VĚSTNÍK

ČESKOSLOVENSKÉ SPOLEČNOSTI

ZOOLOGICKÉ

XLII

1978

1

ACADEMIA PRAHA

ISSN 0042 – 6595

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ

ročník XLII

Vydává Čs. společnost zoologická v Academii, nakladatelství ČSAV, Vodičkova 40, 112 29 Praha 1. Tiskne Státní tiskárna, n. p., závod 4, Sámova 12, 10146 Praha 10. — Objednávky a předplatné přijímá PNS, admin. odbor. tisku, Jindřišská 14, 12505 Praha 1. Lze také objednat u každého poštovního úřadu nebo doručovatele. Cena jednoho výtisku Kčs 10,—, roční předplatné (4 čísla ročně) Kčs 40,—. (Tyto ceny jsou platné pouze pro Československo.)

Sole agents for all western countries with the exception of the German Federal Republic and West Berlin JOHN BENJAMINS B. V., Amsteldijk 44, Amsterdam, (Z.), Holland. Orders from the G.F.R. and West Berlin should be sent to Kubon & Sagner, P. O. Box 68, 800 München 34 or to any other subscription agency in the G.F.R. Annual subscription: Vol. 41, 1978 (4 issues). Dutch Glds 63.—

Toto číslo vyšlo v únoru 1978

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ

Roč. / Tom. 42 Čís. / No. 1 February / Únor 1978

*

Bibliografická zkratka názvu časopisu — *Věst. Čs. spol. zool.*
Abbreviatio huius periodici bibliografica

OBSAH — CONTENTS

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 1—14

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

MORNING DEPARTURE OF ROOKS (CORVUS FRUGILEGUS) FROM THE WINTER ROOST

ZDENĚK HUBÁLEK

Received July 2, 1976

Abstract: During eight winter seasons, 151 morning dispersals were observed of rooks (*Corvus frugilegus* L.) and associated jackdaws (*C. monedula*) at two communal roosts. The birds departed in average 36 minutes before the local sunrise, and one minute after the beginning of the local civil twilight (BCT). The apparent correlation in time between the birds' departure from a roost (T_D) and BCT was analyzed in detail. Several factors were found which influenced T_D: principal factor (dominant Zeitgeber) was the light intensity (predetermined by BCT and the cloud cover); major modifying factors were precipitation, relative humidity of air, and season (day length); minor modifying factors were air temperature, snow cover, and the atmospheric pressure increase overnight. An empirical formula has been proposed for the estimation of the probable time of departure of the birds from a winter roost in the area examined.

INTRODUCTION

The rooks wintering abundantly in Czechoslovakia have their breeding areas in central parts of the European U.S.S.R., mostly eastwards of Moscow between 52—57° N and 37—53° E (Jirsík, 1955; Baruš et al., 1972; Ringing Reports of the Czechoslovak Ornithological Society); they arrive to Czechoslovakia during October/November, and depart predominantly in March.

In the winter areas, circadian movements of rooks (i.e., the morning dispersal from a communal roost to feeding places, the movements within the trophic area, and the afternoon return to the roost) were studied by Zdobnitzky (1907), Šedivý (1949), Gramet (1956), Porath (1964), Rappe (1965), Watson (1967), Heitkamp (1970), Riggenbach (1970), Grodziński (1971) and Rothgänger (1971).

In this study, the onset of the morning dispersal of the rooks and associated jackdaws from two communal roosts has been observed and various variables have been evaluated which could determine the time of the departure.

METHODS

Roosts. Two winter roosts were selected and the observations of the bird departure were made during November till March in 1966/67 through 1973/74.

Roost A was located near Židlochovice (49°01′ N, 16°39′ E) at 180 m above sea level in an alluvial forest (*Populus nigra, Fraxinus excelsior, Alnus glutinosa, Salix* spp., *Quercus robur*; the trees were 10 to 23 m high, and a dense shrub stratum was composed of *Sambucus nigra*) on the right riverside of Svratka. This roost persisted for at least 70 years, and it was utilized by 30,000 to 100,000 of rooks and jackdaws (about 10—15% of the total estimates) in the individual winter seasons under investigation. Ninety-five observations were performed of the

morning dispersal of the birds from this roost in the course of 8 winter seasons 1966/67 through 1973/74.

Roost B was located near Vysoké Mýto (49°58′ N, 16°08′ E) at 310 m above sea level in a spruce (*Picea excelsa*) forest with infrequent *Quercus robur, Larix decidua, Fagus silvatica* (the trees were 20 to 25 m high) and a dense shrub stratum (*Sambucus nigra* predominantly). Fifty-six observations were made at this roost in the seasons 1966/67 and 1967/68 when the total estimates of the birds using the roost were 19,000 and 11,000, respectively (about 10% of jackdaws included).

Time of departure (T_D) of the birds was the instant when the first rooks flied away from the roost in a direction to feeding areas.

Astronomical data were read from astronomical tables (Bouška et al., 1966—1974).

The local sunrise time (T_S) was calculated for individual localities and days according to the formula:

$$T_S = T_S' + d_t \cdot d_\varphi + 4d_\lambda$$

where: T_S, the local sunrise time (in Mid-European Time) in a given locality with geographic coordinates (λ; φ)

T_S', the tabular value of the sunrise time (M.E.T.) for $\lambda' = 15°$ E, $\varphi' = 50°$ N

d_t, a correction for solar declination δ:

δ (°):	0	± 4	± 8	± 12	± 16	± 20	± 24
d_t (min.):	0	∓ 1	∓ 2	∓ 2	∓ 3	∓ 4	∓ 5

$d_\varphi = \varphi - 50°00'$

$d_\lambda = 15°00' - \lambda$.

The beginning of civil twilight (BCT) is the instant when the true geocentrical zenith distance of the central point of the solar disk is 96° (solar depression 6°). Total duration of the civil twilight was extrapoled from Table 12 in Mašek (1921) for individual localities and days, and subtracted from the local sunrise time.

The "civil day" length is the interval between BCT and the end of the local civil twilight (after sunset).

The moon phases were read from the atronomical ephemeris.

Meteorological data. Weather variables were followed 30 minutes before the T_S (unless otherwise indicated), and compared with the data read at 7 h a.m. in close meteorological stations of the State Hydrometeorological Institute. The various data include: Air temperature (mercury thermometer); air relative humidity (hair hygrometer); atmospheric pressure (read at 7 h, and recalculated for sea level); the change of atmospheric pressure between 9 h p.m. of the preceding day and 7 h a.m. of the day of observation; atmospheric visibility (fogginess); cloud cover (in tenths); sky illumination at the T_S (light intensity measured by a calibrated photoelectrical exposimeter directed vertically to the sky); wind speed and direction; precipitation; presence of snow cover and hoarfrost.

A calibration of the exposimeter was performed by luxmeter Metra, and the corresponding values were:

Exposimeter relative values:	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Lux:	42	65	115	200	365	740	1750

RESULTS

In all, 151 morning departures of the rooks and associated jackdaws from their winter roosts were observed (the roost A: 95 cases; the roost B: 56 cases) during 1966 till 1974. The birds departed in average 36.1 minutes before the local sunrise (T_S), and 1.4 minutes after the beginning of the local civil twilight (BCT). The apparent correlation in time between the departure of birds from the roost (T_D) and BCT was analyzed in detail. It was revealed that the precipitation delayed the dispersal of the birds markedly (Table 1). Moreover, the cloud cover and the light intensity at T_S (two interrelated variables) were other even more important factors which determined T_D (Table 2). The measurement of the light intensity of the sky is a more objective method than the estimation of the cloud cover. A graphical re-

Table 1. Difference between the time of rooks' departure from the roost (T_D) and the beginning of the local civil twilight (BCT)

	No. of cases	The difference T_D-BCT (in minutes)*)				
		Average ($\bar{x}$)	Standard deviation (s)	Standard error of mean ($s_{\bar{x}}$)	Range of values	
					Minimum	Maximum
All observations	151	+1.41	±7.90	±0.65	—14	+22
Days without precipitation	127	—0.44	±6.64	±0.59	—14	+19
Days with precipitation	24	+11.21	±5.81	±1.19	0	+22

*) +, T_D later than BCT
—, T_D before BCT

presentation showed a linear dependence of the difference (T_D — BCT) on the light intensity at T_S; the regression equations are shown in Table 3 (the days with precipitation excluded). The question arises if the delay in the birds' departure observed on days with precipitation (see Table 1) was not caused by overcast conditions in such days. An analysis is given in Table 4 which demonstrates that precipitation influenced negatively the relative departure time of the birds regardless of the cloud cover. Rainfall caused a delay of T_D more efficiently than snowfall (about 6 minutes against 4 minutes, respectively).

Table 2. Cloudiness 30 minutes before sunrise, the light intensity at the time of local sunrise, and the difference between T_D and BCT
(The days with precipitation not included in this table)

Cloud cover — in tenths:	0—2	2.5—5	6—8	9—10	10	10 dense
No. of observations	26	22	24	19	26	10
Average difference T_D-BCT in minutes*)	—6.5	—4.6	—1.9	+1.3	+5.7	+8.6
Light intensity at sunrise (exposimeter values):	> 6.5	5.8—6.5	5.0—5.7	4.2—4.9	3.6—4.1	< 3.6
Lux:	> 1100	600—1100	350—600	220—350	150—220	< 150
No. of observations	28	27	15	22	22	13
Average difference T_D-BCT in minutes*)	—6.5	—4.0	—1.6	+2.2	+5.0	+7.9

Remarks: T_D, the time of departure of the birds from a roost BCT, the beginning of the local civil twilight
*) „+", T_D later than BCT
„—", T_D before BCT

Table 3. Regression of the difference T_D-BCT on the light intensity at the local sunrise (The days with precipitation excluded)

	Equation (1)	Equation (2)
The regression equation*)	$y = 21.35 - 4.21x_1$	$y = 37.44 - 14.31x_2$
Standard deviation ($s_{y.x}$) from the regression:	$\pm$ 3.580	$\pm$ 3.641
Standard error (s_b) of the *regression coefficient:*	$\pm$ 0.2757	$\pm$ 0.9606
Fiducial limits ($l_{1,2}$) of the regression coefficient for P = 0.05:	— 4.75 — 3.66	— 16.21 — 12.40
Significance of the regression (t-value):	15.26 $P < 0.001$	14.89 $P < 0.001$

*) $y = T_D$ — BCT (minutes)
x_1, the relative exposimeter values of the light intensity of sky at the local sunrise
x_2, the $\log_{10}$ lux values of the light intensity of sky at the local sunrise

Two important factors determining T_D were so revealed (light intensity, precipitation), and an analysis of other variables is presented in Table 5. The relative delays or accelerations one minute or less against the values expected (on the basis of the light intensity at T_S in respective days) could not be considered as significant. Therefore, the factors which delayed T_D

Table 4. The influence of precipitation on T_D

Days with	No. of observations	Average difference T_D-BCT (minutes)	Average light intensity at sunrise — (minutes) exposimeter values x_1	Expected difference T_D-BCT according to the regression (1)	The relative delay of departure (minutes)
No precipitation; cloud cover 10/10; $x_1 < 4.0$	24	+ 6.9	3.42	+7.0	—0.1
Snowfall	11	+ 9.1	3.81	+5.3	3.8
Rainfall or drizzle	13	+13.0	3.46	+6.8	6.2
Precipitation altogether	24	+11.2	3.62	+6.1	5.1

Table 5. The influence of various variables on T_D
(The days with precipitation not included)

	1	2	3	4	5
	No. of observations	Average difference T_D-BCT (minutes)	Average light intensity at sunrise (exposimeter values)	Expected difference T_D-BCT according to equation (1)	Relative delay (+) or acceleration (—) of T_D (minutes)
Roost location					
1) Roost A	83	+0.5	4.99	+0.3	+0.2
2) Roost B	44	—1.1	5.43	—1.5	+0.4
Air relative humidity					
1) More than 95%	11	+1.4	5.52	—1.9	+3.3
2) 91 to 95%	47	+0.3	5.15	—0.3	+0.6
3) 86 to 90%	24	—2.2	5.50	—1.8	—0.4
4) 81 to 85%	19	—0.1	4.52	+2.3	—2.4
5) 76 to 80%	13	—2.8	5.39	—1.4	—1.4
6) less than 76%	7	—0.6	5.58	—2.1	+1.5
Atmospheric visibility					
1) Less than 300 m	18	+2.2	5.14	—0.3	+2.5
2) 300 to 1000 m	15	+1.3	4.88	+0.8	+0.5
3) 1000 to 3000 m	39	+0.4	5.02	+0.2	+0.2
4) 3000 to 5000 m	20	—2.2	5.75	—2.8	+0.6
5) more than 5000 m	26	—1.7	4.97	+0.4	—2.1
Air temperature					
1) Less than —8° C	7	—1.7	5.16	—0.4	—1.3
2) —8 to —5° C	14	—5.1	5.95	—3.7	—1.4
3) —4.5 to —2° C	38	—1.8	5.56	—2.1	+0.3
4) —1.5 to +1° C	35	+1.0	4.84	+1.0	0.0
5) +1.5 to +5° C	27	+3.5	4.46	+2.6	+0.9
6) more than +5° C	6	+3.0	4.08	+4.2	+1.2
Snow cover					
1) continuous	30	—2.3	5.23	—0.7	—1.6
2) discontinuous	25	+0.8	4.73	+1.4	—0.6
3) absent	72	+0.4	5.13	—0.2	+0.6
Hoarfrost					
1) present	19	—4.3	6.28	—5.1	+0.8
2) absent	108	+0.7	4.91	+0.7	0.0
Atmospheric pressure					
1) 750 to 755.5 torr	16	—1.6	5.47	—1.7	+0.1
2) 756 to 761.5 torr	34	+0.2	5.28	—0.9	+1.1
3) 762 to 767.5 torr	33	—0.1	4.92	+0.6	—0.7
4) 768 to 773.5 torr	30	+0.1	5.11	—0.2	+0.3
5) 774 torr and more	13	—0.9	5.18	—0.5	—0.4

(continued)

Table 5 — continued

	1	2	3	4	5
The pressure change overnight					
1) at least —3 torr (decr.)	18	+0.2	4.89	+0.8	—0.6
2) —1 to —2.5 torr	29	—0.9	5.24	—0.7	—0.2
3) —0.5 to +1 torr	39	+0.3	5.20	—0.5	+0.8
4) +1.5 to +3 torr	22	—1.1	5.23	—0.7	—0.4
5) at least +3.5 torr (incr.)	12	—2.9	5.36	—1.2	—1.7
Wind direction					
1) W to N	51	—0.2	5.10	—0.1	—0.1
2) NNE to E	21	—4.4	5.90	—3.5	—0.9
3) SEE to S	34	+0.9	5.03	+0.2	+0.7
4) SSW to WSW	16	+3.4	4.79	+1.2	+2.2
Wind speed (Beaufort's degrees)					
1) 0 to 0.5	13	+4.1	4.24	+3.5	+0.6
2) 1 to 1.5	32	—1.5	5.48	—1.7	+0.2
3) 2 to 3	46	+0.2	5.15	—0.3	+0.5
4) 3.5 to 4.5	21	—0.7	5.20	—0.5	—0.2
5) 5 to 6	15	—0.5	5.24	—0.7	+0.2
Season					
1) November	21	—1.6	5.79	—3.0	+1.4
2) December	40	0.0	5.02	+0.2	—0.2
3) January	27	+0.7	4.90	+0.7	0.0
4) February	30	—0.6	5.07	0.0	—0.6
5) March	9	+2.9	5.18	—0.4	+3.3
"Civil day" length					
1) 574 minutes or less	31	—1.3	5.18	—0.4	—0.9
2) 575 to 594 min	28	+0.6	5.07	0.0	+0.6
3) 595 to 619 min	19	+1.5	4.69	+1.6	—0.1
4) 620 to 649 min	14	—3.4	8.01	—4.0	+0.6
5) 650 to 689 min	15	—0.3	5.31	—1.0	+0.7
6) 690 minutes and more	20	+2.0	4.92	+0.6	+1.4
Moonlight in the morning					
1) moderate to strong	10	—5.9	6.55	—6.2	+0.3
2) weak	21	—2.2	5.55	—2.0	—0.2
3) absent	96	+0.8	4.93	+0.6	+0.2
Moon phase (the day of a lunation)					
1) 26th to 3rd day	35	—0.9	5.11	—0.2	—0.7
2) 4th to 11th day	37	—1.3	5.57	—2.1	+0.8
3) 12th to 17th day (full moon)	23	+2.0	4.86	+0.9	+1.1
4) 18th to 25th day	32	+0.8	4.94	+0.6	+0.2

were: high relative humidity of air (+3 min), presence of fogs (+2.5 min), high air temperature (+1.5 min), southern winds (+2 min), long day (+1.5 m), November (+1.5 min) and March (+3.5 min) periods. On the other hand, the factors accelerating T_D were: r.h. between 76 and 85%

(−2 min), high accelerating T_D were: r.h. between 76 and 85% (−2 min), high atmospheric visibility (−2 min), continuous snow cover (−1.5 min: that causes a higher light intensity through an efficient light reflection and dispersal), a rapid increase of atmospheric pressure overnight (−1.5 min), frost (−1.5 min). The variables with negligible or no significant influence on the relative T_D were: hoarfrost, actual atmospheric pressure, wind speed, moon

Table 6. Seasonal changes of the difference T_D-BCT as related to the civil twilight duration (CT) on clear and cloudy days

Months:	November	December	January	February	March
Average CT at 50°N (minutes)	36.5	38	37	34	32
Average T_D-BCT (in minutes) on:					
1) clear days:	−6.8	−9.5	−6.4	−4.8	−1.5
2) cloudy days:	+6.2	+4.5	+5.2	+5.2	+8.0

phases, moonlight in the morning, and the roost location. Several variables were found to be interrelated: e.g., atmospheric visibility with the relative humidity of air, wind direction with air temperature, season (month) with air temperature. Uninterrelated were, for example, snow cover with r.h. of air, or month with wind direction.

It may be concluded from this analysis that there are several factors influencing the time of departure of rooks from their roosts:

1) Principal factor: light intensity (that is predetermined by the solar depression and the cloud cover);
2) Major modifying factors: precipitation, relative humidity of air, season (day length);
3) Minor modifying factors: air temperature, snow cover, and the atmospheric pressure increase.

An attempt is possible to construct an empirical formula for the estimation of the probable time of departure (T'_D) of the rooks from a winter roost in the area investigated:

$$T'_D = BCT + \sum_{i=1}^{9} C_i$$

where: BCT, time of beginning of the local civil twilight

C_i, the empirical correction terms (in minutes):

C_1, cloud cover at BCT: (in tenths): 10 (dençe): +8.5; 10 (moderate): +6.5; 10 (thin): +4; 9: +1.5; 8: −0.5; 7: −2; 6: −3; 5: −4; 4: −5; 3: −5.5; 2: −6; 1: −6.5; 0: −7.

C_2, snow cover: continuous: −1.5; discontinuous: −0.5.

C_3, precipitation: rainfall or drizzle: +6; snowfall: +4.

C_4, relative humidity of air: more than 95%: +3.5; 91—95%: +1; 76—85%: −2.

C_5, atmospheric visibility: less than 300 m: +2; more than 5,000 m: −2.

C_6, air temperature: below −5° C: −1.5; +1.5° to +5° C: +1; above +5° C: +1.5.

C_7, the atmospheric pressure increase overnight: at least 3.5 torr: −1.5.

C_8, wind direction: SEE, SE or S: +1; SWS, SW or SWW: +2.

C_9, month: November: +1.5; March: +3.5.

A comparison of the differences between the time of the bird departure expected (T'_D) and observed (T_D) has shown in 146 cases tested that both values are in a good accord: Average difference has been 0.58 minutes (T'_D later than T_D), maximum differences have been $\pm$ 8.5 minutes, standard deviation of differences s = $\pm$ 3.33 min, and standard error of mean difference $\pm$ 0.28 min. A further improvement of the empirical formula is therefore possible by adding a correction term -0.5 (minutes).

DISCUSSION

T_D and sunrise

The time of departure of rooks/and/or jackdaws from their winter roosts was foolowed by Zdobnitzky (1907), Aschoff and v. Holst (1958), Lint (1964) and Grodziński (1971): they all observed T_D about 15 to 50 minutes (average 30—35) before sunrise, the finding being in a good agreement with the present results. Moreover, Aschoff and v. Holst (1958) showed a close correlation between T_D of jackdaws and the beginning of civil twilight (BCT) during a winter season. This correlation has been confirmed in the case of rooks in this study, too.

In *Sturnus vulgaris*, T_D was established approximately at sunrise (Wynne-Edwards, 1929/30; Eastwood et al., 1962; Bohnsack, 1968). *Buteo buteo* and *B. lagopus* had their average T_D 42 and 25 minutes before sunrise, respectively (Schuster, 1949; Schnell, 1969). Also in many other bird species, the diurnal activity was observed to start before sunrise: *Turdus merula* 43 min, *Emberiza citrinella* 39 min, *Passer domesticus* 29 min, *Perdix perdix* 26 min, *Phylloscopus trochilus* 26 min, *Parus major* 22—25 min, *Dendrocopos major* 9 min, etc. (cf. Hinde, 1952; Scheer, 1952; Groebbels, 1956; Aschoff and Wever, 1962: Schubert, 1967, Konradt, 1968; Blase, 1971).

T_D and the sky illumination

The cloud cover and the light intensity are interrelated factors and were found by majority of observers to be of great importance for the beginning (or end) of the diurnal activity of the birds. As a rule, clear sky accelerated T_D (or the beginning of activity) by about 10 to 25 minutes and it delays the end of activity against the days with overcast conditions for example in *Corvus frugilegus* (Zdobnitzky, 1907), *C. monedula* (Aschoff and v. Holst, 1958), *Sturnus vulgaris* (Černý, 1959; Schoennagel, 1959; Zedler, 1965; Hamilton and Gilbert, 1969), *Turdus merula* (Heyder, 1933; Grimm, 1957), *Emberiza calandra* (Gyllin, 1967), *Aegithalos caudatus* (Paechnatz, 1936: Brehme, 1970), *Delichon urbica* (Kareila, 1961), *Passer domesticus* (Konradt, 1968), *Galerida cristata* (Krüger, 1970), *Motacilla alba* (Rappe, 1960), *Larus ridibundus* (Figala, 1956, Helbig and Neumann, 1964), *Lyrurus tetrix* (Lind, 1961), *Buteo buteo* (Schuster, 1949). In this study, the average difference between the relative T_D of the rooks on clear against cloudy days has been about 15 minutes.

Schwan (1921/22) used a term "Arthelligkeit" which means that the beginning (or end) of the diurnal activity of each bird species starts (ends) at a specific value of the light intensity. For example, the average light intensity at the time of the activity onset of *Corvus monedula* was 3 lux

(Aschoff and v. Holst, 1958), *Emberiza citrinella* 2.4 lux (Blase, 1971), *Melospiza melodia* 2 lux (Nice, 1943), *Parus major* 1.5 lux (Kluijver, 1950), *Nycticorax nycticorax* less than 1 lux (Hanzák, 1970), *Phylloscopus trochilus* 25 lux (Schubert, 1967), *Sturnus vulgaris* 50—200 lux (Nice, 1935; Bohnsack, 1968).

Clear sky caused a decrease of the light intensity at the time of the diurnal activity onset of *Corvus monedula* (1.2 lux vs. 5.5 lux on cloudy days: Aschoff and v. Holst, 1958), *Emberiza citrinella* (2.2 vs. 4.1 lux: Blase, 1971) and other species (Groebbels, 1956).

T_D and season

However, the characteristic light intensity of a bird species is not constant in the course of a year. In general, the "Arthelligkeit" is in winter markedly lower than in summer in many species of birds. Aschoff and v. Holst (1958) established T_D of jackdaw approximately at BCT in winter season, whereas the bird departure in summer was at the time of a higher altitude of sun (i.e., later than BCT). The duration of the bird activity ("bird day") was identical with the "civil day" length in winter while it was about 90 minutes shorter than the civil day length in the summer season. The average light intensity at T_D was in winter about 3 lux, and a steady increase of this value was observed from early April up to 70 lux in June; a decrease was marked again from the middle October to the winter values. Bohnsack (1968) ascertained that the average sky illumination at T_D of *Sturnus vulgaris* was 50 lux in spring, 50—5,000 lux in summer, and 50—200 lux in autumn, and an analogous relation was shown by Zedler (1965). Hamilton and Gilbert (1969) observed an earlier departure of starlings relative to sunrise as the winter days shorten. Lehtonen (1947) and Hinde (1952) observed in *Parus major* that its activity onset relative to sunrise delayed by 3 to 20 minutes in March compared with January. The lowest annual "Helligkeitsschwelle" in winter was established also in *Emberiza citrinella* (Blase, 1971), *Passer domesticus* (Konradt, 1968) and *Lyrurus tetrix* (Lind, 1961). Palmgren (1949) observed that the beginning of activity before sunrise increased in caged *Erithacus rubecula* from 50 minutes in October to 65—70 minutes in December, and decreased thereafter to about 50 minutes in March. In an experiment of Aschoff (1965), *Carduelis chloris* and *Pyrrhula pyrrhula* started their activity relatively later and roosted earlier with an increasing length of light-time (L); the light intensity at the times of awakening and roosting became brighter when L was lengthened. This activity pattern is an experimental support of all the mentioned field observations and it is also in accord with the relative delay of the rooks' T_D established in this study during the months March and November, i.e. in the months with a relatively longest L of the season examined. Aschoff (1969) has shown that the duration of the diurnal activity (α) of the birds follows L in the course of a year to a limited degree only: when a day becomes very short, α is relatively greater, and v.v. Intrinsic components of an organism work therefore as a certain "buffering system", and the changes of α are lesser than the variability of L.

T_D and other abiotic factors

Rainfall or heavy fogg caused a delay of T_D (or a speed-up of T_A, the time of arrival of birds to a roost) in *Corvus frugilegus* and *C. monedula* (Zdob-

nitzky, 1907; Gramet, 1956; this study), *Sturnus vulgaris* (Zedler, 1965), *Aegithalos caudatus* (Brehme, 1970), *Galerida cristata* (Krüger, 1970), *Emberiza citrinella* (Blase, 1971), and other birds (Scherr, 1952) Snowfall played the same role in the diurnal activity of *Galerida cristata* (Krüger, 1970).

Gramet (1956) observed a relatively earlier T_A of rooks if the winds were strong, and the T_A was delayed in the days with frost and continuous snow cover. Inversely, Kuroda (1961) marked an earlier roost return of *Sturnus cinereus* in correlation with rising ambient temperature. The temperature, however, is a relatively very weak factor in the diurnal rhythms of the locomotor activity of birds: only when the temperature fluctuation is high enough, it can influence the periodicity (Hoffmann, 1970). Pohl (1971) showed experimentally that a frost (−10° C) accelerated the beginning of the locomotor and feeding activity in *Fringilla coelebs* and *F. montifringilla* by about 10 minutes against the temperature of +20° C.

T_D and biotic factors

Many adverse environmental conditions (low temperature, snow cover, etc.) cause higher feeding demands of the birds. Kuroda (1961) observed shorter feeding days in *Sturnus cinereus* when food was abundant. Hamilton and Gilbert (1969) proposed an "optimum efficiency hypothesis" in this connection: Any condition favorable to energy gain or conservation induces the roosting population to abbreviate foraging actions. The influence of food on periodicity of the diurnal activity of birds has been presumed also by Hanzák (1970) and Krüger (1970).

Two social factors influencing T_D were found by several authors: the number of roosting birds, and their acoustic signals. Bartholomew (1943) observed an earlier T_D of cormorants when their number on a roost was higher. Blase (1971), however, mentioned only a decrease of the temporal interindividual variability (or a better synchronization of T_D) when the number of roosting *Emberiza citrinella* was higher. Acoustic synchronization of rooks and jackdaws shortly before T_D was noticed by Zdobnitzky (1907), Gramet (1956), Aschoff and v. Holst (1958), and of many other species by Schwan (1920), Scheer (1940) and Kareila (1961). Under constant experimental conditions, Gwinner (1966) demonstrated a synchronization of the locomotor activity of *Carduelis spinus* and *Serinus serinus* by play-back of the specific songs from tape-records.

Circadian rhythms (CDR)

According to a definition of Sollberger (1965), CDR is an endogenous rhythm with external correlates, where the natural period (19—29 hours) approaches that of external periods. It is obvious that the capacity of an organism to follow external rhythms would enhance the survival potential of the species.

The awakening of birds and other organisms is due to intrinsic stimuli — "internal clock". It was shown repeatedly that CDR of the birds' activity persist even under constant experimental conditions for a long period with their own spontaneous frequency (Aschoff, 1955, 1958; Aschoff and Wever, 1966) — that means that endogenous factors are responsible for the CDR. The beginning of locomotor activity (e.g., the T_D in this study)

or its end are, however, influenced to a certain extent by exogenous factors called by various authors timing factors, synchronizers or zeitgebers (cf. Aschoff, 1954, 1958). The best recognized synchronizer is the diurnal light--darkness periodicity. The synchronizers are of various types (Sollberger, 1965): dominant (light-darkness), weak (mainly biometeorological influences) or subtle (cosmic radiation, etc.). Latent synchronizers can substitute the dominant Zeitgeber when it it absent or inexpressive (Aschoff, 1954, 1958, 1969). Besides abiotic zeitgebers (LD cycle, humidity and temperature periodicity, etc.) there are also biotic ones (acoustic signals, feeding).

A very useful and heuristic hypothesis has been to compare CDR with oscillators (Pittendrigh and Bruce, 1957; Pittendrigh, 1965; Winfree, 1967; Pavlidis, 1969; Pohl, 1971). CDR is considered to be a self-sustained oscillator which oscillate in constant conditions with its own spontaneous frequency. When the circadian oscillator becomes entrained by a periodic factor in the environment (synchronizer), the steady state is characterized by a distinct phase-relationship between the two oscillations (phase-angle difference: Aschoff, 1965; Aschoff and Wever, 1966) which depends on the ration of the natural frequency of the circadian oscillator to the frequency of the Zeitgeber. The interaction of the endogenous and exogenous rhythms (and the competition among the second ones) is of a very complex nature (cf. Aschoff, 1958; Wever, 1965, 1966; Winfree, 1967; Hoffmann, 1970). The organism can be treated as a " variable frequency transformer" which can derive its own periods from environmental signals with different periods (Brown, 1965; van Laar 1970). However, the exogenous factors can be aperiodic, too. According to Brown (1965), the autophasing is a typical sign of CDR, which means a general mechanism for transforming a geophysical periodic input (Zeitgeber) into a circa-periodic output. Sollberger (1965) supposes a cybernetical basis of CDR with the main system components: input — transducer — output — feedback. The feedback can be positive or negative and it accomplishes a homeostasis of the CDR. A living organism's body act in this sense as a transducer with an environmental input (signal), the output being the modulated rhythm.

An important feature of CDR is a variation of the sensitivity of organisms to a Zeitgeber (Bünning, 1958; Aschoff, 1954, 1969; Menaker and Eskin, 1967) in the course of a day, a year, a life of an organism, etc. The locomotor activity of the birds, for example, starts at a lower light intensity (the sensitivity is greater) in winter than in summer (see above).

Wever (1965, 1966) constructed a mathematical model for CDR and on this basis a prediction was made that the twilight duration may be a Zeitgeber. This hypothesis was confirmed experimentally in 3 species of Fringillidae (Wever, 1967): the longer was the twilight period, the earlier occurred the activity relative to the Zeitgeber. The duration of civil twilight (CT) in November through March varies from 32 to 39 minutes at 50° N. In accord with Wever's hypothesis, these changes could be responsible (at least partly) for the seasonal variation of the difference T_D — BCT observed in this study. On clear days, the relative acceleration of T_D was most pronounced in the period of the longest CT (December). Overcast days, however, did not show such a clear trend of the T_D — BCT difference to follow the changes of the CT duration during the winter season (Table 6). On the other hand, this comparison might indicate that the sun ecliptic

angle with the horizon (solar inclination) before BCT could affect the T_D — — BCT difference: the smaller this inclination, the longer is the CT duration and the longer can stimuli of a low light intensity influence the resting birds. This more long-lasting action of the sub-optimal radiation could result in a relative acceleration of T_D.

Information canal for the light is the retino-hypothalamic tract (optico--endocrine control of the CDR) in vertebrates (cf. Nalbandov, 1962). However, the localisation and general function of the timing mechanism in organisms still remains a question (van Laar, 1970). The periodic physiological changes are attributable also to lower organisms including unicellular ones, therefore the view of Pittendrigh (1965) seems to be reasonable that "biological clock" is an intrinsic property of the cellular construction as a whole. One of the cellular bases for the timing might be the RNA synthesis because its inhibition due to the selective action of actinomycin D distorts the rhythms (van den Driesche, 1973).

