis Tikader & Bastawade, 1983 comb. n. (Figs 7-8)

Isometrus (Closothorax) sankaranensis Tikader & Bastawade, 1983: 311


Comments: The specimen from Periyar was found at the base of a tree under bark, at approximately 900 m elevation. Its total length is 33.5 mm, of which the metasoma amounts to 21.5 mm. This specimen has 17 pectinal teeth. The females from Kalar reach 36.2 and 35.9 mm, of which the metasoma amounts to 22.3 and 21.5 mm, respectively. Both specimens have 14 pectinal teeth. The characters of the species match the description of Tikader & Bastawade (1983), but the subgeneric characters do not differ in any way from those of the type subgenus Isometrus (Vachon 1972, 1982). The features of the subgenus Closothorax do not differ from those of the subgenus Isometrus.

Discussion


Comparing the features characterizing subgenus Closothorax with those characterizing subgenus Isometrus, I come to the conclusion that I. sankaranensis (Tikader & Bastawade 1983) belongs in the subgenus Isometrus Hemprich & Ehrenberg, 1879, which is valid and best characterized by the features given by Vachon (1972 and 1982). The position of the Isometrus species which Tikader & Bastawade (1983) described as belonging in the subgenus Reddyanus ought to be re-examined. For this reason their placement in the subgenus Reddyanus is denoted by a asterisk in the following list of species of the genus Isometrus.

Check list of species of the genus Isometrus Hemprich & Ehrenberg, 1879

subgenus Isometrus Hemprich & Ehrenberg, 1879

= Closothorax Tikader & Bastawade, 1983 syn. n.

I. formosus Pocock, 1893 comb. n. Indonesia (Java, Sumatra)

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2. *maculatus* (De Geer, 1778) South America, Antilles, USA (Florida), Costa Rica, Africa, Madagascar, Pakistan, India, Sri Lanka, China, Burma, Thailand, Laos, Cambodia, Malaysia, Indonesia, Australia, New Guinea
3. *Scorpio americanus* Linneaus, 1758
4. *Isometus angustus* Lepère, 1897
5. *Scorpio duriaei* Herbst, 1800
6. *Buthus (brometis) rumus* Hennig & Ehrenberg, 1828
7. *Lychas ssp. genuis* C.L. Koch, 1845
8. *Scorpio (Lychas) golenetsis* Lucas, 1858
9. *Scorpio gumeniczus* Lucas, 1858
10. *madagascariensis* Roewer, 1934 Madagascar

11. *ontariensis* Tikader & Basuawade, 1983 comb. nov. India (Kerala, Karnataka)
12. *nullus* Pocock, 1895 India (Madhya Pradesh), Maharashtra, Andhra Pradesh, Tamil Nadu

subgenus Red dyneus Vachon, 1972

1. *acanthinuacanthus* Pocock, 1899 India (Maharashtra), Himalayas
2. *acanthus* coelitis Vachon, 1962 Sri Lanka
3. *assimilans* Oates, 1888 Assam, India (Uttar Pradesh), Nepal, Himalayas
4. *basilewskyi* Koch, 1879 Sri Lanka
5. *brachycerus* Vachon, 1962 Sri Lanka
6. *brachycerus* Pocock, 1899 India (Karnataka, Kerala)
7. *buxtoni* Vachon, 1976 New Caledonia
8. *melanochelys* (C.L. Koch, 1867) Australia, New Guinea
9. *m. fuscus* Vachon, 1976 New Caledonia
10. *m. m. melanochelys* v. Fritzsche, 1925
11. *m. p. grisea* Vachon, 1976
13. *m. fuscus* Vachon, 1976
14. *m. fuscus* Vachon, 1976

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*) see the text on the page 201

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BOOK REVIEW


As stated in the preface, in the not too distant future, the environment will be required subject of matter for all college and university students. Environmental issues are already preeminently important throughout the world and critical to the future of human civilization, that we simply cannot have a world where leaders are ignorant of the dynamics of interaction between humans and the environment. Global ecological issues are critical for the future of human civilization. The crises in solid waste disposal, debris washing up on coast beaches, worsening of the air quality, decreasing ozone in the ozone shield threat of global warming and the "greenhouse effect", damage of forest and wildlife, increasing contamination of ground water, nuclear accidents, dying of forests, disappearing of tropical rainforest and wetlands, lakes affected by acid deposition, etc. The volume is organized into four parts and consists of 10 chapters. Numerous diagrams inserted into the text present definitions and explain key terms associated with particular topics. Moreover, there are many "Enrichment Boxes" which are featured in the main text by frames and which highlights various ecological phenomena. There are also environmental career profiles. Each chapter concludes with a summary called "Concepts to Remember", and references for further reading. The book is designed to be used flexibly, the chapters can be taken up in any order. The text is supported by 227 figures including diagrams, line drawings, schemes of ecosystems and material cycles in nature, individual procedures, landscape profiles and charts. Moreover, there are 25 tables, many unnumbered black and white photographs and four colour sheets which illustrate different biomes, landscapes and charts.

