**Taxonomy of the Onosma echioides (L.) L. complex (Boraginaceae) based on morphometric analysis**

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**INTRODUCTION**

According to Ball (1972a), the genus *Onosma* L. (of feminine gender, according to Stearn, 1993) is composed of three species groups, originally described as sections, but presently recognized only as informal groups: (1) Haplotricha, with basal leaves covered by simple setae only; (2) Asterotricha, with basal leaves covered by stellate bristles or asterosetae (i.e. a long tubercled seta with several shorter rays at its basin); (3) Heterotricha, with both simple setae and asterosetae on basal leaves.

The genus *Onosma* comprises c. 150 species, widespread from Spain and Morocco to China, with areas of high diversity in Turkey (Anatolia), Iran and Central Asia (Teppner, 1991a, b, 1996). Following the treatment of the genus in *Flora Europaea*, there are 33 *Onosma* species in Europe (Ball, 1972b), of which five occur in Italy (Teppner, 1971a, b, 1982): *O. fastigiata* (Braun-Blanquet) Lacaita, diploid with 2n = 12 chromosomes (Favarger, 1971), shows only simple setae and occurs in Piedmont and Liguria (NW Italy); *O. visianii* Clem., with 2n = 18 chromosomes (Teppner, 1991a), shows simple setae only, but occurs in Karst near Trieste (NE Italy); *O. arenaria* Waldst. et Kit. subsp. *pennina* Braun-Blanquet, with 2n = 20 chromosomes (Teppner, 1971b, 1996), shows both simple and stellate setae and is known only from one herbarium specimen from Piedmont; *O. helvetica* Boiss., allotetraploid with 2n = 26 chromosomes, shows stellate setae as well as short simple hairs and occurs in N and S Italy with three allopatric subspecies (Peruzzi, Aquaro & Cesca, 2004); *O. echioides* (L.) L., diploid with 2n = 14 chromosomes, shows only stellate bristles and occurs in Sicily, peninsular Italy and in Karst near Trieste (Peruzzi & Passalacqua, 2004).

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Accordingly, the *Onosma echioides* complex is the only Asterotricha group in Italy. Other species of the same group can be found in the Balkans: *O. stellulata* Waldst. & Kit., with glabrous corollas and a different chromosome complement (2n = 22 instead of 2n = 14, which is usual in this complex; Teppner 1981) and *O. erecta* Sibth. & Sm., which is also very similar to *O. echioides* from a karyological point of view (same chromosome number), but distinct for the glabrous corollas and the bracts overtopping the flowers (Teppner, 1988, 1991b).

The variability in *Onosma echioides* has already been studied by Lacaita (1924a, b, ‘complesso di microspecie’), together with problems concerning the correct interpretation of the name *O. echioides*, which, as he demonstrated, should be applied to Italian plants from Central Apennine. This species was first described by Linnaeus (1753) in the genus *Cerinthe* (‘foliis lanceolato-linearibus hispidis, feminibus quaternis distinctis. Hort. Cliff. 48’) and then transferred to the genus *Onosma* (‘foliis lanceolatis hispidis, fructibus erectis’; Linnaeus, 1762). Lacaita (1924a, b) evidenced that Linnaeus himself was aware that his treatment of this species was inadequate and that under this name many potential species were merged [in his own copy of Sp. Pl. ed. 2, he (Linnaeus) wrote for *echioides*: ‘här är flere species’ (here are many species)]. Lacaita (1924a) typified the name *O. echioides* (L.) L. by Colonna’s illustration (*Anchusa echioides lutea, cerinthae flore montana* Columna, Ekphr.: t. 183 – 1606), including only the plants with asterosetae (indicated by Linnaeus with ‘α’, meaning unnamed variety), while he excluded all the plants with simple setae (indicated by Linnaeus with ‘β’). In this way, Lacaita cleaned away the widespread confusion around the name *O. echioides* (L.) L., misapplied by some authors (Rübel & Braun-Blanquet, 1917) and neglected by others (the Italian plants have been called *O. stellulata* or *O. montana* for many years). Lacaita also evidenced that, although Linnaeus quoted as loci classici ‘Austria, Pannonia, Helvetia, Gallia, Italia’, the plants he referred to the unnamed variety ‘α’ are to be found only in Italy and Croatia (Dalmatia); the same author also listed several close units, which he considered as varieties (Fig. 1): var. *columnae* Lacaita nom. illeg. = *O. echioides* L. sensu strictissimo [= var. *echioides*], on the Apennines from Calabria to Marche; var. *dalmatica* (Scheele) Lacaita = *O. dalmatica* Scheele, prevailing in Dalmatia; var. *veronensis* Lacaita = *O. angustifolia* from Rigo’s *exsiccatum*; limited to the Verona province; var. *angustifolia* (Lemh.) Lacaita = *O. angustifolia* Lemh., in Apulia; var. *crinita* (Boiss.) Lacaita = *O. canescens* J. & C. Presl, limited to Sicily. Lacaita based his considerations mainly on morphological characters linked to asterosetae (their qualitative coverage, length and inclination) and to leaves (their width and degree of margin revolution). The same author described also several formas: (1) under var. *columnae*: f. *pseudoerectum* Lacaita, morphologically close to *O. erecta*, on the serpentes close to Castiglioncello (Livorno, Tuscany) and f. *sommieri* Lacaita, close to var. *crinita*, on Mt. Argentario (Grosseto, Tuscany); (2) under var. *dalmatica*: f. *calvescens*, less hairy, in Abruzzo and Dalmatia.

