

Checklist of the *Orchidaceae* of Bosnia and Herzegovina

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with 3 tables

Key words: *Orchidaceae*. – Orchids, biodiversity, checklist, Balkan Peninsula. – Flora of Bosnia and Herzegovina.

Summary

ŠABANOVIĆ E., DJORDJEVIĆ V., MILANOVIĆ Đ., BOŠKAILO A., ŠARIĆ Š., HUSEINOVIĆ S. & RANDJELOVIĆ V. 2021. Checklist of the *Orchidaceae* of Bosnia and Herzegovina. – *Phyton* (Horn, Austria) 61: 83–95, with 3 tables.*

The Balkan Peninsula is recognized as an important center of orchid diversity in Europe. However, the orchid flora of the central Balkans has not been sufficiently studied. This paper presents the first checklist of orchids in Bosnia and Herzegovina. Checking and revision of herbarium material, personal field investigations, and published sources were used to complete the present survey of extant orchid taxa. Categorization of the records of orchid species and subspecies according to the degree of their reliability was performed in detail. With allowance for recent taxonomic and nomenclatural changes, it can now be asserted that a total of 76 orchid species and subspecies and two hybrids belonging to 22 genera are reported for the country. The most species-rich genera are *Orchis* (12 taxa), *Dactylorhiza* (10), *Anacamptis* (8), *Epipactis* (7) and *Ophrys* (7). A peculiarity of the orchid flora of Bosnia and Herzegovina is the presence of two Balkan endemics: *Dactylorhiza cordigera* subsp. *bosniaca* (BECK) SOÓ and *Himantoglossum calcaratum* (BECK) SCHLTR. subsp. *calcaratum*. Due to the great diversity of topography, climatic conditions, soil characteristics, and vegetation, it is assumed that the number of orchid taxa in Bosnia and Herzegovina is higher, and it is expected that new taxa will be recorded over time.

1. Introduction

The family *Orchidaceae* represents one of the largest families in the plant kingdom, with approximately 28,000 species and 880 genera (GIVNISH & al. 2016). In addition to their high species richness, orchids are known for their specific biotic relationships when it comes to mycorrhizal symbionts and pollinators, as well as the fact that they inhabit almost all known terrestrial ecosystems, and that a large number of species are endangered (SWARTS & DIXON 2009). In the temperate zone, orchids are present in smaller numbers compared to the tropics and are exclusively terrestrial plants with rhizomes or tubers (DRESSLER 1981). It should be emphasized that orchid taxonomy is constantly changing, as a

result of new morphometric and molecular analyses that often reveal new relationships among taxa (CHASE & al. 2015).

In Europe, about 250 orchid species from 36 genera have been recorded so far (BUTTLER 1991). The number of orchid taxa in Europe increases gradually from north to south, reaching a maximum in the Mediterranean region. Thus, the largest number of orchid species and subspecies was recorded in Greece (193 taxa; TSIFTSIS & ANTONOPOULOS 2017), Italy (189 species and subspecies; GIROS 2009), and the Iberian Peninsula (122 species and subspecies; BERNARDOS & al. 2007). Although the Balkan Peninsula is an important center of orchid diversity in Europe (DJORDJEVIĆ & al. 2021), research on orchid flora in the central Balkans and especially in Bosnia

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*) Printed volume published ## ### ####

and Herzegovina has been carried out with a great discontinuity in time.

The first data on the orchids of Bosnia and Herzegovina were published by Ami Boué (BOUÉ 1840), when the occurrence of two taxa – *Herminium monorchis* (L.) R. BR. (sub *Satyrium monorchis* PERS.) and *Neottia cordata* (L.) RICH. (sub *Ophrys cordata* L.) was recorded. Later, significant data on the distribution and ecological preferences of orchids were published by the following authors: KUMMER & SENDTNER (1849), PANTOCSEK (1874), ASCHERSON & KANITZ (1877), HOFMANN (1882), BECK (1887), BLAU (1877), CONRATH (1887), FIALA (1890, 1891, 1892, 1893), BRANDIS (1891), MURBECK (1891), MALÝ (1893, 1904, 1905, 1908, 1912, 1928, 1940), PROTIĆ (1898, 1900, 1902), HANDEL-MAZZETTI & al. (1905), RITTER-STUDNIČKA (1954), etc. One of the first surveys of orchid taxa in Bosnia and Herzegovina was provided by BECK (1903), when the occurrence of 56 orchid taxa was noted. Among the significant floristic works, the 'Prodromus Florae Peninsulae Balcanicae' (HAYEK 1933) should be highlighted, in which the author pointed out that 68 orchid taxa from 21 genera grow in Bosnia and Herzegovina. In recent years, more attention has been paid to orchids in this country, resulting in the publication of two books (ŠOLJAN & al. 2014b, ŠABANOVIĆ & al. 2020) and articles related to individual mountains (ŠOLJAN & al. 2014a, BUCALO 2015) or cantons (ŠABANOVIĆ & al. 2019). In addition, some orchid taxa were recorded for the first time in the flora of Bosnia and Herzegovina in recent years: *Neotinea maculata* (DESF.) STEARN and *Himantoglossum robertianum* (LOISEL.) P. DELFORGE (ZELENIKA 2012), *Epipactis muelleri* GODFERY subsp. *muelleri* (TAKÁCS & al. 2014), *Himantoglossum adriaticum* H. BAUMANN (MILANOVIĆ & al. 2015a), *Serapias vomeracea* (BURM. f.) BRIQ. (MASLO & BOŠKAILO 2018), *Serapias parviflora* PARL. (MILANOVIĆ 2019), *Epipactis helleborine* subsp. *orbicularis* (K. RICHT.) E. KLEIN (TOMOVIĆ & al. 2021), *Himantoglossum calcaratum* subsp. *rumelicum* (H. BAUMANN & R. LORENZ) NIKETIĆ & DJORDJEVIĆ and *Serapias bergonii* E. G. CAMUS (MILANOVIĆ & al. 2022). Furthermore, *Liparis loeselii* (L.) RICH. subsp. *loeselii* was rediscovered in this country after more than 100 years (MILANOVIĆ 2012). In addition, data on *Himantoglossum calcaratum* (BECK) SCHLTR. subsp. *calcaratum* inhabiting roadsides in Bosnia and Herzegovina were collected as part of an ecological study (FEKETE & al. 2017), while samples of some *Anacamptis* species were collected in the country for morphometric analyses of this genus on the Balkan Peninsula and Pannonian Plain (RADAK 2019). Overall, the orchid flora in Bosnia and Herzegovina has been studied mainly sporadically, and data on the distribution and ecology of orchids have been available mainly through various floristic surveys

