ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)

ИЗДАНИЕ НА ПРИРОДОНАУЧНИОТ МУЗЕЈ НА РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА

BOTIM I MUZEUT TË SHKENCAVE DE NATYRËS E REPUBLIKËS SE MAQEDONISE SË VERIUT

ACTA

MUSEI MACEDONICI SCIENTIARUM NATURALIUM

Volume 23 2020 Issue 1

Skopje—Скопје—Shkup

Издавач:
Национална установа „Природонаучен музеј на Република Северна Македонија“
Ni “Muzeu i shkencave natyrore i Republikes se Maqedonisë së veriut”

Издавањето на ова списание е целосно финансирано од Министерството за култура на Република Северна Македонија.
Botimi i kësaj reviste është tërësisht i finsnsuar nga Ministria e cultures së Maqedonisë së veruit.

Фотографија на насловната страна (од лево на десно): *Orobanche flava (*Фото: З. Николов); *Cucujus cinnaberinus*, долу (Фото: Olli Pihlajamaa); *Aethionema arabicum*, горе (Фото: А. Теофиловски); *Dianthus pallidiflorus* (Фото: З. Николов).

Дизајн и техничка подготовка: Божин Божиноски

Печати:

Тираж: 200

Интернет страница на електронската верзија: acta.musmacscinat.mk

Адреса на издавачот:
Природонаучен музеј на
Република Северна Македонија
Булевар „Илинден“, 86
1000 Скопје

Adresa e botueist:
Muzeu i shkencave natyrore i
Republikes se Maqedonisë së veriut
Bulevardi “Ilinden”, 86
1000, Shkup

Publisher:
National Institution "Natural History Museum of the Republic of North Macedonia"

The publication of this volume was fully supported by the Ministry of Culture of the Republic of North Macedonia.

Photos on the cover page (from left to right): *Orobanche flava* (Photo: Z. Nikolov); *Cucujus cinnaber*inus, down (Photo: Olli Pihlajamaa); *Aethionema arabicum*, above (Photo: A. Teofilovski); *Dianthus pallidiflorus* (Photo: Z. Nikolov).

Design and technical preparation: Božin Božinoski

Print:

Copies: 200

Web site of the electronic version: acta.musmacscinat.mk

Publisher's address:
Natural History Museum of the Republic of North Macedonia
Boulevard Ilinden, 86
1000 Skopje, Republic of North Macedonia

CONTENTS

UDK: 599.742.2-147.14.087.1(497.7)
Received: 06.10.2020
Accepted: 01.11.2020
Original scientific paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 7-18
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

Morphometric analysis of recent brown bears (*Ursus arctos* Linnaeus, 1758) from Republic of North Macedonia

Biljana Garevska

Natural History Museum of the Republic of North Macedonia, Blvd. Ilinden 86, 1000 Skopje, North Macedonia,
e-mail: b.garevska@musmacscinat.mk

Abstract

The research on morphology and dimensions of the skulls of recent brown bear (Ursus arctos Linnaeus, 1758) showed the morphological and metric variability between intraspecific populations as well as the determination of sexual dimorphism. For the purpose of this study were analyzed 18 recent skulls from the territory of the Republic of North Macedonia and 1 recent skull of the territory of the Republic of Bulgaria. Up to date, published records indicated that the size of the bears from southern part of Europe were smaller, compared to the species of other parts of Europe. For this purpose, were analyzed the bones of the skull and was made the complete description of dentation. The sexual dimorphism according to the morphometry of ectoorbital bone and canines, were studied and confirmed too. Herein, is set the hypothesis concerning the cannines differences between male and female individuals too. Furthermore, was determined that the studded brown bear population belongs to the typical Ursus arctos. In future, the presented tables and forms will contribute to further studies to compare the skulls of bears from Republic of North Macedonia, the Balkans and beyond.

Key words: Skull morphometry, Holocene bears, sex dimorphism.

Introduction

This paper consists part of results obtained in the master thesis „Comparative morphometric characteristics of cave bear (*Ursus spelaeus* Rosenmüller, 1794) and brown bears (*Ursus arctos* Linnaeus, 1758) of Macedonia“. Herein, will point out only the results of metric analysis of recent bears which are in correlation with age and sex dimorphism. In general, Ursidae family represent a small group of 8 species that are classified according to arctoid characteristics and it is believed that their evolution began 15-20 million years ago (Thenius, 1959). Brown bears in south part of Europe origin from late Pleistocene (Spassov, 2003).

Concerning its species variability in the morphology of the skull and teeth makes it difficult to compare the description of the species, especially because of strong relationship between canines (Kurten, 1953). The great confusion in taxonomy of brown bear is mainly because of intraspecific differences such as color of the fur, form of the skull, form of the teeth and growth (Erdbrink, 1953). This refers to the Balkan species as well where Spassov (1990, 2003) and Spassov et al. (2015) proved that many brown bears have a “golden” coat color especially evident in females individual. It is also noted that some activities concerning non-native bear migration from different regions were evident in the past, where brown bears from different habitats/ regions were introduced in new habitats (Misumachi et al., 2020). Population of Balkan brown bears are fragmented, so the south line of bears is adapted on high mountains (Spassov, 2003) and morphologically and genetically differ from north-west European populations and are closer to its Mediterranean populations (Taberlet et Bouvet, 1994; Misumachi et al., 2020).

The study of the skull morphology and morphometry of the brown bear from Republic of North Macedonia and the Balkans in general are important because recent genetic studies, show that the southern European bear populations from the Apennine to the Balkan Peninsula area, differs from the population of more northern Europe (Misumachi et al., 2020). In this respect, the manuscript in question is of interest and provides some useful information, for example on sexual dimorphism, which vary in the different geographical groups of brown bear

(Baryshnikov et al. 2003). According to Baryshnikov et al. (2003) sexual dimorphism is not so expressed in canines at recent bears, raise the question to set the following hypothesis: if their width is greater than 14 mm, it belongs to a male, i.e. if it is less than 13 mm it is a female.

Bearing in mind all this features, the aim of this paper is to provide information about anatomical differences in the skull and teeth which is in connection with the sex dimorphism within *Ursus arctos* species from Republic of North Macedonia and other brown bears from Europe.

Material and methods

The research is based on the morphology and measurement of the separate bones of the skull and teeth of recent bears. Used measurement methods are according to: Couturier (1954) and Von Den Driesch (1976). The nomenclature of the elements of dentation are according to the methods of Dufour (1989) and Baryshnikov et al. (2003, 2007). Methods and principles in zoology as taxonomic procedure and steps in identification used in this study are according to the recommendations from Mayr et al. (1953). The taxonomy determination is according to Grey (1825 in Gromova, 1962). Measurement was done with a shaft with an accuracy of 0.02 mm, the results are rounded to 1 mm for values greater than 50 mm and a tenth of a millimeter for values less than 50 mm. The performed analysis are based on the research carried out on 18 brown bears *Ursus arctos* skulls originating from various localities of Republic of North Macedonia (stored at National Museum of Natural History – Skopje and Faculty of Forest Sciences - Skopje) and 1 found in a cave from Mountain Pirin – Bulgaria (stored at National Museum of Natural History – Sofia). Gained results are then compared with species of the genus *Ursus* found across Europe.

Results

The general features of the brown bear skulls, studied in this paper are listed in Tab. 1. Herein, the obtained morphological similarities relevant for this study are presented. The largest morphological differences occur in the third upper incisor, which is well developed at recent specimens. Greatest feature in the teeth derives from the upper third premolars present in all studied specimens in the form of a tooth or alveolus, which indicates their presence. Tab. 2 contains the metrical results of studied skulls. Furthermore, the analyzes of the obtained parameters (Tab. 2) are compared according to recommendations by Baryshnikov et al. (2003) and Couturier (1954) and further the main measured ratios are pointed out in the Figs.1,2.

Table 1. Main characteristics of *Ursus arctos.* Abbreviations: I^1, I^2, I^3 - upper incisors ce; $p^{1,2,3,4}$ - upper premolars; C - canines; M^1, M^2 - upper molars; I_1, I_2, I_3 - lower incisors; $P_{1,2,3,4}$ - lower premolars; M^1, M^2, M^3 - lower molars.

	Ursus arctos
skull	Completely developed
glabella	Absent
I^1	Mid developed
I^2	Mid developed
I^3	Caniniform
Upper C	Mid developed mesial furrow
$P^{1,2,3}$	present / primitivity
P^4	Paracon without ridges, placement of deuterocon posterior without accessory tubercles
M^1	4 tubercles, poorly developed parastyl and metastyl without accessory tubercles
M^2	4 tubercles without accessory tubercles, the posterior field is not grooved
Lower jaw	Obliquely placed coronoid outgrowth
I_1	Mesial worn out
I_2	Mesial worn out
I_3	Caniniform
Lower C	Poorly developed anterior and posterior boundary line of the surface
$P_{1,2,3}$	present / primitivity
P_4	Paraconid without secondary tubercles
M_1	Double lingual tubercles (metaconid and entoconid) without secondary tubercles central to the tooth
M_2	Double lingual tubercles (metaconid and entoconid) without secondary tubercles central to the tooth
M_3	Ovoid form with smooth surface
Cement	Absent

Table 2. Comparative cranial dimensions of brown bear (*Ursus arctos*) from Republic of North Macedonia. Used abbreviations: TD – Total length – incisive to sagittal crest; EC – ectoorbital width; KD – Condylobasal length – incisive to condyles occipitalis; BD – Basal length – incisive to foramen magnum; ZG – Zygomatic width.

***–Ursus arctos* (mm)**											
Specimen	**TD**	**KD**	**BD**	**ZG**	**EC**	**KD / TD**	**BD / TD**	**ZG / TD**	**EC / TD**	**ZG / EC**	♂ / ♀
Мк 1	284	268	250	152	76	0.94	0.88	0.535	0.267	0.5	♀
Мк 15	322	314	294	184	92.5	0.97	0.91	0.554	0.287	0.502	♀
Мк 17	315	301	287	166	90	0.95	0.91	0.526	0.285	0.542	♀
Мк 19	254	/	/	186	99	/	/	/	/	0.532	♀
Мк 21	308	299	281	178	88	0.97	0.91	0.577	0.285	0.494	♀
Мк 23	252	246	229	143	62	0.97	0.9	0.567	0.246	0.433	♀
Мк 27	253	235	223	137	75	0.92	0.88	0.541	0.296	0.547	♀
Мк 29	256	229	222	146	78	0.89	0.86	0.57	0.304	0.534	♀
Bg 35	321	303.5	286	188	92.5	0.94	0.89	0.585	0.288	0.492	♀
Мк 3	307	290	290	182	97.5	0.94	0.94	0.592	0.317	0.535	♂
Мк 5	290	278	262	167	91.5	0.95	0.9	0.575	0.315	0.547	♂
Мк 7	320	273	250	212	109	0.85	0.78	0.662	0.34	0.514	♂
Мк 9	332	330	308	206	114	0.99	0.92	0.62	0.343	0.553	♂
Мк 11	357	334	313	219	111	0.93	0.87	0.613	0.31	0.506	♂
Мк 13	296	280	258	187	111	0.94	0.87	0.631	0.357	0.587	♂
Мк 20	260	/	/	225	122	/	/	/	/	0.542	♂
Мк 25	302	267	263	175	97	0.88	0.87	0.579	0.321	0.554	♂
Мк 31	380	335	321	232	126	0.88	0.84	0.552	0.331	0.543	♂
Мк 33	357	321	301	210	128	0.89	0.84	0.588	0.358	0.609	♂
SD	39.1	36.4	32.5	28.2	20.4	/	/	/	/	/	/

According to the ratio of the width of the EC/TD (Tab. 2) for determining the sexual dimorphism as the maximum value is 0.304 mm with a ratio in the range of 0.25 - 0.30 mm for female individuals of the species *Ursus arctos* (Fig. 1a). The ectoorbital/total length ratio (Tab. 2) for determining sexual dimorphism has a maximum value of 0.358 mm with a range of 0.31 - 0.36 for male *Ursus arctos* (Fig. 1b). The ratio of zygomatic arches width/forehead width for female *Ursus arctos* has a range of 0.42 - 0.54 mm (Fig. 1c) with a maximum value of 0.547 mm. The ratio ZG/EC for male *Ursus arctos* has a range of 0.5 - 0.61 mm (Fig. 1d) with a maximum value of 0.609 mm.

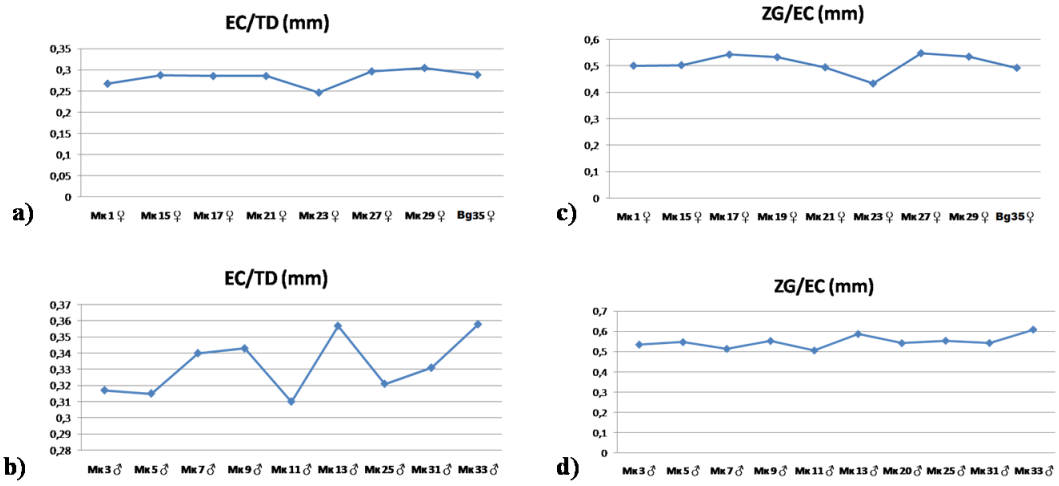

Figure 1. a) Correlation of ectoorbital width/total length (EC/TD) of female bears (*Ursus arctos*); b) Correlation ectoorbital width/total length (EC/TD) at male bears; c) Correlation width of zygomatic arch/ectoorbital width (ZG/EC) for female bears; d) Correlation zygomatic arch/ectoorbital width (ZG/EC) for male bears.

Table 3. Metrical results of mandibles of brown bear (*Ursus arctos*). Used abbreviations: RM – Length of lower jaw Incisive to proc. angularis; Hma/Hmb – Height of lower jaw - under P_4 and M_2; PMa – Length P_4 и M_3; DD – Diastema C - P_4; AC – Height of lower jaw - proc. angulare to proc. coronoideus; CPa - Length C – P_4; CM - Length C - M^2; CMa - Length C - M_3; MC – Distance between mandibular condyles; CCb – External width C - C.

***Ursus arctos* (mm)**													
Specimen	RM	H ma	Hm b	PMa	DD	AC	CP a	CM a	MC	CC b	AC / RM	AC / Hmb	♂ / ♀
Мк 2	205	36	33	77	16	78	62	123	129	35	0.38	0.423	♀
Мк 16	232	42	40	77	33	90	73	140	160	43	0.387	0.444	♀
Мк 18	224	39	35	86	19	89	69	141	144	43	0.397	0.393	♀
Мк 22	220	40	38	77	21	36	67	131	0	0	0.163	1.055	♀
Мк 24	187	33	31	71	17	80	51	115	123	37	0.427	0.387	♀
Мк 28	180	30	28	75	17	70	55	119	122	37	0.388	0.4	♀
Мк 30	190	36	33	79	19	74	58	126	126	42	0.389	0.445	♀
Bg 36	250	44	45	78,5	0	98	71	132	155	44	0.392	0.459	♀
Мк 26	208	37	35	69	25	87	67	129	142	39	0.418	0.402	♂
Мк 32	259	51	51	72	35	116	81	143	184	55	0.447	0.439	♂
Мк 34	244	45	46	71	35	102	75	138	175	42	0.418	0.451	♂
Мк 4	208	36	35	72	0	86	65	127	147	36	0.413	0.406	♂
Мк 6	207	41	41	70	26	86	66	128	134	37	0.415	0.476	♂
Мк 8	236	50	51	82	18	117	76	147	168	45	0.495	0.435	♂
Мк 10	245	49	51	82	22	115	79	146	169	47	0.469	0.443	♂
Мк 12	247	46	44	76	32	106	76	142	189	47	0.429	0.415	♂
SD	23.9	6.3	7.7	5.3	7.4	20	8.5	10	21.9	5.1	/	/	/

In Tab. 3, are presented the relevant measurements for comparative analyzes. The calculated ratio AC/RM (Tab. 3, Fig. 2) has a range of 0.38-0.5 abrupt drop of the curve in the lower jaw Mk 22 which is a result of present deformities in its development, which was obvious before measuring.

The calculated ratio AC/Hmb (Tab.3, Fig. 3) has a range of 0.4–0.55 mm. This sudden growth of the curve of the lower jaw Mk 22 is a result of present deformities in the development of the jaw. The lower jaw of the mandibulae Mk 32 (Tab. 3) has maximum values of all measured dimensions, i.e. deviates from other measurements for *Ursus arctos*. Sex dimorphism according to the ratios presented in Tab. 3 coincides with the one determined according to ratios in Tab. 2. Only the jaw Mk 24 has larger values.

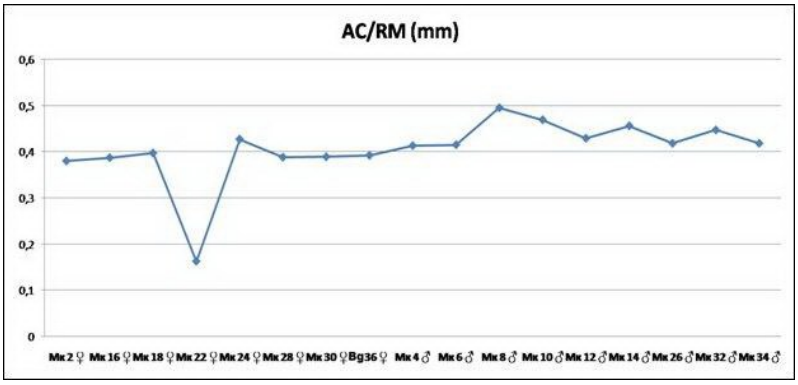

Figure 2. Correlation height of lower jaw - proc. angulare to proc. Coronoideus/length of lower jaw Incisive to proc. Angularis (AC/RM).

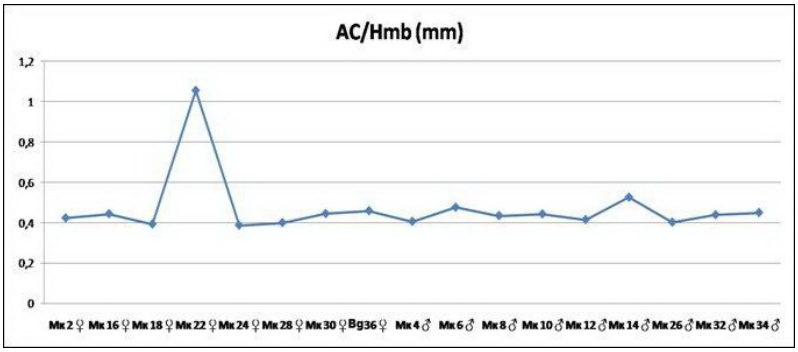

Figure 3. Correlation height of lower jaw - proc. angulare to proc. Coronoideus/height of lower jaw - under M_2 (AC/Hmb).

Table. 4: Metrical results of the teeth at brown bear (*Ursus arctos*). Used abbreviations: C sup. – upper canines; P^4 – fourth upper premolar; M^1 – first upper molar; M^2 – second upper molar; L – length; W - Width.

Specimen	*Ursus arctos* (mm)							
	C sup.		P^4		M^1		M^2	
	L	W	L	W	L	W	L	W
Мк 1	18.22	11.32	15.60	10.68	22.28	16.76	32.30	16.22
Мк 3	17.06	14.40	14.06	9.98	21.68	14.80	31.00	16.44
Мк 5	21.40	14.38	16.46	11.72	22.40	16.70	31.72	16.48
Мк 7	29.20	17.12	16.60	13.88	22.42	16.88	35.10	18.58
Мк 9	26.20	16.02	15.60	11.28	21.16	18.60	37.24	18.54
Мк 11	24.52	16,58	14.06	11.88	21.60	16.11	35.80	17.86
Мк 13	24.1	14.4	11.1	8.9	17.5	13.4	27.8	16.0
Мк 15	21.04	13.24	14.94	11.42	22.00	15.26	37.64	17.52
Мк 17	21.12	13.08	16.54	9.96	21.58	16.50	39.00	18.50
Мк 19	/	/	15.44	10.58	21.52	15.05	32.86	16.96
Мк 20	/	/	/	/	21.86	16.88	35.74	18.52
Мк 21	24.14	15.16	12.32	10.04	20.86	14.02	34.28	19.06
Мк 23	18.10	11.42	14.92	11.18	20.40	14.92	31.74	16.46
Мк 25	20.88	14.04	13.80	11.58	19.42	16.54	31.68	17.14
Мк 27	16.60	11.18	15.78	9.76	20.38	14.76	33.24	16.42
Мк 29	20.84	13.44	16.68	13.48	24.76	17.56	35.30	18.78
Мк 31	22.56	16.12	16.34	12.44	20.68	15.12	34.88	17.00
Мк 33	22.04	15.24	13.58	10.04	20.24	14.66	35.54	15.32
Bg35	19.54	12.48	15.08	12.44	22.32	12.62	21.68	10.18

The measurements present in Tab. 4, were used to test the settled hypothesis for male and female units according dimensions of upper canines. At the Tbls. 4 and 5 are listed measurements of upper and lower the teeth that will potentially allow to further set the taxonomic status of the researched species.

Table 5. Metrical results of teeth of brown bear (*Ursus arctos*). Used abbreviations: C inf. – lower canines; P^4 – fourth lower premolar; M^1 – first lower molar; M^2 – second lower molar; M^3 – third lower molar; L – length; W – Width.