REFERENCES

Aschoff J., 1954: Zeitgeber der tierischen Tagesperiodik. *Naturwissensch.*, **41** : 49—56.

Aschoff J., 1955: Exogene und endogene Komponente der 24-Stunden Periodik bei Tier und Mensch. *Naturwissensch.*, **42** : 569—575.

Aschoff J., 1958: Tierische Periodik unter den Einfluss von Zeitgebern. *Z. Tierpsychol.*, **15** : 1—30.

Aschoff J., 1965: The phase-angle difference in circadian periodicity. "Circadian Clocks" (ed. J. Aschoff): 262—276. Amsterdam, North-Holland Publ. Co.

Aschoff J., 1969: Phasenlage der Tagesperiodik in Abhängigkeit von Jahreszeit und Breitengrad. *Oecologia* (Berl.), **3** : 125—165.

Aschoff J., and D. v. Holst, 1958: Schlafplatzflüge der Dohle, Corvus monedula L. Proc. 12th Internat. Ornithol. Congr.: 55—70. Helsinki.

Aschoff J. and R. Wever, 1962: Beginn und Ende der täglichen Aktivität freilebender Vogel. *J. Ornithol.*, **103** : 2—27.

Aschoff J. and R. Wever, 1966: Circadian period and phase-angle difference in chaffinches (Fringilla coelebs L.-. *Comp. Biochem. Physiol.*, **18** : 397—404.

Bartholomew G. A., 1943: The daily movements of cormorants on San Francisco Bay. *Condor*, **45** : 3—18.

Baruš V., B. Ryšavý, J. Groschaft and Č. Folk, 1972: The helminth fauna of Corvus frugilegus L. (Aves, Passeriformes, in Czechoslovakia and its ecological analysis. *Přírodověd Práce Ústavů ČSAV* (Brno), N. S., **6** (3) : 6—8.

Blase B., 1971: Zur Beginn und Ende der täglichen Aktivität der Goldammer. *Falke*, **18** : 228—241.

Bohnsack B., 1968: Über den Tagesrhythmus des Staren (Sturnus vulgaris) am Schlafplatz *Oecologia* (Berl), **1** : 369—376.

Bouška J., V. Guth, B. Onderlička, J. Ruprecht et al., 1967—1974: Hvězdářská ročenka, vol. 43—50. Praha, Academia.

Brehme S., 1970: Schlafgewohnheiten von Schwanzmeisen im Winter. *Falke*, **17** : 8—14.

Brown F. A., 1965: A unified theory for biological rhythms. "Circadian Clocks" (ed. J. Aschoff). 231—261 Amsterdam, North-Holland Publ. Co.

Bunning E., 1958: Die physiologische Uhr. Berlin-Gottingen-Heidelberg, Springer Verlag

Bunning E., 1967: Known and unknown principles of biological chronometry. *Ann N.Y. Acad. Sci.*, **138** : 515—524.

Černý W., 1959: Hromadné nocoviště špačka (Sturnus vulgaris) na Velkém Tisém a závislost příletu na světelných podmínkách. *Sylvia*, **16** : 129—139

Eastwood E., G A. Isted and G. C. Rider, 1962: Radar ring angels and the roosting behaviour of starlings. *Proc. Roy. Soc. Lond., B*, **156** : 242—267.

Figala J., 1956: Poznámky k biologii racka chechtavého (Larus ridibundus). Sborník předn. I. celostát konfer. Čs. společ. ornitol.: 67—72. Praha.

Gramet P , 1956: Observations sur le processus d'arrivée et de départ du dortoir chez certaines corbeaux. *Bull. Soc. zool. France*, **81** : 207—217.

Grimm H., 1957: Zum Verhalten der Amsel bei abnehmender Tageshelligkeit. *Falke, Sonderh.*, **3** : 47—55.
Grodziński Z., 1971: Daily flights of Rooks Corvus frugilegus Linnaeus, 1758 and Jackdaw Corvus monedula Linnaeus 1758 wintering in Cracow. *Acta zool. cracoviensia*, **16** : 735—772.
Groebbels F., 1956: Untersuchung uber den morgendlichen Beginn und die abendliche Beendigung der Stimmausserungen von Vogelarten. *Orn. Mitt.*, **8** : 61—66.
Gwinner E., 1966: Periodicity of a circadian rhythm in birds by species-specific song cycles. *Experientia*, **22** : 765—766.
Gyllin R., 1967: Dygnsrytm hos kornsparven (Emberiza calandra). *Vår fågelvärld*, **26** : 19—29.
Hamilton W. J. and W. M. Gilbert, 1969: Starling dispersal from a winter roost. *Ecology*, **50** : 886—898.
Hanzák J., 1970: Denní aktivita kvakoše nočního Nycticorax nycticorax (L.) na kolonii. *Sylvia*, **18** : 5—15.
Heitkamp U., 1970: Schlafplatzbeobachtungen an Corviden. *Vogelk. Ber. Niedersachs.*, **2** : 75—78.
Helbig L., and J. Neumann, 1964: Beobachtungen an einem Schlafplatz von Lachmöwen (Larus ridibundus). *Vogelwarte*, **22** : 161—168.
Heyder R., 1933: Das Zurruhegehen der Amsel, Turdus merula L., in seinem Verhältnis zur Tageshelle. *Mitt. Ver. sachs. Orn.*, **4** : 58—80.
Hinde R. A., 1952: The behaviour of the Great Tit (Parus major) and some other related species. *Behaviour, Suppl.*, **2** : 201.
Hoffmann K., 1970: Zur Synchronisation biologischer Rhythmen. *Verh. Dtsch. zool. Ges.*, **64** : 266—273.
Jirsík J., 1955: Naši pěvci: 41—42. Praha, Nakladatelství ČSAV.
Kareila R., 1961: Beobachtungen über den Tagesrhythmus der Mehlschwalbe, Delichon urbica. *Ornis Fenn.*, **38** : 65—72.
Kluijver H. N., 1950: Daily routines of the Great Tit, Parus m. major L. *Ardea*, **38** : 99—135.
Konradt H.-U., 1968: Beobachtungen zur Übernachtung des Haussperlings. *Falke*, **8** : 278—279.
Krüger S., 1970: Die Nächtigungszeiten und die Nächtigungsweise der Haubenlerche im Ablauf eines Jahres. *Falke*, **17** : 158—163.
Kuroda N., 1961: The roosting behavior and the influencing factors in the Grey Starling. *Jap. J. Ecol.*, **11** : 26—34.
Lehtonen L., 1947: Zur Winterbiologie der Kohlmeise, Parus m. major L. *Ornis Fenn.*, **24** : 32—47.
Lind E. A., 1961: Zweiphasigkeit im Morgenflug der Birkhuhns (Lyrurus tetrix). *Ornis Fenn.*, **38** : 96—105.
Lint A., 1964: Tartu ümbruse vareslaste öobimustavadest. *Loodus. Seltsi Aastar.*, **56** : 167—188.
Mašek B., 1921: Hvězdářská ročenka, ročník 1. Praha, Jednota Čes. Mat. Fys.
Menaker M. and A. Eskin, 1967: Circadian clock in photoperiodic time measurement: A test of the Bünning hypothesis. *Science*, **157** : 1182—1185.
Nalbandov A. V., 1962: The role of the endocrine system in the control of certain biological rhythms in birds. *Ann. N.Y. Acad. Sci.*, **98** : 916—925.
Nice M. M., 1935: Some observations on the behavior of starlings and grackles in relation to light. *Auk*, **52** : 91—92.
Nice M. M., 1943: Studies in the life history of the Song Sparrow. *Trans. Linn. Soc. N.Y.*, **6** : 1—328.
Paechnatz H., 1936: Aus dem Tageslauf uberwinternder Schwanzmeisen. *Vogelzug*, **7** : 175—179.
Pavlidis T., 1969: Populations of interacting oscillators and circadian rhythms. *J. theoret. Biol.*, **22** : 418—436.
Palmgren P., 1949: Studien über die Tagesrhythmik gekäfigter Zugvogel. *Z. Tierpsychol.*, **6** : 44—86.
Pittendrigh C. S., 1965: On the mechanism of the entrainment of a circadian rhythm by light cycles. "Circadian Clocks" (ed. J. Aschoff): 277—297. Amsterdam, North-Holland Publ. Co.
Pittendrigh C. S. and V. G. Bruce, 1957: An oscillator model for biological clocks. "Rhythmic and Synthetic Processes in Growth" (ed. D. Rudnick): 75—109. Princeton, Univ. Press.
Pohl H., 1971: Über Beziehungen zwischen circadianen Rhythmen bei Vogeln. *J. Ornithol.*, **112** : 266—278.
Porath F., 1964: Ein Beitrag zur Ökologie der Saatkrähe (Corvus frugilegus L.). *Z. angew. Zool.*, **52** : 31—47.
Rappe A., 1960: Le dortoir citadin de la Bergeronnette grise, Motacilla alba L. *Gerfaut*, **50** : 209—222.
Rappe A., 1965: Notes sur des dortoirs de Corvides. *Gerfaut*, **55** : 4—15.

Riggenbach H. E., 1970: Vorkommen und Schlafplätze der Dohle Corvus monedula in der Umgebung von Basel. *Orn. Beob.*, **67** : 255—269.
Rothgänger H., 1971: Beobachtungen an Krähensammelplätzen. *Falke*, **18** : 351—353.
Scheer G., 1940: Über den Frühgesang der Vögel. *Verh. Orn. Ges. Bayern*, **22** : 137—160.
Scheer G., 1952: Beobachtungen und Untersuchungen über die Abhängigkeit des Frühgesangs der Vögel von inneren und äusseren Faktoren. *Biol. Abhandl.*, H. 3/4 : 1—68.
Schnell G. D., 1969: Communal roosts of wintering Rough-legged Hawks (Buteo lagopus). *Auk*, **86** : 682—690.
Schoennagel E., 1959: Schlafplatzflug der Stare im Verhältnis zur Tageshelligkeit. *Vogelwarte*, **20** : 52—55.
Schubert M., 1967: Probleme der Motivwahl und der Gesangsaktivität bei Phylloscopus trochilus (L.). *J. Ornithol.*, **108** : 265—294.
Schuster L., 1949: ex Blase (1971).
Schwan A., 1920: Vogelsang und Wetter, physikalisch-biologisch untersucht. *Pflügers Arch.*, **180** : 341—347.
Schwan A., 1921/22: Über die Abhängigkeit des Vogelsanges von meteorologischen Faktoren untersucht auf Grund physikalischer Methoden. *Verh. Orn. Ges. Bayern*, **15** : 9—42, 146—186.
Šedivý J., 1949: Havraní kolonie v Pátku nad Ohří. *Sylvia*, **11/12** : 66—72.
Sollberger A., 1965: *Biological Rhythm Research*. Amsterdam-London-New York, Elsevier Publ. Co. 461 pp.
van den Driesche T., 1973: Généralités sur les cycles biologiques et biochimiques. *Bull. Union océanogr. France*, **5** : 29—30.
van Laar W., 1970: A contribution to the problem of the concept "biological clock". *Acta Biotheor.*, **19** : 95—139.
Watson A., 1967: The Hatton castle rookery and roost in Aberdeenshire. *Bird Study*, **14** : 116—119.
Wever R., 1965: A mathematical model for circadian rhythms. "Circadian Clocks" (ed. J. Aschoff): 47—63. Amsterdam, North-Holland Publ. Co.
Wever R., 1966: Ein mathematisches Modell für die circadiane Periodik. *Z. angew. Math. Mech.*, **56**; Sonderh.: 148—157.
Wever R., 1967: Zum Einfluss der Dämmerung auf die circadiane Periodik. *Z. vergl. Physiol.*, **55** : 255—277.
Winfree A. T., 1967: Biological rhythms and the behavior of populations of coupled oscillators. *J. theor. Biol.*, **16** : 15—42.
Wynne-Edwards V. C., 1929/30: The behaviour of starlings in winter. *Brit. Birds*, **23** : 138—153, 170—180.
Zdobnitzky F., 1907: Das Winterleben unserer Corviden (insbesondere von Corvus frugilegus L.) in der weiteren Umgebung Brünns. *Z. mähr. Landesmus.*, **7** : 98—124.
Zedler W., 1965: Beobachtungen an den Schlafplätzen des Stars (Sturnus vulgaris) im Zentrum von München. *Anz. Orn. Ges. Bayern*, **7** : 283—298.

Author's address: Zdeněk Hubálek, Parasitologický ústav ČSAV, Flemingovo nám. 1, 166 32 Praha, ČSSR

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — Str. 15—22

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

THE MORNING PASSAGE OF WINTERING ROOKS (CORVUS FRUGILEGUS) AND JACKDAWS (C. MONEDULA) (AVES: PASSERIFORMES)

ZDENĚK HUBÁLEK

Received July 2, 1976

Abstract: Rooks and jackdaws were counted passing over an observation point disstanced 21 km from a communal winter roost. Observations were made on 50 mornings during 4 winters. The first bird arrived in average 8 minutes before local sunrise, and the time of arrival was markedly influenced by the cloud cover and wind direction. The altitude of the flight was 5 to 200 (usually 15 to 30) m in dependence on the wind direction and speed. The cummulative temporal curve of the numbers of the passing birds was described by a logistic equation. Fifty per cent of the birds flew over in average 15 minutes after the beginning of the morning passage, and about 85% of the birds passed in the first 30 minutes. Analysis of variance showed a lengthening of the flight duration on the mornings with the snow cover and with the winds opposing or perpendicular to the normal flight direction. On the days with a moist ground, the movements lasted shorter.

INTRODUCTION

Circadian movements of wintering rooks (*Corvus frugilegus* L.), jackdaws (*C. monedula* L.) and/or crows (*C. corone* L.) from a communal winter roost to the feeding areas and vice versa were observed by many authors (Zdobnitzky, 1907; Šedivý, 1949; Gramet, 1956, Aschoff and v. Holst, 1960; Porath, 1964; Lint, 1964; Rappe, 1965; Watson, 1967; Konstantinov and Andreev, 1969, Heitkamp, 1970; Riggenbach, 1970; Grodziński, 1971 and Rothgänger, 1971). However, various quantitative features of the regular morning and evening flights have not been studied sufficiently.

The morning passage of the birds was selected for the purpose of this study, because it is much more regular in time and shorter than the evening return to the roost (Gramet, 1956; Lint, 1964; Grodziński, 1971). Numerous environmental variables have been evaluated statistically which could influence the pattern of this morning flight of rooks and jackdaws from a winter roost.

METHODS

Observations were made on 50 mornings (foggy days excluded) during 4 winters (November to February — 1966/67, 1970/71, 1971/72, 1972/73) from a building in the town Brno, Czechoslovakia (49°12′20″ N, 16°35′30″ E) at the elevation 280 m above sea level. The winter roost of the birds was distanced 21 km from this observation post in SSE direction, near Židlochovice (49°00′45″ N, 16°39′20″ E) at 180 m above sea level (for the description of this roost, see Hubálek, 1978). In the various winter seasons under investigation, the roost was utilized by 30,000 to 100,000 of rooks and jackdaws (the second species composed about 10—15% of the tota-

estimates). The terrain between the roost and the observation site varies from flat to gently rolling, with several limited groves and groups of trees, and human settlements. Regular inspections were made of the area between the roost and the observation point, but no other roost of these birds was found in the periods of observations.

The observations continued for 120 minutes following the arrival of the first bird, and the birds (rooks and jackdaws — jackdaws composed usually about 10% of the total number of the birds) were counted in 5 min intervals passing in the direction (with a deviation of ±20°) from the roost over a constant area 200 × 250 metres in front of the building where observations were made.

Weather variables were observed 20 min before sunrise. The instant of the local sunrise was computed from the astronomical ephemeris (cf. Hubálek, 1978).

RESULTS

The average flight speed of the dispersing rooks was 45—50 km/h, and the distance between the roost and the observation point was covered by the nonstop flying birds in about 30 min under calm conditions according to repeated observations. The first bird arrived at the observation post in average 7.8 min before the local sunrise ($s = \pm 8.3$ min, $s_x = \pm 1.2$ min), and the range of the 50 arrival values fluctuated between −25 min (before sunrise) to +9 min (after sunrise). Cloudiness determined significantly ($P < 0.01$; t-test) the mean arrival time; on overcast days, the first bird was observed in average 2.9 min before sunrise, on partly cloudy days 9.6 min, while on clear days the mean arrival time was hastened to 14.7 min before the local sunrise. Another important factor determining the arrival time was the direction of wind. Average arrival of the first bird on mornings with the following wind or calm was 14.1 min before sunrise, whereas in the mornings with the winds perpendicular or opposing to the normal direction of the birds' flight it was 3.2 and 3.4 min, respectively. An estimation of other environmental factors influencing the arrival time of the first morning rook has not been performed because a more appropriate set of data was collected for this purpose by observing the time of departure of the birds directly at the roost in another study (Hubálek, 1978).

The birds flew in scattered flocks, small groups or single individuals (as described also by Aschoff and v. Holst, 1960; Heitkamp, 1970; Grodziński, 1971) 5 to 200 m above the observation area, with the most frequent altitude of flight 15 to 30 m (Zdobnitzky, 1907: 5 to 300 m; Heitkamp, 1970: 20 to 50, rarely up to 200 m). The low-passing (5—10 m) birds were observed on the mornings with marked opposing winds, whereas on the days with the following winds, the birds flew very high over the area (50 to 200 m). A similar pattern was observed in migrating birds of various species by Bruderer (1967), and it indicates that the flying birds in general search for the air currents with an aerodynamic optimum. The velocity of the air laminar flow is namely the lowest near the ground and it increases with the growing altitude. Under strong perpendicular winds, the bird flight was very irregular both in direction and speed, and the normal flight lines of dispersing birds were sometimes shifted to other areas in such days.

The average duration of the morning passage of majority of the birds was about 40 min (Grodziński gives the figure 25—45 min): 50% of the birds flew over in average 15 min after the beginning of the flight, and about 85% of rooks and jackdaws passed in the first 30 min. Figure 1 shows the average number of the "north-flying" birds over the area in 5-min intervals (Frequency curve) and average cummulative number of birds from the onset

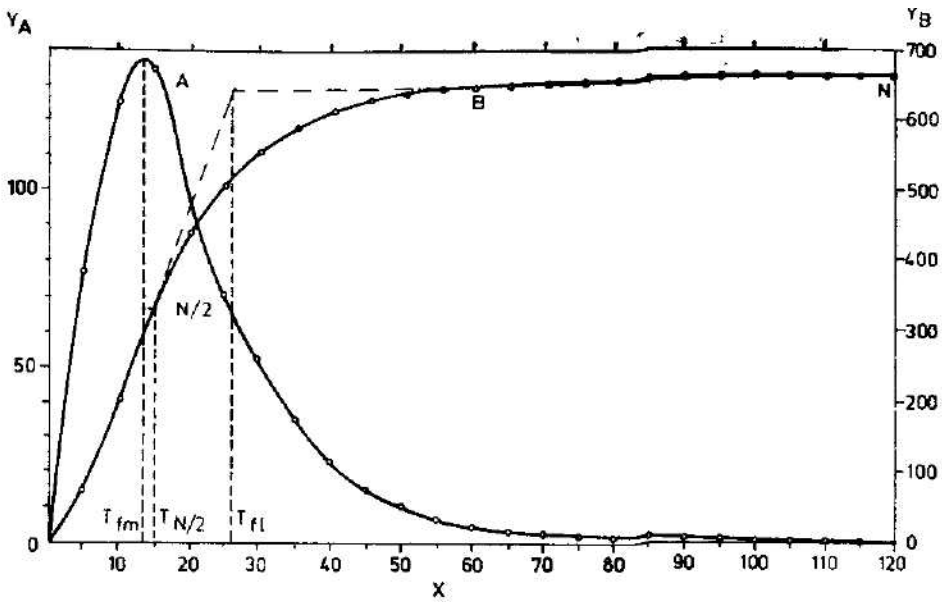


Fig. 1. Average frequency and cummulative curves of the morning passage of rooks and jackdaws (50 observations). A — frequency curve, B — cummulative curve, X — minutes after first the north-flying bird, Y_A — number of passing birds per 5-min interval, Y_B — number of birds from the onset of the passage, N, $T_{N/2}$, T_{fm}, T_{fl} — various quantitative characteristics of the passage — cf. Results for explanation.

on the morning passage (Cummulative curve). The cummulative curve was approximated by the exponential equation (a variant of the logistic curve):

$$n = 180 + 483 \text{ tgh } 0.05\ (t - 9)\ ,$$

where n is the cummulative number of birds passing over the area in the time t (minutes) from the beginning of the morning passage, and tgh is tangens hyperbolicus. Average difference between n observed and n computed (absolute values) at individual 5-min intervals over the 120-min observation period was 5.3 specimens which indicates a relatively very good approximation.

Table 1. Characteristics of the passage curve (50 observations). The symbols explained in the text

	N (specimens)	%N/30m (per cent)	$T_{N/2}$ (minutes)	T_{fm} (minutes)	T_{fl} (minutes)
Average ($\bar{x}$)	666.2	84.6	14.9	15.5	23,1
Minimum	122	56	7	5	12
Maximum	1328	98	28	40	40
Standard deviation (s)	± 306.89	± 10.21	± 4.97	± 7.45	±6.12
Standard error (s_x)	± 43.40	± 1.44	± 0.70	± 1.06	± 0.86

Table 2 Matrix of correlation coefficients (r) among the characteristics of the passage curve (50 observations) Italicized values significant ($P < 0.001$), the other insignificant ($P \geq 0.05$)

	N	%N/30m	$T_{N/2}$	T_{fm}
%N/30m	−0.219			
$T_{N/2}$	+0.218	*−0.631*		
T_{fm}	+0.003	*−0.496*	*+0.873*	
T_{fl}	+0.286	*−0.681*	*+0.695*	*+0.815*

Various quantitative characteristics were derived from the passing curves which are demonstrated in Figure 1

N: The total number of rooks and jackdaws passing the observation area along the direction from the roost ("north-flying" birds)

%N/30m The number of the north flying birds in the first 30 min after arrival of the first bird, in per cent of the total number of the passing birds (N)

$T_{N/2}$ The time (in minutes after the first arriving bird) when 50% of the total number of north flying birds pass

T_{fm} The time when the frequency of the passing birds is greatest (the peak of the frequency curve)

F_{fl} The time of marked flexion of the cummulative curve

The average values and other statistical parameters of these characteristics are surveyed in Table 1 Table 2 shows correlations among individual features of the passing curves of 50 observations N was independent on the other characteristics, $T_{N/2}$, T_{fm} and T_{fl} all were positively interrelated, and

Table 3 Regression equations between the characteristics of the passage curve (Pairs with insignificant correlations excluded)

Independent variate (x)	Dependent variate (y)	The regression equation
$T_{N/2}$	T_{fm}	$y = 1.307x - 3.92$
	T_{fl}	$y = 0.854x + 10.37$
	%N/30m	$y = -1.297x + 103.91$
T_{fm}	$T_{N/2}$	$y = 0.582x + 5.84$
	T_{fl}	$y = 0.669x + 12.69$
	%N/30m	$y = -0.680x + 95.18$
T_{fl}	$T_{N/2}$	$y = 0.565x + 1.83$
	T_{fm}	$y = 0.993x - 7.40$
	%N/30m	$y = -1.138x + 110.88$
%N/30m	$T_{N/2}$	$y = -0.307x + 40.84$
	T_{fm}	$y = -0.362x + 46.14$
	T_{fl}	$y = -0.408x + 57.59$

Table. 4 Abiotic variables and the quantitative characteristics of the morning passage of the birds (Analysis of variance)
Significant ($P < 0.01$) F values italicized

Variable	No. of cases	Average values				
		N	%N/30m	$T_{N/2}$	T_{fm}	T_{fl}
Month						
November	8	564	79.5	13.4	14.4	21.7
December	17	654	88.8	14.9	15.8	22.8
January	14	653	81.9	13.9	13.1	22.8
February	11	777	85.5	17.2	19.0	24.8
F		0.99	2.08	1.23	1.41	0.43
Day length (minutes)						
Below 500	9	590	89.7	14.1	15.3	22.2
500 to 524	17	711	85.1	14.1	13.6	22.3
525 to 574	14	642	78.7	16.0	16.7	25.2
575 or more	10	694	87.6	15.3	17.1	22.1
F		0.44	2.89	0.47	0.61	0.80
Precipitation						
Present	4	558	88.3	11.5	10.0	19.0
Absent	46	676	84.3	15.2	16.0	23.4
F		0.67	0.54	2.02	2.45	1.96
Hoarfrost						
Present	6	596	84.0	14.7	15.3	23.7
Absent	44	677	84.7	14.9	15.5	23.0
F		0.45	0.03	0.04	0.02	0.08
Moist ground						
Markedly	7	640	93.8	12.1	11.9	19.1
Not markedly	43	671	83.1	15.3	16.1	23.6
F		0.08	*7.51*	2.50	1.99	2.99
Snow cover						
Present	19	681	80.8	17.8	19.7	26.8
Absent	31	669	87.0	13.1	12.9	20.8
F		0.08	4.54	*13.30*	*12.17*	*14.58*
Cloudiness (tenths)						
Overcast – dense (10)	11	565	86.4	13.7	14.0	21.3
Overcast (10)	16	697	86.0	15.4	15.3	23.9
Partly cloudy (6–9)	12	728	82.7	14.8	16.2	22.9
Clear (0–5)	11	657	83.0	15.3	16.5	23.8
F		0.76	0.44	0.26	0.24	0.45
Surface air temperature (°C)						
Below −3	12	663	86.1	14.0	15.3	22.2
−3 to −0.5	15	751	80.9	15.9	14.9	24.8
0 to +2	16	571	84.2	15.3	17.1	23.2
Above +2	7	708	91.3	13.1	13.4	20.4
F		1.18	1.81	0.63	0.46	0.92

Table 4 — continued

Variable	No. of cases	Average values				
		N	%N/30m	$T_{N/2}$	T_{fm}	T_{fl}
Relative humidity (%)						
93 or more	11	542	87.6	12.6	13.6	20.6
90 to 92	14	676	86.4	13.9	13.2	21.8
81 to 89	17	691	82.0	17.3	18.5	25.6
80 or less	8	770	83.2	14.5	15.6	23.1
F		1.20	0.89	2.51	1.67	1.89
Horizontal visibility (at ground level)						
Below 1 km	12	508	85.8	13.7	14.3	22.2
1 to 3 km	20	719	84.4	15.4	16.2	23.7
3 to 5 km	7	701	87.7	13.1	13.7	21.0
Above 5 km	11	723	81.8	16.2	16.5	24.1
F		1.86	0.53	0.85	0.36	0.52
Atmospheric pressure (torr)						
Below 760	8	607	79.5	13.7	13.9	21.6
760 to 764	13	660	83.2	14.2	15.4	23.0
764.5 to 770	13	651	85.0	16.0	16.1	24.4
Above 770	16	714	88.1	15.0	15.9	22.7
F		0.29	1.42	0.42	0.16	0.35
Barometric change overnight (torr)						
At least −2 (decrease)	10	772	84.8	15.1	14.7	23.3
−1.5 to −0.5	10	640	81.2	15.2	15.6	23.5
0 to +1.5	19	597	88.2	13.3	14.7	20.8
At least +2 (increase)	11	715	81.4	17.1	17.5	26.3
F		1.05	1.61	1.45	0.38	1.98
Surface wind direction						
Following wind or calm	19	621	88.4	11.8	11.2	19.6
Perpendicular wind	9	679	81.5	15.1	15.2	23.7
Opposing wind	22	701	82.7	17.4	19.4	25.8
F		0.43	2.19	*8.13*	*7.94*	*6.32*
Surface wind speed (m/sec)						
Very low (1.5 or less)	19	648	84.3	15.3	16.1	23.7
Moderate	17	630	85.4	13.6	13.3	21.5
Relatively high (5 or more)	14	734	84.0	15.8	17.4	24.0
F		0.62	0.08	0.87	1.25	0.88

negative correlations occurred between %N/30m on the one hand, and $T_{N/2}$, T_{fm} and T_{fl} on the other hand. The regression equations between significantly correlated features of the flight curve are presented in Table 3.

The analysis of variance was used to examine the influence of 16 abiotic variables on the quantitative characteristics of the morning passage of rooks and jackdaws. At first, significant ($P < 0.001$) differences were shown in N among individual years resulting from unequal population sizes in respective winters. In winter, the roost population of rooks and jackdaws remains fairly constant until late February (unpublished observations). Average total

number of passing birds was at the observation point in 1966/67 (8 cases) 396, in 1970/71 (7 cases) 750, in 1971/72 (19 cases) 556, and in 1972/73 (16 cases) 896 specimens.

No significant differences between years were found in the other quantitative characteristics (%N/30m, $T_{N/2}$, T_{fm}, T_{fl}). In the following analysis, N values were used which were adjusted by multiplying individual N's observed in the winters 1966/67, 1970/71, 1971/72 and 1972/73 by the coefficients 1.682, 0.888, 1.198 and 0.745, respectively. These corrections were derived from the average N for all observations (666), and they nivelized N's of individual years. The analysis of variance showed (Table 4) no significant (at 1% level) influence of the following variables on the quantitative features of the birds' morning passage: day length, month, hoarfrost, cloudiness, air temperature, rel. humidity, horizontal visibility, atmospheric pressure and its change, wind speed, the stage of the lunar cycle (the last variable not included in the Table 4) and possibly precipitation (small number of the mornings with a precipitation tested). No variable influenced the adjusted total number of passing birds. However, no firm conclusions can be drawn without larger samples because of the relatively large variance in N. It seems, for example, that N increased from November to February, possibly for the trophic reasons. %N/30m was significantly higher on the mornings with a markedly moist ground; $T_{N/2}$, T_{fm} and T_{fl} were greater (it means a longer duration of the passage) on days with the snow cover and on mornings with the winds opposing or perpendicular to the normal direction of flight.

On 12 mornings, two or more marked peaks were noted of the frequency curve. A significantly ($P < 0.05$; chi-square test) greater proportion of these cases was formed in December and January (the day length 500 to 575 min) as compared with November and February. Several peaks of frequency were also observed more often on the mornings with following winds. In some cases, the second peak of the north-flying birds occurred distinctly shortly after a sudden change of weather (snowfall, the change of wind direction and/or speed).

DISCUSSION

Rooks, jackdaws and crows dispersing to the feeding areas from a winter roost are funnelling into almost constant flight lines which are located along various orientation points (rivers, roads, railways, churches or other buildings, etc.) as was observed repeatedly by Zdobnitzky (1907), Konstantinov and Andreev (1969), Heitkamp (1970), Rothgänger (1971) or Grodziński (1971). Nevertheless, the total numbers of birds passing over individual observation sites (N) fluctuate considerably during a winter — even on consecutive days (Konstantinov and Andreev, 1969; Heitkamp, 1970; Grodziński, 1971). A high fluctuation of N was confirmed also in our set of 50 morning observations because the coefficient of variation was $V = \pm 41.2\%$ of the mean (adjusted N values).

A limited number of the frequency curves of the morning passage was shown for *Corvus corone* by Konstantinov and Andreev (1969) and for *C. frugilegus* by Grodziński (1971). The last author observed at a point the total number of passing birds on 3 days 1500 to 2500 specimens and counted 70—82% of the passing birds in the first half of the morning flight.

Biotic variables were not evaluated in this study which could also influence the pattern of the morning passage of the rooks and jackdaws: e.g.,

the energetic state of the birds, the abundance (accessibility) of food in the trophic area or the number of individuals of the winter population. Hamilton and Gilbert (1969) described the radar observations of the starling (*Sturnus vulgaris*) dispersal from a winter roost, and they found that the limits of dispersal varied with the roost population size: as the population increased, more distant resources were utilized (intraspecific competition for food). Surprisingly, distances as much as 50 to 80 km from the roost were covered by a part of the dispersing birds. According to my visual observations in various areas of Czechoslovakia, the limits of dispersal of rooks from great winter roosts are 45 to 50 km, and the range covered by majority of the birds is about 20 to 25 km from a roost. These circadian movements suggest interesting analogies with the circaannual migrations of birds, indicating in many respects the importance of further studies.

REFERENCES

Aschoff J. and D. v. Holst, 1960: Schlafplatzflüge der Dohle, Corvus monedula L. *Proc. 12th Internat. Ornithol. Congr., Helsinki* 1958: 55–70.

Bruderer B., 1967: Zur Witterungsabhängigkeit des Herbstzuges in Jura. *Orn. Beob.*, **64** : 57 to 90.

Gramet P., 1956: Observations sur le processus d'arrivée et de départ du dortoir chez certains corbeaux. *Bull. Soc. zool. France*, **81** : 207–217.

Grodziński Z., Daily flights of rooks Corvus frugilegus Linnaeus 1758 and jackdaws Corvus monedula Linnaeus 1758 in Cracow. *Acta zool. cracoviensia*, **16** : 735–772.

