

Bibliographic and scientific overview of publications on intraspecific diversity of molluscs of Albania

Lulzime Dhora

University "Luigj Gurakuqi", Faculty of Natural Sciences, Study Centre for Shkodra Region
Waters, Rr. "Jeronim de Rada", Shkoder, ALBANIA

*Corresponding author: lulzime.dhora@unishk.edu.al

Abstract. This article provides a bibliographic and scientific overview of subspecies and forms in Albanian molluscs. Intraspecific diversity has to do with the levels of variation within species and is studied in individuals within the populations of a species or between populations. This article presents a profound overview of all existing published studies that we could find on the diversity in molluscs of Albania. The reviewed publications are presented in two groups: for subspecies with six published studies, as well as for forms, both in terms of polymorphism of individuals in population and population variation - with seven articles identified. The published knowledge of these phenomena is presented in every case in the form of a summary, extracted directly from the subject of the respective article, together with our own bibliographical indicia which facilitates researchers to use the correct published material that can be used from the reviewed studies. In the molluscs of Albania a high intraspecific diversity is ascertained, in terms of the diversity of subspecies and forms. Therefore, the reviewed publications can be used in terms of solving some problems of genetics, evolution, ecology, and zoogeography.

Key words: Species, subspecies, population, shell, variation, polymorphism, genetics, publication.

Introduction

Based mainly on the Convention on Biological Diversity of United Nations Organization (1992) as well as Burki et al. (2020), we set out below some definitions below for the purposes of the present article.

Biodiversity is the diversity of living organisms, at all levels, and also of terrestrial and aquatic ecosystems. It includes genetic diversity, species diversity and ecosystems diversity. Genetic diversity is seen in terms of genetic structural variation to the individuals inside of a population, and also between populations. Species diversity, otherwise also known as species richness, could be seen according the taxonomic hierarchy. Intraspecific diversity has to do with the levels

inside species, and is studied in individuals within respective populations, or between populations.

In animals there are two accepted levels of taxonomic hierarchy; these are subspecies and form/morph, while in plants and other living organisms this are some differences in this aspect (Phillips, 2020). Subspecies is a category which is listed taxonomically under species; usually it is isolated geographically. The subspecies refer to one from two or more populations of a species that change according to morphological (form) characteristics. The form is either a visual or behavioural difference between organisms of different populations of the same species (Ebach & Williams, 2009). Polymorphism is the occurrence of two or more different forms (morphs) in the

population of the same species. In the case of polymorphism can be find two or more possibilities of a trait in a gene (Phillips, 2020).

The purpose of this study is providing important bibliographic information about the intraspecific diversity of molluscs of Albania, presentation of scientific data published on subspecies and mollusc's forms in Albania. This is important because is related and make possible other more profound studies in the issues of genetics, evolution, ecology and zoogeography. Also this study enriches the theory of studies and help to understand and solve concrete scientific and practical problems, for the conservation of natural values, population's stability and their evolution.

Mollusc diversity is an important food source of fish and waterfowl in lake and mollusc species are intermediate hosts to parasites (Öktener & Georgiev, 2019). That's why the study of diversity and intraspecific diversity of molluscs is important for the entire ecological stability of the lake.

There are several cases where the researchers have published data about the presence of the same mollusc species in places with a considerable distance from each other, as for example in the study of Wohlberedt (1909) and Georgiev (2020) for the presence of *Caucasotachea vindobonensis* (Férussac, 1821) next to Shkodra Lake in Albania and in the area of Matnitsa River in Bulgaria. In such cases it would have been interesting to compare the forms and subspecies of each population and to study the characteristics of polymorphism in each case.

Materials and Methods

The search to find publications on intraspecific diversity of molluscs of Albania was realized mainly by focusing on Dhora & Welter-Schultes (1996a, 1996b), Dhora (2016), Dhora (2020), Dhora (2021), but also in some other publications. The form has been considered only for mollusc's shells, because only this aspect has been studied by the respective authors.