Specimen	***Ursus arctos* (mm)**									
	C inf.		**P_4**		**M_1**		**M_2**		**M_3**	
	L	**W**	**L**	**W**	**L**	**W**	**L**	**W**	**L**	**W**
Мк 2	/	/	/	/	/	/	/	/	/	/
Мк 4	16.26	13.02	11.48	6.68	21.50	7.24	22.52	12.48	17.70	12.24
Мк 6	19.36	13.94	12.28	6.14	21.60	9.46	22.60	14.06	15.88	13.44
Мк 8	28.10	15.04	14.06	7.84	24.36	12.02	24.88	15.74	19.60	14.64
Мк 10	20.00	12.34	14.50	6.94	23.00	12.04	25.68	16.28	20.60	16.24
Мк 12	22.20	12.42	12.14	5.88	21.52	10.14	23/34	14.88	19.00	15.04
Мк 16	23.78	11.50	10.94	5.98	21.70	9.98	23.78	12.06	19.86	13.64
Мк 18	23.50	15.10	12.90	7.00	22.80	11.88	25.10	15.20	22.40	12.72
Мк 22	24.06	17.20	13.00	7.76	22.76	9.96	24.18	13.74	19.12	13.58
Мк 24	19.24	11.22	11.90	6.66	20.38	9.48	23.32	13.68	16.48	13.46
Мк 26	19.18	12.78	10.78	5.96	21.38	10.00	23.08	12.98	16.58	14.16
Мк 28	15.32	11.52	12.76	6.70	21.90	10.26	23.70	13.88	19.50	13.62
Мк 30	21.04	14.82	12.68	7.74	24.26	11.88	25.40	16.66	17.02	15.14
Мк 32	23.12	14.56	13.22	5.08	19.24	9.48	22.08	13.74	23.88	14.16
Мк 34	23.08	12.68	9.14	6.82	19.18	9.66	22.56	13.12	16.44	12.24
Bg 36	19.32	14.42	12.46	6.62	22.88	12.56	22.28	13.66	19.76	15.32

Table 6. Metrical results of skulls of brown bear (*Ursus arctos*). Used abbreviations: CC – Canine width; PA – Width of palatinum between M^2-M^2; PM – Length P^4-M^2; CP - Length C–P^4; CM - Length C-M^2; CCa - Internal width C-C; II – Length of incisive; FT/FV – Transversal and vertical width of foramen magnum; PP – Internal width P^4-P^4; OC - Distance of condyles occipitalis.

Ursus arctos **(mm)**											
Specimen	CC	PA	PM	CP	CM	CC a	II	FV	FT	PP	OC
Мк 1	56	39	69	57	111	31	37	20	34	38	63
Мк 3	62	42	62	60	111	36	36	/	/	40	/
Мк 5	61	41	67	61	113	34	33	18	28	40	66
Мк 7	77	44	73	71	127	44	/	/	/	48	/
Мк 9	72	49	74	70	129	42	43	26	35	49	70
Мк 11	71	50	69	67	124	42	43	27	31	45	66
Мk 13	66	39	56	51	102	39	38	23	28	42	61
Мк 15	62	44	73	67	127	39	41	25	31	45	64
Мк 17	68	44	77	63	127	34	40	22	31	41	69
Мк 19	/	49	69	/	/	/	/	/	/	47	/
Мк 20	/	/	/	/	/	/	/	26	34	/	71
Мк 21	63	42	74	64	119	36	40	19	33	41	61
Мк 23	57	37	64	51	105	33	37	18	30	34	58
Мк 25	63	41	65	61	115	37	37	28	31	40	/
Мк 27	57	37	68	51	105	35	36	19	31	33	60
Мк 29	67	42	74	55	114	35	36	/	/	33	/
Мк 31	77	53	81	73	126	43	45	23	30	47	67
Мк 33	72	48	74	57	123	42	39	22	33	46	67

Bg 35	69	43	71	61.5	122	40	41.5	21	31	43	65
SD	6.6	4.6	5.9	7.2	8.8	3.9	3.3	3.3	2.1	5	3.9

Table 7. Metrical results of skulls at brown bear (*Ursus arctos*). Used abbreviations: OO – Width of skull behind orbits; EC – Ectoorbital width; SP – Height between foramen magnum to sagittal crest; OT – Width between of bulla tympani; DN – Length of nasal bones; NN – Width of nasal bones.

***Ursus arctos* (mm)**										
Specimen	OO	EC	OO / EC	SP	OT	SP / OT	DN	NN	NN / DN	♂ / ♀
Мк 1	63	76	0.82	70	74	0.945	82	26	0.317	♀
Мк 15	71	92.5	0.76	83	136	0.61	80	31	0.387	♀
Мк 17	65	90	0.72	81	133	0.609	87	36	0.413	♀
Мк 19	69	99	0.69	80	130	0.615	/	/	/	♀
Мк 21	69	88	0.78	83	128	0.648	89	32	0.359	♀
Мк 23	65	62	1.04	66	110	0.6	65	29	0.446	♀
Мк 27	62	75	0.82	64	104	0.615	67	29	0.432	♀
Мк 29	70	78	0.89	84	115	0.73	71	22	0.309	♀
Bg 35	82	92.5	0.88	95	140	0.678	87	32	0.367	♀
Мк 3	72	97.5	0.73	71	132	0.537	84	32	0.38	♂
Мк 5	66	91.5	0.72	74	121	0.338	84	32	0.38	♂
Мк 7	71	109	0.65	100	131	0.496	55	38	0.69	♂
Мк 9	79	114	0.69	74	149	0.496	75	32	0.581	♂
Мк 11	73	111	0.65	96	170	0.564	91	36	0.395	♂
Мк 13	83	111	0.74	85	86	0.988	32	37	1.156	♂
Мк 20	68	122	0.55	106	165	0.642	/	/	/	♂
Мк 25	72	97	0.74	79	129	0.612	72	31	0,430	♂
Мк 31	84	126	0.66	100	181	0.552	99	41	0.414	♂
Мк 33	74	128	0.57	91	180	0.505	65	40	0.615	♂
SD	6.5	20.4	/	12.7	29.8	/	6.6	4.9	/	/

Table 8. Comparative metric analysis of *Ursus arctos* from Europe. Used abbreviations: TD – total length; KD - Condylobasal length; BD - Basal length; ZG – Zygomatic width; PA – Width of palatinum between M^2-M^2; OC - Distance of condyles occipitalis; EC – Ectoorbital width; CC – Canine width; RM – Length of lower jaw Incisive to proc. Angularis; AC – Height of lower jaw - proc. angulare to proc. coronoideus; Hma– Height of lower jaw - under P_4; CP - Length C–P^4; CPa - Length C–P_4; PM – Length P^4-M^2; PMa – Length P_4 и M_3; CM - Length C - M^2; CMa - Length C - M_3; OO – Width of skull behind orbits; PP – Internal width P^4-P^4; CCa - Internal width C-C; II – Length of incisive; FT/FV – Transversal and vertical width of foramen magnum; DN – Length of nasal bones; NN – Width of nasal bones; MC – Distance between mandibular condyles; CCb – External width C - C.

Specimen N°	**1**	**2**	**3**	**4**	**5**
Measure-ments (mm)	***Ursus arctos L.* From R. of N. Macedonia**	***Ursus arctos L.*, Couturier, (1954) - France**	***Ursus arctos L.*, Martino, (1939) - Serbia**	***Ursus arctos L.*, Heptner et al., (1967) - USSR**	***Ursus arctos* L., Ruskov and Markov (1974) - Bulgaria**
TD	252-380	141-351	/	311-455 m 275-397 f	277-350
KD	235-335	131-324	270	261-418 m 258-373 f	269-330
BD	222-321	119-304	/	/	252-310
ZG	143-232	87-217	179	175-277 m 147-217 f	166-214
PA	37-53	30-52			
OC	58-70	34-68			
EC	62-126	33-79			
CC	56-77	37-78			
RM	180-250	91-233	194		189-237
AC	36-117	/			
Hma	21-58	18-48			
CP	51-73	13-40			
CPa	51-81	14-39			
P^1 - M^2	72-101	81-95			
P_1- M_3	97-121	96-114			
PM	63-78	62-72			
PMa	67-86	69-82			
CM	105-129	96-120			
CMa	115-147	109-138			
OO	62-84	64-70			61-72
PP	33-49	31-51			
CCa	31-43	26-43			
FV	18-28	16-24			
FT	28-35	23-34			
NN	22-41	19-37	88		
MC	123-189	81-180			
II	33-45	23-46			
DN	55-100	35-91			66-85
CCb	36-55	25-45			

In Tabls. 6, 7 and 8 are presented measurements used for the comparative metric analysis of *Ursus arctos* from Republic of North Macedonia and Europe. Herein, is evident that the specimen number 4 has the largest dimensions, while specimen used in this study (specimen 1) has second larger dimensions and all the rest specimens 2, 3 and 5 has lower dimensions than our analyzed one.

Discussion

Morphologic features of the *Ursus arctos*

In the research itself, as part of the considered problem, the study of the morphology and dimensions of the teeth was imposed, which showed certain anatomical and phylogenetic characteristics of the species.

When analyzing the results of the skulls of the recent brown bear, we can conclude that a similar morphology has been recorded, especially in the wide-open zygomatic arcs and the presence of premolars as characteristics of the species *Ursus arctos* (Tab. 1). Presence of $P^{1,2,3}$ at examined skulls is a primitive feature, typical for the species. Baryshnikov et al. (2004) concluded that *U. arctos has* a number of archaic features which are closer to its ancestor. Deviations in the description, differences in the appearance and size of the skulls are related to sexual dimorphism, individual age and evolutionary development of bears indicate on clear heterogeneity in the skull size and cheek teeth dimensions (Baryshnikov et al., 2004a).

It is characteristic to amplify that there are dimensions that overlap in the examined specimens. From the measured values of the respective quantities and the calculated values for the standard deviation it can be concluded that it is small, but important to say that the measured values are close to the average value of the measurement (Tab. 2). Herein, it is evident that there are three skulls (Mk 23, Mk 27 and Mk 29) that make an outlier, i.e. significantly affect the calculations. As a conclusion about this skulls, we can say that they belong to younger individuals.

Sexual dimorphism of *Ursus arctos*

The sexual dimorphism is important from the aspect that its study can determine the sex of the studied individuals, which indicates a certain percentage or dominance within a population. The measured differences in the dimensions of certain skulls are result of the present sexual dimorphism in this family, so that the size values of a number of metric features are larger in the male individuals (Cregut et al., 2001). In the past and until last decade, determination of sexual dimorphism is based on external appearance such as development of ridges and measurements of the skull (Farkash et al., 2009). Also, the sexual dimorphism at examined units can be determinate according to development and metric size of the forehead (ectoorbital bone) (Spassov, pers. comm.). Obtained correlations (EC/TD and ZG/EC) enable the determination of sex with the studied recent individuals (Fig. 1).The growth of the curve is due to the fact that males have a higher ratio than females.

The results showed that out of the total 19 examined skulls, 10 belong to male, and 9 belong to female bears (Tbls. 2, 3). The finding of sexual dimorphism was also, confirmed by calculated ratios of the dimensions showed in Tab. 2. The ratios presented in graphs allow easier observation of the differences in dimensions between males and females of the species *Ursus arctos.*

Using the methods by Kurten (1955) and Baryshnikov et al. (2003, 2010) to determine sexual dimorphism at cave bears according to different dimensions of canines, the researched dimensions from the recent bears in the study for the upper canine enabled the establishment of the reported hypothesis for sex differentiation in the researched subjects.

When comparing the obtained results for determining the sexual dimorphism according to the dimensions of the canines in recent species, the following hypothesis was taken into consideration: if their width is greater than 14 mm, it belongs to a male, i.e. if it is less than 13 mm it is a female. The obtained results (Tab. 4) showed that 9 individuals were males and 8 females, which confirmed the hypothesis with 89% accuracy, since two skulls (Mk 19 and Mk 20) lack the front parts of the skull. For now, this statement will remain at the level of a hypothesis, since for its complete confirmation it is necessary to process at least 30 skulls.

Taxonomic status of researched species

This study also made it possible to determine the taxonomic status of the species, i.e. whether the bears living in the Republic of North Macedonia belongs to the typical *Ursus arctos arctos* and by what characteristics it differs from the other populations of brown bears living in Europe. According to Barishnikov (2007) and Mizumachi et al. (2020) brown bears from North West Europe and Balkan belong to typical *Ursus arctos arctos,* but the Balkan bears are very close to the South European population (especially to the Italian one) and differ from the bears from Central and North-

ern Europe. Mizumachi et al. (2020) amplify on the possibility that the Balkan Peninsula (Bulgaria) act as a corridor for coexisting of 2 clades.

For determining the examined species and whether belongs to the typical *Ursus arctos arctos*, was used the key of Gray (1825, in Gromova 1962), which is based on the morphology of the skull and the dimensions of the teeth. The expressed percentage of some findings is less than 100% due to small deviations in dimensions or the absence of the corresponding element in the units: (1) The profile of the skull is slightly concave, weakly expressed glabella which is 100% confirmed; (2) Nose opening is round with frame width and height 100% confirmed; (3) P^4 short without parastyl, confirmed with 90% accuracy; (4) M^1 is longer than its width confirmed with 100% accuracy; (5) M^2 is longer twice than its width confirmed with 90% accuracy; (6) The length of M^2 is less or not much less than $P^4 + M^1$ - the accuracy is 89%; (7) P_4 - the gable is narrow, its width not much more than half of the length - accuracy of 100%; (8) M_1 length almost similar to M_2 - 89% accuracy; (9) M_3 almost two times longer than P_4 - accuracy of 85%. The obtained results (Tbls. 1, 4, 5) for now confirm that the examined recent skulls belong to the typical *Ursus arctos arctos*. Metric results helped to determine the taxonomic status of the species and whether it belonged to the typical *Ursus arctos arctos*, using Gromova's (1962) determinant based on the morphology of the skull and the dimensions of the teeth.

Comparative results with other European studies of the recent bear (*Ursus arctos*)

When processing the results of the comparative analysis shown in Tabls. 6, 7 and 8 it can be concluded that the skulls from Republic of North Macedonia have larger dimensions compared to those from the Pyrenees (Couturier, 1954), and those researched from Martino (1939) from the Rugovski mountains and by Ruskov and Markov (1974) from Bulgaria. According to Heptner at al. (1967) bears in the territory of the former SSSR are the largest. On the other hand, differences can also be seen in proportions of the skulls at specimens which belong to Southern group of bears which in general are smaller than bears from former SSSR (Baryshnikov et al. 2004). From the results present in Tab. 8 it is noted that bears from territory of Republic of North Macedonia has decreased in skull size as indicated by Baryshnikov et al. (2004).

Conclusions

In summary, within this paper was concluded that male bears are with larger dimensions of the sculls in general. Observed sex dimorphism of the recent species was determined by the development of the ectorbital bone showed that out of a total of 19 examined skulls, 10 belong to male and 9 to female, respectively. The hypothesis for determining the sex dimorphism according to the dimensions of the canine teeth in recent bear has been confirmed with 89% accuracy, but due to insufficient number of researched units, the conclusion remains at the level of a hypothesis at the moment.

Determination of the taxonomic status of the recent brown bears compared with bears from North West Europe and Balkan belongs to typical *Ursus arctos arctos*. Being assumed that within the newest genetic studies from the territory of Bulgaria, act as a corridor were was confirmed that 2 bear clades coexist, we do not exclude the possibility that and in the territory of Republic of North Macedonia this could be a case. So, in further studies is highly recommend further research besides morphology features and the genetics too. The measured dimensions of bears in this research will make easier to see the differences in size, and that the geographical distribution and type of available food influence the development of *Ursus arctos*.

The analyzed material is relevant to study the morphological value of the skull features of *Ursus arctos* and to determine the metric variability, providing an opportunity to further compare the species of Ursidae family, amplifying on importance for certain findings from individual teeth morphology.

Acknowledgements

I'm very grateful for the collection material supplied for examination by Dr. Svetozar Petkovski (NMNH - Skopje) and Dr. Vladimir Maletić (Faculty of Forest Sciences – Skopje). Many thanks to Dr. Nikolay Spassov (NMNH – Sofia) for review and for his helpful comments on manuscript.

References

Baryshnikov, F.G. Germonprè, M. and Sablin, M. 2003. Sexual dimorphism and metric variability of cheek teeth of the cave bear (Ursus spelaeus), Belg. J. Zool., 133 (2), Belgium, p: 111-119

Baryshnikov, F.G. and Boeskorov, G.G. 2004. Skull of the Pleistocene brown bear (Ursus arctos) from Yakutia, Russia, Russian J. Theriol.3 (2), Saint-Petersburg p:71-75

Baryshnikov, F.G., Mano, T.and Masuda, R. 2004a. Taxonomic differentation of Ursus arctos (Carnivora, Ursidae) from south Okhotsk Sea islands on the basis of morphometrical analysis of skull and teeth, Russian J. Theriol.3 (2), Saint-Petersburg p:77 -88

Baryshnikov, F. G. 2007. Fauna of Russia and neighboring countries, Mammals, Vol. 1, issue 5, N 147, Sankt Petersburg pp; 1- 532

Baryshnikov, F.G., Germonprè, M. and Baryshnikova, V.S. 2010. Cave bear (Ursus spelaeus) from Chamber B of the Goyet Cave in Belgium, Russian J. Theriol. 9(2), Saint-Petersburg p:93-104

Couturier, J.A.M. 1948. Le calvarium de L' ours Brun (Ursus arctos) plèistocenè de la grotte de Malarnaud, extrait du Bulletin de la sociètè d'Antropologie, Tom IX , Paris p:127 - 137

Couturier, J.A.M. 1954. L' ours Brun, Grenoble p:73-155

Cregut, E., and Fosse, Ph. 2001. Holocene brown bears (Ursus arctos L.) in natural traps: exceptional sites of Mont Ventoux (Vaucluse, France), Cadernos Lab. Xeolóxico de Laxe, Coruña, p:325-340

Dufour, R. 1989. Les carnivores pléistocènes de la caverne de Malarnaud (Ariège). Collection E. Harlé, Muséum d'Histoire Naturelle de Bordeaux. D.E.S., Bordeaux 1 p:1-66

Erdbink, D.P. 1953. A review of fossil and recent bears of the old world. Deventer-Drukkerij Jan De Lange p:321-457

Farkaš, V., Gomerčić, T., Sindičić, M., Slijepčević, V., Huber, Đ., Frković, A.and Modrić, S. 2009. Craniometrical analysis and determination of sexual dimorphism in brown bear (Ursus arctos L.) from Croatia, izvorni i znanstveni članci, Šumarski list br.9 -10, Zagreb p:527-537

Gromova, V.I. 1962. Fundamentals of paleontology. Mammals. Geological literature.Moscow p:214-218

Heptner, V.G., Naumov, N.P., Yurgenson, P.B., Sludskiy, A.A., Chirkova, A.F. and Bannikov, A.G. 1967. Mammals of the soviet Union. (In Russian) Vysshaya Shola 2 (1) Moskow p:403-453

Kurtén B. 1953, On the variation and population dynamics of fossil and recent mammal population, Acta Zoologica Fenica 76, pp: 1-122

Kurtén B. 1955. Sex dimotphism and size trends in the cave bear UrsusspelaeusRosenmüller and Heinroth, Acta zoologica Fennica 90, Helsingforsiae, p: 1-46

Mayr, E., Linsley, E.G. and Usinger, R.L. 1953. Methods and principles of systematic zoology. London, p: 16-125

Martino, V. 1939. Graña za sistematiku jugoslovenske divljači. Lovac, br.9-10 Septembar – Oktobar, Sarajevo

Mclellan, B. and Reiner, D.C. 1994. A review of bear evolution, Int. Conf. Bear Res. and Manage. Missoula, Montana, p: 85-96

Mizumachi, K., Spassov, N., Kostov, D. Raichev G.E., Peeva S., Hirata D., Nishita Y., Kaneko Y. and Masuda R. 2020. Mitochondrial haplogrouping of the ancient brown bears (Ursus arctos) in Bulgaria, revealed by the APLP method, Mammal research 65, pp: 413 - 421

Ruskov, M. und Markov, G. 1974. Der braunbär (Ursus arctos L.) in Bulgarien, Sonderdruckaus Z. f. Säugetierkunde Bd.39. H.6, Hamburg und Berlin, pp: 358 – 368

Spassov, N. 1990. Note on the coloration and taxonomical status of the bear (Ursus arctoa L.) in Bulgaria, Historia naturalis bulgarica, kn2, Sofia pp: 64 - 66

Spassov, N.2003. The Brown Bear in the southern Balkans. In:Krystufek, B., B. Flajsman, Huw Griffiths (eds.). Chapter 10. Living with Bears, A large European carnivore in a shrinking world. Ekoforum, Ljubljana, p: 229-244.

Spassov N.,Spiridonov G.,Ivanov V. and Assenov L. 2015. Sighs of the bear life activities and their utilization for the monitoring of the brown bear (Ursus arctos L.) in Bulgaria, Historia naturalis bulgarica, 22: 73-83, Sofia

Taberlet P. and Bouvet J. 1994. Mitochondrial DNA polymorphism, phylogeography, and conservation genetics of the brown bear *Ursusarctos* in Europe*Proc. R. Soc. Lond. B.*255195–200

Thenius, E. 1959. Ursidenphylogenese und Biostratigrafie, Sonderdruck aus "Zeitcshrift für Säugetierkunde", band 24, Berlin, p:78-84

Von Den Driesch, A. 1976. Das vermessen von ternochen aus Vor und Grünge Schichtlichen

siedlungen, München, p: 1-61

UDK: 582.929-196(497.7)
Received: 18.10.2020
Accepted: 26.10.2020
Original scientific paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 19-30
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

New and rare species of the genus *Orobanche* (Broomrapes) in the flora of the Republic of North Macedonia

Zoran Nikolov

Natural History Museum of the Republic of North Macedonia, Blvd. Ilinden 86, 1000 Skopje, Republic of North Macedonia,
e-mail: znikolov61@yahoo.com

Abstract
In the present paper, one new and four rare species of the genus *Orobanche*, in the flora of the Republic of North Macedonia, are presented. *O. flava* is a new species, the other that are rare, are with only one (*O. pubescens, O. hederae*) or two literature data (*O. serbica*). There are also two literature data for *O. cumana,* but one is with certain location while the other is just a name on a list of weeds with major economic impact on agriculture in the Republic of Macedonia. Descriptions of the plants from the alleged locations are given. Photos of all species are also taken. Literature and new data are given in the distribution maps.

Key words: *Orobanche*, flora, host plant, Republic of North Macedonia.

Introduction

The genus *Orobanche* (incl. *Phelipanche* Pomel) is the largest genus of the family Orobanchaceae with 150 (Kreutz, 1995) to 170 species (Uhlich & al., 1995). The most of the Broomrape taxa grow in the temperate and warm regions of Europe, in some parts of western and eastern Asia and in northern Africa (Kreuz, 1995). In Europe, the Mediterranean countries are the richest with *Orobanche* taxa. Some of the species of this genus, encountered in America, eastern Africa, Australia and New Zealand, are supposed to be introduced by human activities (Kreutz, 1995).

The genus *Orobanche* consists of only obligate root parasites. The lack of chlorophyll and well-developed root system made the species of this genus completely dependent on water and nutrients of the host plants. Instead of root, a system of haustoria is developed.

The holoparasitic way of life, that led *Orobanche* taxa to lack or strong reduction of leaves and absence of roots, accompanied with intraspecific variation of corolla's color and corolla's dorsal line as well as the color of the stigma, make the taxonomy of *Orobanche* species extremely difficult.

So far, systematic researches of the genus *Orobanche*, on the territory of the Republic of North Macedonia, are not carried out. Only sporadic data, for different species of this genus, appeared in some floristic or vegetation works that concerned parts of this territory like Grisebach (1844), Grecescu (1899), Dimitrov (1909), Vandas (1909), Stojanov (1921, 1928), Jurišić (1923), Urumov (1923), Bornmüller (1928), Beck (1930), Soška (1937; 1938/39a; 1953), Petrović (1941), Černjavski (1943), Rudski (1943), Micevski (=Micev, 1952), Grupče (1958), Matvejeva (1965; 1968); Drenkovski (1969), Teofilovski (2011).