Hamilton W. J. and W. M. Gilbert, 1969: Starling dispersal from a winter roost. *Ecology* **50** : 886–898.

Heitkamp U., 1970: Schlafplatzbeobachtungen an Corviden. *Vogelsk. Ber. Niedersachs.*, **2** : 75–78.

Hubálek Z., 1978: Morning departure of rooks (Corvus frugilegus L.) from the winter roost. *Věst. Čs. spol. zool.*, **42** : 1—14.

Konstantinov V. M. and V. N. Andreev, 1969: Zimovki vranovych ptic v srednej polose Evropejskoj časti SSSR. *Učen. Zapiski Moskov. Gosud. Pedag. Inst. Im. V. I. Lenina*, no. **362** : 135–144.

Lint A., 1964: Tartu ümbruse vareslaste ööbimistavadest (Roosting of *Corvidae* in Tartu). *Loodus. Seltsi Aastar.*, **56** : 167–188.

Porath E., 1964: Ein Beitrag zur Ökologie der Saatkrähe (Corvus frugilegus L.) *Z. angew. Zool.*, **51** : 31–47.

Rappe A., 1965: Notes sur des dortoirs de corvides. *Le Gerfaut*, **55** : 4–15.

Riggenbach H. E., 1970: Vorkommen und Schlapfplätze der Dohle Corvus monedula in der Umgebung von Basel. *Orn. Beob.*, **67** : 255–269.

Rothgänger H., 1971: Beobachtungen an Krähensammelplätzen. *Falke*, **18** : 351–353.

Šedivý J., 1949: Havraní kolonie v Pátku nad Ohří. *Sylvia*, **11** : 66–72.

Watson A., 1967: The Hatton castle rookery and roost in Aberdeenshire. *Bird Study*, **14** : 116 to 119.

Zdobnitzky F., 1907: Das Winterleben unserer Corviden (insbesondere von Corvus frugilegus L.) in der weiteren Umgebung Brünns. *Z. mähr. Landesmus.*, **7** : 98–124.

Author's address: Zdeněk Hubálek, Parasitologický ústav ČSAV, Flemingovo nám. 2, 166 32 Praha, Czechoslovakia.

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 23—42

Department of Systematic Zoology, Faculty of Natural Sciences, Charles University, Prague

THE INCIDENCE OF MITES OF THE FAMILY BDELLIDAE IN MOSSES FROM A SPRUCE WOOD IN SW-BOHEMIA

FRANTIŠKA LELLÁKOVÁ-DUŠKOVÁ

Received June 10, 1976

Abstract: Results are presented of a study on the incidence of mites of the family Bdellidae in moss samples collected in a spruce wood near Blatná, SW-Bohemia. This group had previously not been studied in Czechoslovakia. In 19 moss species we found 7 species of mites of the family Bdellidae represented by *Bdella iconica* Berlese, *B. muscorum* Ewing, *B. semiscutata* Sig Thor, *Bdellodes longirostris* (Hermann), two heavily damaged species of the genus *Thoribdella*, *Cyta latirostris* (Hermann) and *Biscirus silvaticus* (Kramer). *Bdellodes longirostris* is new for Bohemia. We recorded the numerical representation, the incidence of the individual developmental stages, and obtained new knowledge of the biology and ecology of the species recovered.

INTRODUCTION

During recent studies on the incidence of soil mites of the family Bdellidae from various localities, attention has been given to species of this group living in moss in the vicinity of the Hydrobiological field station near Blatná.

The only study available on mites colonizing moss and lichen off trees in parks and forests was made by Pschorn-Walcher and Gunhold (1957). These authors found two members of the family Bdellidae, i. e., *Cyta latirostris* (Hermann) and *Bdella dispar* Koch. Apart from several brief notes in various faunistic papers, this group of mites has not been studied as yet in Czechoslovakia. The first to mention these mites were Kirchner (1864) and Světlík (1883—4). Kirchner recorded the finding of the species *Cyta latirostris* (he still called it *Ammonia latirostris*) and *A. megacephala* from forest mosses. Except for species of the genus *Scirus*, all remaining species in his paper are mostly synonyma of the species *Bdella longicornis* L. It is of interest that Kirchner divided the mites on the basis of their "natural habitats" which indicates that he did pay attention to the biotopes colonized by these mites.

Světlík in his "Contribution to the identification of our mites" recorded various representatives of mites, but of the family Bdellidae the species *Bdella* sp. only which he still believed to feed exclusively on plants. He placed into this family the genus *Scirus* and also the genera *Linopodes* and *Cheyletus*. More records on the finding of members of this family in various parts of our country are contained in papers by Willmann (1938, 1939, 1954, 1955, 1956) and Pax and Maschke (1935).

MATERIALS AND METHODS

We collected at random samples measuring 15—20 cm by 15—20 cm. The samples had to be of such large size in view of the low numerical representation of the individual mite species

Table 1. Survey of species recovered and their developmental stages in the individual samples

Date	Species	L	P	D	T	♀	♂	Total
Off stone and rock								
Nov. 11, 1964	*Bdella iconica*			2	2	4	1	9
samples no. 1—3, 5—6	*Cyta latirostris*	7	1	14				22
	Odontoscirinae**							
July 11, 1966	*Bdella iconica*		1	1				2
sample no. 3								
August 20, 1966	*Bdella iconica*			5	2			7
samples no. 1, 2								
March 26, 1967	*Bdella iconica*						2	2
samples no. 2, 3	*Bdella semiscutata*					1		1
	Bdella muscorum		1		1			2
July 28, 1968	*Bdella iconica*			7	27			34
samples no. 3, 4	*Bdella muscorum*			1	3	3		7
January 6, 1970	*Cyta latirostris*		30	14	46			90
samples no. 5—9	*Bdella muscorum*	3		1				4
	Bdella iconica			4	2	5		11
	Biscirus silvaticus	2						2
January 26, 1970	*Cyta latirostris*	1	35	52	5			93
samples no. 1—6, 12	*Bdella muscorum*	14	12	21	14	15		76
January 1, 1974	*Cyta latirostris*			2	18	1		21
samples no. 6, 9, 11	*Bdella muscorum*			5	8	10		23
	Bdella iconica					1		1
From forest paths								
Nov. 11, 1964	*Cyta latirostris*	3		8				11
samples no. 4, 7—9	*Biscirus silvaticus*	2						2
	Bdella muscorum					1		1
	Bdella iconica					3	2	5
July 11, 1966	*Bdella iconica*		3	6				9
samples no. 1, 2								
July 19, 1966	*Bdella iconica*		4	13	2			19
samples no. 1, 2								
August 20, 1966	*Bdella iconica*			3				3
samples no. 3, 4	*Bdella muscorum*					1		1
	Biscirus silvaticus					1		1
March 26, 1967	*Bdella muscorum*				4	1		5
samples no. 1, 4	*Cyta latirostris*		2	1				3

** One greatly damaged specimen (*Thoribdella ?*)

Table 1 continued

Date	Species	L	P	D	T	♀	♂	Total
Jan. 26, 1970 samples no. 7—11	*Cyta latirostris*	1	18	4				23
Nov. 19, 1972 samples no. 1—5, 8	*Cyta latirostris*			5	4			9
	Bdella iconica					1		1
Jan. 2, 1973 samples no. 1, 2	*Cyta latirostris*		7	4				11
Jan. 1, 1974 samples no. 7—8, 13, 17	*Bdela iconica*			3	6	14	6	29
	Cyta latirostris		3	14	17			34
	Bdella muscorum				4			4
From forest clearings								
Aug. 20, 1966 samples no. 5, 6	*Bdella iconica*			6	3			9
	Thoribdella sp.			1				1
July 27, 1967 samples no. 1—3	*Bdella iconica*		1	1	2			4
July 28, 1968 samples no. 1, 2	*Bdella iconica*		1	6	17			24
	Biscirus silvaticus			2	1	6		9
Jan. 26, 1970 samples no. 13—15	*Cyta latirostris*		23	17				40
Nov. 19, 1972 samples no. 6—7	*Cyta latirostris*				1			1
Jan. 2, 1973 samples no. 3—4	*Cyta latirostris*		6					6
	Bdella iconica				1	2		3
January 1, 1974 samples no. 3—5, 12	*Bdella iconica*					11		11
	Cyta latirostris				7			7
Inside a high forest								
Sept. 30, 1955	*Bdela iconica*					1		1
Oct. 1, 1955	*Bdella iconica*					1		1
Oct. 2, 1955	*Bdellodes longirostris*					1		1
	Bdella iconica					1		1
June 16, 1956	*Bdella iconica*			1				1
	Cyta latirostris			1				1
Jan. 1, 1974 samples no. 10, 14—16	*Bdella muscorum*		1		7			8
	Cyta latirostris		1	6	16	9		32

Table 1 continued

Date	Species	L	P	D	T	♀	♂	Total
Weathered wall overgrown with moss and grass, in a forest								
Jan. 6, 1970	*Bdella muscorum*	1		2	17	44		64
samples no. 1—4	*Cyta latirostris*			1	3			4
Jan. 1, 1974	*Bdella muscorum*			4	9	3		16
samples no. 1, 2								
Dam of fishponds								
March 20, 1974	*Cyta latirostris*		4	6	8			18
samples no. 1—4	*Bdella iconica*			1		4	1	6

L = larva P = protonymph D = deutonymph
T = tritonymph ♀ = female ♂ = male

in them. The samples were cut off with a knife and transported in linen- or plastic bags to the laboratory. In several instances the mites were shaken out directly from the moss to a white dish (15 by 12 cm) and placed immediately in the fixative (80% alcohol).

Humidity was estimated by means of a 5-grade scale suggested by Klika et al. (1954) from dry (grade 1) to wet (grade 5); pH was not measured.

The bdellids were extracted from the moss in a Berlese-Tullgren funnel modified for specific use by the Department of Soil Zoology. After fixation with 80% alcohol, the mite material was prepared with a method which Atyeo (1960) had taken over from Beer (1954). After clearing the mites with PVA—L—P, they were mounted in Hoyer's modification of Berlese's mounting medium.

Acknowledgements

Thanks are due to RNDr. J. Váňa, Department of Systematic Botany, for the identification of the individual moss species. To Associate Professor Dr. M. Kunst I am indebted for invaluable suggestions during the course of this study. Further appreciation is acknowledged to Mrs. E. Laštovková for technical assistance.

DESCRIPTION OF THE LOCALITY UNDER CONSIDERATION AND ITS CHARACTERISTICS

The area examined is part of the Blatná basin and extends over the western part of the Blatná Hills (Blatenská pahorkatina) (550—600 m above sea level). The altitude of the field station is 460 m. Typical of the area are numerous fishponds. The biggest component of this part of the pluton is a biotite — to amphibolite — biotite granodiorite of a medium granularity, the so-called Blatná type. The Blatná granodiorite is traversed by numerous veins of various types and different age.

The samples were taken from a monoculture of spruce and comprized a total of 19 moss species *Mnium spinulosum* Br. et Sch., *Mnium cuspidatum* Hdw., *Pohlia nutans* Lindb., *Dicranum polysetum* (= *undulatum*) Br. et Sch., *Dicranum scoparium* How., *Brachythecium rutabulum* Br. et Sch., *Plagiothecium curvifolium* Schlieph., *Hypnum cupressiforme* Hdw., *Pleurosium schreberi* Moenk. (= *Hypnum schreberi* Brid.), *Hylocomium splendens* Br. et Sch., *Tortula muralis* Hdw., *Syntrichia ruralis* Brid., *Bryum caespiticium* Hdw., *Amblystegium serpens* Br. et Sch., *Polytrichum formosum* Hdw., *Ptilidium ciliare* (L.) Hampe., *Ptilium crista castrensis* De Not., *Rhytidiadelphus squarrosus* Wtf., *Barbilophosia barbata* (Sch. et Loeske). Mostly, these were

common species occurring from low — to highlands except for the species *Mnium spinulosum* and *Ptilium crista castrensis* with an infrequent incidence, and the species *Barbilophosia barbata* and *Ptilidium ciliare* with a rare incidence. Most numerous in the area under consideration were the species *Pleurozium schreberi*, *Dicranum scoparium*, *Plagiothecium curvifolium*, *Hylocomium splendens*, *Hypnum cupressiforme*, *Mnium spinulosum* and *Pohlia nutans*. The only lichen species present in the samples was *Cladonia furcata* Schr.

In order to assess characteristics of climatic conditions in the locality we measured soil and air temperature and relative air humidity, and made records of the weather. Since none of these factors influenced either the incidence or the number of species and individuals they have not been tabulated.

SURVEY OF THE SPECIES RECOVERED

Subfamily Bdellinae Grandjean, 1938

Bdella iconica Berlese

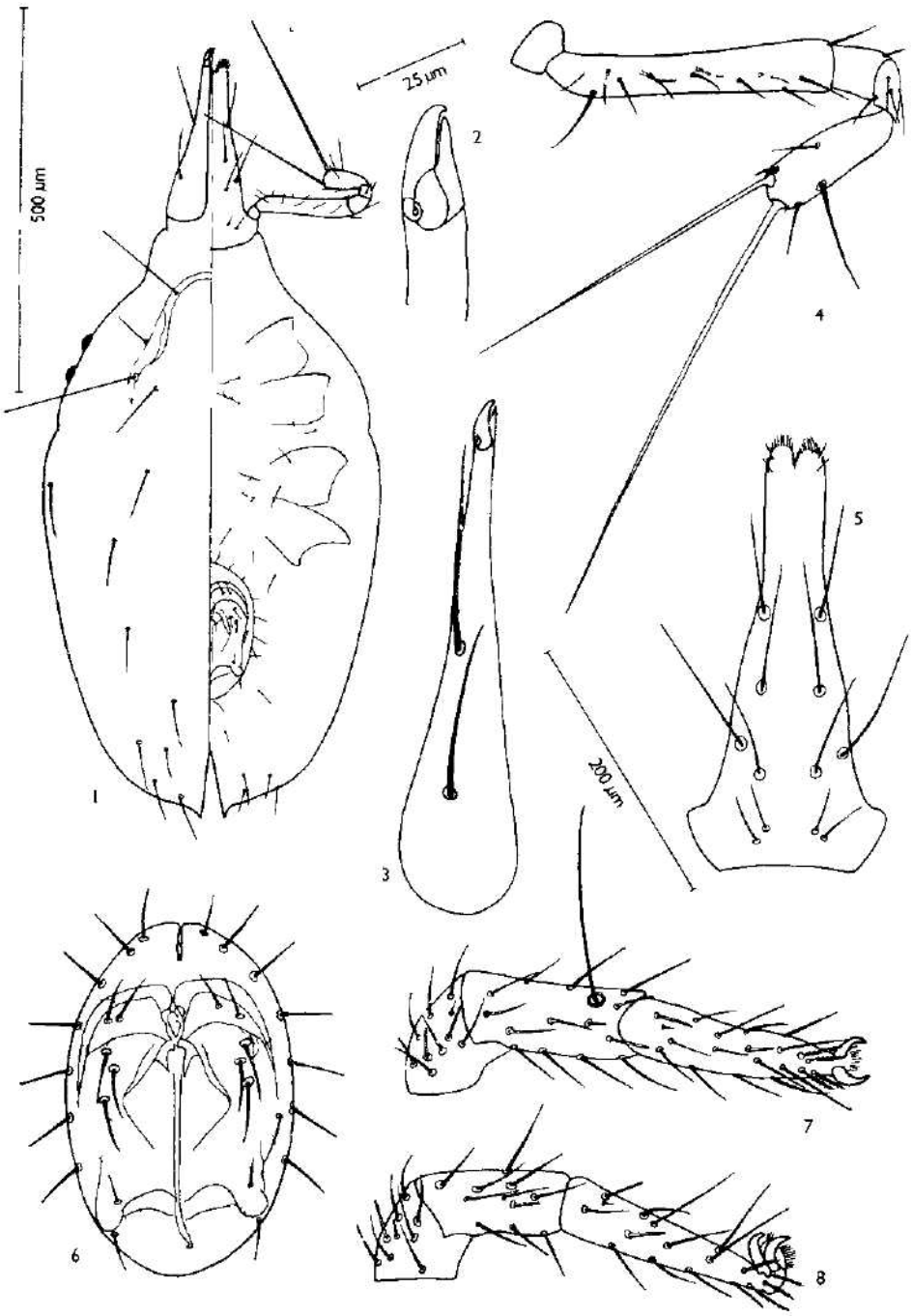
(Figs. 1—10)

This species is closely related to the species *Bdella longicornis* L. and *B. septentrionalis* Atyeo et Tuxen. One of the principal diagnostic signs typical of the species *Bdella iconica* is a short palpal tibiotarsus (Fig. 4), and the striation of the propodosomal shield (Fig. 9) with caudal striae in its anterior portion, longitudinal striae in the posterior portion and straight striae between the posterior sensilla. Wallace and Mahon (1973) mentioned a further character in their key — the ventral hypostomal setae vh_1 and vh_4 which are directed laterally and therefore the main line is formed by other setae (Fig. 5). A typical feature of all adult individuals of B. iconica is the dorsal shield (Fig. 9) which is bell-shaped according to Berlese's "signum".

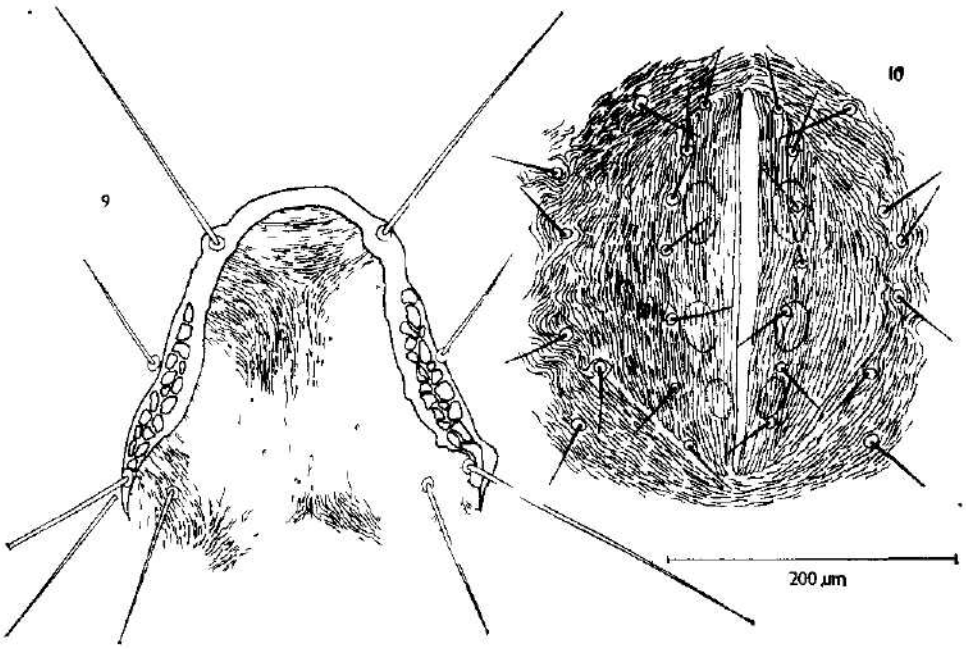
The chelicera of individuals in my material is on the average four times longer than wide, the average number of setae on the palpal basifemur is 13, the tibiotarsus is 3 times longer than wide (2.6—3.2 ×). In addition to drawings of the principal diagnostic signs (Figs. 2, 3, 4, 5, 7, 8), drawings have been made of a total aspect (Fig. 1), the genital plate ♂ (Fig. 6) and ♀ (Fig. 10) because I failed to find their illustrations in the literature.

Geographical distribution: Berlese (1923) gave a description of the species from Italy (Florence — Giardino di Boboli, under bark, und Umbria — Sardegna Bosa, in moss), and from Germany; Thor (1931) reported it from Germany, Italy and Norway, on plants, and from North Africa (1932); Schweizer (1951) from Switzerland, Mihelčič (1958) from Spain, Sellnick (1958) from central and S-Europe. Atyeo and Tuxen (1962) redescribed the species on the basis of material from Iceland, where it appears to be common. The authors found it mainly in sites close to the central uplands, preferably in stands of *Dryas* and the moss *Grimmia*. Atyeo (1963) collected it in Australia (Canterbury; Balmoral State Forest) in the litter fall of *Pinus radiata*. Gomezauri (1963) reported its incidence in Georgia, Alberti (1973) in the GFR in beech litter and under stone heaps in a field.

No records are available on the incidence of *Bdella iconica* from either Moravia or Slovakia. Willmann (1955) found it in SE-Saxony which is a territory extending partly into our country. Although it has not been reported from any other parts of Czechoslovakia, it must be distributed all over the country since I myself found it in a number of localities in West-, Central- and East Bohemia. It was present in material collected in the



Figs 1—8: *Bdella iconica*, male: 1 — total aspect, 2 — chela, 3 — chelicera, 4 — left palpus, 5 — ventral aspect of gnathosoma; 6 — genital region; female: 7, 8 — three distal segments of legs I and II



Figs. 9—10. *Bdella iconica*, 9 — striation pattern on the dorsum of the propodosoma of male; 10 — genital region of female

Pavlovské vrchy in Moravia, in the High Tatra Mts. in Slovakia and elsewhere.

Bionomics: The incidence of *Bdella iconica* is numerous in moss, but occurs also in a variety of terrestrial habitats such as in grass, under rock, in litter fall of coniferous and deciduous trees, etc. Atyeo and Tuxen (1962) suggested its predilection to dry or very dry biotopes. In my own experience the species appears to have broad temperature and humidity tolerances. It occurred in both extremely dry and extremely wet samples. Being a predator as all other bdellids, it colonizes almost every terrestrial habitat where food material (mainly Collembola) is plentiful. It has often been found in pit-fall traps.

At Blatná, *B. iconica* was present in 46% of samples (Table 1), and was the third most numerous bdellid species recovered 22% (a total of 193 individuals) Adult individuals dominated in samples collected in October (2 ♀), November (2 D, 2 T, 8 ♀, 3 ♂), January (7 D, 9 T, 33 ♀, 6 ♂), March (1 D, 4 ♀, 3 ♂); deutonymphs and tritonymphs were in the majority in samples collected in the summer months (July: 10 P, 34 D, 48 T; August: 14 D, 5 T). Adults and older nymphal stages hibernate.

Atyeo and Tuxen (1962) collected in Iceland adult specimens from June 25 to August 19, nymphs from July 1 to 11, and on August 8. Alberti (1973) collected adult individuals in October and November the same as I did.

Tab. 2. *Bdella muscorum* (measures in μm)

Total length	Total width	Length of gnathosoma (+ chelicerae)	Segments of pedipalpus: I.	II.	III.	IV.	V.
584 (506—697)	229 (183—291)	196 (183) (182—208) (166—199)	17	93 (87—100)	17 (13—21)	16 (13—18)	50

Bdella muscorum Ewing

(Figs. 11—23)

Ewing described the species in 1909 from a female found in moss in Muncie, Illinois. Atyeo (1960) synonymized with it 4 more species described by Ewing in later years as *Bdella lata* Ewing, 1910; *B. subnigra* Ewing, 1910; *B. muscorum* var. *minnesotensis* Ewing, 1913; *B. recens* Ewing, 1937. Sig Thor (1931) placed *B. muscorum* among "doubtful" species and suggested that the species under consideration may be a variety of *B. longicornis*.

B. muscorum closely resembles *B. semiscutata* Sig Thor and *B. longicornis*, but may be distinguished mainly by the palpal chaetotaxy (Fig. 16), the chaetotaxy of the legs (Figs. 14, 15), and the striation on the dorsal shield (Fig. 18). Apart from other principal diagnostic signs (Figs. 12, 13, 19, 20 bis 23), a schematic illustration is given of the total aspect (Fig. 11) and the genital plate ♀ (Fig. 17).

Thor did evidently not differentiate in his material *B. muscorum* from *B. semiscutata* counting, e.g., 8—19 setae on the palpal basifemur. One of the most important diagnostic signs differentiating *B. muscorum* from *B. semiscutata* is the number of palpal setae which is 8—11 for the former, 13 and more (13—19) for the latter. The species may readily be confused with one another mainly for a marked similarity in the structure of the dorsal propodosomal shield.

I measured a female of this species collected on January 6, 1970, assessed the chaetotaxy of the pedipalpus and compared my data with Atyeo's (1960) (Tables 2 and 3).

Our data agree in the chaetotaxy of the pedipalpus, but differ considerably in those on total size in that my maximum values correspond to Atyeo's minimum values. On the average, individuals from my material are 20 to 30% smaller than those of Atyeo's material. The same applies to the length of the pedipalpal segments 2, 3, 4 and 5 which are 20% shorter in my material.

Tab. 3. *Bdella muscorum* (after Atyeo, 1960)

Total length	Length of gnathosoma (+ chelicerae)	Segments of pedipalpus: I.	II. + III.	IV.	V.
825 (710—1170)	224 (215) (206—331) (207—300)	15 (13—18)	135 (133—198)	26 (20—35)	60 (55—99)

(Blatná, 6. 1. 1970)

Des	Ves	Number of setae on pedipalpal segments: II.	III.	IV.	V.
149 (141—154)	105 (96—108)	10 (9—11)	1	4	6

Geographical distribution: Atyeo (1960) found *B. muscorum* in a number of states of the U.S.A. (California, Colorado, New Mexico, Kansas, Arkansas, Tennessee, Michigan, Illinois, Maryland), in Alaska (Point Barrow, Chandler Lake region, Umiat, District of Mackenzie), Germany (Ost-Holstein), ČSSR and Iceland. Gomezauri (1963) recorded its incidence from Georgia, Alberti (1973) found it in moss tufts on a stone wall in the German Federal Republic.

Bionomics: *Bdella muscorum* shows a marked predilection to moss, but I failed to recover it in clearings and open spaces. According to Alberti (1973) *B. muscorum* feeds on members of the genus *Nanorchestes*, on Tetranychidae and Collembola.

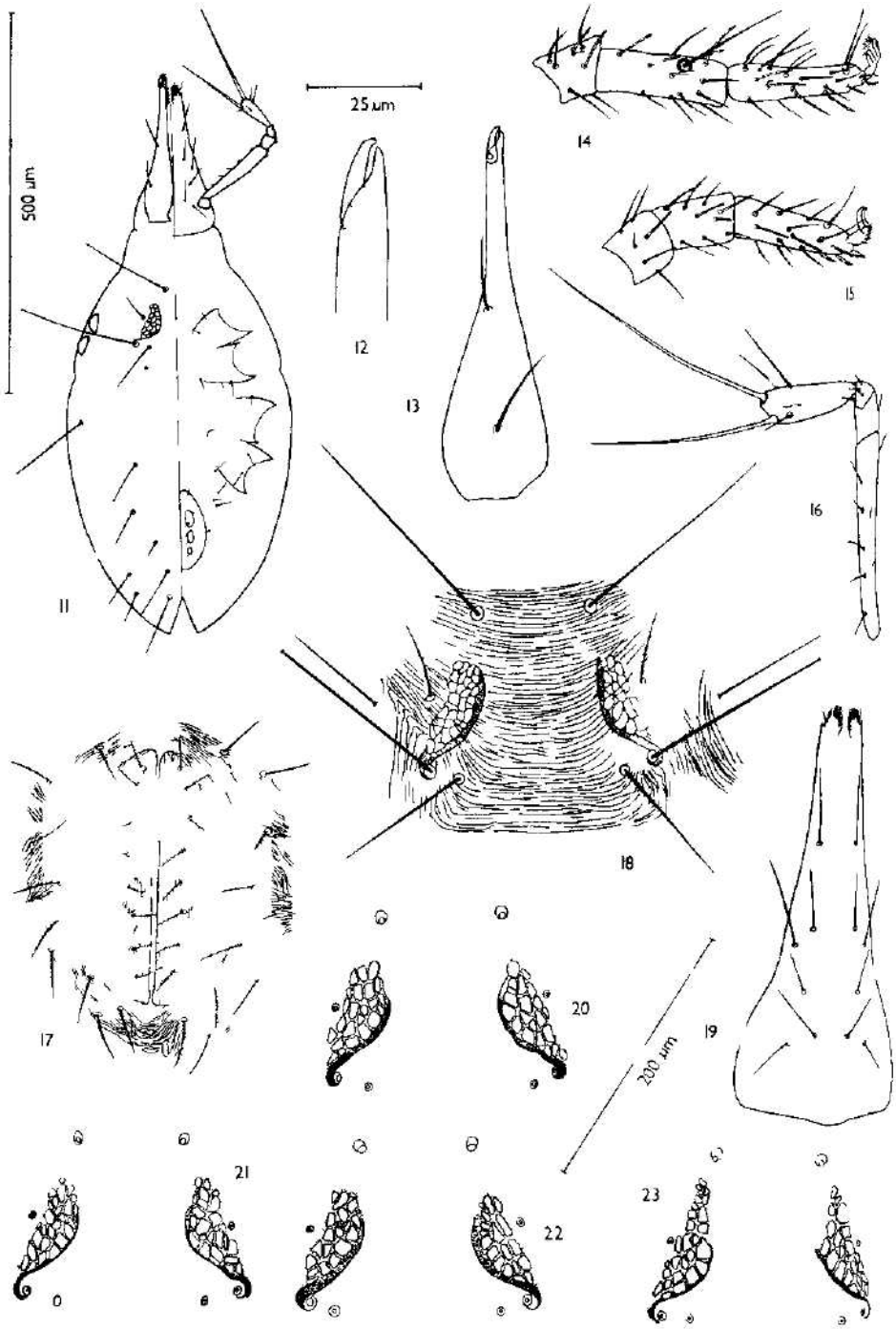
In my material from Blatná, *B. muscorum* was present in 22% of samples, which is half the number of samples containing *B. iconica*. However, the number of individuals in the samples surpassed that of *B. iconica* attaining 24% (a total of 211 individuals) of all bdellids recovered. In January the samples comprized 18 L, 13 P, 33 D, 59 T and 72 ♀ showing a dominance of tritonymphs and adult females. Samples collected in March contained 1 P, 5 T and 1 ♀, July samples 1 D, 3 T and 3 ♀, August samples 1 ♀ and November samples also 1 ♀ only.

Ewing (in Atyeo, 1963) found females in April and June, Atyeo himself in November (Arkansas), February (Kansas) and June (Michigan).

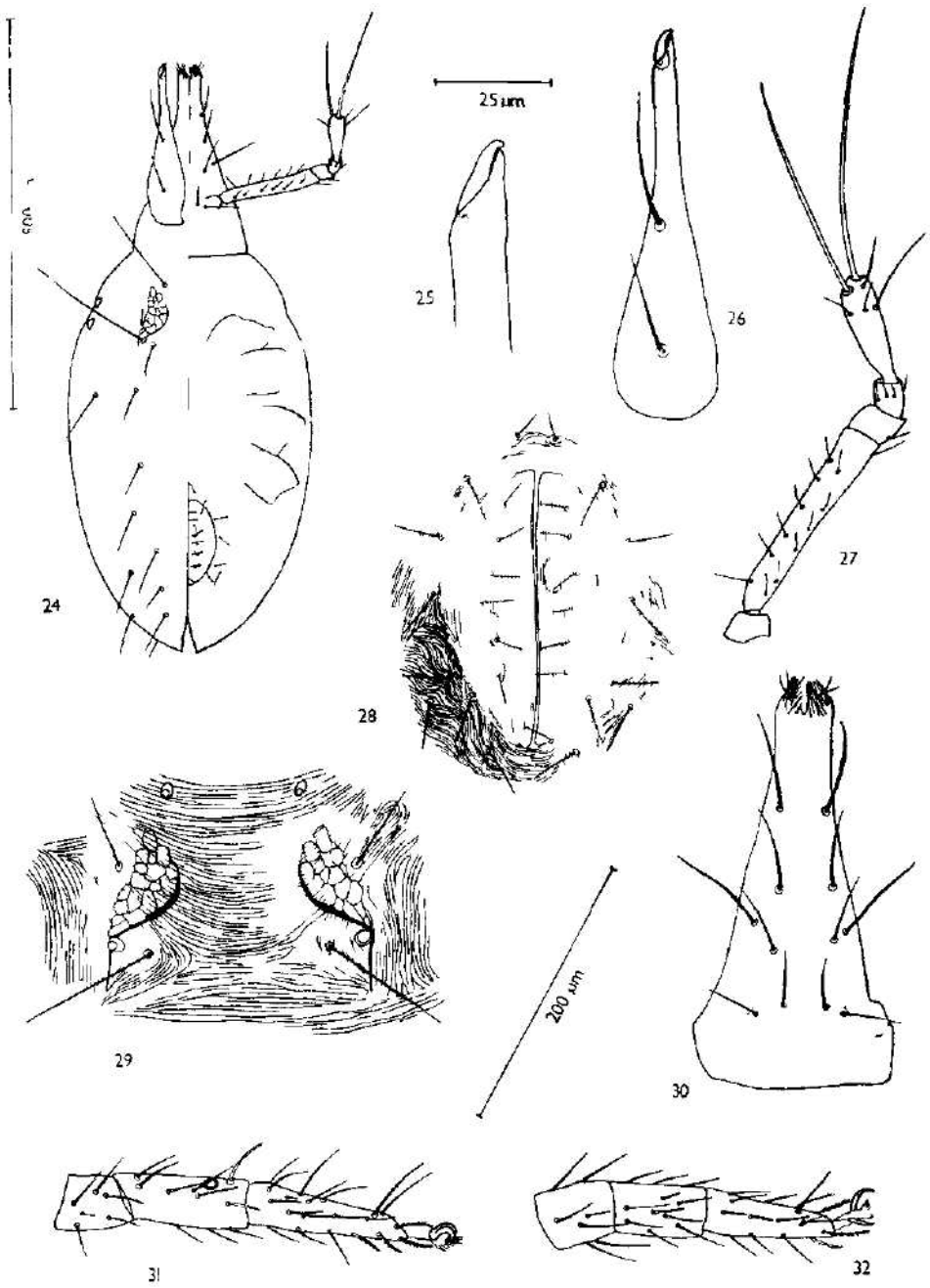
Also for this species my observations of the life cycle agree with Alberti's (1973) data in that he found hibernating eggs, older nymphs and adult specimens. However, adult specimens may be found throughout the year whereby a minimum incidence occurs roughly in mid-summer (July — in my samples August). Individuals which had hibernated complete their development in the summer while those hatched late in the spring (May) have as yet no attained the adult stage. This accounts for the occurrence of two developmental periods (the life cycle is annual) — one at the end of the winter, the other in the autumn.