Part one (5 chapters) introduces basic principles of ecology which are defined as the study how the living and nonliving things in the nature relate together. Discussed are the framework of ecology, energy in ecosystems, material cycles in living systems, populations and communities and evolution and ecology.

Part two (3 chapters) is concerned with human beings in the scheme of natural things, it explores the human need for energy and nutrients, material and water resources. The chapter on population, food and hunger presents two sections. In section A various aspects of human population growth are looked at. Section B outlines the food production, food distribution and economic development, and the impact of biotechnology on agriculture.

Part three (10 chapters) deals with impacts of human activities on health and the environment. Discussed are air pollutants and their sources, the effects of air pollution on human, other organisms and ecosystems. Control of air pollution, water pollution, land use and misuse, wildlife, wilderness, and biological resources, regulation of persistent hazardous materials in the environment, waste disposal in the environment, and environmental aspects of cancer.

Part four (2 chapters) summarizes topics covered up to this point focusing on the roots of environmental problems. For solving this discussed are activities of various human institutions referring to religion, government, law, economy, education, science, medicine, and cities.

This book is based on tradition of two previous editions (1986,1989). It is designed to be used by students heading for leadership positions in business, science, law, government, education, engineering, agriculture and other fields. Its approach is human centered, the term "environmental science" is broader than "ecology".
Supplementary records of earthworms (Lumbricidae) in the Czech Republic

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Abstract. Six earthworm species, Allolobophora eiseni, Dendrobaena hortensis, D. veneta, Eisenia fetida, Lumbricus rubellus and Octolasion tyrranicum, are newly recorded from the Czech Republic. The short descriptions of these species are given together with the data on their distribution and ecology. The list of species so far neglected for the earthworm fauna of the Czech Republic is also included.

INTRODUCTION

On the territory of former Czechoslovakia, faunistic research on the family Lumbricidae dates from the end of the last century (Vegdovsky 1874, 1883). Since that time, more than one hundred papers reporting earthworms from that country has been published. However, modern investigations have been carried out predominantly in Slovakia (Zajonc 1981), whereas large areas in Bohemia and Moravia (Czech Republic) remain unexplored up to now. The present paper attempts to add to our knowledge of earthworm distribution in those areas.

MATERIAL AND METHODS

In the Czech Republic, more than three hundreds localities were sampled for earthworms during the course of 1982 to 1993, from which the material containing 11,582 specimens was obtained. Qualitative as well as quantitative sampling methods were used. Qualitatively, earthworms were collected in various structural parts of the biotopes (under stones, in soil, in moors, in plant remains, in decaying wood, under bark, etc.) to obtain species exhibiting various associations with the environment. Quantitative samples were collected by a combination of hand sorting after digging in the surface layer of the soil, chemical extraction technique of applying a 0.5% solution of formalin, and/or heat extraction of soil samples in modified Meyer’s apparatus (Meyer 1980). The lumbricids obtained were fixed in 4% formalin and stored in 7% solution of the same fixative. Reference specimens are deposited in the author’s collection at the Institute of Soil Biology, České Budějovice.

Code numbers given in parentheses behind the names of localities indicate respective quadrangles on the faunistic map of Czechoslovakia (see Bucher 1982). Where is no other indication, there applies leg. V Přítl.

RESULTS

Allolobophora eiseni (Levinsen, 1884) (Fig. 1a)


Septa 6/7-8/9 only slightly thickened. Seminal vesicles two pairs in 11,12, rudimentary. Spermathecae absent.

DISTRIBUTION. Cosmopolitan. In Europe widespread westwards from Poland, Slovakia and Bulgaria. New species for the Czech Republic.

ECOLOGY. Epigean, acropliophonic and acidotolerant species, occurring under bark of fallen trees, under moss and decaying leaves. Often the dominant species in moorland, bog soils and by streams, pH 3.6-7.6. All my records are derived from the litter layer of deciduous forest soils.

_Dendrobaena hortensis_ (Michaelson, 1890) (Fig. 1b)


DESCRIPTION. Length 15-50 mm, diameter 1.5-4.5 mm, segment number 42-130. Body cylindrical with the posterior region somewhat rhomboid and depressed. Colour reddish purple dorsally, with a colourless papilla-like area round setae cd on segment 11 (or II-12). Pigmentation extends ventrally over the first 14-15 segments and often in the caudal region, otherwise whitish yellow below. Prostomum epi- to tanylostous. First dorsal pore in intersegmental furrow 5/6. Spermathecal pores paired in 9/10 and 10/11, located near the mid-dorsal line. Male pores on segment 15 with small tumescences confined by the furrows 14/15 and 15/16. Clitellum on segments (26) 27-33, saddle shaped reaching down nearly to setal line b. Tubercula pubertatis form elliptical bands or ridges over segments 30, 31, intersegmental furrow 30/31 often not obliterated. Setae widely paired, post-clitellar formula 1.5 : 1 : 1.5 : 1 : 3. Genital tumescences surround setae ab on segments 9,10 11, 12 and in the clitterar region, but often lacking.

