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An updated dichotomous key to the snakes of Europe

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This work presents an updated dichotomous key to all snake species of Europe, based on morphological, morphometric and distributional characters. It gathers data from both the last dichotomous keys concerning European snake species and every following paper giving updates on taxonomic classification or the occurrence of new allochthonous species. The key includes 58 snake taxa, including 57species and one still unnamed taxon, distributed on the European territory, and photographic material for each species. The aim of this paper is to make the identification of all European snake species through a single manuscript more accessible, not only for researchers, but also for citizen science, thus enhancing data collection and assist species conservation.

***Key words*:** dichotomous key; European territory; Ophidia; snakes; species identification.

A dichotomous key is a powerful tool for classification and identification of both objects and above all living organisms (Watson, 2009). It provides the reader with a simple choice method between two paired statements describing alternative morphological characteristics. Once the choice is made, the key guides the user to another couplet of statements, repeating the process until the object or organism is identified (Van Sinh *et al*., 2017; Armiñana-García *et al*., 2020). Dichotomous keys are widespread tools among researchers, technicians and students, but can be useful even to people not belonging to the scientific world (Di Nicola, 2019). This is important to improve the so-called "citizen science", which is becoming very popular both for Europe and single countries (Vohland *et al*., 2021), in particular when referred to technological and social innovation leading to social change (Butkevičienė *et al*., 2021).

The scientific literature is increasingly enriched with new taxonomic keys concerning plant and animal species. Snakes are no exception (just in the last few years, it is possible to cite examples as: Di Nicola, 2019; Mallik *et al*., 2019; Weinell *et al*., 2019; Alshammari & Busais, 2020; Ganesh *et al*., 2020; Spengler Waltrick & Menta Giasson, 2021; Dávalos-Martínez *et al*., 2021).

Over the years, dichotomous keys for snakes present on European or Mediterranean areas have already been created both for popular and scientific literature (e.g. Boulenger, 1913; Venchi & Sindaco, 2006;

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Speybroeck *et al*., 2016), but the numerous scientific researches in the herpetological field, beside an increasing use of molecular techniques and with an even better knowledge of the investigated territories, involve continuous taxonomic updates and more in-depth knowledge of the species distribution. Hence the need to have an updated key, in line with recent systematic updates, with the current distributions of the species and with the presence of alien taxa that settled with stable populations in the last years.

Materials and Methods

The dichotomous key proposed in this work is based on morphological and morphometric characters and on the snake finding locations; it is realized taking as a reference the keys present in the following literature: Boulenger (1913); Venchi & Sindaco (2006); Corti *et al*. (2011); Sindaco *et al*. (2013); Speybroeck *et al*. (2016); Geniez (2018); Di Nicola (2019).

In addition, to obtain updated information at the taxonomic, anatomical (morphological descriptions) and distributional level, the following publications were consulted: Guicking *et al*. (2006); Kreiner (2007); Cabrera-Pérez *et al*. (2012); van de Koppel *et al*. (2012); Mahlow *et al*. (2013); Silva-Rocha *et al*. (2015); Kindler (2018); Kindler & Fritz (2018); Mizsei *et al*. (2018); Faraone *et al*. (2019a, b); Jablonski *et al*. (2019); Paolino *et al*. (2019); Zaher *et al*. (2019); Akbarpour *et al*. (2020); Cattaneo (2020); Clemens & Allain (2020); Freitas *et al*. (2020); Fritz & Schmidtler (2020); Fritz *et al*. (2020); Seghetti *et al*. (2020); Speybroeck *et al*. (2020); Tamar *et al*. (2020); Wallach (2020); Di Nicola *et al*. (2021); van Doorn *et al*. (2021).

The European area considered (Fig. S1), is in agreement with what was established by Speybroeck *et al*. (2020), thus including all territories of the European mainland, Macaronesia (except Cape Verde), Balearic Islands, all Greek and Italian islands, Malta and Cyprus. The easternmost limits of the area include territories west of the Ural Mountains and the Ural River (SW Sverdlovsk Oblast, NW Čeljabinsk Oblast and W Kazakhstan included), north of the Caucasus Mountains and NE Azerbaijan.

The key covers species level only, and does not consider subspecies since there are many taxa requiring a status overhaul (e.g., subspecies are sometimes still based on old and not always reliable morphological descriptions). The key also considers allochthonous snakes, but only species that are present in Europe with reproductive populations have been included, such as *Elaphe schrenckii*, *Elaphe taeniura*, *Indotyphlops braminus* and *Lampropeltis getula* (Cabrera-Pérez *et al*., 2012; van de Koppel *et al*., 2012; Mateo, 2013; Faraone *et al*., 2019a; Paolino *et al*., 2019; Struijk *et al*. 2020; Vella *et al*., 2020; Di Nicola *et al*., 2021; van Doorn *et al*., 2021). *Rhynchocalamus melanocephalus* from Cyprus is also considered, due to three different findings in the period 2013-2018 (Tamar *et al*., 2020). The allochthonous/recently introduced status was made explicit only for species whose allochtony is recent (with the first records occurring in the last decades) and supported by the literature. For taxa likely introduced but whose origin hypotheses are still unclear (e.g. *Eryx jaculus* for Sicily and *R. melanocephalus* for Cy-

prus) the status in the key has not been specified.

Higher taxa (i.e. superfamilies and families) maintain the same partition explained and provided by ZAHER *et al*. (2019). Family Viperidae is separated from all other colubroideans (thus explaining why it does not currently belong to any superfamily), within the robustly supported clade Endoglyptodonta. Colubroideans are represented by superfamilies Elapoidea *sensu stricto* and Colubroidea *sensu stricto*, which are sister clades with robust support. The former contains family Psammophiidae (here represented by genus *Malpolon*) with strong support; while the latter contains family Natricidae (robustly supported) as the sister group (no support) of a bigger clade formed by (moderate support) Colubridae, Grayiidae, Calamariidae, and Sibynophiidae. Thus, Natricidae and Colubridae are listed as distinct taxa.

Superfamily Booidea is represented by genus *Eryx*, which is part of Erycidae family (PYRON *et al*., 2014), and Superfamily Typhlopoidea contains family Typhlopidae with *Xerotyphlops vermicularis* and *Indotyphlops braminus*. For the latter, WALLACH (2020) proposed the new genus name *Virgotyphlops* due to its obligate parthenogenetic reproduction, but pending an investigation it is still listed as *Indotyphlops braminus* as in SPEYBROECK *et al*. (2020).

We have considered the False smooth snake from Lampedusa (Italy) as a separate unit. Based on morphological features (WADE, 2001), most of the recent literature attributes this population to *Macroprotodon cucullatus textilis* (DUMÉRIL & BIBRON, 1854) (KREINER, 2007; CAPULA *et al*., 2011; SINDACO *et al*., 2013; CATTANEO, 2015; DI NICOLA, 2019). However, genetic studies on mitochondrial markers indicate that this population belongs to a possible specific rank clade that also includes samples from central Tunisia (FARAONE *et al*., 2020). This still unnamed taxon is highly genetically distinct from the other *Macroprotodon* species present in the European range (*M. cucullatus*: Kimura 2-parameter distance based on cyt b = 12.9%; *M. brevis*: Kimura 2-parameter distance based on cyt b = 13.4%) (FARAONE *et al*., 2020); furthermore, it is morphologically discriminable from both *M. cucullatus* and *M. brevis* (see WADE, 2001). Therefore, in this context we have provisionally named it "*Macroprotodon* Lampedusa/Tunisia clade".

We have not included in the key the genus *Gloydius* because its presence in Europe (i.e. west side of the Ural river) has not been ascertained yet (see SPEYBROECK *et al*., 2020).

Macrovipera schweizeri taxonomic status is still debated: SPEYBROECK *et al*. (2020) consider the taxon at a specific level, since the subspecies rank suggested by STÜMPEL & JOGER (2009) and STÜMPEL (2012 - PhD dissertation) on a molecular basis is not supported by data published in peer review literature yet and the relevant *Macrovipera* sequences are not available in GenBank as well; FREITAS *et al*. (2020) suggest to consider the Milos viper as a subspecies of *M. lebetinus*, based upon a genetic distance of only 2% (cyt-b) between the two taxa. In this work we maintain the specific status (just like several authors who recently cited the Milos viper in their works -e.g., CATTANEO, 2020; PIZZIGALLI *et al*., 2020; CHOWDHURY *et al*., 2021; DEGEN & BROCK, 2021; KONTSIOTIS *et al*., 2022) ac-

cording to the most recent checklist by the Taxonomic Committee of the Societas Europaea Herpetologica (SPEYBROECK *et al*., 2020).

Some taxa described within the genus *Vipera,* such as *V. lotievi*, *V. magnifica*, *V. nikolskii*, *V. orlovi* and *V. shemakhensis* are not considered valid species according to both FREITAS *et al*. (2020) and SPEYBROECK *et al*. (2020).