(measures in μm)

Des	Ves	Number of setae on pedipalpal segments: II.	III.	IV.	V.
175 (110—220)	129 (129—182)	10 (8—11)	1	4	6



Figs 11—23 *Bdella muscorum*, female 11 — total aspect, 12 — chela, 13 — chelicera 14, 15 — three distal segments of legs I and II, 16 — right palpus, 17 — genital region, 18 — striation pattern on the dorsum of the propodosoma, 19 — ventral aspect of gnathosoma 20, 21, 22, 23 — internal apodemes



Figs 24—32 *Bdella semiscutata* female 24 — total aspect, 25 — chela, 26 — chelicera, 27 — right palpus, 28 — genital region, 29 — striation pattern on the dorsum of the propodosoma, 30 — ventral aspect of gnathosoma, 31, 32 — three distal segments of legs I and II

Tab. 4. *Bdella semiscutata* (measures in μm)

Total length	Total width	Length of gnathosoma (+ chelicerae)	Segments of pedipalpus: I.	II.	III	IV.	V
740	310	220	17	108	25	21	54

Bdella semiscutata Sig Thor

(Figs. 24—32)

Thor (1931) regards this species to be related to *Bdella longicornis* having a number of characters in common with it. Although smaller in general, several individuals attain a size similar to that of *B. longicornis* (Tables 4, 5) Values obtained for females from Blatná do not reach the lowest limit given by Thor for *B. semiscutata*, but surpass considerably the upper limit of *B. muscorum* in my material (Tables 2, 4, 5). Thor measured a small and a big individual and, as seen in the table, the difference was practically 100%

Similar to the foregoing species Thor evidently did not distinguish *B. semiscutata* from *B. muscorum* regarding it as a variety of *B. longicornis* on the basis of Ewing's incomplete description. Since the latter two are elosely related species it is most likely that the bottom values given by Thor are in accord with those given for *B. muscorum*.

Typical of the species is the number of setae (13—19) on the basifemur (Fig. 27), the striation and the network-like conformations on the propodosomal shield (Fig. 29), the chaetotaxy of the legs (Figs. 31, 32).

Geographical distribution: *B. semiscutata* has been reported from a large variety of biotopes both in Europe and North Africa. Thor (1931) found it in Sweden, Norway, Germany and, in 1932, in Grandjean's material from N-Africa; Schweizer (1951) in the Swiss National Park, Mihelčič (1958) in the Guadarrama Mts. in Spain, Gomezauri (1963) in the Georgian SSR, generally in moss and lichen samples, forest litter, under rock, bark, in tree leaves.

Willmann (1939, 1956) found an occasional specimen of the species in Czechoslovakia in the fauna of peat bogs of the Kralický Sněžník — on lichen — (*Cetraria islandica*) and on lichen and under the bark of dwarf spruce. Pax and Maschke (1935) found *B. semisculata* in the cave fauna of the Kralický Sněžník.

Tab. 5. *Bdella semiscutata* (according to Thor, 1931)

Total length	Total width	Length of gnathosoma (+ chelicerae)	Segments of pedipalpus a small specimen (a big specimen): I.	II.	III.	IV.	V.
950—1850	450—800	250—550 (270—420)	15 (30)	139 (330)	34 (60)	30 (38)	72 130

(Blatná, 26. 3. 1967)

Des	Ves	Number of setae on pedipalpal segments: II.	III.	IV.	V.
167	104	13	1	4	6

No reports are available as yet on the incidence of the species in America and Australia, where bdellids have received increased attention in recent years.

Bionomics: *B. semiscutata* colonizes, apart from moss and lichen off trees, forest litter fall; it has been recovered from under rock, leaves, etc.

My samples from Blatná contained 1 ♀ with one broken of pedipalpus only collected on March 26, 1967 in stands of *Hypnum cupressiforme*, *Mnium spinulosum* and *Dicranum scoparium* growing on stones near a forest path leading to the game-keeper's lodge.

Subfamily Odontoscirinae Grandjean, 1938

Bdellodes longirostris (Hermann)

(Figs. 33—40)

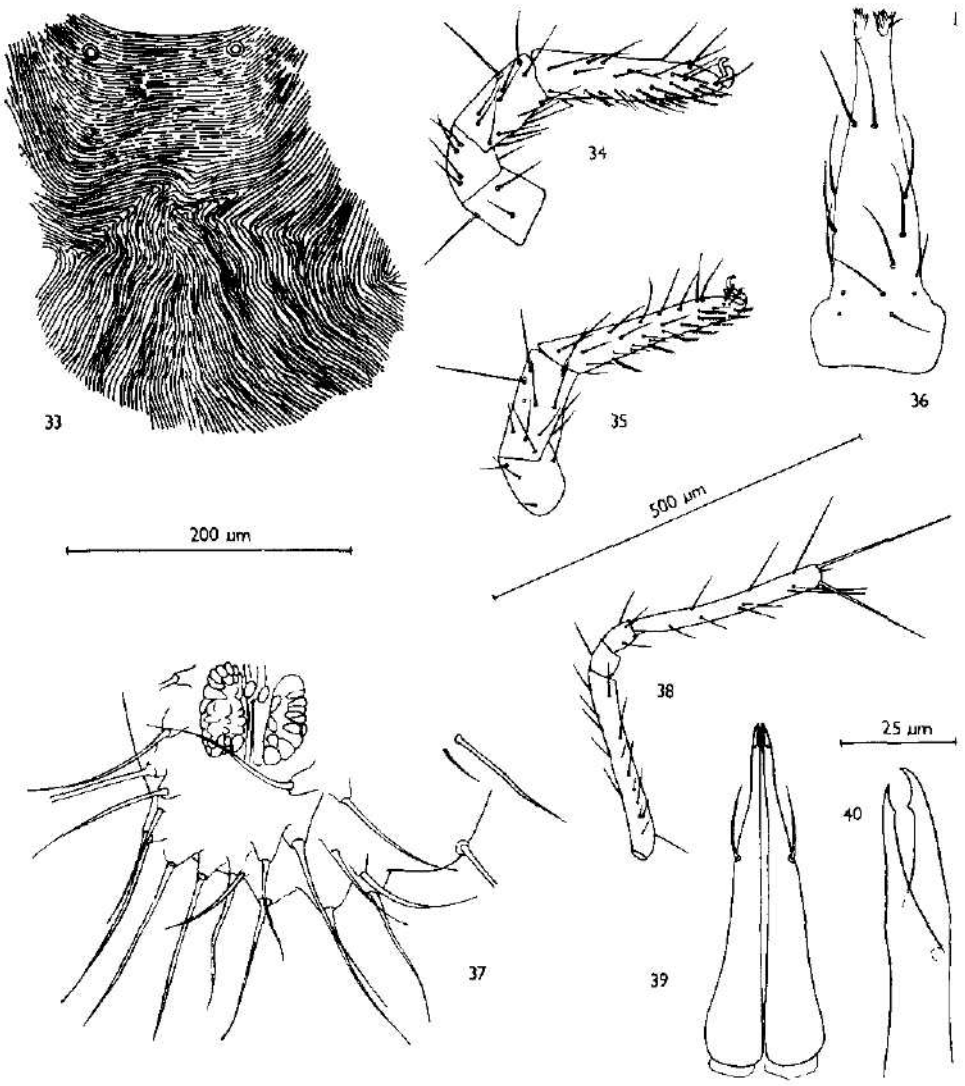
The species is closely related to *Bdellodes porrectus* (Kramer), but may be distinguished by the palpal telofemur and the genu which in *B. longirostris* are of approximately the same length (Fig. 38), and by the chela bearing a praeapical tooth on each digit (Fig. 40). The genu of *B. porrectus* is almost twice as long as the telofemur and approximately half as long as the tibiotarsus. The basifemur of *B. longirostris* bears 10—15 setae, the tibiotarsus 12—14 short setae and 2 long apical setae (Fig. 38); the basifemur of *B. porrectus* bears 5—6 setae, the tibiotarsus 10 short and 2 long setae which are longer than those of the foregoing species.

Geographical distribution: Thor (1931) states that *Bdellodes longirostris* is not numerous, but is widely distributed. It has been found in the majority of European countries, in Asia, North and South America. Schweizer (1951) found it in the Swiss National Park, Womersley (1933) in a number of places in Australia. Atyeo (1971) collected it in the Carribean area and on the Isle of St. Helena.

In Czechoslovakia, its occasional incidence has been reported by Willmann (1954) from Moravia, in several caves of the Moravian Karst, under

(measures in μm)

Des	Ves	Number of setae on podipalpal segments: II.	III.	IV.	V.
200 (450)	150 (350)	8—19	1	3—4	5—7



Figs. 33—40: *Bdellodes longirostris*, female: 33 — striation pattern on the dorsum of the propodosoma; 34, 35 — three distal segments of legs I and II; 36 — ventral aspect of gnathosoma, 37 — genital region, 38 — left palpus, 39 left and right chelicera; 40 — chela

flowerpots at Ořechov, under rock on the shore of the Jedovnický fishpond, under rock in the Sloupské valley, etc. The species is new for Bohemia.

Bionomics: At Blatná, we found one ♀ of *B. longirostris* together with 1 ♀ of *Bdella iconica* (lgt M. Kunst) collected on October 2, 1955 in the moss layer (*Mnium* sp.).

Alberti (1973) recorded the incidence of both juvenile and adult specimens from June till October. The release of spermatophores and oviposition occurs from the late summer to the autumn; in the laboratory, larvae hatched

in May and September. The author inferred that *B. longirostris* feeds on mites of the families Tydeidae and Eupodidae. According to Womersley (1933) the species feeds on *Sminthurus viridis*, an important pest, and on other Collembola.

In the moss samples from Blatná contained two members of the subfamily Odontoscirinae: one heavily damaged deutonymph of the genus Thoribdella, and one heavily damaged nymph which could not be identified reliably (probably a member of the genus Thoribdella).

Subfamily Cytinae Grandjean, 1938

Cyta latirostris (Hermann)

(Figs. 41—48)

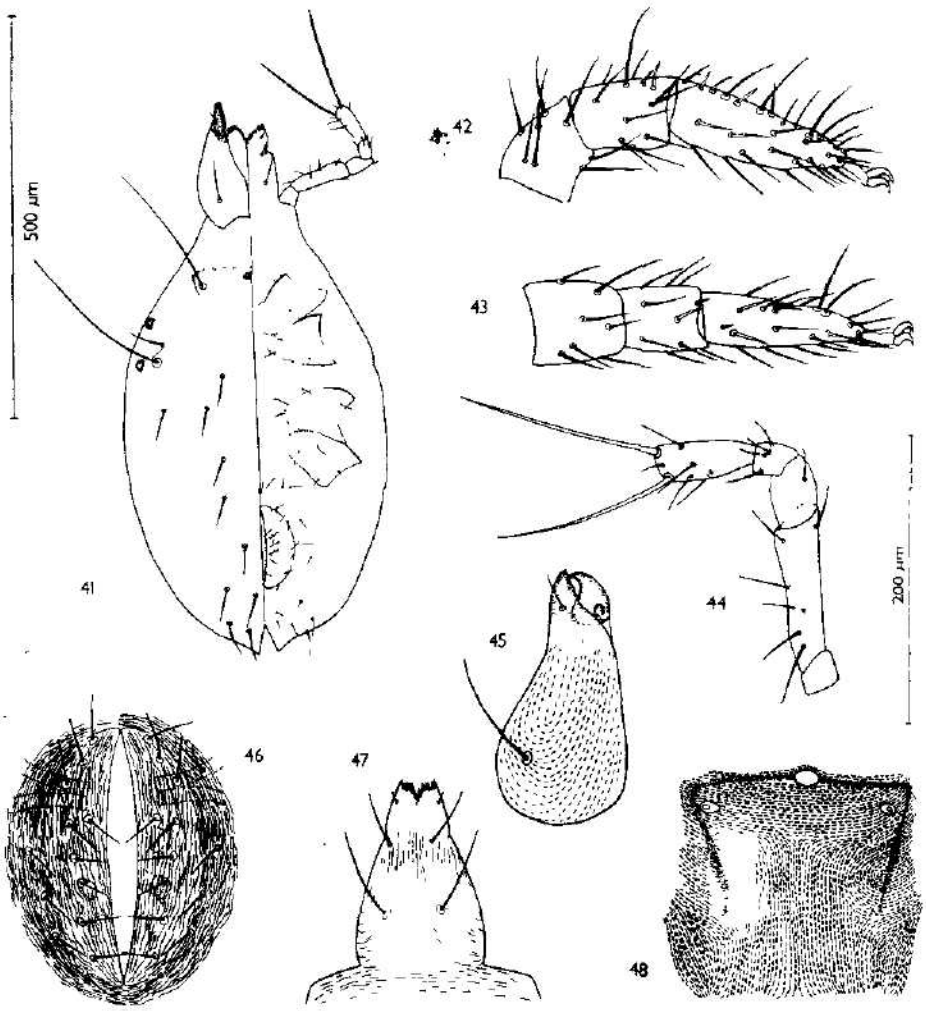
The species has been described repeatedly under various names and synonyms by, e.g., Sig Thor (1905, 1931), Atyeo (1960) and others.

Typical of the genus Cyta are thickened chelicera (Fig. 45), an unpaired median eye (Fig. 48), two pairs of conspicuous ventral hypostomal setae (Fig. 47). It may readily be distinguished from the remaining species by a trichoboth present on tibia IV only. A detailed description of *C. latirostris* has been given by Atyeo (1960). In his material, each palpal genu had 4 setae in all specimens examined except for two individuals from Italy with three setae on the palpal genu which agrees with Thor's (1931) description. Specimens of my material had 4 setae on each genu (Fig. 44).

Wallace and Mahon (1973) surveyed morphological differences and the distribution of species of the genus *Cyta*. They recorded three species representing the genus in Europe. These were *Cyta coerulipes* (Dugès) with 3 trichoboths (on tibia I and IV, on tarsus III), *Cyta latirostris* with one trichoboth on tibia IV, and an undescribed species without a trichoboth recovered by Wallace from the Mediterranean only. It is of interest that Gomezauri (1963) found both individuals with one trichoboth on tibia IV and those without a trichoboth, in Georgia.

Geographical distribution: *C. latirostris* has evidently a cosmopolitan pattern of distribution. It was found in all continents and in numerous countries. In the last century, many authors found it in various countries of Europe and North America. Thor (1931, 1932) found it in Europe, Africa, Asia and America. According to him, its incidence was particularly high in the northern and circumpolar zones. Schweizer (1951) who found the species in the Swiss National Park regarded it as a supalpine and alpine species. Mihelčič (1958) found *C. latirostris* in brown clays in the vicinity of Madrid and regarded it as a rare species. Sellnick (1958) collected it from Lapland to Italy. Atyeo (1960) found it in Panama, Haiti, Cuba, Mexico, the U.S.A., Alaska, etc. He found it in Australia where it had earlier been found by Womersley (1933), and in New Zealand. Together with Tuxen (1962) they recovered the species from all over Iceland from sites of predilection similar to those of *Bdella iconica*, i.e., dry and very dry localities. It was present mainly in moss stands of *Grimmia* and in *Dryas*. Once, they found it in two bird nests.

On our territory, the species was first found by Kirchner (1864) who listed it to the genus *Ammonia* under a number of specific names such as



Figs. 41—48: *Cyta latirostris*, female: 41 — total aspect; 42, 43 — three distal segments of legs I and II; 44 — right palpus; 45 — chelicera; 46 — genital region; 47 — ventral aspect of gnathosoma; 48 — striation pattern on the dorsum of the propodosoma

A. latirostris K., *A. megacephala* Koch, and others. He collected the species under moss in a forest, on wood in a shed, etc. Pax and Maschke (1935) reported it from the area of the Kralický Sněžník, Willmann (1954) from the Moravian Karst and, in 1956, from a protected area of the Kralický Sněžník (one specimen). According to Willmann, the incidence of the species is solitary, but it is present in a variety of biotopes.

Bionomics: *Cyta latirostris* colonizes a variety of habitats, frequently moss, lichen, grass, hay, under rock and fallen trees, under planks, in peat bogs. I myself found it among other places in ant heaps.

In moss samples from Blatná the species occurred in the highest number of individuals, i.e., 46% of all bdellids recovered (391), in the highest number of samples (56%) and in all sites of collection. In Czechoslovakia, it overwinters in the proto-tritonymphal stage. Samples collected in January contained 2 L, 123 P, 114 D, 112 T, 10 ♀, with an almost equal representation of nymphal stages. An almost equal representation of nymphal stages was observed also in the March samples which contained 6 P, 7 D, 8 T. June samples contained 1 D only. It is of interest that nymphal stages were absent in samples collected in July and August; in November the samples contained 10 L, 1 P, 27 D and 5 T.

In their Iceland material, Atyeo and Tuxen (1962) found larvae, protonymphs and deutonymphs in August, tritonymphs in June and July. The authors inferred that the species overwinters in the tritonymphal stage. Alberti (1973) found mainly nymphs from February till April and in November, adults from June till October. Wallace and Mahon (1972) collected *C. latirostris* in agricultural soils in Australia finding occasionally a larger number in pastures. They maintained that *C. latirostris* prefers to feed on Oribatidae but ingests also Collembola, generally Arthropleona, and an occasional Symphypleona. Apparently they do not spin a net around their prey as this does a number of other bdellid species.

Pschorn-Walcher and Gunhold (1957) found this species in not too big numbers in moss- and lichen samples off trees in parks and forests together with the species *Bdella dispar* Koch.

Subfamily Spinibdellinae Grandjean, 1938

Biscirus silvaticus (Kramer)

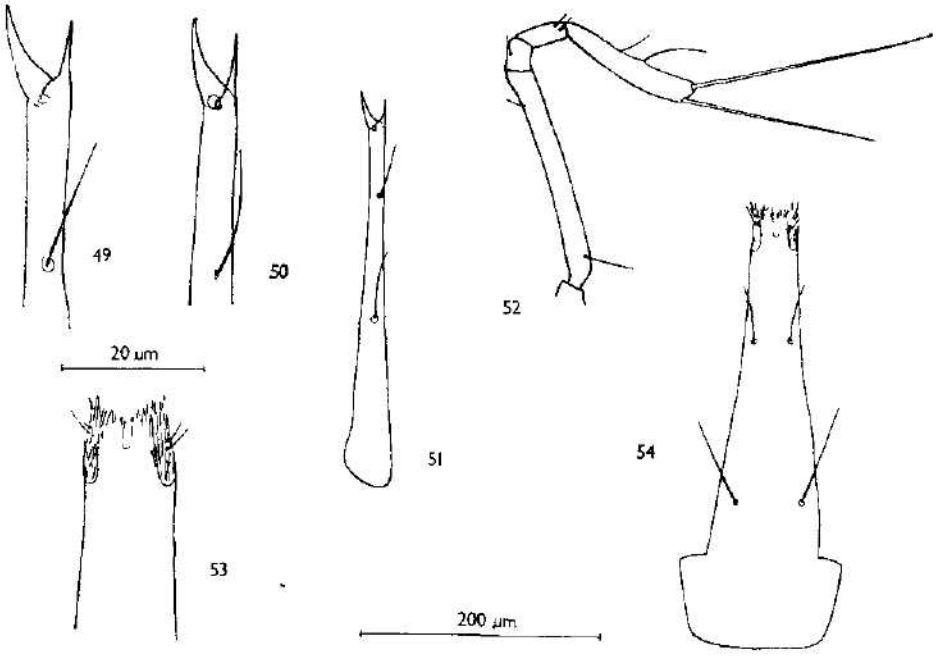
(Figs. 49—54)

Typical of the species are mainly the chaetotaxy of the pedipalpus, the long cylindrical tibiotarsus bearing two short dorsal setae. The tibiotarsus with a typical slight enlargement in its middle attains roughly 2/3rd of length of the basifemur (Fig. 52), two cheliceral setae are shifted in distal direction (Fig. 51). The shape of the chelicera is characteristic of the species (Figs. 49—51).

Geographical distribution: Thor (1931) recorded the species from Germany, France, Switzerland and Norway, Mihelčič (1958) from brown clays near Madrid, brown soil in the Guadarrama Mts., from the Sierra Nevada; Schweizer (1951) from the Swiss National Park, Womersley (1933) from W-Australia, Atyeo (1963) also from Australia (Kimberley Research Station). In 1960, Atyeo found it in a number of American states (Mexico, Haiti, California, Mississippi, Kansas, Colorado, Maryland, Tennessee), in Germany and Iceland, where it sometimes occurred under rock in a *Dryas* stand, in birch scrub, on meadows etc. According to Atyeo the species prefers dryer localities.

In Czechoslovakia it was found by Willmann (1954) in the Moravian Karst (on walls of the caves Kůlna and Kateřinská), under rock in a garden at Boskovice (1939) and in lichen off dwarf spruce at the Kralický Sněžník (1956).

Bionomics: *Biscirus silvaticus* was found in 4 samples from Blatná in moss on rock and stones, along forest paths and in clearings. The number of individuals was low. Two damaged L on November 11, 1964. 2 L on



Figs. 49—54: *Biscirus silvaticus*, female: 49, 50 — chela, 51 — chelicera; 52 — left palpus; 53, 54 — ventral aspect of gnathosoma

January 6, 1970, 2 D, 1 T, 6 ♀ on July 28, 1968, 1 ♀ on August 20, 1966. Larvae overwinter and adult individuals appear as early as in July and August (see Table 1).

Alberti (1973) found nymphs in the summer, adult individuals from October to November, and observed at this time oviposition and the release of spermatophores. In his opinion eggs only hibernate. In the laboratory, hatching larvae occurred in April, in the field in May.

Although low in number, the area of distribution of the species appears to be wide. It colonizes a large variety of biotopes (I myself collected it in many localities of our country).

Biscirus silvaticus feeds mainly on members of the order Collembola.

CONCLUSIONS

1. I have studied for a number of years mites of the family Bdellidae collected from moss in spruce wood near the Hydrobiological field station at Blatná, SW-Bohemia. Samples were taken off stone and rock, on forest paths, clearings, inside a high forest, from a weathered wall in a forest and from the dams of fishponds.

2. The geological substrate consisted of amphibolite-biotite granodiorite of a medium granularity.

3. We examined a total of 92 samples and identified 19 species of mosses (see p. 26). Of these the most frequent were the species *Pleurosium schreberi* Moenk., *Dicranum scoparium* How., *Plagiothecium curvifolium* Schlieph.,

Hylocomium splendens Br. et Sch., *Hypnum cupressiforme* Hdw., *Mnium spinulosum* Br. et Sch. and *Pohlia nutans* Lindb.

4. We found 7 mite species of the family Bdellidae: of the subfamily Bdellinae: *Bdella iconica* Berlese, *Bdella muscorum* Ewing, *Bdella semiscutata* Sig Thor; of the subfamily Odontoscirinae: *Bdellodes longirostris* (Hermann), one damaged deutonymph of the genus *Thoribdella* and one heavily damaged individual assumably of the genus *Thoribdella;* of the subfamily Cytinae: *Cyta latirostris* (Hermann); of the subfamily Spinibdellinae: *Biscirus silvaticus* (Kramer).

5. *Bdellodes longirostris* (Hermann) is new for Bohemia, *Bdella iconica* Berlese is new for Moravia and Slovakia.

6. The most numerous species was *Cyta latirostris* (391 individuals, i.e., 46% of bdellids recovered): it was present in 56% of samples, *Bdella muscorum* (211 individuals — 24% of all bdellids recovered) was present in 22% of samples, *Bdella iconica* (193 individuals — 22% of all bdellids recovered) in 46% of samples. The number of individuals of *Biscirus silvaticus* was small (12—1% of bdellids recovered); it was present in 4% of samples. The remaining species were present always in one sample only, with a solitary incidence.

7. We recorded the incidence of the individual developmental stages. *Cyta latirostris* was found to hibernate in the proto-, deuto- and tritonymphal stage, whereby the representation of all nymphal stages was almost equal. Hibernating stages of *Bdella muscorum* were mainly adult individuals and older nymphs with a dominance of tritonymphs. The situation was similar for *Bdella iconica* with hibernating adult individuals and older nymphs. Larvae of the species *Biscirus silvaticus* hibernated, adult individuals appeared as early as in July and August.

8. *Cyta latirostris* was found in all sites of collection. *Bdella iconica* was present in all samples except for those collected in a high forest and on a weathered wall in a forest. *Bdella muscorum* was found at every collecting site except for those in clearings and free, open spaces.

9. *Bdella muscorum* showed a predilection to moss stands, the remainder was found in a variety of biotopes with different vegetation- and plant covers. Apparently one of the factors responsible is the plentiful food material available.

10. Thor probable failed to distinguish *Bdella semiscutata* and *Bdella muscorum* in his material.

11. Willmann and Pax recorded the frequent finding of *Bdella semiscutata*, but not that of *Bdella muscorum*, in samples from the territory of Czechoslovakia. In my material this situation was reversed, and that does not apply to samples from Blatná only.

12. In my opinion *Bdella semiscutata* and *Bdella muscorum* should be studied on a more extensive material from Europe.

BIBLIOGRAPHY

Alberti, G., 1973: Ernahrungsbiologie und Spinnvermogen der Schnabelmilben (Bdellidae, Trombidiformes). *Z. Morph. Tiere*, **76** (4) : 285—338.

Atyeo, W. T., 1960: A revision of the Mite Family Bdellidae in North and Central America (Acarina, Prostigmata). *Univ. Kans. Sci. Bull.*, **40** (8) : 345—499

Atyeo, W. T., 1963: The Bdellidae (Acarina) of the Australian Realm. *Bull. Univ. Nebraska St. Mus*, **4** (8) : 113—210.

Atyeo, W. T., S. L. Tuxen, 1962: The Icelandic Bdellidae (Acarina). *J. Kans. Ent. Soc.*, **35** (3): 281—298.

Baker, E. W., J. Balock, 1944: Mites of the family Bdellidae. *Proc. Ent. Soc. Wash.*, **46** (7): 176—184.

Beer, R. E., 1954. A revision of the Tarsonemidae of the Western Hemisphere (Order Acarina). *Univ. Kans. Sci. Bull.*, **36** (16): 1109—1112.

Čepek, L., V. Zoubek, 1961: Přehledná geologická mapa ČSSR. ČSAV, Praha. M — 33 — XX Plzeň.

Gomezauri, L. A., 1961: Novyje vidy chiščnych kleščej sem. Bdellidae. *Soobšč. A. N. Gruz. SSR.*, **26** (1).

Gomezauri, L. A., 1963: K izučeniju kleščej semějstva Bdellidae Gruzinskoj SSR. *Soobšč. A. N. Gruz. SSR.*, **30** (2): 47—51.

Grandjean, F., 1938: Observations sur les Bdelles (Acariens). *Ann. Soc. Ent. Fr.*, **104** (4): 1—24.

Kirchner, L., 1864: Die Milben (Acari) Bohmens. Nach ihren natürlichen Standorten zusammengestellt. *Lotos*, **14**: 73—77; 109—110; 125—126; 151—153.

Klika, J., V. Novák, A. Gregor, 1954: Praktikum fytocenologie, ekologie, klimatologie a půdoznalectví. Praha, 773 pp.

Mihelčič, F., 1958: Prostigmata Südeuropas (Spanien). *Eos*, **34** (3): 269—290.

Oudemans, A. C., 1937: Kritisch Historisch Overzicht der Acarologie. *E. J. Brill.*, **3**: 1179 to 1248.

Pax, F., 1944: Alter und Herkunft der Tierbevolkerung im Glatzer Schneegebirge. *Jahrb. Schles. Ges. vaterld. Cultur*, **116**: 37—61.

Pax, F., K. Maschke, 1935: Die Hohlenfauna des Glatzer Schneeberges. I. Die rezente Metazoenfauna. *Beitr. Biol. Glatz. Schneeberg.*, **1**: 4—72.

Pilous, Z., 1948: Naše mechy. Ilustrovaný klíč k určování mechů československých. *Sb. přír. Čsl. bot. spol.*, **1**: 1—324.

Pschorn-Walcher, H., P. Gunhold, 1957: Zur Kenntnis der Tiergemeinschaften in Moos- und Flechtenrasen an Park- und Waldbäumen. *Z. Morph. Ökol. Tiere*, **46**: 342—354.

Sellnick, M., 1958: Untersuchungen über die „Bollnaser Krankheit". I. Milben aus landwirtschaftlichen Betrieben Nordschwedens. *Statens vaxtskyddsenstatt. Meddelanden*, **11**: 38—39.

Schweizer, J., 1951: Die Landmilben des schweizerischen Nationalparkes, 2. Teil, Trombidiformes Reuter 1909. *Ergb. wiss. Unters. Schw. Nat. Park*, **23** (3): 1—172.

Snetsinger, R., 1956: Biology of Bdella depressa, a predaceous mite. *J. Econ. Ent.*, **49**: 745 to 746.

Soliman, Z. R., M. I. Mohamed, 1972a: Biological Studies on the Soil — Inhabiting Bdellid Mite, Spinibdella bifurcata (Acarina: Bdellidae) in U.A.R. *Z. angew. Entomol.*, **70**: 15—23.

Soliman, Z. R., M. I. Mohamed, 1972b: On the Development and Biology of the Predaceous Mite, Neomolgus aegyptiacus Sol. (Acarina: Bdellidae). *Z. angew. Entomol.*, **71**: 90—95.

Světlík, F., 1883—4: Příspěvek ku poznání našich roztočův (Acarida). *Vesmír*, **13**: 13—14, 42—44; 68—69; 103—106; 128—129; 139—141; 175—177.

Thor, S., 1905: Norwegische Bdellidae I, nebst Notizen uber die Synonymie. *Zool. Anz.*, **28**: 69—79.

Thor, S., 1928: 4. Norwegische Bdellidae III und einige Bemerkungen über Haare, Chitinleisten und Schilder am Cephalothorax. *Zool. Anz.*, **77** (9/10): 213—219.

Thor, S., 1931: Bdellidae, Nicoletiellidae, Cryptognathidae. *Das Tierreich*, **56**: V—XIII; 1—87.

Wallace, M. M. H., 1970: Acarina: Prostigmata: Bdellidae of South Georgia. *Pac. Ins. Mon.*, **23**: 107—113.

Wallace, M. M. H., J. A. Mahon, 1973: The taxonomy and biology of Australian Bdellidae (Acari). I. Subfamilies Bdellinae, Spinibdellinae and Cytinae. *Acarologia*, **4**: 544—580.

Willmann, C., 1939: Die Moorfauna des Glatzer Schneeberges. 3. Die Milben der Schneebergmoore. *Beitr. Biol. Glatz. Schneeberg.*, **5**: 427—458.

Willmann, C., 1954: Mährische Acari, hauptsachlich aus dem Gebiete des Mährischen Karstes. *Čsl. Parasitol.*, **1**: 213—272.

Willmann, C., 1955: Milben aus dem sudwestlichen Sachsen. *Abh. Ber. Mus. Tierk. Dresden*, **22**: 207—225.

Willmann, C., 1956: Milben aus dem Naturschutzgebiet auf dem Spieglitzer (Glatzer) Schneeberg. *Čsl. Parasitol.*, **3**: 211—273.

Womersley, H., 1933: A preliminary account of the Bdellidae (Snout Mites) of Australia. *Proc. Roy. Soc. S. Aust.*, **57**: 97—107.