The work on the project "Taxonomy and chorology of the genus *Orobanche* in the Republic of Macedonia", conducted between 2011 and 2013, made an important contribution to the knowledge of this genus, in the flora of the Republic of North Macedonia.

According to the available literature data, the genus *Orobanche*, in the flora of the Republic of North Macedonia, is represented with 23 species. *Orobanche picridis* F.W. Schultz and *Orobanche loricata* Rchb. are given as separate species on the basis of the alleged literature data.

Materials and methods

Voucher specimens are deposited in the Herbarium of the Natural History Museum of the Republic of

North Macedonia. Relevant and reliable literature sources were used for determination of the material: Beck (1890;1930), Hayek (1929), Chater & Webb (1972), Parabućski (1974), Gilli (1982), Buia (1985), Delipavlov (1995), Kreutz (1995), Uhlich & al. (1995), Pujadas Salva & Velasco (2000), Pujadas Salva, A.J. (2003), Pusch & Günther (2009), Piwowarczyk (2014). Photos of all species, from their natural habitats, were taken. Literature and new data for the species are given on the distribution maps.

Results and discussion

1. *Orobanche cumana* Wallr. (Or. Gen.: 58. 1925).

(Syn. *O. cernua* var. *cumana*, Beck, Bibl. Bothanica, 19:143. 1890; O. *cernua* subsp. *cumana* (Wallr.) Soó, Fedes Repert., 83:187. 1972).

Literature data

Mt. Galičica (Černjavski, 1943).

New data

Kumanovo (village Romanovce): along the black road that leads from the highway to the locality "Krasta", sunflower crops, 300 m a.s.l., 26.06.2017 (Leg./Det. Z. Nikolov).

Fig.1. *Orobanche cumana* Wallr. - Habitus, with the host plant *Helianthus annuus* L.

Description

Stem erect, 25-58 cm, simple. Inflorescence lax, 12-39 cm. Calyx up to 8 mm long, deeply bifid, the segments entire. The bracts up to 10 mm long, oval-lanceolate, deflexed at the apex. Corolla 14-17 mm long, yellowish-white at the base and somewhat blue-violet toward the apex of the upper lip, curved at the first third forward, then in the middle almost straight, and again light curved downward at the apex of the upper lip. Stamens inserted at approximately 5 mm from the corolla base. The style, in the upper part, with rare glandular hairs. The two spherical lobes of the stigma are whitish.

The taxonomic status of *Orobanche cumana* (Fig. 1, 2) is still uncertain. This species, described by Wallroth (1845) had been, for a long time, in the works of various authors, taxonomically different evaluated: as variety of *Orobanche cernua* Loefl. (Beck, 1890, 1930; Hayek, 1929), sub-species of *O. cernua* (Soó, 1972), conspecific species with *O. cernua* (Chater & Webb, 1972; Pusch, 2009) or synonym of *O. cernua* (Pignanti, 1982). Contrary to these allegations, in the papers of other authors, these two taxa are given as separate species (Kreutz, 1995; Uhlich & al., 1995; Pujadas-Salva & Velasco, 2000). Delipavlov (1995), for Bulgaria, and Parabućski (1974), for Serbia, recorded *O. cumana* with *O. cernua*, as its synonym.

This discrepancy, in the taxonomical evaluation of *O. cumana*, exists even to nowadays. In one of the most relevant sources: Euro+Med Plantbase (Domina & Raab-Straube, 2010+), *O. cumana* and *O. cernua* are accepted as separate species. But, in another also relevant source - the Plantlist, *O. cumana* is recorded as synonym of *O. cernua*.

Although *O. cernua* and *O. cumana* are closely related species yet, there are certain morphological, ecological and biochemical differences that make clear distinction between them and justify their species level. That is, in the best way, confirmed in the work of Pujadas-Salva & Velasco (2000), for the Iberian Peninsula. *O. cumana* is taller, the inflorescence is laxer and longer. There are also deviations in the bending of the dorsal line as well as of the color and the length of the corolla. Markedly longer and more curved-down are the flowers by *O. cumana.* Differences also appear in the view of habitats as well as in the seed oil content and fatty acid composition.

Fig. 2. *Orobanche cumana* Wallr. - Inflorescence

The flowering period doesn't overlap, for *O. cernua* takes part from March to June, for *O. cumana*, from June to August.

The distribution area of *O. cumana* spans from the entire Mediterranean region of Europe to China, Asia Minor and Central Asia, also northern Africa and Australia, while *O. cernua* inhabits mainly western Mediterranean region of Europe, then through Bulgaria, Asia Minor and central Asia, to China, also in eastern India, northern Africa and Australia (Kreutz, 1995).

The only data, for the presence of *O. cumana*, on the territory of the Republic of Macedonia, we find in Černjavski (1943), for the Mt. Galičica (Suvopolje: Poljce). The data by Kostov & Pacanoski (2007) is only a name on a list of weeds with major economic impact on agriculture in the R. of Macedonia. The new finding is along the black road that leads from the highway to the locality "Krasta" (village Romanovce, town Kumanovo), at altitude of approximately 300 m a.s.l. (Fig. 3).

The plants of our population match the description given by Kreutz (1995), Uhlich & al. (1995) and Pujadas-Salva & Velasco (2000). The only deviation concerns the length of the corolla. By our plants, the corolla length (14-17 mm) is almost the same with the one, given by Kreutz [(1994) (15-18 mm)] and Uhlich & al. [(1995) (15 -18 mm], but shorter, in average, in compare to the length, recorded by Pujadas-Salva & Velasco [(2000) (16)19-22 mm].

Despite to the allegations of Kreutz (1995), Pujadas-Salva & Velasco (2000), Parker (2013), that *O. cumana*

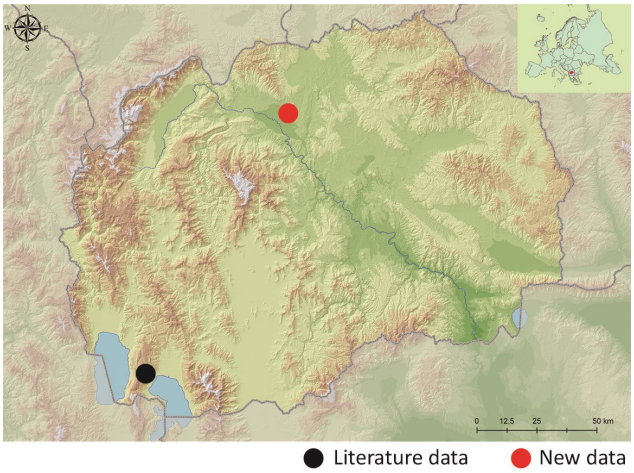

Fig. 3. *Orobanche cumana* Wallr.

parasitizes exclusively on sunflower (*Helianthus annuus* L.), while *O. cernua* mainly on *Artemisia* species or on Solanaceae crops, another authors (Buia, 1985; Uhlich & al., 1995; Pineda-Markos & al., 2014) recorded, beyond the sunflower, other species of Asteraceae and Solanaceae, as host plants for *O. cumana*.

O. cumama, in the alleged locality, in an immense number, parasitizes on sunflower crops (Fig. 1).

2. *Orobanche hederae* Duby (Bot. Gall., ed. 2, 1:350. 1828).

Literature data

Mt. Belasica: village Banjsko (Rudski, 1943).

New data

1. Matka (Skopje): in the vicinity of the dam "Matka", along the narrow path that leads to the caves, 343 m a.s.l., 10.06.2011 (N: 42º 00' 37.8''; E: 021º 30' 46.9'') (Leg./Det.: Z. Nikolov),

2. Debar (village Modrič): in the valley of the river Crn Drim, 594 m.a.s.l., 22.06.2012 (Leg./Det.: Z. Nikolov).

Description

Stem erect, (13)16-34(41) cm, simple, yellowish to yellowish-brown or even brown, with long, glandular hairs. Inflorescence lax, many-flowered (4)6-15(25) cm. The bracts with the same length as the corolla or even longer, oval-lanceolate, with glandular hairs, deflexed at the apex. Calyx segments with glandular hairs, entire or unequally bidentate, connate at the base. Corolla 14 -20 mm long, yellowish to yellowish-brown, with glandular hairs. The dorsal line of the corolla is nearly curved from the base, then almost straight (even) and

Figure 4. *Orobanche hederae* Duby
a) Habitus b) *O. hederae* parasitic on *Hedera helix* L. c) inflorescence detail

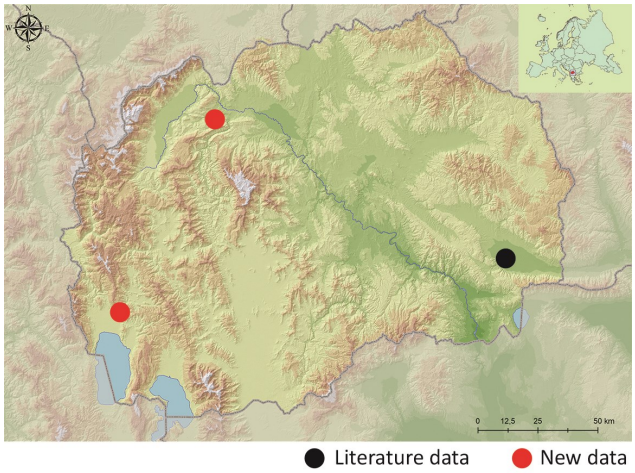

Fig. 5. *Orobanche hederae* Duby

somewhat raised at the upper lip. Stamens inserted at 3-4 mm from the corolla base. The style glabrous or with rare glandular hairs. The stigma consisted of two elongated, globular lobes, yellowish.

The distribution area of *O. hederae* extends from southern Europe (especially the Mediterranean region) to Asia Minor (Turkey), Caucasus countries and Iran, also in western, central and rarely, in eastern Europa (Crimea) and countries from North Africa - Morocco, Algeria (Uhlich & al., 1995; Kreutz, 1995; Pusch & Günther, 2009; Domina & Raab-Straube, 2010+).

The only data, for the presence of *O. hederae*, in the flora of the Republic of North Macedonia, comes from Rudski (1943), for village Banjsko (Mt. Belasica). New findings (Fig. 5.), revealed during the work on the project "Taxonomy and horology of the genus *Orobanche* in the flora of the Republic of Macedonia" (2011-2013), are Matka (dam in the gorge of the river Treska, city of Skopje) and the valley of the river Crn Drim (village Modrič, town Debar).

O. hederae parasitizes mostly on the root of *Hedera helix* L. (Fig. 4 a, b), rarely on other *Hedera*-species. Also, other Araliaceae are possible host plants for *O. hederae* (Pusch & Günther, 2009) as well as *Pelargonium* and other ornamental plants (Kreutz, 1995).

The population at the locality "Matka" is developed on the edge of the dam, on moist and shady site (Fig. 4, a,b). Along the road, in the valley of the river Crn Drim, occurs another population of *O. hederae*.

3. *Orobanche pubescens* D'Urv. (Enum. Pl. Ins. Eux. 76. 1822)

(Syn. *O. versicolor* F.W. Schultz in Flora (Regensburg) 26:129. 1843.)

Literature data

Beck (1930): Mazedonien: "bei Lundzi, naechste Gjevgjeli" (Dimonie).

New data

Matka (Skopje): in the vicinity of the church "Sv. Nedela", 757 m a.s.l., 10.06.2011 (Leg./Det.: Z. Nikolov).

Description

Stem 35 cm, simple, reddish, with long, white glandular hairs, bellow rich, upper scare scale-leafy. Inflorescence 16 cm, cylindrical, upper dense-flowered, bellow rather lax, villous. Scale leaves up to 16 mm, linear-lanceolate, with white- glandular-villous base. The bracts reach the corolla length, lanceolate, white- glandular-villous. Calyx-segments evenly bidentate, teeth

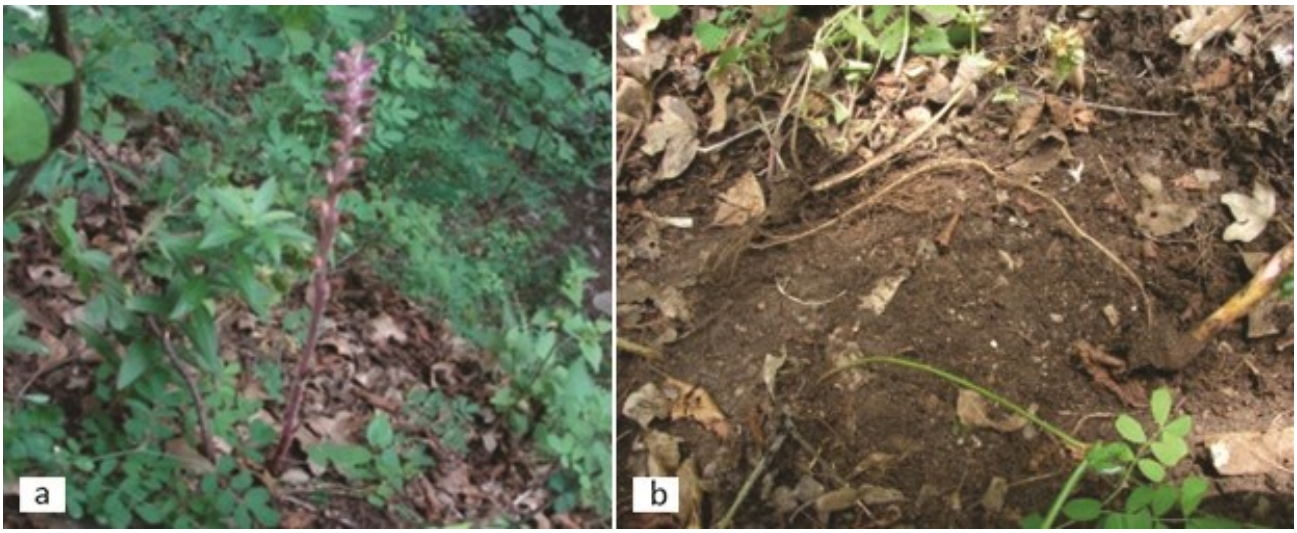

Figure 6. *Orobanche pubescens* D'Urv.
a) Habitus b) *O. pubescens* with the host plant *Lamium maculatum* L.

Figure 7. *Orobanche pubescens* D'Urv. - Inflorescence

long-acuminate, white-glandular-villous. Corolla 16 mm, tubular, yellowish-white at the basis, reddish to the lips, long lanate-pilose outside, mostly on the upper lip; the dorsal line, from the curved base, almost straight. Stamens inserted et 3-4 mm from the base of the corolla. Stigma 2-lobed, reddish.

O. pubescens (Fig. 6, 7) belongs to the Mediterranean elements spread from Spain, France, Italy, Balkans to Crimea and Transcaucasia, also in N.W. Africa (Gilli, 1982; Kreutz, 1995; Uhlich & al., 1995; Domina & Raab-Straube, 2010+).

The only data, for the presence of *O. pubescens,* on the territory of the Republic of North Macedonia, comes from the comprehensive monograph of Beck

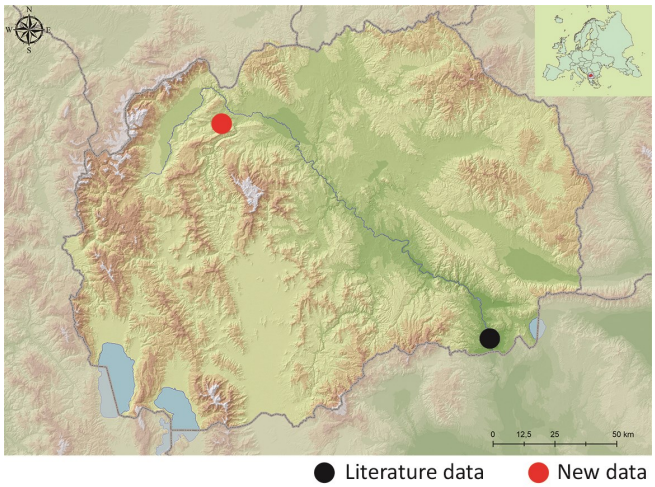

Fig. 8. *Orobanche pubescens* D'Urv.

(1930), for the surrounding of the town Gjevgjelia. On the locality "Matka" (Skopje valley), not far from the dam (Fig. 8), in the vicinity of the church "Sv. Nedela", only one plant of this species that parasitizes on *Lamium maculatum* L. (Fig. 6, b), was found. Although *L. maculatum* is so far unknown to be host plant for this or any other *Orobanche*, another one, of the same genus *Lamium* – *L. garganicum* L. subsp. *striatum* (Sm.) Hayek (Syn. *L. striatum* Sm.) is already known to be host plant, for *O. pubescens* (sec. Bornmüller, in Beck, 1930; Uhlich & al., 1995). Otherwise, *O. pubescens* is parasitic on various species, mostly of Asteraceae, Umbelliferae and Fabaceae, rarely on Lamiaceae and Geraniaceae (Uhlich & al., 1995).

4. *Orobanche flava* F.W. Schultz

Literature data

So far, there are no data for the presence of this species, in the flora of the Republic of North Macedonia.

New data

Jablanica (village Gorna Belica): nearby the village, along the road and Belička river, 1200 m a.s.l., 19.07.2006 (Leg./Det.: Z. Nikolov).

Description

Plants usually in groups, stem (15)23-39 cm, orange-yellowish, glandular-pubescent; scale-leaves up to 20 mm, numerous in the lower, rare in the upper part of the stem; the lower triangular to lanceolate, the upper

Fig. 9. *Orobanche flava* F.W. Schultz

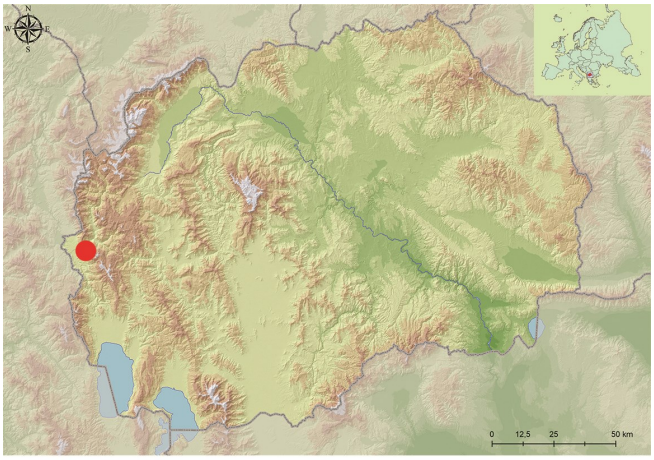

Fig. 10. *Orobanche flava* F.W. Schultz

scale-leaves lanceolate. Inflorescence (4)5-10 cm, many -flowered, dense at first, later, elongated and lax; bracteoles absent; calyx segments usually free, mostly unequally bidentate, rarely entire, glandular-pubescent; corolla up to 23 mm, yellowish, glandular-pubescent, relatively uniformly curved; the upper lip 2-lobbed, the lower 3-lobed, the middle one larger than the side lobes; stamens inserted 4-6 mm from the base of the corolla tube; stigma 2-lobed, yellow.

Orobanche flava (Fig. 9) grows in Central and Eastern Europe: France, Switzerland, Germany, Austria, Czech Republic, Slovakia, southern Poland, Hungary, Romania, Former Yugoslavia and northern Italy (Kreuz, 1995). Later, the presence of this species was confirmed for Spain (Pujadas Salva, 2003). Domina & Raab-Straube (2010), beyond the countries alleged by Kreuz (1995) and Pujadas-Salva (2003), extends the distribution area with Azerbaijan, Armenia, Georgia (A D G), Morocco, R(CS) and Ukraine.

O. flava is a mountain species that parasitizes mainly on species of the following genera of the fam. Asteraceae: *Adenostyles, Petasites, Senecio* and *Tussilago*, and probably on these species of the genus *Aconitum* (fam. Ranunculaceae*) – A. napellus* L. *and A. lycoctonum* L. (Kreutz, 1995; Uhlich & al., 1995; Pusch & Günther, 2009).

The habitat on the Mt. Jablanica (village Gorna Belica), where *O. flava* grows, completely matches the "preferred habitats" for this species, described by Piwowarczyk (2014). Namely, the plants occurred in the tall-herb stands of *Petasites* sp., on stony, wet place, sporadically flooded by the waters of Belička river, at approximately of 1200 m a.s.l. (Fig. 10).

Hitherto, *O. flava* hasn't been recorded for the territory of the Republic of North Macedonia.

5. *Orobanche serbica* Beck & Petrovic

(Syn. *Orobanche ozanonis* F.W. Schultz. ex G. Beck. Biblioth. Bot., 19:249. Stuttgart. 1890).

Literature data

Belasica: village Bansko (Stojanov, 1921); Mt. Galičica (Černjavski, 1943).

New data

Kozjak (village Nova Breznica, city of Skopje), 1107 m.a.s.l.; 03.07.2013. N: 41º 53' 40.6'' E: 021º 53' 28.6'' (Leg./Det.: Z. Nikolov).

Description

Stem (12)14-23(28) cm, swollen at the base, glandular-pubescent, yellowish, rarely purple. Scale-leaves ovate-lanceolate, 10-15(18) mm long, dense bellow, gradually rare up. Inflorescence rather dense, many flowered, 5-8 cm long. Bracts lanceolate, glandular-pubescent, slight shorter than the corolla. Calyx segments free, mostly unequally bidentate. Corolla 16-18 mm long, whitish with purplish nuance to the lips, glan-

Fig. 11. *Orobanche serbica* Beck & Petrović - Habitus of the plant, parasitic on *Artemisia campestris* L.

Fig. 12. *Orobanche serbica* Beck & Petrović - Inflorescence

dular-ciliate, curved at the base, straight in the middle and curved down to the lips; the upper lip subentire, the lower three-lobed, the lobes equal, glandular-ciliate at the margins. Filaments inserted at 4 mm from the corolla-base. Stigma 2-lobed, yellow.

Until recently, *Orobanche serbica* (Fig. 11, 12) was considered to be Balkan endemic species confined to Serbia (Beck, 1890), Serbia and Macedonia (Hayek, 1929), Serbia and Bulgaria (Beck, 1930, Uhlich & al., 1995), Bulgaria and former Yugoslavia (Chater & Webb, 1972), Serbia, Macedonia and Bulgaria (Parabućski, 1974; Delipavlov, 1995). But, as a result of the conclusion of Carlon & al. (2008) that *Orobanche ozanonis* F.W. Schultz is actually a synonym of *O. serbica*, the distribution area of the latest was widened to France and Spain. This solution was soon accepted by Domina & Raab-Straube (2010). In the distribution area of *O. serbica*, given by the later authors, the territory of the Republic of North Macedonia is not included.