or vegetation research (BUCALO 2015, MILANOVIĆ & al. 2015a, MILANOVIĆ 2017, TRAKIĆ & al. 2021, STUPAR & al. 2021). In fact, no critical evaluation of the existing orchid taxa has been made so far, and there is no synthesis of knowledge about orchids in Bosnia and Herzegovina, taking into account new taxonomic and nomenclatural novelties.

The main objectives of this study are: (a) to provide an overview and critical evaluation of the orchid taxa of Bosnia and Herzegovina using the most recent taxonomic treatments of orchids, and (b) to analyze the taxonomic structure of the family *Orchidaceae* in Bosnia and Herzegovina.

2. Materials and methods

Study area. Bosnia and Herzegovina covers an area of 51,209.2 km² and is located in the north-central part of the Balkan Peninsula. The country lies between latitudes 42°33' and 45°16' N and between longitudes 15°43' and 19°37' E and is predominantly hilly to mountainous, with an average altitude of 500 m (ČADRO & al. 2019). Based on the environmental characteristics – mainly climate, topography and geographical location – the country is divided into four regions: West, North, Central-East and South. The North region is a relatively flat area with an average elevation of 304 m; the Central-East region is a rugged, hilly and mountainous terrain, where the range between minimum and maximum elevation is from 169 m to 2310 m, with an average elevation of 916 m; the West region is characterized by hills, plateaus and valleys, with an average elevation of 803 m; and the South region is the Mediterranean part of the country with an average elevation of 731 m (ČADRO & al. 2019). The average annual temperature is 10.9 °C and ranges from 9.7 °C in the northern temperate climate zone to 12.1 °C in the mediterranean climate zone. The average annual precipitation is 1255 mm and ranges from 706 mm to 3259 mm (ČADRO & al. 2019).

Data collection and analysis. All available chorological data on orchids of Bosnia and Herzegovina, both those collected during fieldwork and those obtained from published sources, were considered to compile the present checklist of orchids. Field investigations by the authors were intensively carried out between 2010 and 2021. The collected plant material was deposited in the Herbarium of the Regional Museum Visoko (HRM) and partly in the private collections of E. ŠABANOVIĆ (E.Š.), Đ. MILANOVIĆ (D.M.), B. ILIĆ (I.B.), A. BOŠKAILO (A.B.), and Č. ŠAHOVIĆ (Č.Š.). The overview of orchids and distribution data were also supplemented by checking and revising herbarium material deposited in the Herbarium of the National Museum of Bosnia and Herzegovina (SARA), Herbarium Cro-

Table 1. Overview of orchid taxa in Bosnia and Herzegovina with the literature sources (the earliest reference in which the taxon was published, and the taxon name from this oldest published source), the abbreviation(s) of the herbarium collection(s) containing the herbarium material and vouchers, and the status of presence throughout the country. Symbols and abbreviations (for details see ‘Materials and methods’):

Status categories: + (confirmed taxa), L (unconfirmed but credible records in the literature), ? (unconfirmed, doubtful records), – (erroneous records);

Herbaria listed in INDEX HERBARIORUM (2021): BEOU (Herbarium of the Institute of Botany and Botanical Garden “Jevremovac”, Belgrade), SARA (Herbarium of National Museum of Bosnia and Herzegovina, Sarajevo), ZA (Herbarium Croaticum, Zagreb), ZAHO (Herbarium Ivo and Marija Horvat, Zagreb);

Other herbaria: HRM (Herbarium of the Regional Museum Visoko); A.B. (A. BOŠKAILO), I.B. (B. ILIĆ), D.M. (Đ. MILANOVIĆ), E.Š. (E. ŠABANOVIĆ), Č.Š. (Č. ŠAHOVIĆ);

nhd: no herbarium or field data.