Septa 13/14, 14/15 strongly muscular, those 7/8 - 9/10 somewhat thickened. Seminal vesicles paired usually in segments 9-12 but either or both of the anterior pairs may be rudimentary or fail to develop. Two pairs of spermathecae in segments 9, 10.

DISTRIBUTION. Cosmopolitan species. In Europe from Turkey, Greece, Albania, Macedonia, Italy, France to Portugal. Introduced into England, Switzerland, Germany, Hungary and Slovakia. New species for the Czech Republic.

ECOLOGY. Epigean species, living in decaying forest litter. Now the species is widespread in organic rich soils of greenhouses, gardens and pastures. Both our records come from compost heaps in gardens.
Fig. 1. a. Allotobaphora eiseni, b. Dendrobaena hortensis, c. Dendrobaena veneta, d. Entenia spelaea, e. Lumbricus meliboeus, f. Octolasion tyrtaceum. Scale = 1 cm.
Dendrobaena venosa (Rosa, 1886) (Fig 1c)


DESCRIPTION. Length 21–155 mm, segment number 65–255. Body cylindrical, posterior region tending to become rectangular in transverse section, slightly depressed. Colour, a conspicuous reddish purple mid-dorsal stripe with intersegmental bands mainly incompletely ventrally, interssegmental furrows and most of the ventral surface unpigmented flesh colour to whitish yellow. Prostomium variable from epilobous to tanylobous. First dorsal pore in furrow 5/6. Spermathecal pores in furrows 9/10, 10/11 located near the mid-dorsal line. Male pores with large tumescences confined to segments 15. Clitellum over segments (25, 26) 27-32 (33), saddle-shaped Tubercula pubertatis on (29) 30–31 (32), usually ridge-like but the furrows are seldom completely obliterated, occasionally papillate and nearly circular on segments 30 and 31 only. Setae widely paired, post-clitellar formula 1.5 : 1 : 1.5 : 1.5 : 3. Genital tumescences usually surround setae ab in the clitellar region, at least on segments 30 and 31, ed on 12.


DISTRIBUTION. Transcaucasia westwards through Turkey, Carpatho-Balkan Peninsula, Croatia, Slovenia and Italy into Spain. Found also in Poland, Slovakia, Ireland, England, Wales and California. New species for the Czech Republic.

ECOLOGY. Epigeic species, occurring under decaying leaves and in the top layer of organic rich soils; commonly recorded from compost heaps, manure and sewage beds. Our records are derived from compost heaps in gardens.

Eisenia spelaec (Rosa, 1909) (Fig 1d)

LOCALITIES. Bohemia mer., Puklice (6852), 20.5.1985, 9 ex., Bohemia mer., Hubská n Vlt (6952), 28.5.1985, 18 ex.


DISTRIBUTION. E. spelaec was recorded from Alpine (Italy, Hungary, Slovenia, Croatia) and Carpathian (Ukraine, Roumania, Slovakia) regions. New species for the Czech Republic.
ECOLOGY. Epi-hypogeous species, which occurs in root-layer of most soils in woodland, known also from caves. My material was collected in wet depressions of deciduous and spruce forests.

*Lumbricus melitoeus* Rosa, 1884 (Fig. 1e)

LOCALITIES. Bohemia mer., Purkarce (6852), 20.5.1985, 14 ex., Bohemia mer., Hlibčí n Vit (6952), 28.5.1985, 18 ex.


Septa begin in 4/5, 7/8 and 9/10 somewhat thickened, then thin and membranous posteriorly. Three pairs of seminal vesicles in 9, 11, 12. Two pairs of spermathecae in 9 and 10.

DISTRIBUTION *Lumbricus melitoeus* has been previously recorded from the Alpine region of Italy, Switzerland, Germany, Austria, France and Slovenia. One specimen reported by Piaget (1919) from Sarek region in northern Sweden should also be mentioned here, permitting to consider about boreo-alpine distribution of the species. However, this record has never been confirmed, and I agree with the opinion of Stöp-Browitz (1969) who stated it as doubtful. New speciess for the Czech Republic.

ECOLOGY. Little seems to be known about the habitat and biology of this species. According Zacek (1965) and Wulke (1967) it lives in litter of deciduous forests; Bouché (1972) reports that *L. melitoeus* occurs exclusively in mountains, and is hygrophilous, relative acidotolerant and stenomorphic. Morphological and ecological features indicate that the species belongs to intermediate form between epigeic group of earthworms and anecic one. My records are derived from A-horizon of damp soil in depressions of mixed deciduous forest.