At last, also *Vipera walser* GHIELMI *et al*., 2016 is currently no longer considered a valid species. Although FREITAS *et al*. (2020) asserted the taxon validity arguing that it has been investigated with an efficient integrative approach (investigating phylogenetic divergence and phenotypic variability), and SEGHETTI *et al*. (2020) stated that *V. walser* is clearly distinct from other Italian vipers based on differences in skull osteology, SPEYBROECK *et al*. (2020) consider the acceptance of the new species premature until further nuclear DNA data would confirm the diversity of the *walser* population. Further nuclear data have been provided by DONIOL-VALCROZE *et al*. (2021), showing that *V. walser* and *V. berus marasso* are not recovered as distinct lineages due to cyto-nuclear discordance. On the same basis, also SINDACO & RAZZETTI (2021), in the recent checklist of Italian amphibians and reptiles, do not recognize *V. walser* as a valid species and propose a subspecies rank (*V. berus walser*).

The supporting material file contains the updated checklist of European snakes (Table S1) and the photographic recognition of the species (Fig. S2), numbered and arranged according to the indications of this dichotomous key.

For the nomenclature of the main cephalic scales and for the count of ventral and dorsal scales see the supplementary file in DI NICOLA (2019).

RESULTS

Key to snakes

1a. Worm-like. Dorsal and ventral scales identical, spiny scale on the tip of the tail. Snout rounded in profile, very small eye protected by a semi-transparent shield and visible only as a dark spot.....(**Typhlopidae**) **2**

1b. Snake-like. Ventral scales larger than dorsal ones. Eyes well developed and visible.....**3**

2a. Very small size (up to 17 cm of total length). Ocular plate divided (eye below the suture of two plates). 20 rows of dorsals at mid-body. Allochthonous, probably native to India and SE Asia. European distribution: Portugal (Madeira), Spain (Canary Islands, Mallorca and one mainland population in Almería Province), Malta and Italy (Sicily and Ischia).....***Indotyphlops braminus***

2b. Small size (up to 36 cm of total length). Ocular plate entire. Usually 22-24 (rarely 20 or 26) rows of dorsals at mid-body. European distribution: Serbia, Montenegro, S Balkans, Bulgaria, several Greek Islands, Turkish Thrace, Cyprus, S European Russia, NE Azerbaijan.....
.....***Xerotyphlops vermicularis***

3a. Subcaudals single (or mostly single). Ventrals wide and covering less than half the width of the belly; remaining belly surface covered with small and smooth identical scales as for the dorsum. Head not distinct from the body. Bulky body. Tail short and blunt. Eyes with vertical pupils. Dorsals of the front half of the

body smooth, keeled towards the end. 41-57 rows of dorsals at mid-body.....(**Erycidae**) **4**

3b. Subcaudals paired. Ventrals almost entirely covering the width of the belly. Head more or less distinct from the body. Slenderer body. Longer and pointed tail. Eyes with round or vertical pupils. Less than 30 rows of dorsals at mid-body.....**5**

4a. Usually two or three (rarely four) post-internasal shields. Six or seven scales (rarely four, five or eight) between the eyes. Two or three scales between nasals and the eye. European distribution: S Romania, Bulgaria, S Balkans, several Greek Islands, Turkish Thrace, Italy (S Sicily), Cyprus, S European Russia, NE Azerbaijan.....***Eryx jaculus***

4b. Three or four post-internasal shields. Seven to nine scales between the eyes. Four or five scales between nasals and the eye. European distribution: S European Russia, W Kazakhstan.....***Eryx miliaris***

5a. Top of the head covered by small scales irregularly arranged or at most three shields symmetrically arranged, surrounded by smaller scales. Anal plate usually entire. Eyes with vertical pupils (slit-like in daylight) and dorsals of the trunk keeled.....(**Viperidae**) **46**

5b. Top of the head covered by 9-11 large, smooth and symmetrical shields. Anal plate usually divided. Eyes with round pupils and dorsals of the trunk smooth, keeled or grooved, or eyes with vertical pupils and dorsals of the trunk smooth.....**6**

6a. Evident concavity on top of the head. Frontal scale at its mid-length clearly narrower than supraoculars. Three contiguous scales (two loreals and one preocular) between nasal and eye. Dorsals of the trunk slightly grooved. Typical ridge on top of the eyes consisting of supraocular and the top of the preocular.....
.....**Genus *Malpolon*** (**Psammophiidae**) **7**

6b. Top of the head not concave. Frontal scale at its mid-length not so narrow or even wider compared to supraoculars. Two contiguous scales (one loreal and one preocular) or just one scale (loreal) between nasal and eye. Dorsals of the trunk smooth or keeled. No ridge on top of the eyes.....**8**

7a. Dark saddle on the back never present. In the EU range usually 17 dorsal scales at mid-body, except for Lampedusa, where they have 19 (rarely 20) dorsals. European distribution: from Croatia along the E Adriatic Coast to S Balkans, Serbia, Bulgaria, several Greek Islands, Turkish Thrace, Italy (only Lampedusa), Cyprus, S European Russia.....***Malpolon insignitus***

7b. Dark saddle on the back often present in adult males and even some adult females. Usually 19 dorsal scales at mid-body. European distribution: Iberian Peninsula, Balearic islands (recently introduced), S France and NW Italy.....
.....***Malpolon monspessulanus***

8a. Dorsals clearly keeled, first two rows on the flanks weakly keeled or smooth. One large anterior temporal scale. Usually two or three postoculars. Usually 19 or 21 (rarely 17-23) rows of dorsals at mid-body. Often found close to or in water.....(**Natricidae**) **9**

8b. Dorsals smooth (sometimes barely keeled) or keeled (in this case, only associated with 23, 25 or rarely 27 rows of dorsals at mid-body). Two anterior temporal

scales (occasionally one or three). Usually two postoculars.....(**Colubridae**) **13**

Key to Natricidae

9a. Nostrils not clearly pointing upwards, on sides of the snout. Keeling of dorsals very reduced or absent towards the end of the tail. Nape often with a white/yellowish collar especially in juveniles. Usually one preocular (occasionally two) and three postoculars (rarely two or four). Seven supralabials (rarely six or eight), with 3rd and 4th in contact with the eye. Usually 19 rows of dorsals at mid-body.....**10**

9b. Nostrils pointing upwards. Keeling of dorsals continuous towards the end of the tail. Nape always lacking an evident coloured collar. Usually two preoculars (rarely one or three) and two to four postoculars. Seven or eight supralabials. Usually 19 or 21 rows of dorsals at mid-body...**12**

10a. Reddish iris. Collar and body markings in juveniles only. Adults uniformly olive-green, brown or grey. European distribution: Iberian Peninsula, SW France (only Aude, where also *N. helvetica* occurs, and Pyrénées-Orientales)..... .....***Natrix astreptophora***

10b. Yellow, grey, whitish or orange iris. Collar and body markings even in adults. Usually grey body.....**11**

11a. Collar with narrow white/yellowish bands that faint with ageing. European distribution: indicatively from Rhine River and across the Alps westwards, thus including Germany, the Netherlands, Belgium, Luxemburg, Switzerland, France (also Corsica), Britain, Italy (NE excluded).....***Natrix helvetica***

11b. Collar with larger white/yellowish bands. European distribution: indicatively from Rhine River and NE Italy eastwards to W Kazakhstan and Caucasus Mountains, including countries overlooking the Baltic Sea.....***Natrix natrix***

12a. Seven supralabials (rarely six, eight or nine), with 3rd and 4th touching the eye, and two postoculars (rarely one or three). Usually 21 (rarely 17-23) rows of dorsals at mid-body and 142-167 ventrals. Usually, lateral dark spots with light centre and zigzag longitudinal dark stripe. European distribution: Iberian Peninsula and Balearic Islands, France, Switzerland, NE Italy and Sardinia.....***Natrix maura***

12b. Eight supralabials, with 4rd and sometimes 5th touching the eye, and three postoculars (occasionally two or four). Usually 19 (rarely 17-21) rows of dorsals at mid-body and 160-187 ventrals (rarely 148-198). Usually, lateral dark spots more or less evident without light centre and no zigzag longitudinal dark stripe. European distribution: Central Europe (except Poland and most of Germany), mainland Italy, Balkans, several Greek islands, Turkish Thrace, Cyprus, Moldova, Ukraine, S European Russia, NE Azerbaijan, W Kazakhstan.....***Natrix tessellata***

Key to Colubridae

13a. Pupils vertical, (slit-like in daylight). Only one scale between nasal and eye (loreal). Usually 19 (rarely 17-21) rows of dorsals at mid-body. European distribution: from NE Italy along the E Adriatic Coast to S Balkans, Serbia, Bulgaria, several Greek islands, Cyprus, Malta, S European Russia, NE Azerbaijan.....***Telescopus fallax***

13b. Pupils round, if oval never slit-

shaped. Two contiguous scales between nasal and eye (loreal and preocular).....**14**

14a. Neck not clearly distinct. Narrow crossbands from the back downwards and chain-like pattern along the flanks. Scales smooth and shiny. Juveniles similar to adults. Usually 21 rows of dorsals at mid-body. Allochthonous, native to N America. European distribution: Spain (only Gran Canaria).....***Lampropeltis getula***

14b. Neck usually distinct from the body. Different pattern.....**15**

15a. 6th supralabial in contact or close to the parietal. Eight (rarely seven or nine) supralabials and two (rarely one) postoculars.....**16**

15b. Supralabials well separated from the parietal.....**18**

16a. Usually 21 (rarely 19-23) rows of dorsals at mid-body. Postorbital stripe extends from the eye to the corner of the mouth. Dark collar present. Dorsal colour usually greyish and ventral scales characterized by large dark blotches. European distribution: Central and S Iberian Peninsula.....***Macroprotodon brevis***