More recently, Ball (1972b) and Teppner (1982) considered the group as a single species showing high variability in need of further studies. Greuter, Burdet & Long (1984) considered it instead as an aggregate of three species of doubtful value: *O. echioides* (L.) L. in peninsular Italy, *O. canescens* J. et C. Presl in Sicily, *O. javorkae* Simonkai in NE Italy and Dalmatia. It is worth noting, however, that the correct name...
for the latter species is not *O. javorkae*, described in 1906, but *O. dalmatica* Scheele, described in 1843 (Peruzzi & Passalacqua, 2004). The latter study summarized the morphological and karyological features of the different units belonging to the *O. echioides* group (Tables 1, 2). Accordingly, in the recent checklist of the Italian flora (L. Peruzzi in Conti et al., 2005), this group is treated in the following way: *O. angustifolia* Lehm. (endemic to Apulia and Calabria), *O. canescens* J. & C. Presl (endemic to Sicily), *O. dalmatica* Scheele (endemic to Karst-Dalmatia), *O. echioides* (L.) L. (endemic of the Apennines from Tuscany to Calabria).

The aim of the present work is to clarify the systematic relationships and the taxonomic value of all the units belonging to the *O. echioides* complex, through literature analysis, quantitative analysis of morphological characters at population level, typification of the names involved and establishment of synonymies.

**MATERIAL AND METHODS**

The study was based on herbarium specimens from BM, CLU, FI, PI, RO and living plant material. Digital photos and/or specimens data information were received from BP, BREM, GOET, MEL, PR, REG, S, TUB, W. The *specimens visa* are listed in Appendix S1. This preliminary study allowed us to

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**Table 1. Morphological features of the *Onosma echioides* complex considered in this study**

<table>
<thead>
<tr>
<th>Characters relative to asterosetae:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hair coverage* – degree of hair coverage: 1 = 0–20%; 2 = 20–40%; 3 = 40–60%; 4 = 60–80%; 5 = 80–100%</td>
</tr>
<tr>
<td>2. Hair density* – number of asterosetae for 0.40 cm²</td>
</tr>
<tr>
<td>3. Setae angle* – inclination of setae: 0 = more or less patent (80–100°); 1 = adpressed to patent (5–80°); 2 = adpressed (0–5°)</td>
</tr>
<tr>
<td>4. Setae tuberculate – occurrence of small tubercles on the setae: 0 = absent; 1 = present</td>
</tr>
<tr>
<td>5. Hair simple – occurrence of simple hairs in the calyx: 0 = absent; 1 = present</td>
</tr>
<tr>
<td>6. Astero number – number of asterosetae rays</td>
</tr>
<tr>
<td>7. Astero length – length of asterosetae rays (mm)</td>
</tr>
<tr>
<td>8. Astero angle – the inclination of the asterosetae rays: 1 = more or less patent (80–100°); 2 = adpressed to patent (5–80°); 3 = adpressed (0–5°)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characters relative to the flowers/inflorescences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Leaf length – length of the basal leaves (mm)</td>
</tr>
<tr>
<td>12. Leaf width* – widths of the leaves (proximal, middle, distal) in each of the three-thirds of the stem (mm)</td>
</tr>
<tr>
<td>13. Leaf revolute* – degree of margins revolution: 1 = more or less flat; 2 = slightly revolute; 3 = completely revolute</td>
</tr>
<tr>
<td>14. Leaf number – total number of leaves per stem</td>
</tr>
</tbody>
</table>

*Characters qualitatively considered by Lacaita (1924a, b).
select populations crucial to solve taxonomic questions within the *O. echioides* complex by means of morphometric analysis.

