

THE DYNAMICS OF WOODCOCK (*SCOLOPAX RUSTICOLA* L.) ABUNDANCE IN SOUTHWEST LITHUANIA

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Woodcock (*Scolopax rusticola* L.) is one of two forest Scolopacides in Lithuania. Woodcock is migrating and breeding bird species. The status of woodcock is game species. The hunting season lasts from 20 March to 1 May and from 15 August to 1 December. Investigation performed during 1981-2002 yr. in Marijampolė district Šūnskai forest (23°22' E; 54°37'N). The Šūnskai forest (2000 ha) is typical Southwest Lithuanian forest. There are dominating wet mixed deciduous stands. Woodcocks are hunted intensively in this area (20-40 annually). The aim of this study is to analyze the dynamics of woodcock density and the phenology of male roding (mating flies). The earliest woodcock roding (13 March) observed on 2002 as well as second earliest roding (16 March) observed on 1991. Latest roding (6 April) observed on 1981 and 1982. There were not observed relation between beginning and maximum of roding. The peak of woodcock male roding could be observed on next day after first observation. There are possible that some peaks of roding would exist during one breeding season. The mass woodcock male roding lasts up to the end of April - beginning of May. Later the solitary individuals were observed. There were not observed relation between the beginning and the end of roding. The beginning of roding is determined by climatic factors. The peak of roding observed on various weather conditions. The abundance of woodcock males fluctuated from 3 (1988 yr.) to 16 (1985 yr.) on the peak of roding. The density of woodcocks (bird/km²) fluctuated from 2.9 (1990 yr.) to 9.3 (1984 yr.) during the peak of roding. The reasons of annual woodcock population abundance fluctuation are unknown. It is true to say, there are not observed negative population trend during last 20 yr. and intensive hunting is not factor determining / limiting population abundance.

Key words: Woodcock, roding, abundance

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Introduction

Woodcock *Scolopax rusticola* L. is one of two forest Scolopacides in Lithuania. Woodcock is migrating and breeding bird species. The status of woodcock is game species. It is allowed to still hunt on woodcock on spring. The official hunt-

ing season on spring was alternated in Lithuania. The woodcock hunt was allowed to start rather late (25 April) and it lasts up to 10 May, i.e. only 16 days in 1971 - 1988 yr. period. On 1989 - 2000 yr., considering investigation of woodcock phenology (Pėtelis 1994, 2000), the period of woodcock hunting were prolonged and lasts from 1 April to

10 May. The hunting season from 2001yr. was established even more early: 20 March - 1 May. The last hunting season is the best and concord with the biology of species.

It is important to conserve natural habitats of woodcock and make rational policy of species management on the purpose to keep high population level. The annual population census of woodcock is not performed in Lithuania and population estimation is unknown (Žalakevčius 1995). Every year roughly 3000 woodcocks are shoot during hunting season in Lithuania as well as 3.7 million in whole Europe (Kalchreuter 1994).

The aim of this study is to analyze the dynamics of woodcock density and the phenology of male roding (mating flies). The influence of hunting to woodcock abundance is discussed too.

Study area, materials and methods

The study area was in Marijampolė district Šunskai forest (23°22' E; 54°37'N). The Šunskai forest (2000 ha) is a typical Southwest Lithuanian forest. There are dominating wet mixed deciduous stands that were very favourable for woodcock to inhabit and to breed. Woodcocks were hunted intensively in this area (20-40 annually) during all investigated period.

Investigation is fulfilled on 1981-2002 yr. The census was made on April - May period at the same point. Count of woodcocks was started half an hour before sunset and lasts up to one hour after sunset. There were made 254 bird counts totally. The unit of count was roding male. On the spring roding assists only the birds of local community (Martijnov 1998). During each bird census were exactly noted the start and the end of count, the number of observed roding males in the distance up to 120 m and the direction of fly. Weather conditions were evaluated on the observation of first woodcock male: temperature (°C), wind speed (12 point scale according Bofort), cloudiness (10 point scale) and precipitation (4 categories: 1 - drizzle; 2 - rain; 3 - sleet; 4 - snow). The density of wood-

cocks were estimated according Martijnov (1988):

$$D = \frac{1000n}{VTB}$$

n - the total number of roding males, birds;

V- the flying speed of woodcock (0.67 km/min);

T- the duration of woodcock count (min.);

B- the diameter of counting point (the range of visibility) (m).

The roding period starts when the first woodcock male with roding behavior is observed. We classified the roding seasons to early, normal and late according to the date of first observation. Early roding was when first male is observed up to 19 March as well as normal roding during 20 March - 5 April and late roding - later 6 April.

The mass roding of woodcock was the period when roding was observed every evening. The peak of roding was the evening when were observed maximum males. The last day of mass roding was estimated as the day before when woodcocks start roding with pauses during some evenings.

Spearman correlation coefficient R was used to estimate the dependence of woodcock roding phenological phases as well as abundance and density dynamics. The correlation were not significant if $p > 0.05$. Multivariate statistics direct gradient analysis method Canonical correspondence analysis (CCA) was used to estimate the influence of weather conditions to woodcock roding on the peak. As the result of CCA analysis biplot were performed. In the biplot factors are showed as vectors. Longer vectors are more important. The factors are not correlating if the angle between vectors is 90°. The decrease of the angle between vectors shows positive correlation as well as increase up to 180° - negative. The variables are plotted as swarm. The distance between variables shows dissimilarity: similar variables are plotted close to each other. The influence to each of variable could be described drawing a perpendicular from variable point to the vector. The influence of factor is higher if perpendicular falls in longer section.

Results and discussion

The phenology of woodcock roding

Woodcock males started roding on second part of March (Tab. 1; Fig 1). An average woodcock roding start day was 26 April. Earliest roding was observed on 13 March (2002 yr.) and latest on 12 April (1996 yr.). The period between earliest and latest first observation was 28 days (Tab. 2). Within investigated period early roding was observed in five years (28% of all years), normal roding was observed in nine years (50% of all years) and late roding was observed in four years (22% of all years). The late roding were mostly observed within 1981-1988 yr. period. In 1989-1991 yr. period were mostly observed early roding as well as within 1992-2000 yr. - normal and in 2001-2002 yr. -early again. Within discussed periods were observed late and early woodcock roding year too. We didn't observe any general trend of first woodcock spring roding date in 1981-2002 yr. period.

Table 1. The phenology of Woodcock roding in Southwest Lithuania

Year	Roding date (month day)		
	Start of roding	Peak of roding	End of mass roding
1981	04.06	04.29	05.10
1982	04.06	05.06	05.12
1983	Unknown	04.22	05.08
1984	Unknown	04.28	Unknown
1985	04.03	04.14	05.09
1986	04.05	04.07	04.19
1987	04.10	04.15	05.10
1988	04.02	04.07	05.07
1989	03.17	04.08	04.28
1990	03.18	04.16	04.27
1991	03.16	03.29	05.02
1992	03.29	04.12	04.28
1993	04.01	04.02	05.01
1994	03.26	03.31	Unknown
1996	04.12	04.28	Unknown
1997	03.31	04.01	Unknown
1999	03.21	04.05	05.01
2000	03.21	04.07	05.15
2001	03.14	04.04	05.05
2002	03.13	04.03	04.28

The peaks of woodcock roding were in high variation too. The earliest peak was observed on 29 March (1991 yr.), as well as latest - 6 May (1982 yr.) (Tab. 1; Fig. 2). The period between observed earliest and latest peak dates was 39 days. The peaks of roding were mostly observed within 1-16 April. 25 % of the peaks were observed later and only 10 % early presented period. There were defined some peaks (or highly closed) within one year period. We didn't find any statistical significant relation between the start and the peak of roding ($r=0.10$; $p>0.69$) (Tab. 3). The length of this period varied from 1 to 30 days (avg. 14 days).

The end of mass roding at different years was in high variation and we can define long period (Tab. 1). The earliest end of mass roding was observed on 14 April (1986 yr.) as well as latest on 15 May (2002 yr.). Several woodcock were observed later. Defined period between earliest and latest observation of mass roding was 31 days. The mass roding lasted 30-55 days (avg. 38). An exception was observed in 1986 yr. The mass roding lasted only 15 days (Tab. 2). We didn't find any statistical significant relation between the start and end of mass roding ($r=-0.09$; $p>0.71$). The end of mass roding observed 6-42 days later the peak of roding (avg. 22 days). We didn't find any statistical significant relation between the peak and end of mass roding too ($r=0.33$; $p>0.14$).

The length of roding was very various and continued 4-46 min (avg. 21 min.) on the peak of activity within one year (Tab. 2). We didn't find any statistical significant relation between the length of mass roding (days) and observed birds on the evening ($r=-0.30$; $p>0.19$).

The dynamics of abundance and density

There were observed 3-16 males on the roding maximum (avg. 7.4) (Tab. 2; Fig. 3). The correlation between the length of mass roding (days) and abundance (birds) were not defined statistical significant relation on the peak of roding ($r=-0.53$; $p<0.02$).

Table 2. The length and interdependence of phonological phases of Woodcock roding, woodcock abundance and density in Southwest Lithuania

Year	The time of first roding (days, from earliest observed in 20 yr. period)	The peak of roding (days from first roding), days	The end of peak of roding (days from maximum roding), days	The length of roding peak period, days	The length of roding on the peak day, min	Abundance on the peak day (birds)	Density on the peak day (birds/km ²)
1981	24	23	11	34	26	11	3.7
1982	24	30	6	36	39	9	3.7
1983	Unknown	Unknown	15	Unknown	21	9	5.3
1984	Unknown	Unknown	Unknown	Unknown	4	3	9.3
1985	21	11	24	36	46	16	5.3
1986	23	2	12	15	30	15	6.2
1987	28	5	24	30	26	11	5.3
1988	20	5	29	35	9	3	4.1
1989	4	21	20	42	14	6	5.3
1990	5	28	11	40	13	3	2.9
1991	3	13	42	47	18	8	5.5
1992	6	13	16	30	17	9	6.6
1993	19	1	29	30	19	10	6.5
1994	13	5	Unknown	Unknown	11	6	6.8
1996	28	16	Unknown	Unknown	37	8	3.0
1997	18	1	Unknown	Unknown	23	8	4.3
1999	8	14	26	40	26	11	5.3
2000	8	16	37	55	15	4	3.3
2001	1	20	30	51	15	4	3.3
2002	0	20	25	45	20	8	4.9
Avg.		14	22	38	21	7.4	8

The assessed density was 2.9-9.3 male/km² on the peak of roding (avg. 8.1 male/km²) (Tab. 2). The reasons of annual woodcock population abundance fluctuation were unknown. It is true to say, there were not observed negative population trend during last 20 yr. and intensive hunting was not factor determining / limiting population abundance.

The influence of weather condition on woodcock roding

Weather condition were very various during the peak of roding (Tab. 3; Fig. 4). The temperature alternated from +2 °C to +16 °C as well as wind - from 0 to 5 points, cloud - from 0 to 10 points, precipitation - from clear weather condition to rain.

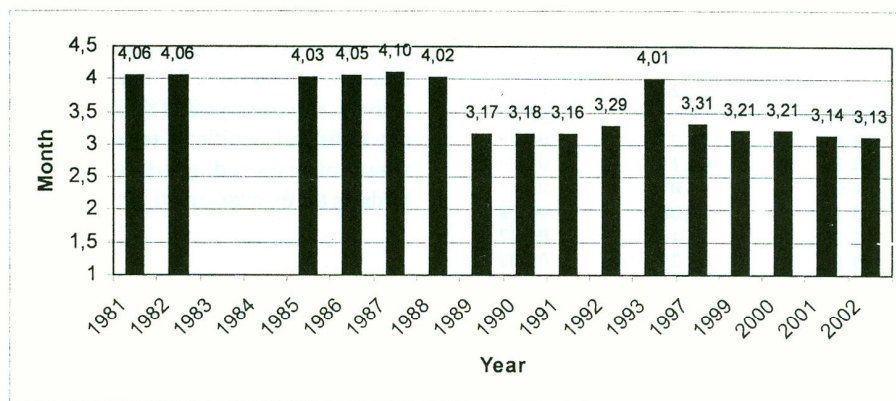


Fig. 1. The start of woodcock roding in southwest Lithuania

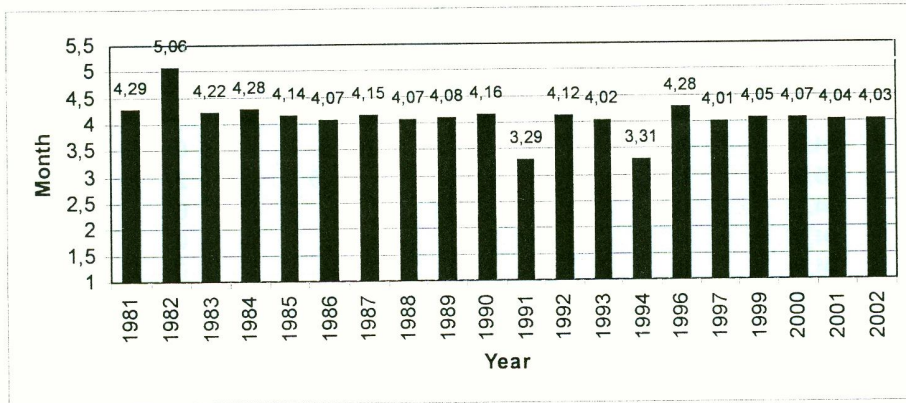


Fig. 2. The peaks of woodcock roding in Southwest Lithuania

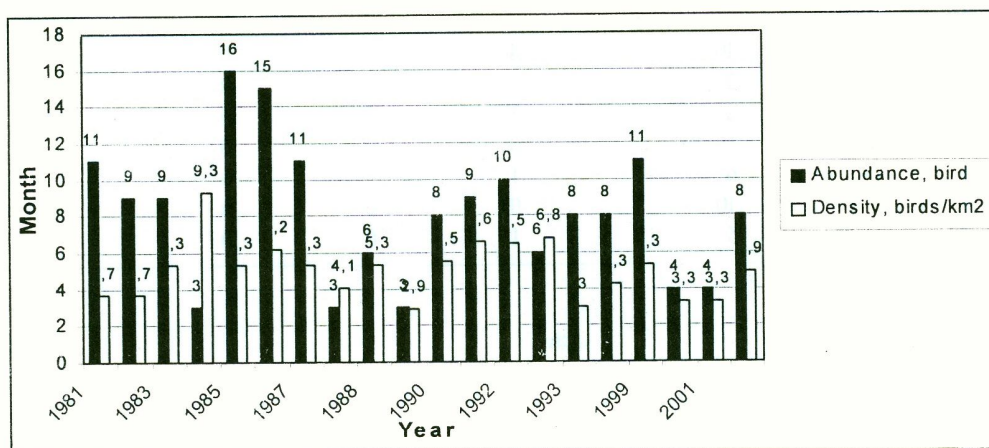


Fig. 3. The abundance and density during the woodcock peak of activity in Southwest Lithuania

Most of scientific sources (Ivanauskas, 1957; Keršulis, 1996, Logminas, 1968) affirm woodcock are roding on warm, calm and rather humid weather. Our study shows that weather condition do not have such influence as expected.

Conclusions

1. The first woodcock roding date was not getting more early or later within 20 yr. period.
2. The peaks of woodcock roding normally ob-

served during 1-16 April.

3. The mass woodcock roding lasted 30-55 (avg. 38) days.

4. The density of woodcocks (bird/km²) fluctuated from 2.9 to 9.3 (avg. 8.1) during the peak of roding. The reasons of annual woodcock population abundance fluctuation are unknown. It is true to say, there were not observed negative or positive population trend during last 20 yr.

5. The peaks of roding could be fulfilled during various weather conditions.

Table 3. Meteorology on the peak of woodcock roding

Year	The date of roding peak	Temperature, °C	Wind, points	Clouds, points	Rain, points
1981	04.29	3	3	0	0
1982	05.06	10	5	10	2
1983	04.22	18	1	1	0
1984	04.28	10	1	5	0
1985	04.14	10	3	6	0
1986	04.07	1	5	10	0
1987	04.15	5	0	8	0
1988	04.07	4	1	1	0
1989	04.08	10	1	10	1
1990	04.16	2	1	0	0
1991	03.29	2	1	0	0
1992	04.12	3	1	0	0
1993	04.02	4	1	0	0
1994	03.31	10	4	3	0
1996	04.28	3	1	1	0
1997	04.01	8	3	0	0
1999	04.05	5	0	0	0
2000	04.07	6	1	3	0
2001	04.04	10	0	0	0
2002	04.03	5	1	0	0

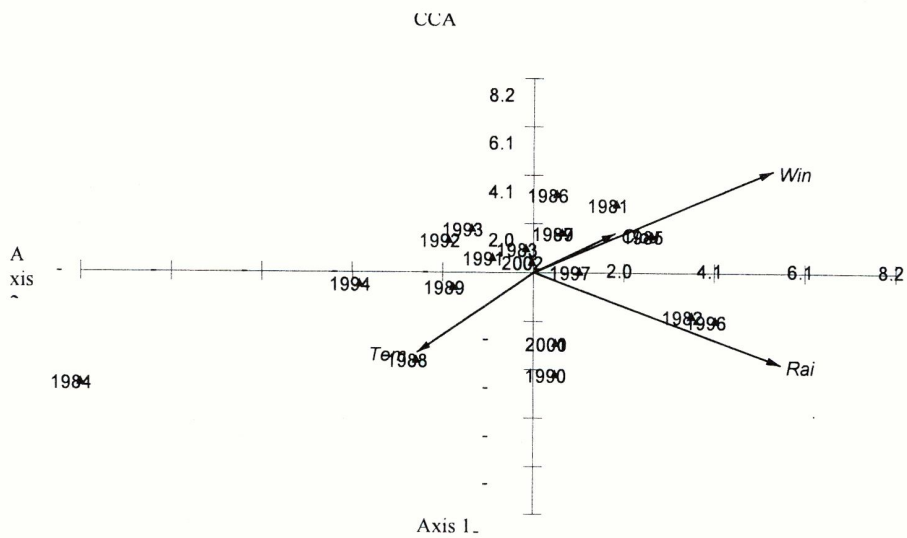


Fig. 4. The dependence of woodcock density on meteorology (wind, rain, cloud, temperature) during the peak of activity

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THE ROLE OF INSECTS IN THE DISPERSION OF WATER MITES

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Depending on the migration ability of parasitized insects water mites can be divided into three groups: 1) the parasites of insects whose imagines are permanently connected with water, 2) the parasites of insects whose imagines periodically leave water, 3) the parasites of insects whose imagines permanently live out of water. The first group is composed of *Hydrachna globosa* (De Geer.), the parasite of *Nepa cinerea* L., *Ranatra linearis* (L.) and *Limnochares aquatica* (L.) parasitizing hemipterans of the genera *Hydrometra* and *Gerris*. The second group comprises all the remaining species of the genus *Hydrachna* and all the species of the genus *Eylais*, which are parasites of water Heteroptera and Coleoptera. The third group is composed of the remaining species of water mites, which parasitize flying insects of the orders Odonata, Ephemeroptera, Plecoptera, Trichoptera, and Diptera. Water mites owe their wide distribution and colonization of new environments to insects parasitized by their larvae. The distribution and the dispersion degree of different species of water mites are varied depending on the parasitized insects. The water mites (*Sperchon*, *Neumania*, *Piona*, *Arrenurus*, etc.) parasitizing insects whose imagines constantly stay outside the water are decidedly the more expansive and in general more frequent species in the current fauna. The water mites (the genera *Limnochares*, *Hydrachna*, and *Eylais*) parasitizing hemipterans and coleopterans are much less expansive and, in spite of the common occurrence of many of them, they are decidedly less numerous than the above group. The range of their environmental occurrence is also limited (chiefly small permanent and astatic water bodies). The groups of water mites that are parasites of insects permanently connected with water are much rarer and least expansive.

Key words: Hydrachnellae, water mites, dispersion, parasitism, insects

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Introduction

Water mites is a group of mites living in water and playing an important of predators role in aquatic biocenoses. They are characterized by a very wide distribution, colonizing almost all water environments. The water mites owe their great capability of dispersion to insects, which they parasitize in the larval stage. The effectiveness of their dispersion is varied, depending on the migration

capacity of the insects. Apart from the selection of host the final reproduction and distribution success of water mites is affected by such elements as the extensity and intensity of infestation, length of the parasitic period, and mortality of larvae in the parasitic stage.

Selection of the host

Depending on the migration ability of parasitized

insects water mites can be divided into three groups (Gledhill 1985):

1. The parasites of insects whose imagines are permanently connected with water;
2. The parasites of insects whose imagines periodically leave water;
3. The parasites of insects whose imagines permanently live out of water.

The first group is composed of *Hydrachna globosa* (De Geer.), the parasite of *Nepa cinerea* L. and *Ranatra linearis* (L.) and *Limnochares aquatica* (L.) parasitizing hemipterans of the genera *Hydrometra* and *Gerris* (Gledhill 1985). Additionally water mites of the genus *Arrenurus* are found on the larvae of dragonflies and coleopterans and these of the genus *Hydrobates* on the larvae of caddis flies. In the case of water mite parasitism on the larvae of insects it is not quite sure if these are proper or facultative hosts selected because no proper host could have been found.