Current taxon name	Literature	Herbarium material	Status
<i>Anacamptis coriophora</i> (L.) R. M. BATEMAN, PRIDGEON & M. W. CHASE subsp. <i>coriophora</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis coriophora</i> L.	SARA, HRM, E.Š., D.M.	+
<i>Anacamptis coriophora</i> subsp. <i>fragrans</i> (POLLINI) R. M. BATEMAN, PRIDGEON & M. W. CHASE	FIALA (1893: 126) → <i>Orchis fragrans</i> POLLM.	SARA, D.M.	+
<i>Anacamptis laxiflora</i> (LAM.) R. M. BATEMAN, PRIDGEON & M. W. CHASE	PANTOCSEK (1874: 27) → <i>Orchis laxiflora</i> LAM.	SARA, D.M.	+
<i>Anacamptis morio</i> (L.) R. M. BATEMAN, PRIDGEON & M. W. CHASE subsp. <i>morio</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis morio</i> L.	SARA, HRM, E.Š., D.M.	+
<i>Anacamptis morio</i> subsp. <i>caucasica</i> (K. KOCH) H. KRETZSCHMAR, ECCARIUS & H. DIETR.	RADAK (2019: 235) → <i>Anacamptis morio</i> (L.) R. M. BATEMAN, PRIDGEON & M. W. CHASE subsp. <i>caucasica</i> (K. KOCH) H. KRETZSCHMAR, ECCARIUS & H. DIETR.	SARA	+
<i>Anacamptis morio</i> subsp. <i>picta</i> (LOISEL.) JACQUET & SCAPPAT.	BECK (1887: 53) → <i>Orchis picta</i> LOIS.	nhd	–
<i>Anacamptis palustris</i> (JACQ.) R. M. BATEMAN, PRIDGEON & M. W. CHASE subsp. <i>palustris</i>	FREYN & BRANDIS (1888: 631) → <i>Orchis palustris</i> JACQ.	SARA, D.M.	+
<i>Anacamptis palustris</i> subsp. <i>elegans</i> (HEUFF.) R. M. BATEMAN, PRIDGEON & M. W. CHASE	BECK (1903: 223) → <i>Orchis palustris</i> [var.] <i>elegans</i> HEUFF.	E.Š., D.M.	+
<i>Anacamptis pyramidalis</i> (L.) RICH.	KUMMER & SENDTNER (1849: 764) → <i>Anacamptis pyramidalis</i> RICH.	SARA, HRM, E.Š., D.M.	+
<i>Cephalanthera damasonium</i> (MILL.) DRUCE	KUMMER & SENDTNER (1849: 765) → <i>Cephalanthera pallens</i> RICH.	SARA, E.Š., D.M.	+
<i>Cephalanthera longifolia</i> (L.) R. M. FRITSCH	KUMMER & SENDTNER (1849: 765) → <i>Cephalanthera ensifolia</i> RICH.	SARA, ZA, HRM, E.Š., D.M.	+
<i>Cephalanthera rubra</i> (L.) RICH.	KUMMER & SENDTNER (1849: 765) → <i>Cephalanthera rubra</i> RICH.	SARA, ZA, HRM, E.Š., D.M.	+
<i>Corallorhiza trifida</i> CHÂTEL.	FREYN & BRANDIS (1888: 630) → <i>Corallorhiza innata</i> R. BR.	SARA, ZAHO, D.M.	+
<i>Cypripedium calceolus</i> L.	ASCHERSON & KANITZ (1877: 22) → <i>Cypripedium calceolus</i> L.	SARA, D.M.	+
<i>Dactylorhiza cordigera</i> (Fr.) Soó subsp. <i>cordigera</i>	HAYEK (1933: 396) → <i>Orchis cordigera</i> [subsp.] <i>rivularis</i> KLINGE	SARA, ZA	+

Table 1 (continued)

Current taxon name	Literature	Herbarium material	Status
<i>Dactylorhiza cordigera</i> subsp. <i>bosniaca</i> (BECK) Soó	BECK (1887: 53) → <i>Orchis bosniaca</i> BECK	SARA, E.Š., D.M.	+
<i>Dactylorhiza fuchsii</i> (DRUCE) Soó subsp. <i>fuchsii</i>	ŠOLJAN & al. (2014a: 57) → <i>Dactylorhiza fuchsii</i> (DRUCE) Soó	E.Š., D.M.	+
<i>Dactylorhiza incarnata</i> (L.) Soó subsp. <i>incarnata</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis latifolia</i> L.	HRM, E.Š., D.M.	+
<i>Dactylorhiza incarnata</i> subsp. <i>cruenta</i> (O. F. MÜLL.) P. D. SELL	MALÝ (1940: 40) → <i>Orchis incarnata</i> var. <i>haematodes</i> (RCHB.) M. SCHULZE	nhd	?
<i>Dactylorhiza maculata</i> (L.) Soó subsp. <i>maculata</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis maculata</i> L.	SARA, ZA, ZAHO, E.Š., D.M.	+
<i>Dactylorhiza maculata</i> subsp. <i>transilvanica</i> (SCHUR) Soó	BLAU (1877: 18) → <i>Orchis maculata</i> var. <i>ochrantha</i>	SARA, HRM, E.Š., D.M.	+
<i>Dactylorhiza majalis</i> (RCHB.) P. F. HUNT & SUMMERH. subsp. <i>majalis</i>	PROTIĆ (1900: 453) → <i>Orchis majalis</i> RCHB.	SARA, I.B., E.Š., D.M.	+
<i>Dactylorhiza saccifera</i> (BRONGN.) Soó subsp. <i>saccifera</i>	BECK (1887: 54) → <i>Orchis saccifera</i> BROGN.	E.Š., D.M.	+
<i>Dactylorhiza sambucina</i> (L.) Soó	KUMMER & SENDTNER (1849: 764) → <i>Orchis sambucina</i> L.	HRM, E.Š., D.M.	+
<i>Dactylorhiza viridis</i> (L.) R. M. BATEMAN, PRIDGEON & M. W. CHASE	KUMMER & SENDTNER (1849: 764) → <i>Coeloglossum viride</i> HARTM.	SARA, D.M.	+
<i>Epipactis atrorubens</i> (HOFFM.) BESSER	ASCHERSON & KANITZ (1877: 22) → <i>Epipactis rubiginosa</i> (CRTZ.) GAUD.	SARA, D.M.	+
<i>Epipactis helleborine</i> (L.) CRANTZ subsp. <i>helleborine</i>	KUMMER & SENDTNER (1849: 765) → <i>Epipactis latifolia</i> ALL.	SARA, ZAHO, E.Š., D.M.	+
<i>Epipactis helleborine</i> subsp. <i>orbicularis</i> (K. RICHT.) E. KLEIN	TOMOVIĆ & al. (2021: 130) → <i>Epipactis helleborine</i> subsp. <i>orbicularis</i> (K. RICHT.) E. KLEIN	SARA, E.Š.	+
<i>Epipactis leptochila</i> (GODFERY) GODFERY subsp. <i>leptochila</i>	MURBECK (1891: 37) → <i>Epipactis latifolia</i> [var.] <i>rectilinguis</i> MURB.	nhd	?
<i>Epipactis microphylla</i> (EHRH.) SW.	KUMMER & SENDTNER (1849: 765) → <i>Epipactis microphylla</i> Sw.	SARA, D.M.	+
<i>Epipactis muelleri</i> GODFERY subsp. <i>muelleri</i>	TAKÁCS & al. (2014: 296) → <i>Epipactis muelleri</i> GODFERY	nhd	+
<i>Epipactis palustris</i> (L.) CRANTZ	PANTOCSEK (1874: 28) → <i>Epipactis palustris</i> CRANTZ	SARA, HRM, E.Š., D.M.	+
<i>Epipactis purpurata</i> SM.	MURBECK (1891:37) → <i>Epipactis latifolia</i> var. <i>varians</i> CRANTZ	SARA, D.M.	+
<i>Epipogium aphyllum</i> Sw.	HANDEL-MAZZETI & al. (1905: 426) → <i>Epipogon aphyllum</i> (SCHM.) Sw.	SARA, ZAHO	+
<i>Goodyera repens</i> (L.) R. BR.	FIALA (1891: 281) → <i>Goodyera repens</i> R. BR.	E.Š., D.M.	+
<i>Gymnadenia conopsea</i> (L.) R. BR	KUMMER & SENDTNER (1849: 764) → <i>Gymnadenia conopsea</i> R. BR.	SARA, HRM, E.Š., D.M.	+