16b. 19 rows of dorsals at mid-body. Dark collar fragmented or absent, belly immaculate or adorned by small blotches.....**17**

17a. 6th supralabial usually in contact to the parietal scale, yellowish-brown ground colour, especially along the ventral and labial scales. Postorbital stripe reduced to a short spot behind the eye. European distribution: Spain (only Mallorca and Menorca).....***Macroprotodon cucullatus***

17b. 6th supralabial separated from the parietal scale, greyish ground colour (brownish mainly in the pre-shedding phases). Postorbital stripe mostly fragmented (it can be also entire as in 16a, or short as in 17a). European distribution: Italy (only Lampedusa).....
***Macroprotodon* Lampedusa/Tunisia clade**

18a. Dorsals at mid-body weakly but clearly keeled (keeling decreases as it descends towards the ventral scales). Usually 25 (sometimes 21-27) rows of dorsals at mid-body.....**19**

18b. Dorsals smooth or only slightly keeled. Variable number of scale rows at mid-body.....**24**

19a. Dark body colouration (often black) with narrow light bands. Allochthonous, native to NE Asia. European distribution: only NE Netherlands (Drenthe Province).....***Elaphe schrenckii***

19b. Different colour and pattern. Outside the Dutch Province of Drenthe.....**20**

20a. Light brown body colouration with a dark interconnected H-shaped dorsal pattern starting 3-4 head lengths behind the cranium, fading into a light stripe towards the tail; marked postocular black streak. Allochthonous, native to SE Asia. European distribution: only NE Belgium (Limburg Province).....***Elaphe taeniura***

20b. Different colour and pattern. Outside the Belgian Province of Limburg.....**21**

21a. Usually rather light brown with four dark stripes along the body (fading towards the tail). Juveniles with a row of dark, often black bordered, irregular spots or bars on the back and one or two series of smaller spots on flanks (sometimes even on belly), on grey ground colour. Subadults with intermediate colours and ornamentations between adults and juveniles. 25 (rarely 23, 26 or 27) rows of dorsals at mid-body. European distribution: Central and S Italy, from Slovenia along

the E Adriatic Coast to S Balkans, Serbia, Bulgaria, several Greek islands.....***Elaphe quatuorlineata***

21b. Different colour pattern (except for juveniles of *E. sauromates* and *E. urartica*).....**22**

22a. Anterior angle of the parietal shield elongated, usually touching only the upper postocular shield. Head with a clear pattern of longitudinal and transverse blotches, black bordered. Belly grey or reddish, with numerous dark spots 23 (or 25) rows of dorsals at mid-body. European distribution: E Ukraine, S European Russia and SE European Russia, NE Azerbaijan, W Kazakhstan.....***Elaphe dione***

22b. Anterior angle of the parietal shield elongated, touching or nearly touching the lower postocular shield. Head of adults uniform dark above. Yellowish or brown ground colour with dark brown spots, usually with black borders and partially fused transversally. Belly yellowish, sometimes with dark spots on outer edges of the ventrals, which are keeled on the sides. 25 (occasionally 23 or 27) rows of dorsals at mid-body.....**23**

23a. Males with relatively shorter pileus, lower rostrum, but longer frontal plate and posterior inframaxillary scute. Upper head surface less convex near orbits, prefrontals and internasals. Rostrum less pronounced. Usually 75 subcaudal pairs and one or three loreal scales. Whitish area separating two blotches behind the head. Lateral sides of the head with a dark stripe running from behind the eye towards the corner of the mouth, clearly separated by lighter colour (from the darker head colouration). Spots are usually elongated and yellow or yellowish. European distribution: NE Greece, Turkish Thrace, Bulgaria, Romania, Moldova, S Ukraine, S European Russia, W Kazakhstan...***Elaphe sauromates***

23b. Males with relatively longer pileus, higher rostrum, but shorter frontal plate and anterior inframaxillary scute. Upper head surface more convex near orbits, prefrontals and internasals. Rostrum more pronounced. Usually 64 subcaudal pairs and one or two loreal scales. Generally darker colouration with dorsal side of the head very dark (sometimes almost black). Lateral sides of the head with a dark stripe running from behind the eye towards the corner of the mouth, less distinguished from head colour. Dorsal body spots are more conspicuous, rounded and typically lined with whitish colour. European distribution: S European Russia, NE Azerbaijan.....***Elaphe urartica***

24a. Nostril in a single nasal scale. Seven supralabials. 15 or 17 rows of dorsals at mid-body. Anatolia and Middle East.....**25**

24b. Nostril between two nasal scales. Eight or more supralabials (seven only in few species). 17 or more rows of dorsals at mid-body.....**28**

25a. 15 rows of dorsals at mid-body...**26**

25b. 17 rows of dorsals at mid-body. Dark collar on the neck, sometimes blurry. Head with more or less distinct blotches. Body colour usually uniform, sometimes with one or two series of dark dots but not on ventrals.....**27**

26a. Dark collar on the neck, consisting in an evident wide band hardly visible from ventral view. On the head of the juveniles, three dark transverse and independent bands of variable width, which can form a crown-like spot. Body colour usually uniform with lighter scales in the

centre. Seven to nine supralabials, small rostral scale non wedged between the internasals. European distribution: S European Russia, NE Azerbaijan.....*Eirenis collaris*

26b. Usually black head with white supralabial. Unpatterned back with orange, grey or light brown colour. Six supralabials, prominent rostral scales wedged between the internasals. European distribution: Cyprus.....*Rhynchocalamus melanocephalus*

27a. Head pattern: dorsals without dark centre and parietal band limited to the parietal scales. Three to five scales from the anterior beginning of the paravertebral scale row to the posterior border of the collar. European distribution: Cyprus.....*Eirenis levantinus*

27b. Head pattern: interocular and parietal band scythe-like and parietal band sometimes joined to the interocular in the median line. One or two scales from the anterior beginning of the paravertebral scale row to the posterior border of the collar. European distribution: some Greek islands, Turkey (Istanbul area), S European Russia, NE Azerbaijan.....*Eirenis modestus*

28a. 17 or 19 rows of dorsals at mid-body.....**29**

28b. More than 19 rows of dorsals at mid-body.....**37**

29a. 17 rows of dorsals at mid-body. European distribution: endemic to Cyprus.....*Hierophis cypriensis*

29b. 19 rows of dorsals at mid-body...**30**

30a. Neck with dark spots or a dark collar. Body with rather "double" colouration, first greyish and then beige-brown till the tail tip. Dorsals with single apical pits. Extremely slender body.....**31**

30b. Different pattern, colouration and body shape.....**32**

31a. Neck with a dark, white bordered collar. Eyes with dark anterior and posterior borders. Spots irregularly decreasing in size along the body and more separated from each other. European distribution: E Bulgaria, Turkish Thrace.....*Platyceps collaris*

31b. Neck with two dark, white bordered spots on sides, sometimes joined in a collar. Eyes with white anterior and posterior borders. Spots gradually decreasing in size along the body and less separated from each other. European distribution: from Croatia along the E Adriatic Coast to S Balkans, Serbia, Bulgaria, several Greek islands, Cyprus, S European Russia, NE Azerbaijan.....*Platyceps najadum*

32a. Seven (rarely eight) supralabials, with 3rd and 4th in contact with the eye. Dark band from nostrils to the sides of the neck across the eyes and sometimes a blurry mark from eye to eye. Dark ventrals. European distribution: all Europe except Iceland, Ireland, Central and N Great Britain and N Scandinavia; not uniform distribution in E Europe.....*Coronella austriaca*

32b. Eight supralabials. Different pattern.....**33**

33a. Greenish-yellow ground colour, often with predominant black or dark green crossbars on foreparts. Rest of the body with yellowish longitudinal streaks. Melanism prevailing in the eastern and southern part of its range. 187-227 ventrals. European distribution: Pyrenees, France, S Switzerland, Italy, W Slovenia, NW Croatia, Malta.....*Hierophis viridiflavus*

33b. Different colour.....**34**

34a. Dark blotches and often small light

spots and streaks on foreparts. Dorsals always narrowly pale edged. Melanism absent. 167–186 ventrals. European distribution: from Slovenia along the E Adriatic Coast to Greece, Serbia, several Greek islands.....***Hierophis gemonensis***

34b. Rather uniform colouration. Dorsals usually not narrowly pale edged. Melanism frequent. More than 185 ventrals. Large sized (up to 250 cm).....**35**

35a. Black dorsum. Top of the head black or slightly lighter, with brown shades. European distribution: some S Greek islands, Cyprus.....
.....***Dolichophis jugularis***

35b. Not black dorsum.....**36**

36a. Dorsum greyish-brown to olivaceous (greyish-brown in preserved specimens), sometimes copper head. Light longitudinal central streak on dorsal scales. Belly white to yellow. European distribution: Balkans, Hungary, Moldova, Ukraine, S European Russia, W Kazakhstan.....***Dolichophis caspius***

36b. Dorsum orange to bright brick red (light brown to reddish brown in preserved specimens). Dark longitudinal central streak of variable intensity on dorsal scales. Belly yellow to orange (ochraceous in preserved specimens). European distribution: S European Russia, NE Azerbaijan.....***Dolichophis schmidti***

