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Biodiversity: time for detailed local studies

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Biodiversity studies are not only listings of species in local, regional and worldwide faunas and floras. Infraspecific variation might appear an even more exciting field for biodiversity studies. It is common knowledge that species (especially those prospering ones) have large distribution areas. Individuals, demes and populations commonly inhabit distribution areas of their own species unevenly. Remarkable variation of environmental conditions is usually present inside these distribution areas, causing specific trends of adaptive evolution inside the same species, resulting in fixation of locally specific character states, and enforcing designation of various infraspecific units (biotypes, ecotypes, races, subspecies etc.) inside the species. Therefore, detailed ecological, morphological and molecular studies of local populations seem to be urgent for a better understanding of biodiversity and natural management. All this knowledge is summarized by systematics, and might also result in a critical revision of the taxonomic status of a species under analysis. The above statements are illustrated by an example of aphid biodiversity and systematics studies in Lithuania.

Key words: biodiversity, organismal diversity, infraspecific structure, *Aphis oenotherae*, Lithuania

INTRODUCTION

The common understanding of biodiversity is rather narrow, including only diversity within species, between species and that of ecosystems. Regionally, biodiversity is usually restricted as conduction of lists of local faunas and floras, with the main attitude to their conservation [1, 2]. The aim of this paper is to draw greater attention and encourage studies in the other fields of biodiversity in Lithuania, with the focus on infraspecific variation and emphasis on the complex studies of local populations. An example will be from the taxonomic studies of aphid species *Aphis oenotherae* Oestlund, 1887 (Hemiptera, Sternorrhyncha: Aphididae).

Biological diversity – concepts, definitions and common understanding

From the numerous definitions of the term Biological diversity, or simply Biodiversity [3], the most widely accepted seems to be the following: "Biological diversity or biodiversity is 'the variety of life', and refers collectively to variation at all levels of biological organization" [1]. This variety of life is expressed in a multiplicity of ways and is therefore divided between different key elements (building blocks) in some handbooks. For example, Gaston & Spicer [1] have presented three principle elements of biodiversity. Genetic diversity concerns nucleotides, genes, chromosomes, individuals and populations. Organismal diversity includes individuals, populations, infraspecific taxa, species, genera, families, phyla, and domains (kingdoms). Ecological diversity starts with populations, and continues with niches, habitats, ecosystems, landscapes, bioregions to biomes. Noticeably, population level is present in all building blocks (elements) of biodiversity. This is inevitable, because a population is an elementary unit of biological evolution; it is the smallest unit of life, being capable to evolve on its own [4]. Once having accepted the above-mentioned concept of biodiversity, one can argue that biology is the science of biodiversity, because biology is a scientific study of living organisms. Naturally, such a broad concern of biodiversity provokes different applications of the term, including the specialised and narrow ones. Article 2 of the Convention on Biological Diversity (CBD) depicts biodiversity as variability among living organisms from all ecosystems and the ecological complexes of which they are part, including diversity within species, between species and of ecosystems [5]. One can argue that such understanding excludes the genetic block of biodiversity. On the other hand, in the frame of the Convention on Biological Diversity (signed under the auspices of United Nations in Rio de Janeiro in 1992), biodiversity is concerned not on its own, but with the objective of "the conservation of biological diversity, the sustainable use of its components...” (Article 1 of CBD). Therefore, in the common knowledge, the term biodiversity is usually associated with the conservation and nature protection. This results in an evil practice when decision makers and budget keepers prefer funding the conservation of biodiversity (e.g., nature protection and sustainable development) rather than the study of biodiversity (e.g., taxonomy).

Of course, stocktaking of the local and worldwide species lists, arranging the checklists of faunas and floras is an important and primeval task concerning biodiversity studies, as is the protection of biodiversity. Nonetheless, deeper studies of local populations are of no less importance, especially when concerning the need of the conservation policy.