In the locality "Kozjak" (village Nova Breznica, Fig. 13), where *O. serbica* grows "dominate rocky, dry grasslands on the calcareous bedrocks, rarely dry meadows and clearings in the oak belt or the rests of *Pinus nigra* forests" (Nikolov, 2019). The plants of this, not numerous population, match (without deviations) the descriptions given by Beck & Petrovic (1885), Beck (1890, 1930), Hayek (1929), Chater & Webb (1972), Parabućski (1974), Delipavlov (1995), Uhlich & al. (1995). The whitish corolla, with purplish nuance to the lips, the yellow, 2-lobed stigma and the ovate-

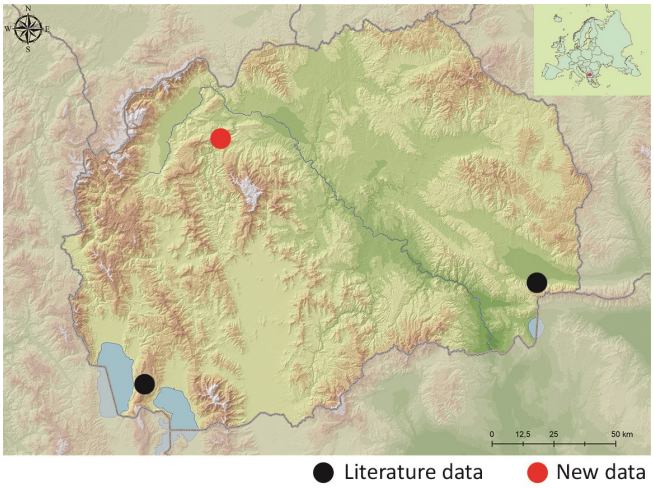

Fig. 13. *Orobanche serbica* Beck & Petrović

lanceolate scale-leaves make this species in the field easy recognizable.

O. serbica is parasitic only on species of the genus *Artemisia* (Beck & Petrovic, 1885; Beck, 1890, 1930; Chater & Webb, 1972; Parabućski, 1974; Uhlich et al., 1995; Carlon & al., 2005). In the locality "Kozjak" *O. serbica* parasitizes on the root of *A. campestris* (Fig. 11.), the same host species alleged by Parabućski (1974).

Conclusion

The result of the work on the material of the genus *Orobanche*, collected from 2006-2017, mostly from 2011-2013, is as following:

1. *Orobanche flava* – first record of the flora of the Republic of North Macedonia, new species, parasitic on *Petasites* sp., discovered on the Mt. Jablanica (village Gorna Belica),

2. *Orobanche cumana* - rare species, parasitic on *Helianthus annuus*, registered on a locality nearby the village Romanovce (town Kumanovo),

3. *Orobanche hederae* - rare species, parasitic on *Hedera helix*, encountered on the localities Matka (city of Skopje), valley of the river Crn Drim (village Modrič, town Debar),

4. *Orobanche pubescens* - rare species, parasitic on *Laminum maculatum*, found on the locality Matka (city of Skopje), and

5. *Orobanche serbica* - rare species, parasitic on *Artemisia campestris*, discovered on the locality Kozjak (village Nova Breznica, city of Skopje).

Acknowledgement

I express my thanks to the reviewers Kiril Stojanov and Bostjan Surina for their helpful suggestions in the manuscript-improvement. Also, great thank to Aco Teofilovski for his help in the determination of the host plants.

References

Beck, G. & Petrović, S., 1885. In Petrović: *Orobanche serbica*. Additamenta ad Floram Agry Nissani, p. 146 -147. Beograd.

Beck, G., 1890: Monographie der Gattung *Orobanche*. Bibl. Bot., 19:1-275. Theodor Fischer, Cassel.

Beck, G., 1930: Orobanchaceae. In: Engler, A. (Eds.). Das Pflanzenreich Regni vegetabilis conspectus, 96 (IV/261):1–348. Verlag von Wilhelm Engelmann, Leipzig.

Bornmüller, J., 1928: Beiträge zur Flora Mazedoniens. III. Sammlungen in den Kriegsjahren 1916 – 1918. Bot. Jahrb. Syst. 61. Beibl. 140 : 1 – 195.

Buia, A., 1985: Orobanchaceae B. Juss. In: Savulescu, T. (ed.). Flora Republicii Populare Romine, 8:33-72. Academia Republici Populare Romine, Bucuresti.

Carlon, L. & al., 2005: More on some *Orobanche* L. and *Phelipanche* Pomel (*Orobanchaceae*) from the western Palearctic. Documentos Jard. Bot. Atlantico (Gijon), 3:1-72 (In Spanish, plus an Appendix in English).

Carlon, L. & al., 2008: More on some *Phelipanche* Pomel, *Boulardia* F.W Schultz and *Orobanche* L. (Orobanchaceae) from the western Palearctic. Documentos Jard. Bot. Atlantico (Gijon), 6:1-128 (In Spanish, plus an enlarged abstract in English).

Chater, A.O. & Webb, D.A., 1972: *Orobanche*. In: Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M. & Webb, D.A. Flora Europaea, 3:286-293. Cambridge.

Černjavski, P., 1943: Beitrag zur Kenntnis der Flora der Umgebung des Ochridasees. Ohridski zbornik, 35 (2):11-88. Srpska Kraljevska Akademija. Posebna izdanja. Beograd

Delipavlov, D., 1995: *Orobanche*. In: Kožuharov, S.I. & Kuzmanov, B.A. (Eds.). Flora Republicae Bulgaricae, 10:291-325. BAN. Sofia.

Dimitrov, A., 1908: Materijali po florata na Bitolskata okolnost. Periodičesko spisanie na Bugarskoto književno društvo, 69(1-2):693-748. Bugarsko

književno društvo, Sofija. Plovdiv.

Domina, G. & Raab-Straube, E. von (2010+): *Orobanche*. – In: Euro+Med Plantbase – the information resource for Euro-Mediterranean plant diversity. This work is licensed under a Creative Commons Attribution-ShareAlike 3.0 Unported license (CC-By-SA-3.0 Unported) (http:// ww2.bgbm.org/EuroPlusMed/query.asp).

Drenkovski, R., 1969: Ein Überblick über die flora des Vodnogebirges. GzPMF, Skopje, 21, 163 - 184.

Foley, M., 2000: A morphological comparison between some British *Orobanche* species (Orobanchaceae) and their closely-related non-British counterparts from continental Europe: *Orobanche reticulata* Wallr. s.I. Watsonia, 23:257-267. Botanical Society of Britain & Ireland.

Genevieve, G., Roeckel-Drevet, P., Grezes-Besset, B., Shindrova, P., Ivanov, P., Grand-Ravel, C., Vear, F., Tourvielle de Labrouche, D., Channet, G. & Nicolas, P., 1998: Study of the variability and evolution of *Orobanche cumana* populations infesting sunflower in different European countries. Theor. Appl. Genet (1998) 96: 1216-1222. Springer-Verlag.

Gilli, A., 1982: *Orobanche*. In: Devis, P. (Eds.). Flora of Turkey and the East Aegean Islands, vol. 7:1-23. Edinburg University Press.

Grecesku, D., 1899: Plantes de la Macedoine, apartenant Au vilayet de Monastir. Faculte de Medicine de Bucarest, Labaratoire de Botanique, 01-52 pp. Imprimerie de "L'independence Roumaine". Bucarest.

Grisebach, A., 1843: Spicilegium Florae rumelicae et bithynicae. Synopsin plantarum, 2:1-548. F. Wieweg, Brunsvigae.

Grupče, Lj., 1958: Vrz rastitelnosta na Skopska Crna Gora. FFU - Skopje, 9:3-80.

Hayek, A., 1929: Prodromus Florae Peninsulae Balcanicae, 2:224-225. Verlag des Repertoriums. Dahlem bei Berlin.

Jurišić, Ž., 1923: Prilog flori Južne Srbije. Spom. SKA, 60:1-45.

Kostov T. & Pacanoski Z., 2007: Weeds with major economic impact on agriculture in Republic of Macedonia. Pakistan Journal of Weed Science Research, 13 (3/4):227-239.

Kreutz, C.A.J., 1995: *Orobanche*. Die Sommerwurzarten Europas. Band 1. Mittel- und Nordeuropa. Maastricht: Stichting Natuurpublicaties Limburg, 1-159.

Matvejeva, L., 1965: Prilog poznavanju flore planine Žeden. ACTA, Mus. Maced. Scient. Nat., Skopje, 10 (2) : 27-65.

Matvejeva, J., 1968: Floristčki karakteristiki na Osoj. Fragmenta balcanica, Mus.Maced.Scient.Nat., Skopje, 6(15):141:148.

Micev, K. (=Micevski), 1952: Florata na Taorskata Klisura. GZbFF, kn. V., str. 1-54.

Nikolov, Z., 2019: *Orobanche elatior* Sutton and *Orobanche centaurina* Bertol. (Orobanchaceae) in the locality “Kozjak” (Skopje) in North Macedonia. ACTA Musei Macedonici Scientiarum Naturalium, 22/1:13 -20. Skopje.

Parabućski, S., 1974: *Orobanche*. In Josifović: Flora SR Srbije (ed.), 6:286-308. SANU, Beograd.

Parker, C., 2013. The parasitic Weeds of the Orobanchaceae. In: Joel, M.D., Gressel, J. & Musselman, L.J. Parasitic Orobanchaceae. Parasitic Mechanisms and Control Strategies. Springer. Heidelberg, New York, Dordrecht, London.

Petrović, J., 1941: Contribution to the flora of Skopje valley. Bulletin de la societe scientifique de Skoplje, 22(8):79-89.

Pignatti, S., 1982: Flora d’Italia. Volume II, Edagricole, Bologna.

Pineda-Markos, R., Pujadas-Salva, A. & Fernandez-Martinez, M. J., Stojanov, K., Velasco, L., Perez-Vich, R., 2014: The genetic structure of wild *Orobanche cumana* Wallr. (*Orobanchaceae*) Populations in Eastern Bulgaria Reflects Introgressions from Weedy Populations. Hindawi Publishing Corporation. The Scientific World Journal (http:// dx.doi.org./10.1155/2014/150432).

Piwowarczyk, R., 2014: *Orobanche flava* (Orobanchaceae) in Poland: current distribution, taxonomy, hosts and plant communities. Biodiv. Res. Conserv., 34:41-52. Sciendo.

Plantlist - A working list of all plant species that is result of the collaboration of Royal Botanic Gardens, Kew and Missouri Botanical Garden (http:// www.theplantlist.org).

Pujadas Salva, A.J. & Velasco, L., 2000: Comparative studies on *Orobanche cernua* L. and *O. cumana* Wallr. (*Orobanchaceae*) in the IberianPeninsula. Botanical Journal of the Linnean Society, 134: 513–527.

Pujadas Salva, A.J. (2003). *Orobanche flava* Mart. ex F.W. Schultz (Orobanchaceae) en la Península Ibérica. Anales Jard.Bot. Madrid 60(2): 387-393.

Pusch, J. & Günther, K.F., 2009: Gattung *Orobanche*. In:

Wagenitz, G. (Herausg.). Gustav Hegi Illustrierte Flora von Mitteleuropa, vol. VI/1A. Lieferung 1: 14–99, Weissdorn-Verlag, Jena.

Rudski, I., 1943: Contribution to the knowledge for the flora of Strumica surounding. Monographiarum, 136. Sectio Scientiarum Naturalium et Mathematicarum, 35. Acta Achridensia, 2:205-238. Regia Academia Serbica. Belgradi.

Soška, Th., 1937: Beitrag zur Kenntnis der Schluchtenfloren von Südserbien, I Teil. BSS Sk., t. XVIII, fasc. 6, p. 223 - 238.

Soška, Th., 1938-1939a: Beitrag zur Kenntnis der Schluchtenfloren von Südserbien, II Teil. BSS Sk., t. XX, fasc. 7, p. 35-58.

Soška, Th., 1953: Beitrag zur Kenntnis der Schluchtenfloren von Mazedonien. IV. Teil, Östliche Grenzschluchten. ACTA, Mus.Maced.Scien.Nat., Skopje, 1-3:61-77.

Stojanov, N., 1921: Floristički materijali od Belasica. Godišnik na Sofijskiot Univerzitet (ALF-Z), 15-16:1-133. Sofija.

Stojanoff, N., 1928: Thracische und mazedonische Herbarmaterialen des Verstorbenen Prof. Dr. Theodor Nikoloff. Spisanie BAN, 37(18):49-209, Sofija.

Teofilovski, A., 2011: Prilozi za florata na Republika Makedonija. Privatno izdanie, 1-142. Skopje.

Uhlich, H. & al., 1995: Die Sommerwurzarten Europa. Gattung *Orobanche*. Magdeburg: Westarp-Wiss.

Urumovъ, Iv. K., 1923: PrinosÔ za florata na B±lomorskata TrakiÔ. Spisanie BAN, 28(13):1-107. Sofija. (kniga br. 48).

Vandas, C., 1909: Reliquiae Formanekianae. Enumeratio critica plantarum vascularum i quasitineribus in Haemo peninsula et Asia Minore (Bithynia) factis collegit Dr. E. Formanek, Professor gymnasii Brunensis Bohemici. Brunae.

UDK: 591-196(497.7)
Received: 05.10.2020
Accepted: 25.10.2020
Original scientific paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 31-37
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

Some new and confirmed taxa in the flora of the Republic of North Macedonia

Aco Teofilovski
Public Enterprise Nacionalni šumi, Pero Nakov bb, 1000 Skopje, North Macedonia
acoteofilovski@hotmail.com

Abstract
One species and one subspecies which were not reported and three species which remained unconfirmed in the edition "The flora of the Republic of Macedonia" (Micevski 1985-2005), are reported in this paper. *Aethionema arabicum* and *Dianthus superbus* subsp. *superbus* are reported for the first time in the flora of the Republic of North Macedonia while the occurrence of the following doubtfully known species is confirmed with exact herbarium specimens: *Anemone sylvestris*, *Peucedanum cervaria* and *P. longifolium.* The phytogeographic importance of the recorded locality of the mainly SW Asian species *Aethionema arabicum*, near Štip, is discussed. Distribution of each taxa is mapped.

Key words: *Aethionema arabicum, Dianthus superbus* subsp. *superbus,* first record, confirmation, flora, species, Republic of North Macedonia.

Introduction

During the author's floristic excursions in the recent years, in the frame of the personal floristic studies, professional work and some applicative projects, floristic data from various parts of the country were collected. A wide range of terrestrial habitat types were included in the mentioned field studies: stony and rocky places, wet places, meadows, pastures, forests, ruderal places etc. In this paper is presented a selection of some noteworthy floristic data referring to taxa belonging to the genera which are treated in the so far published volumes of "The flora of the Republic of Macedonia" (Micevski 1985-2005, Matevski 2010).

Material and methods

During the field work appropriate herbarium specimens were collected and stored in the private herbarium of the author. Photographs of live specimens and their habitats are also taken in the field. Identification of the collected plants was conducted according to: The flora of the Republic of Macedonia (Micevski 1985-2005), Flora Europaea (Tutin & al., 1964 -1980), as well as some other relevant regional and national floras and monographic works. Relevant floristic literature is used to provide the chorological data (if present) for each of the treated taxa.

Results and discussion

Aethionema arabicum (L.) Andrz. ex DC. (Figs. 1, 2)

Štip: 0.9 km E of Jamularci village, open stony place, 230 m, 41°43'55.77"N, 22° 3'6.85"E, 9.5.2020, leg. A. Teofilovski & D. Mandzukovski, det. A. Teofilovski.

This is a new species in the flora of the Republic of North Macedonia.

Description: Annual with slender, simple or branched stems 10-15 cm. Lower leaves c. 15 mm, ovate, acute, the upper ovate, acute, cordate-amplexicaul at the base. Petals 2-3 mm, purplish. Silicula 6-12 mm, suborbicular, emarginated at the apex, with up to 6 seeds, very densely crowded, imbricate; style 0·5-1 mm, shorter than notch (Chater & Akeroyd 1993).

Aethionema W. T. Aiton is a genus of 75 species, with Turkey, which flora includes 56 species (of which 31 endemic), representing a center of its diversity (Ceter & al. 2018). In the flora of Balkan Peninsula (including Aegean Islands) seven species of this genus are present, of which three endemic to Greece and one to Bulgaria (Chater & Akeroyd 1993, Marhold 2011). In

Fig. 1. *Aethionema arabicum*
(Štip, Jamularci village, photo. A. Teofilovski)

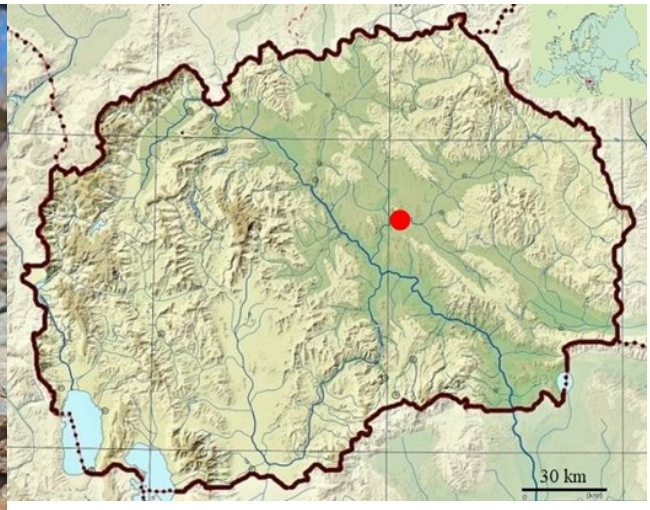

Fig. 2. Distribution of *Aethionema arabicum*
in the Republic of North Macedonia

the Republic of North Macedonia, the only other representative of this genus known to occur is *A. saxatile* (L.) W. T. Aiton which has a frequent occurrence in stony and rocky limestone areas of the country (Micevski & Matevski 1995). The latter species is easily distinguished from *A. arabicum* by its perennial habitus, leaves not cordate-amplexicaul at the base and fruits not densely crowded and imbricate.

The range of distribution of *A. arabicum* includes: Iran, Transcaucasia, Syria, Anatolia, East Aegean islands (Rodos) and the east part of Balkan Peninsula (Stojanoff & Stefanoff 1923, Hedge 1965, Tan & Suda 2002). In the mainland of Europe it was confirmed only on a single locality in the east part of Bulgaria (Sliven, Sotirya village) (Stojanoff & Stefanoff 1923, Stanev 2015) while the reported presence in Thrace and European part of Turkey (Hayek 1924, Chater 1964, Chater & Akeroyd 1993), according to the available data seems not to be confirmed (Hedge 1965, Velev 1970, Tan & Suda 2002). Nevertheless, Hedge (1965) reported this species quite close to the European part of Turkey, on the Asiatic coast of Dardanelles (Çanakkale).

On the locality near Jamularci village, *A. arabicum* grows as a pioneer species on shallow eroded soil, between more or less loose stones. It is a pronounced xero-thermophytic habitat, with a poor herbaceous plant cover. The recorded population is very small, with not more than 25 specimens observed, occupying an area of about 50 m^2. On the locality near Sliven in E Bulgaria, where the total population has been estimated to 50-60 individuals, the species grows on open or shrubby eroded stony terrains and screes, on limestone (Stanev 2015), in Turkey on fields and stony slopes (Hedge 1965), while on the island of Rodos (Greece) on ophiolitic rocks (Tan & Suda 2002).

From a phytogeographical point of view, the new locality of *A. arabicum* in the central part of the Republic of North Macedonia, is an interesting finding of an isolated miniature disjunction and a new easternmost point of the species range. The distances from the closest confirmed localities in E Bulgaria (Sliven) and NW part of Asiatic Turkey (Çanakkale) are 375 and 400 km, respectively.

The population of *A. arabicum* in the Republic of North Macedonia is an important point in its general distributional range, requiring an urgent valorization of the threats and appropriate conservation measures. The current conservation status of this species in Bulgaria is Critically Endangered (Stanev 2015).

Anemone sylvestris L. (Figs. 3, 4)

Delčevo: 1.1 km E of Zvegor village, black pine forest, limestone, 870 m, 41°57'50.72"N, 22°49'6.47"E, 24.6.2020, leg. A. Teofilovski & D. Mandzukovski, det. A. Teofilovski.

A rare species, which presence in the flora of the Republic of North Macedonia was obscurely known from a single report referring to Dub Mt., in the southeastern part of the country (Cirimotić 1958). This data was not confirmed in "The flora of S.R. Macedonia" (Micevski 1985).

Fig. 3. *Anemone sylvestris*
(Delčevo, Zvegor village, photo A. Teofilovski)

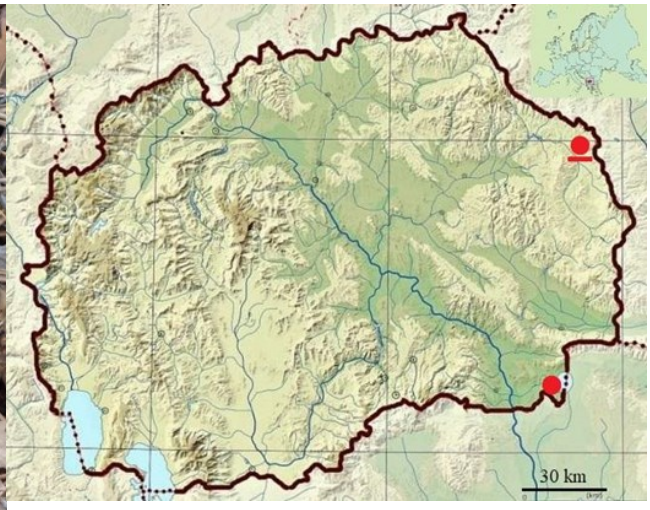

Fig. 4. Distribution of *Anemone sylvestris* in the Republic of North Macedonia. The underlined symbol is new locality.

A. sylvestris is an Eurasian species with a restricted distribution in the southern part of Europe and Balkan Peninsula. Among the country neighboring the Republic of North Macedonia, in Serbia it is restricted to southern part of Vojvodina and the vicinity of Belgrade (Gajić 1992), distributed in most of the floristic regions in Bulgaria (Assyov 2012), while missing from the flora of Kosovo, Greece and Albania (Gajić 1992, Strid 2002, Barina & al. 2018).

Dianthus superbus L. subsp. *superbus* (Figs. 5, 6)

Berovo: 1 km south of Avramski Kolibi, meadows, 1025 m, 41°37'11.41"N, 22°50'44.65"E, 2.8.2017, leg. & det. A. Teofilovski.

This is the first report of this subspecies in the flora of the Republic of North Macedonia. About 20 individuals were recorded growing in a somewhat moist meadow, on deep silicate soil.