The pertinent records were extracted by studying the entire content of the respective articles, and not only of the abstract in question.

Results and Discussion

Based on issues covered in the scientific studies here, the listed publications are divided in two groups: firstly, on the diversity of sub-species

and diversity of forms, and secondly on polymorphism of individuals in populations and population variation.

Diversity of subspecies

Dhora & Welter-Schultes (1996a, 1996b), Dhora & Dhora (2019): Diversity of subspecies represents genetic diversity, and this is quite expressed in the molluscs of Albania. Based on Dhora & Welter-Schultes (1996a), where also the subspecies level was studied, is concluded that for 292 species 220 subspecies were recorded. About 80% of these numbers of species and subspecies belong to terrestrial molluscs; in turn, about 80% of the number of subspecies of this group belongs to 6 families: Clausiliidae with 82 subspecies, Helicidae with 30, Hygromiidae with 21 and the remaining belonging to Cochlostomatidae, Enidae, and Zonitidae.

Bank (2011): In this publication, realized in the frame of Fauna Europaea Project, a checklist of terrestrial and freshwater molluscs of 8 Balkan countries is presented: Albania, Bosnia-Herzegovina, Croatia, North Macedonia, Slovenia, Serbia, Kosovo and Montenegro. In the totality of the species of this list hosted by Albania, there are 154 subspecies, of which 22 belong to the genus *Cochlostoma*.

Nordsieck (2009): In this article is published a revised list of species of the genus *Montenegrina* O. Boettger 1877. The relevant taxonomic characters for species classification, and also the differences from the previous classification, are provided. Descriptions are given for new species and subspecies: *Montenegrina dedovi*, *M. dedovi lacmosensis*, *M. perstriata macrovoensis*, *M. perstriata tenebrosa* and *M. skipetarica robusta*.

Dhora (2010): Genus *Montenegrina* O. Boettger 1877, with its distribution of about 40,000 km², includes a few surface areas in Montenegro, Albania, the western part of North Macedonia and Greek Epirus, and could be considered to representing the surfaces with the highest number of species per genus in the Clausiliidae family.

The distribution surface for this genus with 22 species and 72 subspecies consists of hotspots, i.e. important centers of fauna processing of one from most important genera of Clausiliidae family.

From 22 species of genus *Montenegrina*, 13 (or 59%) are found in Albania and from 72 subspecies, 39 subspecies are found in Albania and these belong

to 9 species. In Albania, all represent the two subspecies of *Montenegrina helvola* and *Montenegrina laxa*. Potentially in Albania one could also find species of genus *Montenegrina*, which are found in countries beyond/ neighboring Albania, and even next to the Albanian border. Albania represents the dominant part in the area covered by the genus and hosts the highest number of species and subspecies.

Diversity of forms, polymorphism of individuals in population and population variation

Hesse (1928): Here, the author has written on 17 exemplars of *Theodoxus fluviatilis* (Linne, 1758) found in Ohrid Lake. For 5 of them, he sets out that are of form *trifasciata* Mke, that is characterized by three longitudinal strips over the shell; the others being of form *scutariensis* Walderd, with purple-brown zigzag lines, and form *maculata* Villa with this same decor but interrupted with clear white spots.

Dhora (2004a): Here, the collections of *Theodoxus fluviatilis* (Linne, 1758) are edited, which are in the scientific fund of the laboratory of zoology of Shkodra University "Luigj Gurakuqi" and the shell forms of different populations are studied in this publication. In there, 11 locations where *Theodoxus fluviatilis* is found in Albania are described. The most typical forms of the shell decors of these populations are revealed, and this phenomenon is related to the biotopes' influences where they live, with their respective adaptations for survival.

In the study of Falkner (1990), the form typical is presented as being more widespread in Central Europe, with a network often combined with strips. This form has been as found to be predominant in the populations in many studied waters which belong to the hydrological network of Drin River.