Field investigations were conducted in Calabria (S Italy: Montea and Dirupata), Sicily (Quacella), Tuscany (C Italy: MRufo), near Verona (N Italy) and in Dalmatia (Split) (Fig. 1, Appendix S2). Twenty individuals for each population (19 for Dalmatia) where used for morphometric analyses. The populations investigated were selected after herbarium and bibliography study among those that appeared crucial towards solving taxonomic questions.

Despite *O. echioides* var. *veronensis* looking at first sight very close to *O. angustifolia* (Peruzzi & Passalacqua, 2004), when visiting the population in June 2007 we realized that this taxon is actually almost identical to *O. dalmatica* in terms of flower features and number of stems. However, as the population showed only a few individuals (7–9) and the collection of material for our study could damage their viability, we avoided sampling it for morphometry.

Because of the wide range of occurrence of this taxon, southwards close to populations of *O. angustifolia* (Fig. 1), and because of the different growing substrate (see Appendix S2), we included instead two populations of *O. echioides* s.s.

For morphometric analysis, we considered all the previously quoted diagnostic characters among the considered units (see Lacaita, 1924a, b; Fig. 2), but also the characters which appeared to be potentially important for the separation of taxa in the course of our study (*ex novo*) (Table 1, Appendix S3).

Characters concerning stems and corollas were measured in the field, while all other characters were measured in laboratory using dried material. Microcharacters were observed using a Zeiss Stemi SV 11 stereomicroscope, with the aid of a micrometric slide, the central area (a circle of about 0.40 cm²) of which was also used as reference unit for counting the number of asterosetae (‘hair density’, see above).

The resulting data matrix was processed using the statistical and multivariate analysis softwares Data Desk 6.1 (Velleman, 1997), SYN-TAX 2000 (Podani, 2001) and SPSS 14.0 (Norušis, 2005). After character selection using test statistics, as explained below, Cluster and principal coordinate analyses were performed using the Gower coefficient for mixed data extended to ordinal characters (Podani, 1999). First, constant characters were excluded; for the remaining ones we used a significance test (we excluded characters with $P > 0.001$). After Bloom’s normalization, continuous characters that passed normality tests (the Kolmogorov–Smirnov D-test and the Shapiro–Wilk W-test) and the homoscedasticity test (Levene statistic) were subject to analysis of variance (ANOVA) and F statistic (F). The Kruskal–Wallis test (K) was used for continuous characters that failed the normality or homoscedasticity tests and for semiquantitative characters. Binary characters were subject to Pearson’s $\chi^2$-statistic test (P). All statistic values are shown in Appendix S3. Moreover, strictly related characters (the same character measured in different parts of the individual) were subject to Spearman’s correlation ($\rho$); when the correlation was over 0.600 (Appendix S4), we excluded the characters with lower statistic values at the populational level (Appendix S3), to avoid the additive effect on multivariate analysis. The resulting data matrix was of 99 cases (individuals) $\times$ 36 variables (characters).

In order to evidence trends of affinities/diversities among taxa, we explored the meaningful characters throughout the comparison of population variability.