Fig. 5. *Dianthus superbus* subsp. *superbus*
(Berovo, Avramski Kolibi, photo A. Teofilovski)

Fig. 6. Distribution of *Dianthus superbus* subsp. *superbus* in the the Republic of North Macedonia

Fig. 7. *Peucedanum cervaria*, parts of herbarium specimen (Tetovo, Rogačevo village, photo A. Teofilovski)

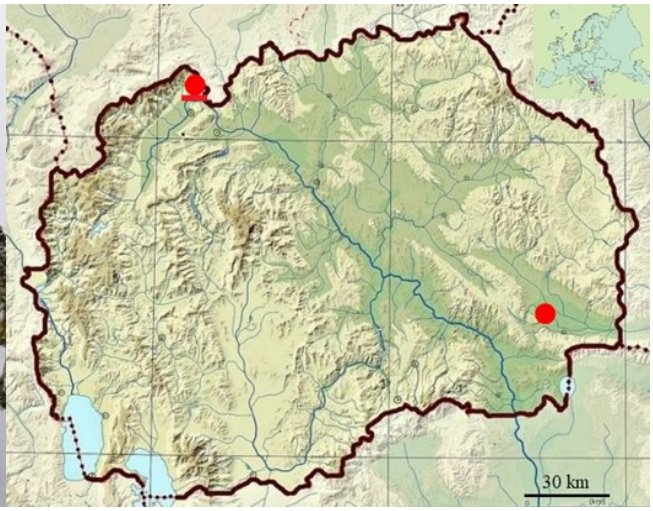

Fig. 8. Distribution of *Peucedanum cervaria* in the Republic of North Macedonia. The underlined symbol is new locality

The collected specimens are entirely green plants with petal limbs ca. 20 mm long, therewith clearly matching to *D. superbus* subsp. *superbus*. The only other subspecies of *D. superbus* also occurring in the Republic of North Macedonia, the high mountain taxa subsp. *alpestris* Čelak, is recognized by its, in general, glaucous appearance and longer petal-limbs (30 mm). Micevski [1993, sub *D. superbus* subsp. speciosus (Reichenb.) Pawl.] reported subsp. *alpestris* only from Šar Mountains (Elak) in the same time referring to it all literature reports of *D. superbus* s.l. The latters originate from the high parts of Šar Mountains (Rudoka, Vraca) (Horvat 1936) and Osogovo Mt. (Carev Vrv) (Urumov 1923).

Peucedanum cervaria (L.) Lapeyr. (Figs. 7, 8)

Tetovo: Šar Mountains, near the road to Rogačevo village, grassy place, 740 m, 42°8'50.80"N, 21° 9'27.88"E, 11.7.2018, leg. & det. A. Teofilovski.

This is the first confirmation of this species in the Republic of North Macedonia. The only report in the literature, referring to Strumica (Kosovi Nivi) (Rudski 1943), was not considered a reliable data in "The flora of the Republic of Macedonia", and thereby, the species was not included in the checklist of the genus *Peucedanum* L. (Matevski 2005).

On the locality near Rogačevo village, only one specimen was recorded growing in a grassy place near the road to Staro Selo village. The additional efforts to find more individuals along the mentioned road appeared unsuccessful.

The range of *P. cervaria* encompasses much of C & S Europe and Algeria, including all Balkan countries except Greece, Kosovo and European part of Turkey (Hand 2011, Nikolić 1973). In the flora of Albania and Bulgaria, according to the available data it has only a restricted distribution (Assyov & al. 2012, Barina & al. 2017) while its occurrence in some parts of Serbia is very common (M. Niketić 2020, pers. comm.)

P. cervaria is easily distinguished from the other European *Peucedanum* species by its characteristic

Fig. 9. *Peucedanum longifolium*
(Štip, Bogoslovec, photo. A. Teofilovski)

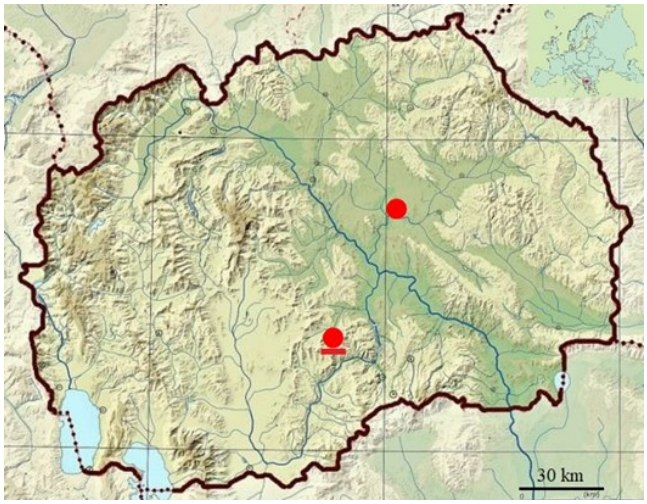

Fig. 10. Distribution of *Peucedanum longifolium* in the Republic of North Macedonia. The underlined symbol is new locality.

ovate to ovate-oblong leaf lobes which length is 12-30 (50) mm.

Peucedanum longifolium Waldst. & Kit. (Fig. 9, 10)

Štip: Bogoslovec, stony and shrubby places, S slopes, 480-570 m, 41°45'6.23"N, 22°2'26.88"E, 20.5.2019, leg. A. Teofilovski & D. Mandzukovski, det. A. Teofilovski.

This is a first confirmation of the species occurrence in the flora of the Republic of North Macedonia. It was included in the treatment of the genus *Peucedanum* L. in "The flora of the Republic of Macedonia" (Matevski 2005) on a base of the only literature report from the vicinity of Prilep (Dren) (Stojanoff 1928).

The distributional area of this species includes: Turkey, Transcaucasia, Georgia and all Balkan countries (Hand 2011). It belongs to the taxonomically difficult *P. officinale* complex, represented in Balkan Peninsula also by the S, C & W European species *P. officinale*. The latter was reported only recently for the first time in the Republic of North Macedonia, from the serpentine and limestone areas northwest of Skopje (Raduša, Orašje) (Teofilovski 2015).

P. longifolium differs from *P. officinale* generally by the narrower, up to 1 mm wide and keeled leaf-lobes and shorter fruit pedicels. Having in consideration the difficulties in delimitation, Frey (1989) in his monographic work of some sections in the genus *Peucedanum*, proposed a subspecific rank of *P. longifolium* in the frame of *P. officinale*. However, this proposal was not accepted in the recent synthetic floristic works and broader databases (Hand 2011, Assyov & al. 2012, Dimopoulos & al. 2013, Barina & al. 2018, The Plant List). Waiting to a modern taxonomic study, all the so far treatments of *P. officinale* complex seem to be considered only provisional.

On Bogoslovec hill, *P. longifolium* occurs abundantly on an area of c.10 ha, on dry shrubby and stony places. All the examined individuals have keeled and narrow leafs lobes (0.5 mm), umbellules with less than 25 flowers and relatively short and strait fruiting pedicels (10-14 mm), therewith satisfactorily matching to *P. longifolium* (see Tutin 1968, Hartvig 1986).

Conclusions

Aethionema arabicum, a species with a main distribution in SW Asia and only a single previously known locality in the mainland of Europe (Sliven, E Bulgaria), is recorded for the first time in the flora of the Republic of North Macedonia. Ca. 25 individuals were recorded in a small area in the vicinity of Jamularci village (Štip). The new record is of significant phytogeographic importance, representing a new easternmost disjunction of the species range, with the closest known locality Sotirya village (Sliven, E Bulgaria) being situated 375 km northwest – west.

Dianthus superbus subsp. *superbus,* a lowland subspecies *of D. superbus,* is recorded for the first time in the flora of the Republic of North Macedonia, near Avramski Kolibi (Berovo).

The following three species, known from a single old literature report but not confirmed in the edition "The flora of the Republic of Macedonia" (Micevski 1985-2005), were confirmed with specific herbarium specimens:

- *Anemone sylvestris,* previously known only from a single report from Dub Mt. (Cirimotić 1958), is recorded near Zvegor village (Delčevo).

- *Peucedanum cervaria*, reported only from Strumica (Kosovi Nivi) (Rudski 1943), is recorded at the foothill of Šar Mountains, near Rogačevo village (Tetovo).

- *Peucedanum longifolium*, reported only from Dren village (Prilep) (Stojnoff 1928), is recorded on Bogoslovec hill (Štip).

Acknowledgments

A largest part of the work was conducted in the frame of the project "The Nature Conservation Pro-

gramme in the Republic of North Macedonia – Phase II" (*Swiss Agency for Development and Cooperation; implemented by* Pharmahem – Skopje and HELVETAS Swiss Intercooperation; contractor Macedonian Ecological Society) to which the author expresses his gratitude. I am also grateful to the reviewers D-r Mitko Kostadinovski and D-r Marjan Niketić for the critical suggestions that improved the earlier version of the manuscript.

References

Assyov, B., Petrova, A., Dimitrov, D. & Vassilev, R., 2012. Conspectus of the Bulgarian vascular flora. Distribution maps and floristic elements. ed. 4, Bulgarian Biodiversity Fondation, Sofia.

Barina, Z., Mullaj, A., Pifkó, D., Somogyi, G., Meco, M., & Rakaj, M., 2017. Distribution maps. - In: Barina, Z. (ed.): Distribution atlas of vascular plants in Albania. Hungarian Natural History Museum, Budapest, 47-445.

Barina, Z., Somogyi, G., Pifkó, D. & Rakaj, M., 2018. Checklist of vascular plants of Albania. Phytotaxa, 378: 1 – 339.

Ceter, T., Geven, F., Sahin, A.A., & Ceter, S., 2018. Examination of pollen morphology of some *Aethionema* (Brassicaceae), from Turkey. Communications Faculty of Science University of Ankara Series C, 289(1): 11-24.

Chater, A.O. & Akeroyd, J. R., 1993. *Aethionema* R. Br. - In: Tutin, T. G., Burges, N. A., Chater, A. O., Edmondson, J. R., Heywood , V. H., & Moore, D. M. (eds) Flora Europaea (2nd edition). 1: 179–182 Cambridge: Cambridge University Press.

Chater, A.O., 1964: *Aethionema* R. Br. - In: T. G. Tutin & al. (eds.), Flora Europaea 1: 322. Cambridge: Cambridge University Press.

Cirimotić, J., 1958. Zur Kenntnis der Flora des Gebirges Dub bei "Doiran See". Annuaire de la institut de Sylviculture. Skopje, 3: 175-210. (In Macedonian)

Dimopoulos, P., Raus, Th., Bergmeier, E., Constantinidis, Th., Iatrou, G., Kokkini, S., Strid, A. & Tzanoudakis, D., 2013. Vascular plants of Greece: An annotated checklist. Englera, 31: 1-372.

Frey, R., 1989. Taxonomische Revision der Gattung *Peucedanum*: Sektion *Peucedanum* und Sektion *Palimbioidea* (Umbelliferae). Candollea, 44: 257-327.

Gajić M. 1992. *Anemone* L. In: Sarić M. (ed.), The Flora of Serbia 1, Serbian Academy of the Sciences and the Arts, Beograd, 317-324.

Hand, R., 2011. Apiaceae. – In: Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. http://www.emplantbase.org/home.html.

Hartvig, P., 1986. *Peucedanum* L. In: Strid, A. (ed.), Mountain Flora of Greece, Vol. 1. London, Cambridge University Press, pp. 714-722.

Hayek, A., 1924-1927. Prodromus Florae peninsulae Balcanicae, 1. Repertorium specierum novarum regni vegetabilis. 30 (1): 1-1193.

Hedge, I. C., 1965. *Aethionema* R. Br., In: Davis, P. H. (ed.), Flora of Turkey and the east Aegean Islands. 1: 314-330, Edinbugh University Press.

Horvat, I., 1936. Istraživanje vegetacije planina Vardarske banovine II. Ljetopis Jugoslavenske Akademije, Zagreb, p. 47- 51.

Marhold, K., 2011. Brassicaceae. – In: Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. http://www.emplantbase.org/home.html.

Matevski, V., 2005. *Peucedanum* L. In: Micevski, K. (ed.). The Flora of the Republic of Macedonia 1(6). pp. 1627-1635, Macedonian Academy of Sciences and Arts, Skopje. (In Macedonian)

Matevski, V., 2010. The Flora of the Republic of Macedonia, 2(1). Macedonian Academy of Sciences and Arts, Skopje, 1-187. (In Macedonian)

Micevski, K. & Matevski, V. 1995. *Aethionema* R. Br. In: Micevski K. The flora of the Republic of Macedonia, 1(3). Macedonian Academy of Sciences and Arts, Skopje, 717-719.

Micevski, K., 1985. The flora of SR Macedonia, 1(1). Macedonian Academy of Sciences and Arts, Skopje, 1-152. (In Macedonian)

Micevski, K., 1993. The flora of the Republic of Macedonia 1(2). Macedonian Academy of Sciences and Arts, Skopje, 153-391. (In Macedonian)

Micevski, K., 1995. The flora of the Republic of Macedonia, 1(3). Macedonian Academy of Sciences and Arts, Skopje, 398-778

Micevski, K., 1998. The flora of the Republic of Macedonia 1(4). Macedonian Academy of Sciences and Arts, 781-1113. (In Macedonian)

Micevski, K., 2001. The flora of the Republic of Macedonia 1(5). Macedonian Academy of Sciences and Arts, Skopje, 1121-1430. (In Macedonian)

Micevski, K., 2005. The flora of the Republic of Macedonia 1(6). Macedonian Academy of Sciences and Arts, Skopje 1433-1715. (In Macedonian)

Nikolić, V., 1973. Apicaeae Lindley. In: Josifović, M. (ed.). Flore Republique Socialiste de Sebie. Vol. V. Academie Serbe des Sciences et des Arts, Beograd, 183-349. (In Serbian).

Rudski, I., 1943. Beitrag zur Kenntnis der Flora der Umgebung von Strumica. Ohridski zbornik, 35(2): 205-238. (In Serbian)

Stanev, S., 2015. *Aethionema arabicum*, in Peev, D., Petrova, A., Anchev, M., Temniskova, D., Denchev, C.M., Ganeva, A., Gussev, Ch. & Vladimirov, V. (eds.). Red Data Book of the Republic of Bulgaria 1. Plants & Fungi. Institute of Biodivetsity and Ecosystem Research. Sofia.

Stojanoff, N., 1928. Thracische und Mazedonische Herbarmaterialen des Verstorbenen Prof. Dr. Theodor Nikoloff. Zeitschrift der Bulgarische Akademie der Wissenschaften, 18: 49-209.

Stojanoff, N. & Stefanoff, B., 1923. Zur Flora Bulgariens und Mazedoniens. Oesterreichische botanische Zeitschrift, 72: 85–92.

Strid, A., 2002. *Anemone* L. In: Strid, A. & Tan, K. (eds.), Flora Hellenica 2, pp. 25-29, Koeltz Scientific Books, Königstein.

Tan, K. & Suda, J., 2002. *Aethionema* R.Br. – In: Strid, A. & Tan, Kit (eds), Flora Hellenica. Vol. 2, pp. 261-265. Gantner Verlag, Ruggell.

Teofilovski, A., 2014. Reports 213-239. In: New floristic records in the Balkans: 25. (compilators Vladimirov V., Matevski V., Dane F., Kit Tan). Phytologia Balcanica, 20(2-3): 295-301.

Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (eds.), 1964-1980. Flora Europaea 1-5. The University Press, Cambridge.

Tutin, T.G., 1968. *Peucedanum* L. In: Tutin T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M. & Webb, D.A. (eds.), Flora Europaea, Vol. 2. Cambridge, Cambridge University Press, pp. 360-364.

Urumov, Iv.K., 1923. Beiträge zur Flora of Belomorska Trakija. Issue of Bulgarian Academy of Sciences, 28 (13): 1-107.

Velev, St., 1970. *Aethionema* R. Br., In: Jordanov, D. (ed.). Flora Republica Popularis Blgaricae. Vol. IV. Academia Scientarium Bulgarica, Institutum Botanicum cum Horto, Sofia, 557 – 558. (In Bulgarian)

UDK: 582.661.51(497.7)
Received: 17.09.2020
Accepted: 18.10.2020
Original scientific paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 39-44
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

Dianthus pallidiflorus Ser., another steppe-element in the flora of the Republic of North Macedonia

Zoran Nikolov

Natural History Museum of the Republic of North Macedonia, Blvd. Ilinden 86, 1000 Skopje, North Macedonia,
e-mail: znikolov61@yahoo.com

Abstract
Dianthus pallidiflorus, a steppe-element described from southern Russia, is recorded for first time, for the flora of the Republic of North Macedonia. The only, so far, known locality is "Tekijski rid", nearby the village Tekija (Skopje valley). A survey of different approaches and solutions, in the works of many authors, for the existence and taxonomic rank of another species – *Dianthus aridus* (described from Bulgaria) that concerns *D. pallidiflorus* (as separate species, synonym or included to *D. pallidiflorus*), is also given. Photos of the plants and the locality as well as drawings of taxonomic important parts of the flower are also presented.

Key words: *Dianthus pallidiflorus*, steppe-species, "steppe-like" vegetation, Flora, Republic of North Macedonia.

Introduction

Dianthus pallidiflorus is a steppe species, described by Seringe (1824) from southern Russia - in herbidis ad Volgam [(in Krasnoarmeisk (Sarepta), Shishkin, 1935)].

The appearance of "steppe" and steppe elements, in the flora of the Republic of North Macedonia, has caused attention for a long time (Košanin, 1924; Černjavski & al., 1937; Micevski, 1971, 1978, 2001; Micevski & Matevski, 1987; Matevski & al., 2008). Whether "natural steppe" or not, was questionable for the vegetation that develops in the central part of the country, between the towns Veles, Štip and Negotino. Based on comparison and lack of some key elements that characterized the real, natural steppe, Micevski (1971) suggested the term "steppe-like" vegetation, as the most proper. Nevertheless, it didn't diminish the significance of this vegetation because of the presence of steppe species or species with semi-desert origin as relicts of the former steppe vegetation that developed on this territory (Micevski, 1971, 1978; Matevski & al., 2008). Within the steppe region, Matevski et al. (2008) recorded the following endemic and relict species: *Tulipa mariannae* Lindner, *Astragalus cernjavskii* Stoj., *Heptaptera macedonica* Micevski and *Salvia jurisicii* Košanin, with very restricted distribution. Four more species, *Hedysarum macedonicum* Bornm., *Ferulago macedonica* Micevski, *Onobrychis megalophylla* Gris. and *Potentilla tridentula* Vel., are with somewhat wider distribution, but still limited to the territory of the Republic of North Macedonia (Matevski et al., 2008). Besides, two other steppe species: *Cardopatium corymbosum* (L.) Pers. and *Galatella villosa* (L.) Rchb. fil. are found only in this central steppe region in the Republic of North Macedonia, but are also distributed in other countries. The list of the species found only in the steppe-like region is supplemented by the following halophytes: *Artemisia maritima* L., *Kraschenikovia ceratoides* (L.) Gueldenst. *Camphorosma monspeliaca* L. and *Camphorosma annua* Pall. (Matevski et al, 2008). In the survey of the steppe species, the same authors recorded also *Astragalus parnassi* Boiss., *Morina persica* L. and *Convolvulus holosericeus* M.B. To this list of species of steppe origin, *Astragalus gracaninii* Micevski, found in the steppe-like locality "Krasta" (v. Pčinja, Kumanovo) should be added (Micevski, 1971, 2001).

Here we present the finding of another steppe species of plant, *Dianthus pallidiflorus* Ser., which is the first record for the flora of the Republic of North Macedonia.

Fig. 1. *Dianthus pallidiflorus* Ser.
a) Habitus
b) Flower with longer epicalyx scales (c. ⅔ as long as the calyx)
c) Flower, with shorter epicalyx scales (c. ½ as long as the calyx)

Materials and methods

The plants were collected from the locality "Tekijski rid", in the vicinity of the village Tekija, eastern part of Skopje valley, c. 20 km from the capital. Voucher specimens are deposited in the herbarium of the Natural History Museum of the Republic of North Macedonia. Relevant literature sources were used for the determination of the material (Hayek, 1924; Shishkin, 1935; Stojanov, 1966; Petrova, 1992; Tutin & Walters, 1993).

Taxonomic status

Taxonomic status of *D. pallidiflorus* is stable, only the rank is different, by different authors. Seringe (1824) described this taxa as *D. pallidiflorus* sp. n. that was later accepted in the works of many authors: Lessing (1835), Boissier (1867), Shishkin (1936), Grossgeim (1945), Petrova (1992), Tutin & Walters (1993), Fedorončuk & Čornei (2005), Petrova & Vladimirov (2009), Marhold (2011). Schmalhausen (1895), who changed the species-rank of *D. pallidiflorus* to subspecies of *Dianthus campestris* Bieb. (*D. campestris* subsp. p*allidiflorus*), found his followers in the works of Stojanov & Achtarov (1935), Stojanov (1966), Dimitrov (2002), Uruşak & al. (2013).

Dianthus aridus Griseb., separate species or?

Grisebach (1873 ex Janka) described *Dianthus aridus* sp. n. from the territory of Bulgaria (Sliven). The appearance of this species didn't question the existence nor the taxonomic rank of *D. pallidiflorus*, but the dilemma whether this species should be treated as a separate (Hayek, 1924; Petrova, A., 1992; Zarkos & al., 2018), be included to *D. pallidiflorus* (Tutin & Walters, 1993) or synonymized (Marhold, 2011), still exists. The comparation of the original descriptions of *D. pallidiflorus* (Seringe, 1824) and *D. aridus* (Grisebach, ex Janka, 1873), even the one of Seringe is really short, reveals that the only reliable difference that actually separate these two species is the layout of the flowers. Namely, Seringe (1824) alleged "floribus solitaries", while in Grisebach's diagnosis (1873) stands "flores fasciculati, fasciculi 3-4flori". The solitary flowers stand on longer, the flowers in clusters, on shorter pedicels.

The existence or the taxonomic rank of *D. aridus* was treated differently, in the works of many authors that primarily concerned the flora from the Balkan Peninsula (Hayek, 1924; Stojanoff & Achtarov, 1935; Stojanov, 1966; Petrova, 1992; Tutin & Walters, 1993; Dimitrov, 2002; Assyov, Petrova, Dimitrov & Vasilev, 2012).

Hayek (1924), in his capitol work, alleged *D. aridus* for Bulgaria, Thracian and Macedonia. Regarding the layout and the color of the flowers, Hayek (1924) noticed: "flowers solitary vel 2-4-ni" and "lamina ochroleuca". In Grisebach's original description, the flowers are "fasciculati: fasciculi 3-4 flori" and the lamina is "leucantha". Consequently, plants with solitary flowers as well as plants with flowers in groups of 2-4 can be considered as *D. aridus*.