Biodiversity and systematics

When dealing with biodiversity, one should remember systematics – “the scientific study of the kinds and diversity of organisms and of any and all relationships among them” ([6]: 7). The following passage of Mayr [7] clearly explains the specific role of systematics in biodiversity studies. Systematics is unique among the biological sciences in its dominant concern with diversity. In all subdivisions of functional biology the main concern is with basic processes and mechanisms shared by all or most organisms. Hence the reductionist tendency at the cellular and molecular levels – the endeavor to reduce everything to common denominators, i.e. to penetrate to the universal building stones. Biology would become very one-sided if all biologists were to share this objective. It is the student of systematics who helps to restore the balance by his interest in and insistence on uniqueness. One of the major preoccupations of systematics is to determine, by comparison, what the unique properties of every species and higher taxon are. Another is to determine what properties certain taxa have in common with each other, and what the biological causes for the differences or shared characters are. Finally, it concerns itself with variation within taxa. Systematics helps to build proper classifications, and classification makes the organic diversity accessible to the other biological disciplines.

Systematics deals with populations, species, and higher taxa. No other branch of biology occupies itself in a similar manner with this level of integration in the organic world. It not only supplies urgently needed information about these levels but, more important, it cultivates a way of thinking, a way of approaching biological problems which is tremendously important for the balance and well-being of biology as a whole. There is a need for someone to stress the diversity of the living world, the most truly biological quality of organisms. However legitimate the study is of that which organisms have in common (much of it being the physics and chemistry of organisms), it is equally legitimate to study the unique characteristics of taxa at all levels down to the subspecies. Therefore, one can hardly discriminate between systematics and biodiversity, because systematics endeavors to order the rich diversity of the Living World (biodiversity) and to develop methods and principles to make this task possible**.** When supporting systematics, we support biodiversity studies. Naturally, biodiversity studies provide material for systematics and taxonomy.

An example from Lithuania – aphid biodiversity studies

When performing studies of aphid (Hemiptera, Sternorrhyncha: Aphididae) fauna in Lithuania, a new for the local fauna aphid species – *Aphis oenotherae* Oestlund, 1887 – has been found in 2002 in the surroundings of Vilnius [8]. Later on, *A. oenotherae* appeared to be widespread throughout Lithuania and was recorded in Belarus also [9]. The fact would remain of minor importance from the viewpoint of biodiversity studies (just one more country in Europe received one more aphid species already available in other European countries), unless the detailed studies of the Lithuanian clones of *A. oenotherae.*

A. oenotherae has been originally described from Minnesota (USA [10]), later reported as widespread over the other states of USA also [11]. It is supposed as being introduced to Europe at the end of the last century, and has already been reported from Italy [12], Spain [13], United Kingdom [14], Germany [15], southern Poland [16], also Czech Republic and Slovakia (Holman 2000, personal communication).

Patch [17] provided an experimental evidence for the Nearctic populations of *A. oenotherae* (at the time under the name of *A. sanborni*) being holocyclic species, alternating between *Ribes* spp. (currants and gooseberries) and *Epilobium* herbs (Onagraceae, the same plant family that the genus *Oenothera* belongs to). Therefore, Nearctic populations of *A. oenotherae* are supposed to be a holocyclic heteroecious species alternating between Ribes spp. and Onagraceous herbs. In Europe, *A. oenotherae* is known to be anholocyclic (having no bisexual reproduction), inhabiting various species of *Oenothera* in the field [18, 14]. Müller [15] has reported on successful transfer experiments to other herbaceous hosts of the plant family Onagraceaea (*Godetia*, *Gaura*, *Epilobium*, *Fuchsia*, *Chamaenerium* and *Clarkia*). Thus, the European populations of *A. oenotherae* are reported as being anholocyclic ones [18, 14], i. e. they reproduce by parthenogenesis only.

In Lithuania, we have found *A. oenotherae* heavily infesting *Oenothera biennis* and other species of the genus *Oenothera*. The aphids cause severe leaf roll and deformation of the stem and inflorescences of their hosts. Up to 80% of *Oenothera biennis* plants appear to be infested in some places. We failed to find *A. oenotherae* inhabiting *Epilobium*, *Chamaenerium* or other plants of the family Onagraceae in

Table. ***Aphis oenotherae* samples used for the morphological analysis when constructing the cladogram presented in Fig. 1. *Oe* = *Oenothera***