*Ocillasio tyrraeum* (Savigny, 1826) (Fig. 1f)


DESCRIPTION. Length 25-160 mm, diameter 2.5-6 mm, segment number 87-135. Body cylindrical, slightly octagonal posteriorly. Colour whitish grey to blue, rarely rosy pink or brownish; unpigmented. Prostomium tanylobous. First dorsal pore in or behind furrow 8/9, mostly between 10/11 and 12/13. Spermathecal pores paired in furrows 9/10, 10/11, opening slightly above setal line c. Male pores paired on segment 15 above line b, with large tumescences obliterating parts of furrows 14/15 and 15/16 and encroaching onto the adjacent segments. Clitellum extends over...
saddle shaped reaching down to within setal line ab. Tubercula pubertatis form longitudinal bands within the ventral border of the chitellum throughout its entire length, i.e., 30-35. Setae closely paired anteriorly, becoming widely paired to distant more posteriorly, immediate postchitellar formula 3.3.1.6·1.3·1.7.3. Genital tumescences surround setae ab and often cd or segments (9) 10 (11) 12 and also setae on (21) 22 (23).

Septa 6/7-14/15 muscular. Seminal vesicles in 9-12, the two posterior pairs being larger than the two anterior ones. Spermathecae two pairs in 10 and 11.

DISTRIBUTION. Ochotona tytaretum seems to occur in southern and western Europe, the Middle East and most of North America with introduced populations in South Africa, India, Australia and Oceania. However, records of this species have been often confused with those of O. lacteum (Savigny, 1826). New species for the Czech Republic.

ECOLOGY. Hypogean, neutrophilous and acidophilous species. It lives in various biotopes, from pastures, arable land and gardens to forests, where is often found under stones and logs, in decaying leaves, compost, peat; in soils of pH 4.3-8.1. It seems to be more hygrophilous than O. lacteum, being more abundant in moist soils of bogs, caves and stream banks.

CONCLUSIONS

Finnistic research of earthworms resulted in additional six species of hirudinids being newly recorded from the Czech Republic. Together with the records presented here, the list of the Czech earthworms fauna contains the following taxa:

1. Allolobophora chlorotica chlorotica (Savigny, 1826)
2. Allolobophora extenu (Levensen, 1884)
3. Allolobophora brevi (Černy, 1935)
4. Allolobophora moravica (Píšť et Hosticková, 1944)
5. Allolobophora parva Eisen, 1874
6. Aporrectodea caliginosa caliginosa (Savigny, 1826)
7. Aporrectodea caliginosa trapetosa (Dugès, 1828)
8. Aporrectodea georgii (Michael, 1890)
9. Aporrectodea hauflerzki hauflerzki (Rosa, 1897)
10. Aporrectodea intermedia intermedia (Savigny, 1826)
11. Aporrectodea longa longa (Ule, 1885)
12. Aporrectodea rorea rorea (Savigny, 1826)
13. Dendrobena attenuata attenuata (Michael, 1902)
14. Dendrobena horrens (Michael, 1890)
15. Dendrobena hirsuta (Coutoni, 1905)
16. Dendrobena inermis (Cerny, 1935)
17. Dendrobena octaedra (Savigny, 1826)
18. Dendrobena vernalis vernalis (Savigny, 1826)
19. Dendrobena vernalis vernalis (Savigny, 1826)
20. Dendrodrilus rubidus rubidus (Savigny, 1826)
21. Dendrodrilus rubidus subterraneus (Eisen, 1874)
22. Dendrodrilus rubidus vernalis (Eisen, 1874)
23. Eisenia fetida fetida (Savigny, 1826)
24. Eisenia fetida fetida (Savigny, 1826)
25. Eisenia fetida fetida (Savigny, 1826)
26. Eisenia fetida fetida (Savigny, 1826)
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BOOK REVIEW


As emphasized in the introduction, up to now no single work has brought the whole gamut of the arthropods, including insects, together with diseases, parasites, and infestations for which they are responsible, in the postural form such as this in the "Colour Atlases" in this series. The phylum Arthropoda, defined as joint-limbed animals protected by an exoskeleton, contains the largest number of species of any phylum in the animal kingdom. Many of them are of considerable importance to human and veterinary medicine because they act hosts in the transmission cycles of some of the most troublesome and, in many cases, lethal diseases that affect man and animals. In the course of this evolution, man has greatly influenced the geographical distribution of many arthropod species. The disastrous disruption of human society and the environment by war and famine has always been associated with surges of arthropod-borne and other diseases. Global warming through the so-called "greenhouse effect" brings with it the positive danger that a number of major vector-borne diseases will extend beyond their present geographical limits. Many arthropods cause various degrees of discomfort, not pathological changes. This book consists of five parts containing 19 sections or chapters each. Each part characterizes a particular group of arthropods and diseases associated with them. It includes a general textual part and figures complemented with descriptive legends. A total number of figures is 990. They constitute colour photographs of organisms and pathomorphological changes in organs and tissues caused by them, terrestrial biomes and ecological aspects, technological procedures and appropriate equipment, schematics, schematic drawings and diagrams, life cycles, and charts of geographical distribution of diseases. In the acknowledgements numerous authors from all parts of the world are cited who gave the assistance in providing pictures and their personal expertise. Acknowledgements are made also to various scientific organizations. In addition, there are 32 tabular reviews summarizing information and classification schemes of the phylum Arthropoda, arthropod vectors of diseases, arboviruses and other arthropod-borne agents, and particular groups of arthropods of medical importance.