### Table 2. Synthesis of karyological data known in literature for the *Onosma echioides* complex

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Chromosome number</th>
<th>Locality</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. echioides</em></td>
<td>$2n = 14$</td>
<td>Abruzzo</td>
<td>Teppner, 1971b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Central Apennine</td>
<td>Teppner, 1971b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tuscany (9 localities)</td>
<td>Mengoni et al., 2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tuscany, Pomarance</td>
<td>Coppi, Selvi &amp; Bigazzi, 2006</td>
</tr>
<tr>
<td><em>O. angustifolia</em></td>
<td>$2n = 14$</td>
<td>Gargano (Apulia)</td>
<td>Grau, 1968 (sub <em>O. echioides</em>)</td>
</tr>
<tr>
<td><em>O. canescens</em></td>
<td>$2n = 14$</td>
<td>Madonie (Sicily)</td>
<td>Raimondo, Rossitto &amp; Ottonello (1983)</td>
</tr>
<tr>
<td></td>
<td>$2n = 14 + 1B$</td>
<td>Monte Cuccio, Palermo (Sicily)</td>
<td>Peruzzi &amp; Passalacqua (2004)</td>
</tr>
<tr>
<td><em>O. dalmatica</em></td>
<td>$2n = 14$</td>
<td>Trieste (Friuli)</td>
<td>Teppner, 1971b (sub <em>O. javorkae</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timavo, Trieste (Friuli)</td>
<td>Kieft &amp; Loon, 1978 (sub <em>O. echioides</em>)</td>
</tr>
<tr>
<td></td>
<td>$2n = 14$</td>
<td>Garda (Veneto)</td>
<td>Teppner, 1974 (sub <em>O. echioides</em> var. <em>veronensis</em>)</td>
</tr>
<tr>
<td></td>
<td>$2n = 14 + 0-1B$</td>
<td>Near Adria; Bosnia, Croazia, Montenegro</td>
<td>Teppner, 1971b (sub <em>O. javorkae</em>)</td>
</tr>
</tbody>
</table>
range, using boxplots for continuous characters (Loftus, 1993) or contingency tables for semiquantitative and discrete quantitative characters with few character states (Legendre & Legendre, 1998).

RESULTS

Morphometric analysis: The principal coordinate analysis (PCoA; Fig. 3) shows on the first two axes (explained variance: 24.53% and 18.61%) a good separation of the four units, with only the two populations of *O. echioides* s.s. clearly overlapping. The population from Sicily (*O. canescens*) is the best differentiated, with scarcely dispersed individuals well separated from others, while other populations show high variation within populations, with populations appearing close to each other.

Cluster analysis [the unweighted pair-group method with arithmetic mean (UPGMA)] identifies four main groups (Fig. 4): group a includes only individuals of *O. dalmatica*, but not all of them; group b includes all the individuals of *O. angustifolia* and two individuals of *O. echioides* s.s.; group c includes all the individuals of *O. canescens*, but also a single individual of *O. dalmatica*; finally, group d includes only individuals of *O. echioides* s.s. – but not all of them – and also a single individual of *O. dalmatica*. There are also single individuals that fall in different clusters (i.e. Split 18 in *O. canescens*; Split 14 in *O. echioides*; MRufoli 12 and 13 in *O. angustifolia*) as several subgroups of *O. dalmatica* (a1) and *O. echioides* s.s. (d1), which correspond to ‘intermediate’ individuals in PCoA (Fig. 3). By using other agglomeration methods, the
structure of the phenogram and the general classification are similar, while the two cited subgroups are arranged in different ways: united in a single subgroup within O. echioides s.s. (Incremental Sum of Square, result not shown); or the subgroup (d1) of O. echioides inserted between O. dalmatica and O. angustifolia, linked to the latter (Minimum Average Distance in new cluster, result not shown).

The Sicilian population (Quacella), referring to O. canescens, is clearly the best differentiated. The high hair coverage on the leaves (Table 3; upper third of stem: K = 63.039; lower third of stem: K = 58.876), already used to circumscribe this unit, is statistically significant. Instead, the asterosetae density (Fig. 5) is less significant, with the exception of the upper third of the stem (K = 59.139), especially in comparison with O. echioides s.s. It is noteworthy that these two characters vary in different portions of the plant and, while on the stem the variability widely overlaps with other units, on the leaves there is a certain degree of differentiation. On average, setae (Fig. 6) are longer in all portions of the plants (on the upper third of the stem: K = 54.758), but certainly O. canescens is marked by the flowers that are bigger in all their parts (Fig. 7); the length (K = 67.920) and the width of corolla (K = 41.282) and the length of the calyx teeth (F = 58.234) are higher in average and totally discriminate this unit from O. dalmatica.