Table 1 (continued)

Current taxon name	Literature	Herbarium material	Status
<i>Gymnadenia densiflora</i> (WAHLENB.) A. DIETR.	ASCHERSON & KANITZ (1877: 22) → <i>Gymnadenia conopsea</i> [var.] <i>densiflora</i> (WAHLENB.) A. DIETR.	nhd	?
<i>Gymnadenia frivaldii</i> HAMPE ex GRISEB.	BJELČIĆ & al. (1969: 104) → <i>Gymnadenia frivaldii</i> HAMPE ex GRIS.	D.M.	+
<i>Gymnadenia nigra</i> (L.) RCHB. f.	KUMMER & SENDTNER (1849: 764) → <i>Nigritella angustifolia</i> RICH.	nhd	-
<i>Gymnadenia odoratissima</i> (L.) RICH.	PROTIĆ (1900: 453) → <i>Gymnadenia odoratissima</i> RICH.	SARA, D.M.	+
<i>Gymnadenia rhellicani</i> (TEPPNER & E. KLEIN) TEPPNER & E. KLEIN	ŠILIĆ (2002: 212) → <i>Gymnadenia rhellicani</i> (TEPPNER & E. KLEIN) TEPPNER & E. KLEIN	SARA, ZAHO, BEOU, E.Š., D.M.	+
<i>Gymnadenia</i> × <i>chanousiana</i> G. FOELSCHÉ & W. FOELSCHÉ [= <i>G. conopsea</i> × <i>G. rhellicani</i>]	FRITSCH (1909: 182) → <i>Gymnadenia suaveolens</i> (VILL.) WETTST. = <i>Gymnadenia conopsea</i> × <i>nigra</i>	nhd	?
<i>Gymnadenia</i> × <i>heufferi</i> (A. KERN.) WETTST. [= <i>G. nigra</i> × <i>G. odoratissima</i>]	HAYEK (1933: 408) → <i>Gymnadenia odoratissima</i> × <i>nigra</i>	nhd	?
<i>Gymnadenia</i> × <i>intermedia</i> PETERM. [= <i>G. conopsea</i> × <i>G. odoratissima</i>]	HAYEK (1933: 408) → <i>Gymnadenia conopsea</i> × <i>odoratissima</i>	nhd	?
<i>Hermidium monorchis</i> (L.) R. BR.	BOUÉ (1840: 442) → <i>Satyrium monorchis</i> PERS.	nhd	L
<i>Himantoglossum adriaticum</i> H. BAUMANN	MILANOVIĆ & al. (2015b: 102) → <i>Himantoglossum adriaticum</i> H. BAUMANN	SARA, D.M.	+
<i>Himantoglossum calcaratum</i> (BECK) SCHLTR. subsp. <i>calcaratum</i>	BECK (1887: 55) → <i>Aceras caprina</i> LINDL. var. <i>calcarata</i> BECK	SARA, D.M.	+
<i>Himantoglossum calcaratum</i> subsp. <i>rumelicum</i> (H. BAUMANN & R. LORENZ) NIKETIĆ & DJORDJEVIĆ	MILANOVIĆ & al. (2022) → <i>Himantoglossum calcaratum</i> subsp. <i>rumelicum</i> (H. BAUMANN & R. LORENZ) NIKETIĆ & DJORDJEVIĆ	D.M.	+
<i>Himantoglossum caprinum</i> (M. BIEB.) SPRENG.	ASCHERSON & KANITZ (1877: 21) → <i>Aceras hircina</i> var. <i>caprina</i> (M. B.) LINDL	nhd	-
<i>Himantoglossum hircinum</i> (L.) SPRENG.	BLAU (1877: 16) → <i>Aceras hircinum</i>	nhd	-
<i>Himantoglossum robertianum</i> (LOISEL.) P. DELFORGE	ZELENIKA (2012: 26) → <i>Himantoglossum robertianum</i>	nhd	L
<i>Limodorum abortivum</i> (L.) SW.	KUMMER & SENDTNER (1849: 765) → <i>Limodorum abortivum</i> Sw.	E.Š., D.M.	+
<i>Liparis loeselii</i> (L.) RICH.	MALÝ (1905: 485) → <i>Liparis loeselii</i>	D.M.	+
<i>Malaxis monophyllos</i> (L.) SW.	MALÝ (1908: 563) → <i>Malaxis monophyllos</i> (L.) Sw.	nhd	-
<i>Neotinea maculata</i> (DESF.) STEARN.	ZELENIKA (2012: 26) → <i>Neotinea maculata</i>	nhd	+