Part 1 focuses on the zoology of the arthropods with particular reference to evolution, classification, physiology, and life cycles.

Part 2 is the most extensive (112 pages). It deals with arthropods as disease vectors. Following chapters are covered here: arboviruses, rickettsiae, bacterial infections, malaria, leishmaniasis and thelesamos, trypanosomiasis, leishmaniasis, and helminthases. Arboviruses include such important pathogens as those causing yellow fever, dengue, Japanese B encephalitis, and Rift Valley fever. There is an overview of hard and soft ticks, their main hosts, distribution, and associated diseases or pathogens. Further on classification and causes of hemorrhagic fevers, mosquito bites implicated in the transmission of arboviruses, arthropod diseases transmitted by ticks, mites, and lice, and other infections caused by bacteria, viruses, and protozoa are discussed here. The section on malaria provides insights into the morphology of anopheline mosquitoes, life cycle of malariac plasmodia, methods of anopheline mosquitoes surveys, malaria vector species in subgenera Anophelinae, Celled, Neopropylinae and Kentiinae in the Old and New Worlds, and methods for malaria control. Following sections are devoted to leishmaniasis and thelesamos and to trypanosomiasis in South America and Africa with classification of trypanosomas, with reservoirs and control measures. The section on leishmaniasis gives comprehensive overviews of sandfly vectors and Leishmania species in the Old and New Worlds followed by figures demonstrating life cycles, epidemiological and clinical aspects. Arthropod-borne helminthases cover wide variety of infections with nematodes, cestodes, and trematodes, in the life of which arthropods play an essential role as intermediate hosts. There is a concise overview of crustacean intermediate hosts of lung flukes that effect man. In last years additional about 11 Plasmodium

(to be continued on p. 216)
A new species of *Anthaxia* from Cyprus (Coleoptera: Buprestidae)

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Taxonomy, *Anthaxia aureoviridis* sp. n., Coleoptera, Buprestidae, Cyprus

Abstract. *Anthaxia* (s. str.) *aureoviridis* sp. n. (A. fulgarana species group) is described, illustrated and compared with *A. fulgarana* (Schrank, 1789)

*Anthaxia* (s. str.) *aureoviridis* sp. n. (Figs 1, 3)

Description. Rather small, flattened, slightly hirsute species with well developed sexual dichromatism: head, pronotum and ventral side of body golden green, pronotum with two large black spots, elytra dark golden, golden-green or brown-green with indistinctly separate blue-green postscutellar stripe, reaching nearly three fifth of elytral length (male), or head and pronotum black, clypeus, pronotal margins and central part of pronotum with blue lustre, elytra brick-red with golden green or blue-green postscutellar stripe, ventral side of body black with green lustre (female); elytra and ventral side of body with microscopic white pubescence.

Head small, clypeus slightly incurved anteriorly, transversely wide and deep longitudinal depression, vertex about 1.7 times as wide as width of eye; sculpture of head very indistinct, consisting of polygonal cells without central granas which are almost covered by microsculpture (mainly in female); eyes small, not projecting beyond outline of head; antennae short, black with metallic lustre in both sexes, the third antennal segment short, only slightly longer than the second or the fourth, segments 5 - 10 triangular, about as long as wide, the 11th segment slightly elliptical.

Pronotum wide, 1.8 times wider than long, slightly vaulted, with large and deep laterobasal depressions; anterior pronotal margin slightly lobate medially, posterior margin almost straight, lateral pronotal margins regularly rounded and incurved before posterior angles; maximum pronotal width in middle; sculpture of laterobasal pronotal depressions consisting of very prolonged cells, forming typical longitudinal keels along pronotal margins, central part of pronotum with rounded and polygonal cells anteriorly and with several irregular transverse wrinkles in posterior part; whole pronotum with basal microsculpture, central part sharply punctured anteriorly.

Scutellum pentagonal, somewhat wider than long, black with golden green lustre (male) or black (female).

Elytra subparallel, 1.5 - 1.6 times as long as wide at humeral part; humeral swellings and basal transverse elytral depressions well developed; elytral epipleurae narrow, not reaching apex of elytra; elytral lateral margins widely rounded in apical third and straight before apex, each elytron rounded separately; apical margins of elytra with extremely fine, almost indistinct lateral serration; elytral structure grany, very homogenous, with fine basal microsculpture and with feeble, short irregular longitudinal and transverse wrinkles; apex of elytra with distinct, large
and deep punctures; elytra somewhat less lustrous than pronotum.

Ventral side of body with fine basal microsculpture, almost matt, reticulate structure more distinct only on basal abdominal sternites; anal sternite simply rounded in both sexes, lateral serration almost indistinct; male mesotrochanters with sharp, metatrochanters with somewhat shorter and blunt spine.