As far as other populations are concerned, the Dirupata, referring to O. angustifolia, shows the lowest dispersion/variation within population (Fig. 3). Statistical analysis confirms the relevance of the adpressed setae to characterize O. angustifolia in respect to the other taxa (Table 4; on the leaf of upper third of stem: K = 72.646. Fig. 2A). Although this character state is not distinctive, as it is partially shared with O. dalmatica, only in O. angustifolia it is constant for all plant portions. To a lesser extent, the revolute leaf margin is also an indication (K = 48.036). However, in general, there are no clearly distinctive features for this unit. Indeed, although the within-population variability of single characters shows a low dispersion of values, it overlaps with both O. dalmatica and O. echioides s.s., to some extent linking the latter two units.

The variability of O. echioides (populations of Montea and MRufoli) overlaps with O. angustifolia (as shown above) and, above all, with O. canescens. It differs quite well from the former in the degree of setae inclination (Table 4, Fig. 2B) and from the latter in the degree of asterosetae coverage (Table 3). True differential character states are lacking. This explains the affinity of O. echioides with O. canescens (Fig. 3, negative values on the first PCoA axes; Fig. 4, clusters c and d linked) and the uncertain classification of part of its individuals (Fig. 4, cluster d1) under O. angustifolia.

Figure 4. Unweighted pair-group method with arithmetic mean (UPGMA) dendrogram of Onosma echioides group. Cases are labelled as follow: D, Dirupata; M, Montea; MR, MRufoli; Q, Quacella; S, Split. Main clusters are indicated by letters (a, b, c and d), while relevant subgroups are indicated by 1.

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The Split population, referring to *O. dalmatica*, is marked by the flowers that are smaller on average (Fig. 7), while the leaf features (higher length; not revolute margins), lower asterosetae coverage on the leaves (Table 3) and larger size of the stems, are all statistically less significant. Indeed, in all these characters, the variability of *O. dalmatica* overlaps with that of *O. angustifolia*, as evidenced by their affinity in multivariate analysis.

**DISCUSSION**

The *O. echiodes* complex shows high variability, with systematic units of sufficiently good circumscription (as demonstrated by multivariate analysis, Figs 3, 4), but with no single clear discriminant character.

Quacella (*O. canescens*) resulted in being the most isolated unit in PCoA (Fig. 3), but, because of its closeness to some extreme individual of Split, cluster analysis (Fig. 4) failed to recognize it as a definitely distinct group. *O. canescens* showed also a certain affinity with *O. echioides* s.s. (MRufoli + Montea). Indeed, Lacaita (1924a, b) had already noted this in also describing *O. echioides* f. *sommieri* Lacaita for the plants of *O. echioides* (i.e. in Argentario Promontory, Tuscany) which resembled *O. canescens*. These two units also share their preference for mountain habitats (500–1500 m a.s.l.) by generally growing in less xeric places in comparison with those of *O. angustifolia* and *O. dalmatica*, which instead generally prefer hilly coastal habitats (0–500 m a.s.l.).

MRufoli and Montea completely overlap in both PCoA (Fig. 3) and cluster analysis (Fig. 4), thus confirming that *O. echioides* s.s. is a rather homogeneous taxon, even at the opposite extremes of its range. Most of the populations of *O. echioides* s.s. from Tuscany grow on serpentines. Mengoni et al. (2006) studied all the Tuscan populations through DNA fingerprinting [amplified fragment-length polymorphism (AFLP) markers] and found that the populations on serpentine are not genetically distinct from those growing on limestone. The areas with serpentine were colonized several times by plants coming from neighbouring limestone areas. Our analyses confirm the homogeneity of the limestone (i.e. Montea) and serpentine (i.e. MRufoli) populations and therefore we consider *O. echioides* f. *pseudoerectum* Lacaita to clearly fall within the variability of *O. echioides* s.s.

Split appears the most variable of the studied population (Fig. 3), partly overlapping with both *O. echioides* s.s. (MRufoli + Montea) and Quacella and showing affinity with *O. angustifolia* (Fig. 4). The great variability of *O. dalmatica*, which can resemble extreme individuals of all other considered taxa, very likely...
caused the report (Lacaita, 1924a) of *O. echioides* for Trieste (NE Italy) and Istria (Croatia), as well as that of *O. dalmatica* for Abruzzo, Lucania (Basilicata) and Campania. In particular, the high variability of *O. dalmatica* in the hair coverage and inclination of the setae lead Lacaita to describe his *f. calvescens*, which has no taxonomic value.

Finally, Dirupata is well defined by PcoA (Fig. 3), but shows a partial overlap with MRufoli and affinity with *O. canescens* (Fig. 4).