37a. One preocular, pre-subocular absent.....**38**

37b. One or more pre-suboculars present.....**43**

38a. Dark band from eyes to the sides of the neck and from eye to eye. Another dark streak under the eye. Belly chequered or striped. 8 supralabials, with 4th and 5th in contact with the eye. 21 (rarely 23) rows of dorsals at mid-body. European distribution: Iberian Peninsula, S France, Central and N Italy.....***Coronella girondica***

38b. Head and belly pattern different. Usually 23 (rarely 21) or more rows of dorsals at mid-body.....**39**

39a. Rostral shield large and pointed between the internasals. Dorsum with two evident longitudinal dark stripes on grey or beige ground colouration. Dark H-shaped blotches on juveniles' back, even connected in a ladder design. 27 (rarely 25 or 29) rows of dorsals at mid-body. 201-220 ventrals. European distribution: Iberian Peninsula, Balearic islands (recently introduced), S France.....***Zamenis scalaris***

39b. Rostral shield not pointed between the internasals. Different pattern, with or without stripes (which are not so evident).....**40**

40a. Ventrals not keeled. Reddish or brown black-bordered blotches (sometimes connected in longitudinal lines) on the back……**41**

40b. Ventrals strongly keeled. Juveniles with spotted pattern and two dark streaks, one from the eye to the corner of the mouth and one under the eye, that both faint with ageing. 23 (rarely 21) rows of dorsals at mid-body.....**42**

41a. Ochre or light brown spots with black borders on the back (two rows separated by a vertebral light line in ssp. *hohenackeri* or one row of connected spots in ssp. *taurica*). Ochre iris. 23 (rarely 25) rows of dorsals at mid-body. 203-230 ventrals. European distribution: S European Russia (close to Caucasus)....***Zamenis hohenackeri***

41b. Orange to brown spots with black borders on the back or two dorsal longitudinal stripes with black borders (at least on

inner margin). Red iris. 27 (rarely 25 or 29) rows of dorsals at mid-body. 220-260 ventrals. European distribution: S Italy (Apulia, E Basilicata and SE Sicily), from Croatia along the E Adriatic Coast to S Balkans, Serbia, Bulgaria, several Greek islands, Malta, Turkish Thrace and Crimea.....***Zamenis situla***

42a. Adults often with four longitudinal dark stripes but blurry and not always clearly distinct from ground colouration. Nape without blotches. Belly greyish. Orange to red iris. European distribution: endemic to S Italy and Sicily.....
.....***Zamenis lineatus***

42b. Adults usually with grey-brown, greenish or blackish uniform colouration, often with small white dots, something with four faint longitudinal dark stripes. Nape with light blotches. Belly yellowish. Ochre iris. European distribution: NE Spain, mainland France, Great Britain (recently introduced), N and Central Italy, Central Europe, Balkans, Moldova, S and W Ukraine, S European Russia. In Apulia (SE Italy) there are individuals genetically attributable to this species but with an intermediate morphology between *Z. longissimus* and *Z. lineatus*.....
.....***Zamenis longissimus***

43a. Two preoculars and one or more pre-suboculars. Two supralabials touching the eye. Dorsals obtusely or faintly keeled.....**44**

43b. Preocular single. No supralabials (or just one) touching the eye. Dorsals smooth.....**45**

44a. Dorsal roundish spots usually separated. 23 rows of dorsals at mid-body. 82-107 subcaudals in males, 82-107 in females. European distribution: several Greek islands, Cyprus, S European Russia (close to Caucasus).....***Hemorrhois nummifer***

44b. Dorsal spots never roundish and usually joined to form a zigzag pattern. 21 scale rows of dorsals at mid-body. 74-99 subcaudals in males, 70-94 in females. European distribution: S European Russia, NE Azerbaijan.....***Hemorrhois ravergieri***

45a. Dorsal colour with widely separated spots. Head pattern with more or less distinct transverse bar or dark blotch on nape. Usually one supralabial touching the eye not necessarily on both sides of the head. 23-25 rows of dorsals at mid-body. European distribution: Malta.....
.....***Hemorrhois algirus***

45b. Dorsal colour with large dark polygonal spots (with darker borders) clearly distinct from ground colouration. Typical horseshoe marking on head. No supralabials touching the eye due to the presence of a series of small suboculars. 27-29 (rarely 25) rows of dorsals at mid-body. European distribution: Iberian Peninsula, Balearic island (recently introduced), Italy (Sardinia and Pantelleria).....
.....***Hemorrhois hippocrepis***

Key to Viperidae

46a. Snout rounded. Only small scales on top of the head. Intercanthals keeled. Only Greece, Turkey, S European Russia, NE Azerbaijan and Cyprus.....**47**

46b. Snout rounded, upturned or horned. Top of the head with small or few large scales. Intercanthals smooth or possibly just a few keeled.....**49**

47a. Supraoculars large. European distribution: Greece (eastern Thrace), Turkish Thrace and several Greek and Turkish islands from Dodecanese Archipela-

go.....***Montivipera xanthina***

47b. Supraoculars divided.....**48**

48a. 23 (rarely 19-25) rows of dorsals at mid-body. Dorsal pattern consisting of two series of transverse alternate bars, often light and not so evident and joined forming a zigzag band. European distribution: endemic to Greece (W Cyclades islands of Kimolos, Milos, Polýaigos and Sifnos)..... .....***Macrovipera schweizeri***

48b. 25 (rarely 23) or more rows of dorsals at mid-body. Dorsal pattern consisting of two series of transverse alternate dark bars, often joined forming a zigzag band. European distribution: S European Russia, NE Azerbaijan, Cyprus..... .....***Macrovipera lebetinus***

49a. Snout rounded. Frontal and parietal scales mostly present.....**50**

49b. Snout upturned or horned. Frontal and parietal mostly replaced by smaller scales.....**56**

50a. Nostril in the centre of the nasal..**51**

50b. Nostril close to the lower edge of a rather large nasal shield.....**52**

51a. Head clearly distinct from the body. Snout just slightly sharp. Parietals and frontal variably fragmented. European distribution: N Iberian Peninsula, SW France.....***Vipera seoanei***

51b. Head moderately distinct from the body. Snout rounded. Parietals and frontal usually entire. European distribution: almost all of Europe (often restricted to higher elevations in W and C of the continent), except Caucasus, Iberian Peninsula, Iceland and Ireland.....***Vipera berus***

52a. Sometimes just 17 rows of dorsals at mid-body. Shorter body (up to 35 cm, females rarely up to 45). 2nd, 3rd and 4th supralabials wide under the eye. European distribution: endemic to S Albania and Greece.....***Vipera graeca***

52b. 21 rows of dorsals at mid-body. Larger body (50/60 cm, up to 65 cm). Supralabials rather similar.....**53**

53a. 21 rows of dorsals at mid-body, reduced to 19 rows on the second part of the body. 135-150 ventrals. European distribution: Ukraine, Russia, W Kazakhstan.....***Vipera renardi***

53b. 21 rows of dorsals on the first part of the body, reduced to 19 rows before reaching the mid-body. 133-135 ventrals (or more).....**54**

54a. Usually one apical in contact with the rostral shield. Upper side of the nasorostral shield straight. Upper preocular in contact with the nasal. Head with large shields. Usually less than 13 intercanthals + inter-supraoculars. No yellow, orange or red in dorsal background colour. Absent from Caucasus territory. European distribution: SE France, Central Italy, Austria, Hungary, Balkans, Moldova..... .....***Vipera ursinii***

54b. Usually two apicals in contact with the rostral shield. Upper side of the nasorostral shield rounded. Upper preocular in contact with or separated from the nasal. Dorsal background colour usually yellow, orange or red. Present on Caucasus territory.....**55**

55a. Head narrow, barely distinct from the body and flat or convex above. Head less wide than the distance from snout tip to the angle of the mouth. Dorsal pattern different. There are totally melanistic individuals, without light spots. Rostral shield is usually in contact with one apical scale. European distribution: E Caucasus Mountains.....***Vipera dinniki***

55b. Head wide, clearly distinct from the body. Head as wide as the distance from snout tip to the angle of the mouth. Rostral shield is usually in contact with two apical scales. Dark or black ground colour (with a yellow to red pattern that always persists in labials of melanistic specimens). European distribution: W Caucasus Mountains.....***Vipera kaznakovi***

56a. Tip of snout more or less upturned because of high rostral scale but without a scaly horn. Two to four small scales covering the raised part of the snout. Frontal and/or parietals sometimes present. 9-11 supralabials. 21 rows of dorsals at mid-body (occasionally 22-23, rarely 17-24). European distribution: NE Spain, mainland France, SW Germany, Switzerland, Italy (except Sardinia), W Slovenia.....***Vipera aspis***

56b. Tip of snout with a scaly horn formed by several small scales. Frontal and parietals rarely present. Two rows of suboculars (occasionally one, rarely three).....**57**

57a. Rostral scale scarcely reaching an evident horn, usually covered with 5-20 scales. 21 rows of dorsals at mid-body (occasionally 20-23). European distribution: NE Italy, S Austria, Balkans, several Greek islands, Turkish Thrace.....
.....***Vipera ammodytes***

57b. Rostral scale reaching an evident horn, usually covered with three to eight scales. 21-23 rows of dorsals at mid-body. European distribution: Iberian Peninsula.....***Vipera latastei***

Discussion

Following the latest taxonomic updates and the recent species considered part of the European herpetofauna, the checklist of European snakes currently has 57 species (see Table S1) as well as one taxon that needs to be better defined (*Macroprotodon* Lampedusa/Tunisia clade). Four out of 57 of these species are allochthonous to our range, thus adding one more non-native species (*Elaphe taeniura*) to the three (*E. schrenckii*, *Indotyphlops braminus* and *Lampropeltis getula*) already listed in the checklist by Speybroeck *et al*. (2020). One species (*Rhynchocalamus melanocephalus*), recently found in Cyprus, may be attributed to human-mediated dispersion or natural colonization, since a Cypriot specimen showed genetic similarity to another one from northern Israel; further investigations will be needed to clarify the origins of the specimens from Cyprus (see Tamar *et al*., 2020).