![Figures 1-4. 1 - aedeagus of Anthaxia aureoviridis sp. n. (holotype); 2 - the same, A. fulgorana; male metatibia of A. aureoviridis sp. n. (holotype); 4 - the same, A. fulgorana.]

Legs rather short, male metatibiae with shallow inner preapical incuration or almost straight (Fig. 3), meso- and metatibiae of female not modified.

Aedeagus short, parameres distinctly enlarged in basal part and shortly narrowed before middle, apex of parameres widely, regularly rounded (Fig. 1).

Length 3.8 - 4.9 mm (holotype 4.9 mm), width 1.6 - 2.0 mm (holotype 2.0 mm).

**Type Material.** Holotype - male: Cyprus, Kykko, 5.-7. vii. 1993, M. Kafka leg. Allotype - female: the same data. Paratypes - 17 males and 4 females: the same data (4 males and 1 female); Cyprus, Saltria, 31 v. -3 vi. 1993, M. Kafka leg. (1 male and 1 female); Cyprus, Kykko, 5.-7 vii. 1993, M. Krajcik leg. (9 males and 1 female); Cyprus, Saltria, 31 v. -3 vi. 1993, M. Krajcik leg. (3 males and 1 female). Holotype and allotype in the collection of author. Paratypes in the collection of Ing M. Kafka, Dr M. Krajcik and author.

**Host Plant.** Unknown.
DIFFERENTIAL DIAGNOSIS. *Anthaxia aureoviridis* sp. n. (*A. fulgurans* species group) belongs by colouration of male antennae and sculpture of elytral apex to *A. fulgurans* species complex sensu Bílý (1984). This new species with well developed sexual dichromatism (undeveloped in *A. nigricollis* Abeille, 1904, slightly developed in *A. mellitebris* Obenberger, 1918 - Obenberger 1938) differs from *A. fulgurans* (Schrank, 1789) by fine, homogenous and less lustrous structure of elytra, by form of male metatibiae (Figs 3, 4), indistinct sculpture of frons, by form of aedeagus (Figs 1, 2) and by brick-red elytral colouration of female.

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numae species have been described as parasites of man in parts of Far East, in West Africa and Latin America. Part 3 comprises arthropods as ectoparasites. Discussed here are sources of medical importance that can give rise to generalized or systemic and cutaneous allergic reactions. Insects are represented by hemipterans (genus *Cimex*), sucking insects and flies.

Part 4 concentrates on arthropods as endoparasites in humans. Recorded in this part are zoonotic infections with parasitic nematodes. *Proteocephalus crotali* parasitizes some snakes, and larval stages of this parasite cause the syndrome "halkoun" or "marara" or lesions in internal organs (liver, lungs, eyes). In following chapters included are scabies and demodex infections, myiasis with five families/subfamilies and 16 genera of myiasis-producing dipterans, and finally tungiasis that caused by the tropical chigger or jigger flea *Tunga penetrans*.

Part 5 is concerned with harmful and venemous arthropods. Scorpions of medical importance belong to the Buthidae and Chactidae superfamilies with some 45 genera or species from the Mediterranean region, from Africa, North and South America, from Asia and Australia. In following chapters the whip scorpions and pseudoscorpions are mentioned. Spiders harmful to man include six suborders. Clinical aspects with systemic reactions and necrotic lesions of amethystic/without/venomous/wave/venom/are figured here. Crustaceans contain a diverse collection of arthropods. In addition to their importance as intermediate hosts, a number of spider have been implicated at the cause of poisoning through consumption by man. About 35 tropical or subtropical crustacean species from four classes/subclasses are known or suspected to be toxic to man. In following sections figured are diplapods, chilopods, and insects (Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera) capable to produce damaging bites or dangerous envenomations. In conclusion, a bibliography offers a comprehensive list of references to the primary literature.

This publication is closely related to "A colour atlas of Tropical Medicine & Parasitology", third edition 1989, by W. Peters and H. M. Gilles. It is a vital illustrated guide to a wide range of readers, students, physicians, general practitioners to tropical specialists and medical entomologists. Its patorious form impressive concerning variety of colours and hireness of animal harmful to human health. Some clinical aspects figured here are literally dramatic. This colour atlas presents an essential complement to classical textbooks of tropical medicine, medical zoology and parasitology, in particular entomology.

*Jindrich Jirouš*
Comment on the supraspecific taxon *Tergosmia* and redeescription
of *Osmia agilis* (Hymenoptera: Apoidea: Megachilidae)

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Taxonomy, redeescription, *Osmia agilis*, *Tergosmia*, *Megachilidae*, *Hymenoptera*, *Palearctic region*

Abstract. The position and status of *Tergosmia* Warncke, 1988 within the tribe Osmini is discussed and a
detailed redeescription of *Osmia agilis* Morawitz, 1875 is given.