Table 1 (continued)

Current taxon name	Literature	Herbarium material	Status
<i>Neotinea tridentata</i> (SCOP.) R. M. BATEMAN, PRIDGEON & M. W. CHASE subsp. <i>tridentata</i>	KUMMER & SENDTNER (1849: 763) → <i>Orchis variegata</i> ALL.	SARA, ZA, HRM, E.Š., D.M.	+
<i>Neotinea ustulata</i> (L.) R. M. BATEMAN, PRIDGEON & M. W. CHASE	KUMMER & SENDTNER (1849: 764) → <i>Orchis ustulata</i> L.	SARA, HRM, E.Š., D.M.	+
<i>Neotinea</i> × <i>diétrichiana</i> (BOGENH.) H. KRETZSCHMAR, ECCARIUS & H. DIETR. nothosubsp. <i>diétrichiana</i> [= <i>N. tridentata</i> subsp. <i>tridentata</i> × <i>N. ustulata</i> var. <i>ustulata</i>]	MALÝ (1928: 145) → <i>Orchis tridentatus</i> × <i>ustulatus</i> CANUT	SARA, D.M.	+
<i>Neottia cordata</i> (L.) RICH.	BOUÉ (1840: 442) → <i>Ophrys cordata</i> L.	SARA, ZAHO, D.M.	+
<i>Neottia nidus-avis</i> (L.) RICH.	KUMMER & SENDTNER (1849: 765) → <i>Neottia nidus avis</i> RICH.	SARA, E.Š., D.M.	+
<i>Neottia ovata</i> (L.) BLUFF & FINGERH.	KUMMER & SENDTNER (1849: 765) → <i>Listera ovata</i> R. BR.	HRM, E.Š., D.M.	+
<i>Ophrys apifera</i> HUDS.	BLAU (1877: 11) → <i>Ophrys apifera</i>	SARA, E.Š., D.M.	+
<i>Ophrys bertolonii</i> MORETTI	PANTOCSEK (1874: 28) → <i>Ophrys bertolonii</i> MORETTI	SARA, A.B., D.M.	+
<i>Ophrys fuciflora</i> (F. W. SCHMIDT) MOENCH subsp. <i>fuciflora</i>	ASCHERSON & KANITZ (1877: 22) → <i>Ophrys fuciflora</i> (SEG.) RCHB.	SARA	+
<i>Ophrys fusca</i> LINK	FIALA (1890: 311) → <i>Ophrys myodes</i> JACQ.	SARA	+
<i>Ophrys insectifera</i> L. subsp. <i>insectifera</i>	PROTIĆ (1898: 672) → <i>Ophrys muscifera</i> HUDS.	E.Š., D.M.	+
<i>Ophrys scolopax</i> subsp. <i>cornuta</i> (STEVEN) E. G. CAMUS	KUMMER & SENDTNER (1849: 765) → <i>Ophrys cornuta</i> STEV.	SARA, E.Š., D.M.	+
<i>Ophrys sphegodes</i> MILL. subsp. <i>sphegodes</i>	KUMMER & SENDTNER (1849: 765) → <i>Ophrys aranifera</i> HUDS.	SARA, E.Š., D.M.	+
<i>Ophrys sphegodes</i> subsp. <i>atrata</i> (RCHB. f.) A. BOLÒS	BECK (1887: 55) → <i>Ophrys atrata</i> LINDL.	nhd	?
<i>Orchis anthropophora</i> (L.) ALL.	PROTIĆ (1902: 29) → <i>Aceras anthropophora</i> R. BR.	nhd	L
<i>Orchis italica</i> POIR.	PANTOCSEK (1874: 26) → <i>Orchis longicruris</i> LK.	SARA, Č.Š.	+
<i>Orchis mascula</i> (L.) L. subsp. <i>mascula</i>	ASCHERSON & KANITZ (1877: 21) → <i>Orchis mascula</i> L.	nhd	L
<i>Orchis mascula</i> subsp. <i>speciosa</i> (MUTEL) HEGI	KUMMER & SENDTNER (1849: 764) → <i>Orchis mascula</i> var. <i>speciosa</i> KOCH	SARA, E.Š., D.M.	+
<i>Orchis militaris</i> L. subsp. <i>militaris</i>	HOFMANN (1882: 219) → <i>Orchis militaris</i> L.	SARA, HRM, E.Š., D.M.	+
<i>Orchis pallens</i> L.	KUMMER & SENDTNER (1849: 764) → <i>Orchis pallens</i> L.	SARA, E.Š., D.M.	+
<i>Orchis pauciflora</i> TEN.	MALÝ (1904: 183) → <i>Orchis provincialis</i> BALB. var. <i>pauciflorus</i> (TEN.) RCHB.	SARA, D.M.	+

Table 1 (continued)