Stojanoff & Achtaroff (1935), in the detailed study of the genus *Dianthus*, for the territory of Bulgaria, alleged *D. pallidiflorus* as a subspecies of *D. campestris*. In spite of the data for the epicalyx length by Seringe (1824), the authors noticed that the epicalyx scales in subsp. *pallidiflorus*, that usually reach the half of the calyx, can sometimes reach even the base of the calyx teeth. In the frame of this subspecies, they separated

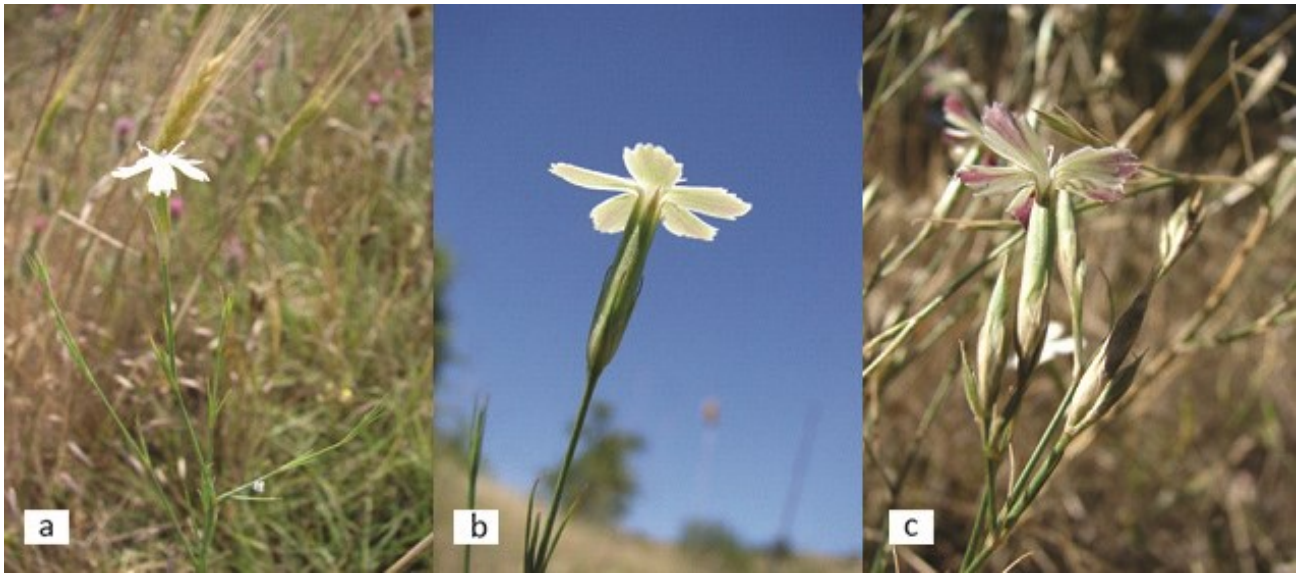

Fig. 2. *Dianthus pallidiflorus* Ser.
a) Habitus b) Flower (light-greenish below) c) Flowers (pale-pink below)

two varieties: *pseudoramosissimus* Stoj & Acht., with "solitary flowers, rarely 2-3; epicalyx scales 4; calyx 13-15 mm; flowers white to pale pink", and var. *aridus* (Jka) Stoj. & Acht. (*D. aridus* Janka), with "flowers mostly 2-4; epicalyx scales 4-6; calyx 10-13 mm long; flowers white". Apparently, the layout of the flowers is the main difference between these two varieties.

Stojanov later (1966) kept the same combination – *D. campestris* subsp. *pallidiflorus*, but this time he treated *D. aridus*, *D. aridus* var. *puberulus* and *D. campestris* var. *pseudoramosissimus* as synonyms of the subspecies *pallidiflorus*.

Petrova (1992), on the base of the habitus, layout of the flowers and the length of the pedicels, alleged *D. pallidiflorus* and *D. aridus* as separate species, for the territory of Bulgaria.

Tutin & Walters (1993) also recorded *D. pallidiflorus*, but they included *D. aridus* to *D. pallidiflorus*. The description of some characteristics is as following: flowers usually long-pedicilate; epicalyx-scales usually 4, ⅓ - ¾ as long as calyx; calyx 10-14 mm; petal-limb 4-6 mm, white or pale-pink.

Dimitrov (2002), following the line of Stojanov (1966), recorded *D. campestris* subsp. *pallidiflorus*. But, in spite of Stojanov (1966), who synonymized *D. aridus*, Dimitrov included *D. aridus* to subsp. *pallidiflorus*.

Marhold (2011) accepted *D. pallidiflorus* and synonymized *D. aridus* Janka, *D. moeticus* Klokov and *D. campestris* subsp. *pallidiflorus* (Ser.) Schmal. In the distribution area of the species, he included Bu, Gr, Tu, U (K,U).

Uruşak & al. (2013), alleged *D. campestris* subsp. *pallidiflorus*, for the territory of European Turkey.

Finally, the data for the presence of *D. aridus* in Greece (Zarkos, Christodoulou, Tan & Vold., 2018), actualizes again the existence and the species rank of this taxa.

Description of the plants from the locality Tekijski rid (village Tekija), Skopje valley

Multicaulis, herbaceous perennial, with stout stock. Stem up to 60 cm, branched above, puberulent in the lower part. Basal leaves absent at anthesis, cauline 2-5 cm long, liniear, acute, serrulate, glabrous, shorter than internodes. Leaf-sheaths, in the lower part of the stem c. 4 mm long. Flowers solitary, long pedicelate. Epicalyx scales 4, ovate-lanceolate with scarious margins, c. ½, very rare ¾ of the calyx length, the inner scales shorter aristate, the outer varying, from shorter to longer aristate, sometimes reaching almost the base of the calyx teeth. Calyx (12)13-14(15) mm, glabrous, calyx teeth up to 6 mm, with scarious-ciliate margins. Petal-limbs dentate, bearded, white above and light greenish or rarely pale-pink, bellow.

Distribution

D. pallidiflorus is a steppe element, described by Seringe (1824), from southern Russia. Tutin & Walters (1993), extend the distribution area of *D. pallidiflorus* (including *D. aridus*) from S. E. Europe to S.E. Russia, including Bu,? Gr Rs (?C. W. K. E.). Data for the pres-

ence of *D. pallidiflorus*, on several localities in Ukraine, we find in the work of Fedoronçuk & Čornei (2005). According to Marhold, (2011), the distribution area of this species (Syn. *D. aridus*) includes the territories of Greece, Bulgaria, Ukraine and Turkey.

Results and discussion

Dianthus pallidiflorus Ser. in DC. Prodr. 1: 358 (1824).

[Syn. *D. campestris* subsp. *pallidiflorus* (Ser.) Scmalh. in Ledeb., Fl. Ross. 1: 447. (1895); *D. maeoticus* Klok. in Scient. Magaz. of Biology:13 (1927)].

– Skopje: village Tekija, locality "Tekijski rid", 300-350 m.a.s.l., 26.06.2015; Leg./Det.: Z. Nikolov.

– Skopje: village Tekija, locality "Tekijski rid", 373 m.a.s.l., 28.07.2020; N: 41º59.850' E: 021º40.638'. Leg./Det.: Z. Nikolov.

The plants, collected from the locality "Tekijski rid" (village Tekija), match the description of *D. pallidiflorus* given by Seringe (1824), Boissier (1867), Shishkin (1935), Tutin & Walters (1993). The flowers are dominantly solitary (Fig. 1, a; Fig. 2, a,b), the corolla is white above, greenish or rarely pale-pink below (Fig. 2, a,b,c), calyx ± cylindrical (Fig. 3, a), epicalyx scales that are sometimes with different length (Fig. 3, d,e), usually reach the half of the calyx length (Fig. 3, b), rarely the base of the calyx teeth (Fig. 3, c). The petals have tuft of hairs at the base (Fig. 3, f).

Vital and numerous population of *D. pallidiflorus* grows on dry grasslands (Fig. 4, a) with *Paliurus spina-christi* Mill. and *Quercus pubescens* Willd. as well as on former arable lands, following often the edges and the middle line of black roads. The flowering period lasts from the end of June to the end of August.

D. pallidiflorus is a new species for the flora of the Republic of North Macedonia and "Tekijski rid" (village Tekija) is so far, the only known locality (Fig. 4, b).

Micevski (1993), among the species of the genus *Dianthus* recorded in the literature but not confirmed during the researches for the Flora of the Republic of North Macedonia, alleged Hayek's data for *D. aridus* Griseb. ex Janka (1924). Nevertheless, the match of our plants with the diagnosis of Seringe (1824), Boissier (1867), Shishkin (1935), Tutin & Walters (1993) allows us, without any doubt, to stay confirm that the population that grows on this locality belongs to *D. pallidiflorus*. The latest data from Greece (Zarkos, Christodoulou, Tan & Vold., 2018) that brought back *D. aridus* in focus of interest, will surely initiate new researches in

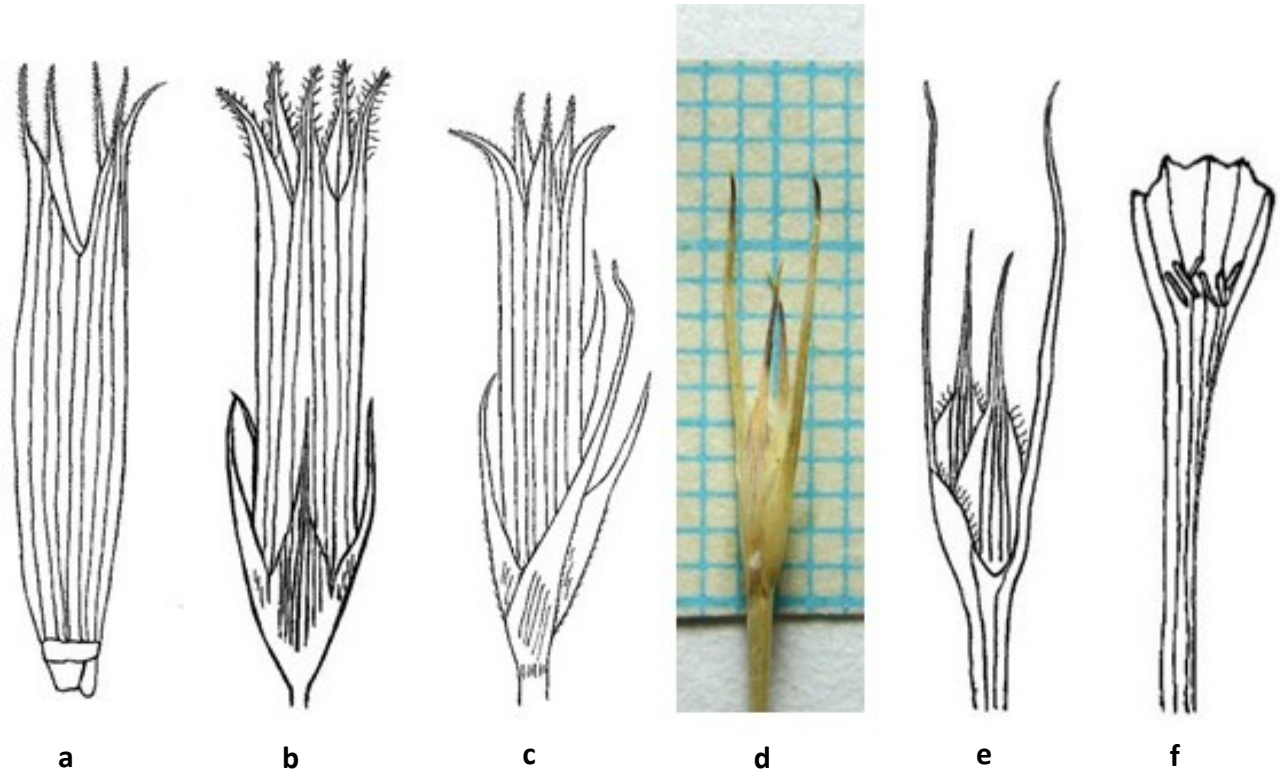

Fig. 3. a) Calyx b) Calyx with epicalyx (c ½) c) Calyx with epicalyx (c. ⅔) d, e) Epicalyx (different length of outer and inner scales) f) Petal with tuft of hairs

a **b**

Fig. 4. *Dianthus pallidiflorus* Ser.
a) Locality "Tekijski rid" (village Tekija) b) Distribution map

order to justify or eventually dispute its status, as a separate species.

This finding of *D. pallidiflorus*, in the eastern part of Skopje valley (village Tekija), elongated the already existed list of steppe species and enriched the flora of the Republic of North Macedonia with one interesting flora's element, from the Russian steppes.

Acknowledgements

I am grateful to the reviewers Vlado Matevski and Dimitar Dimitrov for their help and useful suggestions in improving the manuscript.

References

Assyov, B., Petrova, A., Dimitrov, D. & Vasilev, R., 2012: Conspectus of the Bulgarian vascular flora. Forth revised and updated edition. Bulgarian Biodiversity Foundation. Sofia.

Boissier, E. 1867: Flora Orientalis, I:504-505. Thalamiflorae. Geneve.

Černjavski, P., Rudski, I. & Soška, T., 1937: Kratak pregled vegetacije Južne Srbije. Spom. 25-god. Osl. Južne Srbije, 135-159. Skopje.

Dimitrov, D., 2002: *Dianthus campestris* subsp. *pallidiflorus* (Ser.) Schmal. (incl. *D. aridus* Griseb.). In: Greuter, W. & Raus, Th. (Ed.). Med-Checklist Notulae, 21. Willdenowia, 32:196.

Fedoronçuk, M.M. & Čornei, I.I., 2005: РИД *Dianthus* L. (Caryophyllaceae) Флори Украини: Таксономичний I Созологичний анализ. Заповидна справа в України. Том 11. Винуск 2.

Grisebach, A. von, 1873. *Dianthus aridus*. In: Plantarum novarum turcicarum breviarium. Victore de Janka. II. ÖBZ, 23:196. Wien.

Grossgeim, A. A., 1945: Flora Kavkaza, 2:287. (Eds.) Tom III. Saururaceae – Caryophyllaceae. Baku.

Hayek, A., 1924: Prodromus Florae peninsulae Balcanicae, 1:242. Verlag des Repertoriums, Berlin-Dahlem.

Lessing, Ch. Fr., 1835: Beitrag zur Flora des südlichen Urals und der Steppen. Linnaea, 9:169. Halle.

Marhold, K. (2011): Caryophyllaceae. – In: Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity.

Matevski, V. & al., 2008: Flora and Vegetation of the Macedonian Steppe. SAZU, Ljubljana.

Micevski., K., 1971: *Astragalus grcaninii* Micevski sp. n. in the flora of Macedonia. Annuaire. Faculté des Sciences Naturelles de L'Université Kiril et Metodij, 23:121-130. Skopje.

Micevski, K., 1971: "Steppe" vegetation in Macedonia. Annuaire. Faculté des Sciences Naturelles de L'Université Kiril et Metodij, 23:131-150. Skopje.

Micevski, K. & Matevski, V., 1987: Territorial distribution of endemics in SR Macedonia and the problem of their threats. Special editions, 14:199-207. Academy of Sciences and Arts. Dep. of Nat. Scien. Saraevo.

Micevski, K., 1993: The Flora of the R. of Macedonia,

I/2:390. Eds. Macedonian Academy of Sciences and Arts. Skopje.

Petrova, A., 1992: Caryophyllaceae. In: Andreev, N. & al. Opredelitel na višite rastenija vo Bugarija. Nauka i Iskustvo. Sofija.

Petrova, A. & Vladimirov, V., 2009: Red List of Bulgaria vascular plants. Phytologia Balcanica, 15(1):63-94. Sofia.

Schmalhausen, I.F., 1895: Flora of Middle and South Russia, Crimea and North Caucasus, 1:447. Kiev.

Seringe, N. Ch., 1824. *Dianthus*. In: De Candolle, A.P. Prodromus systematis naturalis regni vegetabilis, 1:358. Parisiis.

Shishkin, B.K., 1936. Caryophyllaceae. In: Komarov, V.I. (Eds.) Flora of the USSR, 6:634-635. Moskva – Leningrad.

Stojanoff, N. & Achtaroff, B., 1935: Kritische Studien über die Nelken Bulgariens. Sbor. Akad. Nauk, 29:67 -68. Sofia.

Stojanov, N., 1966. *Dianthus* L. In: Jordanov, D. (Eds.). Flora of the People's Republic of Bulgaria, 3:426. Bulgarian Academy of Sciences, Sophia.

Tutin, T.G. & Walters, S.M., 1993. *Dianthus* L. In: Tutin T.G. & al. Eds. Flora Europaea, 1:244 (second edition). Cambridge University Press. Cambridge.

Uruşak, E.A. & al., 2013: The flora of Yıldız Mountains (Kırklareli) Biosphere Project area. Tübitak, 37: 225-269. Turkish Journal of Botany.

Zarkos, G., Christodoulou, V., Tan, K. & Vold, G., 2018: *Dianthus aridus* Griseb. ex. Janka. In: Vladimirov, V., Aybeke, M. & Tan, K. New floristic records in the Balkans: 36*. Reports 156-180. Phytologia Balcanica, 24(2): 285. Sofia.

UDK: 595.76-152(497.7)
595.76-152(497.16)
Received: 05.11.2020
Accepted: 28.11.2020
Original scientific paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 45-50
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

First records of rare saproxylic beetle *Cucujus cinnaberinus* (Scopoli, 1763) in the Republic of North Macedonia and Montenegro

Aleksandra Cvetkovska-Gjorgjievska[1], Jaakko Mattila[2], Petri Ahlroth[3], Slavčo Hristovski[1]

[1] Institute of Biology, Faculty of Natural Science and Mathematics, Ss. Cyril and Methodius University, Arhimedova 3, P.O. Box 162, 1000 Skopje, Republic of North Macedonia

[2] Finnish Museum of Natural History, University of Helsinki, P.O. Box 17 (Pohjoinen Rautatiekatu 13), FI-00014, Helsinki, Finland

[3] Finnish Environment Institute, Mechelininkatu 34a, P.O.Box 140, FI-00251 Helsinki, Finland

Corresponding author: Aleksandra Cvetkovska-Gjorgjievska (acgorgievska@yahoo.com)

Abstract:

This paper provides first data of the species *Cucujus cinnaberinus* in the Republic of North Macedonia and Montenegro, with notes on its ecology and habitat preference. The material includes specimens collected by four experts on separate field trips on three mountains on the south, east and west parts in the Republic of North Macedonia, and in the central parts of Montenegro.

All of the records originate from mountain forested areas – four are from beech forests and two from Molika pine forests. Three of the records include larval specimens while single adult specimen was found in each of the remaining four localities.

The research suggests that the species inhabits broad-leaved forests and pine forests at higher altitudes in investigated area, but the possibility of its presence in other habitats should be considered also.

These records of *Cucujus cinnaberinus* will contribute to the identification of Special Areas of Conservation within the future Natura 2000 network in two countries.

Key words: *Cucujus cinnaberinus*, habitats, Montenegro, Republic of North Macedonia

Introduction

The establishment of the Natura 2000 network and the transposition of the EU Bird and Habitats Directives into national legislation are one of the key goals that EU associate countries need to achieve in the process of approaching the EU. Among tasks to be fulfilled is to determine the presence, population status and distribution of species of the community interest. For the Republic of North Macedonia and Montenegro, as candidate countries for accession to EU, seven saproxylic beetle species: *Cerambyx cerdo* Linnaeus, 1758*, Lucanus cervus* (Linnaeus, 1758), *Morimus funereus* Mulsant, 1862*, Osmoderma eremita* (Scopoli, 1763*), Rosalia alpina* (Linnaeus, 1758), *Buprestis splendens* Fabricius, 1775 and *Cucujus cinnaberinus* (Scopoli, 1763) are considered as priority in identification of Natura 2000 sites and management of forests. These species are tightly associated with the old-growth and well preserved forests, and many of them are with limited abilities to colonise other types of habitats.

Among them, *Cucujus cinnaberinus* is found throughout much of Europe but it is largely absent in the south and west. The strongest populations are in central Europe, expanding in central-eastern Europe but declining in the surrounding areas (Nieto et al. 2010). Nieto et al. (2010) even considered that *Cucujus cinnaberinus* may be extinct from the following countries: Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, Serbia, and Spain mainland. However, recent publications confirm its presence in the following Balkan countries: Albania, Bosnia and Herzegovina, Bulgaria and Croatia (Guéorguiev et al. 2008; Kovács et al. 2012; Šag et al. 2016; Kulijer & Miljević 2017).

This European endemic is listed in the following international legal instruments and agreements: Annex II and IV of the Habitats Directive; Appendix II of the Bern Convention and Appendix I of the Resolution 6 of the Bern Convention; International Union for Conservation of Nature (IUCN) Red List of Threatened Species with Near Threatened (NT) status on global level; as well as European Red List of saproxylic beetles with Near Threatened (NT) status. It was considered that fragmentation and degradation of forests are main factors causing the decrease of a long-term survival for most saproxylic beetles, including *C. cinnaberinus*. As a result of their stenotopic behavior, limited dispersal ability and microhabitat specialization, it has been listed as vulnerable (VU) (IUCN 2009), but many new records suggest that this species is more common and probably less threatened in Europe, or even going through a phase of expansion (Mazzei et al. 2011), thus the status is downlisted from Vulnerable to Near Threatened. The species was listed as Not Evaluated in the Red List of saproxylic mediterranean beetles (García et al. 2018), and its distribution in the Mediterranean region was considered marginal with more than 25% of its global population occurring outside the region.

This paper provides first data about the presence and distribution of *Cucujus cinnaberinus* in the Republic of North Macedonia and Montenegro with notes on its ecology and habitat preference.

Materials and methods:

The material includes specimens collected during separate field trips on three mountains (Bukovik, Malesh and Pelister) in the Republic of North Macedonia and in ancient Black Pine Nature Reserve Crna Poda in Montenegro.

The field trips carried out on Bukovik Mt. were in the scope of the project „Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning“, implemented by the Macedonian Ecological Society.

The research on Malesevski Mt. was conducted as part of the project for Nature Conservation Programme in Republic of North Macedonia – related to the improvement of the status of natural values of Bregalnica region and defining areas of conservation importance - Natura 2000, organized by Macedonian Ecological Society and Farmahem.

The research carried out on Pelister Mt. was part of the EU Twinning project „Strengthening the capacities for effective implementation of the acquis in the field of nature protection“, led by the Finnish Environment Institute.

Findings from the Nature Reserve Crna Poda, Durmitor National Park were result of EU project “Establishment of NATURA 2000 network - Montenegro “

Beetle fauna was collected manually with active searching under bark of the dead tree trunks.

The material is deposited in the personal collection of J. Mattila from Helsinki, Finland (specimens from Pelister Mt.), and the National Collection of Invertebrates at the Institute of Biology, Faculty of Natural Sciences and Mathematics in Skopje (specimens from Maleshevo Mt. and Bukovik Mt.).

Research area:

Pelister Mt. (2601 m a.s.l.) is located in the southwestern part of Republic of North Macedonia. In 1948, due to the special natural beauties, historical and scientific significance of forest areas, part of Pelister Mt. was declared as a National Park and covers an area of 17150 hectares. Forests of the Macedonian five-needle pine - Molika *Pinus peuce* Griseb. are remarkable value of the Pelister National Park. Beech *Fagus sylvatica* L. forests are also dominant forest habitat on Pelister Mt.

Bukovik Mt. (1528 m a.s.l.) is situated in the western part of the country. This is a small mountain (98 km^2) that borders with high mountains of Suva Gora, Dobra Voda and Bistra. The mountain is dominated by climazonal vegetation of mountain beech forest (as. *Calamintho grandiflorae-Fagetum* Em), and is recognized as core of corridor areas in the national ecological network.