The second group comprises all the remaining species of the genus *Hydrachna* and all the species of the genus *Eylais*. These mites are parasites of water hemipterans of sub-families Corixinae and Cymatinae and of the genus *Notonecta*, and also of water Coleoptera of the families Haliplidae, Dytiscidae, Gyrrinidae, Hydraenidae, and Hydrophilidae (Baker 1971, Cichocka 1995, Davids 1973, 1997, Davids & Schoots 1975, Zawal 2002, 2003).

The third group is composed of the remaining species of water mites, which parasitize flying insects of the orders Odonata, Ephemeroptera, Plecoptera, Trichoptera, and Diptera. The most frequently infested insects are dragonflies of the suborder Zygoptera and dipterans of the families Chironomidae and Culicidae (Baker et al. 1991, Conroy & Kuhn 1977, Davids 1997, Gledhill et al. 1982, Hevers 1978, Kuwets & Davids 1984, Meyer 1985, Stechmann 1976/77, Zawal 2001).

The larvae of water mites of the first and second group directly attack this stage of insects, which they parasitize (mostly the imago). Larvae classed in the third group have to attack the last preimaginal stage (the last larva or nymph of the insect), not passing on the imago until it leaves water. In this short period of life the larvae of water mites do not parasitize, being passively brought out of the water (phoresia).

The selection of hosts depends on several factors. One of them is the body structure and the way the larva moves.

According to Kramer (1989) four morphological types of water mites' larvae can be differentiated:

1. "Hydrachna"
2. "Piona"
3. "Hydrodroma"
4. "Eylais"

Larvae of the first type swim very well hence they stay in the water depth and parasitize water hemipterans (Nepomorpha) and coleopterans (Dytiscidae, Hydraenidae, and Hydrophilidae).

Larvae of the second type also very well swim (remaining in the water depth) yet they are parasites of flying insects (Ephemeroptera, Plecoptera, Odonata, Trichoptera, and Diptera).

Larvae of the third type are much worse adapted to active swimming. They have no swimming hairs hence directly after hatching they approach the water surface. There they move running on the water surface or on emergent parts of plants and wet shore. These larvae are parasites of dipterans (Culicidae and Chironomidae).

Larvae of the fourth type like those described above swim poorly hence they move running on the water surface. They are parasites of water hemipterans (Nepomorpha) and coleopterans (Halipidae, Dytiscidae, Gyrrinidae, Hydraenidae,

and Hydrophilidae).

It can be easily observed that the larvae of water mites remain either in the depth of water or on its surface, this surely necessitating the selection of a suitable host. Well swimming larvae of the "Piona" type look for the host in the water hence they attack the last preimaginal stage (the nymph - in the case of holometabolic insects, or the last larval stage - in the case of hemimetabolic ones). In this case we do not encounter parasitism but phoresia, causing the movement of water mites' larvae from aquatic to land environments while the actual host is the imago of the given insect.

The "Hydrachna" type larvae also swim well and look for the host in water. The fact that their hosts are insects from a different group (Heteroptera and Coleoptera) results from the different environment in which these water mites occur (see below). The "Hydrodroma" and "Eylais" type larvae run on the water hence they infect insects which can be encountered here (nymphs of Culicidae and Chironomidae - in the case of larvae of the "Hydrodroma" type and Heteroptera and Coleoptera imagines in the case of the "Eylais" type larvae). Like in the group described above differences in the selection of hosts are due to the environmental distribution of water mites.

It is worth noting that the classification of water mites with respect to the type of larvae does not quite agree with respect to the groups of parasitized insects. These are only the water mites with larvae of the "Piona" and "Eylais" type which are parasites of one group of insects: "Piona" - group three (imagines live out of the water) and "Eylais" - group two (imagines periodically leaving the water). Water mites with "Hydrachna" type larvae in part parasitize insects of group one (imago permanently connected with water) and in part those of group two (imagines periodically leaving water). The water mites of the "Hydrodroma" type are parasites of insects of groups one and three.

Another agent affecting the selection of hosts is the environment where the parasite and host occur, i.e. the place where the infection is possible.

It is fairly clear in the case of water mites with the "Piona" type larva. These water mites colonize very different types of waters and everywhere where the larvae of their host insects occur. It is obvious that depending on the environment the form of host-parasite pairs varies. Lake Species connected with the sublittoral or profundal parasitize Chironomidae, Rheophilous Species (e.g. Sperchon) are parasites of Simuliidae, while species of small water bodies and these connected with the littoral parasitize Odonata, Trichoptera, Culicidae, and Chironomidae (Baker et al. 1991, Conroy & Kuhn 1977, Davids 1997, Gledhill et al. 1982, Hevers 1978, Kuwets & Davids 1984, Stechmann 1976/77, Zawal 2001).

In the case of water mites with larvae of the "Hydrodroma" type the situation is also clear. In most cases they are "half-water" mites, occurring in astatic reservoirs or in the zones of ecotone and epilittoral of small permanent water bodies and lakes. Their larvae infest nymphs of dipterans of the families Culicidae and Chironomidae at the time when the nymphs are attached to the water surface (Meyer 1985).

With respect to water mites with larva of the "Eylais" type the environments where the parasite and host co-occur, are small permanent water bodies and the phytolittoral of lakes. In this case the selection of host species depends on their longevity, which permits the parasitic larva attaining a considerable body increase, characteristic of these water mites Cichocka 1995, Zawal 2003).

The situation is more complicated in respect of water mites with the "Hydrachna" type larvae. They live in astatic water bodies and in the shallow littoral of small permanent reservoirs and lakes. These habitats are ephemeral necessitating the selection of such a developmental strategy, in which the longest stage is the parasitic larva. The purpose of this stage is the survival in periods of unfavourable environmental conditions, e.g. drying - in summer and chilliness - in winter. Hence the insects whose imagines survive the period of late summer, autumn, and winter outside of those environments, should be selected as hosts. Hemipterans and coleopterans

are such insects (Cichocka 1995, Zawal 2002). No characteristic fauna of hemipterans or aquatic coleopterans can be found in the discussed habitats yet the above-mentioned insects visit them numerous in spring. In this period they are infested by water mites of the genus *Hydrachna*, then with the worsening conditions (gradual drying) they leave these water bodies, returning in the next spring there.

Extensy and intensity of infestation, time of parasitism, and mortality of the parasitic larva

The environments where appropriate hosts and parasites occur, the way they move, and in what part of the habitat they most frequently and for the longest periods occur determine the possibilities of their contacts, and hence the degree of difficulty in the course of infestation.

The water mites with the "Piona" type larvae most easily contact their hosts. Larvae of this type swim in the water depth where larvae of flying insects, i.e. their hosts also occur. In this connection the contact between these animals is fairly easy, bringing about a high (reaching 50-70%) extensity of infestation, (*Arrenurus* on Zygoptera). The contact between larvae of the "Hydrodroma" type and their hosts is slightly more difficult. E.g., the larvae of *Hydrodroma despiciens* (O. F. Müll) can find their host (a nymph of Culicidae or Chironomidae) when it remains just under the water surface (extensity of infestation reaching 50%) (Meyer 1985). Similarly larvae of the "Eylais" type can attack their hosts (Heteroptera, Coleoptera) at the moment when they are taking up air. However, in this case the situation is more difficult since hemipterans and coleopterans remain under the water surface for a considerably shorter time than Culicidae. Therefore, in this case the extensity of infestation is lower, reaching about 10% (Zawal 2003). Larvae of the "Hydrachna" type show a similarly low extensity of infestation (a maximum of about 30%) (Cichocka 1995, Zawal 2002). In this case it is brought about by a certain environmental diversity of occurrence of parasites and hosts (see above) and a pro-

nounced rate of movements of the hosts, making the attachment of parasites to their bodies more difficult.

The intensity of infestation is also associated with the possibility of contacts between the parasites and hosts, however in this case a significant factor is also the size of the host body. Dragonflies of the suborder Zygoptera are most intensively infested (up to dozens of parasites on one host). These insects are both fairly large and easily accessible for parasites. Dipterans are less intensively infested (several parasites on one host). They are easily accessible though their small dimensions decrease the intensity of infestation. Hemipterans and coleopterans show the lowest intensity of infestation (a few parasites on an individual). This chiefly depends on the difficult contact of parasites with the host and partly on its small size.

The period of parasitism is varied in different water mites. In the case of water mites with the larva of "Hydrachna", "Hydrodroma", and "Eylais" types the parasitic phase takes from a few days (*Limnochares aquatica*) to a few months (wintering including) (*Hydrachna* and *Eylais*). Water mites with the "Piona" type larvae are parasites for about a week. The length of the parasitic period is associated with increases in body weight of the parasitic larva. The larvae of the "Piona" and "Hydrodroma" types increase their bodies several times while those of the remaining types more than ten times.

Water mites of the long period of parasitism are characterized by the high mortality of larvae in the parasitic stage (70-90%), particularly increasing when the parasite is attached to the outer body surfaces of the host (*Hydrachna inermis* Piers.). For water mites with a short parasitic period the mortality at this stage has not been determined yet, however it seems to be decidedly lower.

The extensity and intensity of infestation, the length of the parasitic period, and the mortality of the parasitic larva effect the greatest reproduction success and hence the effectiveness of dispersion of water mites with larvae of the "Piona"

type, followed by "Hydrodroma". Against this background water mites with larvae of the "Hydrachna" and "Eylais" type attain distinctly poorer effects.

Recapitulation

As the above observations show various species of water mites considerably differ by the accepted developmental strategy. The extensity and intensity of infestation, the length of the period of parasitism, and the mortality of the parasitic larva condition the reproduction success of the different species of water mites, and hence their numbers. On the other hand owing to various degrees of the migration abilities of host insects the effectiveness of water mites' dispersion depends on the selection of hosts.

1. The insects whose imagines are permanently connected with water are parasitized by a small number of water mite species of various systematic groups. They are characterized by the lowest expansion of all the species of water mites, low extensity of infestation, varied length of the parasitic period, and a small participation in the total water mites' fauna.

2. Water mites of the genera *Hydrachna* and *Eylais* are parasites of insects whose imagines temporarily stay outside the water. These are species migrating on fairly long distances though on account of the low extensity of infestation, the long parasitic period, and high mortality of the parasitic stage of larvae their expansion and share in the total water mites' fauna is fairly low.

3. The remaining (decidedly most) species of water mites are parasites of insects whose imagines permanently stay outside the water. These species of high infestation extensity, short period of parasitism, and low mortality in the parasitic stage of larvae are characterized by a high expansiveness and have a large share in the total fauna of water mites.

Water mites owe their wide distribution and colonization of new environments to insects

parasitized by their larvae. The distribution and the dispersion degree of different species of water mites are varied depending on the parasitized insects. The water mites (*Sperchon*, *Neumania*, *Piona*, *Arrenurus*, etc.) parasitizing insects whose imagines constantly stay outside the water (Odonata, Ephemeroptera, Plecoptera, Trichoptera, and Diptera) are decidedly the more expansive and in general more frequent species in the current fauna. The water mites (the genera *Limnochares*, *Hydrachna*, and *Eylais*) parasitizing hemipterans and coleopterans are much less expansive and, in spite of the common occurrence of many of them, they are decidedly less numerous than the above group. The range of their environmental occurrence is also limited (chiefly small permanent and astatic water bodies). The groups of water mites that are parasites of insects permanently connected with water are much rarer and least expansive.

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FAUNA OF TERRESTRIAL MOLLUSCS IN THE FORESTS OF GAUJA NATIONAL PARK

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Pilāte D. 2003. Fauna of terrestrial molluscs in the forests of Gauja National Park. *Acta Biol. Univ. Daugavp. 3 (1): 15 - 20.*

In August 2000 a survey of malacofauna was carried out in the forests of Gauja National Park (Gauja NP). This paper summarizes information on material gathered during 1989 - 2000. In the forests of Gauja NP 52 species of terrestrial molluscs were stated, that is 61% of those registered in Latvia until 2000. Among three groups of forest biotopes (pine forests, spruce forests, broad - leaved forests) the largest number of species (49) has been registered in broad - leaved forests (particularly in ravines and on slopes). Among the registered species 17 have been identified as rare and threatened ones in Latvia. For two species - *Ena montana* and *Clausilia cruciata* microsanctuaries should be formed to protect them.

Key words: terrestrial molluscs, forest biotopes, Gauja National Park

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Introduction

Gauja NP was founded in 1973 and it is located in mid-Vidzeme, on both sides of the River Gauja. The ancient valley of the River Gauja is a unique formation of relief in the Baltic area. The total area under forests in the park is 48 592 ha. The forests mainly surround the Gauja and its tributaries. Above half of them are pine and spruce forests. Broad - leaved forests are typical for the ancient valley of the Gauja River. There are few damp forests due to the peculiar character of the relief (Gaujas... 1999).

The first publication on malacofauna of the present territory of Gauja NP was issued in 1933. In an issue of School Museum on a Gauja exhibition, investigation results on mollusc fauna, which were carried out by malacologist H. Petersons in the whole length of the Gauja valley, were published (Pētersons 1933). In 1942 H. Schlesch pub-

lished the widest complete on Latvian malacofauna of that time about collected information from sites of 43 land mollusc species on the present territory of Gauja NP. The majority of data comes from Sigulda and its vicinity - Turaida and Krimulda (Schlesch 1942). K. Greke (1999a, b) also indicate on some sites within Gauja NP where rare and recently discovered mollusc species has been found.

In 2000 a survey of mollusc species was carried out in Gauja NP by gathering the results of previous years and doing additional study of malacofauna. This paper presents information on the results of survey carried out in forests of Gauja NP.

Material and methods

The forest malacofauna has been studied in Au-

gust 2000 in three forest biotopes of Gauja NP - in pine, spruce and broad - leaved forests. The investigations have been done in 14 different sites. Additionally, identification of material collected by R. Lebuss, D. Pilate and V. Pilats during 1989 - 2000 has been done. In total, data on 28 sites of Gaujas NP has been collected.

In 2000 14 plots of old-growth forest were selected for study. At each site 3 -5 l of litter from 10 x 20 m large area was collected. The collected litter was dried and then sifted on modified malacologic soil sieves (Dunger, Fiedler 1997). Identification keys (Kerney et al. 1983; Rudzīte 1999) were used to identify mollusc species. The collected material is deposited at the Latvian Museum of Natural History.

Results and discussion

The composition of mollusc species in forests of Gauja NP

Until the year 2000, 85 land mollusc species have been registered in Latvia (Greke 1999a,b; Rudzīte 2000; Dreijers 2000; Pilāte 2000). During the survey of forests in Gauja NP 52 terrestrial mollusc species have been registered, that is 61% of the total number of terrestrial mollusc species registered in Latvia (Table 1).

Broad-leaved forests growing in ravines are the

most rich in mollusc species while 91% of all the mollusc species occurring in forests of Gauja NP were found there (Table 1). Broad-leaved forests are most suitable for molluscs, and their fauna is usually more various there (Лихачев, 1962; Шилейко, 1978; Pilāte 2000). The diversity of species is high due to continuity of forests in the ancient valley and ravines of Gauja NP undisturbed by forest management activities and due to complex relief there (Gaujas... 1999). Out of 52 mollusc species found in forests of Gauja NP, 10 of them have been registered only in broad-leaved forests, these are *Vertigo alpestris*, *Ena montana*, *E. obscura*, *Balea biplicata*, *Zonitoides nitidus*, *Lehmania marginata*, *Arion circumscriptus*, *A. fasciatus*, *Trichia hispida* and *Perforatella rubiginosa*.

There is no great difference between malacofauna in pine forests of Gauja NP and in those of other parts of Latvia - the number of species and their composition is similar everywhere, i.e., in this type of forests the diversity of mollusc species is the most scanty (Pilāte 2000; 2001). Only the species *Arianta arbustorum* found in pine forests of Gauja NP should be underlined. In other places of Latvia where malacofauna was studied in pine forests, the species *A. arbustorum* was not registered. It is reasonable to consider this species to be ecologically very plastic while it occurs everywhere in Gauja NP and in a great number.

The following species *Carychium tridentatum*,

Table 1. Terrestrial mollusc species found in forests of Gaujas NP in the years 1989 – 2000. (2. – 4. category RDB – Red data book of Latvia; CM – decision of Council of Ministers; PF – pine forests; SF – spruce forests; BLF – broad-leaved forests)

Species	Protection status			Forest habitat		
	Category of RDB	CM	PF	SF	BLF	
1	2	3	4	5	6	
<i>Acicula polita</i> (Hartmann, 1840)	4	x		x	x	
<i>Carychium tridentatum</i> (Risso, 1826)			x	x	x	
<i>Carychium minimum</i> O.F. Müller, 1774			x	x	x	

Fauna of terrestrial molluscs in the forests of Gauja National Park

1	2	3	4	5	6
<i>Cochlicopa lubrica</i> (O.F. Müller, 1774)			x	x	x
<i>Cochlicopa lubricella</i> (Porro, 1838)				x	x
<i>Vallonia costata</i> (O.F. Müller, 1774)				x	x
<i>Vallonia pulchella</i> (O.F. Müller, 1774)					
<i>Acanthinula aculeata</i> (O.F. Müller, 1774)				x	x
<i>Columella edentula</i> (Draparnaud, 1805)			x	x	x
<i>Columella aspera</i> Walden, 1966				x	x
<i>Vertigo pusilla</i> O.F. Müller, 1774				x	x
<i>Vertigo substriata</i> (Jeffreys, 1833)			x	x	x
<i>Vertigo ronnebyensis</i> (Westerlund, 1871)	4		x		
<i>Vertigo alpestris</i> Alder, 1838		x			x
<i>Ena montana</i> (Draparnaud, 1801)	3	x			x
<i>Ena obscura</i> (O.F. Müller, 1774)		x			x
<i>Cochlodina laminata</i> (Montagu, 1803)				x	x
<i>Cochlodina orthostoma</i> (Menke, 1830)	3	x		x	x
<i>Ruthenica filograna</i> (Rossmäslar, 1836)	3	x		x	x
<i>Macrogastrea ventricosa</i> (Draparnaud, 1801)		x		x	x
<i>Macrogastrea plicatula</i> (Draparnaud, 1801)		x		x	x
<i>Clausilia cruciata</i> Studer, 1820	3	x		x	x
<i>Clausilia pumila</i> C.Pfeiffer, 1828	3	x		x	x
<i>Clausilia dubia</i> Draparnaud, 1805	3	x		x	x
<i>Laciniaria plicata</i> (Draparnaud, 1801)		x		x	x
<i>Balea biplicata</i> (Montagu, 1803)					x
<i>Bulgarica cana</i> (Held, 1836)	3	x		x	x
<i>Succinea putris</i> (Linnaeus, 1758)			x	x	x
<i>Succinea oblonga</i> Draparnaud, 1801				x	x
<i>Punctum pygmaeum</i> (Draparnaud, 1801)			x	x	x
<i>Discus ruderatus</i> (Ferussac, 1821)			x	x	x
<i>Zonitoides nitidus</i> (O.F. Müller, 1774)					x
<i>Euconulus fulvus</i> (O.F. Müller, 1774)			x	x	x
<i>Vitrina pellucida</i> (O.F. Müller, 1774)				x	x
<i>Vitrea crystallina</i> (O.F. Müller, 1774)				x	x
<i>Vitrea contracta</i> (Westerlund, 1871)	4			x	
<i>Aegopinella pura</i> (Alder, 1830)				x	x
<i>Nesovitrea hammonis</i> (Ström, 1765)			x	x	x
<i>Nesovitrea petronella</i> (L.Pfeiffer, 1853)			x	x	x
<i>Limax cinereoniger</i> Wolf, 1803		x		x	x
<i>Malacolimax tenellus</i> O.F. Müller, 1774				x	x
<i>Lehmannia marginata</i> (O.F. Müller, 1774)					x
<i>Arion subfuscus</i> (Draparnaud, 1805)			x	x	x
<i>Arion circumscriptus</i> Johnston, 1828					x
<i>Arion fasciatus</i> (Nilsson, 1822)					x
<i>Bradybaena fruticum</i> (O.F. Müller, 1774)				x	x
<i>Euomphalia strigella</i> (Draparnaud, 1801)				x	x
<i>Trichia hispida</i> (Linnaeus, 1758)					x
<i>Perforatella rubiginosa</i> (A.Schmidt, 1853)					x
<i>Perforatella bidentata</i> (Gmelin, 1788)				x	x
<i>Arianta arbustorum</i> (Linnaeus, 1758)			x	x	x
<i>Cepaea hortensis</i> (O.F. Müller, 1774)				x	x
Total:	10	15	14	40	49

C. minimum, *Cochlicopa lubrica*, *Columella edentula*, *Vertigo substriata*, *Succinea putris*, *Discus ruderatus*, *Euconulus fulvus*, *Nesovitrea hammonis*, *N. petronella* and *Arianta arbustorum* have been registered in all groups of forest biotopes of Gauja NP. These mentioned species are occurring most often not only in Gauja NP, but all over Latvia as well (Rudzīte 1999; Pilāte 2000). However, four species: *Bradybaena fruticum*, *Cochlodina laminata*, *Macrogastra ventricosa* and *M. plicatula* often and in a large number have been observed in spruce forests and, particularly, in broad-leaved forests. Except the species mentioned before, three species - *Ena obscura*, *Laciniaria plicata* and *Euomphalia strigella*, in great number have been stated in the ravines. These species, obviously, prefer forests growing on more expressed relief. Occurrence and distribution of eight species - *Acicula polita*, *Balea biplicata*, *Clausilia cruciata*, *Cochlodina orthostoma*, *Ena montana*, *Vertigo alpestris*, *V. pusilla* and *Vitrea contracta* in Gauja NP are characterised as rare and narrow. These species, except *V. pusilla*, are rare in the whole territory of Latvia (Rudzīte 1999).