Author's address: Dr. Františka Lelláková-Dušková, CSc., Katedra systematické zoologie přírodovědecké fakulty KU, Viničná 7, 128 44 Praha 2, Czechoslovakia.

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 43—51

Institute of Virology, Slovak Academy of Sciences, Bratislava,
Institute of Parasitology, Czechoslovak Academy of Sciences, Praha,
Natural History Faculty, Comenius University, Bratislava

APTERYGOTA IN NESTS OF SMALL MAMMALS IN THE WESTERN CARPATHIANS

JOSEF NOSEK, MILAN DANIEL, †MILAN MRCIAK

Received September 30, 1976

Abstract: The occurrence of Apterygota in nests of 6 species of small mammals (*Clethrionomys glareolus, Microtus arvalis, Pitymys subterraneus, Apodemus flavicollis, Talpa europaea* and *Sorex araneus*) has been studied in the region of Vsetínské Vrchy and Javorníky (Western Carpathians). In 275 nests examined there were 3243 specimens of Apterygota belonging to two species of the order Protura and 51 species of the order Collembola. Seven species were dominant and represented 89% of all specimens. The changes in nest inhabitation in relation to different seasons and biotopes were also studied. The results are compared with the findings of Apterygota in nests of small mammals in the Eastern Carpathians.

INTRODUCTION

The present report deals with partial results of a complex research of small mammal parasites and inhabitants of their nests carried out in the Western Carpathians by the workers of the Institute of Parasitology, Czechoslovak Academy of Sciences, Prague and Department of Systematic and Ecological Zoology, Comenius University, Bratislava in cooperation with the Zoological Institute, USSR Academy of Sciences, Leningrad. It follows the papers by Mrciak, Daniel and Rosický (1966), Daniel and Holubičková (1972), Ryba, Rosický, Daniel and Mrciak (1975) and Bukva, Daniel and Mrciak (1976) dealing with parasitic and nest arthropods from the same nests as those examined in our study.

The species composition of Apterygota in nests of mammals is very similar to the fauna of their primary habitats: forest litter, plant detritus, bark, moss and soil. Some of the Collembola, however, are well adapted to the life in nests, where individual species show high abundance, higher than in the soil. Other orders of Apterygota, i.e., Protura, Diplura and Thysanura, have low abundance and small number of species, because their primary habitats are quite different.

MATERIAL AND METHODS

Fields works were performed in the years 1959—1960 in the upper reaches of the Vsetínská Bečva river and its tributaries (Eastern Moravia) from about 450 m upwards to about 760 m a.s.l. The material originates from 18 localities mostly covered by the forest (e.g., localities Dynčák, Krivý Grúň, Kyčerka, Makytka, Babská, Vlčí údolí, Rybjanka, Razula, Ostrižná, Stanovice). In addition to these localities, the material was collected also on clearings with a rich vegetation (loc. Vranča, Halenkov, Kyčerka), meadows (loc. Halenkov, Karolinka, Nový Hrozenkov, Hovězí) and fields (loc. Halenkov, Karolinka, Velké Karlovice). More detailed data

Tab. 1. Inhabitation of small mammalian nests by the Apterygota in V. Karlovice region (the West Carpathians)

Hosts	*Cl. glareolus*	*M. arvalis*	*A. flavicollis*	*P. subterraneus*	*T. europaea*	*S. araneus*	Total
Number of examined nests	167	42	23	4	7	32	275
Number of inhabited nests	97	17	14	2	3	17	149
Number of Apterygota collected	1865	151	818	58	10	341	3243
Frequency of Apterygota in %	57.5	40.5	60.9	50?	42.9?	53.1	54.4
Average number of Apterygota per inhabited nest	19.4	8.9	58.4	29?	3.3?	20.1	21.8
Average number of Apterygota per one nest	11.2	3.6	35.6	14.5?	1.4?	10.7	11.8
Number of species	40	19	20	8	2	15	53
Number of predominant species	4	3	3	2	1	4	6

on the geomorphology, climatic and vegetational conditions of the region, individual localities and methods are given in the papers by Mrciak, Daniel and Rosický (1966) and Schvarczová (1963).

A total of 275 nests of the following rodents and insectivores were obtained: *Clethrionomys glareolus* (167 nests); *Microtus arvalis* (42 nests); *Apodemus flavicollis* (23 nests); *Pitymys subterraneus* (4 nests); *Talpa europaea* (7 nests); *Sorex araneus* (32 nests). Three nests were not

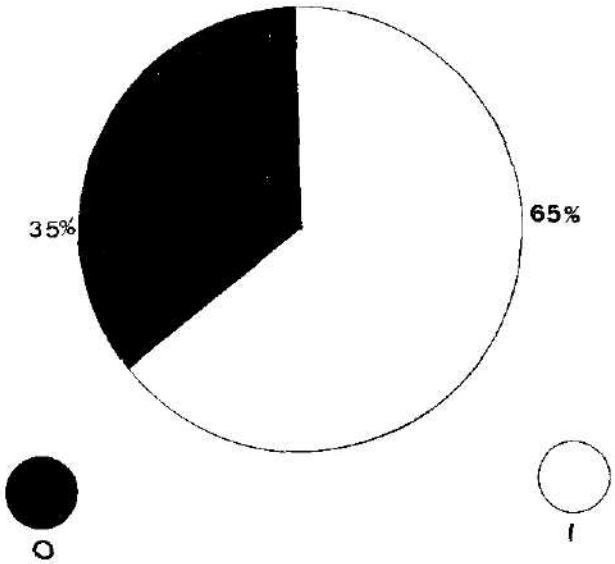


Fig. 1. Percentage of individuals of different Collembolan families in mammalian nests (dominant species only) I — Isotomidae, O Onychiuridae.

identified. The nests were collected in winter, spring and summer. Apterygota were assorted according to the nests and preserved in 70% alcohol. The preparations for the determination were prepared in Svan's medium. A total of 3243 specimens of Apterygota were obtained (Table 1) and soil samples were taken for ecological comparison of the fauna from nests and their environment.

RESULTS

Apterygota were found in 149 nests, i.e. in 54.4% of all nests collected. The total number of Apterygota was 3243 specimens, average number in positive nests 21.8 and in all nests examined 11.8 specimens (Table 1). The

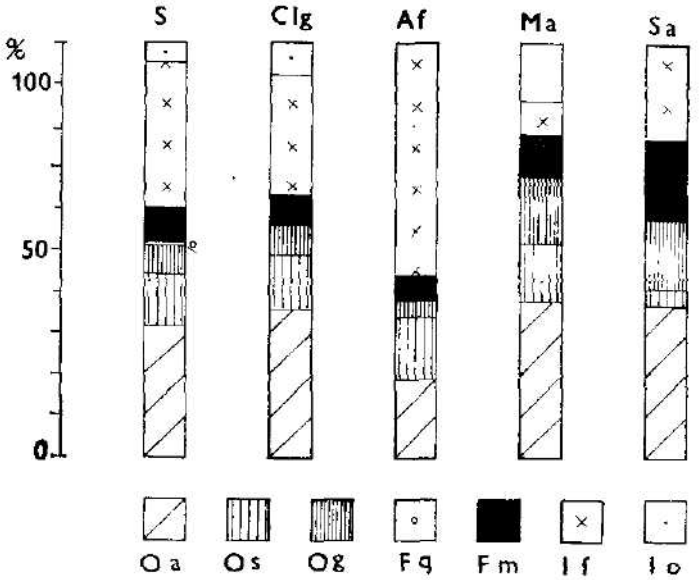


Fig. 2. Percentage of dominant species of Collembola in mammalian nests: Clg — *Clethrionomys glareolus*, Af — *Apodemus flavicollis*, Ma — *Microtus arvalis*, Sa — *Sorex araneus*, Oa — *Onychiurus armatus*, Os — *Onychiurus sibiricus*, Og — *Onychiurus granulatus*, Fq — *Folsomia quadrioculata*, Fm — *Folsomia multiseta*, If — *Isotoma fennica*, Io — *Isotoma olivacea*.

Apterygota belonged to 53 species (2 species of Protura and 51 species of Collembola); 7 of them were dominant and represented 89% of all specimens collected. Nine of the found taxons (*Acerentomon nemorale, Onychiurus subnemoratus, O. campatus, O. granulosus, O. denisi, Anurida pygmaea, Folsomia fimetaroides, Isotoma albella* and *Entomobrya corticalis*) were not recorded in the nests of small mammals in the Eastern Carpathians (Nosek and Vysotskaya, 1973). Generally, Isotomidae and Onychiuridae predominated (Fig. 1).

An analysis of the occurrence of Apterygota in the nests of mammals revealed the differences between the individual mammal species:

C. glareolus — frequency 57.5%; mean number of Apterygota per inhabited nest 19.4; mean number of Apterygota per examined nest 11.2; number of collected species 40; 4 dominant species (*Onychiurus armatus, O. sibiricus,*

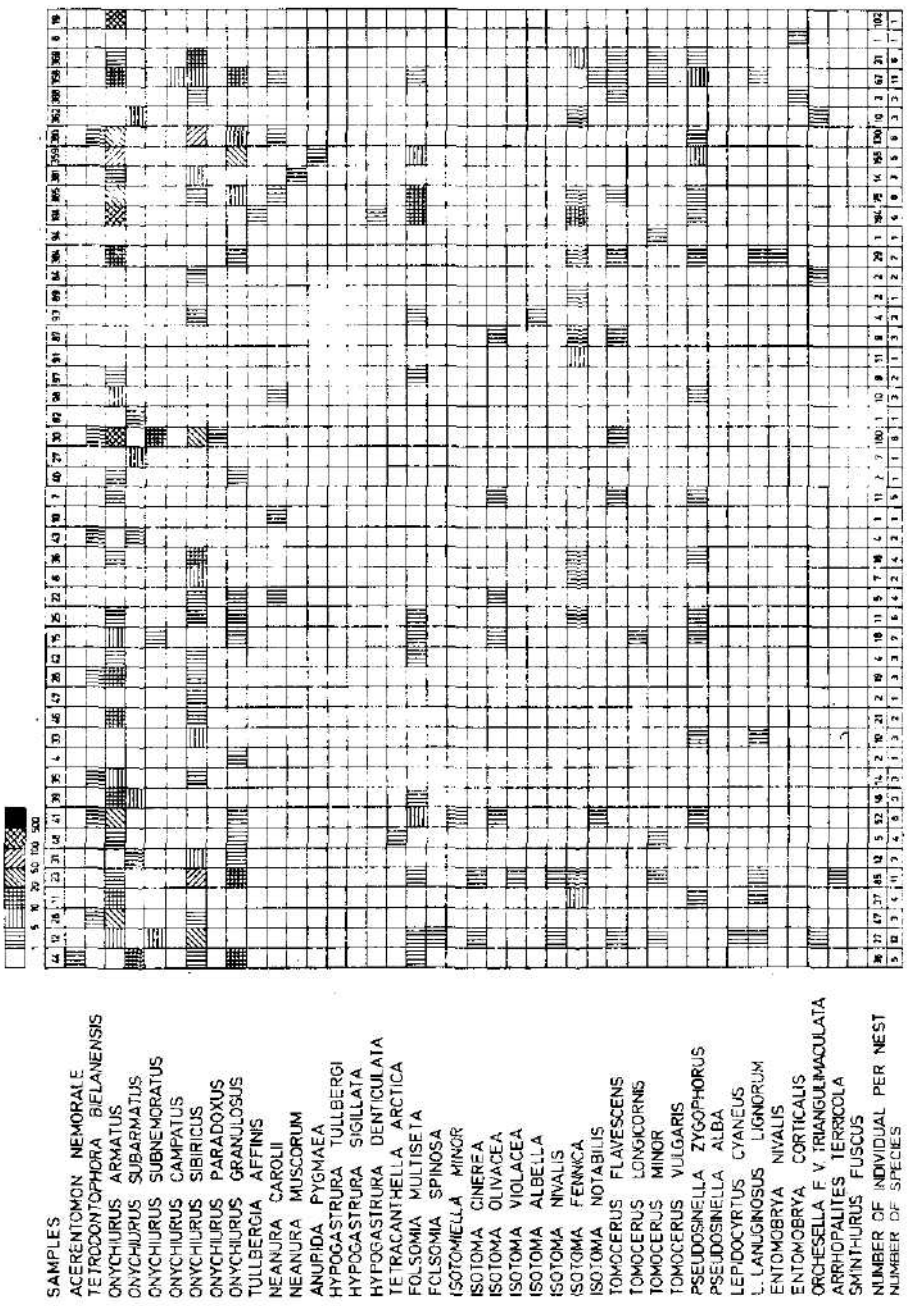


Fig. 3. Analysis of Apterygotan synusy *Onychiurus sibiricus* in the nests of bank vole *Clethrionomys glareolus* in the winter period.

Isotoma fennica and *I. olivacea*) represent 87% of all specimens collected in nests of this mammal (Table 1).

M. arvalis — frequency 40.5%; mean number of Apterygota per inhabited

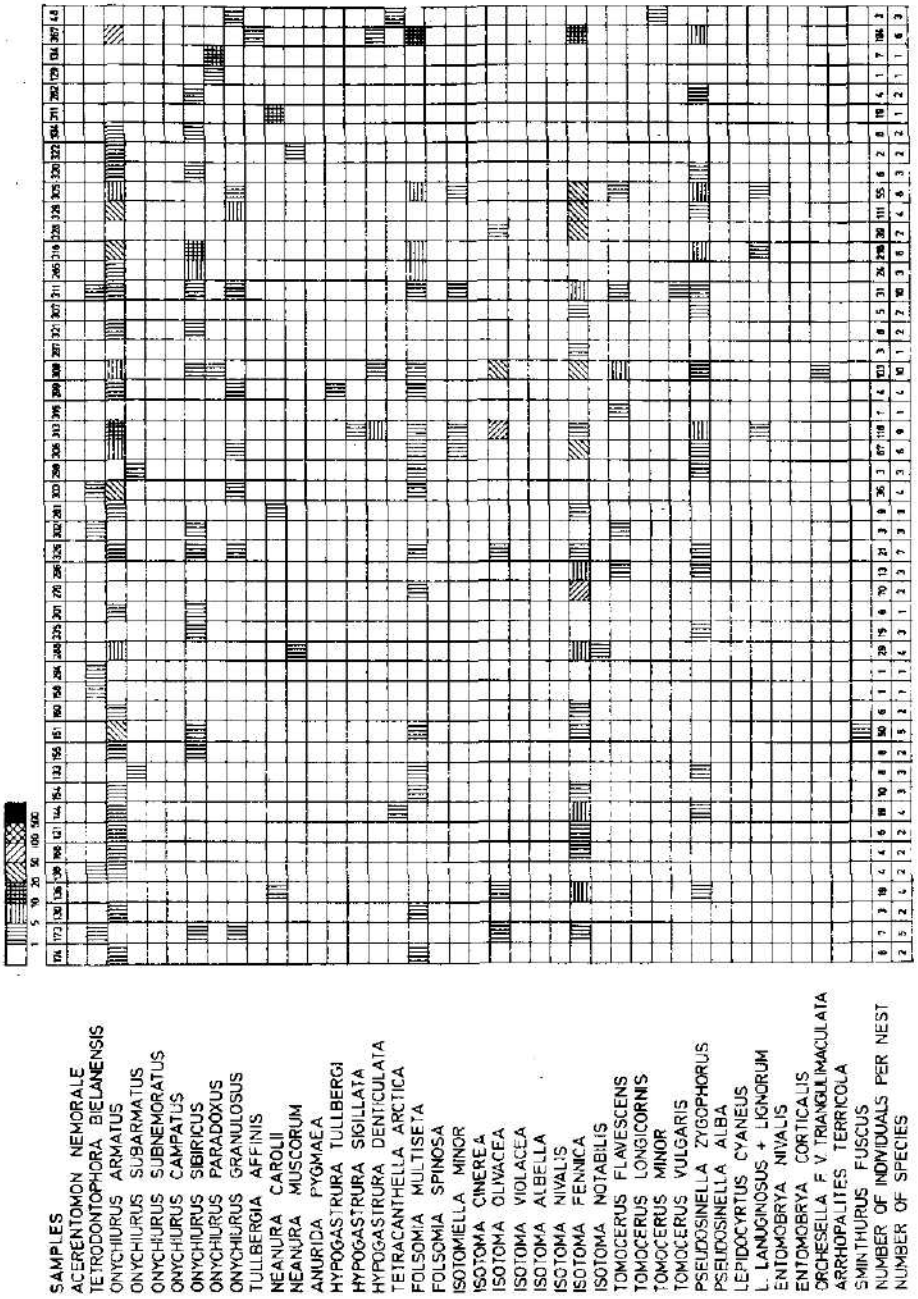


Fig. 4. Analysis of Apterygotan synusy *Onychiurus sibiricus* in the nest of bank vole *Clethrionomys glareolus* in the spring and summer period.

nest 8.9; mean number of Apterygota per examined nest 3.6; number of collected species 19; 3 dominant species (*O. armatus*, *O. sibiricus* and *I. fennica*) prevail also in the nests of *A. flavicollis*.

Tab. 2. The presence of Apterygota in the nests of small mammals

Apterygotan species	*Cl. glareolus*	*M. arvalis*	*A. flavicollis*	*P. subterraneus*	*T. europaea*	*S. araneus*	Soil samples
Acerentomon dispar			+				
Acerentomon nemorale	+						
Tetrodontophora bielanensis	+	+				+	+
Onychiurus armatus	+	+	+		+	+	+
Onychiurus subarmatus	+		+				+
Onychiurus subnemoratus	+						
Onychiurus campatus	+						
Onychiurus sibiricus	+	+	+			+	+
Onychiurus paradoxus	+						
Onychiurus granulosus	+	+	+			+	+
Onychiurus denisi						+	
Onychiurus variabilis						+	+
Tullbergia affinis	+						
Neanura carolii	+		+				
Neanura muscorum	+		+			+	
Neanura conjucta						+	
Anurida pygmaea	+						
Willemia anophthalma			+				
Hypogastrura bengtssoni		+					
Hypogastrura tullbergi	+						
Hypogastrura sigillata	+						
Hypogastrura denticulata	+	+					+
Tetracanthella arctica	+						
Folsomia quadrioculata				+			
Folsomia multiseta	+	+	+	+		+	+
Folsomia spinosa	+		+				+
Folsomia fimetaroides			+				
Isotomiella minor	+			+			+
Isotoma cinerea	+						
Isotoma olivacea	+	+		+		+	+
Isotoma violacea	+		+				+
Isotoma viridis			+	+			+
Isotoma albella	+						
Isotoma nivalis	+	+	+				+
Isotoma fennica	+	+	+		+	+	+
Isotoma notabilis	+	+		+			+
Tomocerus flavescens	+	+	+				+
Tomocerus longicornis	+						
Tomocerus minor	+	+	+				+
Tomocerus vulgaris	+						
Heteromurus nitidus		+					+
Pseudosinella zygophora	+	+	+	+		+	+
Pseudosinella alba	+	+					
Lepidocyrtus cyaneus	+	+					
Lepidocyrtus curvicollis							+
Lepidocyrtus lanuginosus + + *lignorum*	+	+	+	+		+	+
Entomobrya nivalis	+					+	+
Entomobrya corticalis	+						
Orchesella flavescens v. *triangulimaculata*	+	+	+			+	+
Arrhopalites terricola	+						
Sminthurus lubbocki							+
Sminthurus fuscus	+						

A. flavicollis — frequency 60.9%; mean number of Apterygota per inhabited nest 58.4; mean number of Apterygota per examined nest 35.6; number of species 20.

S. araneus — frequency 53.1%; mean number per inhabited nest 20.1; mean number per examined nest 10.7; number of species 12; 4 dominant species (*O. armatus, O. granulosus, Folsomia multiseta, Isotoma fennica*).

The percentage of dominant species of Collembola in the nests of *C. glareolus, A. flavicollis, M. arvalis* and *S. araneus* is shown in Fig. 2. If we compare this analysis with a similar one from the Eastern Carpathians, there are evident differences in the representation of individual dominant species, especially I. fennica (see Nosek and Vysotskaya, 1973, p. 58, Fig. 9).

The analysis also revealed that the abundance of Collembola in the nests of mammals living in the forest in the mountains (*C. glareolus* and *A. flavicollis*) is higher than in the nests located in the open areas. The inhabitation of nests of some Collembola species is much higher in summer, which is related to their reproduction (e.g., *Isotoma fennica* and *I. olivacea*).

Of interest is the synusy of the Collembola, which resembles an uncomplete synusy of *Onychiurus sibiricus* (according to Nosek), known from subalpine soils of beech and spruce-beech forests of the Low Tatras Mountains (Nosek, 1969). The number of constant, occasional and acompanying species, however, is lower in the studied area and even some western elements were found to occur here (Figs. 3 and 4).

SYNOPSY AND ECOLOGY OF THE COLLECTED SPECIES OF APTERYGOTA

The collected species are listed in Table 2. Two species of Protura, namely *Acerentomon nemorale* Wom. (1 specimen) and *Acerentomon dispar* Stach (1 specimen) were also recorded. The ecology of most of the species is described in the paper by Nosek and Vysotskaya (1973). In the present study we mention only the ecology of vicarious species of the fauna of the Western Carpathians.

Acerentomon nemorale Womersley, 1927

Distribution: England, France, Austria, Czechoslovakia (Nosek 1973).

Ecology: This species lives in the humus. Mammal nests: *C. glareolus*.

Onychiurus subnemoratus Gisin, 1957

Distribution: Austria, Czechoslovakia.

Ecology: This species lives in the forests and peat-bogs. Mammal nests: *C. glareolus*.

Onychiurus campatus Gisin, 1952

Distribution: Denmark, German Federal Republic, German Democratic Republic, Austria, Switzerland, Czechoslovakia, Iceland.

Ecology: This species occurs most frequently in the soil of moist meadows and plant detritus of alpine and subalpine meadows. Mammal nests: *C. glareolus*.

Onychiurus denisi Stach, 1934

Distribution: Central Europe.

Ecology: This species lives in large areas under pine-needle and leaf litter and also in caves. Mammal nests: *Sorex araneus*.

Onychiurus granulosus Stach, 1930

Distribution: Poland, Hungary, Austria, Bulgaria, Czechoslovakia.

Ecology: This species lives in the forests under the bark of rotten woods and in leaf litter. Mammal nests: *C. glareolus*, *M. arvalis*, *A. flavicollis* and *S. araneus*.

Anurida pygmaea Bömer, 1901

Distribution: From Scandinavia and some Arctic islands to the Carpathians and Alps.

Ecology: This species lives in the moss, under the bark of rotten woods, in pine-needle litter and humus soil of meadows and forests. Mammal nests: *C. glareolus*.

Folsomia fimetaroides (Axelson, 1903)

Distribution: Finland, Sweden, Latvia, England, Austria, Czechoslovakia.

Ecology: This species lives in plant detritus and humus soil. Mammal nests: *A. flavicollis*.

Isotoma albella Packard, 1873

Distribution: Holarctic.

Ecology: This species lives under the bark of rotten trees and in the moss

Mammal nests: *C. glareolus*.

Entomobrya corticalis (Nicolet, 1841)

Distribution: Europe.

Ecology: This species lives mostly under the rotten bark of various woods, in the moss and lichens covering the trunks and branches of trees. Mammal nests: *C. glareolus*.

CONCLUSION

Two species of Protura and 51 species of Collembola were found in the nests of small mammals collected in the surroundings of V. Karlovice. The nest inhabitation with some species of Collembola is much higher in the summer, which is related with the reproduction biology of the species. Of the 275 nests collected, 149 were inhabited by Apterygota. The frequency of Apterygota in nests was 50.4%, mean number per inhabited nest 21.8 and mean number per examined nest 11.8 specimens. The percentage of dominant species of Collembola in the nests of *C. glareolus*, *A. flavicollis*, *M. arvalis* and *S. araneus* markedly differed from that in the mammal nests from the Eastern Carpathians. A synusy resembling the uncomplete synusy of *Onychiurus sibiricus* was observed in the nests of *C. glareolus*. From the biocoenotical view, the nest of a mammal represents for the Collembola an environment to which the nidicolous species adapted themselves during the evolution and where the topical and trophic relations were settled.

REFERENCES

Bukva, V., M. Daniel, M. Mrciak, 1976: Oribatid mites (Acari, Oribatei) in the nests of small mammals in the Western Carpathians. *Věstn. Čs. spol. zool.*, **40** (4) : 241—254.

Daniel, M., B. Holubičková, 1972: Interspecific relationships of gamasoid mites in the nests of Clethrionomys glareolus. *Folia parasit.* (Praha), **19** : 67—86.

Gisin, H., 1960: Collembolenfauna, Europas. Mus. Hist. nat. Genève, 312 pp.
Mrciak, M., M. Daniel, B. Rosický, 1966: Parasites and nests inhabitants of small mammals in the Western Carpathians. I. Mites of the superfamily Gamasoidea (Parasitiformes). *Acta F.R.N. Univ. Comen.* (Bratislava), **13** Zool.: 71—116.
Nosek, J., 1969: The investigation on the Apterygotan fauna of the Low Tatras. *Acta Univ. Carolinae. Biol.*, **1967** : 349—528.
Nosek, J., 1973: The European Protura, their taxonomy, ecology and distribution with keys for determination. Genève: Mus. Hist. nat. Genève, 345 pp.
Nosek, J., Sixl, W., 1975: Collembolen aus Baumhohlen der Steiermark (Österreich). *Rev. suisse Zool.*, **82** : 531—538.
Nosek, J., Vysotskaya, S. O., 1973: The investigation on Apterygota from nests of small mammals in the East Carpathians (Ukrainian SSR). *Biol. práce* **19** (5) : 1—80.
Palissa, A., 1964: Apterygota. Die Tierwelt Mitteleuropas Collembola 1—299. Leipzig: Verlag von Quelle & Meyer.
Ryba, J., B. Rosický, M. Daniel, M. Mrciak, 1975: Siphonaptera of small terrestrial mammals and their nests in the Western Carpathians. *Folia parasit.* (Praha), **22** : 45—56.
Schvarcová, L., 1963: Rastlinné zloženie hniezd drobných zemných hlodavcov a hmyzožravcov vo vzťahu ku geografickým činiteľom. Thesis (unpubl.) Prírodoved. fak. univ. Komen., Bratislava, 108 pp.
Vysotskaya, S. O., Nosek, J., 1974: Apterygotan synusies of mammalian nests. *Pedobiologia*, **14** : 251—255.

Authors' address Ing. J. Nosek, CSc., Virologický ústav SAV, Mlynská dolina 1, 809 39 Bratislava, Czechoslovakia. Dr. M. Daniel, CSc., Parasitologický ústav ČSAV, Flemingovo nám. 2, 166 32 Praha 6, Czechoslovakia

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 52—59

Department of Systematic Zoology, Charles University, Praha

THE ABUNDANCE, GROWTH AND PRODUCTION OF THE CHUB POPULATION IN THE KLÍČAVA RESERVOIR DURING THE YEARS 1967—1975

KAREL PECL, KAREL PIVNIČKA & KEWAL KRISHAN TANDON

Received October 27, 1976

Abstract: In 1967—1975, the relationship between growth, abundance and production of 4th—10th age groups of the chub, *Leuciscus cephalus* (Linnaeus, 1758), the position of the chub among other species and its growth rate in comparison with other localities in Czechoslovakia were studied in the Klíčava reservoir. It has been found that the slope of the abundance-growth relationship in the chub is very similar to that of the perch and 2—3 times steeper than that for the roach. Theoretical maximum abundance of the chub with respect to its production has been calculated as 376 chubs per ha, the corresponding maximum for perch and roach are 79 and 870 fish per ha respectively. Growth rate for the chub in the Klíčava reservoir has been found to be very good especially in the first nine age groups. Considering that the benthos in the Klíčava reservoir is limiting, the piscivorous feeding habits of the older chubs can be expected.

The chub, *Leuciscus cephalus* (Linnaeus, 1758) is the third species in the Klíčava reservoir in which it was possible to assess the abundance and the production. Relationships amongst abundance, growth and production are the main aims of this paper. However, comparison with the perch and the roach is also given, wherever possible.

MATERIAL AND METHODS

The abundance of the chub population was estimated using Schnabel's method in the years 1967, 1968 and 1975. In all other years it was reconstructed from the estimations made in 1967/1968 and 1975, using the mean survival rate ($s = 0.582$) (Table 1). The samples of the chub, used for the growth study, were small with the exception of 1967—1968, therefore their age composition could not serve as a test for the reconstructed numbers of fish in the individual age groups as was the case in roach (Holčík and Pivnička, 1975) and perch (Pivnička and Švátora, 1976). Nevertheless, the reconstruction with only the survival rate was the sole method how to find out anything about the numbers of chub in the Klíčava reservoir in the years when assessments were not made. Weights were calculated from the log-log relationship between standard length (in mm) and weight (in g), the equation used was $\log w = 3.0123 \log l - 4.7681$. For the calculation of the relationships between abundance and growth in individual age groups, the growth was characterised by the mean total weight of the particular age group attained at the time of the last annulus formation. The index of production of the age group was not used because for the older age groups it is possible to write an approximate equation $\Delta w_i^t \doteq G_i^t B_i^t$, i.e. the absolute increment is nearly equal to the partial corresponding value of the index of production of that age group.

For the relationships between the abundance and growth and between the abundance and production the following equations were used

$$(y = a + bx,\ y = a - b \ln x,\quad y = ax^b;\quad y = x(ax^b) \quad \text{and} \quad y = x(a - b \ln x).$$

In all cases the corresponding correlation coefficients were also calculated. For abbreviations and equations used in this paper, see Pivnička and Švátora (1976).

Table 1. Abundance of chub in the Klíčava reservoir in 1967—1975, and kilograms of total (P) and available production (P_A). (* — estimated values). The values of the index of production (P_I) are given in grams.

Age group	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	*900	*3060	1790	820	315	184	157	337	*373
4	*2320	*522	1790	1040	478	184	107	91	*196
5	*362	*1297	304	1040	618	278	107	62	*53
6	*90	*252	755	176	618	360	156	62	*36
7	*99	*80	147	439	103	360	210	91	*36
8	*42	*21	47	86	255	60	210	122	*56
9	*90	*50	12	27	36	148	35	122	*71
10	*42	*60	29	7	36	6	86	21	*71
Total	3945	5342	4874	3635	2495	1580	1068	908	889
P (4th—10th age group)	308.2	181.1	141.3	216.3	256.6	181.0	63.3	57.0	40.6
P_A (4th—10th age group)	236.7	141.5	106.0	164.1	199.3	137.3	47.7	44.8	30.7
P_I (4th—10th age group	401	456	300	364	529	597	320	498	390

The calculation of maximal (theoretical) values of abundance and production per ha was based on the equation of the production-abundance relationship ($y = x(a - b \ln x)$. The first derivation of this equation was taken to zero. It was, then, directly possible to calculate the maximum theoretical value of abundance and the corresponding value of production as under:

$$y' = a - b \ln x - b\,, \quad a - b \ln x - b = 0\,, \quad \ln x = \frac{a - b}{b}\,.$$

RESULTS AND DISCUSSION

The position of the chub population among other species

The position of the chub population in the Klíčava reservoir among other species can be seen from Fig. 1, where the total (gross) production (for 4th—10th age groups) of roach, perch, chub and rudd are plotted against the individual years. In 1964 the abundance of chub was very small so the estimation of the total production and also abundance was impossible. Holčík (1970) carried out only the rough visual estimation on about 200 specimens in older age groups. Nevertheless in 1967 the abundance of chub increased up to 4000 specimens in the 3rd—10th age groups (Pivnička, 1971). Beginning from this year the share of the chub population was on the second (after roach) or third (after roach and perch) position as regards its ichthyomass, abundance and total production (Holčík and Pivnička, 1972). This situation has not changed even after 1972. The two peaks of production in roach and chub are similar in 1967 and 1971, but in 1975 the production of chub goes down. This may either be due to some errors in calculations or natural causes. However, the past trend indicates that the abundance and production of the chub population will follow the same course as in roach in the following years. This is very interesting, especially

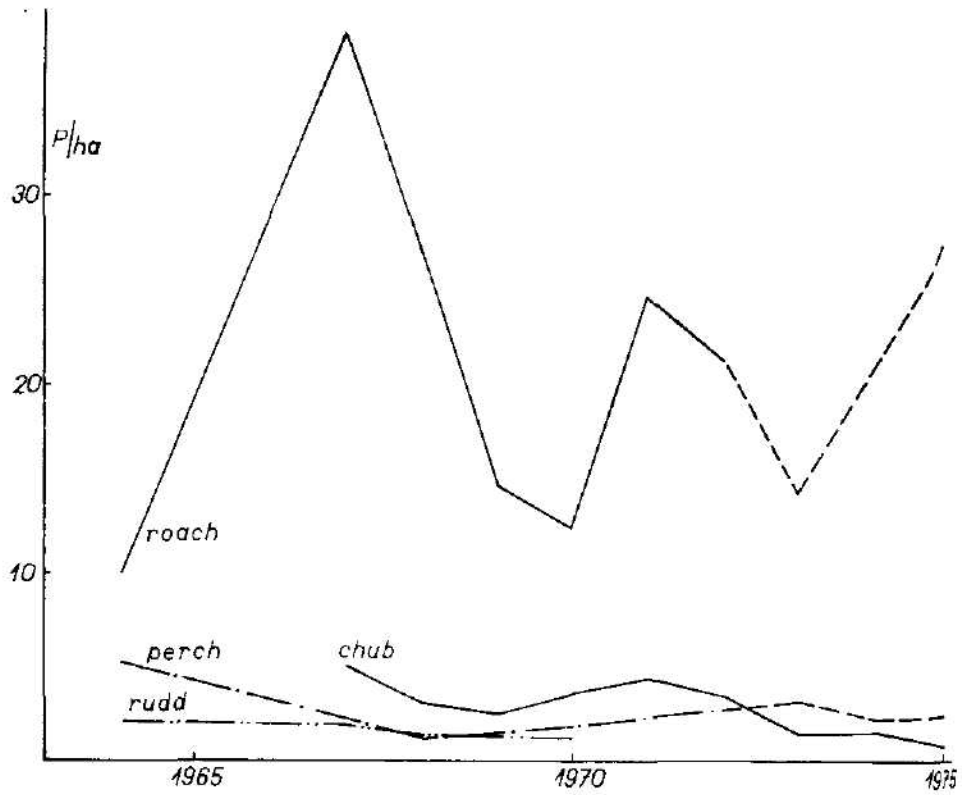


Fig. 1. Position of the chub population among other species in the Klíčava reservoir (total production/ha in different years)

when we take into account that the spawning time of both species is different. The chub spawns later than roach (the time difference is about 1—2 weeks) and the entire spawning is done in two instalments. The second spawning is after about one month (Pecl, 1969). It appears that the first instalment of eggs for chub is more important from the point of strength of its newly recruited year classes because it is difficult to suppose that the external conditions are the same every year at the time of spawning of both species.