The dichotomous key provided here allows the identification by using morphological characters (especially pholidosis and colouring) together with the area of discovery. This key is therefore to be considered a field instrument, but it can be useful even with museum specimens if the samples are arranged with the place of origin. Moreover, this work can make the identification of snake species for the citizen science more accessible, thus enhancing data collection and assist species conservation. Another silver lining is dealing with monitoring the diffusion of allochthonous species, making easier to detect them in new territories and limit their expansion.

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References

ALSHAMMARI, A.M. & BUSAIS, S.M. (2020). Distribution of snakes in Ha'il Province, Saudi Arabia, with an identification key to the species. *Russian Journal of Herpetology* 27(1): 5-10.

AKBARPOUR, M.; RASTEGAR-POUYANI, N.; FATHINIA, B. & RASTEGAR-POUYANI, E. (2020). A new species of the genus *Eirenis* Jan, 1863 (Squamata: Colubridae) from Kerman Province in South-central Iran. *Zootaxa* 4868 (1):117-128.

ARMIÑANA-GARCÍA, R.; FIMIA-DUARTE, R.; IANNACONE, J.; GUERRA-VÉLIZ, Y.; ZAMBRANO -GAVILANES, F.E. & LEYVA-HAZA, J. (2020). Construction and use of dichotomous keys for the identification of different taxa of vertebrates in Cuba. *Biotempo* 17(1): 23-35.

BOULENGER, G.A. (1913). *The snakes of Europe*. Methusen & Co. Ltd, London, UK.

BUTKEVIČIENĖ, E.; SKARLATIDOU, A.; BALÁZS, B.; DUŽÍ, B.; MASSETTI, L.; TSAMPOULATIDIS, I. & TAUGINIENĖ, L. (2021). Citizen Science Case Studies and Their Impacts on Social Innovation, *In* K. VOHLAND, A. LAND-ZANDSTRA, L. CECCARONI, R. LEMMENS, J. PERELLÓ, M. PONTI, R. SAMSON & K. WAGENKNECHT (eds.) *The Science of Citizen Science*. Springer, Cham, Switzerland, pp. 309-329.

CABRERA-PÉREZ, M.A.; GALLO-BARNETO, R.; ESTEVE, I.; PATIÑO-MARTÍNEZ, C. & LÓPEZ-JURADO, L.F. (2012). The management and control of the California kingsnake in Gran Canaria (Canary Islands): Project LIFE+ *Lampropeltis*. *Aliens: The Invasive Species Bullettin, Newsletter of the IUCN/SSC Invasive Species Specialist Group* 32: 20-28.

CAPULA, M.; CORTI, C.; LUISELLI, L. & SALVI, D. (2011). *Macroprotodon cucullatus* (Geoffroy de Saint-Hillaire in Savigny, 1827), *In* CORTI, C., CAPULA, M., LUISELLI, L., RAZZETTI, E. & SINDACO, R. (eds) *Fauna d'Italia, Reptilia, Vol. XLV*. Calderini, Bologna, pp. 517-522.

CATTANEO, A. (2015). Contributo alla conoscenza dei serpenti delle isole del canale di Sicilia. *Naturalista Siciliano* 34: 3-28.

CATTANEO, A. (2020). *Macrovipera Schweizeri* (WERNER, 1935): comparison of the populations of Milos and Sifnos Islands (SW Cyclades) (Serpentes Viperidae). *Naturalista siciliano* S. IV, XLIV (1-2): 127-154.

CHOWDHURY, A.; ZDENEK, C.N.; DOBSON, J.S.; BOURKE, L.A.; SORIA, R. & FRY, B.G. (2021). Clinical implications of differential procoagulant toxicity of the Palearctic viperid genus *Macrovipera*, and the relative neutralization efficacy of antivenoms and enzyme inhibitors. *Toxicology Letters* 340: 77-88.

CLEMENS, D.J. & ALLAIN, S.J. (2020). First record of the aesculapian snake (*Zamenis longissimus*) in South Wales. *Herpetological Bulletin* 152: 30-31.

CORTI, C.; CAPULA, M.; LUISELLI, L.; RAZZETTI, E. & SINDACO, R. (2011). *Fauna d'Italia, Reptilia, Vol. XLV*. Calderini, Bologna, IT.

DÁVALOS-MARTÍNEZ, A.; ZÁIZAR-GUTIÉRREZ, V.F.; CRUZ-SÁENZ, D.; ROLDÁN-OLVERA, E.D. & WILSON, L.D. (2021). The Michoacán Centipede Snake, *Tantilla cascadae* WILSON & MEYER, 1981 (Squamata: Colubridae): New record for Jalisco, with notes on conservation, biogeography, and a key to the species of the genus in western Mexico. *Herpetology Notes* 14: 263-268.

DEGEN, R. & BROCK, K. 2021. Rare behavioral observations of the Milos Viper, *Macrovipera schweizeri* (WERNER, 1935), on Sifnos Island, Greece. *Herpetology Notes* 14: 1357-1360.

DI NICOLA, M.R. (2019). A revised dichotomous key to the snakes of Italy (Reptilia, Squamata, Serpentes), according to recent systemat-

ic updates. *Zootaxa* 4686(2): 294-296.

DI NICOLA, M.R.; CAVIGIOLI, L.; LUISELLI, L. & ANDREONE, F. (2021). *Anfibi & Rettili d'Italia*. Collana Historia naturae (8), Edizioni Belvedere, Latina, IT.

DONIOL-VALCROZE, P.; URSENBACHER, S.; MEBERT, K.; GHIELMI, S.; LADDAGA, L.; SOURROUILLE, P.; KARIŞ, M. & CROCHET, P.A. (2021). Conflicting relationships of *Vipera walser* inferred from nuclear genes sequences and mitochondrial DNA. *Journal of Zoological Systematics and Evolutionary Research* 59(8): 2307-2320.

DOWLING, H.G. (1951). A proposed standard system of counting ventrals in snakes. *British Journal of Herpetology* 1: 97-99.

FARAONE, F.P.; BARRACO, L.; GIACALONE, G.; MUSCARELLA, C.; SCHIFANI, E. & VECCHIONI, E. (2019a). First records of the Brahminy blind snake, *Indotyphlops braminus* (DAUDIN, 1803) (Squamata: Typhlopidae), in Italy. *Herpetology Notes* 12: 1225-1229.

FARAONE, F.P., RUSSOTTO, S., BARRA, S.A., CHIARA, R., GIACALONE, G. & LO VALVO, M. (2019b). Morphological variation of the newly confirmed population of the Javelin sand boa, *Eryx jaculus* (LINNAEUS, 1758) (Serpentes, Erycidae) in Sicily, Italy. *Acta Herpetologica* 14: 135-139

FARAONE, F. P.; MELFI, R.; DI NICOLA, M.R.; GIACALONE, G. & VALVO, M.L. (2020). The genetic identity of the only Italian population of the genus *Macroprotodon* GUICHENOT, 1850 on the island of Lampedusa, Sicily. *Vertebrate Zoology* 70(2): 235-240.

FREITAS, I.; URSENBACHER, S.; MEBERT, K.; ZINENKO, O.; SCHWEIGER, S.; WÜSTER, W.; BRITO, J.C.; CRNOBRNJA-ISAILOVIC, J.; HALPERN, B.; FAHD, S.; SANTOS, X.; PLEGUEZUELOS, J.M.; JOGER, U.; ORLOV, N.; MIZSEI, E.; LOURDAIS, O.; ZUFFI, M.A.L.; STRUGARIU, A.; ZAMFIRESCU, S.R.; MARTÍNEZ-SOLANO, Í.; VELO-ANTÓN, G.; KALIONTZOPOULOU, A. & MARTÍNEZ-FREIRÍA, F. (2020). Evaluating taxonomic inflation: towards evidence-based species delimitation in Eurasian vipers (Serpentes: Viperinae). *Amphibia-Reptilia* 41 (3): 285-311.

FRITZ, U. & SCHMIDTLER, J.F. (2020). The Fifth Labour of Heracles: Cleaning the Linnean stable of names for grass snakes (*Natrix astreptophora, N. helvetica, N. natrix* sensu stricto). *Vertebrate Zoology* 70(4): 621-665.