In general, the mollusc fauna of forests in Gauja NP can be considered as very rich.

Rare and endangered species of terrestrial molluscs

Among 20 species of terrestrial molluscs included in the Red Data Book of Latvia (Spuris 1998), 10 species (*Acicula polita*, *Vertigo ronneybyensis*, *Ena montana*, *Cochlodina orthostoma*, *Ruthenica filograna*, *Clausilia cruciata*, *C. pumila*, *C. dubia*, *Bulgarica cana* and *Vitrea contracta*) have been stated in forests of Gauja NP in the result of survey carried out.

25 species of land molluscs are included in the list of protected species in Latvia (Latvijas ... 2000). 16 species of them were stated in Gauja NP. For two species - *Ena montana* and *Clausilia cruciata*, microsantuaries need to be established (Table 1).

Acicula polita is rare in the forests of Gauja NP. Small number of individuals has been stated only in two sites - a linden forest in Roču reserve and a spruce forest in Nurmižu reserve. In other parts of Latvia the species occurs in various forest biotopes in small numbers (Pilāte 2000).

Vertigo ronneybyensis is not rare in pine forests of Gauja NP, nevertheless that it has been classified as rare in Latvia (Spuris 1998). In the studies of forest malacofauna in other places of Latvia the species has usually been registered as more abundant in coniferous forests, particularly in pine forests (Pilāte 2000, 2001).

Until recent six sites of *Vertigo alpestris* were known in Latvia (Rudzīte 1999). In Gauja NP *V. alpestris* was stated only in one site in a broad-leaved forest near Gūdu rocks. Obviously, the species is rare in Gauja NP.

Until the survey one unchecked site of *Ena montana* species was known in the territory of Gauja NP, and in other places of Latvia were four unchecked sites (Spuris 1998). The collection of Latvian Museum of Natural History includes mollusc samples collected by T. Kamšs in the 1960-ies on the banks of the Amata. By testing the site indicated by T. Kamšs at the present Roču reserve, the species *E. montana* was repeatedly stated and its population was estimated as small. The biotope is a natural linden forest of area below one hectare that is surrounded by spruce forests. In 2000 one more site of the species was found in the Amata valley near Dzilnas rock. Another species - *E. obscura* often occurred in ravines and on slopes.

There are 13 Clausiliidae species known in Latvia. 11 species were stated in Gauja NP. Nine of them are rare and endangered, namely: *Cochlodina orthostoma*, *Ruthenica filograna*, *Clausilia cruciata*, *C. pumila*, *C. dubia*, *Macrogastra ventricosa*, *M. plicatula*, *Laciniaria plicata* and *Bulgarica cana*. *Clausilia dubia*, *Macrogastra ventricosa* and *M. plicatula* have been observed more often and in a large number. In Latvia, in broad-leaved forests and natural spruce forests these are common Clausiliidae species (Pilāte

2000). *Laciniaria plicata* was most often observed in ravines and on slopes. The species *Cochlodina orthostoma* and *Clausilia cruciata* have been the most rarely stated in Gauja NP (Table 1). These two species occur rarely also all over Latvia (Spuris 1998; Rudzīte 1999). The other species - *Ruthenica filograna*, *Clausilia pumila* and *Bulgarica cana* occur more often in Gauja NP, however in a small number.

Among the surveyed sites in Gauja NP *Vitrea contracta* was found only in a spruce forest of Kazu valley. The species has been distributed all over Latvia, however rare (Rudzīte 1999).

Limax cinereoniger was registered in two sites of Gauja NP - near Sudas bog and in Kazu valley during the survey. H. Schlesch (1942) has mentioned localities of species near Sigulda, Turaida and Krimulda. *L. cinereoniger* is distributed all over Latvia, however, it occurs only in a separated localities, mainly in broad-leaved forests (Rudzīte 1999; Pilāte 2000).

Conclusions

In the survey of mollusc species it has been found that 52 terrestrial mollusc species occur in the forests of Gauja NP, and that is 61% of all the species in Latvia known until 2000.

The forest malacofauna of Gauja NP is very rich. The most rich it is in the broad-leaved forests in ravines, on slopes and river valleys, particularly on the territories of Nurmīžu, Roču un Krimulda reserves.

The greatest diversity of mollusc species (49) has been stated in biotopes of broad-leaved forests. The scantiest malacofauna has been stated in pine forests, i.e., 14 species.

Gauja NP is of great importance for conservation of diversity terrestrial mollusc fauna in Latvia and for the protection of rare and endangered species. Half of the species registered in the Red Data Book of Latvia and 16 land mollusc species particularly endangered in Latvia occur in the for-

ests of Gauja NP.

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PECULIARITIES AND CHANGES OF BENTHIC COMMUNITIES IN THE RESERVOIRS OF SMALL HPP IN LATVIA

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Poppels A. 2003. Peculiarities and changes of benthic communities in the reservoirs of small HPP in Latvia. *Acta biol. Univ. Daugavp.*, 3 (1): 21 - 23.

Building of HPP reservoirs on small streams changed ecological conditions in the rivers. Reophyl species were replaced by lymnophyl. Characteristic lymnophyl species of Ephemeroptera - *Cloenon dipterum*, *Caenis horaria* and *Baetis niger* became common for reservoirs. The highest abundance and biomass of Ephemeroptera in Zoobenthoss were stated in riverine part of reservoirs due to species of Ephemeroptera characteristic for running waters. *Cloenon dipterum*, *Baetis rhodani* in high abundance and biomass dominated in littoral part on the silt bottom. Changes of ecological conditions caused increase in number and biomass of Chironomidae and Oligochaeta. Benthic fauna of the HPP reservoirs is highly productive.

Key words: Ephemeroptera, zoobenthoss, reservoirs, streams

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Introduction

Extensive process of building of HPP on the small streams last 10 years caused damage of habitats and changed ecological conditions of small streams. At the period 2001-2003 there were made observations of benthic fauna, especially Ephemeroptera fauna in the dammed reservoirs of HPP and in the undamaged stretches of the small streams. Aim of the study was to obtain changes of benthic fauna, especially Ephemeroptera fauna due to changes of ecological conditions.

Materials and methods

A zoobenthos samples were taken from soft bottom with the Ekman-Berge or Petersen grab, and samples covered 1/40 m². For stony bottom, wilding or stonepipe sampler was used. Qualita-

tive samples of Ephemeroptera was obtained by surber. Sieves with a mesh size of 0.5 mm were used, and samples were preserved in 4% formaldehyde solution. Animals were sorted from the sieved samples (APHA Standard Methods 1992). Samples were collected in the reservoirs of small HPP: Lācīšu reservoir, Gaujas reservoir, Variņu reservoir, Rankas reservoir and Galgauskas reservoir. In total 50 samples (10 samples from each of the reservoirs - 5 samples from profundal zone and 5 samples from littoral zone) were sampled. Taxonomic keys used for identification of species of Ephemeroptera were Chernova 1964, Landa 1969, Remm 1970 and Spuris 1982.

Results and discussion

In the process of overflow with water considerable areas stay under the water inter alia tributar-

ies of streams, grasslands and woodlands. Due to process of agedness of man made reservoirs there are observed changes in the grounds of bottom. Former stretch of rhithral covered by pebbles, cobbles and sand nowadays practically became a part of reservoir covered by silt and sludge. Creeks of the new reservoirs now are covered by detritus. Ecological conditions in man made reservoir became more similar to lake lakes ecosystem than to river. Typical reophyl benthic species are changed by lymnophyl species. Characteristic lymnophyl species of Ephemeroptera *Cloenon dipterum*, *Caenis horaria* and *Baetis niger* are common for these reservoirs. *Radix ovata*, *Viviparus contectus*, *Bithynia tentaculata*, *Valvata piscinalis* and *Limnaea stagnalis* are common on macrophytes. Changes of ecological conditions caused increase in number of Chironomidae and Oligochaeta (Fig. 1)

Numbers of individuals and biomass of zoobenthoss organisms shows that zoobenthoss of the reservoirs is highly productive (Fig. 2, Fig. 3)

In the man made HPP reservoirs alongside typi-

cal limnophyl species there are observed species of zoobenthoss typical for streams, for example from Ephemeroptera - *Ephemerella ignita*, *Heptagenia sulphurea*, from Mollusca - *Viviparus viviparus*, *Theodoxus fluviatilis* in small amounts. The highest abundance and biomass of Ephemeroptera in Zoobenthoss were stated in riverine part of reservoirs due to species of Ephemeroptera characteristic for running waters such as *Ephemerella ignita*, *Heptagenia flava* and *Heptagenia sulphurea* on sandy-silt layer. Typical limnophyl species *Cloenon dipterum*, *Baetis rhodani* were stated in high abundance and biomass not only in littoral part, but in all the Reservoirs on the silt bottom. Down from hydrotechnical buildings of HPP beds of the rivers are changed: rivers look like as channels - deeper, banks are fixed without trees and bushes. Yet, down from the dam due reophyl nature of rivers benthic species characteristic for running, oxygen rich waters are common. *Caenis horaria*, *Ephemerella ignita*, *Heptagenia sulphurea*, *Heptagenia lateralis* dominated. Investigations shows that zoobenthoss of the reservoirs is highly productive and it is invaluable for benthophagus fishes. Zoobenthos of reservoirs enclosed more than 65 species of invertebrata.

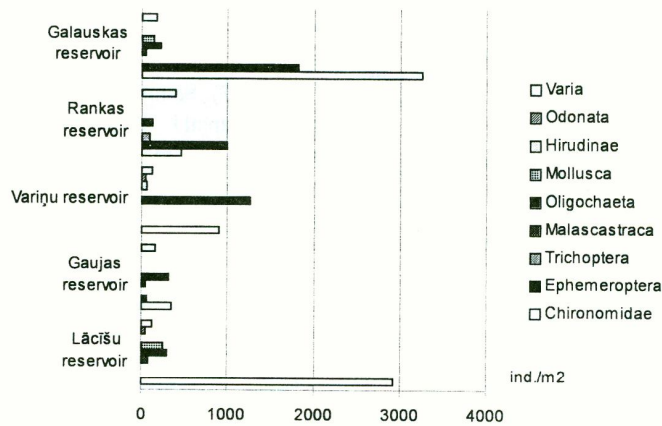


Figure 1. Numbers of individuals of taxonomic groups of zoobenthoss (ind./m2) in the reservoirs of HPP.

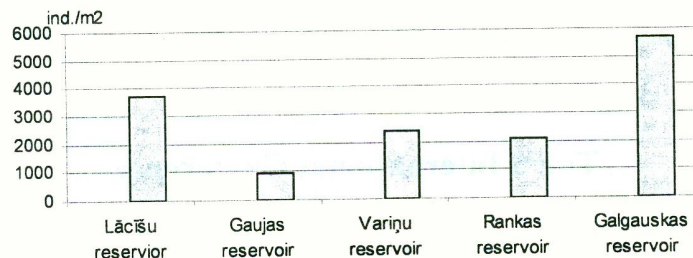


Figure 2. Numbers of individuals (ind./m²) in the reservoirs of HPP

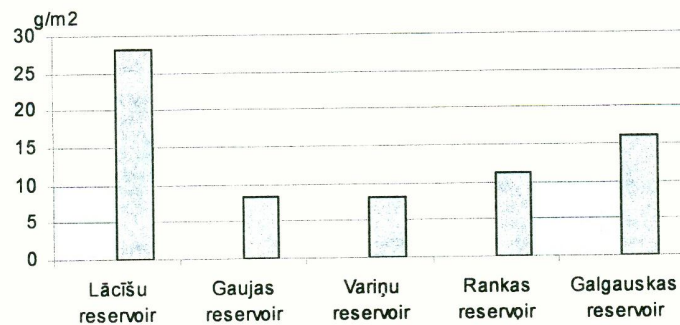


Figure 3. Biomass of zoobenthos (g/m²) in the reservoirs of HPP.

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WILLOWS (*SALIX* L.) OF *DAPHNELLA* SER. EX DUBY SECTION IN LATVIA

Pēteris Evarts-Bunders

Evarts-Bunders P. 2003. Willows (*Salix* L.) of *Daphnella* Ser. ex DUBY section in Latvia. *Acta Biol. Univ. Daugavp.*, 3 (1): 25 - 32.

Section *Daphnella* is one of the most complicated of Latvia's *Salix* genus. There are three species - *S. acutifolia* Willd., *S. daphnoides* Vill. and *S. pomeranica* Willd., which have not mentioned as unaffiliated species in Latvia. In some cases they have been mentioned as variety of *S. daphnoides*. Determination of these species is quite difficult due to morphological polymorphism and widespread hybridization of species in this section. These plants are wild-growing or very commonly cultivated. Individuals of this species can go over to wild somewhere. Two species of the section *Daphnella* (all our autochthonal taxa) are growing beyond the borders of their continuous areal – *S. acutifolia* in eastern and *S. pomeranica* in northern Latvia.

Key words: Willow, *Salix*, Latvia, dendrology, areal.

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Introduction

Section *Daphnella* is quite small, well-defined group of Eurasian boreal willows. To the section belongs small trees or tall shrubs with characteristic bluish overlaid on young shoots. Species of section are easy to differentiate for several other signs, too. They have bigger generative buds than vegetative, luxurious catkins, which blow earlier than appear leaves, therefore twigs from trees of species of this section are used as Easter decoration in Latvia.

These species have characteristic lineary lanceolate leaves with well-developed petioles, remaining all vegetation season on the shoots. Determination of morphological borders of the species is quite difficult in this section. The complexity of this procedure is increased by the fact that we

must deal with really wild and with cultivated but go over to wild taxa. These expansive species are hybridizing easily with wild-growing taxa in Latvia so they can made danger for existence of local species in future. All this can act as reason for different understanding of morphological borders of this section taxa by different scientists, for example, the mentioning of only one species – *S. daphnoides* s.l. in their works (Расиньш 1959).

The data about autochtonity of this section species in Latvia are quite cotractory. The most widespread viewpoint is that *S. daphnoides* is growing autochthonically and cultivated (without analysis of interspecies taxa), and *S. acutifolia* – cultivated only (Seemen 1908 – 1910; Starcs 1925; Floderus 1931; Galeniēks 1965). References about fact that *S. acutifolia* can be appointed as wild-

growing species in Latvia are mentioned at first in the E. Hulten's investigation (Hulten 1950), and in some publications in Lithuania and Estonia (Krall, Viljasoo 1956, 1971; Smaliukas 1996, 1997). The autochtonity of *S. pomeranica* (as variety *S. daphnoides* still) is mentioned in the R. Cinovskis' works (Cinovskis 1979, 1993). However, detailed analysis of this species localities and morphological borders is not presented in any publication.

Materials and methods

The investigations on the spreading of willow genus species in Latvia were initiated in 1993. Researches were made during scientific expeditions in different locations of Latvia, especially in the regions, which lack herbarium materials and thereby it was not possible to judge equitably about the distribution of the specific species, particularly in eastern Latvia. Herbarium materials were analysed in the all largest available herbariums: University of Latvia (LU), Institute of Biology, laboratory of Botany (LATV), herbarium of A. Rasiņš (HRAS), National Botanical garden, Department of Dendrology (HBN), LU faculty of Biology (RIG), Latvian Museum of Natural History (LDM), University of Daugavpils (DAU), Teiči Nature reserve (TVR). Materials about largest herbariums of other Baltic countries were summarised too: in Lithuania – Institute of botany (BILAS), in Estonia – University of Tartu (TU) and Tartu Institute of Zoology and Botany (TAA). All the available data from literature about distribution of section *Daphnella* species in Latvia were summarised.

Results and discussion

Salix daphnoides Vill.

Salix daphnoides Vill. 1789, Hist. Pl. Dauphin. 3: 765, tab. 50, fig. 7; J. Fleisch. und Em. Lindem., 1839, in J. Fleischer., Fl. Esth. Liv. Kurl.: 342, p.p; Ledeb., 1850, Fl. Ross. 3, 2: 602; Wimmer, 1866, Salices Europaeae: 4, p.p; Schneider, 1906, Laubholzk. 1: 48, p.p., quoad var. *typica*; Starcs, 1925, Koku un krūmu noteic: 71, p. max. p., excl.

var. *pomeranica*; Назаров, 1936, Фл. СССР, 5: 180; Galenieks, 1955. Latv. PSR fl., 2: 50, p.p; Расиньш, 1959, Ивы Латв. ССР, in Раст. Латв. ССР, 2: 111, p.p; Rechinger, fil, 1964, Fl. Europ. 1: 52; Скворцов, 1968, Ивы СССР: 204; p.p; Krussmann, 1978, Laubgeh. 3: 299; Скворцов, 1981, Фл. Европ. части СССР, 5: 31, p.p; Cinovskis et al., 1993, Fl. of Balt. Countr, 1: 171, p.p., excl. var. *pomeranica*.

Large shrub or small tree, 10 - 12 m high, occasionally up to 15 m with perimeter up to 20 (30) cm. Twigs olive green or dark brown, never reddish, glabrous, pruinose when young. Buds compressed dorsally, dark reddish-brown, in basal part with white hairs. Young shoots 1,7 - 2,4 mm wide with white silky hairs (especially at the top of shoot). Bark lemon-yellow inside with characteristic bitter taste. Leaves lanceolate or narrowly obovate 6 - 11 cm long and 1.8 - 3,5 cm wide; dark lustrous green above, dull glaucous below, at first youngest 2 - 3 leaves thinly woolly, soon glabrous. Margins of leaves glandular serrate, sometimes slightly revolute, petioles 0.5 - 1.4 cm long, straw-yellow, extended at base. Petioles well developed, ovate or narrowly ovate. Catkins on twigs crowded appear early before the leaves in april. Catkin scales ovate, shortly acute, whitish at base, apex dark blackish-brown, densely hairy. Male flower with 2 free, glabrous stamens. Ovary conically ovoid, yellow-green, glabrous. Style 2 - 3 times shorter than ovary, stigma narrowly linear. Capsules glabrous, about 4 mm long, ripening in last part of april or may (See fig 1 and 6).

The mountains of central and partially south Europe (Alps and Pyrenees) are the main spreading areal of *S. daphnoides*. According to the opinion of many west European dendrologists species is distributed in wider territory (Meikle 1984; Chmelar, Meusel 1979, 1986 a. o). It should be explained by wide cultivating, particularly this species was planted to reinforce the coastal and continental dunes and then naturalised.

According to the data of A. Lakševics, *S. daphnoides* has been planted in Latvia at least since 1836 (Расиньш 1959). This non-indigenous

species is planted widely in parks, roadsides, but especially in sandy coastal soils and on continental dunes and has been going over to wild. It occurs in seaside of the Baltic sea and Riga gulf, vicinity of Daugavpils on the degraded continental dunes, in the adjacency of artificial reservoir of the planned hydroelectric station in Daugavpils and in old country parks commonly.

Species must not considered as wild growing in Latvia and in Baltic republics at all. About it speaks the fact that mainly one clone is presented. This central Europe species is growing more quickly and is bigger than similar *S. pomeranica* which is wild-growing in Baltic region, beside that this species is more expansive than indigenous one.

Species is hybridizing with *S. acutifolia*, *S. caprea*, *S. purpurea* (*S. × calliantha* J. Kern.), *S. phylicifolia*, *S. viminalis*, *S. repens* (*S. × maritima* Hartig.), and *S. rosmarinifolia* in Latvia. Natural hybrids have been founded very rare. Many of them have known only from one or several localities. Cultivated hybrid *S. acutifolia* × *daphnoides* 'Pachal' is exception, because it has been planted in Latgale region for long time, but it becomes quite popular in other territory of Latvia last years. It is going over to wild sometimes (See fig. 7)

***S. pomeranica* Willd.**

S. pomeranica Willd., 1813, Enum. Hort. Berol. Suppl: 66.

- *S. daphnoides* Vill. var. *pomeranica* (Willd.) Koch, 1837, Syn: 646; J. Fleisch. und Em. Lindem., 1839, in J. Fleischer, Fl. Esth. Liv. Kurl.: 342; Klinge, 1882, Fl. Est. Liv. Curl.: 422; Schneider, 1906, Laubholz. 1: 48; Starcs, 1925, Koku un krūmu noteic: 71; Krüssmann, 1978, Laubgeh. 3: 299; Cinovskis, 1979, Sortiments: 159; Cinovskis et al., 1993, Fl. of Balt. Countr, 1: 172.

- *S. daphnoides* subsp. *pomeranica* (Willd.) Cin., in herb.