Current taxon name	Literature	Herbarium material	Status
<i>Orchis provincialis</i> BALB. ex LAM. & DC.	PANTOCSEK (1874: 27) → <i>Orchis provincialis</i> BALB.	SARA, D.M.	+
<i>Orchis purpurea</i> HUDS. subsp. <i>purpurea</i>	KUMMER & SENDTNER (1849: 763) → <i>Orchis fusca</i> JACQ.	SARA, HRM, E.Š., D.M.	+
<i>Orchis purpurea</i> subsp. <i>dinarica</i> LAKUŠIĆ, nom. inval.	LAKUŠIĆ (2005) → <i>Orchis purpurea</i> subsp. <i>dinarica</i>	nhd	–
<i>Orchis quadripunctata</i> CIRILLO ex TEN.	MALÝ (1904: 184) → <i>Orchis quadripunctatus</i> CYRILL	SARA, D.M.	+
<i>Orchis simia</i> LAM. subsp. <i>simia</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis simia</i> LAM.	SARA, ZA, HRM, E.Š., D.M.	+
<i>Orchis spitzelii</i> SAUT. ex W. D. J. KOCH subsp. <i>spitzelii</i>	KUMMER & SENDTNER (1849: 764) → <i>Orchis spitzelii</i> SAUT.	SARA, E.Š., D.M.	+
<i>Orchis</i> × <i>hybrida</i> (LINDL.) BOENN. ex RCHB. [= <i>O. militaris</i> × <i>O. purpurea</i>]	HAYEK (1933: 398) → <i>Orchis militaris</i> × <i>purpurea</i>	nhd	L
<i>Platanthera bifolia</i> (L.) RICH.	KUMMER & SENDTNER (1849: 764) → <i>Platanthera bifolia</i> RICH.	SARA, E.Š., D.M.	+
<i>Platanthera chlorantha</i> (CUSTER) RCHB. subsp. <i>chlorantha</i>	KUMMER & SENDTNER (1849: 764) → <i>Platanthera chlorantha</i> CUST.	SARA, ZA, E.Š., D.M.	+
<i>Pseudorchis albida</i> (L.) Á. LÖVE & D. LÖVE	ASCHERSON & KANITZ (1877: 22) → <i>Gymnadenia albida</i> (L.) RICH.	SARA, ZAHO, D.M.	+
<i>Serapias bergonii</i> E. G. CAMUS	MILANOVIĆ & al. (2022) → <i>Serapias bergonii</i> E. G. CAMUS	SARA, E.Š., D.M.	+
<i>Serapias parviflora</i> PARL.	MILANOVIĆ (2019: 49) → <i>Serapias parviflora</i> PARL.	SARA, D.M.	+
<i>Serapias vomeracea</i> (BURM. f.) BRIQ.	MASLO & BOŠKAILO (2018: 24) → <i>Serapias vomeracea</i> (BURM.) BRIQ.	nhd	L
<i>Spiranthes aestivalis</i> (POIR.) RICH.	HAYEK (1933: 414) → <i>Spiranthes aestivalis</i> (LAM.) RICH.	nhd	?
<i>Spiranthes spiralis</i> (L.) CHEVALL.	HOFMANN (1882: 219) → <i>Spiranthes autumnalis</i> RICH.	E.Š., D.M.	+
<i>Traunsteinera globosa</i> (L.) RCHB.	KUMMER & SENDTNER (1849: 764) → <i>Orchis globosa</i> L.	SARA, E.Š., D.M.	+

aticum (ZA), Herbarium Ivo and Marija Horvat (ZAHO) and the Herbarium of the Institute of Botany and Botanical Garden “Jevremovac”, University of Belgrade (BEOU).

The identification and revision of orchid taxa were performed according to BUTTLER (1991) and DELFORGE (2006). The nomenclature of the taxa follows the World Checklist of Selected Plant Families (WCSP 2020) and Euro+Med Plantbase (EURO+MED 2006).

Depending on the degree of reliability of the presence of the orchid taxa in Bosnia and Herzego-

vina, the status of orchid taxa is classified into the following categories:

(+) confirmed (taxa whose occurrence has been confirmed by field research or examination of herbarium material);

(L) unconfirmed (taxa whose data have been published and whose presence has not been confirmed by field research and relevant herbarium material, but which are assumed to occur in the country);

(?) doubtful (taxa with uncertain occurrence in Bosnia and Herzegovina due to inaccurate locali-

ties, unavailable herbarium material, lack of suitable habitats, or other incorrect assumptions);

(-) erroneous (erroneously reported taxa: taxa where all specimens from herbarium collections have been incorrectly identified, or obviously erroneous reports without herbarium material).

In addition to the status of orchid taxa in Bosnia and Herzegovina, the list contains the following data for each orchid taxon: current taxon name; literature (the earliest known reference in which the taxon was published and the taxon name from the oldest published source); the abbreviation of the name of the herbarium collection containing the herbarium material and vouchers. If there are no herbarium or field data, the abbreviation 'nhd' is used.

The final richness of orchid taxa in Bosnia and Herzegovina was calculated as the sum of the number of orchid species and subspecies from the categories of confirmed taxa (+) and unconfirmed taxa whose occurrence in the country is suspected and supported by relevant literature sources (L). These two categories of taxa were used to perform the taxonomic analysis of orchids in Bosnia and Herzegovina.

3. Results

3.1. Checklist of the orchids of Bosnia and Herzegovina

Using data from field research as well as data from herbarium collections and published sources, a list of taxa of orchids of Bosnia and Herzegovina was compiled (Table 1). The total number of confirmed orchid taxa in Bosnia and Herzegovina is 71 species and subspecies and one hybrid, the number of unconfirmed orchid taxa is five species and subspecies and one hybrid, the number of uncertain taxa is five species and subspecies and three hybrids, and finally the number of erroneously listed taxa is six (Tables 1 and 2).