Abbreviated in Fig. 1	Label data	Label hostplant
Calif	Berkeley, California, USA, 1963.10.30	*Oe.* sp.
Cantabri	Comillas, Santander, Cantabria, Spain, 1981.05.24	*Oe biennis*
Colorado	Denver, Colorado, USA, 1925.04.12	*Oe. biennis*
Druskini	Druskininkai, Lithuania, 2002.08.02, No 8	*Oe casimiri*
Gliwice	Przechliebie, Gliwice, Poland, 2002.06.25, No 4	*Oe. subterminalis*
Grodno	Siabryn'-Ivjevsk, Grodno, Belorus', 2002.08.29, No 02-323	*Oe biennis*
Hawaii	Haleakala, Maui, Hawaii, 1999.04.02, No 7199	*Oe.* sp.
Katowice	Katowice, Poland, 1999.07.19, No	*Oe. flaemingina*
London	Chelsea, London, Great Britain, 1992.07.09, No 6106	*Oe. biennis gr.cult*
Lublin	Gnojno, Lublin, Poland, 2002.06.27, No 5	*Oe. oakesiana*
Manitoba	Spruce Woods, Manitoba, Canada, 1973.07.26, No V 75-26-7	*Oe. parviflora*
Moravia	Bzenec, Moravia, Czech Rep. 1984.07.04, No 18 726-7	*Oe. biennis*
NCarolin	Wrightsvile Beach, North Carolina, USA, 1964.04.25, No 262	*Oe.* sp.
Potsdam	Kleinmachnow- Potsdam, Germany 1988,06,08 No 20137	*Oe. biennis*
S. Korea	Pyomg Chang Kun, Bong Pyomg Myen, South Korea, 1999.06.03, No 99Ho652	*Oe. odorata*
Sandomie	Dunkowice, Sandomierz, Poland, 2000.07.21, No 52/20	*Oe biennis*
Sicily	Zafferana-Catania, Sicily, 1977.09.21	*Oe. stricta*
Siedlce	Siedlce, Poland, 2002.06.26, No 2	*Oe. brevihypanthialis*
Skirgisk	Skirgiskes, Vilnius region, Lithuania, 2002.10.09, No 02-108	*Oe biennis*
Slovakia	Chotin, Slovakia, 1984.06.25, No 18512+18520	*Oe biennis*
Swinoujs	Uznam, Swinoujscie, Poland, 1972,08,15, No 4013	*Oe biennis*
Toronto	Toronto Ravine, Ontario, Canada, 1968.08.31	*Oe. biennis*
Treviso	Salgareda, Treviso, Italy, 2000.09.04, No 87/20/582	*Oe. stucchii*
Valakamp	Valakampiai-Vilnius, Lithuania, 2002.07.05, No 02-73	*Oe biennis*
Wales	Mid Glamorgam, S. Wales, Great Britain, 1992.07	*Oe.* sp.

Lithuania in the field, despite special searches. In the pot cages, when having no possibility to colonize *Oenothera* plants, aphids fed on *Epilobium adenocaulon* for several parthenogenetic generations. Clonal aphids (both winged and apterous ones) refused to accept cultivated black and red currants as host plants. Winged males and apterous oviparous females appeared in the field and in the pot cages on the *Oenothera* plants from the beginning of October, and the winter eggs were laid on the rosette leaves of first-year *Oenothera* plants. Thus, *A. oenotherae* is monoecious holocyclic on *Oenothera* spp. (probably also on *Epilobium* spp.) in Lithuania. This is a new knowledge concerning the life cycle of this aphid species in Europe and Nearctics.

Morphologically, aphids of the genus *Aphis* collected on O*enothera biennis* in Belarus and Lithuania appeared to be indistinguishable from *A. oenotherae* samples from other places of the species distribution area: their antennae and siphunculi were short (relatively to body length) and marginal tubercles on the abdominal segments II–VI were absent [9]. The STATSOFT computer programme STATISTICA for WINDOWS (Kernel release 5.5 A) has been used for the cladistic analysis of 25 samples of *A. oenotherae* from 12 countries (apterous viviparous females) exploiting fifteen morphological characters. These were the lengths (in mm) of: antennal segments III–V; articular width of antennal segment III; the basal part of antennal segment VI; cauda; longest hair on antennal segment III; processus terminalis on antennal segment VI; siphunculus; second segment of hind tarsus; apical rostral segment; and maximum width of antennal segment III. The counts were of: hairs on cauda; additional hairs on the apical rostral segment; marginal tubercles on abdominal segments II–VI. Data concerning aphid samples are presented in Table. Cladistic analysis based on the above-listed morphological characters did not reveal any morphological specificity of Lithuanian samples (Fig. 1). Lithuanian samples appeared in two main separate clades.