Usually large shrub, seldom small tree up to 6 – 8 (10) m high. Twigs olive-green or violet-brown, pruinose with dense glaucous bloom. Young shoots about 2 mm wide with white silky hairs, unlike *S. daphnoides* young shoots and leaves are hairy up to 5 -10 cm length. Bark lemon yellow inside with characteristic bitter taste. Leaves lanceolate or narrowly lanceolate 5 - 8 cm long and 1 – 1,8 cm wide; dark lustrous green above, dull glaucous below. Unlike *S. daphnoides* species with substantially shorter, narrower leaves, apex shortly acuminate. Margins of leaves glandular serrate, sometime slightly revolute. Petioles 1 - 2 cm long, yellow, not extended at base, stipules ovate or lanceolate. Catkins appear early before

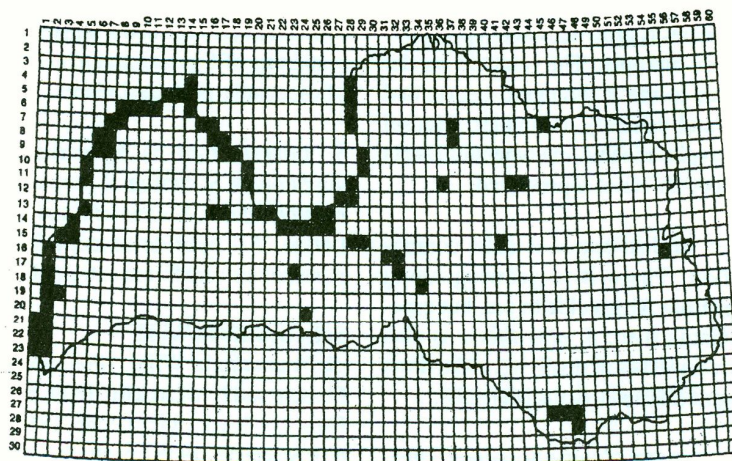


Fig 1. Distribution of *S. daphnoides* in Latvia (places where species going over to wild).

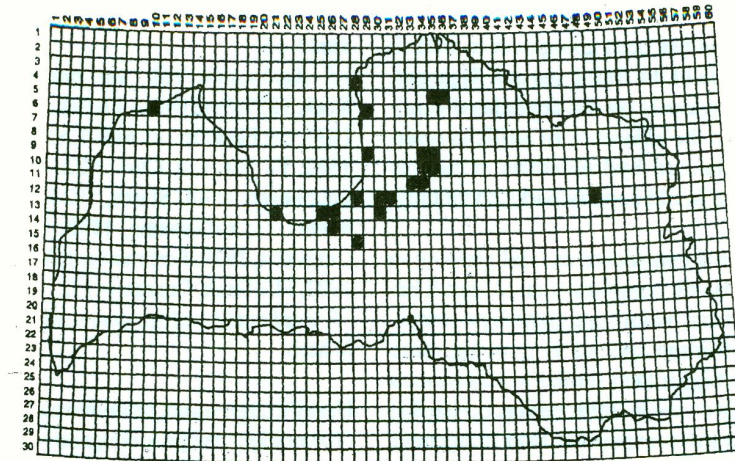


Fig. 2. Distribution of *S. pomeranica* in Latvia

the leaves in april, richly blooming.

Catkin scales ovate, shortly acute, densely hairy. Male flower with 2 free, glabrous stamens. Ovary conically ovoid, yellow-green, glabrous. Style 2-3 times shorter than ovary. Capsules glabrous, about 4 mm long, ripened in may (See fig. 2 and 5).

This species is indigenous for Baltic region. The primary areal of *S. pomeranica* is south-eastern and eastern coast of Baltic sea. It is wild-growing species in Gauja (Koiva) river basin not only in Latvia, but in south-eastern part of Estonia too. In Lithuania species is growing seldom predominantly in seaside biotopes. The southern border of areal reaches to the Kaliningrad region and Northeast Poland possibly. (Chmelar, Meusel 1979, 1986). In spite of name, in Pomerania (north Poland) this species is not represented.

Interconnection of distribution is quite complicated in Latvia. There it is growing along Daugava-river from Aizkraukle to sea, but especially along Gauja-river. *S. acutifolia* is also known from lower reaches of small rivers who flows into the Riga gulf (Jūrmala, Roja, Melnsils).

There are several morphologically various transition forms between *S. daphnoides* and *S. pomeranica* at seaside and it becomes more

widely spread last years according to the herbarium materials and our observation results. Obviously there is widespread hybridization between these two species and therefore is not possible to classify originated specimens accurately. Most of such hybridogenous specimens are coming from biotopes with anthropogenic influence. Obviously cross-pollination of species is disturbed while expansive *S. daphnoides* has been hybridizing widely at similar biotopes. *S. pomeranica* as wild-growing tree is not represented in eastern Latvia. In all regions of Latvia it is found in plantations too.

Protection arrangements must be undertaken for remaining of *S. pomeranica* including it in the list of especially protected plants.

S. pomeranica is hybridizing with *S. daphnoides*, *S. caprea*, *S. purpurea*, *S. repens*, *S. rosmarinifolia*, *S. viminalis* and *S. dasyclados* in Latvia. All hybrids (except *S. daphnoides* x *pomeranica*) are found extremely rarely.

Salix acutifolia Willd.

Salix acutifolia Willd. 1806, Sp. Pl. 4, 2: 668; J. Fleisch. und Em. Lindem., 1839, in J. Fleischer., Fl. Esth. Liv. Kurl. : 341; Ledeb. 1850, Fl. Ross. 3, 2: 601; Schneider, 1906, Laubholz. 1: 44; Starcs, 1925, Koku un krūmu noteic: 72; ?азаров, 1936, Фл. СССР, 5: 181; Galenieks, 1955. Latv. PSR fl., 2: 51;

Rechinger, fil, 1964, Fl. Europ. 1: 54; Скворцов, 1968, Ивы СССР: 213; Krussmann, 1978, Laubgeh. 3: 299; Скворцов, 1981, Фл. Европ. части СССР, 5: 32; Cinovskis et al., 1993, Fl. of Balt. Countr, 1: 172.

- *S. pruinosa* Bess., 1816, Cat. Hort. Crem: 121; Wimmer, 1866, Salices Europaeae: 9; Klinge, 1882, Flora Est., Liv. u. Curl.: 422.

- *S. daphnoides* subsp. *acutifolia* (Willd.) A. Blytt., 1906, Haandb. Norg. Fl.: 259; Расиньш, 1959, Ивы Латв. ССР, in Раст. Латв. ССР, 2: 106.

A large shrub or small tree, usually 6 (8) m high. Twigs tiny, flexible, reddish-brown or greenish, pruinose with dense glaucous bloom, glabrous. Buds glabrous, blackish-brown or reddish-brown. Leaves lanceolate or linear-lanceolate, apex with a long acumen, cuneate at base, 6 - 15 cm long, 0.7 - 1.2 cm wide, dark lustrous green above, bluish or dull glaucous below, completely glaucous, margins glandular-serrate. Petioles short, slender 0.5 - 1.5 cm long, glabrous, without glandules. Stipules lanceolate, acute, margins serrate. Catkins on twigs scattered, sessile or nearly sessile, 2.5 - 3.5 cm long, appear early before the leaves in april, densely pilose with silky hairs especially before blooming. Catkin scales ovate, whitish at base, apex dark blackish-brown, densely hairy.

Male flowers with 2 glabrous stamens, ovary conically ovate, compressed, nearly sessile, glabrous. Style short, stigma oblongate, sinuate. Capsules glabrous ripened in may (See fig. 3 and 4).

S. acutifolia have a wide areal - European part of Russia from tundra to the Volga-river mouth on the Caspian sea. Over the Urals and in West Europe this species is not found. This willow is cultivated very widely out of its natural areal and it is going over to wildness here and there. Thereby the borders of its autochthonous areal are not possible to determine easily. As it is defined by Skwortsow (Скворцов 1968), the western border of its geographical distribution is drawn along the line: southern part of Onega-lake - the upper and middle course of Northern Dvina (The Severnaya Dvina) and the lower reaches of the rivers Dona and Dnieper and their confluents. Thereby the autochthony of this species in the Daugava-river basin and in Baltic States should be disclaimed. This point of view is supported by majority of Latvia's specialists (Cinovskis 1979; Фарапе 1989; Gavrilova, Sulcs 1999; e.o.).

S. acutifolia is cultivated often in Latvia, especially the vegetatively multiplied male specimens with aim to use as Easter decoration. This species is planted together with *S. daphnoides* in

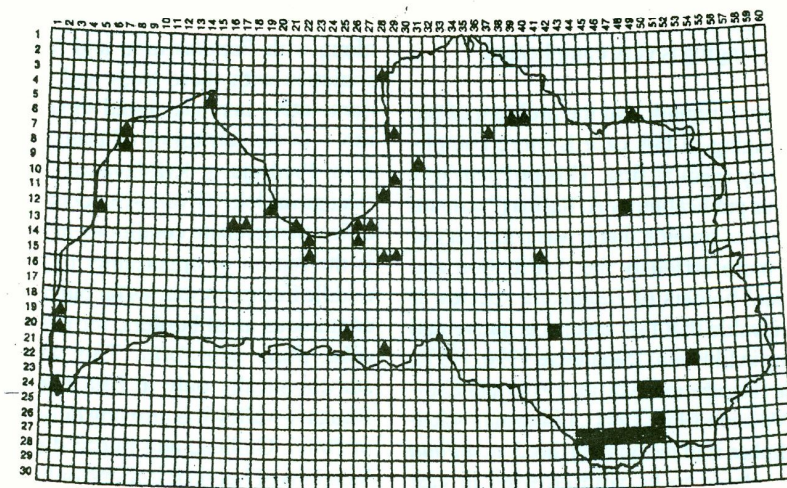


Fig 3. Distribution of *S. acutifolia* in Latvia (triangle- cultivated and going over to wild; circle - natural localities)



Fig.4. *S. acutifolia*. Shoot with leaves



Fig. 5 Leaf of *S. pomeranica*

dunes, in sandy riverbanks, roadsides and other places to protect them from erosion in all the territory of Latvia. It is going over to wildness intensively here and there and forming natural hybrids with *S. daphnoides* and *S. pomeranica*. Such hybrids are found the most frequently in anthropogenic biotops and the determination of their taxonomic belonging is very complicated.

It is necessary to remark that the problem of the species belonging in this case is more complicated as it may seem at first. This problem was accented in his publication by A. Rasiņš (?асиньш 1958). He was of opinion that it was necessary to investigate more seriously the distribution and morphological borders of *Daphnella* species. It is quite believable that this species is native and wild-growing in Lithuania (Smaliukas 1996, 1997), Byelorussia (Парфенов, Мазин 1986) and Estonia (Krall, Viljasoo 1956, 1971). Lithuanian scientist D. Smaliukas is of the opinion that *S. acutifolia* can be considered to be wild-growing in east Lithuania from Dzukia to Zarasai district. There it is growing in dry sandy soils in the river valleys.

The north-west border of continuous distribution of this species is located in the middle of territory of Byelorussia. From this region to north are situated some natural isolated growing-places predominantly in the upper course of the rivers Nemuna and Daugava (Парфенов, Мазин 1986). In its natural areal *S. acutifolia* is growing often along with *Populus alba* and *Salix alba*. Plant societies with these trees and *S. acutifolia* as dominating taxa are found in south-east Latvia too – in the territories of Daugava-river valley from Piedruja to Krāslava and in Nature park ‘Daugavas loki’ (Evarts-Bunders 2001). The specific microclimate conditions in Daugava-valley is the reason of opportunity to remain a lot of middle European species far out of their Northern continuous areal borders, for example, *Populus alba*, *Salix acutifolia*. This willow is found autochthonically only in East Latvia, but out of Daugava-valley it is growing only in some places of Balvi, Gulbene and Ludza districts. In other locations of Latvia it is found only in plantations. Only some male specimens are going over to wild sometimes.



Fig. 6. Leaf of *S. daphnoides*



Fig. 7. Leaf of *S. acutifolia* x *daphnoides*

In accordance with our investigations and literature data the following hybrids of this species are known in Latvia: *S. caprea*. (*S.* × *propinqua* A. et G. Camus), *S. daphnoides*, *S. cinerea*, *S. dasyclados*, *S. purpurea*, *S. myrsinifolia*, *S. repens*, and *S. viminalis* (Starcs 1925; Galenieks 1955; Расиньш, 1959; Cinovskis, Rasiņš, Viljasoo, Smaliukas 1993). All mentioned hybrids (as an exception hybrid with *S. daphnoides*) are found very seldom.

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GENUS *TRIFOLIUM* L. IN FLORA OF LATVIA

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This paper contains a review about genus *Trifolium* L. species – history of investigation, geographical distribution in Latvia and systematic. The review is based on botanic literature and analysis of herbarium material. Distribution maps of 5 species in Latvia are given.

Key words: *Trifolium*, systematic, distribution, Latvia.

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Introduction

Clovers are widespread in Latvia, but there is relatively low number of species in flora. Most of the botanics both in Latvia as well as abroad accept genus *Trifolium* L. in wide sense. Other authors accept *Trifolium* in narrow sense and add the rest of species to genus *Lupinaster* Adans., *Amoria* C. Presl and *Chrysaspis* Desv. This rise a question on how useful it is to divide Latvian species into several genus.

The aim of this work is to make more precise taxonomy of genus *Trifolium* s.l. in Latvia.

Material and Methods

To ascertain the taxonomy of genus *Trifolium* L. s.l. all the available literature concerning systematic botany both from Latvia as well as other regions was analyzed.

Along with the study on literature, herbarium material was investigated as well. Lists of species of floristic investigations and herbarium materi-

als at Laboratory of Botany of LU Institute of Biology (LATV) as well as private collections off A. Rasiņš, A. Āboliņa and K. Veinbergs kept there, LU Museum of Botany (RIG) have been used.

Authors for taxa are given in accordance with Brummitt R.K., Powell C.E. (1992). Authors, not included in this book, are given in full name.

Species distribution in Latvia was analyzed by evaluation scale accepted by the Institute of Biology, Laboratory of Botany (Fatare 1992). Scale consist of 6 grades: very rare – 1-10 findings; rare – 11-30; rather rare – 31-100; not rare – 101-250; rather frequent – 251-500; frequent – 501-750 findings. Species geographical distribution maps were made using square method (Табака и др. 1980). Finding (locality) affirmed by herbarium marked as ●, finding from list of floristic investigation – o.

Results and discussion

Genus *Trifolium* was first described by Carl von Linnaeus in 1753. Genus is included either in family *Leguminosae* Juss. (*Fabacea* Lindl.) or

Papilionacea Gireke (*Fabacea*). C. Linnaeus divided genus *Trifolium* in five indefinite groups of taxonomical rank – *Lotoidea*, *Vesicaria*, *Lupulina*, *Lagopoda* and *Meliloti* (Росков 1989). Since then comprehension about range of genus as well as its taxonomic structure has been changed several times. Already in 1763 M. Adanson separated genus *Lupinaster* Adans., and in 1818 A. Desvaux separated genus *Chrysaspis* Desv., which included species of group *Lupulina* (Росков 1989). In 1832 C. Presl preserved both latter mentioned genus, in addition he changed the name of last one for *Amarenum* C. Presl, and added seven more genus: *Trifolium* L. s.str., *Amoria* C. Presl, *Galearia* C. Presl, *Mistyllus* C. Presl, *Paramesus* C. Presl, *Calycomorphum* C. Presl, *Micranthemum* C. Presl (Росков 1989). In 1839 F.G. Fleischer and E. Lindemann divided genus *Trifolium* s.l. into four indefinite units of taxonomical rank: *Lagopus* Koch, *Fragifera* Koch, *Trifoliastrum* Ser., *Chronosemium* Ser. (Fleischer & Lindemann 1839). In 1842 C.F. Ledebour divided *Trifolium* s.l. into sections *Lagopus* Koch, *Calycomorphum* C. Presl, *Fragifera* Koch, *Vesicastrum* Koch, *Lupinaster* Mönch., *Trifoliastrum* Ser., *Chronosemium* Ser. (Ledebour 1842). In 1883 M. Lojaco promoted sections *Lagopus* and *Trifoliastrum* in rank of subgenus, and in the last one included four sections of Ledebour: *Lupinaster*, *Trifoliastrum*, *Fragifera* and *Chronosemium* (Росков 1989). E.G. Bobrov accepted M. Lojaco's system in Flora of USSR, and in each subgenus included many sections (Бобров 1945):

1. subgen. *Trifoliastrum* (Ser.) Peterm.
 1. sect. *Involucraria* Hook.
 2. sect. *Lupinaster* Link
 3. sect. *Amoria* C. Presl
 4. sect. *Micranthemum* C. Presl
 5. sect. *Mistyllus* C. Presl
 6. sect. *Chronosemium* Ser.
 7. sect. *Galearia* C. Presl
2. subgen. *Lagopus* Bernh.
 1. sect. *Stenostoma* Gibelli et Belli
 2. sect. *Probatostoma* Gibelli et Belli
 3. sect. *Trichostoma* Bobr.
 1. subsect. *Intermedia* Gibelli et Belli

2. subsect. *Leimonophyllum* Herm.

4. sect. *Hiantia* Bobr.

5. sect. *Calycomorphum* C. Presl

Later E.G. Bobrov concluded, that each subgenus belongs to the separate tribe (Бобров 1967). Thereafter all clovers were divided into eleven genus: *Trifolium* L. s.str., *Calycomorphum* C. Presl into tribe *Trifolieae* Bronn.; *Lupinaster* Adans., *Lojaconoa* Bobr., *Loxospermum* Hochst., *Ochreata* (Lojac.) Bobr., *Amoria* C. Presl, *Paramesus* C. Presl, *Mistyllus* C. Presl, *Amarenum* C. Presl, *Galearia* C. Presl into tribe *Lupineae* Bobr. According to E.G. Bobrov Latvian sections of species *Lupinaster*, *Amoria*, *Galearia* and *Chronosemium* are adopted to the rank of genus, the name of the last one changing to *Amarenum*. In his last threatment of genus E.G. Bobrov (Бобров 1987) accepted genus *Trifolium* s.str., maintaining genus *Lupinaster* and *Amarenum*, changing the name of the last one for *Chrysaspis*, but genus *Amoria*, *Galearia*, *Mistyllus* and *Calycomorphum* reduced to the rank of subgenus:

1. gen. *Trifolium*
 1. subgen. *Trifolium*
 1. sect. *Stenostoma* Gibelli et Belli
 2. sect. *Probatostoma* Gibelli et Belli
 3. sect. *Trifolium*
 2. subgen. *Amoria* (C. Presl) Hossain
 3. subgen. *Galearia* (C. Presl) Hossain
 4. subgen. *Mistyllus* (C. Presl) Hossain
 5. subgen. *Calycomorphum* (C. Presl) Peterm.
2. gen. *Lupinaster*
3. gen. *Chrysaspis*

Yu.R. Roskov (Росков 1989) in the same way as J.G. Bobrov (Бобров 1987) accepted genus *Trifolium* in a narrow sense maintaining genus *Lupinaster* and *Chrysaspis*. Difference expresses in genus *Trifolium* s.str. division:

1. subgen. *Trifoliastrum* (Ser.) Peterm.
 1. sect. *Amoria* (C. Presl) Lojac.
 2. sect. *Mistyllus* (C. Presl) Godr.
 3. sect. *Galearia* (C. Presl) Godr.
 4. sect. *Micranthemum* (C. Presl) Gibelli et Belli

5. sect. *Calycomorphum* (C. Presl) Griseb.
2. subgen. *Trifolium*

D.E. Coombe (Coombe 1968) in Flora Europaea preserved genus *Trifolium* in a wide sense with three subgenus:

1. subgen. *Falkatula* (Brot.) D.E. Coombe
2. subgen. *Lotoidea* Pers.
 1. sect. *Lupinaster* (Fabr.) Ser.
 2. sect. *Paramesus* (C. Presl) Godr.
 3. sect. *Lotoidea*
 4. sect. *Cryptosciadium* Čelak.
 5. sect. *Mistyllus* (C. Presl) Godr.
 6. sect. *Vesicastrum* Ser.
 7. sect. *Chronosemium* Ser.
3. subgen. *Trifolium*
 1. sect. *Trifolium*
 2. sect. *Trichocephalum* Koch

At present two opinions prevale. One accepts *Trifolium* s.l. as it is used in Flora Europaea (Coombe 1968) and another accepts four genus *Lupinaster*, *Amoria*, *Chrysoaspis*, *Trifolium* (Yakovlev et al. 1996).

Genus *Amoria* includes species characterized by leaves with 3 leaflets, leaflets glabrous, lateral veins usually thickened, 2-3 times branching, ending in serrate denticles; flowers pedicellate, pedicels elongated at fructification; bracts present; calyx with more or less equal teeth, tube with 10-20 veins; standard free, wings and keel fused at 1/3-1/2 of their length; legumes with 2-4 seeds, dehiscent at ventral suture or indehiscent.

Genus *Chrysoaspis* includes species characterized by leaves with 3 leaflets, base of leaflet petiolule with dark-brown hairs, veins straight, unbranching, ending in obtuse denticles; flowers pedicellate; bracts present; calyx bilabiate, 3 lower teeth 2-4 times longer than 2 upper ones, tube with 5 veins; corolla with free petals; legumes with 1 seed, indehiscent.