The peculiarities of *Tergosmia* Warncke

The position of *Tergosmia* that was established by Warncke, 1988 originally as a subgenus of
*Osmia* appears - due to the unusual combination of certain structural characters - unquestionably
un Certain if not somewhat ambiguous. In the case that all the supraspecific taxa described as yet
within Osmini are considered as subgenera of a single large genus *Osmia*, *Tergosmia* is revealed
as an intermediate taxon between the *Osmia*-like and the *Anthocopa*-like subgenera complexes.
Nevertheless if within Osmini a certain number of these supraspecific taxa are virtually
recognized as distinct genera (each of them with a number of respective subgenera) the position
of *Tergosmia* remains doubtful. While several but not insignificant characters (i.e. the lack of a
stria on the ventrolateral portion of tergite 1, the shape of apical margin of the female clypeus,
the short and basally widened uncus of fore and middle tibiae of the females, and the shape of
apical margin of the male tergite 7) recall markedly the genus *Anthocopa*, some others (as the
distinctly punctiform notallices in both sexes, in the male sex the rounded lateral portion of the
apical margin of the tergite 6 without any suggestion of sharply pointed teeth so well pronounced
in *Anthocopa*-like subgenera, the lack of a paired membranous of the gradulus of the sternite 6,
and the only four exposed sternites) correspond on the contrary well with the large complex of
subgenera allied to *Osmia* s. str.

If the point of view to split up the large genus *Osmia* into several distinct genera is a right and
warranted trend in the present classification it seems best to raise *Tergosmia* to the generic level
(including the meanwhile monotypic subgenus *Heterosmia* recently separated from *Tergosmia* by
Tkalčů, 1993) because of its evidently intermediate character; it clearly deviates both from
*Osmia* and from *Anthocopa* and cannot be simply associate with any of them, unless the global
conception of both these genera is considerably altered.

*Osmia agilis* Morawitz, comb. n.

*Osmia agilis* Morawitz, 1875: 88-89, female, male.

After being briefly described in Latin and more extensively so in Russian language from-live
various localities of Middle Asia only little can be found in the literature in regard to this apparently rare, locally distributed and hence poorly known species. Ducke (1900) recapitulating the Latin part of the original description and adding the faunistic record published by Morawitz (1880) obviously did not know it from his own experience and put it - perhaps only due to the incorrectual colour given by Morawitz (1. c.) as "aeono-submacans" (p. 17) - to the Osmia versicolor-group of the subgenus Chalcospis. Friese (1911) followed Ducke (1900) and presented only a very short and insufficient diagnosis in German. Popov (1967: 70) likewise mentioned the species as a member of the subgenus Chalcospis and added one new faunistic record. Recently Zanden (1988: 123) put Osmia agilis to the subgenus Caerutospis, established by himself. The same author (Zanden 1991) published supplementary notes to the original description (p. 49) in addition to the designation of the lectotype (p. 48) and presented (p. 71) four sketches of structural details, i.e. the apical margin of the femaleclypeus in two different views, the apical margin of the male clypeus and the apical margin of the male tergites 6 and 7. Although Warncke (1988) did not include O. agilis in his established subgenus Tergospis, there is no doubt this is where it really belongs as subsequently the same author (Warncke 1992) confirmed.

REDESCRIPTION

FEMALE MORPHOLOGY Inner orbits in their lower two thirds converging below. Mandibles tridentate. Mouth parts of moderate length. Maxillary palp 5-segmented. Sides of galeae with sparse erect hooked yellow bristles, longest basally and gradually becoming short toward apex. Upper margin of lateral ocelli situated distinctly above supraorbital line. Ocellareaecular distance 512 μm, ocellar-ocellar distance 288 μm. Clypeus (like in other Tergospis-species) markedly protuberant (Fig. 1), its lateral margins rather long, apical margin narrow, straight, overhanging base of labrum, polished and slightly impressed transversely, surface of clypeus uniformly covered by dense punctures (20 μm) with interspaces mostly distinctly narrow and polished. Frontoverte- tex, mesoscutum and scutellum with punctuation but slightly coarser (35 μm), less uniformly arranged and less crowded; polished interspaces here and there wider, on frontovertextex intermixed with scattered minute punctures (10 μm) in some places. Size of punctures of genal area similar to that of clypeus. Proximal segments of flagellum as in Fig. 2. Tegulae polished and bare except for fine punctuation (10 μm) of their anterior parts and along outer margins. Propodeal triangle dull throughout with a wide, coarsely roughened basal transverse zone, remaining lower portion obscurely reticulate. Adjacent parts of propodeum equally dull, with shallow, ill defined fine punctures and chaggerened interspaces. Uncus of protibia very short and wide, without a sharp pointed spine (obviously a valid superspecific character, not mentioned by Warncke (1988)). Strigilis as in Fig. 3. Hind coxae with a sharp ventral carina. Tergite 1 with well developed gradulus, disappearing laterally; its basal concave portion medially extensively bare, polished except for shallow reticulation along median longitudinal sulcus. Median part of dorsal surface of tergite 1 moderately densely punctured, punctures round and of rather uniform size (25 μm), interspaces of 1 to 2 puncture width, polished; lateral parts generally more densely punctate with rather narrow interspaces. Ventrolateral portion of tergite 1 without stra. Tergite 2 anterior to gradulus dull, sharply chaggerened throughout, with a few scattered indistinct fine punctures (15 μm). Punctuation of exposed surfaces of tergites 2-5 similar to that of dorsal part of tergite 1, only on tergite 5 slightly denser; a wide belt along apical margin of tergites 4 and 5 abruptly covered with dense confluent small punctures. Tergite 6 with dense and sharply delimited fine (15-20 μm) punctures, separated by very narrow, obscurely chaggerened but rather shining interspaces.