FRITZ, U.; RAZZETTI, E. & SCHMIDTLER, J.F. (2020). The valid scientific names of the barred grass snake and its subspecies from mainland Italy and Sicily. *Amphibia-Reptilia* 41(4): 553-558.

GANESH, S.R.; DEUTI, K.; PUNITH, K.G.; ACHYUTHAN, N.S.; MALLIK, A.K. & VOGEL, G. (2020). A new species of *Lycodon* (Serpentes: Colubridae) from the Deccan Plateau of India, with notes on the range of *Lycodon travancoricus* (BEDDOME, 1870) and a revised key to peninsular Indian forms. *Amphibian & Reptile Conservation* 14(3): 74-83.

GENIEZ, P. (2018). *Snakes of Europe, North Africa and the Middle East. A photographic guide.* Princeton University Press, US.

GUICKING, D.; GRIFFITHS, R.A.; MOORE, R.D.; JOGER, U. & WINK, M. (2006). Introduced alien or persecuted native? Resolving the origin of the viperine snake (*Natrix maura*) on Mallorca. *Biodiversity & Conservation 15* (9): 3045-3054.

HEDGES, S.B.; MARION, A.B.; LIPP, K.M.; MARIN, J. & VIDAL, N. (2014). A taxonomic framework for typhlopid snakes from the Caribbean and other regions (Reptilia, Squamata). *Caribbean Herpetology* 49: 1-61.

JABLONSKI, D.; KUKUSHKIN, O.V.; AVCI, A.; BUNYATOVA, S.; KUMLUTAŞ, Y.; ILGAZ, Ç.; POLYAKOVA, E.; SHIRYAEV, K.; TUNIYEV, B. & JANDZIK, D. (2019). The biogeography of *Elaphe sauromates* (PALLAS, 1814), with a description of a new rat snake species. *PeerJ* 7: e6944.

KINDLER, C. (2018). Phylogeography of the Ibero -Maghrebian red-eyed grass snake (*Natrix astreptophora*). *Organisms Diversity & Evolution* 18:143-150.

KINDLER, C. & FRITZ, U. (2018). Phylogeography and taxonomy of the barred grass snake (*Natrix helvetica*), with a discussion of the subspecies category in zoology. *Vertebrate Zoology* 68(3): 269-281.

KONTSIOTIS, V.J.; RAPTI, A. & LIORDOS, V. (2022). Public attitudes towards venomous and non -venomous snakes. *Science of the Total Environment* 831: 154918.

KREINER, G. (2007). *The snakes of Europe: all species from west of the Caucasus Mountains*. Edition Chimaira, Frankfurt, DE.

MAHLOW, K.; TILLACK, F.; SCHMIDTLER, J.F. & MÜLLER, J. (2013). An annotated checklist, description and key to the dwarf snakes of the genus *Eirenis* JAN, 1863 (Reptilia: Squamata: Colubridae), with special emphasis on the dentition. *Vertebrate Zoology* 63(1): 41-85.

MALLIK, A.K.; ACHYUTHAN, N.S.; GANESH, S.R.; PAL, S.P.; VIJAYAKUMAR, S.P. & SHANKER, K. (2019). Discovery of a deeply divergent new lineage of vine snake (Colubridae: Ahaetuliinae: *Proahaetulla* gen. nov.) from the Southern Western Ghats of Peninsular India with a revised key for Ahaetuliinae. *PLoS ONE* 14 (7): e0218851.

MATEO, J.A. (2013). Culebrilla de las macetas – *Ramphotyphlops braminus*, *In* A. SALVADOR & A. MARCO (eds.) *Enciclopedia Virtual de los Vertebrados Españoles*. Museo Nacional de Ciencias Naturales, Madrid. Available at http://www.vertebradosibericos.org/. Retrieved on 20/02/2022.

MIZSEI, E.; ZINENKO, O.; SILLERO, N.; FERRI, V.; ROUSSOS S.A. & SZABOLCS, M. (2018). The distribution of meadow and steppe vipers (*Vipera graeca*, *V. renardi* and *V. ursinii*): a revision of the New Atlas of Amphibians and Reptiles of Europe. *Basic and Applied Herpetology* 32:77-83.

PAOLINO, G.; SCOTTI, R. & GRANO, M. (2019). First detection of the "flowerpot snake" *Indotyphlops braminus* (DAUDIN, 1803) (Serpentes Typhlopidae) in Ischia (Italy): a new possible invasive species. *Biodiversity Journal* 10 (4): 321-324.

PIZZIGALLI, C.; BANFI, F.; FICETOLA, G.F.; FALASCHI, M.; MANGIACOTTI, M.; SACCHI, R.; ZUFFI, M.A.L. & SCALI, S. (2020). Eco-geographical determinants of the evolution of ornamentation in vipers. *Biological Journal of the Linnean Society* 130(2): 345-358.

PYRON, R.A.; REYNOLDS, R.G. & BURBRINK, F.T. (2014). A Taxonomic Revision of Boas (Serpentes: Boidae). *Zootaxa* 3846(2): 249-260.

SEGHETTI, S.M.; VILLA, A.; TSCHOPP, E.; BERNARDINI, F.; LADDAGA, L.; FANELLI, M.; LEVI, R. & DELFINO, M. (2020). Skull osteology of *Vipera walser* (Squamata, Viperidae): Description, variability, ontogeny, and diagnostic characters in comparison to other Italian vipers. *Journal of Morphology* 282(1): 5-47.

SILVA-ROCHA, I.; SALVI, D.; SILLERO, N.; MATEO, J.A. & CARRETERO, M.A. (2015). Snakes on the Balearic Islands: an invasion tale with implications for native biodiversity conservation. *PloS one*, 10(4): e0121026.

SINDACO, R.; VENCHI, A. & GRIECO, C. (2013). *The Reptiles of the Western Palearctic. 2. Annotated checklist and distributional atlas of the snakes of Europe, North Africa, Middle East and Central Asia, with an Update to Volume 1.* Edizioni Belvedere, Latina, IT.

SINDACO, R. & RAZZETTI, E. (2021). An updated check-list of Italian amphibians and reptiles. *Natural History Sciences* 8(2): 35-46.

SPENGLER WALTRICK, C. & MENTA GIASSON, L.O. (2021). Taxonomic key to the snakes (Squamata: Ophidia) species of the Itajaí Valley, Santa Catarina, Brazil. *Papéis Avulsos de Zoologia*, Museu de Zoologia da Universidade de São Paulo 61: e20216120.

SPEYBROECK, J.; BEUKEMA, W.; BOK, B. & VAN DER VOORT, J. (2016). *Field Guide to the Amphibians & Reptiles of Britain and Europe.* Bloomsbury Publishing Plc, London, UK.

SPEYBROECK, J.; BEUKEMA, W.; DUFRESNES, C.; FRITZ, U.; JABLONSKI, D.; LYMBERAKIS, P.; MARTINEZ-SOLANO, I.; RAZZETTI, E.; VAMBERG-

ER, M.; VENCES, M.; VÖRÖS, J. & CROCHET, P.A. (2020). Species list of the European herpetofauna – 2020 update by the Taxonomic Committee of the Societas Europaea Herpetologica. *Amphibia-Reptilia* 41(2): 139-189.

STRUIJK, R.R.J.H.; TER HARMSEL, R.; LAAN, R. & PARK, D. (2020). Reproduction in an introduced population of *Elaphe schrenckii* (STRAUCH, 1873) in Eelde, the Netherlands. *Russian Journal of Herpetology* 27(6): 325-333.

STÜMPEL, N. (2012). Phylogenie und Phylogeographie eurasischer Viperinae unter besonderer Berücksichtigung der orientalischen Vipern der Gattungen *Montivipera* und *Macrovipera*. PhD Thesis, TU Carolo-Wilhelmina zu Braunschweig, Braunschweig, DE.

STÜMPEL, N & JOGER, U. (2009). Recent advances in phylogeny and taxonomy of near and middle eastern vipers – an update. *ZooKeys* 31: 179-191.

TAMAR, K.; WIEDL, H. J.; MAZA, E.; JABLONSKI, D. & MEIRI, S. (2020). Discovery of the Black-headed Ground Snake *Rhynchocalamus melanocephalus* (JAN, 1862) in Cyprus (Reptilia: Colubridae). *Zoology in the Middle East* 66(2): 118-123.

VAN DE KOPPEL, S.; VAN KESSEL, N.; CROMBAGHS, B.H.J.M.; GETREUER, W. & LENDERS, H.J.R. (2012). *Risk Analysis of the Russian Rat Snake (*Elaphe schrenckii*) in the Netherlands*. Naturbalans – Limes Divergens BV, Nijmegen/ ReptielenZoo SERPO, Delft/Radboud University, Nijmegen, NL.

VAN DOORN, L.; SPEYBROECK, J.; BRYS, R.; HALFMAERTEN, D.; NEYRINCK, S.; ENGELEN, P. & ADRIAENS, T. (2021). Aesthetic aliens: invasion of the beauty rat snake, *Elaphe taeniura* COPE, 1861 in Belgium, Europe. *BioInvasions Records* 10(3): 741-754.

VAN SINH, N.; WIEMERS, M. & SETTELE, J. (2017). Proposal for an index to evaluate dichotomous keys. *ZooKeys* 685: 83-89.