Genus *Lupinaster* includes species characterized by leaves with 3-7 (9) leaflets; inflorescence umbellate; flowers pedicellate; bracts present; calyx with more or less equal teeth, tube with 10 veins; corolla with free petals; legumes with 1-6 seeds;

dehiscent at ventral suture.

Genus *Trifolium* s.str. includes species characterized by leaves with 3 leaflets, leaflets usually pilose, veins 3-4 times branching, ending in irregular denticles; flowers sessile; bracts absent; calyx with equal teeth, or lower one longer than others, tube with 10 or 20 veins; petals fused at 1/3-2/3 of their length; legumes with 1 seed, lower part scarious and upper part coriaceous, seed released by breaking of scarious part.

Diagnostically important characters of genus rank are hard to evaluate as there are relatively small number of species in flora of Latvia, only 18-20 species. Besides Latvian Herbariums are missing foreign herbarium materials of *Trifolium* s.l. taxa. Therefor more useful for flora of Latvia would be to retain one genus – *Trifolium* L. s.l. as it is in flora of other European and Northamerican countries.

List of *Trifolium* species

T. alpestre L.

Trifolium alpestre L. 1763, Sp. Pl., ed. 2: 1082; J. Fleisch. und Em. Lindem. 1839, in J. Fleisch., Fl. Esth. Liv. Kurl.: 252; Līvena, 1957, Latv. PSR Fl., 3: 160; Coombe, 1968, Fl. Europ. 2: 170; Бобров, 1987, Фл. европ. части СССР, 6: 203..

Rare, mostly in Daugava valey. (Fig. 1)

T. angustifolium L.

Trifolium angustifolium L. 1753, Sp. Pl.: 769; Coombe, 1968, Fl. Europ. 2: 170; Бобров, 1987, Фл. европ. части СССР, 6: 201; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 81. Adventitious. Referring to literature – in Rīga (13/26) (Шулц 1977). Herbarium material have not been seen.

T. arvense L.

Trifolium arvense L. 1753, Sp. Pl.: 769; J. Fisch. 1778, Vers. Naturg. Livl.: 273; Līvena, 1957, Latv. PSR Fl. 3: 162; Coombe, 1968, Fl. Europ. 2: 167; Бобров, 1987, Фл. европ. части СССР, 6: 204.

Frequent, in all territory.

***T. aureum* Pollich**

Trifolium aureum Pollich, 1777, Hist. Pl. Palat. 2: 344; Pētersone, 1980, in Pētersone un Birkmane, Latv. PSR augu noteic., 2. izd.: 233; Coombe, 1968, Fl. Europ. 2: 166.

Chrysaspis aurea (Pollich) Greene, 1897, Pittonia, 3: 204; Бобров, 1987, Фл. европ. части СССР, 6: 211.

Trifolium agrarium L. 1753, Sp. Pl.: 772, p.p., nom. ambig.; J. Fisch. 1778, Vers. Naturg. Livl.: 273.

Trifolium strepens Crantz, 1769, Stirp. Austr., ed. 2, 2: 411, nom. illeg.; Rasiņš, 1946, in Bickis, Latv. augu noteic.: 199; Līvena, 1957, Latv. PSR Fl. 3: 155.

Frequent, in all territory.

***T. campestre* Schreb.**

Trifolium campestre Schreb. 1804, in Sturm, Deutschl. Fl., 1, 4, 16: 13; Rasiņš, 1946, in Bickis, Latv. augu noteic.: 199; Līvena, 1957, Latv. PSR Fl. 3: 156; Coombe, 1968, Fl. Europ. 2: 166.

Trifolium agrarium L. 1753, Sp. Pl.: 772, p.p., nom. ambig.

Trifolium procumbens L. 1755, Fl. Suec.: 261, nom. ambig.; Ferber, 1784, in J. Fisch., 1784, Zusätze Vers. Naturg. Livl.: 157.

Chrysaspis campestris (Schreb.) Desv. 1818, Obs. Pl. Angers: 164; Бобров, 1987, Фл. европ. части СССР, 6: 211.

Rather rare, in Coastal Lowland and in Western Latvia. (Fig. 2)

***T. dubium* Sibth.**

Trifolium dubium Sibth. 1794, Fl. Oxon.: 231; Rasiņš, 1946, in Bickis, Latv. augu noteic.: 199; Līvena, 1957, Latv. PSR Fl. 3: 156; Coombe, 1968, Fl. Europ. 2: 166.

Trifolium minus Sm. 1802, in Relhan, Fl. Cantabr., ed. 2: 290; Bickis, 1923, Latv. augu noteic., 2. izd.: 101.

Chrysaspis dubia (Sibth.) Desv. 1818, Obs. Pl. Angers: 165; Бобров, 1987, Фл. европ. части СССР, 6: 212.

Rather rare, mostly in Coastal Lowland and in Western Latvia. (Fig. 3)

***T. expansum* Waldst. et Kit.**

Trifolium expansum Waldst. et Kit. 1807, Pl. Rar. Hung. 3: 237; Бобров, 1987, Фл. европ. части

СССР, 6: 204, in obs.; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 81.

Trifolium pratense var. *expansum* (Waldst. et Kit.) Hausskn. 1895, Mitt. Thür. Bot. Ver. 8: 25.

Trifolium pratense var. *americanum* Harz, 1891, Bot. Centr. 45: 106; Coombe, 1968, Fl. Europ. 2: 168.

Escaped cultivated plant. Herbarium material have not been seen.

***T. fragiferum* L.**

Trifolium fragiferum L. 1753, Sp. Pl.: 772; Ferber, 1784, in J. Fisch., 1784, Zusätze Vers. Naturg. Livl.: 157; Līvena, 1957, Latv. PSR Fl. 3: 157; Coombe, 1968, Fl. Europ. 2: 165; Бобров, 1987, Фл. европ. части СССР, 6: 206.

Galearia fragifera (L.) C. Presl, 1832, Symb. Bot. 1: 50.

Amoria fragifera (L.) Roskov, 1990, Бот. журн. 75, 5: 719.

Rare, mostly in Coastal Lowland. (Fig. 4)

***T. hybridum* L.**

Trifolium hybridum L. 1753, Sp. Pl.: 766; J. Fisch. 1791, Vers. Naturg. Livl., 2. Aufl.: 578; Līvena, 1957, Latv. PSR Fl. 3: 153, p.p.

Trifolium hybridum subsp. *hybridum*, Coombe, 1968, Fl. Europ. 2: 163.

Trifolium hybridum var. *hybridum*, Бобров, 1987, Фл. европ. части СССР, 6: 205, in obs.

Amoria hybrida (L.) C. Presl, 1832, Symb. Bot. 1: 47.

Frequent, in all territory.

a. subsp. *hybridum*

Stems glabrous or in upper part with sparse hairs, hollow. Heads 20-27 mm long. Corolla white, later pink, 6-7 times longer than calyx tube, 7-12 mm long.

b. subsp. *elegans* (Savi) Asch. et Graebn. 1907, Syn. Mitteleur. Fl. 6, 2: 496; Coombe, 1968, Fl. Europ. 2: 163.

Trifolium elegans Savi, 1798, Fl. Pis. 2: 161; J. Fleisch. und Em. Lindem. 1839, in J. Fleisch., Fl. Esth. Liv. Kurl.: 254; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 81.

Trifolium hybridum var. *elegans* (Savi) Boiss. 1872, Fl. Or. 2: 145; Бобров, 1987, Фл. европ. части СССР, 6: 205, in obs.

Trifolium hybridum L., Līvena, 1957, Latv. PSR Fl. 3: 153, p.p.

Stems in upper part with hairs, not hollow. Heads 16-20 (22) mm long. Corolla purple, 4-5 times longer than calyx tube, 5-7 mm long.

***T. incarnatum* L.**

Trifolium incarnatum L. 1753, Sp. Pl.: 769; Бобров, 1987, Фл. европ. части СССР, 6: 203; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 81.

Trifolium incarnatum subsp. *incarnatum*; Coombe, 1968, Fl. Europ. 2: 168.

Adventitious. Very rare, Cīrava (17/5), Koknese (18/37), Krustpils (20/41).

***T. lupinaster* L.**

Trifolium lupinaster L. 1753, Sp. Pl.: 766; Coombe, 1968, Fl. Europ. 2: 161; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 81.

Lupinaster pentaphyllus Moench, 1802, Suppl. Meth. Pl.: 50; Бобров, 1987, Фл. европ. части СССР, 6: 209.

Adventitious. Very rare, Koknese (18/37), surroundings of Paugas (18/38).

***T. medium* L.**

Trifolium medium L. 1759, Amoen. Acad. 4: 105; J. Fleisch. und Em. Lindem. 1839, in J. Fleisch., Fl. Esth. Liv. Kurl.: 252; Līvena, 1957, Latv. PSR Fl. 3: 158; Coombe, 1968, Fl. Europ. 2: 169; Бобров, 1987, Фл. европ. части СССР, 6: 203.

Frequent, in all territory.

***T. montanum* L.**

Trifolium montanum L. 1753, Sp. Pl.: 770; J. Fisch. 1784, Zusätze Vers. Naturg. Livl.: 131; Līvena, 1957, Latv. PSR Fl. 3: 152; Coombe, 1968, Fl. Europ. 2: 161; Бобров, 1987, Фл. европ. части СССР, 6: 205.

Amoria montana (L.) Soják, 1979, Ēas. Nār. Muz. Praze. øada pøir. 148. 2: 78.

Frequent, in all territory.

***T. pratense* L.**

Trifolium pratense L. 1753, Sp. Pl.: 768; J. Fisch. 1784, Zusätze Vers. Naturg. Livl.: 130; Līvena, 1957, Latv. PSR Fl. 3: 160; Coombe, 1968, Fl. Europ. 2: 168; Бобров, 1987, Фл. европ. части СССР, 6:

203.

Trifolium striatum auct., non L.; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 82; Tabaka, Krall and Jankeviciene, 1996, in Kuusk, Tabaka and Jankevičienē, Fl. Balt. Countr. 2: 151; Gavrilova un V.A. Šulcs, 1999, Latv. vask. augu fl.: 40.

Frequent, in all territory.

***T. repens* L.**

Trifolium repens L. 1753, Sp. Pl.: 767; J. Fisch. 1778, Vers. Naturg. Livl.: 272; Līvena, 1957, Latv. PSR Fl. 3: 153; Coombe, 1968, Fl. Europ. 2: 162; Бобров, 1987, Фл. европ. части СССР, 6: 205.

Amoria repens (L.) C. Presl, 1832, Symb. Bot. 1: 47.

Frequent, in all territory.

***T. retusum* L.**

Trifolium retusum L. 1753, Demonstr. Pl.: 21; Coombe, 1986, Fl. Europ. 2: 163; Бобров, 1987, Фл. европ. части СССР, 6: 206; Табака, 1988, в Табака и др., Фл. сосуд. раст. Латв. ССР: 82.

Trifolium parviflorum Ehrh. 1792, Beitr. Naturk. 7: 165.

Amoria retusa (L.) Dostál, 1982, Seznam Cėvn. Rostl. Kvit. Ēeskoslov.: 143.

Adventitious. Known one finding in Rīga (14/26).

***T. sativum* (Schreb.) Crome**

Trifolium sativum (Schreb.) Crome, 1824, in Boenn., Prodr. Fl. Monast.: 222; Līvena, 1957, Latv. PSR Fl. 3: 161; Бобров, 1987, Фл. европ. части СССР, 6: 204.

Trifolium pratense var. *sativum* Schreb. 1804, in Sturm, Deutschl. Fl. 1, 4, 15: 12; Coombe, 1968, Fl. Europ. 2: 168.

Trifolium pratense subsp. *sativum* (Schreb.) Schübl. et G. Martens, 1834, Fl. Würtemb.: 465.

Escaped cultivated plant. Rather rare.

***T. spadiceum* L.**

Trifolium spadiceum L. 1755, Fl. Suec., ed. 2: 261; Grindel, 1803, Bot. Taschenb. Liv. Cur. Ehstl.: 227; Līvena, 1957, Latv. PSR Fl. 3: 154; Coombe, 1968, Fl. Europ. 2: 165.

Chrysoaspis spadicea (L.) Greene, 1897, Pittonia, 3: 205; Бобров, 1987, Фл. европ. части СССР, 6: 211.

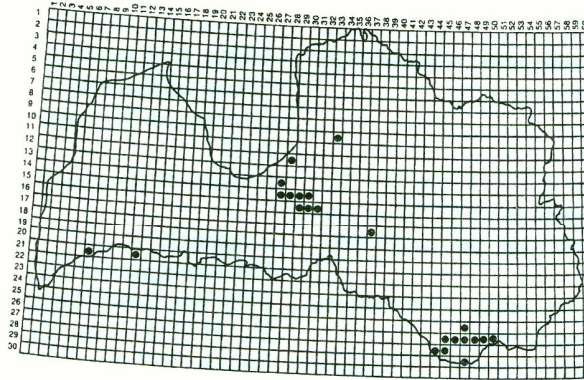


Fig.1. Distribution of *Trifolium alpestre*.

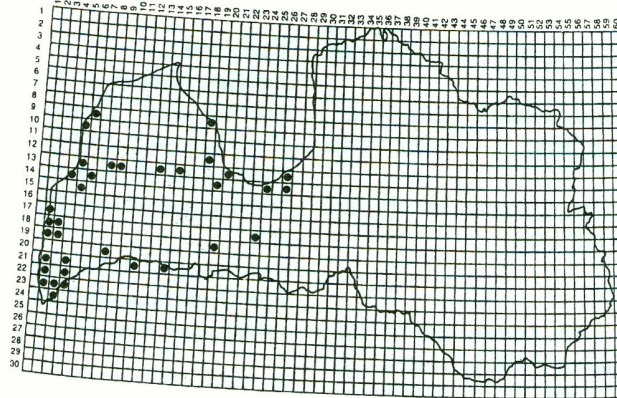


Fig.2. Distribution of *Trifolium campestre*.

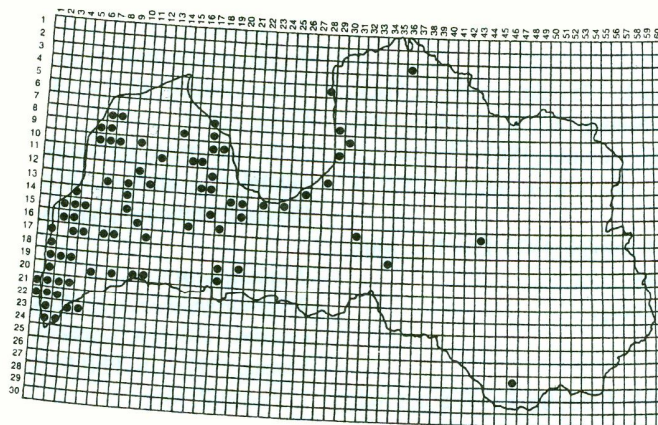


Fig.3. Distribution of *Trifolium dubium*.

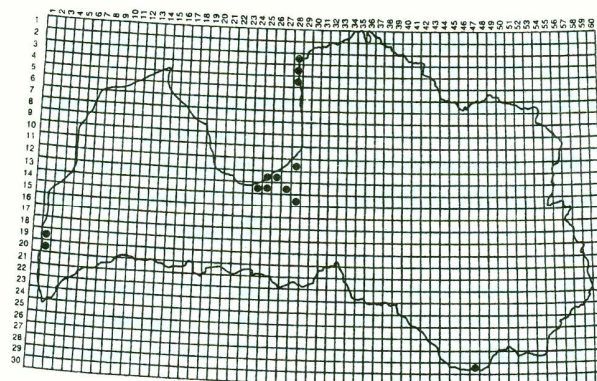


Fig.4. Distribution of *Trifolium fragiferum*.

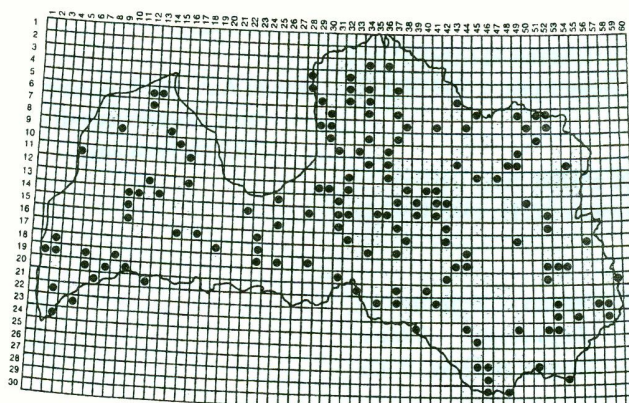


Fig.5. Distribution of *Trifolium spadiceum*

Amareus spadiceus (L.) C. Presl, 1832, Symb. Bot. 1: sine pag.
Rather frequent, in all territory. (Fig. 5)

Cambridge, pp. 157-172.

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EFFECT OF THE LIME FOREST - GRASSLAND EDGE ON GROUND VEGETATION

Vitas Marozas

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The objective of this study was to estimate the edge effect on species richness in agriculturally maintained forest-grassland boundaries of lime dominated forest and to determine how species respond to forest edge. The study area was selected in Southwest Lithuania. The impact of edge effect on overall herbaceous species composition of lime dominated forest was evaluated by means of Canonical Correspondence Analysis. Herbs and mosses species diversity in lime dominated forest was the highest one at the forest edge and decreased towards the forest interior zone. The highest decrease in number of species occurred at the distance from 0 to 5 m from the edge. The highest cover of herbs and mosses was at the forest edge. CCA biplots showed a good correlation of overall species composition and distance from the forest edge. The species were divided into five classes according to their response to edge effect.

Key words: canonical correspondence analysis, forest edge effect, forest fragmentation, species diversity.

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Introduction

Fragmentation changes the spatial nature of the landscape, increases the amount of edge habitat and induces changes in both the abiotic and biotic environment. Fragmentation and habitat loss are among the most important causes of worldwide species decline (Haila 1999; Murcia 1995). In many parts of mixed European forest zone, logging has transformed the forest landscape into patches of forest islands of various sizes that are isolated from one another by open fields. One of fragmentation and related habitat loss consequences is decreasing proportion of interior habitat and increasing proportion of edge (Ranney et al. 1981; Harris 1984; Murcia 1995; Haila 1999, Matlack & Litvaitis 1999).

Forest fragmentation necessarily leads to the increase in the amount of forest edge. Changes of abiotic and biotic conditions in the edges compared with the intact habitat are called edge effect. These numerous effects include changes in wind, humidity, radiation, predation, parasitism, and species interactions (Saunders et al. 1991; Chen et al. 1995; Murcia 1995; Risser 1995; Donovan et al. 1997; Voller 1998). Compared with forest interiors, forest edges typically have different plant species composition and community structure. Edges influence both the ecosystem structure and function through their roles of sites of exchange of energy, materials, and organisms between patches (Hansen et al. 1988; Chen et al. 1996).

Changes in structure, composition and function

of edges primarily result from alteration of microclimate, following the structural modification of the landscape. Microclimate, including solar radiation, moisture, wind, and temperature is a primary driver of ecosystem and landscape-level processes such as photosynthesis, regeneration, plant growth, nutrient cycling, and decomposition (Geiger 1965; Perry 1994). At forest edges microclimatic variables (light intensity and duration, relative humidity, air temperature) and soil factors (pH, organic carbon, total nitrogen, available phosphorus, soil moisture and temperature) change fast over short distances.

In response to these conditions, vegetation structure and composition at the edge are different as compared to the one in the forest interior. To counteract the negative effects of edges it is important to understand how species respond to the conditions at the habitat edges (Haila 1999). Forest edges are preferred habitat of many species. Edges of forest fragments are easily invaded by species from surrounding ecosystems and some species may continue invading through the edge into the forest interior. Edge habitat is unsuitable for species requiring interior habitat and consequently such species may be lost if fragments become too small (Haila 1999).

The extent of the edge effects penetration into the forest is important. Knowledge of edge width is critical for management focusing on the preservation of the natural characteristics of forests (Brothers 1993) and for setting priorities for conservation. Edge effects are the most significant consequences of fragmentation resulting from natural and human-caused disturbances. The area influenced by edges is an important measurement for ecological studies and natural resource management.

Few studies have been conducted on plant species richness on man-made forest boundaries (Wales, 1972; Ranney et al. 1981; Williams-Linera 1991, Laurance 1991; Malcom 1994; Matlack 1994; de Casenave et al. 1995; Luczaj & Sadowska 1997; Burke & Nol 1998) and they have been only sporadic ones in Europeans forest zone (Luczaj & Sadowska 1997).

The objective of this study was to estimate the edge effect on species richness in agriculturally maintained forest-grassland boundaries of lime dominated forest and to determine how species respond to forest edge.