3.2. Taxonomic analysis

Out of a total of 87 species and subspecies of *Orchidaceae* reported for the flora of Bosnia and Herzegovina (Table 1), a taxonomic analysis of 76 species and subspecies was carried out (confirmed taxa and taxa whose data have been published but whose presence has not been confirmed by fieldwork and relevant herbarium material, but which are assumed to occur in the country). The total number of orchid species and subspecies are classified in 22 genera (Table 3). The most taxa-rich genera are *Orchis* (12 species and subspecies), *Dactylorhiza* (10), *Anacamptis* (8), *Epipactis* (7), and *Ophrys* (7). The genera *Gymnadenia* and *Himantoglossum*

Table 2. Categorization of orchid species and subspecies reported from Bosnia and Herzegovina according to the degree of reliability.

Number of Taxa	Percentage	Category
71	81.61 %	confirmed (+)
5	5.75 %	literature (L)
5	5.75 %	doubtful (?)
6	6.89 %	erroneous (-)

Table 3. Representation of genera in the orchid flora of Bosnia and Herzegovina.

Genus	Number of species and subspecies
<i>Orchis</i>	12
<i>Dactylorhiza</i>	10
<i>Anacamptis</i>	8
<i>Epipactis</i>	7
<i>Ophrys</i>	7
<i>Gymnadenia</i>	4
<i>Himantoglossum</i>	4
<i>Cephalanthera</i>	3
<i>Neotinea</i>	3
<i>Neottia</i>	3
<i>Serapias</i>	3
<i>Platanthera</i>	2
<i>Corallorhiza</i>	1
<i>Cypripedium</i>	1
<i>Epipogium</i>	1
<i>Goodyera</i>	1
<i>Herminium</i>	1
<i>Limodorum</i>	1
<i>Liparis</i>	1
<i>Pseudorchis</i>	1
<i>Spiranthes</i>	1
<i>Traunsteinera</i>	1

glossum are represented by four taxa each, the genera *Cephalanthera*, *Neotinea*, *Neottia* and *Serapias* are represented by three taxa, while *Platanthera* is represented by two taxa. Ten genera (*Corallorhiza*, *Cypripedium*, *Epipogium*, *Goodyera*, *Herminium*, *Limodorum*, *Liparis*, *Pseudorchis*, *Spiranthes* and *Traunsteinera*) are represented by a single taxon.

4. Discussion

The orchid flora of Bosnia and Herzegovina has been studied with great discontinuity over time. The interruption of research was particularly pronounced in the 1990s due to the state of war. However, even today it is a challenge to research the orchid flora in this country, considering the aggravating factors, such as the remnants of minefields from the war period. In relation to all orchid taxa reported so far from the territory of Bosnia and Herzegovina, the presence of 81.61% is confirmed. The presence of a significant proportion of taxa (5.75%) could not be confirmed so far, although they are assumed to occur in the country. Data on these taxa were found in published sources, but there is no evidence for them in herbarium collections or photographic material.

Among the unconfirmed taxa, *Orchis mascula* subsp. *mascula* is particularly noteworthy. Although KRETZSCHMAR & al. (2007) stated that both subspecies of *Orchis mascula* (subsp. *mascula* and subsp. *speciosa*) grow in the central Balkans, field research and insight into herbarium material revealed the presence of only subsp. *speciosa*. A similar situation was found in the orchid flora of Serbia (DJORDJEVIĆ & al. 2021), further indicating the need for a detailed study of this species in the central Balkans.

Although *Dactylorhiza majalis* subsp. *majalis* is a confirmed taxon of Bosnia and Herzegovina, there is a possibility that numerous records in the literature could be based on misidentifications and actually refer to *D. cordigera*. In fact, two other taxa of the *Dactylorhiza majalis* group grow in this country: *Dactylorhiza cordigera* subsp. *cordigera* (subendemic in the Balkans and Carpathians) and *D. cordigera* subsp. *bosniaca* (endemic in the Balkans). Overall, the whole group needs a detailed revision using morphometric and molecular studies in Southeast Europe.

Among the erroneously recorded taxa, the first to be mentioned are *Himantoglossum hircinum*, a species that grows mainly in western and central Europe (DELFORGE 2006), and *Himantoglossum caprinum*, which grows mainly in the Crimea (MOLNÁR & al. 2012). The confusion about the status of occurrence of *Himantoglossum* taxa is mainly caused by the frequent uncritical use of names like *H. hircinum* and *H. caprinum* in the floristic literature, usually without insight into the infraspecies level. However, according to recent studies, records of *H. caprinum* outside the Crimea are actually renamed *H. jankae* SOMLYAY, KREUTZ & ÓVÁRI (MOLNÁR & al. 2012) or *H. calcaratum* subsp. *jankae* (SOMLYAY, KREUTZ & ÓVÁRI) R. M. BATEMAN, MOLNÁR & SRAMKÓ (BATEMAN & al. 2017). However, the current name for

this taxon is *H. calcaratum* subsp. *rumelicum* (H. BAUMANN & R. LORENZ) NIKETIĆ & DJORDJEVIĆ (NIKETIĆ & al. 2018) which was already included in the World Checklist of Selected Plant Families (WCSP 2020). Field observations and detailed insights into herbarium material revealed the presence of two *Himantoglossum* taxa in Bosnia and Herzegovina (*H. adriaticum* and *H. calcaratum* subsp. *calcaratum*), whereas *H. calcaratum* subsp. *rumelicum* was recently found for the first time in this country (MILANOVIĆ & al. 2022). *Himantoglossum calcaratum* subsp. *calcaratum* occurs in the central Balkans, mainly in western Serbia, eastern Bosnia and Herzegovina and northern Montenegro, and is an endemic taxon of the Balkan Peninsula (DELFORGE 2006, DJORDJEVIĆ & al. 2016, 2020). The localities of this taxon in Bosnia and Herzegovina represent the westernmost points of its distribution. In addition, according to published sources (ZELENIKA 2012), *Himantoglossum robertianum* (LOISEL.) P. DELFORGE grows in the southern region of Bosnia and Herzegovina (locality Čitluk), but there is a lack of herbarium or photographic material to confirm this.