VELLA, A.; VELLA, N.; MIFSUD, C.M. & MAGRO, D. (2020). First records of the Brahminy blindsnake, *Indotyphlops braminus* (DAUDIN, 1803) (Squamata: Typhlopidae) from Malta with genetic and morphological evidence. *Natural and Engineering Sciences* 5(3): 122-135.

VENCHI, A. & SINDACO, R. (2006). Annotated checklist of the reptiles of the Mediterranean countries, with keys to species identification. Part 2 - Snakes (Reptilia, Serpentes). *Annali del Museo Civico di Storia Naturale "G. Doria"*, Genova, XCVIII: 259-364.

VOHLAND, K.; GÖBEL, C.; BALÁZS, B.; BUTKEVIČIENĖ, E.; DASKOLIA, M.; DUŽI, B.; HECKER, S.; MANZONI, M. & SCHADE, S. (2021). Citizen Science in Europe, *In* K. VOHLAND, A. LAND-ZANDSTRA, L. CECCARONI, R. LEMMENS, J. PERELLÓ, M. PONTI, R. SAMSON, & K. WAGENKNECHT (eds.) *The Science of Citizen Science*. Springer, Cham, Switzerland: 35-53.

WADE, E. (2001). Review of the false smooth snake genus *Macroprotodon* (Serpentes, Colubridae) in Algeria, with a description of a new species. *Bulletin of the British Museum (Natural History)* 67: 85-107.

WALLACH, V. (2020). How to easily identify the flowerpot blindsnake, *Indotyphlops braminus* (DAUDIN, 1803), with proposal of a new genus (Serpentes: Typhlopidae). *Podarcis* 11(1): 4-12.

WATSON, S. (2009). Classification and dichotomous key: Tool for teaching identification. *The Science Teacher* 76: 50-54.

WEINELL, J.L.; HOOPER, E.; LEVITON, A.E. & BROWN, R.M. (2019). Illustrated Key to the Snakes of the Philippines. *Proceedings of the California Academy of Sciences*, Series 4, 66(1): 1-49.

ZAHER, H.; MURPHY, R.W.; ARREDONDO, J.C.; GRABOSKI, R.; MACHADO-FILHO, P.R.; MAHLOW, K.; MONTINGELLI, G.G.; BOTTALLO QUADROS, A.; ORLOV, N.L.; WILKINSON, M.; ZHANG, Y.P. & GRAZZIOTIN, F.G. (2019). Large -scale molecular phylogeny, morphology, divergence-time estimation, and the fossil record of advanced caenophidian snakes

(Squamata: Serpentes). *PLoS ONE* 14(5): e0216148.

An updated dichotomous key to the snakes of Europe

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SUPPLEMENTARY MATERIAL

Table S1: species list of European snakes according to Speybroeck et al. (2020) and with the updates indicated in this work.

- Suborder: Serpentes Linnaeus, 1758
  - Superfamily: Typhlopoidea Gray, 1845
    - Family: Typhlopidae Merrem, 1820
      - Genus: *Indotyphlops* Hedges, Marion, Lipp, Marin and Vidal, 2014
        - Species: *Indotyphlops braminus* (Daudin, 1803)
      - Genus: *Xerotyphlops* Hedges, Marion, Lipp, Marin and Vidal, 2014
        - Species: *Xerotyphlops vermicularis* (Merrem, 1820)
  - Superfamily: Booidea Gray, 1825
    - Family: Erycidae Bonaparte, 1840
      - Genus: *Eryx* Daudin, 1803
        - Species: *Eryx jaculus* (Linnaeus, 1758)
        - Species: *Eryx miliaris* (Pallas, 1773)
  - Superfamily: Elapoidea Boie, 1827
    - Family Psammophiidae Boie, 1827
      - Genus: *Malpolon* Fitzinger, 1826
        - Species: *Malpolon insignitus* (Geoffroy Saint-Hilaire, 1827)
        - Species: *Malpolon monspessulanus* (Hermann, 1804)
  - Superfamily: Colubroidea Oppel, 1811
    - Family: Natricidae Bonaparte, 1840
      - Genus: *Natrix* Laurenti, 1768
        - Species: *Natrix astreptophora* (Seoane, 1884)
        - Species: *Natrix helvetica* (Lacépède, 1789)
        - Species: *Natrix maura* (Linnaeus, 1758)
        - Species: *Natrix natrix* (Linnaeus, 1758)
        - Species: *Natrix tessellata* (Laurenti, 1768)
    - Family: Colubridae Oppel, 1811
      - Genus: *Coronella* Laurenti, 1768
        - Species: *Coronella austriaca* Laurenti, 1768
        - Species: *Coronella girondica* (Daudin, 1803)
      - Genus: *Dolichophis* Gistel, 1868
        - Species: *Dolichophis caspius* (Gmelin, 1789)
        - Species: *Dolichophis jugularis* (Linnaeus, 1758)
        - Species: *Dolichophis schmidti* (Nikolsky, 1909)
      - Genus: *Eirenis* Jan, 1863
        - Species: *Eirenis collaris* (Ménétries, 1832)
        - Species: *Eirenis levantinus* Schmidtler, 1993
        - Species: *Eirenis modestus* (Martin, 1838)
      - Genus: *Elaphe* Fitzinger, 1833
        - Species: *Elaphe dione* (Pallas, 1773)

Species: *Elaphe quatuorlineata* (Bonnaterre, 1790)
Species: *Elaphe sauromates* (Pallas, 1814)
Species: *Elaphe schrenckii* Strauch, 1873
Species: *Elaphe taneiura* Cope, 1861
Species: *Elaphe urartica* Jablonski, Kukushkin, Avcı, Bunyatova, Ilgaz, Tuniyev and Jandzik, 2019
Genus: *Hemorrhois* Boie, 1826
Species: *Hemorrhois algirus* (Jan, 1863)
Species: *Hemorrhois hippocrepis* (Linnaeus, 1758)
Species: *Hemorrhois nummifer* (Reuss, 1834)
Species: *Hemorrhois ravergieri* (Ménétries, 1832)
Genus: *Hierophis* Fitzinger *in* Bonaparte, 1834
Species: *Hierophis gemonensis* (Laurenti, 1768)
Species: *Hierophis viridiflavus* (Lacépède, 1789)
Species: *Hierophis cypriensis* (Schätti, 1985)
Genus: *Lampropeltis* Fitzinger, 1843
Species: *Lampropeltis getula* (Linnaeus, 1766)
Genus: *Macroprotodon* Guichenot, 1850
Species: *Macroprotodon brevis* (Günther, 1862)
Species: *Macroprotodon cucullatus* (Geoffroy Saint-Hilaire, 1827)
Genus: *Platyceps* Blyth, 1860
Species: *Platyceps collaris* (Müller, 1878)
Species: *Platyceps najadum* (Eichwald, 1831)
Genus: *Rhynchocalamus* Günther, 1864
Species: *Rhynchocalamus melanocephalus* (Jan, 1862)
Genus: *Telescopus* Wagler, 1830
Species: *Telescopus fallax* (Fleischmann, 1831)
Genus: *Zamenis* Wagler, 1830
Species: *Zamenis hohenackeri* (Strauch, 1873)
Species: *Zamenis lineatus* (Camerano, 1891)
Species: *Zamenis longissimus* (Laurenti, 1768)
Species: *Zamenis scalaris* (Schinz, 1822)
Species: *Zamenis situla* (Linnaeus, 1758)
Superfamily: Not assigned*
Family: Viperidae Oppel, 1811
Genus: *Macrovipera* Reuss, 1927
Species: *Macrovipera lebetinus* (Linnaeus, 1758)
Species: *Macrovipera schweizeri* (Werner, 1935)
Genus: *Montivipera* Nilson, Tuniyev, Andrén, Orlov, Joger and Herrmann, 1999
Species: *Montivipera xanthina* (Gray, 1849)
Genus: *Vipera* Garsault, 1764

Species: *Vipera ammodytes* (Linnaeus, 1758)
Species: *Vipera aspis* (Linnaeus, 1758)
Species: *Vipera berus* (Linnaeus, 1758)
Species: *Vipera dinniki* (Nikolsky, 1913)
Species: *Vipera graeca* Nilson and Andrén, 1988
Species: *Vipera kaznakovi* (Nikolsky, 1909)
Species: *Vipera latastei* (Boscá, 1878)
Species: *Vipera renardi* (Christoph, 1861)
Species: *Vipera seoanei* (Lataste, 1879)
Species: *Vipera ursinii* (Bonaparte, 1835)

*According to Zaher *et al*. (2019)

Figure S1: Geographical area considered in the key, according to SPEYBROECK *et al*. (2020). Image credits: Google Earth Pro, v. 7.3.4.8248, modified.