Material and Methods

The study area is located in South-western Lithuania (54° 21' – 54° 55' N, 23° 29' – 23° 41' E). The study area falls in the transitional deciduous coniferous mixed forest zone of Europe (Ahti et al. 1968). Plain landscape and leached moraine podsol soils prevail. Annual mean temperature ranges from +6.3 to +6,7° C and temperatures of the warmest and coldest months (July and January) are from +16.5 to +17.5 and from –5.0 to –4.7° C, respectively. The annual mean precipitation is between 650 and 750 mm. Period with snow continues from 75 to 90 days (Bukantis 1994). Dominant tree species are: *Picea abies*, *Pinus sylvestris*, *Betula pendula*, *Betula pubescens*, *Populus tremula*, *Fraxinus excelsior*, *Quercus robur*, *Tilia cordata* (Karazija 1988). The landscape is extensively fragmented due to forest conversion to agricultural and urban areas in the XIX century.

Ten transects were established in well-developed agricultural grassland and forest edges. Sites were chosen to minimise slope, canopy heterogeneity, human interference and local variation in other factors, which might affect species composition. Transects began at the bases of trees that formed the edges and extended perpendicularly in the forest. The length of transects was 30 m. At the each transect square form (1x1) plots were set up at distances of 0 m, 5 m, 10 m, 15 m, 20 m, 25 m and 30 m from the forest edge.

Vegetation sampling was conducted during July and August of 2000. All herbaceous species and mosses were recorded and percentage cover of each species was estimated in each plot. Overall herbs and mosses cover was also estimated. Plant species nomenclature is according Jankeviciene (1998).

The impact of edge effect on overall herbaceous species composition in lime dominated forest was evaluated by means of Canonical Correspondence Analysis (CCA) (Jongman et al. 1987) using the program CANOCO for Windows (ter Braak&Šmilauer 1998). Transect identifiers were used as covariables to analyse only the response to the distance from the forest edge. Significance was tested by the distribution-free Monte Carlo test (499 permutations).

In order to estimate reaction of each species to the edge effect, the frequency of each species at the recorded distances from the forest edge was calculated. These frequencies were used for species distribution to the following classes according to their reaction to edge effect: 1) species found only in the contact zone, 2) species that penetrate some distance into the forest, 3) species that seemed to decrease in frequency along the transect from the edge, 4) species that seemed to increase in the frequency along the transect from the edge, 5) species that neither increased nor decreased in frequency from the edge (adopted from the Burke&Nol 1998).

Results

Species richness of herbs and mosses in lime-dominated forest was the highest one in the forest edge and decreased dramatically at the distance 5-10 m. Then species number increase again until 20 m from the edge and become stable towards the forest interior (Fig. 1).

The highest decrease in number of species occurred at the distance from 0 to 5 m from the edge. The main reason of the increased species richness at the edge was penetration of species from the adjacent grassland. The highest cover of herbs and mosses was at the forest edge and decreased at the distance 5 m. Then cover increase until 15 m from the edge and become stable towards the forest interior (Fig. 2).

The relationship of overall species composition in the lime-dominated forest to the distance from the forest edge shows CCA biplot (Fig. 3). Correlation of overall species composition and distance from the forest edge is 0.929, Monte Carlo

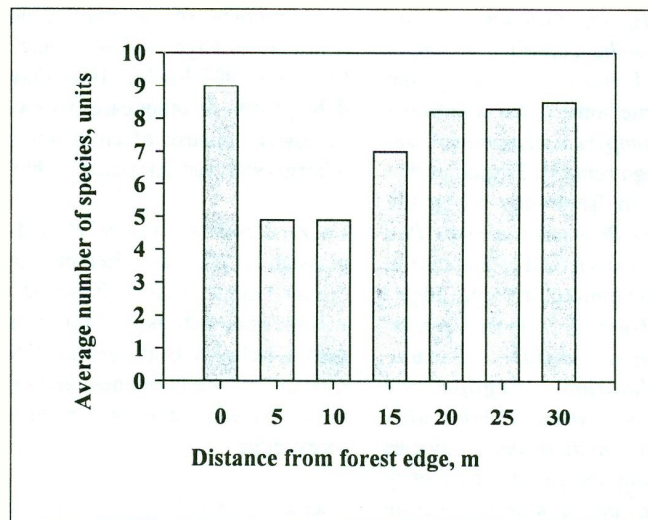


Fig. 1. Dependence of average number of species of undergrowth, herbs and mosses from distance to forest edge

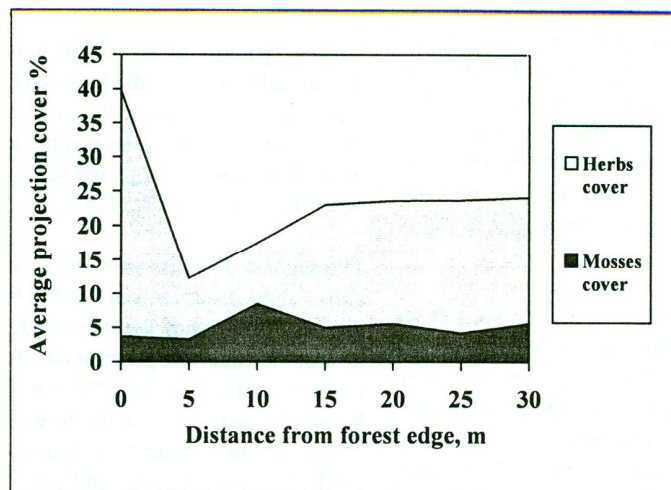


Fig. 2. Dependence of herbs and mosses average projection cover from distance to forest edge

test - $p=0.002$. The species found at different distances from the forest edge are shown in Table 1.

These species were divided into five classes: 1) species found only in the contact zone (0-5 m) - *Alchemilla sp.*, *Centaurea jacea*, *Festuca rubra*, *Fragaria vesca*, *Hypericum perforatum*, *Leucanthemum vulgare*, *Galium verum*, *Tanacetum vulgare*, *Trifolium alpestre*, *Trifolium montanum*, *Veronica chamaedrys*, *Vicia sepium*; 2) species that penetrate some distance into the forest (0-15 m) - *Melampyrum nemorosum*, *Veronica officinalis*, *Ajuga reptans*; 3) species that seemed to decrease in frequency along the transect from the edge - *Brachythecium sp.*, *Poa nemoralis*; 4) species that seemed to increase in the frequency along the transect from the edge - *Campanula trachelium*, *Lathyrus vernus*, *Pulmonaria obscura*, *Milium effusum*, *Plagiomnium undulatum*, *Aegopodium podagraria*, *Carex sylvatica*, *Ranunculus cassubicus*, *Ranunculus lanuginosus*; 5) species that neither increased nor decreased in frequency from the edge - *Atrichum undulatum*, *Asarum europaeum*, *Convallaria majalis*, *Carex digitata*, *Hepatica nobilis*, *Stellaria holostea*, *Viola riviniana*.

Discussions

In some cases edge effect increases plant species richness (Ranney et al. 1981; Zolyomi 1987; Brothers and Springarn 1992; Matlack 1994; Burke & Nol 1998). Low densities or complete absence of some forest plant species may occur at the edge, but other species may be more common at restricted to edge habitats (Ranney et al. 1981; Chen et al. 1992; Matlack 1994; Fraver 1994; Burke & Nol 1998). In other cases species richness may be lower because of environmental variation (Harris 1988; van der Maarel, 1990).

Luczaj & Sadowska (1997) found that the forest-grassland border had different characters for various taxonomic groups. The forest-grassland edge was the zone with both maximal and minimal of species richness. Burke & Nol (1998) found a significant decline in richness and relative cover of the herbaceous layer at 5 m distance from the forest edge.

Species of broad ecological diapason, usually intolerant to light shading have been determined to occur at the forest edge. In the forest interior species are frequently found to be tolerant to the

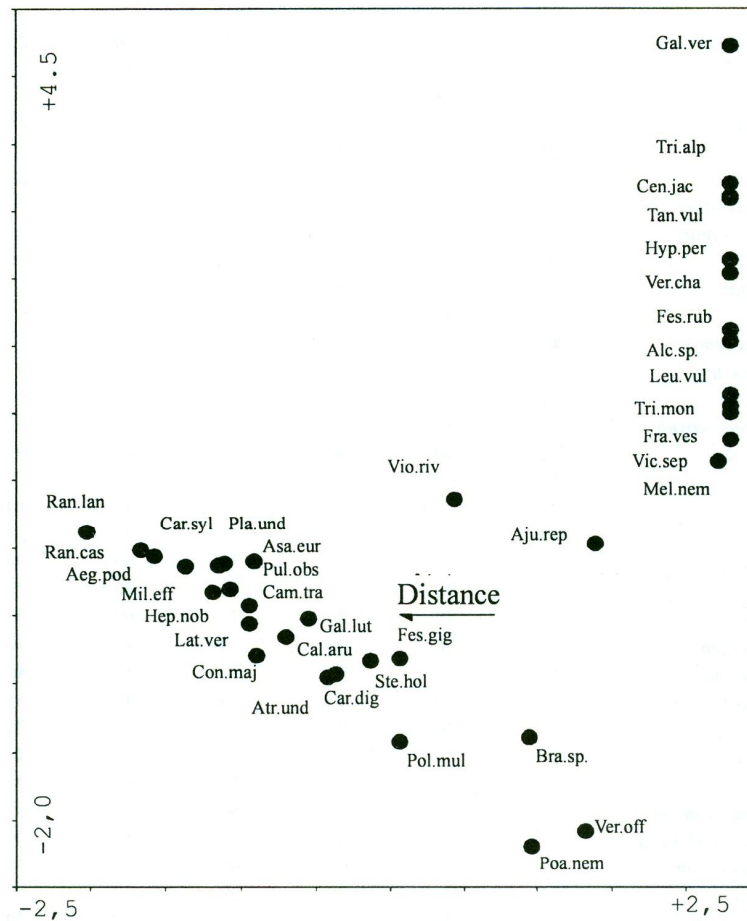


Fig. 3. Dependence of herbs and mosses species from distance to forest edge.

Aeg.pod - *Aegopodium podagraria*, Aju.rep - *Ajuga reptans*, Alc.sp. - *Alchemilla* sp., Asa.eur - *Asarum europaeum*, Atr.und - *Atrichum undulatum*, Bra.sp. - *Brachythecium* sp., Cal.aru - *Calamagrostis arundinacea*, Cam.tra - *Campanula trachelium*, Car.dig - *Carex digitata*, Car.syl - *Carex sylvatica*, Cen.jac - *Centaurea jacea*, Con.maj - *Convallaria majalis*, Fes.gig - *Festuca gigantea*, Fes.rub - *Festuca rubra*, Fra.ves - *Fragaria vesca*, Gal.lut - *Galeobdolon luteum*, Gal.ver - *Galium verum*, Hep.nob - *Hepatica nobilis*, Hyp.per - *Hypericum perforatum*, Lat.ver - *Lathyrus vernus*, Leu.vul - *Leucanthemum vulgare*, Mel.nem - *Melampyrum nemorosum*, Mil.eff - *Milium effusum*, Pla.und - *Plagiomnium undulatum*, Poa.nem - *Poa nemoralis*, Pol.mul - *Polygonatum multiflorum*, Pul.obs - *Pulmonaria obscura*, Ran.cas - *Ranunculus cassubicus*, Ran.lan - *Ranunculus lanuginosus*, Ste.hol - *Stellaria holostea*, Tan.vul - *Tanacetum vulgare*, Tri.alp - *Trifolium alpestre*, Tri.mon - *Trifolium montanum*, Ver.cha - *Veronica chamaedrys*, Ver.off - *Veronica officinalis*, Vic.sep - *Vicia sepium*, Vio.riv - *Viola riviniana*

Table 1. Frequency of the species in the lime forest depending from the distance to forest edge

Name of the species	Distance to forest edge, m						
	0	5	10	15	20	25	30
<i>Alchemilla sp.</i>	20	0	0	0	0	0	0
<i>Centaurea jacea</i>	60	0	0	0	0	0	0
<i>Festuca rubra</i>	100	0	0	0	0	0	0
<i>Fragaria vesca</i>	30	0	0	0	0	0	0
<i>Hypericum perforatum</i>	40	0	0	0	0	0	0
<i>Leucanthemum vulgare</i>	40	0	0	0	0	0	0
<i>Galium verum</i>	30	0	0	0	0	0	0
<i>Tanacetum vulgare</i>	30	0	0	0	0	0	0
<i>Trifolium alpestre</i>	40	0	0	0	0	0	0
<i>Trifolium montanum</i>	40	0	0	0	0	0	0
<i>Veronica chamaedrys</i>	40	0	0	0	0	0	0
<i>Vicia sepium</i>	40	0	0	0	0	0	0
<i>Melampyrum nemorosum</i>	90	50	0	0	0	0	0
<i>Veronica officinalis</i>	20	30	40	0	0	0	0
<i>Ajuga reptans</i>	40	0	30	30	0	0	0
<i>Poa nemoralis</i>	50	100	100	100	40	10	0
<i>Brachythecium sp.</i>	60	60	80	20	0	30	20
<i>Stellaria holostea</i>	40	0	70	20	60	30	10
<i>Viola riviniana</i>	20	0	0	40	20	20	20
<i>Atrichum undulatum</i>	20	40	70	70	60	50	60
<i>Galeobdolon luteum</i>	30	70	60	100	100	100	100
<i>Asarum europaeum</i>	20	0	0	50	100	80	100
<i>Convallaria majalis</i>	0	60	40	20	40	60	50
<i>Carex digitata</i>	0	40	0	50	40	20	30
<i>Hepatica nobilis</i>	0	40	0	0	20	40	60
<i>Festuca gigantea</i>	0	0	0	10	0	0	0
<i>Polygonatum multiflorum</i>	0	0	0	10	0	0	0
<i>Calamagrostis arundinacea</i>	0	0	0	50	50	40	30
<i>Campanula trachelium</i>	0	0	0	40	20	30	20
<i>Lathyrus vernus</i>	0	0	0	30	20	20	20
<i>Pulmonaria obscura</i>	0	0	0	30	20	40	40
<i>Milium effusum</i>	0	0	0	30	80	100	80
<i>Plagiomnium undulatum</i>	0	0	0	0	30	10	30
<i>Aegopodium podagraria</i>	0	0	0	0	50	70	90
<i>Carex sylvatica</i>	0	0	0	0	40	20	30
<i>Ranunculus cassubicus</i>	0	0	0	0	30	30	30
<i>Ranunculus lanuginosus</i>	0	0	0	0	0	30	30

light shading, characteristic to a forest species. Investigations in lime dominated forest grassland edges and previous studies have shown that edges are characterised by the species that are shade intolerant, have good vegetative reproduction, and are most often associated with early stages of secondary succession (Wales 1972; Ranney et al. 1981; Whitney & Runkle 1981).

Species from adjacent agricultural ecosystems can penetrate into a narrow band at the edge of a forest fragment (Murcia 1995) and the presence of these species can result in modification of the vegetation structure and floristic composition as compared to the interior (Ranney et al. 1981). Occurrence of edge species, different species richness in edges and the occurrence of exotic spe-

cies at the edges are all features that depend on the particular ecological conditions, and the ecology of the species present, rather than on intrinsic properties of edges.

Conclusions

Herbs and mosses species diversity in lime dominated forest was the highest one at the forest edge and decreased towards the forest interior zone. The highest decrease in number of species occurred at the distance from 0 to 5 m from the edge. The highest cover of herbs and mosses was at the forest edge.

CCA biplots showed a good correlation of overall species composition and distance from the forest edge. The species were divided into five classes according to their response to edge effect.

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BIRD`S-FOOT/FOWL-FOOT (*ORNITHOPUS PERPUSILLUS*) IN LITHUANIA

Kęstutis Kazimieras Vilkonis

Vilkonis K. K., 2003: Bird`s-foot/ Fowl-foot (*Ornithopus perpusillus* L.) in Lithuania. *Acta Biol. Univ. Daugavp.*, 3 (1): 49 - 52.

The first time *Ornithopus perpusillus* L. was reported in Lithuania in 1898 when the only site was indicated at Klaipėda harbour. In 2000 the species was found in the Curonian Spit near Nida and in two more places almost in the centre of the country. The ecological conditions, structure of the community, characteristics of the habitat and the distribution of the species are discussed and described in the paper. It is supposed that *Ornithopus perpusillus* is naturally distributed in the Curonian Spit and Prienai district and that the locality appears to be situated apart to the east from the main distribution area.

Key words: *Ornithopus perpusillus*, biology, community, distribution, Lithuania

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Introduction

More than a century later, in 1998 on the seaside of Lithuania Bird`s-foot/Fowl-foot (*Ornithopus perpusillus* L.) was found again. At that time it was a unique known habitat of the species in Lithuania. The zone of the seaside is very dynamic. The ways of distribution of many species are mixed up here, therefore it is possible to discuss the status of *Ornithopus perpusillus*. As the local flora of the seaside and its saturation with species is regulated by special, only for this zone peculiar natural and anthropogenous factors, such as the sea climate and the intensive tourism, a favorable way of intrusion of foreign species is obvious. To prove, that *Ornithopus perpusillus* here is a strange species, is impossible. It is more acceptable to think, that this species here is local, constantly growing within the limits of the area, because in 2000 two new places of habitat were found considerably to the east of the Curonian Spit, almost in central Lithuania.

Technique

The research was carried out from August 3, 1998 in the Curonian Spit, to July 13 and 17, 2000 and the vicinities of the villages Poshventis (N 54°39'43,5'', E 24°03'16,3'') and Pociunai (N 54°39'29,2'', E 24°03'16,7'') [Prienai district, central Lithuania]. The vegetative community is described by the technique of J. Braun - Blanquet (1964), in the 10 x 10 m² size square. The names of syntacsonomy are presented according to the code of Phytosociological nomenclature specifications (Barkmann et al. 1986). The names of vascular plants and lichens are from the following sources: R. Jankeviciene (1998), Z. Gudzinskas (1999), J. Motiejunaite (1999) publications. The prevalence of the species (1 fig.) in Poland is taken from A. Zajac, M. Zajac (2001), in Lithuania (except the Curonian Spit and middle Lithuania) and Estonia from V. Kuusk et al. (1996), in Russia (Kaliningrad Region) from N. N. Andronova, G. G. Kucheneva (1978) presented materials. The

samples are stored in the herbarium of the Botany Institute (BILAS) of the Academy of Sciences of the Lithuanian Republic.

Biology and prevalence

15 species of genus *Ornithopus* L. grow in the world (Vasiljeva 1987). These species are distributed in Europe and Northern Africa (Algeria). In the Lithuanian Republic grow two species of this genus - *Ornithopus perpusillus* L. and *Ornithopus sativus* Brot. In Lithuania the latter species grow in the fields; and sometimes, as a weed it grows on kerbs, roadside or in crops (Stancevicius 1971). This brief report presents the data on a very rare species in Lithuania - *Ornithopus perpusillus*.

Ornithopus perpusillus L. Sp.Pl.: 743. 1753; Abromeit et al., Fl. Ost-u.Westpr., 1: 190. 1898; Stancevicius in Liet.Fl., 4: 401. 1971. - Bird's-foot/ Fowl-foot (Jankeviciene 1998).

This annual low (5-30 cm) plant with a rod root has some ramified stalks. The stalks are thin rising or lying, covered with rich white pubescences. The leaves are not in pairs plumose (pinnate), combined from 13-25 leaflets of 0.1-0.6 cm length and of 0.1-0.2 cm width. The leaflets are oblong elliptic or oval with blunt (obtuse) tops, the stipules are small and pointed. The length of pedicels (peduncles) is equal to the length of the leaves or a little bit longer. The flowerets are sessile, 5-7 collected together in brushes, reminding of umbellate (umbelliferous) little heads. The bracts are squamous. The cup is covered with piloses, its scallops are 3 times shorter than the tube. The nimbus is brightly violet: the sail is with reddish fibres and a concave top. The keel is obtuse, yellowish, it is shorter than the oars. The beans are located oblique-skew, their length is 1-2 cm, the width is about 0.2 cm; they are bent, covered with piloses, combined of 5-7 brown, oval, reticulate nervate segments. The seeds are like eggs, yellow or yellow brown, with a smooth surface, their length is 1.5 mm. The plants blossom from the end of May to the beginning (middle) of August.

Ornithopus perpusillus is a species of eucoenic distribution. The area of the species is in the territories of Belgium, Denmark, France, Germany, Italy, Ireland, the British Isles, the Netherlands, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Russia (Kaliningrad Region), Moldova, the Ukraine, Algeria (only northern part) (Wiersema 1990) and it passes from the temperate, through submeridian up to the meridian zones. In some countries the frequency of prevalence of this species and occupied areas are rather different. In Germany *Ornithopus perpusillus* is distributed very unevenly. Most frequently it grows in the bank sands of big rivers, such as the Oder, the Elbe and especially the Rhein. In Northern Bavaria and Thüringen it is seldom met (Markgraf 1976). In Poland this species is rather rare, it grows in bank sands of the big rivers and in seaside sandy meadows. It is more often found on the banks of the Oder and the Vistula, and near Gdynia there passes the eastern border of the species' distribution. (Pobedimova 1956). In Denmark and Sweden the species is also seldom found (Ingelög et al. 1993). In Latvia *Ornithopus perpusillus* is not found now, it is mentioned only in old references, and in Estonia it is found on the island of Hiiumaa and it is considered a casually brought species (Kuusk et al. 1996). In the Ukraine the species grows in the vicinities of Dnepropetrovsk and Kherson. In Russia two habitats of this species are known: the extreme northern one next to Sankt Petersburg (where the species is considered to be casually brought) (Vasiljeva 1987) and the extreme east near Kaliningrad, 1.5 km to the east from the railway station of Ladushkino (Andronova, Kucheneva 1978).