Body length ca. 6.5 mm (according to Morawitz (1875) 7 mm), length of fore wing 5 mm. INSECTUM as indicated for the male sex below. Teeth of mandibles dull reddish-brown.
The colouring defined by Morawitz (1875) as "acneo-submacans" appears very inconspicuous, recently defined by Zanden (1999: 49) as "Abdomen schwach erfarbig".

PUBESCENCE. Colour similar to that of male. No tufts of bristles arising beneath anterior clypeal margin (a supraspecific character, common to all the Tergosmia-species hitherto known, but not mentioned by Warncke 1988). Fasciae of rather long white hairs on tergites 1-3 only laterally; tergites 4 and 5 each with entire band along apical margin, consisting of shorter recumbent white hairs. Scopa whitish.

Figs. 1-12. Tergosmia acme (Morawitz), 1 - Clypeus, female with polished and slightly impressed apical area, 2 - three basal flagellae segments of right antenna, female, 3 - strigilis, female, 4 - head in frontal view, male, 5 - right mandible, male, 6 - palps maxillares, male, 7 - strigilis, male, 8 - tergites 6 and 7 (a = gradulus, b = impunctate swollen and strongly polished area), 9 - same, tergites more exposed, 10 - genitalia, male, in dorsal view, 11 - same in dorso-lateral view, 12 - venation of fore wing, male. Scale for Fig. 6 = 0.5 mm, for others = 1 mm.

MALE-MORPHOLOGY. Inner orbits converging below for their whole length (Fig. 4). Mandibles tridentate (Fig. 5). Mouth parts as in female, but sides of galeae lacking any hooked hairs. Position of ocellar triangle similar to that of female. Ocellocular distance 460 μm, ocellotemporal distance 352 μm. Clypeus with anterior margin markedly 3-lobed (Fig. 4), surface dull, with punctation very fine (15-20 μm) and confluent (otherwise thickly covered with pubescence in fresh specimens) except for anterior lobes which are bare and strongly polished. Palps maxillaries as in Fig. 6. Sculpture of head and thorax similar to that of female; roughened mediobasal portion of propodeal triangle less distinct. Strigilis as in Fig. 7. Hind coxae with only a feeble suggestion of a ventral carina. Sculpture of tergites also similar to the female. Tergites 2-6 each with distinct gradulus, pregradular portion sharply and uniformly shagreened; exposed dorsal parts of these tergites shining, only slightly more densely punctured than in female (tergite 6 but very densely so). Interspaces very narrow to a half puncture width. Tergites 4-6 with very fine punctation along apical margins (similar to that of these parts of tergites 4 and 5 in female sex). Configuration of tergites 5 and 7 as in Fig. 8 and 9; tergite 7 posterior to gradulus slightly
constricted transversely, in front of middorsal emargination with an impunctate swollen and strongly polished area. Margin of sternite 1 moderately arcuate, with a feeble middorsal emargination. Stermites 2 and 3 broadly arcuate. Sternite 4 with broad middorsal margin straight. Stermite 5 with rather deep and greatly widened middorsal emargination. Stermite 6 broadly rounded. Ground between punctures chagrined on sternite 1-5. Genitalia as in Figs. 10 and 11.

Body length ca. 6-7 mm.


Pubescence. Rather long and uneven, dense on clypeus but not very dense on remaining parts of head and thorax, partly so on tergite 1, short on remaining tergites. Colour: pale whitish-yellow on head, pale brownish-yellow on thoracic dorsum. Tergites 2-6 with subapical fasciae of short recumbent whitish hairs. Stermites 1-3 with loose, rather long recumbent hairs along apical margins. Hairs of sternite 4 only short and inconspicuous. A large mediobasal portion of sternite 5 covered with dense short recumbent velvety pubescence, middorsal emargination of sternite 5 with long dense recumbent pale yellow bristles. Stermite 6 having dense short recumbent velvety pubescence on mediobasal portion and short loose inconspicuous hairs on remaining part.


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Fig. 1. Surface specimen of the organ of Corti from the basal region of the cochlea (Vervet Monkey). OHC = outer hair cells; IHC = inner hair cells. Bar = 20 micrometers.

Fig. 2. Surface specimen of the organ of Corti from the apical region of the cochlea (Vervet Monkey). OHC = outer hair cells; IHC = inner hair cells. Bar = 20 micrometers.
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