The growth of chub from the Klíčava reservoir in comparison with other localities

The growth of chub (in length) in the Klíčava reservoir (mean for the years 1967—1975) has been compared with the mean growth of chub from 44 localities (including Klíčava reservoir). It is plotted in Fig. 2. Using t-test and supposing the same variability in the mean growth of chub from Czechoslovakia as in the case of the Klíčava reservoir one can see that with the exception of 1st, 10th, 11th and 12th age groups the growth of chub from the Klíčava reservoir is significantly better. A little different situation arises when we compare the values of the total increments, which in the case of the Klíčava reservoir are better only in the 2nd and 3rd age groups and

worse in the 8th and 11th age groups. In the other age groups there are no differences between absolute increments.

Very similar situation, i.e. good growth in the younger age groups and its decreasing rate in the older ones, was also observed in roach from the Klíčava reservoir in comparison with roach from the Lipno reservoir (Pivnička, 1972). The differences between the absolute increments were at first in favour of roach from the Klíčava reservoir (in first four age groups), then in favour of roach

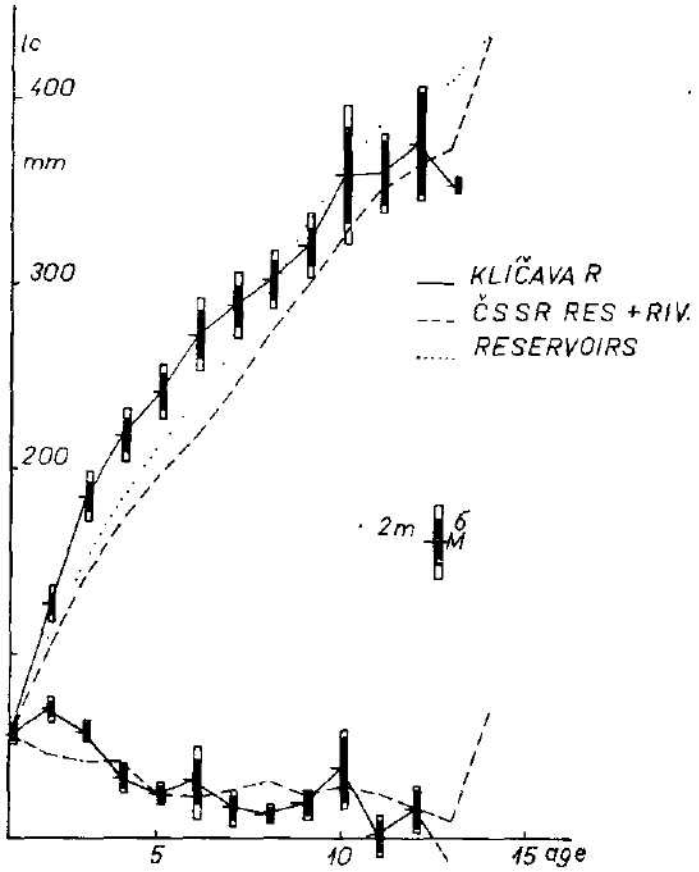


Fig. 2, Growth in leugh of chub in the Klíčava reservoir (mean for the years 1967—1975) pared with growth from rivers and reservoirs and from reservoirs only. (M mean, σ standard deviation, m standard error of the mean)

from the Lipno reservoir (in all older age groups). The increments from the Lipno reservoir being about 100% and better than those from the Klíčava reservoir. The differences in the growth of younger and older age groups in chub (Klíčava reservoir in comparison with the mean growth from all Czechoslovakia) are not so high. However, the Czechoslovak mean growth of chub was calculated from the data of almost equal numbers of rivers and reservoirs. When we take into account the growth from all reservoirs

Table 2. Correlation coefficient (* significant at 5% level, ** significant at 1% level) for different types of equation

Age group	Except years	$y = a - b \ln x$	$y = a - bx$	$y = ax^b$
4		—0.1796	—0.1824	—0.1336
5	75, 73	—0.2684	+0.2195	—0.2822
6	71, 70	—0.5170	—0.4872	—0.8451**
7	70, 75	—0.6867*	—0.6392*	—0.7282*
8		—0.5846*	—0.4927	—0.5618*
9	67, 72, 74	—0.9197**	—0.8733**	—0.9073**
10	69, 70	—0.2335	—0.7400*	—0.4337
P_1	69, 73, 75	—0.5102	—0.6982*	—0.5125
		$y = x(a - b\ln)$		$y = x(ax^b)$
P		—0.1075	+0.8981**	—0.1678
P_A		—0.1047	+0.8939**	—0.1631

(namely Slapy, Orava, Pastviny and Vranov) see in Pecl (1969) the acceleration in the mean growth beginning with the 8th age group is more evident. The *limitation of benthos in the Klíčava reservoir* (Hruška pers. com.) was the main reason advanced for the explanation of this phenomenon in the case of roach (Pivnička, 1972). However, the very good growth of the chub in almost all age groups in the Klíčava reservoir, in comparison with the other reservoirs, can be explained due to its piscivorous feeding habits (Holčík pers. com.).

The relationship between abundance and growth

This relationship was evaluated successively for the 4th—10th age groups. with the exception of the 4th age group where all points (from all years) were used, in all other age groups some of them (usually one two or three) were excluded from the calculation of the given relationship (Table 2). There were especially such values (abundance or growth), which strongly deviated from the general and expected type of the abundance-growth curve (when taken into account they changed the decreasing trend of the calculated

Table 3. Coefficients „b" for chub, perch and roach and for two types of equations

Age group	Chub $y = a - b \ln x$	Chub $y = ax^b$	Roach $y = a - b \ln x$	Roach $y = ax^b$	Perch $y = a - b \ln x$
3			— 4.4190	—0.0346	— 4.9221
4	— 8.7189	—0.0260	— 6.7412	—0.0490	—12.2812
5	—16.8861	—0.0607	—17.3608	—0.1108	+ 8.7331
6	—37.7816	—0.4715	— 8.6132	—0.0884	—18.6931
7	—106.2833	—0.2315	—27.1764	—0.1127	—93.2439
8	—58.2998	—0.1324	—25.3806	—0.0941	—44.6548
9	—67.5303	—0.1385			
10	—44.0507	—0.1222			

relationship into an opposite one). The decreasing and curvelinear relationship between growth and abundance in different fish species was confirmed by Ivlev (1947), Backiel and LeCren (1967) and in the case of roach and perch by Pivnička (1975) and Pivnička and Švátora (1976). The difficulties which emerged in connection with the expulsion of some values would be discussed elsewhere.

In case of chub from the Klíčava reservoir the values of correlation coefficients were significant twice at 5% level and twice at 1% level (for the equation $y = ax^b$); twice at 5% level and once at 1% level (for the equation $y = x(a - b \ln x)$ (Table 2). Very interesting is the comparison among chub, roach and perch as regards the slope of the abundance-growth relationship (coefficient "b" of the equation under question) (Table 3). For the logarithmical relationship it is possible to speak about the increasing trend of "b" coefficient as the fish are growing old (up to the 7th age group), then some small decreasing (or smoothing) can be observed. A possible interpretation is that as the fish are growing old the competition for food is becoming more stronger and also the individuals probably become senile. As regards the absolute values of "b" coefficient they are very similar to one an other in chub and perch, whereas they are very different for chub and roach (those for roach are 2—3 times lower). We are of the opinion that this is in good agreement with the type of population of both species. The roach population is in general very abundant, it is about ten times larger than chub and about 5 times larger than perch. Thus in roach the greater increase in the population number has not such an influence on growth than in the case of perch and chub. This may be due to the fact that roach utilizes the entire water column and is omnivorous. It can be supposed, that the high values of "b" coefficient in the chub and also in the perch are disadvantageous for both in their competition with roach.

As regards the minimal reasonable abundance in individual age groups (i.e. such abundance per ha when the next acceleration in growth is practically impossible) we cannot say anything. In roach it was 1—5 (10) fish ha, in perch 1 fish/ha. In chub with the exception of the 4th age group there exists the real observed values of growth for the abundance being equal or less than 1 fish/ha.

The relationship between abundance and production

The low abundance of the chub in the Klíčava reservoir is probably responsible for a rather straight line than curvilinear relationship between abundance and production calculated for all years (available P_A and total production P). The values of correlation coefficients for both curvilinear relationships are very low (Table 2). On the other hand when the straight line relationship was calculated the correlation coefficients attained the significant value. Thus it is clear that the theoretical maximum values of abundance and production calculated for the curvilinear relationship are very high (e.g. for P_A the theoretical maximum abundance attains the value of $283 \cdot 10^6$!). When some of the extreme points are excluded (i.e. from 1967 and 1971) theoretical maximum value of abundance decreases to 2688 fish/ha and the correlation coefficient increases to the value of −0.3337. Finally when this relationship is calculated only with the values from 1968, 1970, 1972 and 1974. then the theoretial maximum value of abundance decreases

further to 376 fish per ha and the correlation coeficient increases to the value —0.5718. Therefore it is very difficult to come to a final conclusion. However, in the case of the abundance-growth relationship some points were excluded; if not then the slopes in the individual age groups for chub would be very near to those for roach, i.e. 2—3 times lower. In spite of this the roach has theoretical maximum of 870 fish per ha. On the other hand, perch with the high values of the slope in the abundance growth relationship has the maximum theoretical value of abundance of 79 fish. Thus it seems that the maximum of 376 fish per ha for chub can be considered as realistic.

SUMMARY

In the years 1967—1975 the relationship between growth, abundance and production of the chub population in the Klíčava reservoir (4th—10th age groups) was studied. The growth rate, in comparison with other localities from Czechoslovakia, and its position among other species in the Klíčava reservoir were also considered. The abundance of the chub population was estimated using Schnabel's method in 1967, 1968 and 1975. In all other years the abundance was reconstructed using the value of the survival rate ($s = 0.582$) calculated from two estimations from 1967 and 1968. The growth was studied using 852 fish. The individual relationships were calculated using equations $y = a - bx$, $y = a - b \ln x$, $y = ax^b$, $y = x(a - b \ln x)$ and $y = x(ax^b)$. The results are summarized as follows:

1. The chub and roach show the peak of production in the same years. It seems that for the chub the first spawning has much more importance for the strength of its year classes.

2. The correlation coefficients for the growth-abundance relationships were significant in four cases for the equation $y = ax^b$ and in three cases for the equation $y = a - b \ln x$. The slope of this relationship is very similar to that for perch, but 2—3 times steeper than that for roach. This is a disadvantage for the chub (and also for the perch) in their competition with the roach.

3. The reasonable curvilinear relationship between abundance and production was obtained only when it was calculated with the values from 1968, 1970, 1972 and 1974. Theoretical maximum abundance for chub, calculated from the equation $y = x(a - b \ln x)$, attains the value of 376 chubs per ha, the corresponding maximum for perch and roach are 79 and 870 fish per ha respectively.

REFERENCES

Backiel, T., and E. D. LeCren, 1967: Some density relationship for fish population parameters. In: S. D. Gerking: The biological basis of freshwater fish production. — Blackwell Scient Publ. Oxford and Edinburgh: 261—295.

Holčík, J., 1970: The Klíčava reservoir. An ichthyological study. *Biol. práce*, **15** : 5—94.

Holčík, J., and K. Pivnička, 1972: The density and production of fish populations in the Klíčava reservoir (Czechoslovakia) and their changes during period 1957—1970. *Int. Revue ges. Hydrobiol.*, **57** : 883—894.

Holčík, J., and K. Pivnička, 1975: On the use of mark-recapture method for fish population estimation in lakes and large reservoirs. *Zoologické listy*, **24** : 277—287.

Ivlev, V. S., 1947: Vhjane plotnosti posadky na rost karpov. *Bjull. Mosk. Obshch. Ispyt Pir*, **52** : 29—37 (in Russian).

Pecl, K., 1969: Jelec tloušť (Leuciscus cephalus (Linnaeus, 1758)) v Klíčavské údolní nádrži. M. Sc. theses, unpublished (in Czech).

Pivnička, K., 1971: Plodnost, růst, mortalita a produkce rybích populací v Klíčavské údolní nádrži v souvislosti s jejich početností v letech 1957—1970. Ph. D. thesis, unpublished. (in Czech).

Pivnička, K., 1972: Index of production — a new parameter for evaluation of growth and production capacity of fish illustrated with reference to roach Rutilus rutilus (Linnaeus, 1758). *Věst. Čs. spol. zool.*, **36** : 269—274.

Pivnička, K., 1975: Abundance, growth and production of the roach (Rutilus rutilus (L.)) population in the Klíčava reservoir during the years 1967—1972. *Int. Revue, ges. Hydrobiol.*, **60** : 209—220.

Pivnička, K., and M. Švátora, 1976: The abundance, growth and production of the perch population in the Klíčava reservoir during the years 1963—64 and 1967—1972. *Věst. Čs. spol. zool.*, **40** : 32—40.

Authors' adresses. Karel Pecl, prom. biol., Oblastní muzeum v Písku

RNDr. Karel Pivnička, CSc., Katedra systematické zoologie PřF KU, 128 44 Praha, Viničná 7, ČSSR

PhD. Kewal Krishan Tandon, Reader in Zoology, Department of Zoology, Panjab University, Chandigarh-14, 160014, India

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 60—68

Lehrstuhl fur Zoologie der Universitat Olomouc

STRATIFIKATION DER ORGANISMEN IN DER OBERSCHICHT DER SANDKIESSEDIMENTE UNTER DER AKTIVEN STRÖMUNG DER FLÜSSE

OTAKAR ŠTĚRBA

Eingegangen am 29. Juli 1976

Abstract: With the use of a new method, stratification of organisms living in the upper 10 cm of gravel-sand fluvial deposits was carried out. These gravel-sand sediments form the bottom of lowland rivers and are constantly flooded by the surface water of the river. It was found that the stratification of organisms in this layer is uniform. The number of organisms from benthal (i.e. the sediment layer of 0—3.3 cm) is nearly by two times smaller than the number of benthic organisms from the layer of 3 4—10.0 cm.

Using the example of contamination of the surface flow of a river at the time of sugar-beet harvest the author demonstrates the importance of organisms living in the gravel-sand bottom under the active stream for benthos, as well as for the whole ecosystem of the river in a wider sense of the word. The colonial bacterias *Sphaerotilus natans* totally suppress benthos from the surface of the bottom, while its development from 3 cm lower remains intact.

Die biologische Erforschung des Sandkiesbodens unter der aktiven Stromung der Flüsse, die in den letzten Jahren an unserem Lehrstuhl durchgeführt wurde, brachte interessante Ergebnisse. Es wurde festgestellt, dass diese Sedimente bis in die Tiefe von 100 cm reichlich mit der Gesellschaft belebt werden, die vor allem durch Organismen von Benthos bestimmt ist, ergänzt durch Organismen von Seston und kleineren Mengen stygobionter oder stygophiler Arten. Diese Gesellschaft ist kvalitativ und kvantitativ reicher als der Benthos, der als Gesellschaft der Oberfläche des Flussbodens betrachtet wurde. Die bis unlängst noch ganz unbekannte Gesellschaft der Flusssedimente unter dem aktiven Strom ist in das Ekosystem des Stromes im breiterem Sinne des Wortes eingegliedert und seine Gesellschaft hat vielseitige Bedeutung für die Belebung der Oberflächenschicht der Flüsse. Die Tatsache hat u. a. Bedeutung für das Begreifen der ökologischen Gesetze der Flüsse und begründet die Notwendigkeit des Schützes des natürlichen Flussbodens.

Es wurde festgestellt (Štěrba, Holzer, 1977), dass in typischen Sandkiesflüssen die Gesamtzahl der Tiere aus der Schicht der Sedimente 5—100 cm über dem Benthos zahlenmässig ungefähr 4 bis 12mal überwiegt (der mittlere Strom der Morava, der Váh und der Donau), wobei die Sedimente in der Schicht bis 10 resp. bis 20 cm die grösste Belebung haben; tiefer ist die Belebung der Sedimente merklich geringer. Die wichtigste Schicht ist demzufolge die der oberen 10 cm-Schicht, wo auch die Grenze zwischen dem klassisch begriffenen Benthos und der Gesellschaft der interstitialen Gewässer der Sedimente des Flussbodens liegt.

METHODIK

Die vorangehende Erforschung der Sandkiessedimente der Flüsse, die mittels der Methode eingebohrter Stahlzylinder durchgeführt wurde, ermöglichte die Entnahme der Sedimente in Schichten minimal von 10 cm Höhe (Štěrba, 1973, 1976; Štěrba, Holzer, 1977). Für eine mehr detaillierte Analyse der oberen 10 cm — Schicht der Sedimente habe ich deswegen eine Methode entwickelt, die die Entnahme der Sedimente in 3,3 cm — Schichten ermöglicht. Die Grundlage dieser Methode ist eine Stahlblechwand von einer Höhe der Seiten von 25 cm und einer Breite von 26 cm. An der Vorderseite der Trennwand sind Rillen, in die ein Metallrahmen mit ausgespannter Müllerseide eingeschoben wird, wo die mitgeführten Organismen (Seston) eingefangen werden. Im Blechboden der Trennwand ist in rundes Loch, in welches ein Metallring von einem Innendurchmesse von 14,2 cm und einer Höhe von 15 cm eingepasst ist (die Breite des Ringes ist gleich als bei der Methode Štěrba, Holzer 1977). Von der Unterkante des Ringes sind in der Entfernung von 3,3 cm drei halbkreisförmige Schlitze, in die sich eine Metalltrennwand einschieben lässt. Der Metallring kann sobei in die Sedimente genau nach 3,3 cm eingeführt werden und die so abgetrennte Schicht der Sedimente geben wir in die Blechtrennwand ab. Die Tiere aus diesem Volumen werden kvantitativ in dem Planktonnetz, das in der Unterkante der Blechtrennwand eingeschoben ist, eingefangen (Abb. 1., 2.). Die Tiere, die mit den Steinen im Netz eingefangen wurden, habe ich durch die Methode von mehrmaliger Verdünnung und Filtrierung durch ein kleines Planktonnetz gewonnen und kvantitativ unter einer Stereolupe herausgenommen.

Die Entnahme alle 3 Proben aus den oberen 10 cm-Schicht der Sedimente dauert mit Hilfe von dieser Methode ungefähr 10 Minuten.*)

Die Einteilung der oberen 10 cm-Schicht der Sedimente in Drittel wurde vor allem deshalb durchgeführt, weil die oberste (0—3,3 cm Schicht) im Groben die Schicht vorstellt, die bei der üblichen Methode der Erforschung des Benthos als Benthal betrachtet wird. Die Steine, die im Flussboden dachseinförmig schräg in der Stromrichtung eingelagert sind, stecken mit ihrem unteren Teil im Grund und ihr freier Oberteil ragt in der Regel in das freie Wasser nicht mehr als nur 2 cm. Bei der Entfernung der Steine ist der Flussboden bis ungefähr in die Tiefe von 3,3 cm berührt und aus dieser Schicht ist der Benthos eingefangen. Die Steine der obersten Schicht sind auch mit niedrigeren Pflanzen bewachsen, hingegen in den unteren Schichten treffen wir die Pflanzen nicht mehr. Der Pflanzerwuchs festigt und verstopft auch in einem gewissen Mass die oberste Schicht der Sedimente.

Wenn in der oberen Schicht Steine klar über den feineren Fraktionen (feinem Geröll und Sand) überwiegen, ist die untere Schicht (6,7—10 cm) schon granulometrisch ausgeglichen und es handelt sich hier um typischen mittel — bis groben Kies, mit reichem Zusatz von feinen Fraktionen.

Die Mittelschicht (3,4—6,6 cm) stellt den Übergang zwischen beiden erwähnten Schichten dar. Sie ist ideal durchwässert, ungefestigt durch Pflanzenverwachsungen und dank einer Menge von grossen Steinen ist sie auch leicht zutrittbar für grössere benthische Organismen. Granulometrisch inklimiert sie zur *Oberschicht*, die Mehrzahl der anderen Faktore kommt *in ihr* zur Geltung wie in den unteren Schichten (Absenz von Licht und Pflanzen, Ausschliessung der Turbulenzströmung u. s. w.). Der Kontakt zwischen allen drei Schichten ist natürlich der Mehrzahl der benthischen Organismen ermöglicht.

LOKALITÄTEN UND MATERIAL

Die Untersuchung wurde in sechs Lokalitäten von vier Tieflandflüssen durchgeführt.

1. Morava — Chomoutov: Die Lokalität ist an der Nordgrenze der Stadt Olomouc situiert, unter der Strassembrücke der Ortschaft Chomoutov. Bis Januar 1976 führte der Fluss Morava mittel-alfa-mesosaprobes Wasser, in den Herbst- und Wintermonaten war hier eine starke Entfaltung von *Spaerotilus natans* (Zuckerrübenkampagne). Im Jahre 1976 sank die Saprobität auf den Übergang zwischen Alfa- und Betasaprobiten. In dieser Lokalität habe ich 20 Sonden abgenommen (1975: 25. IV. — 1×; 6. V. — 1×; 19. VIII. — 2×. 2. X. — 1×; 22. X. — 2×; 6. XI. — 2×; 1976: 13. V. — 11×). Aus der Gruppe Copepoda, die im weiteren zusammenfassend angeführt wird, handelte es sich um die Arten *C. staphylinus* (Harpacticoida) und *Ac. languidus* (Cyclopoida).

2. Morava — Olomouc: *Lokalität* unter der hohen Wasserwehr in Olomouc. Bis Anfang von 1976 der schlechtere Teil Alfa-Mesosaprobiten mit Entfaltung von *Sph. natans* in der Zuckerrübenkampagne, im Jahre 1976 mittel-alfamesosaprobes Wasser. Es wurden 20 Sonden ent-

---

* Ich danke dem Kollegen M. Holzer für die Mittarbeit bei Arbeiten im Terrain.

nommen (1975: 15. 9. — 2×; 16. 9. — 1×; 30. 9. — 2×; 1976: 10. 3. — 2×; 7. 5. — 13×). Copepoda durch die Art *C. staphylinus* vertreten.

3. **Morava — Tovačov**: Die Lokalität an dem Zusammenfluss der Morava mit der Bečva unter der Stadt Tovačov. Im Jahre 1975 Übergang der Alfamesosaprobität und Polysaprobität, im Jahre 1976 Alfamesosaprobität. Es wurden 20 Sonden abgenommen (1975: 14. 5. — 2×, 20. 8. — 2×; 21. 11. — 1×; 1976: 11. 5. — 15×). Die Copepoda durch die Art *C. staphylinus* und Cyclopoida juv. vertreten.

4. Bečva — **Tovačov**: Die Lokalität an dem Fluss Bečva vor dem Zusammenfluss mit der Morava, Übergang von Beta- und Alfamesosaprobität. Es wurden 20 Sonden entnommen (1975: 14, 5, — 2×, 20. 8. — 2×, 21. 11. — 1×; 1976: 11. 5. — 15×). Copepoda durch die Art *C. staphylinus* und Cyclopoida juv. vertreten.

5. Váh — Ratnovce: Die Lokalität am mittleren Strom des Flusses Váh, ungefähr 500 m unter dem Damm des Stausees bei Pieštany. Übergang von Beta- und Alfamesosaprobität. Es wurden 22 Sonden entnommen (1975: 17. 6. — 3×, 18. 6. — 3×, 8. 10. — 3×; 1976; 1. 4. — 2×, 20. 5. — 11×). Copepoda: *C. staphylinus* (Harpacticoida), *Par. fimbriatus*, *Ac. languidus*, *Macroc. albidus* (Cyclopoida), Cladocera: *Daphnia pulex*, *D. cuculata*, *Chyd. sphaericus*, *Alona costata*, *Leygig. leydigni*.

6. Donau — Vojka: Lokalität am linken Ufer der Donau an der „Žitný ostrov" Insel, Flusskilometer 1.838, Übergang der Beta- und Alfamesosaprobität. Entnommen wurden 29 Sonden (1975: 19. 3. — 6×, 9. 10. — 2×; 1976: 2. 4. — 16×, 19. 5. — 5×). Copepoda: *C. sta-*

Tafel No. 1: Die durchchnittliche Abundanz der Organismen in den Lokalitäten, berrechnet auf die Fläche von 1 m². A = Schicht 0—3,3 cm, B = 3,4—6,6 cm, C = 6,7—10,0 cm.

Organismen	Morava — Chomoutov			Morava — Olomouc			Morava — Tovačov		
	A	B	C	A	B	C	A	B	C
Hydra sp.							3		
Nematoda	328	734	1026	63	270	503	722	951	1252
Eiseniella tetraedra									
Oligochaeta	2221	2245	1637	2775	2663	2423	2636	2631	2531
Herpobdella octoculata	36	42	90		6	9	286	159	120
Glossiphonia complanata							9	3	
Ancylus fluviatilis	6	6	9						
Sphaerium sp.									
Cladocera									
Copepoda	45	54	72		3	18	27	12	12
Rivulogammarus roeselii	42	54	72	6	6		3		
Niphargus sp.									
Asellus aquaticus	27	117	192		6		18	12	15
Hydracarina	3								
Colombolla									
Baetis sp.	6	9				3	24	21	18
Torleya major									
Potamanthus luteus									
Hydropsyche sp.	30	27	33				6	18	3
Chironomus gr. *thummi*				686	482	542			
Chironomidae	352	250	211	214	135	126	229	129	87
Ceratopogon sp.	3								
Simulidae									
Tipulidae									
Insgesamt	3099	3538	3342	3744	3571	3624	3963	3936	4038
A + B + C		9979			10939			11964	

phylinus, Nitocrella hibernica (Harpacticoida), *Euc. serrulatus, Ac. crassicaudis, Ac. languidus* (Cyclopoida).

In allen Lokalitäten überwiegt Flussgeröll mittlerer Grosse bis grob, die Grosse der uberwiegenden Zahl der Steine im Abstand von 20,0 bis 40,0 mm, in der Richtung Tiefe nimmt die Zahl der feinen Fraktionen zu. In der Lokalität an der Donau ist das Geröll einigermassen kleiner, es fehlt nahezu die Fraktion des Feinsandes, das Sediment ist homogener.

Insgesamt wurden 131 Sonden aus der 10 cm-Schicht der oberen Sedimente abgenommen. d. h. 393 einzelner Proben, von denen insgesamt 17 801 Tiere herausgenommen wurden.

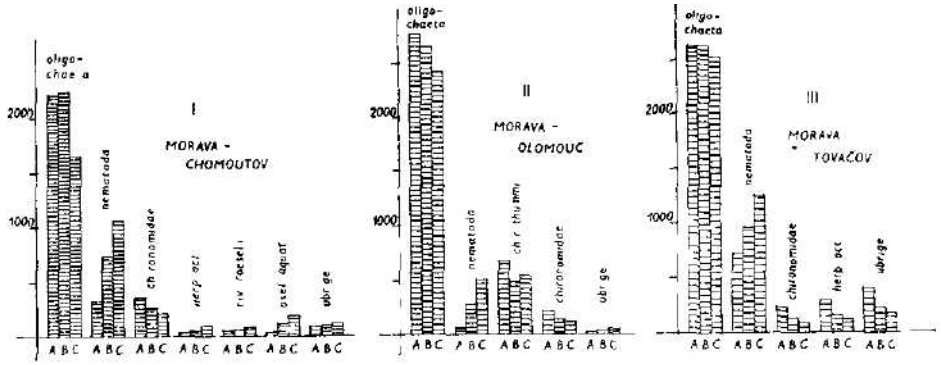
DIE FESTGESTELLTE GEMEINSCHAFT UND IHRE STRATIFIKATION

Es wurden insgesamt 34 Taxone festgestellt, das Artenspektrum ist natürlich viel bunter, denn die Hauptgruppen wurden meistenteils nicht näher determiniert.

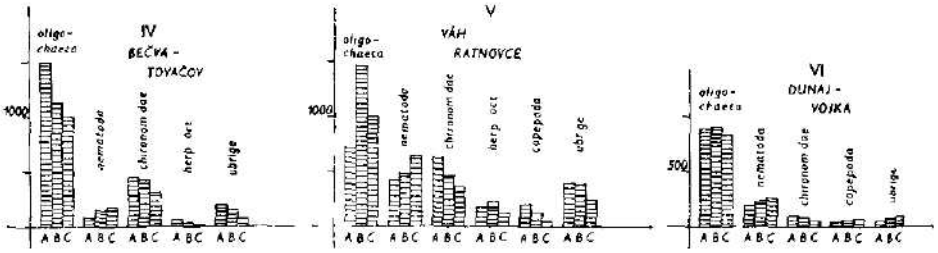
Die Zusammensetzung der Gemeinschaft ist durch den Gesamtcharakter des Stromes bestimmt, vor allem durch mässig strömendes Wasser, Sandkiesboden und verhältnissmässig starke organische Verunreinigung des Oberflächenstromes.

Zwei der wichtigsten Gruppen — Oligochaeta und Chironomidae — gehören zu den typischen benthischen Formen der Flüsse von diesem Cha-

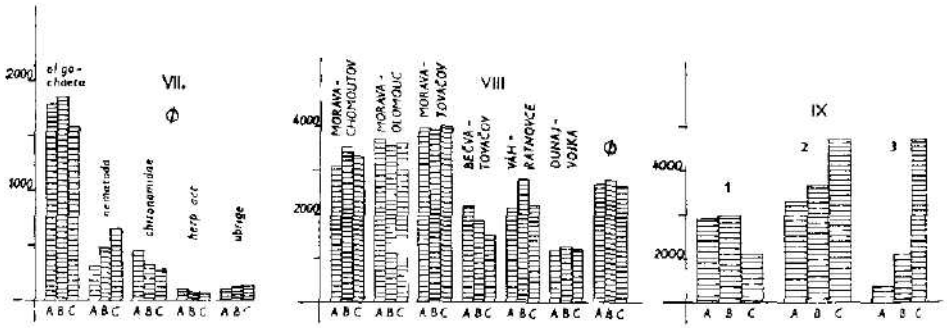
Bečva — Tovačov			Váh — Ratnovce			Dunaj — Vojka			Alle Lokalitäten, Durchschnitt		
A	B	C	A	B	C	A	B	C	A	B	C
									3		
75	147	163	425	494	640	87	108	119	300	472	640
18	18	12							3	3	2
1496	1126	999	718	1464	1005	885	898	837	1788	1838	1522
57	33	18	172	218	118	4	7	4	93	78	60
6	6	3	49	40	23	4	2	2	11	8	5
							2		1	1	2
								2			+
			49	57	49				8	9	8
15	3		100	57	43	37	55	72	37	31	36
3	6				3				9	11	13
								2			+
			14	9	3				10	24	35
									+		
								2			+
12	3	9							7	6	5
39	39	24							7	7	6
18	33	9							3	5	2
								2	6	7	6
									114	80	90
445	424	304	631	465	359	94	89	48	327	249	189
									+		
			2						1		
12	15								2	3	
2196	1853	1541	2164	2804	2243	1214	1288	1230	2730	2831	2670
	5590			7211			3732			8235	



Graph 1—3: Die Durchschnittsabundanz der Organismen in den Lokalitaten Morava — Chomoutov, Morava — Olomouc und Morava — Tovačov, uberrechnet auf die Flache 1 m². A = 0—3,3 cm B = 3,4—6,6 cm, C = 6,7—10,0 cm.