First time in Lithuania *Ornithopus perpusillus* was mentioned by J. E. Gilibert, however his data concerns the historical territory of Lithuania. It specifies, that this species was found near the city of Grodnam, in the present territory of Beloruss (Gilibert 1782). In other early botanical sources (Abromeit et al. 1898) it is pointed out that *Ornithopus perpusillus* was found in the of city Klaipėda, in the port on a heap of sand from a ship ballast. In later generalizing editions of the Lithuanian flora (Snarskis 1954, 1968; Lekavicius

1989) in the genus of *Ornithopus* L. is described only one species of *Ornithopus sativus* Brot. A. Stancevicius (1971) emphasises, that after J. Abromeit et al., (1898) in the indicated habitat *Ornithopus perpusillus* in Lithuania was not found any more. Later Z. Gudzinskas (1999) *Ornithopus perpusillus*, as casually brought species, included in the list of not native plants. In the most known herbariums of Lithuania (BILAS, WI) there were no samples of this species up to the present times.

Habitat

In the territory of its habitat *Ornithopus perpusillus* grows both in natural and in anthropogenous areas. However, in the central part of the area this species usually grows in natural places of habitat: in sandy meadows, in sands with grasses, in dry pine woods and in open places in woods, and on the borders of the area - in anthropogenous habitats: in the fields, friable deposits, next to roads, on dumps of dust. In the basic area *Ornithopus perpusillus* grows in communities of associations *Koelerio-Corynephoretea* Klika in Klika et Novak 1941 the classes *Carici arenariae-Airetum praecocis* Westh. et al. 1962 and *Airo caryophylleae-Festucetum ovinae* R. Tx. 1955. Here this species is very characteristic in the vegetation of sandstones.

In Lithuania *Ornithopus perpusillus* is found in the three places: on the Curonian Spit 1.5 km to the south of the city Nida on 3 August, 1998 (J. Stankeviciute), and in two places almost in the centre of the country - south of the city Kaunas, near to river Oshvencia to the villages of Poshventis (Prienai district, N 54°39'43,5'' E 24°03'16,3'' - 13 July, 2000 (V. Stukonis) in a pine forest and of Pociunai (Prienai district, N 54°39'29,2'' E 24°03'16,7'' - 17 July, 2000 (K. K. Vilkonis) on both sides of a pine forest on a sandy pasture. On the Curonian Spit *Ornithopus perpusillus* grew on a sandy lawn in a community of low grasses. Apart *Ornithopus perpusillus* here grew *Aira praecox*, *Anthoxanthum odoratum*, *Calluna vulgaris*, *Carex arenaria*,

Danthonia decumbens, *Deschampsia flexuosa*, *Festuca ovina*, *Hieracium umbellatum*, *Melampyrum nemorosum*, *Peltigera canina*, *Peplis portula*, *Pilosella officinarum*, *Poa pratensis*, *Radiola linoides*, *Rumex acetosella*, *Vicia angustifolia*, *V. lathyroides*. The ground here is sandy. The square from different sides is limited by rich thickets of *Calluna vulgaris*, *Empetrum nigrum* among which single low trees *Pinus sylvestris* and *Betula pendula* grow. In central Lithuania both *Ornithopus perpusillus* habitats differ from those at the seaside. Here are sandy pasturable waste ground and a wood lawn with low grasses and bushes. In these habitats *Aira praecox*, *Carex arenaria*, *Danthonia decumbens*, *Deschampsia flexuosa*, *Peplis portula*, *Radiola linoides*, *Vicia lathyroides* do not grow. The outer wood grass-plot and a square are limited by little shrubs *Calluna vulgaris* and *Juniperus communis* (Stankeviciute 2002).

The latter two habitats obviously differ from the habitat on the Curonian Spit. These locations should be considered to be more anthropogenous areas. On the basis of the data in the references concerning the habitat of *Ornithopus perpusillus* in the central part of Lithuania (Poshventis, Pociunai, Prienai district) in this geographical latitude it is necessary to consider it the most eastern point of habitat of this species. We suppose that *Ornithopus perpusillus* in Lithuania grows within the limits of its area, at the very edge of it.

Following the examples of changes of sandy communities, in the course of time in these communities the quantity of species characteristic of the wood areas will increase, the processes of overgrowth of a grassy cover will take place. The character of the community will change and it will cause changes of the ground.

In order to preserve in Lithuania the habitats of *Ornithopus perpusillus* - a very rare species in the country - rational measures of protection are necessary based on longitudinal monitoring and on thorough scientific research. First of all the territory of the wood at the villages of Poshventis and Pociunai with the adjacent habitats of this species should be declared reservations.

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BIODIVERSITY AND IMMUNOLOGY : LOOKING FOR AN ADDITIONAL CRITERION

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An attempt of using the immunological methods for the clarification of phylogenetic relationships of four cestode species from the genus *Diphyllobothrium* (Cestoda: *Diphyllobothriida*): *D. dendriticum*, *D. ditremum*, *D. vogeli* and *D. latum* from Karelia is described. It has been found out that the species *D. dendriticum* and *D. ditremum* possess a distinct antigenic affinity. A species *D. latum* has not revealed the antigenic affinity with any of the studied species. These data are in agreement with the results of analysis of the ecological-geographical criterion.

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Introduction

A comparative-immunologic study of four cestode species of the genus *Diphyllobothrium* - *D. latum* L., 1758, *D. dendriticum* (Nitzsch, 1824), *D. ditremum* (Creplin, 1825), and *D. vogeli* (Khulow, 1953) has been carried out (Bylund, 1975). We have also quantitatively estimated a degree of antigenic affinity among these species and have given a comparative analysis of data of immunologic and ecological-geographical taxonomic criteria.

With the development of immunotaxonomy it becomes more and more obvious that the use of serologic data is advantageous not only for verification of taxonomic arrangements, based on the classical taxonomic criteria (Babyanskas, Sroga et al., 1975). In some cases immunologic methods allow to resolve the taxonomic problems, an answer to which cannot be found using the classical criteria. Thus, the immunologic methods allow in particular to estimate quantitatively a degree of serologic (antigenic) affinity between related taxa of the same rank which is adequate in

principle to clarification of a degree of their phylogenetic relationships. The numeric data on a degree of similarity and difference of taxa are evidently very important for reconstruction of phylogenetic relationships and elaboration of natural taxonomic system for any group of organisms. As long ago as 1928, K. Landsteiner stated that a phylogenetic tree of animal Kingdom might be made only when taking into account the data of comparative serology.

This work is intended to attempt the study of taxonomic relationships of different cestode species of the genus *Diphyllobothrium* based on their immunospecificity at specific level.

Materials and methods

A work was carried out in the territory of Karelia. Strobilae of *D. latum* obtained from experimentally infected dogs, strobilae of *D. dendriticum* and *D. ditremum* - from spontaneously invaded gulls (*Larus canus*, *L. fuscus*, *L. argentatus*) and terns (*Sterna hirundo*). The obtaining of antigens for

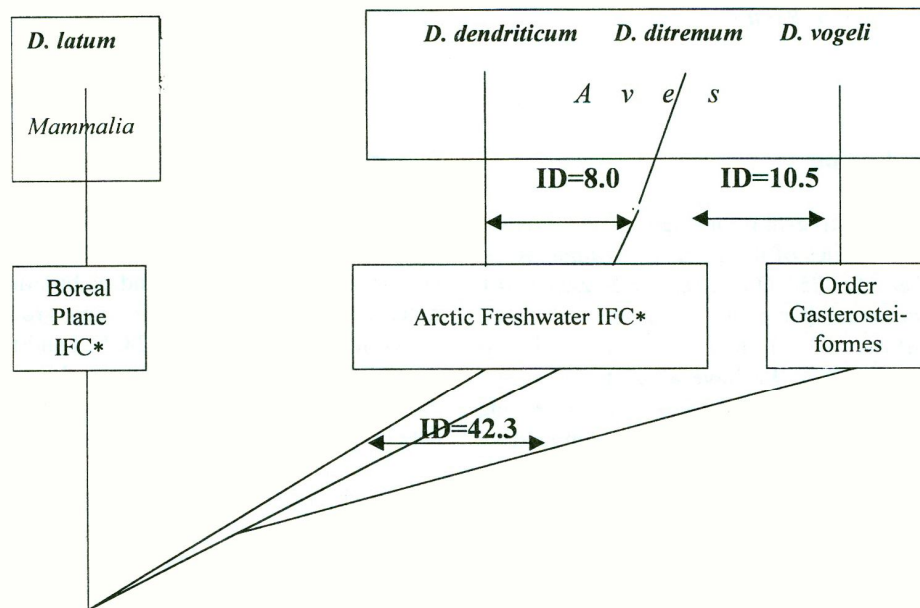
immunization and scheme of rabbits immunization was done by universally adopted methods with own modifications. A dose of introduced antigen into rabbits during immunization was 10 mg of protein determined by Louri method for each 2 kg of a rabbit body weight. Antiserum revealed a titre 0.009 mg of protein. Ringprecipitation and gemagglutination reactions for estimat serologic relationships were used.

Results

As could be expected the least amount of antigen is required for the reactions in case of homologous variants. This amount varied from 0.0045 mg (*D. vogeli*) to 0.059 mg (*D. ditremum*). In all cases of heterologous reactions the amount of need's

antigen protein was always much higher then in homologous reactions. These data demonstrated the presence of marked differences in antigen composition among the four studied species, thus supplying an additional evidence of a specific validity of all studied forms of cestodes.

The more antigenic affinity between two compared species, the less amount of antigen is known to be required to obtain a positive results in serologic reactions. Based on this universal rule it is possible estimate quantitatively degree of antigenic affinity in four studing species. It is appropriate for such a quantitative estimation to calculate the immunologic distance (ID) (Mainard 1957), describing a ratio between the amount of antigenic protein needed for reactions in homologous and heterologous variants:



* - Ichthyofaunistic complex

A species *D. latum* as seen stand apart within the limits of the genus. The cross reactions between this species and three other the serologic reactions were observed in none of the variants of experiments. This result demonstrates that this species is the most distant, judging from the composition of antigenic components, from all studied representatives of the genus and

accordingly less related to them taxonomically.

To judge by the ID *D. dendriticum* and *D. ditremum* are the most closely related species. The cross reactions between them have demonstrated the presence of positive serologic results with the use of minimum amounts antigenic protein (ID=8.0). It is important to notice

that these two species are also very similar over the entire group to taxonomic characters, commonly used in cestode taxonomy. That is just why a specific validity of these species for a long time raised doubts and caused individual discussions.

The species *D. vogeli* is close to the above groups, however, judging by ID its position is rather individual. A degree of its antigenic affinity shows its closer relations with *D. ditremum* (ID=10.5) than with *D. dendriticum* (ID=42.3).

The literature and the actual data obtained in the region where the present study was carried out (Karelian region) allow to compare a degree of antigenic affinity with some characteristics of life cycles of these species and, in particular, with the peculiarities of their ecological isolation while parasitizing the supplementary and definitive hosts.

It is first of all easy to observe, that the most related in their antigenic composition species *D. dendriticum* and *D. ditremum* are characterized by a minimum degree of ecological isolation at the last stages of their life cycle. A range of their supplementary hosts is mainly composed of typical representatives of the Arctic Freshwater Ichthyofaunistic Complex (in the interpretation of Yakovlev 1964). From the taxonomic point of view most fish hosts of these cestode species belong to a family *Salmonidae*. In the water reservoirs of Europe a host range of *D. dendriticum* involves 13 fish species, that *D. ditremum* – 10 species; in 8 of these fish species the plerocercoids of both species of cestodes are found.

A comparison of qualitative properties of the environment of 1st order utilized by species *D. dendriticum* and *D. ditremum* at the given stage of their life cycle unambiguously demonstrates that both species are placed in a common ecological niche, limited to the mentioned IFC. A presence of ecological isolation between these species may be established only when comparing the quantitative indexes, which show the rate of infection of individual host species. Thus in the

foci studied by us the maximum indexes of extensity and intensity of *D. dendriticum* invasion are observed in sig. (*Coregonus lavaretus*), while in other fish hosts (genera *Salmo*, *Salvelinus*, *Thymallus*) only single specimens of this parasite were found. A fish *Coregonus albula* is an obligatory host of *D. ditremum* in the same water reservoirs, in other salmon fish species (including sig) this parasite is observed extremely rarely.

In this way a degree of ecological divergence of the species under study at this stage of their life cycle is very low and the interspecific isolation is of a relative character.

The data on a host range of these species are much less clear. A differential diagnosis of *D. dendriticum* and *D. ditremum* strobilae was developed rather recently. The most recent findings were identified based on morphological characters, most of which did not reflect the real specific morphological differences between these species. Judging from the literature data the species *D. dendriticum* is distributed in Europe only in larid birds, whereas *D. ditremum* tends to parasitize birds from the genera *Gavia*, *Phalacrocorax*, *Ardea* and some others.

However, in the foci studied by us the presence of such a distinct divergence of hosts was not confirmed. Both the species were found only in birds of Laridae family, the presence of *D. dendriticum* and *D. ditremum* in one and the same bird (*L. canus*, *L. fuscus*, *S. hirundo*) being observed rather often. In this case the indexes of extensity and intensity of invasion of individual hosts with each of the cestode species considered were similar, a fact excluding even the presence of a relative ecological isolation of these species at the expense of formation of the obligatory host-parasite systems with different bird species from a general range of hosts.

Therefore two of three parasitic stages in a life cycle of *D. dendriticum* and *D. ditremum* occur in the same conditions of the environment of the 1st order: in groups of supplementary and final hosts united by a common ecological-

geographical genesis and with close phylogenetic. It is quite natural to expect a low degree of specific divergence in this evolutionary situation. Just this fact is reflected in the literature data demonstrating a considerable similarity of the given species in a wide range of taxonomic characters.

As a result their specific validity raised doubts for a long time as we already mentioned. A similarity of the antigenic composition in strobilae of these cestodes observed in the present study follows (and confirms) from a low degree of specific divergence of these species.

The species *D. vogeli* which is closer in its antigenic composition to the species *D. ditremum* was already mentioned to be related to the above pair of species in its ID. The literature lacks the data on a range actual final hosts of *D. vogeli*. At the same time the analysis of composition of supplementary hosts of *D. vogeli* demonstrates essential differences from *D. dendriticum* and *D. ditremum*. At this life cycle stage *D. vogeli* characterized by the extremely limited range of hosts (two fish species) and the strict specificity to a single phylogenetic line of fishes – order *Gasterosteiformes*. This cestode species is practically not found in salmon species-hosts of the two above discussed species of cestodes. The ecological isolation of this species at one of the parasitic stages of its life cycle occurring in the environment of the 1st order, and differing in quality from the parasitic stages of *D. dendriticum* and *D. ditremum* may be assumed to predetermine a change in antigenic spectrum and decrease in a degree of *D. vogeli* serologic affinity with the mentioned pair of species.

This assumption is well confirmed on the example of *D. latum*. Although the supplementary hosts of this species belong to various phylogenetic lines of the class *Pisces* (*Esociformes*, *Perciformes*, *Cypriniformes* and *Gadiformes*), they represent rather a uniform and isolated group in faunistic aspect, being the typical components of the “boreal plane ichthyofaunistic complex”. Just in fish species of this complex the high indexes of extensity and intensity of invasion with plerocercoids *D. latum* are recorded. We can not

speak about the absolutely ecological isolation of this species in the mentioned complex, because the plerocercoids of *D. latum* were many times recorded from fishes belonging to other ichthyofaunistic complexes and in the first place to “arctic freshwater complex” (salmonid and thymallid fishes).

However, the extremely low indexes of invasion in these fishes no doubt indicate that the parasite-host relations of *D. latum* with the representatives of all the ichthyofaunistic complexes except the “boreal plane complex” are occasional and a principle flow of this invasion is naturally, although relatively, restricted to the limits of a single helminth-faunistic complex.

The following stage of *D. latum* life cycle reveals even more clear ecological isolation. This species is known to be a specific parasite of mammals and does not develop in birds – the obligatory final hosts of the three cestode species discussed above, even in the experimental conditions.

At the discussed stage of the life cycle *D. latum* occupies a specific ecological niche with new qualities and does not go out of its limits (absolute isolation). Other species of the genus among those associated with fresh water biocenoses are practically not subjected to the ecological radiation into this niche which is practically not observed (only single findings of *D. dendriticum* are recorded from mammals).

Therefore the species *D. latum* is characterized on the one hand by the isolated existence in the environment of the 1st order, principally differing from other species of the genus and, on the other hand, by the absence of antigenic affinity with the other species of the genus, recorded from the same territory.

Summing up the above data we will pay attention to some general points above all the existence of distinct immunologic differences between species living in the same conditions of the environment of the 1st order and hardly differentiated in all characters commonly used in taxonomy of cestodes (*D. dendriticum* – *D. ditremum*) should

be noted. This shows the importance of immunologic criterion for substantiation of validity and, consequently, for biodiversity of species. Secondly, a certain correlation between the peculiarities of ecological specialization of species and a degree of their antigenic affinity may be observed within the genus under study. And, at last, the immunologic differences between species living in the same (or similar) conditions of the environment of the 1st order though present, are not significant.

Finally in case of ecological specialization of a species to basically different conditions of the environment of the 1st order (ecological isolation) its immunologic distance with other species decreases. The more specific is the ecology of a given species at each of the parasitic stages, the more stages are subjected to ecological specialization, and the less are the immunologic distance with other related species.

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SEVERAL CHARACTERISTICS OF ERYTRON SYSTEM AND IMMUNE SYSTEM IN CHERNOBYL CLEAN-UP WORKERS FROM LATVIA 14 YEARS AFTER THE ACCIDENT

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The incidence of micronuclei (Howell-Jolly bodies) in peripheral blood erythrocytes was evaluated as an index of genotoxic exposure. The purpose of the present study was to investigate the frequency of micronucleated erythrocytes as well as erythrocytes refractive index, and their correlations with several immunological parameters in the peripheral blood in Chernobyl clean-up workers from Latvia 14 years after Chernobyl NPP accident. 40 residents of Latvia who participated in 1986 during the first three weeks after the accident (with maximal radiation exposure) in the clean-up work of the Chernobyl nuclear power plant explosion aftereffects and 46 healthy blood donors were examined in this study. From each individual person 10000 erythrocytes were examined for the presence of micronuclei. Erythrocytes (RBC) were also investigated using newly elaborated method based on RBC refractive index properties at different pH. Refractive indices of RBC were measured at 19 different pH for each individual and appropriate curve constructed. The level of immunoglobulins (IgA, IgG and IgM), the number of peripheral blood leukocytes (PBL), lymphocytes (Ly), monocytes (Mo), T-lymphocytes and their subpopulations (CD2+, CD3+, CD4+, CD8+), and NK cells (CD16+) were determined in the peripheral blood. Data were statistically analyzed using the ANOVA test. We didn't find significant differences in the frequency of micronucleated erythrocytes between the control and exposed groups as well as correlations between the number of micronucleated erythrocytes and investigated immunological indices. There were three significant maxima of the refractive index: at pH 2.25, 6-8, and 12.20. The curves of the Chernobyl clean-up workers when compared each other within the group showed distinct dispersion. Besides them, the isoelectric point was shifted to the alkaline end of the pH scale in comparison with the control curves: isoelectric point of clean-up workers curves corresponded to pH=7.8 whereas those of the control group members' curves were at 6.5. Changes of the isoelectric point correlated with the lead concentration in urine in exposed persons. The number of CD3+ cells as well as level of IgG was significantly decreased ($p<0.05$) in Chernobyl clean-up workers versus control group. The changes in the refractive properties of clean-up workers RBC could be regarded as a phenotypic manifestation of a somatic mutation in bone marrow precursors of RBC. The changed immunological parameters reflect impaired functions of the immune system in Chernobyl clean-up workers 14 years after the nuclear accident.

Key words: Chernobyl clean-up workers, micronucleated erythrocytes, erythrocytes refractive index, immunoglobulins A, G, M, T-cells, NK cells.

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Introduction

Approximately 6000 residents of Latvia participated in the clean-up works in Chernobyl. In 1986, clean-up workers were officially allowed to accumulate up to 25 cGy before being sent home (Ginzburg & Reis 1991), but several reports indicated that doses may have been much higher (Mironova et al. 1998). The clean-up workers were endangered by external radiation as well as by internal radiation (Ginzburg & Reis 1991). Sources of internal radiation were contaminated food, water, air dust etc. by radionuclides released into the environment during the accident. Methods of retrospective estimation of received radiation until now are widely used in toxicological studies (Ilyinskikh et al. 1999). Peripheral blood erythrocytes (RBC) are known to have a rather high radio-resistance (Chukhlovina et al. 1994). Nevertheless, various changes of RBC morpho-functional properties, such as, activation of their enzymatic activity, stimulation of erythroid progenitor cells (Gruzdev et al. 1994), increase of the number of methemoglobin-containing RBC (Bilko et al. 1996), raise in hemoglobin content (Pivnik et al. 1996), elevated frequency of mutant erythrocyte glycoprotein A gene (Livingston et al. 1997) have been examined in Chernobyl clean-up workers. The obtained results demonstrate that exposure to ionizing radiation induces long-lived mutations in bone marrow stem cells and that these cells continue to produce circulating erythrocytes with damages years to decades after exposure (Fenech et al. 1997, Gong et al. 1999). Until now is no conclusive view on the late biological effects of low dose radiation at the level of cells.