Phylogenetic analysis of 34 samples of 8 species of the genus *Aphis* L. (including 10 samples of *A. oenotherae* from Lithuania, Poland and South Korea) based on maximum parsimony analysis of the studied region of nuclear sequence of EF 1α showed *A. oenotherae* to be well separated from the other European species of the subgenus *Bursaphis* of the genus *Aphis* (for details, see [19]). Again, Lithuanian samples appeared in separate clades, together with samples from S. Korea and Poland (Fig. 2).

For the present, Lithuanian populations of *A. oenotherae* do not seem to be much different in their morphology and sequences of the studied fragments of EF 1α when compared with those from S. Korea and Poland. Nonetheless, the specificity of their life cycle (holocycle and monoecy on *Oenothera* spp.) suggests them to be different from the Nearctic representatives of *A. oenotherae*. Although similar morphologically, Nearctic populations of *A. oenotherae* should be checked in their molecular features. This might result in the description of aphid species new for science.

CONCLUSIONS

1. Biodiversity studies are not only the stocktaking of the local and worldwide species and arranging the checklists of faunas and floras. Deeper studies of local populations (infraspecific and genetic diversity) are of equal importance.

2. Biological systematics and biodiversity are inseparable, because systematics endeavor to order the rich diversity of the Living World (biodiversity) and to develop methods and principles to make this task possible. Funding of systematic studies equals the support for biodiversity studies.

3. A complex studies of the Lithuanian populations of *A. oenotherae* (Hemiptera, Sternorhyncha, Aphididae) revealed them to be clearly distinct in their host specificity and life cycle (monoecious holocyclic on *Oenothera* spp.) from the European (anholocyclic on *Oenothera* spp) and Nearctic (heteroecious holocyclic alternating between *Ribes* spp. and Onagraceae, including *Oenothera* spp.) populations of the same species.

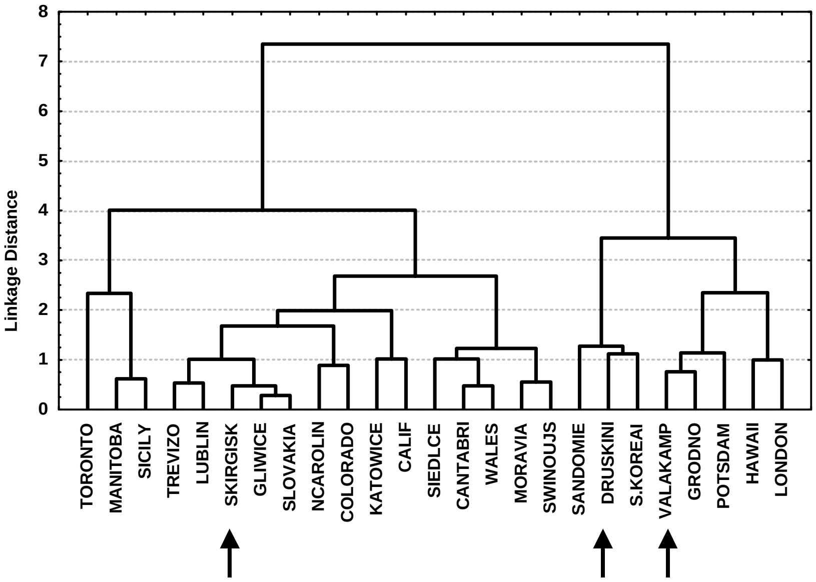

Fig. 1. Hierarchical tree plot (Euclidean distance, complete linkage) of 25 samples of *Aphis oenotherae* from 12 countries based on fifteen morphological characters of apterous viviparous females. Arrows indicate samples from Lithuania. Detailed information on aphid samples used is presented in Table