Anacamptis morio subsp. *picta* is also an erroneously recorded taxon, as it grows mainly in the western Mediterranean region of Europe, including the Iberian Peninsula, the southern French mainland, and Corsica (KRETZSCHMAR & al. 2007). Records of this taxon in Bosnia and Herzegovina, however, were based on misidentifications and refer to *A. morio* subsp. *morio* or *A. morio* subsp. *caucasica*, both of which occur in the area of the central Balkans (KRETZSCHMAR & al. 2007, RADAK 2019).

Another erroneously reported taxon is *Gymnadenia nigra* (= *Nigritella n.*), as it grows only in Scandinavia and is endemic there (DELFORGE 2006). Insight into the herbarium material and field research revealed that the records in Bosnia and Herzegovina refer to *G. rhellicani*, which is consistent with a recent study stating that this species occurs in southeastern Europe, including the central Balkans (HEDRÉN & al. 2018).

Malaxis monophyllos is another taxon listed by error, considering that, when the name of this species was published, the author himself denied its occurrence in Bosnia and Herzegovina, emphasizing that this claim actually referred to *Liparis loeselii* (MALÝ 1908).

Confusion among taxa also occurs within the *Anacamptis palustris* group. In the floristic literature of Bosnia and Herzegovina, several taxa are listed at the species level as *Anacamptis laxiflora* (= *Orchis l.*). Revision of herbarium material and field research revealed the dominant occurrence of *A. palustris* subsp. *elegans* throughout the country, as well as the occurrence of *A. laxiflora* mainly in

the southern region, while *A. palustris* subsp. *palustris* proved to be much rarer. Confusion and mistakes in taxon identification within this group exist also in Serbia (DJORDJEVIĆ & al. 2018), and throughout the Balkans, but a detailed morphometric study has shown clear differences between these taxa (RADAK 2019).

The territory of Bosnia and Herzegovina is a transition zone of two *Dactylorhiza* species, *D. fuchsii* and *D. saccifera*. Although *D. fuchsii* has a wide distribution in the country according to published sources, it is suspected that it is often misidentified and that these chorological data actually refer to *D. saccifera*. At the same time, these taxa are often misidentified as *D. maculata*, and apparently authors/collectors are sometimes unaware of the infraspecific taxa known in this genus.

Although herbarium material of *Neotinea maculata* is lacking in the herbaria, the species was recently found in Bosnia and Herzegovina (locality Čitluk) and there is photographic material confirming its occurrence (ZELENKA 2012).

The orchid flora in Bosnia and Herzegovina is dominated by the genus *Orchis* (Table 3), which is not surprising, since the entire southern region of the country is directly influenced by the mediterranean climate, as well as due to the large number of habitats that favor the development and survival of this genus (DELFORGE 2006, KRETZSCHMAR & al. 2007, GIROS 2009).

The presence of a mediterranean climate is one of the important reasons explaining the significant number of species of the typically Mediterranean genus *Ophrys* in Bosnia and Herzegovina (Table 3). Since the entire southern region near the Adriatic Sea is under the influence of the mediterranean climate, it can be assumed that the number of *Ophrys* and *Serapias* taxa in this country is higher. According to BECK (1903), *Serapias lingua* L. is also mentioned for Bosnia and Herzegovina from the site of Sutorina. However, this locality now belongs to the territory of Montenegro, so future research should investigate the possible occurrence of this species in Bosnia and Herzegovina.

A large number of *Dactylorhiza* taxa (Table 3) can be expected, considering the presence of various grassland ecosystems and fens, which are the main habitats of this genus (PILLON & al. 2006).

A significant number of representatives of the genus *Epipactis* (Table 3) is not surprising, considering that forest ecosystems and especially beech forests are very widespread in the country as the most important habitats of this genus (DELFORGE 2006). It is known that the Balkan Peninsula is an important center of diversity of this genus, along with the Apennine Peninsula and Central Europe (EFIMOV 2008, TRANCHIDA-LOMBARDO & al. 2011). It is

assumed that a considerable number of new *Epipactis* taxa will be recorded in future research.

5. Conclusions

Based on long-term personal field investigations, checking and revision of herbarium material and relevant published sources, a total of 76 orchid species and subspecies and two hybrids belonging to 22 genera have been recorded in Bosnia and Herzegovina. Although more field research on the orchid flora of the country has been published in recent years, data on the distribution of many orchid taxa are lacking. Moreover, a revision of some taxonomically difficult orchid groups is required. Therefore, the present study shows a clear need for further field and biosystematic studies to fill these gaps. Accordingly, the number of orchid taxa reported here is certainly not definitive. In addition, it is expected that new taxa will be found through future research, particularly *Epipactis* and *Ophrys* taxa, considering suitable habitats and climatic conditions. The checklist of orchids of Bosnia and Herzegovina presented here is the first systematic overview of the orchid taxa of the country with categorization of records according to their degree of reliability and represents a fundamental tool for floristic, taxonomic, chorological and conservation research.

Acknowledgements

We are grateful to the Environmental Fund of the Federation of Bosnia and Herzegovina (<https://fzofbih.org.ba/>) for supporting this research. Vladan DJORDJEVIĆ, PhD was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (number 451-03-9/2021-14/200178).

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(Received 8 Oct 2021, accepted 1 Dec 2021)