The in vivo micronucleus test detects the effect of mutagenic agents on chromosomes by the identification of eccentric fragments and lagging chromosomes (Schmid 1975). The micronuclei or the extranuclear chromatin-containing bodies or Howell-Jolly bodies in the peripheral erythrocytes result from loss into the cytoplasm of chromosomal fragments or whole chromosomes during cell division. The most dangerous mutagenic agent is radiation, especially in combination with chemicals (Müller 1989). Quantitative assessment

of micronucleated erythrocytes in persons exposed to radiation have been studied (Ilyinskikh et al. 1999, Ilyinskikh et al. 1997).

Immune system, especially cellular immunity, is known as very vulnerable to radiation and toxic activity (Tuschl et al. 1995).

It is possible to measure the light refractive index in separate erythrocytes. Additional information about hemoglobin amino acid content is possible to obtain by measuring refractive index in erythrocytes at different pH (Lehninger 1992). Each molecule of amino acid contains an amino group (NH₂) on the one end and carboxyl group (COOH) on the other end, and different side groups (R). R-groups are classified by their polarity: 1) apolar or hydrophobe R-groups, 2) uncharged polar R-groups, 3) "+" charged R-groups, 4) "-" charged R-groups. Classic theory of light dispersion in fluids can also be applied to a cell. According to the theory, light refractive index depends on the light wavelength or on the frequency of light waves. There is a relationship between polarisability of atom or molecule and light refractive index. In general, if material consists of molecules of different polarisability, the total polarisability can be obtained as a sum of all molecules polarisability. It is necessary to take into account, that molecule is affected by external electric field and by electric fields induced by neighboring molecules (Volkenshtein 1951). According to the light dispersion theory, the light refractive index formula is as follows:

$$n = \Re(\sqrt{\epsilon}) = 1 + \frac{N q^2}{\epsilon_0 m} \frac{\omega_0^2 - \omega^2}{(\omega_0^2 - \omega^2) + 4\gamma^2 \omega^2}$$

where

ϵ	- material permeability,
N	- number of molecules,
m	- molecule's mass,
q	- molecule's charge,
ω	-oscillation frequency,
ω_0	-oscillation self frequency.
$2\gamma = g/m$	-force index - similar to friction force.

This formula suggests that protein R-group charge can effect the value of refractive index regardless of its charge sign. Dissociation of protein molecules R-group describes each protein and depends on the content of amino acids in the cell. Ionization radiation can generate somatic cell mutations with following changes in the composition of the hemoglobin amino acids and structure.

The purpose of the present study was to investigate the frequency of micronucleated erythrocytes as well as erythrocytes refractive index, and their correlations with several immunological parameters in the peripheral blood in Chernobyl clean-up workers from Latvia 14 years after Chernobyl NPP accident.

Materials and methods

40 residents of Latvia (age 40±6) who participated in clean-up activities in Chernobyl in May of 1986 for two weeks and 46 those having no professional contacts with radioactivity (control) were examined. Each of the clean-up workers had 2-6 various chronic diseases. Individuals suffering from acute infection, oncological diseases and active autoimmune diseases were excluded. In 17 of 40 examined Chernobyl clean-up workers external radiation exposure was documented. The documented external radiation dosage the investigated Chernobyl clean-up workers were exposed to was 0,02 to 0,26 Gy. However, it is generally considered that the actual doses could be two or even three times higher (Ginzburg & Reis 1991, Mironova et al. 1998).

Conventional examination of peripheral blood

Individuals of both studied groups (Chernobyl clean-up workers and control group) were screened by using conventional hematological laboratory tests carried out on an appropriate analyzer Cell-Dyn-1700 (Abbot, USA-Germany). For each individual, peripheral blood samples were collected from vein into disposal vacuum tubes containing EDTA. Number of PBC, hemoglobin

(HGB), hematocrit (HCT), mean cell volume (MCV), mean cell hemoglobin (MVH), mean cell hemoglobin concentration (MCHC), RBC distribution width (RDW) have been analyzed from the data obtained from the analyzer.

Micronucleus test in peripheral blood erythrocytes

Analysis was carried out by the method according as described by Schmid (1975). The frequency of micronucleated erythrocytes was manually scored through an immersion objective lens. For each individual 10000 erythrocytes were examined.

Polarizing-interference microscopy of RBC

Mixtures of polyvinylpyrrolidone 15 (Serva) and buffers of different pH (1:1) were used as embedding media. The refractive index of the embedding media was stable ($n=1.5133 \pm 0.0001$) and independent from the type and pH of the buffer. It was used as a standard value for the evaluation of the refractive indices at different pH. Smears were embedded in the buffered medium and the refractive index for 35 RBC was measured. After rinsing in distilled water the same slide was embedded in another buffered polyvinylpyrrolidone medium, and the next 35 measurements were taken at each of the subsequent 17 different pH in the range of pH=2 - pH=13. Nomarski type polarizing-interference microscope was used for the measurements of the light phase retardation. Using the measured RBC thickness the refractive index was calculated for each pH value with standard error $n 0.0001$, pH 0.05.

Immunological investigations

Lymphocyte subpopulations (CD2, CD3+, CD4, CD8, CD16) were determined by indirect immunofluorescence using the appropriate specific monoclonal antibodies (Immunotech Coulter Company, Marseille, France). Levels of serum immunoglobulins A, G and M were detected by radial immunodiffusion (Manchini et al. 1965).

Analysis of blood and urine lead concentrations

Lead in peripheral blood were determined by atomic absorption spectrophotometer (Perkin Elmer 403 with graphite furnace HGA 2200) using a deuterium background compensation system (Loon 1986). Standard solutions of metals (Acros Organics, Geel, Belgium) were used. Quality control was performed with Nycomed whole blood standards.

Lead in urine was sedimented in complex with sodium and calcium chloride, dissolved in diluted hydrochloric acid (Gorn 1982), and determined by atomic absorption spectrophotometer in an air-acetylene flame (AAS-3, Carl Zeiss, Germany). Normal values are 50-270 $\mu\text{g/l}$ for blood lead and 3-18 $\mu\text{g/l}$ for urine.

Statistical analysis

The data are printed as mean (\bar{x}) \pm standard deviation (D). Data were analyzed by ANOVA test. Significance was considered at <0.05 .

The relationship between the account of micronucleated erythrocytes and erythrocytes refractive index, immunological indices, level of lead in PB and urine have been analyzed using Pearson correlation coefficient r .

Results

No differences were found in the number of micronucleated erythrocytes in peripheral blood of Chernobyl clean-up workers and the control group. Resulted curves of the refractive indices of both groups were of different configuration having a leg in the acid part of the pH scale (the acid leg), a middle part with maximum (isoelectric point) and two minimums and a leg in the alkaline part of the scale (the alkaline leg). The curves of the individuals from the control group overlap each other, especially the isoelectric point and the alkaline legs (Fig 1). On the contrary, the curves of the clean-up workers when compared each other within the group showed distinct dispersion of their middle parts and their legs (Fig. 1). Besides them, the middle part of the curves of the

clean-up workers was shifted to the alkaline end of the pH scale: isoelectric point of the curves of clean-up workers corresponded to $\text{pH}=7.3$ whereas the isoelectric point of the control group members' curves was at $\text{pH} = 6.5$. In both groups refractive index was in range $n=1.5886-1.6786$. The number of CD4^+ , CD8^+ , CD16^+ cells except the number of CD3^+ no had significantly differences in investigated group in comparison with those in the control group. The level of IgG was found decreased in Chernobyl clean-up workers. The number of CD3^+ cells as well as the level of IgG in Chernobyl clean-up workers was decreased. The mean lead concentration in blood was below 40- $\text{mkg}\%$ in exposed group ($34.1 \pm 15.2 \text{ mkg}\%$). The mean lead concentration in urine in those was increased above 0.05 mkg/l ($0.08 \pm 0.12 \text{ mkg/l}$). As is shown in table 4, any correlations between micronucleated erythrocytes and other laboratory indices not have been found. Erythrocytes refractive index in the Chernobyl clean-up workers correlated with the lead concentration in urine in those.

Discussion

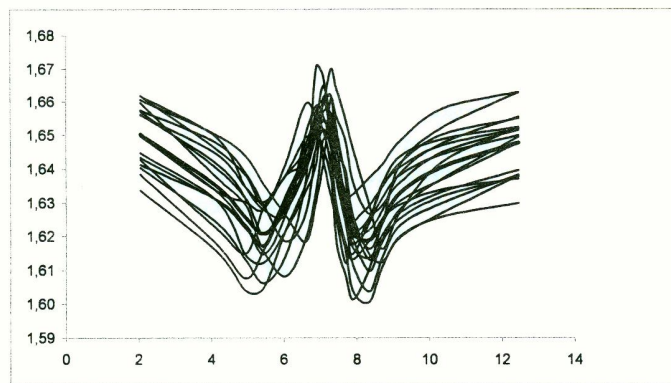
It is well known that erythrocytes have a limited life span in the peripheral circulation of approximately 120 days and the spleen rapidly removes micronucleated erythrocytes. This study was performed using blood samples after exposure beyond the lifetime of the exposed erythrocytes. So, we had some problems with the interpretation of our results.

We have found refractive properties of the RBC of individuals involved 14 years ago in the clean up of the Chernobyl accident to be affected. We observed three maximum values of refractive indices of RBC along the pH scale, where protein charge is larger due to their basic (arginin or lysine) or acid (aspargin acid or glutamine acid) R-groups dissociation. The refractive index of RBC at nine most characteristic pH (see tab. 4) had significant positive correlation with the lead concentration in urine in exposed persons and did not have any correlations with concentration of lead in peripheral blood. This finding confirms

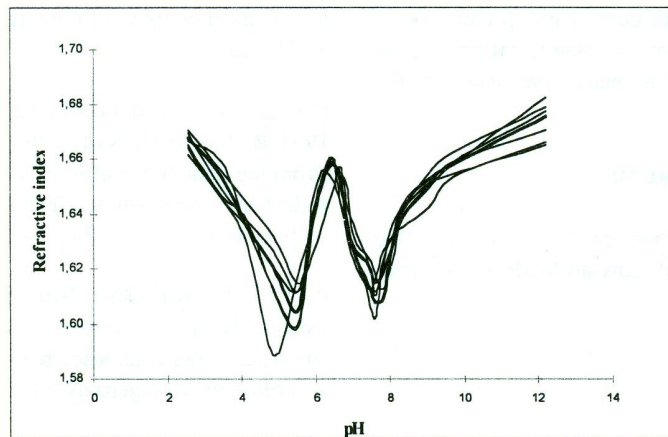
Several characteristics of erytron system and immune system in Chernobyl clean-up workers from Latvia

Table 1. Correlation between refractive index at nine different pH and several laboratory data

	HTC	MCV	MCH	C3	Lead in urine
n=	9	6	6	7	23
2.05	-0.63	-0.24	-0.34	0.6	0.63
4.15	-0.38	0.04	-0.17	0.61	0.64
4.95	-0.35	-0.05	-0.37	0.70	0.69
5.45	-0.13	0.07	-0.21	0.72	0.53
8.35	-0.51	0.00	-0.14	0.50	0.56
8.70	-0.30	-0.32	-0.54	0.73	0.51
9.20	-0.51	-0.57	-0.72	0.81	0.62
10.35	-0.58	-0.59	-0.71	0.80	0.77
12.45	-0.70	-0.60	-0.63	0.65	0.85



a



b

Fig. 1. Curves constructed from refractive indices of RBC measured at 19 different pH. Chernobyl clean-up workers: individual curves (a) and mean curve (c, — .); control group people: individual curves (b)

the possible influence of increased concentration of lead in the human body as the one of most responsible factor for the structural and chemical changes of erythrocytes.

The number of micronucleated erythrocytes in Chernobyl clean-up workers from Latvia did not differ from that in control group. Our finding is controversial to data of other investigators (Ilyinskikh et al. 1997, Shoikhet et al. 1994, Ilyinskikh et al. 1999, 1996). In our study the observed same number of micronucleated erythrocytes in both groups of Chernobyl clean-up workers and control group could be explained by the fact that inhabitants of Latvia involving in clean-up works in Chernobyl in 1986 continued to live in nonpolluted by radionuclides territories (in Latvia). Certain disturbances of the immune system in clean-up workers were established. The decreased number of CD3+ and decreased level of IgG in exposed persons in comparison with control group was observed. Similar results were reported before (Malickaite et al. 1997, Bruvere et al. 1995). The statistical analysis did not revealed any significant correlation between the micronucleated erythrocytes and the immune indices neither in the clean-up workers or control group.

Nevertheless, the differences in the refractive properties of RBC in Chernobyl clean-up workers in comparison with control group could be regarded as a phenotypic manifestation of a somatic mutation in bone marrow precursors of RBC.

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DEVELOPMENT OF PHYTOPLANKTON COMMUNITIES IN THE DAUGAVA RIVER HYDRO POWER PLANT RESERVOIRS

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Druvietis I. 2003. Development of phytoplankton communities in the Daugava river hydro power plant reservoirs. *Acta Biol. Univ. Daugavp.*, 3 (2): 67 - 70.

Development of phytoplankton in the Daugava Reservoirs characterized by spring and autumn diatom peak and summer peak of blue-greens. Highest phytoplankton biomasses in Daugava reservoirs were observed in summer period characterised by lower discharge of water. Cyanobacterial bloom in the reservoirs dominated by mixed composition of blue-greens *Microcystis* species.

Key words: phytoplankton, algal blooms, *Microcystis*.

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Introduction

In the monography "Hydrobiology of Daugava River" in 1967 Antonija Kumsare, famous Latvian hydrobiologist wrote that in the Keguma reservoir, phytoplankton blooms have not been observed and blue-green algae do not developed (Кумсаре 1967, Kumsare 1972). She predicted hypothesis, that after filing all the cascade, changes from rhithral to potamal and eutrophication processes must cause algal (cyanobacterial) blooms. However blue-green (cyanobacterial) blooms have been observed above all the Daugava Reservoirs more than last 20 years. The prediction of A. Kumsare has now occurred due to the construction of hydroelectric dams.

Methods

Phytoplankton samples in Plavinu reservoir were collected in june and october by Ruttner type water sampler for quantitative analysis. Samples

were immediately fixed with Lugol solution. Phytoplankton species biomass was determined by counting cell numbers and measuring cell volumes. Algal volume was converted to biomass by assuming the specific density of the cells to be equal to that of water. Live samples used for qualitative species identification were taken with a 10 (m plankton net by vertical hauls through the water column. Cell numbers were determined with a Zeiss microscope using magnifications of 100x, 200x, 400x, and 600x.

Results and discussion

Phytoplankton succession in Daugava Reservoirs comprises by a spring diatom development, followed by a period with relatively low phytoplankton biomass dominated by green algae and small amount of diatoms. July and August are characterised by blooms of cyanobacteria (Druvietis 1998). After filling of the Riga Reservoir in 1975, first cyanobacteria blooms were noted

at this site in 1977. Typical development of phytoplankton was observed in 1978 - 1980 in Riga Reservoir characterised by spring and autumn diatom peak and summer peak of blue-greens (Fig. 1)

In July and August of 1979, the biomass of cyanobacteria reached 2.5-3.0 mg/l. Further studies of the dynamics of cyanobacteria in the years 1987, 1991, 1999 and 2002 have indicated a possible relationship between water temperature and cyanobacteria biomass in the Rigas Reservoir. Highest phytoplankton biomasses in Riga reservoir caused by algal blooms of *Microcystis* were observed in summer period characterised by lower discharge of water (Fig. 2).

The highest cyanobacteria biomass ever recorded in August 1999, in connection with observations of enhanced water temperatures above 27 °C during July and August. Enhanced temperature above 27°C in July and August 1999 would be the reason for extensive cyanobacterial bloom by mixed composition dominated by *Microcystis* species (mainly *M. aeruginosa*, *M. wesenbergii*, *M. viridis*).

The maximum of phytoplankton biomass more than 85 mg L⁻¹ was recorded in August 1999 (former observed summer maximum biomass was

24.7mg L⁻¹ in July 1991) in the lower Reservoir of Cascade - Riga Reservoir (Druvietis & Rodinov, 2001). In July 1999 there were observed increase of cyanobacteria biomass in cascade of Reservoirs downstream the Daugava River .

In September 1999, the almost uniform *Microcystis* spp. bloom was partly replaced by other cyanobacterial genera (also toxin-producing), such as *Anabaena* spp. and *Oscillatoria* spp. (Druvietis I. & V. Rodinov, 2001). In second part of September and in October cells of cyanobacteria collapsed and started to settle in the bottom. Phytoplankton of October and November are characterised by week development of diatoms *Aulacoseira* spp., *Asterionella formosa* and unicell diatoms.

In the last years in the mouth of the Daugava toxic bloms were stated (Balode et al. 2000; Balode M. & I. Puriņa 2001).

In June 2002 and October 2002 phytoplankton samples were taken in Plavinu reservoir. June phytoplankton species composition was characterised by low numbers of cells and phytoplankton biomass. Highest numbers of cells were observed near by surface of water and were practically formed by algae divisions Cyanophyta,

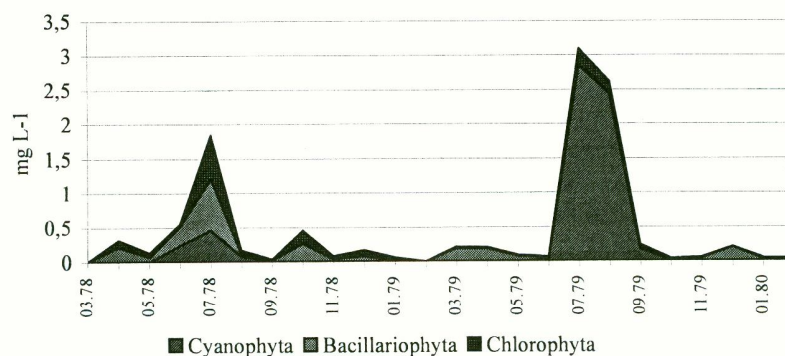


Fig. 1. Development of phytoplankton in Riga Reservoir (1978-1980) according Druvietis & Rodinov (2001)

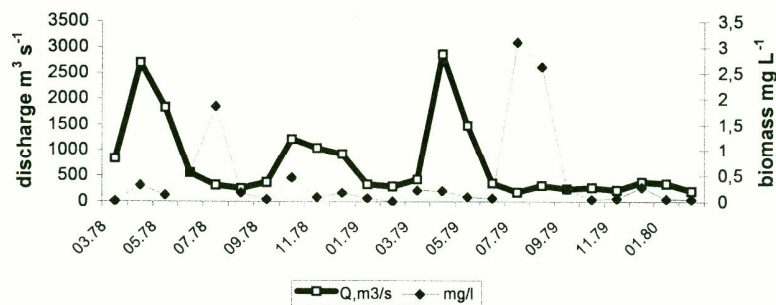


Figure 2. Dynamics of phytoplankton biomass mg l^{-1} and discharge of water m^3s^{-1} observed in Riga Reservoir according Druvietis (1999)

Cryptophyta, Bacillariophyta and Chlorophyta (Fig. 3).

Diatoms *Aulacoseira italica*, *A. italica* var. *tenuissima*, *Asterionella formosa*, Cryptophytes and Flagellates were dominated.

ter and sediment of the lower Daugava are mainly determined by the operation of the Riga HPP and by periodical inflow of brackish waters from the Riga Gulf and as well by intensity of hydrodynamic processes due to the impact of Riga city (Springe et al. 1999).

The hydrochemical composition features of wa-

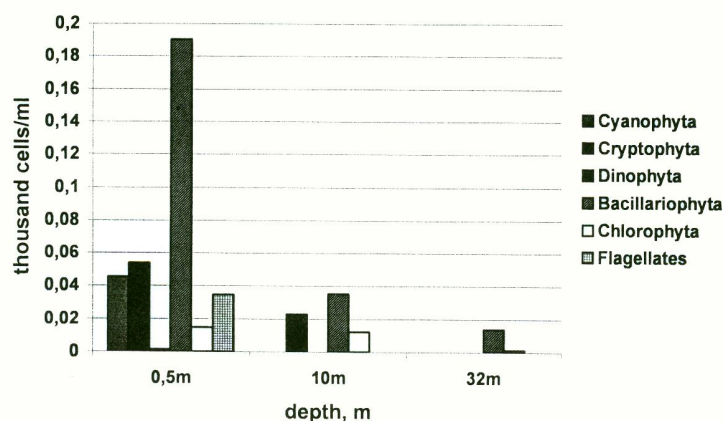


Fig. 3. Number of phytoplankton cells thousand cells/ml in water layer in Plavinu Reservoir

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