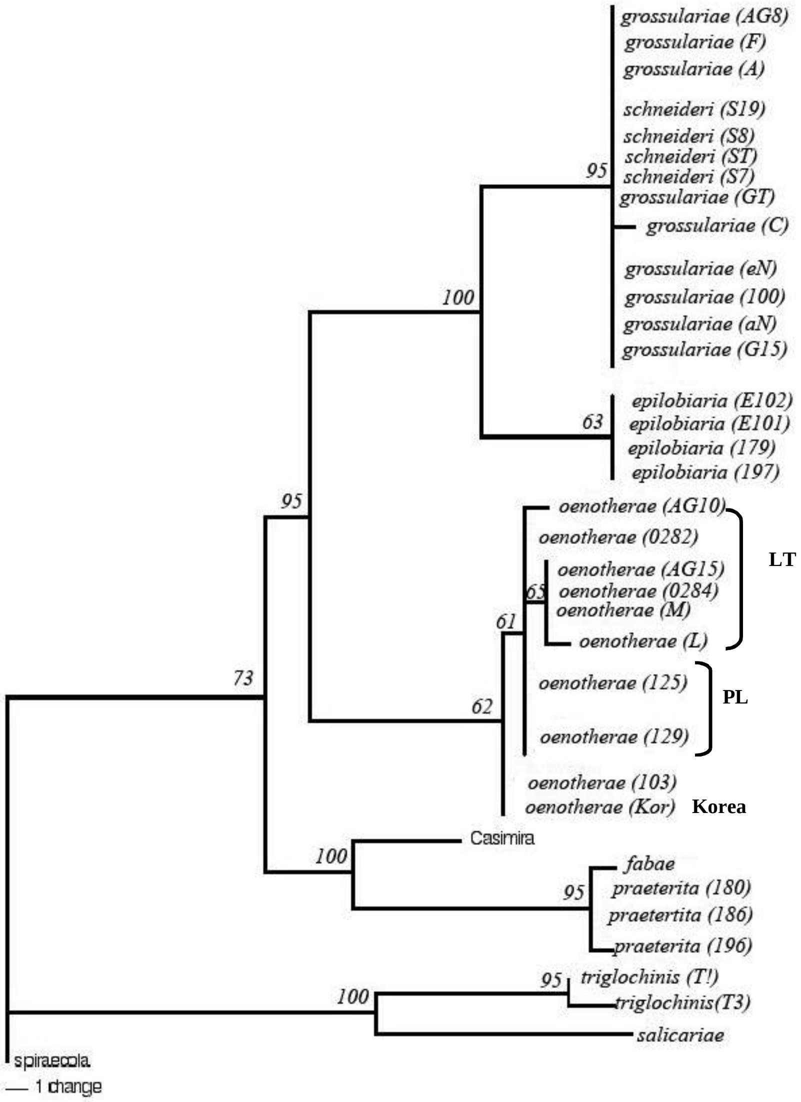

Fig. 2. Maximum parsimony tree based on the studied region of EF 1a in the genus *Aphis* L. Bootstrap support based on 1000 replicates is indicated for nodes with greater than 50% support. Samples of *A. oenotherae* from Lithuania are marked as LT, from Poland as PL, from South Korea as Korea (after [19])

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BIOĮVAIROVĖ: METAS VYKDYTI IŠSAMIUS LOKALIUS TYRIMUS

Santrauka

Bioįvairovė turi būti suvokiama ne vien tik kaip regioniniai ir viso pasaulio organizmų rūšių sąrašai. Vidurūšinė įvairovė yra ne mažiau svarbus bioįvairovės elementas. Rūšys užima nemažas teritorijas netolygiai jose pasiskirstydamos. Įvairios aplinkos sąlygos rūšies areale lemia skirtingas (kartais priešingas) tos rūšies populiacijų evoliucijos kryptis, atsiranda didelė įvairovė rūšių viduje: ekotipai, morfotipai, rasės, porūšiai ir pan.. Išsamūs vietinių populiacijų tyrimai tiesiog būtini siekiant geriau suvokti biologinę įvairovę bei ją racionaliai valdyti. Biologinė sistematika šiame kontekste tampa svarbiu teoriniu ir praktiniu bioįvairovės tyrimo įrankiu. Šie teiginiai straipsnyje iliustruojami pavyzdžiais apie amarų bioįvairovės ir sistematikos tyrimus Lietuvoje.