The Maleshevski Planini or Maleshevo Mt. (1748 m a.s.l.) occupies the eastern part of Republic of North Macedonia and comprise the upper watershed of the Bregalnica River. Dominant forest vegetation is beech, Black pine *Pinus nigra* J.F.Arnold and Scots pine *Pinus sylvestris* L. forest.

Nature Reserve „Crna Poda“ is part of the Durmitor National Park in Montenegro. On the other hand, Durmitor National Park is core zone of the Tara Biosphere Reserve. Old-growth stand of European black pine for-

est dominates the Reserve.

Results and discussion

The first records of very rare saproxylic beetle *Cucujus cinnaberinus* from the territory of the Republic of North Macedonia and Montenegro are presented.

Republic of North Macedonia

Records on Pelister Mountain:

Locality: Baba Mountain, Pelister National Park; 41.026693°, 21.181050°; 1610 m a.s.l.

Habitat: managed mountain forest dominated by Molika pine *Pinus peuce,* near the road to Mt. Pelister. This forest had very few dead trees, at least in the vicinity of mountain road. The beetle was registered under the bark of dead standing *Pinus peuce* with diameter approximately 40 cm. Most of the bark had already fallen on the upper parts of the trunk and specimen was found on the base of the tree, where there was still some bark left. Tree was partially exposed to sunlight.

Date: 16.5.2018

Collecting method: active searching

Material: 1 adult specimen

Leg. & det.: Jaakko Mattila

Figure 1. Molika pine forest on Pelister Mt. (photo Jaakko Mattila)

Locality: Nizhepole, Pelister National Park; 40.978980°, 21.252964°; 1372 m a.s.l.

Habitat: close to alpine ski center in open landscape with very few trees. Under the bark of dead standing fire damaged *Pinus peuce,* diameter 15 cm. Tree was completely exposed to sunlight. This particular trunk was a real surprise, as it did not seem to be suitable for *Cucujus*. It was already very dry and small diameter of tree did not suggest that it could be habitat for this species. Location was also open and only scarce growing small pine trees occurred there, while more dense forests were nearby in the west of the mountain.

Date: 20.5.2018

Collecting method: active searching

Material: 1 fragment of dead adult specimen

Leg. & det.: Jaakko Mattila

Larvae were not recorded in Pelister National Park, so it is not clear if specimens actually developed in *Pinus peuce* trunks they were found. However, *Pinus peuce* is the dominant tree species in both locations, and as such, most probable larval host tree. More investigations are needed to confirm this host relationship.

Records on Malesevski Mt.

Locality: Zamenicka River, Malesevski Mt. 41.657332°, 22.912396°, 1005 m a.s.l.

Habitat: Beech forest near Zamenicka River, under a bark of a fallen beech tree. The narrow riparian belt is represented by old beech trees. The surrounding was also mature beech forest without old trees. *Cucujus* larva was found under bark of large beech stump.

Date: 15.07.2020

Collecting method: active searching

Material: 1 larval specimen

Leg. & det.: S. Hristovski and A.C. Gjorgjievska

Locality: Studena Voda, Malesevski Mt., 41.693529°, 22.990575°, 1520 m a.s.l.

Habitat: The locality is a managed beech forest with presence of some very old beech and aspen trees *Populus tremula* L. (Fig. 2). There were a considerable number of dead trunks of beech and aspen. All of the larvae were found on a fallen dead tree of aspen with a diameter of approximately 40 cm.

Date: 16.07.2020

Collecting method: active searching

Material: adult and 21 larval specimens

Leg. & det.: S. Hristovski and A.C. Gjorgjievska

Notes: The adult specimen was missing its left antenna.

Figure 2. Studena Voda on Maleshevski Mt. (photo Slavčo Hristovski)

Locality: Strednjacka River, Malesevski Mt., 41.700951°, 22.996936°, 1400 m a.s.l.

Habitat: A pile of beech trunks (several years old) in a mountain meadow surrounded by a beech forest. The beech forest was under intensive logging. The single adult specimen was found under the bark of a fallen beech tree next to the river.

Date: 16.07.2020

Collecting method: active searching

Material: 1 adult specimen

Leg. & det.: S. Hristovski and A.C. Gjorgjievska

Notes: The species was collected with other saproxylic beetles (*Sinodendron cylindricum* (Linnaeus, 1758) - Lucanidae, *Melasis buprestoides* (Linnaeus, 1761) - Eucnemidae, *Morimus funereus* Mulsant, 1862 and *Leptura quadrifasciata* Linnaeus, 1758 – Cerambycidae). All of these specimens of other species were collected by air-traps placed on logs.

Records on Bukovik Mt.:

Locality: Bukovik Mt.; 41.672171°, 20.877628°; 1360 m a.s.l.

Habitat: Old-growth beech forest. The forest was intensively logged during the field research. The adult specimen was found on a fallen beech tree with a diameter of approximately 60 cm.

Date: 11.07.2020

Collecting method: active searching

Material: 1 adult specimen

Leg. & det.: S. Hristovski

Notes: The specimen was missing its left metatibia.

Montenegro

Records from Crna Poda:

Locality: Crna Poda, Mojkovac, Montenegro; 43.0086903°, 19.4233063°; 883,74 m a.s.l.

Habitat: Under the bark of couple of large fallen trunks of Black pine *Pinus nigra* diameter over 50 cm. This forest stand was rather open and sun exposed. It had suffered from the forest fire, which had killed several trees.

Date: 7.05.2017

Collecting method: active searching

Material: several larvae and few pupae

Leg. & det.: Jaakko Mattila, Tapio Kujala and Petri Ahlroth, photographed by Tapio Kujala.

This paper presents the first confirmed records of the species *Cucujus cinnaberinus* from the Republic of North Macedonia and Montenegro. In the Republic of North Macedonia it was found on three mountains on the south, east and west parts (Fig. 3). The record from Montenegro is situated in the central parts of the country (Fig. 4).

All of the records are from mountain forested areas – four are from beech forests and two from Molika pine forests. Three of the records are based on larval specimens while single adult specimen was found in each of the remaining four localities (Fig. 5).

The species prefers broad-leaved forests and pine forests at higher altitudes, but the possibility of its presence in a riverine willow and poplar forests in lowland areas should be considered as well.

In the Republic of North Macedonia and Montenegro this species was registered in localities with high ecological importance. All of them are Nature Reserve, nationally protected areas (or proposed for protection), proposed Emerald sites, Important Plant Areas (Brajanoska et al. 2009), etc. We hope that the presented records of *Cucujus cinnaberinus* will also contribute to the identification of Special Areas of Conservation within the future Natura 2000 network in both countries.

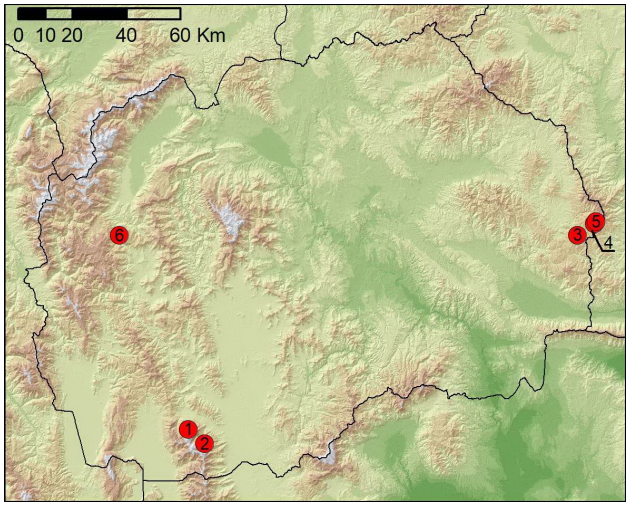

Figure 3. Distribution of *Cucujus cinnaberinus* in the Republic of North Macedonia (1. Pelister National Park, Pelister Mt., 2. Pelister National Park, Nizhepole, 3. Malesevski Mt., Zamenicka River, 4. Malesevski Mt., Studena Voda, 5. Malesevski Mt., Strednjacka River, 6. Bukovik Mt.)

Figure 4. Distribution of *Cucujus cinnaberinus* in Montenegro

Figure 5. *Cucujus cinnaberinus* larva from Studena Voda, Maleshevo Mt., photo Slavčo Hristovski (right) and imago from Pelister Mt., photo Olli Pihlajamaa (left)

Acknowledgement

The authors would like to thank Vasko Avukatov (Macedonian Ecological Society, Skopje) for preparation of maps of distribution of *Cucujus cinnaberinus* in the Republic of North Macedonia and Montenegro.

References

Brajanoska, R., Čivić, K., Hristovski, S., Jones-Walters, L., Levkov, Z., Melovski, Lj., Melovski, D. and Velevski, M. 2009. Background document on Ecological Networks – Project: Development of the National Ecological Network in FYR Macedonia (MAK-NEN). MES, Skopje, Republic of Macedonia; ECNC, Tilburg, the

Netherlands.

García, N., Numa, C., Bartolozzi, L., Brustel, H., Buse, J., Norbiato, M., Recalde, J.I., Zapata, J.L., Dodelin, B., Alcázar, E., Barrios, V., Verdugo, A., Audisio, P., Micó, E., Otero, J. C., Bahillo, P., Viñolas, A., Valladares, L., Méndez, M., El Antry, S., Galante, E. (2018). The conservation status and distribution of Mediterranean saproxylic beetles. Malaga, Spain: IUCN. xii + 58 pp.

Guéorguiev, B., Doychev, D., Ovcharov, D. 2008. Cucujidae (Coleoptera: Cucujoidea) – a new family to the fauna of Bulgaria. Historia naturalis bulgarica 19: 93 -97.

IUCN 2020. *The IUCN Red List of Threatened Species. Version 2020-2*. https://www.iucnredlist.org. Downloaded on 09 July 2020 Kovács, T., Németh, T., Merkl, O. 2012. Beetles new to Albania, Croatia and Serbia (Coleoptera: Elateridae, Cucujidae, Melandryidae, Cerambycidae). Folia Historico-naturalia Musei Matraensis 36: 43-44.

Kulijer, D., Miljević, I. 2017. New records and the distribution of saproxylic beetles (coleoptera) important for the establishment of the Natura 2000 ecological network, in the Sutjeska National Park and wider area of Mt. Zelengora. Glasnik Šumarskog fakulteta Univerziteta u Banjoj Luci 26: 5–14.

Mazzei, A., Bonacci, T., Contarini, E., Zetto, T., Brandmayr, P. 2011. Rediscovering the 'umbrella species' candidate *Cucujus cinnaberinus* (Scopoli, 1763) in Southern Italy (Coleoptera Cucujidae), and notes on bionomy *Cucujus cinnaberinus* in southern Italy. Italian Journal of Zoology, 78(2): 264–270

Nieto, A., Mannerkoski, I., Putchkov, A., Tykarski, P., Mason, F., Dodelin, B., Horák, J., Tezcan, S. 2010. *Cucujus cinnaberinus*. The IUCN Red List of Threatened Species 2010: e.T5935A11921415. https://dx.doi.org/10.2305/IUCN.UK.2010-1.RLTS.T5935A11921415.en

Šag, M., Turić, N., Vignjević, G., Lauš, B. i Temunović, M. (2016). The first record of the rare and threatened saproxylic Coleoptera, Cucujus cinnaberinus (Scopoli, 1763), Rhysodes sulcatus (Fabricius, 1787) and Omoglymmius germari (Ganglbauer, 1891) in Kopački rit Nature Park. *Natura Croatica, 25* (2), 249 -258. https://doi.org/10.20302/NC.2016.25.20

UDK: 585.734.063.6/.7(497.7)
Received: 05.10.2020
Accepted: 16.10.2020
Review paper

Acta Musei Macedonici Scientiarum Naturalium, 2020, Vol. 23, pp: 51-60
ISSN: 0583-4988 (printed version)
ISSN: 2545-4587 (on-line version)
Available on-line at: www.acta.musmacscinat.mk

A check list of the mayfly fauna (Insecta; Ephemeroptera) of the Republic of North Macedonia with a short literature review

Biljana Rimcheska

Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd., 1000 Sofia, Bulgaria;
e-mail: rimceska@gmail.com

Abstract
This paper summarizes published records contributing to our knowledge regarding the Ephemeroptera fauna from the territory of the Republic of North Macedonia. Based on this comprehensive review the recent mayflies' fauna of North Macedonia consists of 80 species that belongs to 20 subgenera, 28 genera and 15 families. As the presence of two of those species (*Palingenia longicauda* (Olivier, 1791) and *Neoephemera maxima* (Joly, 1870)) is doubtful, we could assume that the more accurate number of species is 78. A further increase in the number of recorded species could be expected, as some taxa (*Ecdyonurus* and *Rhithrogena*, for example) are insufficiently studied at the moment

Key words: Ephemeroptera, review of literature, nomenclature, taxonomy.

Introduction

The earliest known reference of the ephemeropteran fauna from the territory of North Macedonia dates back from 100 years ago and is attributed to Ulmer (1920), who mentioned the first mayfly record, the adult form of *Neoephemera maxima* (Joly, 1870). Šamal (1935) studding the mayfly larvae stated 12 more species, including description of one new species, so by the end of 1940's a total of 14 mayfly species were known (Ikonomov, 1951). The most significant breakthrough considering mayflies' taxonomy and diversity from the region came with Ikonomov (1951; 1953; 1954a,b,c; 1958; 1960; 1961a,b,c; 1962a,b,c,d; 1963a,b; 1964; 1970). During his extensive research Ikonomov noted a total of 55 species and 4 subspecies (Ikonomov 1960). From that number 9 species (*Baetis* (*Baetis*) *meridionalis* Ikonomov, 1954, *B.* (*B*.) *vardarensis* Ikonomov, 1962, *B.* (*B*.) *kozufensis* Ikonomov, 1962, *Centroptilum pirinense* Ikonomov 1962, *Electrogena mazedonica* (Ikonomov, 1954), *Choroterpes* (*Euthraulus*) *balcanica* (Ikonomov 1961), *Paraleptophlebia lacustris* Ikonomov, 1962, *Ephemerella maculocaudata* (Ikonomov, 1961), and *Caenis strugaensis* Ikonomov, 1961) were previously unknown, thus being described for the first time by Ikonomov (Ikonomov 1954b,c; 1961a,b,c; 1962c,d; 1963a). The complete check list of species recorded by Ikonomov, with the valid (updated) taxonomy (based on Bauernfeind and Soldan 2012), is presented in **Table 1**.

By the end of 1970's the mayfly fauna is enriched by 5 species (*Ecdyonurus* (*Helvetoraeticus*) *zelleri* (Eaton, 1885), E. (*Ecdyonurus*) *aurantiacus* (Burmeister, 1839), *E*. (*E*.) *dispar* (Curtis, 1834), *Baetis* (*Baetis*) *lutheri* Müller-Liebenau, 1967, *Siphlonurus* (*Siphlonurus*) *armatus* (Eaton, 1870)) (Puthz 1980). More than 20 years later, 6 more species (*Paraleptophlebia ruffoi* Biancheri, 1956, *Baetis* (*B*.) *melanonyx* (Pictet, 1843), *Ecdyonurus* (*H*.) *picteti* (Meyer-Dür, 1864), *Rhithrogena savoiensis* Alba-Tercedor & Sowa, 1987, *Rh.* gr. *hybrida* Eaton, 1885, *Rh. braaschi* Jacob, 1974) were added to the mayfly fauna of North Macedonia (Tanasijević 1981; Vidinova 1998; Memeti et al. 1999). Most recently, Jacob (2003) note the first record of *Baetis* (*Labiobaetis*) *balcanicus* Müller-Liebenau & Soldan, 1981, Bauernfeind and Soldan (2012) enriched with another three species (*Metreletus balcanicus* (Ulmer, 1920), *Paraleptophlebia cincta* (Retzius, 1783), *P. werneri* Ulmer, 1920) and Slavevska-Stamenković et al.

Table 1. List of Ephemeropteran species described and reported by Ikonomov (1959), and corrected valid names according Bauernfeind and Soldan (2012).

Old name	Valid name
Ameletus inopinatus	***Ameletus inopinatus Eaton, 1887***
Siphlonurus aestivalis	***Siphlonurus* (*Siphlonurus*) *aestivalis* (Eaton, 1903)**
Pseudocloeon hyalopterum	***Baetis* (*Acentrella*) *hyalopterum* (Bogoescu, 1951)**
Baetis carpatica	***Baetis* (*Baetis*) *alpinus* (Pictet, 1843)**
Baetis venustulus	***Baetis* (*B.*) *fuscatus* (Linnaeus, 1761)**
Baetis bioculatus	***Baetis* (*B.*) *fuscatus* (Linnaeus, 1761)**
Baetis meridionalis	***Baetis* (*B.*) *meridionalis* Ikonomov, 1954**
Baetis vardarensis n. sp.	***Baetis* (*B.*) *vardarensis* Ikonomov, 1962**
Baetis kozufensis n. sp.	***Baetis* (*B.*) *kozufensis* Ikonomov, 1962**
Baetis tenax	***Baetis* (*B.*) *vernus* Curtis, 1834**
Baetis vernus	***Baetis* (*B.*) *vernus* Curtis, 1834**
Baetis tricolor	***Baetis* (*Labiobaetis*) *tricolor* Tshernova, 1928**
Pseudocentroptillum sp. *strugaensis*	***Baetis (Nigrobaetis) digitatus* Bengtsson, 1912**
Baetis pumilus	***Baetis* (*N.*) *muticus* (Linnaeus, 1758)**
Baetis niger	***Baetis* (*N.*) *niger* (Linnaeus, 1761)**
Baetis rhodani	***Baetis* (*Rhodobaetis*) *rhodani* (Pictet, 1843)**
Centroptilum luteolum	***Centroptilum luteolum* (Müller, 1776)**
Centroptilym pirinense n. sp.	***Centroptilum pirinense* Ikonomov 1962**
Cloeon dipterum	***Cloeon* (*Cloeon*) *dipterum* (Linnaeus, 1761)**
Cloeon praetextum	***Cloeon* (*Similicloeon*) *praetextum* Bengtsson, 1914**
Centroptiloides ambigua	***Cloeon* (*S.*) *simile* Eaton, 1870**
Procleon lychnidensis	***Procloeon* (*Procloeon*) *bifidum* (Bengtsson, 1912)**
Isonychia ignota	***Isonychia* (*Isonychia*) *ignota* (Walker, 1853)**
Oligoneuriella poecile	***Oligoneuriella pallida* (Hagen, 1855)**
Oligoneuriella rhenana	***Oligoneuriella rhenana* (Imhoff, 1852)**
Ecdyonurus insignis	***Ecdyonurus* (*Ecdyonurus*) *insignis* (Eaton, 1870)**
*******Ecdyonurus flumminum*	***Ecdyonurus* (*E.*) *submontanus* Landa, 1969**
Ecdyonurus venosus	***Ecdyonurus* (*E.*) *venosus* (Fabricius, 1775)**
Ecdyonurus epeorides	***Ecdyonurus* (*Helvetoraeticus*) *epeorides* Demoulin, 1955**
Heptagenia trimaculata	***Electrogena affinis* (Eaton, 1887)**
*Heptagenia macedonica*n. sp.	***Electrogena mazedonica* (Ikonomov, 1954)**
Heptagenia coerulans	***Heptagenia* (*Dacnogenia*) *coerulans* Rostock, 1878**
Heptagenia flavipes	***Heptagenia* (*Heptagenia*) *longicauda* (Stephens, 1836)**
Epeorus assimilis	***Epeorus* (*Epeorus*) *assimilis* Eaton, 1885**
Iron yougoslavicus	***Epeorus* (*Ironopsis*) *yougoslavicus* (Šamal, 1935)**
Rhithrogena aurantiaca	***Rhithrogena diaphana*** species group.

Rhithrogena semicolorata	***Rhithrogena semicolorata* (Curtis, 1834)**
Euthraulus balcanicus	***Choroterpes* (*Euthraulus*) *balcanica* (Ikonomov, 1961)**
Habroleptoides robusta	***Habroleptoides confusa* Sartori & Jacob, 1986**
Habroleptides modesta	***Habroleptoides confusa* Sartori & Jacob, 1986**
Habrophlebia konjarensis	***Habrophlebia fusca* (Curtis, 1834)**
Habrophlebia lauta	***Habrophlebia lauta* Eaton, 1884**
Paraleptophlebia lacustris n. sp.	*****Paraleptophlebia lacustris* Ikonomov, 1962**
Paraleptophlebia submarginata	***Paraleptophlebia submarginata* (Stephens, 1836)**
Ephemera lineata	***Ephemera* (*Ephemera*) *lineata* Eaton, 1870**
Ephemera hellenica	***Ephemera* (*E.*) *hellenica* Demoulin, 1955**
Palingenia longicauda	***Palingenia longicauda* (Olivier, 1791)**
Polymitarcis virgo	***Ephoron virgo* (Olivier, 1791)**
Potamanthus luteus	***Potamanthus luteus* (Linnaeus, 1767)**
Ephemerella ignita	***Ephemerella ignita* (Poda, 1761)**
Ephemerella maculocaudata	***Ephemerella maculocaudata* (Ikonomov, 1961)**
Chitonophora sp. nympha *unicolorata*	***Ephemerella mucronata* (Bengtsson, 1909)**
Ephemerella notata	***Ephemerella notata* Eaton, 1887**
Ephemerella spinosa n. sp.	***Serratella ikonomovi* (Puthz, 1971)**
Torleya major	***Torleya major* (Klapalek, 1905)**
Caenis macrura	***Caenis macrura* Stephens, 1835**
Orelanthus macedonicus	***Caenis horaria* (Linnaeus, 1758)**
Caenis lycnidensis	***Caenis strugaensis* Ikonomov, 1961**
Prosopistoma foliaceum	***Prosopistoma pennigerum* (Müller, 1785)**

Legend: *According to illustrations provided by Ikonomov (1959), the *Ecdyonurus flumminum* resembles most the *Ecdyonurus (E.) submontanus* description; **According to Bauernfeind and Soldan (2012) *Paraleptophlebia lacustris* is omitted from species list, amplifying on misidentification (listed as synonym of *Paraleptophlebia cincta* (Retzuis, 1783)). In Fauna Europaea taxa list this species exist as species so far known from 2 countries (Belfiore and Thomas, 2013, https://fauna-eu.org).

(2016) confirmed the presence of *Caenis pseudorivulorum* Keffermüller, 1960. The full relevant taxa records are listed in **Table 2**, where summarizes all available literature sources.

The newest relevant publications include the report of *M. balcanicus* (larva and imago) (Rimcheska and Vidinova 2018) and partial contribution with Ephemeroptera records concerning some streams from Ohrid Lake watershed is given in Trajanovski et al. (2019).