Graph 4—6: Die Durchschnittsabundanz der Organismen in den Lokalitaten Bečva — Tovačov, Váh — Ratnovce und Donau — Vojka, uberrechnet auf die Flache 1 m². A = 0—3,3 cm, B = 3,4—6,6 cm, C = 6,7—10,0 cm.



Graph 7: Die Durchschnittsabundanz der Organismen aus allen Lokalitaten.
Graph 8: Die Durchschnittsabundanz samtlicher Organismen in den Lokalitaten.
Graph 9. Der Einfluss der Zuckerrubenkampagne auf die Lokalitat Morava — Chomoutov 1 — ausserhalb der Kampagne, 2 — Anfang der Kampagne, 3 — Vollperiode der Kampagne A = 0—3,3 cm, B = 3,4—6,6 cm, C = 6,7—10,0 cm.

rakter, dergleichen als Hirudinea, *Rivulogammarus roeselii*, *Asellus aquaticus*, Ephemeroptera und Trichoptera.

Eine besondere typologische Stellung nimmt die zweite zahlreichste Gruppe ein — die Nematoda. Ihre Vertreter leben zwar üblich im Benthal, doch inklinieren mehr zu den interstitialen Gewassern der Sedimente (Štěrba, Holzer, 1977). Nematoda können wir also nicht als eine typische benthische Gruppe betrachten.

Der Charakter der festgestellten Gemeinschaft wird also vor allem durch benthische Gruppen gestaltet, weiter dann durch die Gruppe Nematoda, und wird ergänzt durch einige Arten vom Seston und durch einen unbedeutenden Prozentsatz von Stygobioten (*Niphargus*) oder Stygophilen (*Ac. languidus*, *C. staphylinus*). Das Übergewich der benthischen Formen über den anderen ist in dieser Schicht begreiflich ausgeprägter, als bei dem Vergleich der Oberschicht mit der Schicht bis 100 cm Tiefe.

Die Stratifikation der Organismen in der oberen 10 cm-Schicht der Sedimente ist in der Tafel Nr. 1 und in den Graphen Nr 1—8 dargelegt. Alle Werte sind hier auf die Fläche von 1 m² in der entsprechenden Schicht uberrechnet.

Wenn wir die durchschnittliche Abundanz gesamter festgestellter Organismen aus allen Lokalitäten vergleichen (Graph Nr. 7), sehen wir, das die Mehrzahl der Organismen in der Mittelschicht lebt (3,4—6,6 cm — 2.831 Stuck unter einer Fläche von 1 m²), etwas weniger in der Oberschicht (2.730 Stück) und am wenigsten in der unteren Schicht (2670 Stück). Die Unterschiede in der Gesamtabundanz sind jedoch klein und sind nicht in den einzelnen Lokalitäten regelmässig. Wir können deshalb konstatieren, dass, soweit es sich um die Durchschnittszahl aller Organismen handelt, die ganze obere 10 cm-Schicht der Sedimente im Grundsatz gleichmässig belebt ist

Die wichtigste Gruppe — Oligochaeta — erreicht in der Regel ihre grösste Entwicklung in den zwei oberen Schichten. Die einzige Ausnahme ist die Lokalität Váh — Ratnovce, wo es in der Oberschicht die wenigsten Oligochaeta gibt. Das ist durch das Vorkommen grösserer Rollsteine auf der Oberfläche des Flussbodens der Lokalität zu erklären.

Die zweite zahlreichste Gruppe — Nematoda — hat eine ganz eindeutige Stratifikation. Von der Oberfläche des Bodens in die Tiefe wächst die Zahl der Nematoda und dieser Trend schreitet offenbar fort bis in die Tiefe von 20 resp. 30 cm (Štěrba, Holzer, 1977).

Eine umgekehrte Stratifikation hat die dritte zahlreichste Gruppe, Chironomidae. Die meisten von ihnen leben in der Oberschicht, in Richtung Tiefe nimmt ihre Zahl ab.

Verhältnissmässig gleichmässige Einschichtung weisen Hirudinea und *Riv. roeselii* auf. Ihre zahlenmässige Vertretung ist zwar merklich niedriger als bei vorhin erwöhnten Gruppen, der Anteil an der Biomasse jedoch ist bedeutungsvoll.

Die Zusammenfassung der übrigen Organismen ist in den oberen 10 cm-Schicht gleichmässig eingeteilt. Beachtlich ist das Vorkommen einiger typisch „benthischen" Organismen in der mittleren und unteren untersuchten Schicht (*Baetis*, *Torlea minor*, *Potamanlus luteus*, *Hydropsyche*, *Ancylus fluviatilis*, *Sphaerium*, *Asellus aquaticus*).

Die Stratifikation und die Zusammensetzung der Lebewesen-Gemeinschaft in den Sedimenten des Flussbodens wird durch eine Reihe von Faktoren

Tafel No. 2: Der Einfluss der Zuckerrübenkampagne auf die Lokalität Morava — Chomoutov

Organismen	I				II				III			
	A	B	C	A+B +C	A	B	C	A+B +C	A	B	C	A+B +C
Oligochaeta	3016	2927	1079	7022	379	569	2275	3223	221	679	3966	4866
Nematoda	369	693	773	1835	189	822	1390	2401	284	995	2133	3412
Chironomidae	353	298	256	907	2086	569	316	2971		47	63	110
Rivulogammarus roeselii		4	4	8	8	632	758	2212	63	63	174	300
Asellus aquaticus	4	4	4	12	506	1959	1833	4298		111	537	648
Herpobdella octoculata	8	4	8	20		63	316	379	158	190	363	711
Copepoda	50	50	88	188	126	126		252	16	63	47	126
Baetis sp.	8	13		21	63			63				
Hydropsyche sp.	4	4		8	442	316	442	1200	32	47	79	158
Ceratopogon sp.	50			50	63			63				
Hydracarina	4			4								
Anoylus fluviatilis					126	63	126	315		16	16	32
Hydra sp.											32	32
Insgesamt	3866	3997	2212	10075	4612	5309	7456	17377	774	2211	7410	10395

bestimmt; darunter gehört u. a. auch die Reinheit des Oberflächenteils des Flusses. Ein typisches Beispiel dafür sind die Verhältnisse in der Lokalität Morava — Chomoutov, die im Herbst und Winter durch die Abwässer einer höher gelegenen Zuckerfabrik beeinflusst wird.

Im Verlauf der ersten drei Wochen der Zuckerrübenkampagne (Anfang Oktober) wird der Flussboden durch eine zusammenhängende und dicke Schicht von Kolonien *Sp. natans* samt Begleitflora überzogen, die je nach Wasserstand bis Ende Januar oder Februar überlebt. Die Verhältnisse in dieser Lokalität mit Hinsicht auf Einfluss der Abwässer aus der Zuckerfabrik zeigt die Tafel Nr. 2 und der Graph Nr. 9.

In dem ersten Teil der Tafel Nr. 2 sind Durchschnittswerte aus der Periode ausser der Kampagne (15 Sonden), der zweite Teil der Tafel gibt den Anfang der Zuckerrübenkampagne wieder, wenn der Flussboden noch nicht mit den Kolonien *Sp. natons* überzogen war (1 Sonde vom 2. 10. 1975 — der Zeitabschnitt des Herbstmaximums der Entwicklung der Organismen). Der letzte Teil der Tafel führt Durchnschnitte aus 4 Sonden an, und zwar in der vollen Entfaltung *Sp. natons* (22. 10. und 6. 11. 75). In der Periode ausserhalb der Kampagne sind die Verhältnisse in der Lokalität ähnlich wie in anderen Lokalitäten, mit leichtem Übergewicht der Organismen in den oberen zwei Schichten Schon in den ersten Tagen der Kampagne kommt es zu einer Abnahme der Zahl der Organismen in den oberen zwei Schichten, besonders aber in der obersten Schicht, die von den Abwässern unmittelbar in Mitleidenschaft gezogen wird. Im Verlauf der Kampagne, wenn es zu einer vollen Entwicklung *Sp. natans* kommt, ist die Abnahme in den oberen zwei Schichten enorm,

während in der Schicht 6,7—10 cm die Zahl der Organismen die gleiche wie am Anfang der Kampagne ist (in einer von 2 Proben, die am 22. 10. entnommen wurden, war in der Oberschicht keines von den untersuchten Tieren gefunden!).

Dieser Fal beweist klar die Bedeutung der Sandkiessedimente für den Schutz der Organismen vor Vergiftungen oder anderen negativen Einflüssen in dem Oberflächenteil des Flusses.

Der Verlauf der Entwicklung der Belebung der Sedimente in der Zuckerrübenkampagne weist auch darauf hin, in welcher Weise sich die Organismen des Bodens retten. Wir nehmen an, dass diejenigen Organismen des Benthal, die durch die Vergiftung des freien Wassers direkt betroffen sind (d. h. der Benthos auf der Oberfläche des Bodens), nicht fähig sind vo der Vergiftung aktiv in die tieferen Schichten der Sandkreise zu flüchten. Wenn nämlich die Tiere von der Bodenoberfläche aktiv vor der Vergiftung in die interstitialen Gewässer der Sedimente flüchten möchten, müsste ihre Zahl in der 6,7—10 cm-Schicht merklich grösser sein als am Anfang der Zuckerrübenkampagne. Im Gegenteil, es scheint, dass sich vor der Vergiftund nur die benthischen Organismen retten, die in den tieferen Schichten bereits vor dem Anfang der Vergiftung sind. Diese Organismen beleben dann allmählich die vergiftete Oberfläche des Bodens.*)

ZUSAMMENFASSUNG

Die angewendete Methode hat die Untersuchung der Stratifikation der Organismen in der oberen 10 cm-Schicht der Sandkiessedimente unter dem aktiven Strom der Tieflandflüsse ermöglicht. In 6 Lokalitäten der Flüsse Morava, Bečva, Váh und Donau wurden 393 Proben aus 131 Sonden abgenommen, aus denen 17.801 Tiere gewonnen wurden.

Die festgestellte Gemeinschaft besteht vor allem aus benthischen Formen *(Oligochaeta, Nematoda, Insektenlarven, R. roeselii, As. aquaticus, Hirudinea u. a.)*, weiter dann aus der Gruppe Nematoda, die zu den interstitialen Gewässern der Sedimente inkliniert, und diese Formen sind durch einige Vertreter des Sestons und der Stygobionte oder Stygophile ergänzt.

Zahlenmässig sind die Sedimente in der oberen 10 cm-Schicht im ganzen gleichmässig belebt, wenn auch die einzelnen Drittel dieser Schicht nicht exakt gleichen Charakter haben, was sich durch verschiedene Einschichtung einiger Gruppen zeigt.

Die oberste Schicht der Sedimente (0—3,3 cm), die wir als Benthal s. str. bezeichnen, enthält beinahe zweimal weniger der benthischen Tiere als die Gemeinschaft der übrigen zwei untersuchten Schichten (3,4—10,0 cm).

Die benthischen Organismen, die so zahlreich in den tieferen Schichten der Sedimente leben, haben zweifellos eine grosse Bedeutung für die Ergänzung des Benthos an der Oberfläche des Flussbodens.

---

*) Dieser Vorstellung entsprechen auch die Versuche, die auf unserer Arbeitsstatte durchgefuhrt wurden (Střížová 1975). Bei der Simulation der Vergiftung in einem Versuchsflussbett haben die Versuchstiere eine Vergiftung mit konzentriertem Phenol nur dann sicher überlebt, wenn sie unter einer Sandschicht schon vor dem Anfang der Vergiftung versteckt waren. Sofern ich die Tiere am Anfang der Vergiftung and er Oberflache des kunsthchen Bodens befanden, d. h. direkt im Kontakt mit dem vergifteten Wasser waren, gelang es ihnen niemals sich in den Sand unter ihnen zu verkriechen.

Die interstitialen Gewässer der Sandkiesablagerungen sind ein bedeutsvolles ökologisches Refugium der benthischen Fauna bei Kalamitäten im Oberflächenteil des Flusses. Ein typisches Beispiel sind die Verhältnisse in der Lokalität Morava — Chomoutov, die im Herbst durch Zuckerfabrikawässer berührt wird, was sich durch Dezimation der Organismen in den oberen zwei Schichten erwies, während in der Schicht 6,7—10,0 cm der Vernichtungseinfluss der Oberflächenvergiftung nicht mehr zum Vorschein kam.

Die erzielten Ergebnisse knüpfen an die vorhergehende Erforschung der Sandkiessedimente in die Tiefe bis 100,0 cm an. Sie haben Bedeutung für die theoretische und praktische Hydrobiologie, Ökologie sowie für Wasserwirtschaft. Sie bezeugen, dass der Benthos, begriffen als eine Gemeinschaft der Bodenoberfläche, nur einen kleineren Teil der Gesamtzahl der benthischen Organismen, die in den Flusssedimenten unterhalb der aktiven Strömung leben, vorstellt. Mit Hinsicht auf die Verbundenheit des Benthal und der interstitialen Gewässer der Sedimente unterhalb der aktiven Strömung kann der Benthos jederzeit durch benthische Organismen aus dem Sedimenten ergänzt werden, was eine besonders grosse Bedeutung nach Vergiftungen

Diese Tatsachen rufen die Notwendigkeit eines folgerichtigen Schutzes des Sandkiesbodens unserer Flüsse hervor. Eine Beschädigung der natürlichen Struktur des Bodens kann zur Degradation der Entfaltung des Benthos, zur Unmöglichkeit seiner Regeneration und damit zu einer wessentlichen Herabsetzung der selbstreinigenden Fähigkeit der Flüsse führen, bei der der Benthos eine bedeutende Rolle spielt.

SCHRIFTTUM

Helan, J., Kubíček, F., Losos, B., Sedlák, E., Zelinka, M., 1973: Production Conditions in the Trout Brooks of the Beskydy Mountains. *Fol. Sc. Nat. Univ. Brno*, **14** : 5—105

Holzer, M., 1975: Fauna podzemních poříčních vod pod aktivním tokem. Disertation, Olomouc 1—84.

Koláčný, M., 1975: Fauna podzemních poříčních vod s ohledem na strukturu sedimentu. Disertation, Olomouc: 1—55

Střížová, M., 1975: Sledování aktivního pohybu zástupců fauny podzemních poříčních vod Disertation, Olomouc : 1—48

Štěrba, O., 1973: *Research Problems of the Phreatic Water Fauna. VIth Int. Congr. Spel* Olomouc: 153—Abstracts

Štěrba, O., 1975: Research Problems of the Phreatic Water Fauna. VIth Int. Congr. Spel. Olomouc, im Druck

Štěrba, O., Holzer, M., 1977: Fauna der interstitiellen Gewasser der Sandkiessedimente unter der aktiven Stromung. *Věst. Čs. spol. zool.*, **41** : 144—159

Die Abbildungen 1 und 2 siehe am Ende des Heftes.

Anschrift des Verfassers: Doc. RNDr. O. Štěrba, Lenínova 25, 770 00 Olomouc, ČSSR.

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 69—76

FURTHER NOTES ON THE GROWTH OF PIKE, ESOX LUCIUS FROM CZECHOSLOVAKIA (OSTEICHTHYES: CLUPEIFORMES)

Department of Systematic Zoology, Charles University, Prague

KEWAL KRISHAN TANDON* and OTA OLIVA

Received June 10, 1976

Abstract: Growth rate of pike, *Esox lucius* Linnaeus, 1758, collected during the years 1965—1975, has been studied from the scales of 87 specimens. Pikes of 11+ years were recorded. Hile's nomogram, prepared by Oliva (1955) for the pikes in Czechoslovakia, was used for the back-calculation of lengths at the formation of respective annuli. The index of species average size and growth increment have been found to be similar in specimens from the rivers Berounka and Vltava. Our data when compared with earlier authors indicate relatively slow growth of pikes.

INTRODUCTION

Growth of pike has been studied from time to time in Czechoslovakia. The studies were initiated by Oliva (1955) and followed by Čihař (1961), Frank and Vostradovský (1961), Balon (1965), Vostradovský (1968) and Poupě (1974). Van Oosten (1960) and Frost and Kipling (1961) described the growth of pike from the United States of America. Toner and Lawler (1969) published a synopsis of the biological data on pike. Very valuable results concerning the various aspects of population dynamics of pike, based on a very large material from great valley water river reservoir Lipno, were obtained by Vostradovský (1968, 1969a, b, c and 1970, 1971).

One of us (O. Oliva) has been receiving samples of scales of pikes from anglers' catches for a number of years. Thus the scales analysed for the present study do not form a homogenous collection. In general the growth of pikes constitutes an interesting problem since the fish is up to the length of 200 mm partially and from 200 mm purely piscivorous (Vostradovský, 1971).

MATERIAL AND METHODS

Scales collected during the years 1965—1975 were sorted out locality-wise. Three to four scales were used for the study but only one was read under the microprojector (Carl Zeiss, Jena, magnification 17.5) using the centro-lateral scale radius. The larval and the marginal marks were ignored. First of May was taken as the time of formation of an annulus. This made the reading of the scales easier. Hile's nomogram prepared by Oliva (1955) was used for the back-calculation of lengths at respective annuli (with a correction factor of 4 cm). Since the collector recorded total length in each case, it was converted to body length using the following conversion factor:

Total length = 1.146 Standard length (calculated from the data of Oliva, 1955).

*) Department of Zoology, Panjab University, Chandigarh (India). This paper is a part of work in Prague sponsored by UNESCO course on the modern problems in biology.

Table 1. Growth of pike, *Esox lucius* from the river Berounka

Number of specimens	Age group	Average standard length (in cm) at the time of capture, ranges in brackets	
25	III	44.9 (38–50)	
7	IV	50.1 (47–53)	
7	V	65.3 (62–70)	
1	VIII	83	
			Average 1) Annual increment 2) Index of species average size 3)

RESULTS

The result of the analysis are presented in Tables 1 to 3. It can be seen that the average size of a pike at the formation of 8th annulus is 75 cm in Berounka river whereas smaller pikes in our collection are from the river Vltava, but the rate of growth and the index of species average size are almost the same in both localities. The absence of larger pikes in Vltava may be due to the fact that when fishing was conducted the larger pikes either escaped the anglers' hooks or were absent. Hence the data from these localities can be pooled. The curvilinear relationship between the scale radius and the standard length, and the nomogram used for the back-calculations are shown in Figure 1. The data for the lower size groups were taken from

Table 2. Growth of pike, *Esox lucius* from the river Vltava

Number of specimens	Age group	Average standard length (in cm) at the time of capture, ranges in brackets	
22	III	45.6 (40–55)	
5	IV	54.8 (49–59)	
2	V	64.0 (63–65)	
1	VI	65	
			Average 1) Annual increment 2) Index of species average size 3)

	Average back-calculated lengths (in cm), ranges in brackets							
	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
	22.0 (18–26)	30.6 (27–35)	38.3 (34–45)					
	20.1 (18–22)	30.0 (28–33)	37.9 (35–41)	44.3 (41–47)				
	19.3 (17–23)	27.1 (25–35)	36.1 (31–42)	46.0 (42–50)	56.0 (53–59)			
	23	31	38	48	52	59	67	75
1)	21	30	38	46	54	59	67	75
2)	9	8	8	8	5	8	8	
3)			9.4 cm					

Oliva (1955). The conversion factor (total length/standard length) at each length has been plotted against the standard length (Fig. 2) to show that the length of caudal fin decreases with the increase of fish length and becomes constant when the fish is 100 cm.

The „trophy" pikes of anglers, collected from various tributaries of the Labe river, were also studied. Although the number of such pikes was very small, nevertheless the results are quite interesting and are presented in Table 3. The examination of scales showed that one of the pikes was 11+ years and the back-calculated length at the time of formation of 11th annulus was 88 cm. This specimen was male and the body length at the time of capture was 99 cm. On the other side of the scale was a female of 109 cm body length whose age was assessed 9+ years. It appears that females grow faster whereas males show stunted growth and perhaps live longer than females.

	Averages back-calculated lengths (in cm), ranges in brackets.					
	l_1	l_2	l_3	l_4	l_5	l_6
	21.8 (20–26)	30.3 (27–34)	38.0 (34–44)			
	22.8 (21–25)	31.6 (29–33)	38.4 (35–40)	46.0 (42–49)		
	21.0 (21)	28.5 (28–29)	34.0 (34)	44.5 (42–44)	52.5 (52–53)	
	25	33	39	45	51	57
1)	23	31	37	45	52	57
2)	8	6	8	7	5	
3)			9.5 cm			

Table 3. Growth of pike, *Esox lucius* from the Labe river system

Number of specimens	Age group	Average standard length (in cm) at the time of capture, ranges in brackets	l_1	l_2
1	IV	56	19	31
5	VII	80.2 (72—92)	21.2 (18—24)	29.8 (26—34)
2	VIII	82.0 (79—85)	22.5 (21—24)	30.5 (30—31)
6	IX	97.3 (90—109)	18.0 (17—20)	24.7 (21—27)
1	X	85	22	30
1	XI	99	21	24
		Average 1)	21	28
		Annual increment 2)	7	
		Index of species average size 3)		

The gut contents of 18 "trophy" pikes, caught from 3/9/1972 to 3/9/1975, revealed following interesting points:

a) The incidence of empty stomachs is almost equal in males and females.

b) Pikes are piscivorous feeding on carps and perches alike. The food consists of *Alburnus alburnus*, *Rutilus rutilus*, *Blicca bjoerkna*, *Perca fluviatilis*, *Leuciscus cephalus*, *Tinca tinca*, *Carassius carassius* and *Barbus barbus*.

Table 4. Comparison of the growth rate (in mm) of pike, *Esox lucius* from different localities

Author/year	Locality	l_1	l_2
Poupě, 1974	Inundation area of river Labe in Central Bohemia	167	319
Oliva, 1956	Backwater "Poltruba"	171	312
Frank & Vostradovský, 1961	Lipno valley water reservoir	163	252
Authors	i) Vltava river	230	310
	ii) Berounka river	210	300
	iii) "Trophy" pikes	210	280
	Bohemia (average i) to iii)	217	297
Čihař, 1961	Slapy valley water reservoir	222	364
Balon, 1965	Orava valley water reservoir	232	340
Vostradovský, 1968	Lipno valley water reservoir (average 1959 to 1967)	249	382

	Average back-calculated lengths (in cm), ranges in brackets								
	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
	36	43							
	37.0 (30—42)	44.2 (36—54)	52.0 (39—69)	62.4 (55—78)	71.8 (65—87)				
	37.0 (34—40)	43.5 (40—47)	51.5 (51—52)	57.0 (54—60)	65.5 (65—66)	74.5 (74—75)			
	31.0 (28—37)	39.2 (34—49)	49.5 (41—62)	60.2 (48—72)	67.7 (52—80)	77.8 (66—90)	87.0 (80—100)		
	37	42	48	53	63	71	75	80	
	32	37	48	62	69	73	78	82	88
1)	35	42	50	59	67	74	80	81	88
2)	7	8	9	8	7	6	1	7	
3)			8 cm						

c) The food habits of fishes above 60 cm (total length) are almost the same.

DISCUSSION

That the growth of pikes depends upon the source of food supply has been shown by Oliva (1955, 1956, 1957, 1958, 1959, 1960), Vostradovský (1968)

of Czechoslovakia

Average back-calculated lengths (in mm)								
l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
450	579	670	790	—	—	—	—	—
440	570	—	—	—	—	—	—	—
326	415	488	494	—	—	—	—	—
370	450	520	570	—	—	—	—	—
380	460	540	590	670	750	—	—	—
350	420	500	590	670	740	800	810	880
367	443	520	585	670	745	800	810	880
460	527	652	790	—	—	—	—	—
424	475	590	681	756	757	852	879	—
469	565	679	741	926	930	—	—	—

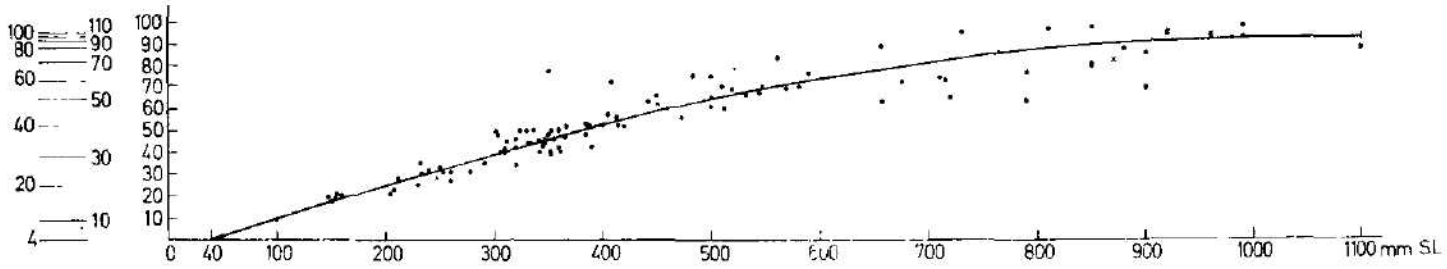


Fig. 1. Relationship between centro-lateral scale radius (in mm) and standard length (in mm) of pike, *Esox lucius* along with the nomogram.

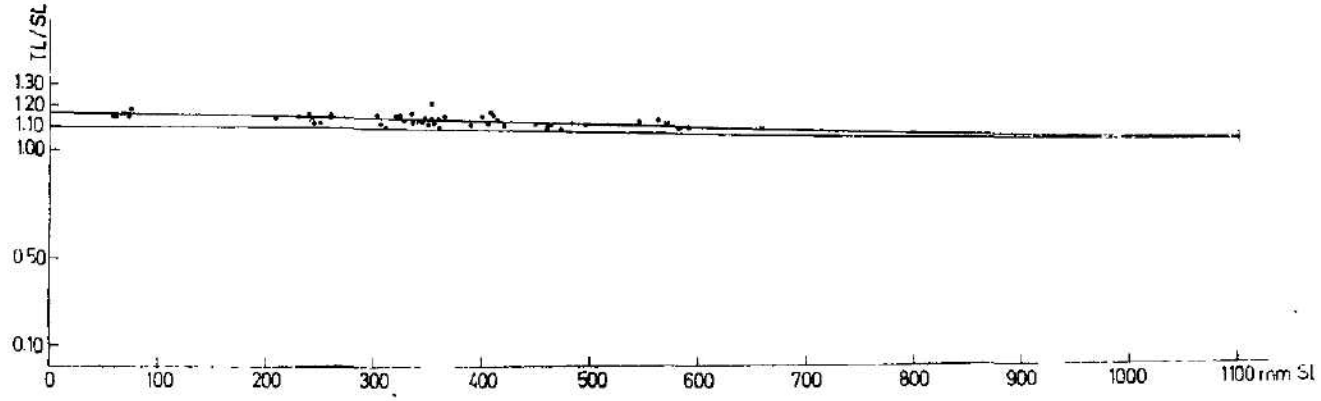


Fig. 2. Relationship between the standard length (in mm) and conversion factor (total length/standard length) of pike, *Esox lucius* at respective lengths.

and Poupě (1974). We are of the opinion that temperature, food supply and space are the major factors controlling the growth of pikes in different bodies of water. A comparative statement of growth from different localities is given in Table 4.

Vostradovský (1971) commented that the food spectra of pike are considerably wide, although several fish species form the most important part. According to him perch and roach constitute the major items of food. He also observed cannibalistic behaviour of pike, but this is not clear from our sample which is perhaps due to its very small size at our disposal.

In a series of communications Vostradovský detailed the various aspects of pikes as under:

In one communication (1969a) he remarked that in female fish the daily weight increases are greater than in males. The migrating pikes show greater length and weight increases than the "staying-in-place" fish which seek or wait for the prey within a limited range. This, according to him, is the most important cause of the differences in the growth of pikes in the same locality. This was also observed by Oliva (1956).

Again (1969b) he pointed out the balance of numbers of both sexes with a slight predominance of males over females, with deviations depending upon the time and method of collecting material. Continuing his observations (1969c) he described that females survive up to the highest age classes (with a lower annual rate of mortality). He further writes that a higher degree of mortality occurs in both sexes after the fish attains a length of 500 mm (after the 3rd year of life).

In 1970 he commented that female pikes had better coefficient of condition than males. From this remark of his it can be inferred that females attain larger size and weight than males.

Our observations are in conformity with those of Vostradovský (1970) in so far that females attain larger size during their life span but differ in having lower ages than males.

Acknowledgements

We are grateful to Mr. Jiří Pásek for his never failing interest in the collection of scale samples of pikes from the rivers Vltava and Berounka in the suburbs of Prague. The scales from the "trophy" pikes were furnished by Dr. Jan Porkert, to whom we express our sincere thanks. The necessary data on the trophy pikes were supplied by individual anglers, using questionaires, our thanks are also due to them.

The senior author is also thankful to Dr. G. P. Sharma, Professor and Head of the Department of Zoology, Panjab University, Chandigarh (India), and to UNESCO for enabling him to carry out this work in Prague, Czechoslovakia.

SUMMARY

Growth of pike, *Esox lucius* Linnaeus, 1758 was studies from scales procured from different localities of Czechoslovakia in the years 1965—1975.

Hile's nomogram was used for the back-calculation of lengths.

Pikes of 11+ years of age and 99 cm of body length were recorded.

Males may live longer than females but show slow growth.

Growth increment has been found to be almost the same from the different localities of the Labe river system.

The rate of growth in our material was observed to be relatively slow as compared with the data of earlier authors.

LITERATURE

Balon E. K., 1965: Wachstum des Hechtes (Esox lucius L.) in Orava-Stausee. *Zeits. f. Fisch u. deren Hilfswiss.*, (12) *N. F.* : 113—158.

Čihař J., 1961: Růst ryb ve Slapské údolní nádrži. *Živ. výroba* (6), **4** : 295—302.

Frank S., J. Vostradovský, 1961: Prvé poznatky o změnách a rozvoji růstu štik a plotic v údolní nádrži Lipno. *Sborník Krajského vlast. muzea v Čes. Budějovicích, přír. vědy*, **3** : 161 až 167.

Frost W. E., C. Kipling, 1961: Some observations on the growth of pike (Esox lucius) in Windermere. *Verh. Inter. Verein. Limnol.*, **14** : 776—781.

Oliva O., 1955: Složení rybích populací a množství biomasy ryb ve třech polabských tůních. *Acta Univ. Carolina, Biol.*, **1** (1) : 61—74.

Oliva O., 1956: K biologii štiky (Esox lucius L.). *Věst. čs. spol. zool.*, **20** (3) : 208—223.

Oliva O., 1957: Některé zkušenosti s hubením ryb při studiu rybích populací. *Věst. čs. spol. zool.*, **21** (4) : 263—275.

Oliva O., 1958: O růstu cejna velkého [Abramis brama (L.)] v Polabí. *Acta Univ. Carolinae, Biol.* **1958** (2) : 169—196.

Oliva O., 1959: Ještě k otázce množství ryb v přirozených nádržích a metodice jeho odhadu. *Věst. čs. spol. zool.*, **23** (3) : 280—288.

Oliva O., 1960: Další příspěvek k poznání složení rybích populací v Polabí. *Věst. čs. spol. zool.*, **24** (1) : 42—49.

Poupě J., 1974: Note on growth of the pike, Esox lucius Linnaeus, 1758 in the Central Bohemia inundation area of the river Labe. *Věst. čs. spol. zool.*, **38** (4) : 279—284.

Toner E. D., G. H. Lawler, 1969: Synopsis of biological data on the pike, Esox lucius Linnaeus, 1758. FAO Fish. Synopsis, No. 30, Rev. 1, Roma.

Van Oosten J. W., 1960: The true pikes. Fishery leaflet (496), Washington 25, D.C., April 1960 Fish and Wildlife Service, U.S. Dept. of Interior.

Vostradovský J., 1968: Dynamika populace štiky obecné (Esox lucius L.) v údolní nádrži Lipno. CSc. Theses, 110 pp., Výzk. úst. rybář., pracoviště Lipno n./Vlt.

Vostradovský J., 1969a: Značkování, migrace a růst značkovaných štik v údolní nádrži Lipno. *Bul. VÚR Vodňany*, 3 : 9—18.

Vostradovský J., 1969b: Vývoj úlovků a poměr pohlaví štiky obecné (Esox lucius L.) v údolní nádrži Lipno. *Bul. VÚR Vodňany*, **4** : 1—11.

Vostradovský J., 1969c: Úmrtnost, přežívání, biomasa a abundance štiky obecné (Esox lucius L.) v údolní nádrži Lipno. *Živoč. výroba*, **14** (42), 10/11 : 799—812.