The form *scutariensis* Walderdorff – with parallel zigzag lines, has been found only in lakes and Buna River.

The network form *reticulata* Dhora has been found dominant in Kendalla population, may be because of the water salinity there.

The form *maculata* Villa has been found in Kendalla too.

In Zejmen and Vukaj, in cold springs there are populations that are almost uniform and may be isolated, and forms almost black with a few

white spots that may be can be grouped in *dalmaticus* Partsch, known also to be present in lakes but also across a wide territory.

In any exemplar of Zejmen, the long spots – in a complex form of 2-4 strips along spirals – are evident, which approaches with form *trifasciata* Mke, presented by Hesse (1928) for Ohrid Lake.

Dhora (1996): In the South coast of Buna River, in the estuary from the lake. A muddy shore with debris of the plant *Ceratophyllum demersum* L. and further shallow water, covered by plants *Trapa natans* and *Nuphar luteum*.

On the mud of the coast and also in the water, between vegetation, are found *Viviparus mamillatus* (Küster, 1852) with density 40 per square meter. All individuals were adult. Extreme measures of the shells, for two exemplars, were 52 mm: 38 mm and 37 mm: 26 mm. The shells of collected exemplars generally were tanned because of the environment's strong decomposition processes. Many forms the shells were covered by bryozoans and algae, which obstructed the strips' view. As an interesting case we single out an exemplar where the shell, with measures of 42 mm: 30 mm, had a colour similar to yellow, with very clear strips.

In the western coast, next to Tarabosh mountain, near Shiroka village. The plot, at the bottom of the water, is soft. Submerged vegetation is quite dense, composed mainly by *Ceratophyllum demersum*, *Potamogeton* sp. and *Myriophyllum* sp. During shells study it was ascertained their polymorphism. In 5 exemplars with shells almost similar in measures, about 28 mm: 23 mm, have been noticed with different appearances of the shells: shell with three highlighted strips; shell with three non-clear strips; shells where two upper strips were joined; shells with one bright strip in the middle of the spirals and with brown parts up and down; and shells with a horn colour, without strips and shadows.

Wohlberedt (1909): The author writes that *Caucasotachea vindobonensis* (Férussac, 1821) has been collected in Shkodra next to the lake – and that it is suspected to be of *costulata* form.

Dhora (1985): The polymorphism of individuals and variation of populations is noticed, better than in every other group, in the molluscs of genus *Cepaea*. In this article three populations of the snail *Cepaea vindobonensis* (Férussac, 1821) are described, found in the Shkodra district.

The population of Shirq forest is composed by poplar, *Populus alba* and *Populus canadensis*, mixed with white willow *Salix alba* and herbaceous plants. Among 90 collected snails are distinguished by 18 shell variants. The most important ones are: white-in-yellow, without strips; yellow with 4 strips; white-in-yellow with 3 thick strips; white-in-yellow with 5 visible strips, where two lower strips are thicker and separated; and white-in-yellow with light brown strips. In this population the shells with yellow gradients prevail, with 5 strips.

The population in Velipoja coastal plant formation, with a mixture of woods white poplar *Populus alba*, white willow *Salix alba* and wild pine *Pinus halepensis*, garland thorn *Paliurus aculeatus* and coastal herbaceous vegetation. 12 individuals of snail *Cepaea vindobonensis* were found where the shells are with a white background, with 5 clear strips, and where the two ones above are thin.

The population in the Ragami forest in Bajza is composed by Macedonian oak *Quercus trojana*, flowering ash *Fraxinus ornus*, garland thorn *Paliurus aculeatus* and herbaceous vegetation. 10 individuals of the snail *Cepaea vindobonensis* were found, with a white-in-yellow shell and in the majority the middle strip (third one) is very visible.

These populations in forests are considered interesting in the study of Ozgo & Komorowski (2009).