Presolska (2014) explained why the misidentification (Table 2) of the *Epeorus sylvicola* records from some Balkan countries occur, as pointing out on the proposed synonym, *E. sylvicolus* (Pictet) for two different species (*E. assimilis* Eaton, 1885 and *E. sylvicolus* (Pictet, 1865)) proposed by Puthz (1973), and as later stated by Thomas et al. (2000) this proposed synonym mentioned by numerous European specialist is not valid. Furthermore, Presolska (2014) also revised the material from her institutional collection and confirmed that these materials belong to *E. assimilis* species. In addition to this finding also all collections of the recent larval materials from different sites from territory of North Macedonia refer to *E. assimilis* (Rimcheska, Vidinova, unpublished data). Thereafter, all the mentions (Puthz 1980; Memeti et al. 1999) of *E. sylvicola* for the territory of North Macedonia are not valid as well

Table 2. Check list of the established mayfly species from the fauna of North Macedonia with the relevant literature sources.

Author, publication, year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Recorded species	Ulmer 1920	Šámal 1935	Šámal 1939	Ikonomov 1951	Ikonomov 1953	Ikonomov 1954a	Ikonomov 1954b	Ikonomov 1954c	Ikonomov 1958	Ikonomov 1960	Ikonomov 1961a	Ikonomov 1961b	Ikonomov 1961c	Ikonomov 1962a	Ikonomov 1962b	Ikonomov 1962c	Ikonomov 1962d	Ikonomov 1963a	Ikonomov 1963b	Ikonomov 1964	Ikonomov 1970	Puthz 1980	Tanasijević 1981	Vidinova 1998	Memeti et al. 1999	Jacobs 2003	Bauernfeind, Soldan 2012	Slavevska-Stamenković et al. 2016	Rimcheska, Vidinova 2018
Family Ameletidae McCafferty, 1991																													
Genus *Ameletus* Eaton, 1885																													
Ameletus inopinatus Eaton, 1887									X	X												X					X		
Genus *Metreletus* Demoulin, 1951																													
***Metreletus balcanicus* (Ulmer, 1920)**																											X		X
Genus *Siphlonurus* Eaton, 1868																													
Subgenus *Siphlonurus* Eaton, 1868																													
***Siphlonurus* (*Siphlonurus*) *aestivalis* (Eaton, 1903)**									X																		X		
***Siphlonurus* (*S.*) *croaticus* Ulmer, 1920**										X										X	X	X					X		
***Siphlonurus* (*S.*) *armatus* (Eaton, 1870)**																						X					X		
Family Baetidae Leach, 1815																													
Genus *Baetis* Leach, 1815																													
Subgenus *Acentrella* Bengtsson, 1912																													
***Acentrella* (*Baetis*) *hyalopterum* (Bogoescu, 1951)**										X						X				X		X					X		
Subgenus *Baetis* Leach, 1815																													
Baetis alpinus species-group																													
***Baetis* (*Baetis*) *alpinus* (Pictet, 1843)**										X						X				X	X	X			X		X		
***Baetis* (*B.*) *melanonyx* (Pictet, 1843)**																									X				
Baetis fuscatus species-group																													
***Baetis* (*B.*) *fuscatus* (Linnaeus, 1761)**				X	X				X	X						X				X	X	X			X		X		
Baetis lutheri species-group																													
***Baetis* (*B.*) *lutheri* Müller-Liebenau, 1967**																						X					X		
***Baetis* (*B.*) *meridionalis* Ikonomov, 1954**								X	X	X						X				X		X					X		
***Baetis* (*B.*) *vardarensis* Ikonomov, 1962**										X						X				X		X					X		
Baetis vernus species-group																													

***Baetis* (*B.*) *kozufensis* Ikonomov, 1962**					X		X			X			X
***Baetis* (*B.*) *vernus* Curtis, 1834**				X	X		X	X	X	X	X		X
Subgenus *Labiobaetis* Novikova & Kluge, 1987													
***Baetis* (*Labiobaetis*) *balcanicus* Müller-Liebenau & Soldan, 1981**												X	X
***Baetis* (*L.*) *tricolor* Tshernova, 1928**					X		X			X			X
Subgenus *Nigrobaetis* Novikova & Kluge, 1987													
***Baetis (Nigrobaetis) digitatus* Bengtsson, 1912**					X		X			X			
***Baetis* (*N.*) *muticus* (Linnaeus, 1758)**		X	X	X	X		X	X	X	X	X		X
***Baetis* (*N.*) *niger* (Linnaeus, 1761)**		X			X		X			X			X
Subgenus *Rhodobaetis* Jacob, 2003													
*****Baetis* (*Rhodobaetis*) *gemellus* Eaton, 1885**	X	X	X	X						X			
***Baetis* (*Rh.*) *rhodani* (Pictet, 1843)**		X	X	X	X		X	X	X	X	X		X
Subfamily Cloeninae													
Genus *Centroptilum* Eaton, 1869													
***Centroptilum luteolum* (Müller, 1776)**		X	X	X	X			X		X			X
***Centroptilum pirinense* Ikonomov 1962**				X	X		X			X			X
Genus *Cloeon* Leach, 1815													
Subgenus *Cloeon* Leach, 1815													
***Cloeon* (*Cloeon*) *dipterum* (Linnaeus, 1761)**		X	X	X	X		X	X		X			X
Subgenus *Similicloeon* Kluge & Novikova, 1992													
***Cloeon* (*Similicloeon*) *praetextum* Bengtsson, 1914**		X			X		X						X
***Cloeon* (*S.*) *simile* Eaton, 1870**					X			X		X			X
Genus *Procloeon* Bengtsson, 1915													
Subgenus *Procloeon* Bengtsson, 1915													
***Procloeon* (*Procleon*) *bifidum* (Bengtsson, 1912)**					X		X			X			X
Subgenus *Pseudocentroptilum* Bogoescu, 1947													
***Procloeon* (*Pseudocentroptilum*) *pennulatum* (Eaton, 1870)**		X	X	X						X			X
Superfamily Heptagenioidea													
Family Isonychiidae Burks, 1953													
Genus *Isonychia* Eaton, 1871													
Subgenus *Isonychia* Eaton, 1871													
***Isonychia* (*Isonychia*) *ignota* (Walker, 1853)**					X			X		X			X
Family Oligoneuriidae Ulmer, 1914													
Genus *Oligoneuriella* Ulmer, 1924													
***Oligoneuriella pallida* (Hagen, 1855)**					X	X		X		X			X
***Oligoneuriella rhenana* (Imhoff, 1852)**			X	X	X			X		X			X
Family Heptageniidae Needham, 1901													
Subfamily Ecdyonurinae Ulmer, 1920 (1905)													

Genus *Ecdyonurus* Eaton, 1868														
Subgenus *Ecdyonurus* Eaton, 1868														
***Ecdyonurus* (*Ecdyonurus*) *aurantiacus* (Burmeister, 1839)**											X			X
***Ecdyonurus* (*E.*) *dispar* (Curtis, 1834)**											X			X
***Ecdyonurus* (*E.*) *insignis* (Eaton, 1870)**	X		X				X		X	X	X			X
***Ecdyonurus* (*E.*) *submontanus* Landa, 1969**							X							
***Ecdyonurus* (*E.*) *venosus* (Fabricius, 1775)**			X	X		X	X		X	X	X		X	X
Subgenus *Helvetoraeticus* Bauernfeind & Soldan, 2012														
***Ecdyonurus* (*Helvetoraeticus*) *epeorides* Demoulin, 1955**						X			X					
***Ecdyonurus* (*H.*) *helveticus* (Eaton, 1883)**				X		X	X			X	X		X	X
***Ecdyonurus* (*H.*) *picteti* (Meyer-Dür, 1864)**													X	
***Ecdyonurus* (*H.*) *subalpinus* Klapálek, 1907**	X										X			X
***Ecdyonurus* (*H.*) *zelleri* (Eaton, 1885)**											X			X
Genus *Electrogena* Zurwerra & Tomka, 1985														
***Electrogena affinis* (Eaton, 1887)**							X	X	X		X			
***Electrogena mazedonica* (Ikonomov, 1954)**						X	X	X	X	X	X			X
Genus *Heptagenia* Walsh, 1863														
Subgenus *Dacnogenia* Kluge, 1988														
***Heptagenia* (*Dacnogenia*) *coerulans* Rostock, 1878**						X	X	X	X	X	X			X
Subgenus *Heptagenia* Walsh, 1863														
***Heptagenia* (*Heptagenia*) *longicauda* (Stephens, 1836)**							X	X	X		X			X
Subgenus *Kageronia* Matsumura, 1931														
***Heptagenia* (*Kageronia*) *fuscogrisea* (Retzius, 1783)**			X	X							X			X
Genus *Epeorus* Eaton, 1881														
Subgenus *Epeorus* Eaton, 1881														
***Epeorus* (*Epeorus*) *assimilis* Eaton, 1885**	X			X		X	X			X				X
*******Epeorus* (*E.*) *sylvicola* (Pictet, 1865)**											X		X	
Subgenus *Ironopsis* Traver, 1935														
***Epeorus* (*Ironopsis*) *yougoslavicus* (Šamal, 1935)**	X	X		X	X	X	X			X	X		X	X
Genus *Rhithrogena* Eaton, 1881														
Rhitrogena diaphana species-group														
***Rhithrogena* gr. *diaphana* Navás, 1917**	X		X	X		X	X		X	X	X	X	X	
***Rhithrogena savoiensis* Alba-Tercedor & Sowa, 1987**												X	X	
Rhitrogena hybrida species-group														
***Rhithrogena* gr. *hybrida* Eaton, 1885**												X	X	
Rhitrogena semicolorata species-group														
***Rhithrogena braaschi* Jacob, 1974**												X	X	X
***Rhithrogena* gr. *semicolorata* (Curtis, 1834)**	X		X	X		X	X			X	X			X
Superfamily Leptophlebioidea														

Family Leptophlebiidae Banks, 1900															
Genus *Choroterpes* Eaton, 1881															
Subgenus *Euthraulus* Barnard, 1932															
***Choroterpes* (*Euthraulus*) *balcanica* (Ikonomov, 1961)**				X	X	X						X			X
Genus *Habroleptoides* Schoenemund, 1929															
***Habroleptoides confusa* Sartori & Jacob, 1986**			X	X	X					X	X	X		X	X
Genus *Habrophlebia* Eaton, 1881															
***Habrophlebia fusca* (Curtis, 1834)**					X				X			X			X
***Habrophlebia lauta* Eaton, 1884**					X					X		X			X
Genus *Paraleptophlebia* Lestage, 1917															
***Paraleptophlebia cincta* (Retzius, 1783)**															X
****Paraleptophlebia lacustris* Ikonomov, 1962**					X			X		X	X	X		X	
***Paraleptophlebia submarginata* (Stephens, 1836)**			X		X					X		X			X
***Paraleptophlebia ruffoi* Biancheri, 1956**													X		X
***Paraleptophlebia werneri* Ulmer, 1920**															X
Superfamily Ephemeroidea															
Family Ephemeridae Latreille, 1810															
Genus *Ephemera* Linnaeus, 1758															
Subgenus *Ephemera* Linnaeus, 1758															
***Ephemera* (*Ephemera*) *danica* Müller, 1764**	X		X	X	X						X	X		X	X
***Ephemera* (*E.*) *lineata* Eaton, 1870**	X	X		X	X					X		X			X
***Ephemera* (*E.*) *vulgata* Linnaeus, 1758**				X											
***Ephemera* (*E.*) *hellenica* Demoulin, 1955**				X						X		X			X
Family Palingeniidae Albarda, 1888															
Genus *Palingenia* Burmeister, 1839															
***Palingenia longicauda* (Olivier, 1791)**				X	X					X		X			X
Family Polymitarcyidae Banks, 1900															
Genus *Ephoron* Williamson, 1802															
***Ephoron virgo* (Olivier, 1791)**				X	X					X		X			X
Family Potamanthidae Albarda, 1888															
Genus *Potamanthus* Pictet, 1843															
***Potamanthus luteus* (Linnaeus, 1767)**					X					X		X			X
Superfamily Ephemerelloidea															
Family Ephemerellidae Klapálek, 1909															
Genus *Ephemerella* Walsh, 1863															
***Ephemerella ignita* (Poda, 1761)**	X	X	X	X	X		X			X	X	X		X	X
***Ephemerella maculocaudata* (Ikonomov, 1961)**					X		X			X		X			X
***Ephemerella mucronata* (Bengtsson, 1909)**					X		X					X		X	X

***Ephemerella notata* Eaton, 1887**			x	x	x		x		x		x	x	
Genus *Serratella* Edmunds, 1959													
***Serratella ikonomovi* (Puthz, 1971)**					x		x		x		x	x	
Genus *Torleya* Lestage, 1917													
***Torleya major* (Klapalek, 1905)**					x		x		x		x	x	
Superfamily Caenoidea													
Family Caenidae Newman, 1853													
Genus *Caenis* Stephens, 1836													
***Caenis horaria* (Linnaeus, 1758)**		x	x					x			x	x	
***Caenis macrura* Stephens, 1835**		x	x	x	x				x	x	x	x	
***Caenis pseudorivulorum* Keffermüller, 1960**													x
***Caenis strugaensis* Ikonomov, 1961**				x	x	x					x	x	
Family Neoephemeridae Traver, 1935													
Genus *Neoephemera* McDunnough, 1925													
***Neoephemera maxima* (Joly, 1870)**	x										x	x	
Family Prosopistomatidae													
Genus *Prosopistoma* Latreille, 1833													
***Prosopistoma pennigerum* (Müller, 1785)**				x	x				x		x	x	

(Table 2). These doubts are mention and by Bauernfeind and Soldan (2012) where besides *Epeorus* (*Epeorus*) *sylvicola* and *Baetis* (*Rhodobaetis*) *gemellus* are subject of misidentification. Concerning reported misidentification of *Paraleptophlebia lacustris* (proposed as synonym of *P. cincta*) in Bauernfeind and Soldan (2012) in this review will be listed as a relevant species (Ikonomov 1960) as long as the comparison between the available material from southern Balkan and central Europe will be proceeded for further analyzes. Besides this two misidentified species, in the book of Mayflies, Bauernfeind and Soldan (2012) amplify that the previously recorded mayfly species *Neoephemera maxima* and *Palingenia longicauda*, nowadays are listed as extinct species from North Macedonia. In that order can be concluded that the current recorded taxa are down to 78 existing species (Table 2).

The presence of *Rhithrogena gorganica* Klapalek, 1907 (Belfiore and Thomas, 2013, https://fauna-eu.org.) should be discussed further. Most likely this record has been taken from Šamal (1935) and it could be a subject of misidentification, because this species is endemic, and probably restricted to Carpathian Mountains (Bauernfeind and Soldan 2012). In addition to these misidentifications, Ikonomov (1970) stated, he visited all sites listed in Šamal (1935, 1939), and 40 years later he confirmed the presence/or correct determination of only 9 species from previously reported 13 by Šamal (Table 2). The published records of *Rhithrogena goeldlini* Sartori & Sowa 1988 (gr. *diaphana*), *Rh. degrangei* Sowa 1969, *Rh. gratianopolitana* Sowa, Degrange & Sartori 1986 and *Rh. hercynia* Landa 1969 (gr. *hybrida*) (Vidinova 1998), due to doubtful presence of recorded *Rhithrogena* species in the region (Bauernfeind and Soldan 2012) will be re-evaluated and revised further (Vidinova pers. comm.).

In the near future an extensive research focusing on Ephemeroptera fauna is needed in order to provide a more relevant data, and to clarify noted controversies. A further increase in the number of recorded species could be expected, as some taxa (*Ecdyonurus* and *Rhithrogena*, for example) are insufficiently studied at the moment. Providing more accurate knowledge on the diversity and presence of mayflies in North Macedonia is significant because many of those species are valuable indicators for water quality, and should be included in all competent hydroecological studies of its habitats.

Acknowledgements

Would like to express my gratitude to Yanka Vidinova for motivating me to prepare this summary, and for her support and suggestions improving the final version of this manuscript. Also I'm using this opportunity to thank to the two reviewers that gradually contribute to the improvement of the last version of this paper.

References

Bauernfeind E. & Soldan T. 2012. The Mayflies of Europe (Ephemeroptera). Apollo Books, Ollerup, 781 pp.

Belfiore C. & Thomas A. 2013. Ephemeroptera. Accessed through: Fauna Europaea at http://www.faunaeur.org/full_results.php?id=193549

Ikonomov P. 1951. Contribution à l'étuded' éphéméroptères de la Valléed' Ochrida. Annuaire de la Faculté de Philosophiede l'Université de Skopje, Section des sciences naturelles, 4(3): 1-33.

Ikonomov P. 1953. Ephemeroptera der Umgebung des Prespa-Sees. Annuaire de la Faculté de Philosophie de l'Université de Skipje, Section des sciences naturelles, 6(7):1-29.

Ikonomov P. 1954a. Über das Weibchen von *Iron jugoslavicus* Samal. Fragmenta Balcanica, 1(1): 1-6.

Ikonomov P. 1954b. [Über eine neue *Heptagenia* (Ephem.) aus Mazedonien]. Fragmenta Balcanica, 1 (7): 57-68.

Ikonomov P. 1954c. [Über eine neue larve der Gattung *Baetis* (Ephem) aus Mazedonien]. - Fragmenta Balcanica,1(11): 95-105.

Ikonomov P. 1958. Preliminary notes on the nymphs of Ephemeroptera found in Macedonian waters. Verh. Int. Ver. Limnol., 13: 858-859.

Ikonomov P. 1959. Ephemeroptera of Macedonia. PhD dissertation, Skopje.

Ikonomov P. 1960. Die Verbreitung der Ephemeroptera in Mazedonien. Acta Musei Macedonici Scientiarum Naturalium, 7(3): 41-74.

Ikonomov P. 1961a. Eintagsfliegen (Ephemeroptera) Jugoslaviens, *Euthraulus balcanicus* n. sp. (Leptophlebiidae). Fragmenta Balcanica, 4(1): 1-10.

Ikonomov P. 1961b. Ephemeroptera Jugoslaviens. *Caenis strugaensis* sp. n. (Caenidae). - Fragmenta Balcanica, 4(2): 11-19.

Ikonomov P. 1961c. Eintagsfliegen (Ephemeroptera) Mazedoniens. Fam. Ephemerellidae. Acta Musei Macedonici Scientiarum Naturalium, 8(3): 53-74.

Ikonomov P. 1962a. Eintagsfliegen (Ephemeroptera) Jugoslavicus. *Oligoneuriella poecile* sp. n. Fragmenta Balcanica, 4(10): 69-79.

Ikonomov P. 1962b. Eintagsfliegen (Ephemeroptera) Jugoslavicus. *Oreianthus macedonicus* (Ulmer) = (*Rhoënanthus* Ulm.). Fragmenta Balcanica, 4(11): 81 -91.

Ikonomov P. 1962c. Baëtidae (Ephemeroptera) macedoniens. Faculté des Sciences Naturelles de Úniversité de Skopje. Biologie, 13: 83-140.

Ikonomov P. 1962d. Eintagsfliegen (Ephemeroptera) Jugoslavicus. *Paraleptophlebia lacustris* n. sp. Fragmenta Balcanica, 4(17): 129-138.

Ikonomov P. 1963a. Eintagsfliegen (Ephemeroptera) Macedoninens. Genus *Heptagenia* (Ecdyonuridae). Annuaire de la Faulté des Sciences d'Université de Skopje (1962), 14(7): 155-165.

Ikonomov P. 1963b. Ephemeroptera Jugoslaviens. *Habrophlebia sp. nympha konjarensis*. Annuaire de la Faulté des Sciences d'Université de Skopje (1962), 14(9): 175-181.

Ikonomov P. 1964. Die Eintagsfliegen (Ephemeroptera) des Flusses Varder. Annuaire de la Faulté des Sciences d'Université de Skopje, 15(5): 191-198.

Ikonomov P. 1970. Repartition des larves Éphéméroptères et Plécoptères dans les coursd'eau de Macédoine. Annuairede la Faculté des Sciences d'Université de Skopje (1969), 22: 5-11.

Jacob, U. 2003. Baetis Leach 1815, sensu stricto oder sensu lato. Ein Beitrag zum Gattungskonzept auf der Grundlage von Artengruppen mit Bestimmungsschlüsseln. Lauterbornia, 47: 59-129.

Memeti A., Russev B. & Janeva I. 1998. Ephemeroptera- and Plecoptera (Insecta) in the river Tetovska/ Vardar and its tributaries in the Shar Mountains, Macedonia. Lauterbornia, 33: 45-48.

Presolska Y. 2014. Composition, distribution and ecology of the order Ephemeroptera (Insecta) in Bulgaria-. PhD thesis, IBER-BAS, Sofia, Bulgaria, 373pp. (In Bulgarian).

Puthz V. 1973. Zwei neue Synonyme in der Gattung *Epeorus* Eaton (Insecta, Ephemeroptera, Heptageniidae). Rev. Suisse Zool., 80(2): 577-580.

Puthz, V. 1980. Ergebnisse der Albanien-Expedition 1961 des Deutschen Entomologischen Institutes. 94. Beitrag (Ephemeroptera). Beiträge zur Entomologie = Contributions to Entomology, 30(2): 343-355.

Rimcheska B., Vidinova Y. 2018. New records of

Metreletus balcanicus (Ulmer, 1920) (Ephemeroptera: Ameletidae) from Republic of Macedonia. Journal of Entomological Research Society, 20(3): 123-127.

Šámal J.1935. Les Ephémèreset les Plécoptères des ruisseaux de la Yougoslavie méridionale. Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie Bd. VII, 113–116.

Šámal J. 1939. Iron jugoslavicus nov. spec. Glasnik, Bulletin de la Société Scientifique de Skoplje, Vol. XX: 89–95.

Slavevska-Stamenković V., Rimcheska B., Vidinova Y., Tyufekchieva V., Paunović M., Ristovska M. & Prelić D. 2016. Contribution to the knowledge of Ephemeroptera, Plecoptera and Trichoptera from Republic of Macedonia. Acta zoologica bulgarica, 68 (2): 199-206.

Tanasijevic M. 1981. New find of the species *Paraleptophlebia ruffoi* Biancheri, 1956 (Ephemeroptera, Leptophlebiidae). Nov nalaz vrste *Paraleptophlebia ruffoi* Biancheri, 1956 (Ephemeroptera, Leptophlebiidae). Godisnjaka Bioloskog Instituta Univerziteta u Sarajevu, 34: 165-166.

Thomas A; Marie V; Brulin M. 2000. Corrections á la faune des Ephèmères d'Europe occidentale: 2. *Epeorus assimilis* Eaton, 1885 est une espèce valide, distincte d'*E. sylvicolus* (Pictet, 1865) [Ephemeroptera, Heptageniidae]. Ephemera (1999), 1(2): 85-91.

Trajanovski, S., Budzakoska Gjoreska, B., Kenderov, L., Trajanovska, S., Zdraveski, K., & Trichkova, T. (2019). Potential threats to benthic macroinvertebrate fauna in Lake Ohrid watershed: Water pollution and alien species. Acta Zoologica Bulgarica, Supplement 13: 91-98.

Ulmer G. 1920. Neue Ephemeropteren. Archiv für Naturgeschichte, 85A(11): 1-80.

Vidinova Y. 1998. New *Rhithrogena*-species (Ephemeroptera: Heptageniidae) for the fauna of Macedonia. Lauterbornia 33: 49-51.