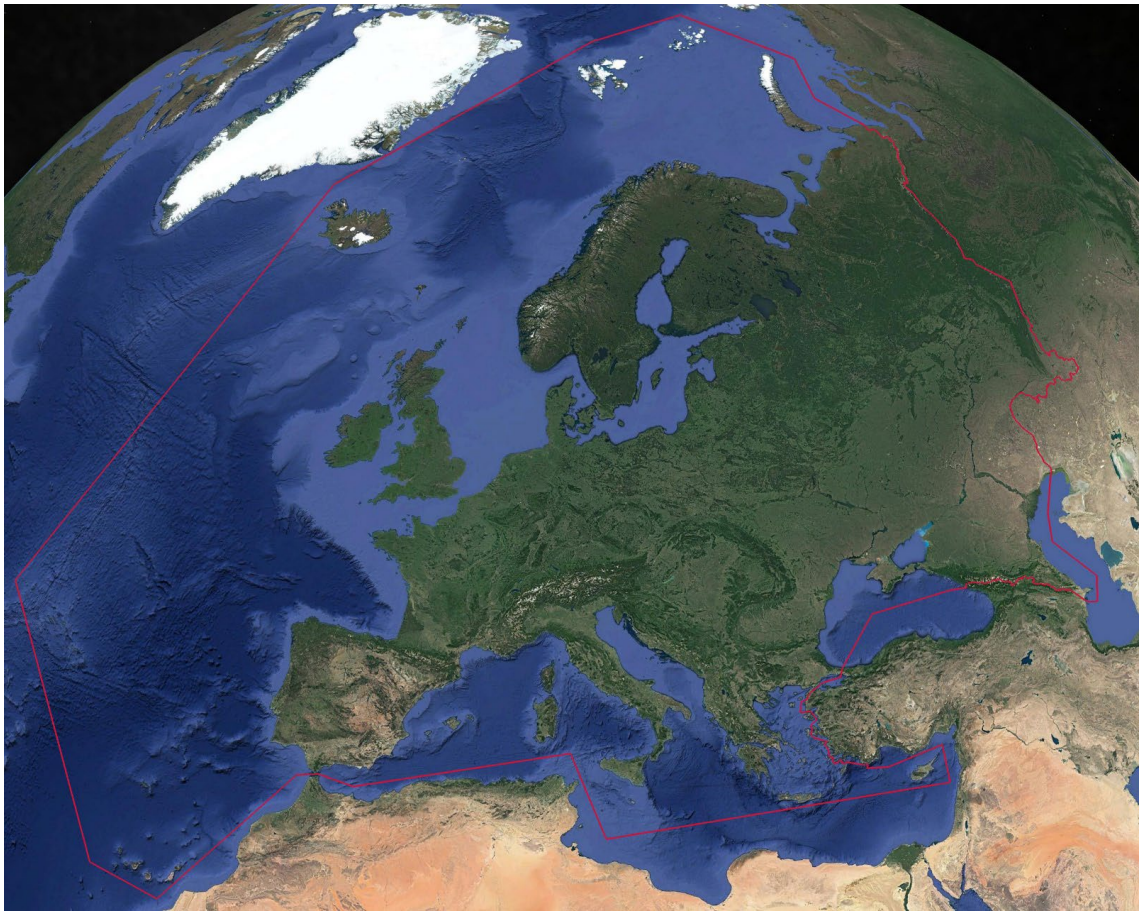

Figure S2: dorsal (left) and head profile (right) photographs of European snakes. The numbering and order of presentation of the species is based on the dichotomous key provided in this work. Note: examples of adult colourations are shown here, but each species may present a more or less high chromatic variability and for some taxa the colouration of the juveniles is different from that of the adults.

2a. ***Indotyphlops braminus.*** Photo credits: Matteo R. Di Nicola.

2b. ***Xerotyphlops vermicularis*****.** Photo credits: Doru Panaitescu.

4a. ***Eryx jaculus.*** Photo credits: Matteo R. Di Nicola.

4b. *Eryx miliaris*. Photo credits: Matthias Rechter.

7a. *Malpolon insignitus*. Photo credits: Matteo R. Di Nicola

7b. *Malpolon monspessulanus*. Photo credits: Matteo R. Di Nicola.

10a. *Natrix astreptophora*. Photo credits: Jordi Ribó Ferrer (left); Eduardo Fernandez Melendez (right).

11a. ***Natrix helvetica.*** Photo credits: Matteo R. Di Nicola.

11b. ***Natrix natrix.*** Photo credits: Matteo R. Di Nicola.

12a. ***Natrix maura.*** Photo credits: Matteo R. Di Nicola.

12b. ***Natrix tessellata.*** Photo credits: Matteo R. Di Nicola.

13a. ***Telescopus fallax.*** Photo credits: Matteo R. Di Nicola.

14a. ***Lampropeltis getula.*** Photo credits: Brian Hinds (left); Chad M. Lane (right).

16a. ***Macroprotodon brevis.*** Photo credits: Pedro Verdejo Díaz

17a. ***Macroprotodon cucullatus.*** Photo credits: Jordi Ribó Ferrer.

17b. *Macroprotodon* Lampedusa/Tunisia clade. Photo credits: Matteo R. Di Nicola.

19a. *Elaphe schrenckii*. Photo credits: Andrei Kotkin.

20a. *Elaphe taeniura*. Photo credits: Laura & Bobby Bok.

21a. *Elaphe quatuorlineata*. Photo credits: Matteo R. Di Nicola.

22a. *Elaphe dione*. Photo credits: Wang Xiaohe & Ryabov Sergei.

23a. *Elaphe sauromates*. Photo credits: Oleksandr Zinenko.

23b. *Elaphe urartica*. Photo credits: Diego Reggianti.

26a. *Eirenis collaris*. Photo credits: Hendrik Pempelfort.

26b. *Rhynchocalamus melanocephalus*. Photo credits: Avigail Sella.

27a. *Eirenis levantinus*. Photo credits: Rani Sturm.

27b. *Eirenis modestus*. Photo credits: Robin Gloor (left); Konstantinos Kalaentzis (right).

29a. *Hierophis cypriensis*. Photo credits: Doru Panaitescu.

31a. *Platyceps collaris*. Photo credits: Ehab K. Eid.

31b. *Platyceps najadum*. Photo credits: Robin Gloor (left); Mirko Galuppi (right).

32a. *Coronella austriaca*. Photo credits: Matteo R. Di Nicola.

33a. *Hierophis viridiflavus*. Photo credits: Matteo R. Di Nicola.

34a. *Hierophis gemonensis*. Photo credits: Mirko Galuppi.

35a. *Dolichophis jugularis*. Photo credits: Konstantinos Kalaentzis.

36a. *Dolichophis caspius*. Photo credits: Doru Panaitescu.

37b. *Dolichophis schmidti*. Photo credits: Laura & Bobby Bok.

38a. *Coronella girondica*. Photo credits: Matteo R. Di Nicola.

39a. *Zamenis scalaris*. Photo credits: Antonio J. Garcia Franco.

41a. *Zamenis hohenackeri*. Photo credits: Robin Gloor.

41b. *Zamenis situla*. Photo credits: Matteo R. Di Nicola.

42a. ***Zamenis lineatus.*** Photo credits: Matteo R. Di Nicola.

42b. ***Zamenis longissimus.*** Photo credits: Matteo R. Di Nicola.

44a. ***Hemorrhois nummifer.*** Photo credits: Konstantinos Kalaentzis.

44b. ***Hemorrhois ravergieri.*** Photo credits: Laura & Bobby Bok.

45a. ***Hemorrhois algirus.*** Photo credits: François Rancon.

45b. ***Hemorrhois hippocrepis.*** Photo credits: Matteo R. Di Nicola.

47a. ***Montivipera xanthina.*** Photo credits: Matteo R. Di Nicola.

48a. ***Macrovipera schweizeri.*** Photo credits: Matteo R. Di Nicola.

48b. ***Macrovipera lebetinus.*** Photo credits: Renato Massa.

51a. ***Vipera seoanei.*** Photo credits: Matthieu Berroneau.

51b. ***Vipera berus.*** Photo credits: Matteo R. Di Nicola.

52a. ***Vipera graeca.*** Photo credits: Robin Gloor.

53a. ***Vipera renardi.*** Photo credits: Gregoire J. Meier.

54a. ***Vipera ursinii.*** Photo credits: Matteo R. Di Nicola.

55a. ***Vipera dinniki.*** Photo credits: Robin Gloor.

55b. ***Vipera kaznakovi.*** Photo credits: Robin Gloor.

56a. ***Vipera aspis.*** Photo credits: Matteo R. Di Nicola.

57a. ***Vipera ammodytes.*** Photo credits: Matteo R. Di Nicola.

57b. ***Vipera latastei.*** Photo credits: Matthieu Berroneau.

REFERENCES

SPEYBROECK, J.; BEUKEMA, W.; DUFRESNES, C.; FRITZ, U.; JABLONSKI, D.; LYMBERAKIS, P.; MARTINEZ-SOLANO, I.; RAZZETTI, E.; VAMBERGER, M.; VENCES, M.; VÖRÖS, J. & CROCHET, P.A. (2020). Species list of the European herpetofauna – 2020 update by the Taxonomic Committee of the Societas Europaea Herpetologica. *Amphibia-Reptilia* 41(2): 139-189.

ZAHER, H.; MURPHY, R.W.; ARREDONDO, J.C.; GRABOSKI, R.; MACHADO-FILHO, P.R.; MAHLOW, K.; MONTINGELLI, G.G.; BOTTALLO QUADROS, A.; ORLOV, N.L.; WILKINSON, M.; ZHANG, Y.P. & GRAZZIOTIN, F.G. (2019). Large-scale molecular phylogeny, morphology, divergence-time estimation, and the fossil record of advanced caenophidian snakes (Squamata: Serpentes). *PLoS ONE* 14(5): e0216148.