Dhora (1994): In this article the population of *Theba pisana* (Müller, 1774) of Velipoja is covered. The shells of 940 adult individuals, clinging on the sandy plants in Velipoja: *Eryngium maritimum*, *Echinophora spinosa*, *Paliurus aquileatus*, *Scolymus hispanicus*, *Echium vulgare*, *Aristolochia clematitis*, *Rubus ulmifolius*, *Verbascum phlomoides*, *Arundo plinii*, *Pinus pinea*, *Scrophularia* sp., etc. are covered.

The shell background is often white, but sometimes with a yellow shade. The decor is polymorph and is represented by set of stripes or designs, which in some cases are joined or reduced.

From 940 specimens, 618 or 66% have four sets of strips, with a number that varies. The last set of strips is more stable than others, and in the majority of cases is represented by a single thick strip.

In 26% of the specimens some strips are in the form of ears. Almost in half of the specimens, the number of strips decreases, while in 122 specimens the number of strips decreases from 5 to 2, 1 and 0.

This fact makes it more difficult to draw conclusions about the phenomenon in the population, but it shows that the reduction could have occurred in several ways. The specimens without strips and those with one strip (the fourth) have a maximal height of shell 2 mm or smaller.

Dhora (2004b): In this study the presence of polymorphism of shells and variation of this polymorphism in different populations of *Eobania vermiculata* (Müller, 1774) in Albania is set out. The work's results are presented in the following according to the occurrences:

In Shkodra, in the city park, clinging at the height behind the trunks of trees, 6 individuals of *Eobania vermiculata* were found, with a shell that is completely white.

In Velipoja, in the plants in the beach area and between buildings, 5 individuals of *Eobania vermiculata* were found all with a cream background and with four strips.

In Tirana, in the garden in front of Natural Sciences Museum, in the branches of an orange tree, 16 shells of snail *Eobania vermiculata* were collected; all shells were with an almost milk colour. 3 shells had a decor of 4 strips, 10 had light strips, and 3 were without strips.

In Tirana, in the zoo, a large number of individuals of *Eobania vermiculata* were found clinging behind decorative tree trunks in the garden. All individuals had a white shell.

At Kavaja Rock, collected shells of *Eobania vermiculata* are with almost equal shells but with a phenotypic decor structure: 10 white without strips, 12 individuals with 4 strips in the last spiral; the two above constructed with thick interrupted signs, and one individual with this decor but a lighter one.

In Divjaka, a pine forest in the seacoast with a sub-forest of shrubs and herbs. 13 shells of *Eobania vermiculata* were found with a white background. 7 from them are white, without strips, 3 shells with clear strips, where the first and second strips (in fact 2 + 3) are thicker, and 3 as above but lighter.

In Vlora, next to the pine forest in the old beach. The vegetation of *Eryngium*, *Datura*, *Xanthium*, *Amaralidaceae*, etc. In total 26 adult individuals were found: 3 white individuals, 5 individuals with 4 strips, strips 2 and 3 being joined; as well as 18 individuals with a cream background, with a pale decor, often almost no visible.

In Saranda city, 35 individuals of *Eobania vermiculata* were found clinging to the plant *Nerium oleander*, all with a very pale décor so that in the first view the shells seem almost white.

Conclusions

Already we know the phenomenon the high intraspecific diversity, and thus the diversity of subspecies and forms, of molluscs of Albania. The content of this phenomenon is presented in every case in the form of a summary, extracted directly from the subject of the reviewed articles, together with own bibliographical indicia, which facilitates researchers to use the correct published material that can be used in their studies.

In the bibliography 13 publications which have covered the intraspecific diversity in molluscs of Albania are listed, of which 6 treat subspecies, while 7 treat forms, the phenomenon of polymorphism of individual shells in population, and also the variation of this phenomenon in different populations.

I believe that the presentation of this article in the form of a detailed bibliography adds value to the article. As a prepared material, it is available to researchers in the field of genetics, evolution, ecology and also the practical and managerial problems. Also this study could serve as an experience for the researchers from other countries.

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