Vostradovský J., 1970: Vztah délky a váhy, koeficient kondice a vztahy délek u štiky (Esox lucius L.) z Lipna. *Živoč. výroba*, **16** (43), 7/8 : 497—508.

Vostradovský J., 1971: Potrava štiky obecné (Esox lucius L.) v údolní nádrži Lipno. *Práce výzk. ústavu rybář. a hydrobiol., Vodňany*, **9** : 159—189.

Authors' addresses: Kewal Krishan Tandon, MSc., PhD., Reader in Zoology, Dept. of Zoology, Panjab University, 160014 Chandigarh, India, Doc. Dr. Ota Oliva, CSc., Dept. Systematic Zoology, Fac. Sci., Charles University, Viničná 7, 128 44 Praha 2.

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
Svazek XLII — Číslo 1 — 1978 — Str. 77—79

Chair of Zoology, University of Agriculture, Brno
Zoological Institute, University of Oslo
Institute of Vertebrate Zoology, Czechoslovak Academy of Sciences, Brno

SCANNING ELECTRON MICROSCOPIC STUDIES ON THREE SPECIES OF THE GENUS SYPHACIA (NEMATODA)

FRANTIŠEK TENORA, RICHARD WIGER, VLASTIMIL BARUŠ

Received December 20, 1976

Abstract: New data on the morphology of three species of the genus *Syphacia* Seurat, 1916, namely *Syphacia obvelata* (Rud., 1802), *S. nigeriana* Baylis, 1928 and *S. stroma* (Linstow, 1884), are presented. The surface structure of body cuticle of all species and the head structure of *S. obvelata* and *S. nigeriana* have been studied. The main criteria separating *S. obvelata* from *S. nigeriana* have been established.

The method of scanning electron microscopy (SEM) has been used in the last years for the determination of some morphological characters of parasitic worms. A basic paper dealing with the nematodes of the genus *Syphacia* was published by Ogden (1971). In our studies, we have used the SEM method for the determination of some morphological characters of *S. obvelata*, *S. nigeriana* and *S. stroma*.

MATERIAL AND METHODS

The nematode specimens used in our studies originated either from the same hosts as those on which the original descriptions of species were based (*S. obvelata* and *S. stroma*) or from the same hosts as the specimens used for the redescription (*S. nigeriana*). Fifteen female specimens of each species were examined by SEM. The exact data on the origin and hosts of the individual species are as follows:

— *Syphacia obvelata* (Rud., 1802), caecum, *Mus musculus*, loc. Hodonín, Czechoslovakia
— *Syphacia stroma* (Linstow), small intestine, *Apodemus sylvaticus*, Oslo, Norway
— *Syphacia nigeriana* Baylis, 1928, caecum, *Clethrionomys glareolus*, *Microtus agrestis*, Kviteseid, Norway

The specimens were first washed in distilled water, fixed in 10% formalin and then dehydrated through an alcohol series. The specimens were then critical point dried.

RESULTS

1. *Syphacia obvelata* (Rud., 1802)

The cephalic plate is relatively large and markedly elongated laterally (Plate I, fig. 1). The facial mask is marked off laterally by two submedian papillae and one amphid and surrounded by a cuticular rim covered with small bosses. The mouth is triangular, possessing three inconspicuous lips with rounded upper margin. The height of the lips is always less than half their width. The submedian papillae are massive, semi-spherical. The papillae on the inner circle were indistinct in our material (Plate II., fig. 1).

Three massive triangular teeth with rounded tips protrude from the mouth cavity. On the inner side of each tooth is a longitudinal thickening in the median line. The outer upper margin of the teeth is smooth. On the inner side near the upper margin of the teeth there are longitudinal dentigerous ridges consisting of 28—33 teeth each. The teeth are mostly longer than wide and their tips are rounded (Plate II., fig. 2).

The cuticle has distinct transverse striations with a regular conspicuous median ridge in the transverse striae. The margins of the striae and the top of the ridge are rounded. Longitudinal ribs, rounded in the section, are slightly prominent and situated between individual transverse rings of the cuticle (Plate I., fig. 2). The transverse striations of the cuticle are less distinct near the lateral alae. Fine longitudinal striations can be observed on the transverse striae on both sides of the lateral alae. The lateral alae are rounded in the section and approximately five times wider than the longitudinal ribs (Plate I., fig. 3).

Discussion: The specimens used in our studies conform to the description of *S. obvelata* published by Quentin (1971). The SEM examination revealed that the surface structure of the body is similar to that of *S. eutamii* Tiner, 1948 (compare Ogden, 1971, Plate 5A). Our observations concerning the structure of lips and the presence of minute ridge-like teeth are quite new.

2. *Syphacia nigeriana* Baylis, 1928

The cephalic plate is of a relatively small size, without a marked lateral elongation. The facial mask is circular, marked off laterally by two submedian papillae and one amphid. The submedian papillae are semi-spherical. The cuticular rim is more or less reduced, the bosses are inconspicuous. The mouth is triangular, with three marked lips, distinctly higher than those of *S. obvelata*. The upper margin of lips is rounded. Three massive triangular teeth protrude from the mouth cavity (Plate III., fig. 1).

The cuticle has distinct transverse striations with slightly prominent longitudinal ribs between the transverse striae (Plate III., fig. 4, Plate IV. fig. 4). Inside the transverse striae there are two narrow cuticular ribs (Plate III., fig. 3, Plate IV., fig. 5). The transverse striations of the cuticle are less distinct or indistinct near the lateral alae. The longitudinal lateral alae are of the same shape as those of *S. obvelata* (Plate III., fig. 2).

Discussion: There are different views on the independence of *S. nigeriana* in the literature (Quentin, 1971; Ogden, 1971; Hartwich, 1975). It is possible, however, that the specimens examined by Ogden (1971) by means of SEM and considered to be *S. obvelata* belonged to the species *S. nigeriana*. Although the author indicated that he studied *S. obvelata*, his material was not obtained from the typical host (*Mus musculus*) and from the area of the original description (Europe). The author's drawing of the cephalic plate of *S. obvelata* conforms to that of *S. nigeriana* (compare Quentin, 1971). The author mentions in the text that "the head bears three prominent lip-lobes" which also corresponds more to the species *S. nigeriana*. Our results support the opinion of Quentin (1971) and Hartwich (1975) that *S. obvelata* and *S. nigeriana* are bona species. Our studies complement some data obtained by Quentin (1971) with the light microscope. The species *S. obvelata* and *S. nigeriana* differ substantially in the morphology of the

cephalic plate and the structure of lips. The surface cuticular structure of *S. nigeriana* is very similar to that of *S. obvelata* and resembles also that of *S. eutamii* (see Ogden, 1971, Plate 5A).

3. *Syphacia stroma* (Linstow, 1884)

The cuticle has marked transverse striations (Plate IV., fig. 1). The transverse striae divide the body surface into wide parallel fields. No median ridges are present in the transverse striae and the longitudinal ribs are also lacking (Plate IV., fig. 2, 3).

Discussion: Until recently it has been very difficult to separate two related species, as *S. obvelata* and *S. stroma*, on the basis of their morphological characters. The differential diagnosis of these two species was first published by Quentin (1971). His observations by light microscopy are now complemented by new data obtained during our SEM studies of *S. stroma*. According to our results, *S. stroma* markedly differs from *S. obvelata* in its surface structure. *S. obvelata* possesses both transverse striations and longitudinal ribs, whereas only transverse striations are present in *S. stroma*.

CONCLUSION

The results of SEM studies of *S. obvelata*, *S. nigeriana* and *S. stroma* are presented. The species *S. obvelata* and *S. nigeriana* cannot be separated on the basis of their surface structure, since they possess both transverse striations and longitudinal ribs. Morphologically they differ mainly in the head structure. The species *S. stroma* differs fundamentally from *S. obvelata* and *S. nigeriana* in the absence of longitudinal ribs in the surface structure. Quite new data about the head structure and the morphology of teeth and inner dentigerate ridges of *S. obvelata* are also given. The surface structure of the cuticle of *S. stroma* has been studied for the first time, similarly as the detailed morphology of the cuticular transverse striations in the species studied.

Acknowledgements

The present study was conducted within the framework of the cultural cooperation between Norway and Czechoslovakia whereby Associate Professor František Tenora (ČSSR) visited the University of Oslo. The scanning electron microphotographs were taken at the Electron Microscopical Unit for Biological Sciences, University of Oslo. Financial support was provided by the Zoological Institute and the Norwegian Research Council for Arts and Sciences.

REFERENCES

Hartwich, G., 1975: I. Rhabditida und Ascaridida. Die Tierwelt Deutschlands, 62 Teil. Jena.
Ogden, C. G., 1971: Observations in the systematics of nematodes belonging to the genus Syphacia Seurat, 1916. *Bull. British Mus. (Nat. Hist.), Zool.*, **20** (8) : 255—280 (with 5 plates).
Quentin, J. C., 1971: Morphologie comparée des structures céphaliques et génitales des Oxyures du genre Syphacia. *Ann. Parasit. Hum. Comp.*, **46** (1) : 15—60.

The plates will be found at the end of this issue.

Authors' addresses: Asoc. Prof. Dr. F. Tenora, CSc., Chair of Zoology, University of Agriculture, 662 65 Brno, Zemědělská 1, Dr. R. Wiger, Zoological Institute, University of Oslo, Oslo 3, Blindern, Ing. V. Baruš, DrSc., koresp. member of ČSAV, Institute of Vertebrate Zoology, Czechoslovak Academy of Sciences, 603 65 Brno, Květná 8.

John McKelvey, Jr., Man against Tsetse. Cornell University Press, Ithaca 1973, 306 str., ilustr.

Přečte-li si někdo pouhý název recenzované knihy, stěží si udělá správnou představu o jejím obsahu. Kniha je přírodovědná, zoologická i lékařská, ale především historická. Historie se ráda zabývá různými boji a válkami, ale zpravidla mezi týmž druhem organizmů, kterým je Homo sapiens. Historie boje člověka s jinými druhy tvorstva již tak obvyklé nejsou. McKelveyova kniha představuje takovou výjimku, když popisuje dramatický zápas člověka v Africe se spavou nemocí, s naganou domácích zvířat a s uvedenou mouchou tsetse či glosinou, která se později ukázala být přenašečem těchto chorob. Sleduje jej od prvopočátku, kdy se nevědělo nic o původci onemocnění ani o jeho přenašečích a kdy malatný stav nemocného obyvatelstva byl lecký přičítán k jejich povahovým vlastnostem. Uvádí všechny dohady o příčinách (u zvířat pastva, vdechování něčeho škodlivého, ale i „jedovaté" bodání mouchami), všechny ty omyly a pokusy vedoucí nakonec k poznání, které se dnes zdá snad jakoby samozřejmé. Oživují tu postavy zoologů (např. Robineau Desvoidy, Bigot), lékařů a přírodovědců (např. Bruce, Castellani, Koch) i cestovatelů (např. Livingston), kteří svou prací nějak přispěli nebo se vyslovili k uvedenému tématu. K objevu trypanosom jako původců onemocnění a jejich přenosu se druží popis vlastního boje s nemocí, léčení (atoxyl, tryparsamid atd.) a přímých i nepřímých zásahů proti glosinám (např. vypalováním porostu, hubením divoké zvěře, přestěhováváním obyvatelstva), včetně sveráznych nápadů (např. pobít krokodýly, na kterých glosiny sají!). Objeví se řada dalších postav (např. Schweitzer, Jamot, Nash). Líčení událostí a organizace akcí je tu dovedeno až do současnosti, k použití insekticidů, sterilantů i juvenoidů (kde je připomenut také K. Sláma).

Světová zdravotnická organizace (WHO či OSM) vyhlásila v současné době boj šesti nejzávažnějším tropickým chorobám, kterými ještě v dnešní době strádají miliony lidí. Jsou mezi nimi i trypanosomiaze, u nichž se odhaduje, že jimi trpí (včetně Chagasovy nemoci) 10 milionů lidí (Nature 262 : 86, 1976). McKelveyova kniha o africké trypanosomiáze a glosinách je tedy, ač historická, velmi aktuální. Boj pokračuje, a každý, kdo se zajímá o tuto problematiku, v ní najde pro sebe věci nejen nové a zajímavé, ale i podnětné. Je psána jasně a dobře se čte. Obsáhlá literatura je uvedena na konci knihy ve zvláštní komentované části, rozdělené podle jednotlivých obsahových celků.

J. Chalupský

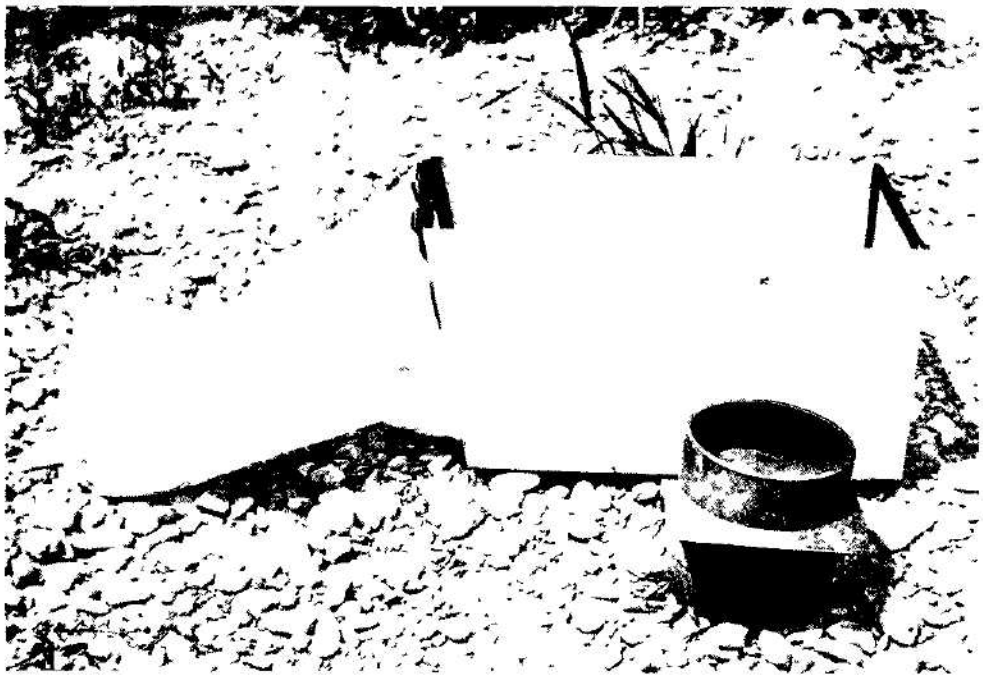


Abb. 1. Das Probenentnahmegerat fur die Verteilung der oberen 10 cm-Schicht der Sandkiesablagerungen.

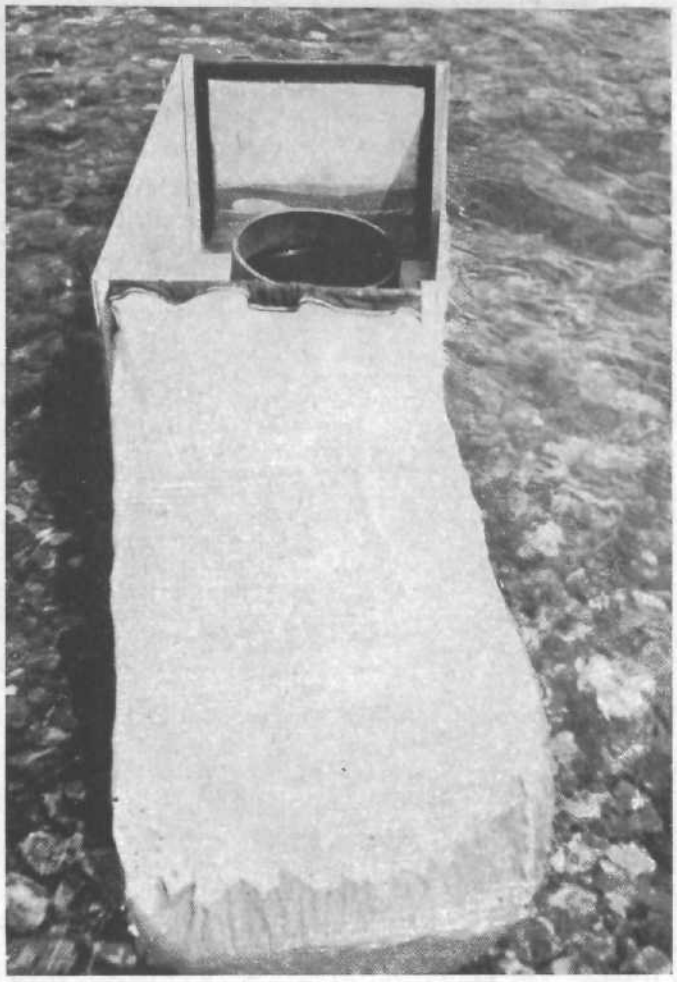
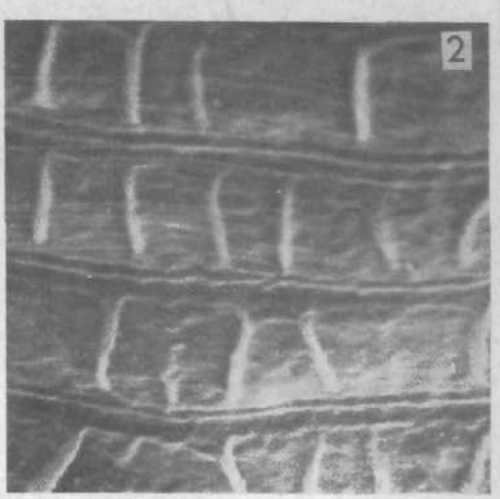


Abb. 2. Das Probenentnahmegerät für die Verteilung der oberen 10 cm-Schicht der Sandkiesablagerungen.



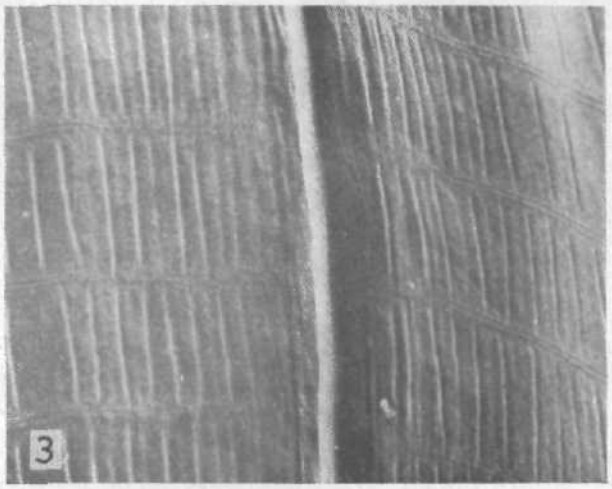
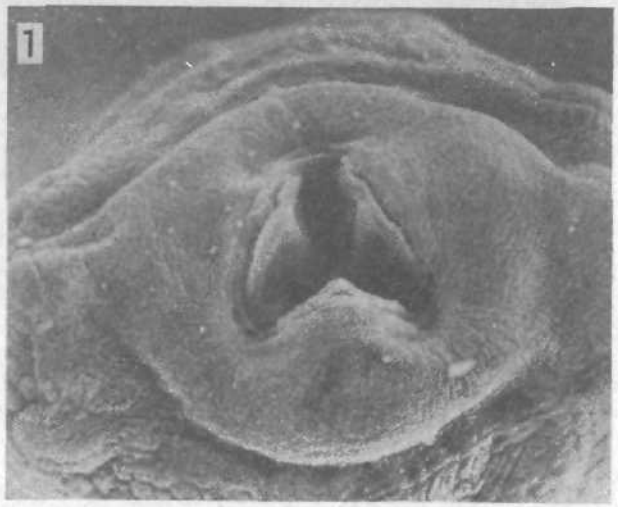


Plate I.

Fig. 1. Cephalic plate of *S. obvelata*, apical view, ×1,400

Fig. 2. Detail of transverse striation and longitudinal ribs of the cuticle of *S. obvelata*, ×10,000

Fig. 3. Cuticle with transverse striae and longitudinal ribs of *S. obvelata*. Lateral ala runs in the middle (lateral view), ×3,000



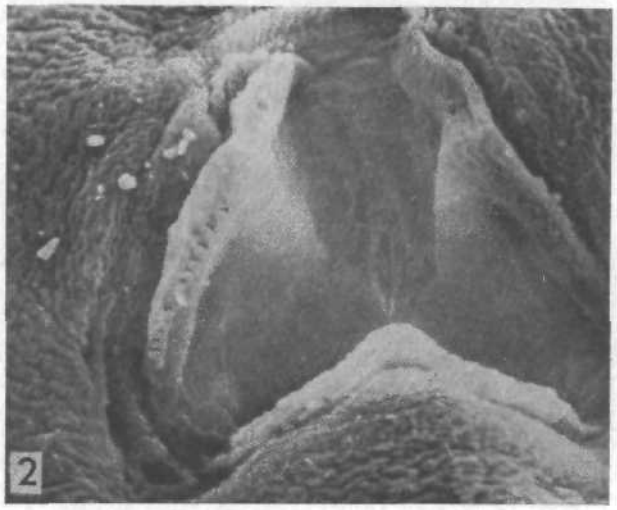


Plate II.

Fig. 1. Facial mask with cuticular rim and minute bosses (at the bottom) of *S. obvelata*. Triangular mouth with three incospicuous lips and teeth (apical view), ×3,000

Fig. 2. Mouth and detail of teeth and ridges with small teeth of *S. obvelata*, ×7,000

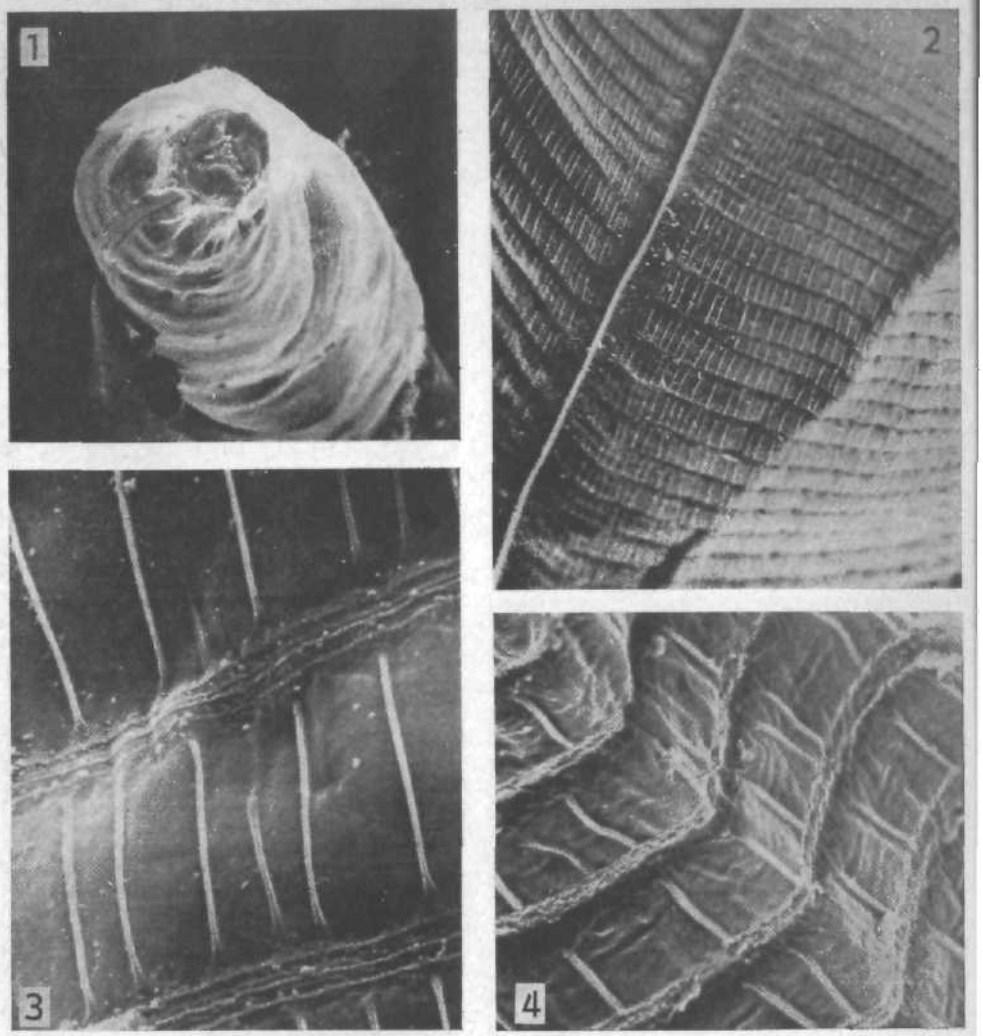


Plate III.

Fig. 1. Anterior end of body with cephalic plate (apical view) of *S. nigeriana* (host *Cl. glareolus*), ×300

Fig. 2. Cuticle with lateral ala, transverse striation and longitudinal ribs of *S. nigeriana* (host *Cl. glareolus*), ×1,000

Fig. 3. Cuticular septa in transverse stria of *S. nigeriana* (host *Cl. glareolus*), ×5,000

Fig. 4. Detail of transverse striation and longitudinal ribs of the cuticle of *S. nigeriana* (host *Cl. glareolus*), ×3,000

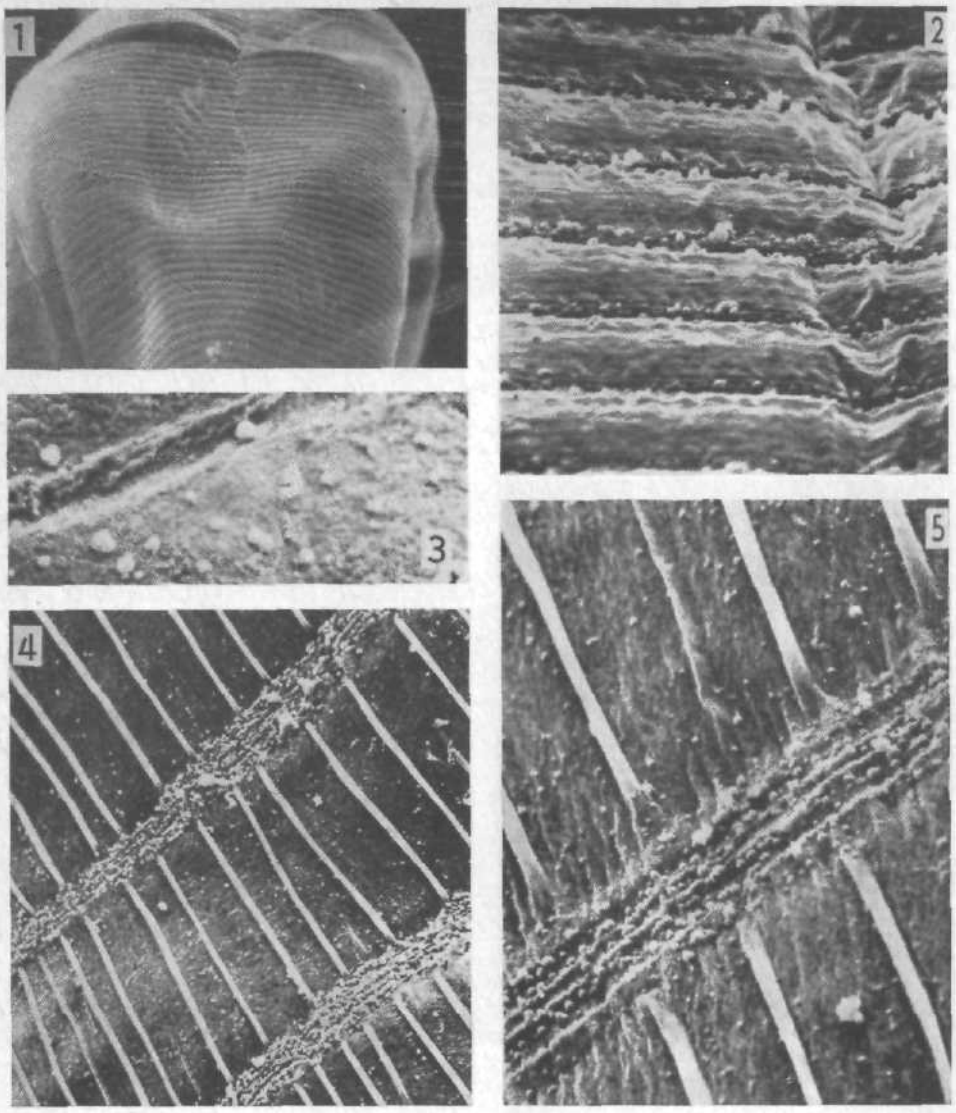


Plate IV.

Fig. 1. Transverse striation of the cuticle of *S. stroma*, ×300

Fig. 2. Transverse striation of the cuticule of *S. stroma*, detail, ×1,000

Fig. 3. Detail of transverse stria of *S. stroma*, the absence of longitudinal cuticula rribs is evident, ×14,000

Fig. 4. Detail of transverse striations and longitudinal ribs of the cuticle of *S. nigeriana* (host *M. agrestis*), ×3,000

Fig. 5. Cuticular septa in transverse stria of *S. nigeriana* (host *M. agrestis*), ×10,000

POKYNY PRO AUTORY

Věstník Československé společnosti zoologické uveřejňuje původní vědecké práce členů společnosti v rozsahu nejvýše 30 stran rukopisu, napsané v některé z kongresových řečí, a dále články, hodnotící životní dílo našich zoologů, vyžádané redakcí. Práce autorů, kteří nejsou členy společnosti, budou přijímány jen výjimečně.

Formální úprava prací:

Rukopis (originál a 1 kopie) musí být psán na stroji s většími typy obřádek, na stránce 30 řádek, řádky po 60 úhozech, bez větších oprav. Rukopisy, které by neodpovídaly těmto formálním požadavkům, budou vráceny k přepsání.

Hlavička práce: 1. Název pracoviště. 2. Název práce (u prací taxonomických v závorce za názvem systematické zařazení druhu nebo skupiny — např. Ostracoda; Cypridinidae), obojí v řeči, v níž je práce psána. 3. Jméno a příjmení autora.

Vlastní práce: 1. Velmi stručný abstrakt, v rozsahu nejvýše 15 řádek, v angličtině. 2. Úvod do problematiky (stručně). 3. Materiál a metodika (u známých metod pouze odkaz). 4. Vlastní část experimentální nebo popisná. 5. Diskuse. 6. Závěr. 7. Seznam citované literatury (nikoliv bibliografie!). 8. Adresa autora. 9. Tabulky, texty k obrázkům a grafům. Celý rukopis je průběžně stránkován.

Citace prací proveďte podle jednotného vzoru: autor, rok, název, časopis (mezinárodními bibliografickými zkratkami), ročník, sešit pouze v případě, že ročník není průběžně stránkován, stránky. U knižních titulů nakladatel a místo vydání. Např.: Hrabě S., 1975: Second contribution to the knowledge of marine Tubificidae (Oligochaeta) from the Adriatic Sea. *Věst. Čs. spol. zool.*, 39 : 111—119.

Přepis cyrilice proveďte podle mezinárodních pravidel vědecké transliterace (nikoliv fonetické transkripce) — viz ISO Recommendation R 9 International System for the transliteration of cyrillic characters 1. Ed. October 1955 nebo Zekalle R., 1964. *Pedobiologia*, 4 : 88—91, Jena.

Obrázky a grafy kreslete černou tuší na kladívkový nebo pausovací papír v poměru 1 : 1 až maximálně 1 : 3, u taxonomických prací musí mít obrázky měřítko. Obrázky kreslete pokud možno tak, aby mohly být všechny stejným způsobem zmenšeny. Fotografie musí být ostré, kontrastní, na lesklém papíře. Obrázky sestavte do tabulí, které by bylo možno reprodukovat na šíři strany (126 mm), nebo s textem na celé zrcadlo (126 × 188 mm). Obrázky nebo obrazové tabule průběžně očíslujte a v rukopise vyznačte místo, kam mají být zalomeny.

Tabulky jsou tištěny jako otevřené, tj. bez svislých chlmek. V tabulkách oddělte vodorovnými linkami jen záhlaví tabulky a dolní okraj. Tabulky protokolárního charakteru nebo opakující údaje z textu, případně tak velké, že by je nebylo možné vytisknout na dvě protilehlé strany, nebudou přijímány.

V taxonomických pracích dodržujte zásady, ustanovení a doporučení mezinárodních pravidel zoologické nomenklatury.

V rukopisu nepředpisujte zásadně žádné typy písma, označte pouze tužkou po straně části, které mají být vysazeny petitem.

Práce zasílejte na adresu: Doc. Dr. K. Hůrka, CSc., výkonný redaktor Věstníku Čs. spol. zool. Vinična 7, 128 44 Praha 2.

Redakční rada