**Figure 5.** Boxplots expressing the population variability of the hair density. The outlined central box depicts the middle 50% of the data, extending from upper to lower quartile; the horizontal bar is at the median. The ends of the vertical lines (or ‘whiskers’) indicate the minimum and maximum data values, unless outliers are present in which case the whiskers extend to a maximum of 1.5 times the inter-quartile range. Circles indicate outliers, unless extreme outliers are present in which case the circles extend to a maximum of three times the inter-quartile range and the extreme outliers are indicated as asterisks.

**Figure 6.** Boxplots expressing the population variability of the setae length (see Fig. 5 for further explanation).
From a karyological point of view, all the units share the same diploid complement, with $2n = 14$ chromosomes (Table 2). In literature, there are two other $2n = 14$ counts for *O. echioides*, which, however, cannot be referred to any of the four considered units (Tissot-Daguette, 1972; Vasudevan, 1975). A further $2n = 14$ count based on extra-Italian material (Strid, 1983) very likely refers to *O. erecta*. There was evidence for the possible occurrence of B-chromosomes in all the taxa involved in this study, with the exception of *O. echioides* s.s.

All the units have similar autoecology, growing mostly on limestone (rarely on serpentine and gypsum), in hilly–mountainous (rarely coastal) open garigues, with little soil.

The four units are allopatric, although there is a contact between the distribution range of *O. echioides* s.s. and that of *O. angustifolia* in S. Italy (N Calabria). In the latter area there is, however, no physical overlapping because of the different ecological requirements of the two taxa.

**CONCLUSIONS**

According to our results, all the taxa involved in this study can be considered as part of a single diploid, highly variable species: *O. echiodes* (L.) L., as already suggested by Teppner (1982). However, as the infraspecific variability is sufficient to distinguish four morphological groups and they are linked to geographical distribution, it is appropriate to consider…

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**Table 4.** Contingency table of the degree of setae inclination, in the different portions of the plant

<table>
<thead>
<tr>
<th>Locality</th>
<th>Split</th>
<th>Dirupata</th>
<th>Quacella</th>
<th>Montea</th>
<th>MRufoli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Calyx</td>
<td>2 16 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf lower third</td>
<td>–</td>
<td>5 14</td>
<td>–</td>
<td>–</td>
<td>20</td>
</tr>
<tr>
<td>Leaf upper third</td>
<td>–</td>
<td>13 6</td>
<td>–</td>
<td>–</td>
<td>20</td>
</tr>
<tr>
<td>Stem lower third</td>
<td>1 3</td>
<td>15</td>
<td>–</td>
<td>–</td>
<td>20</td>
</tr>
<tr>
<td>Stem upper third</td>
<td>3</td>
<td>12 4</td>
<td>–</td>
<td>–</td>
<td>20</td>
</tr>
</tbody>
</table>

Setae inclination: 1, more or less patent (80–100°); 2, adpressed to patent (5–80°); 3, adpressed (0–5°).
them at the taxonomic rank of subspecies. Consequently, we propose here the following new taxonomic setting for the *O. echioides* complex:

**Onosma echioides** (L.) L., Sp. Pl. ed. 2: 196 (1762)
≡ *Cerinthe echioides* L. Sp. Pl.: 173 (1753)

Lectotypus (designated by Lacaita, 1924a) – *Anchusa echioides lutea, cerinthae flore, montana* Columna, Ekphr.: t. 183 (1606)

subsp. *echioides*

Distribution: endemic to Apennines (from Tuscany to NW Calabria)

≡ *O. angustifolia* Lehm., Pl. Asperif. 1: 361 (1818)

Lectotypus (here designated): in ripibus montis Gargano Apuliae, V.1812, Sieber (Herb. Lehmann, MEL!)
≡ *O. cinerea* sensu Sieber in *exsiccata*, non Schreb.

Distribution: endemic to SE Italy (Apulia to Calabria).

≡ *O. dalmatica* Scheele, Flora (Regensburg) 26: 560 (1843).

Lectotypus (here designated): Dalmatien, s.d., Petter (TUB, n° 003103 sub *O. stellulata*)

In Bremen (BREM), Goettingen (GOET) and Regensburg (REG), where parts of Herbarium Scheele are conserved, there are no sheets of *O. dalmatica*. As in the protologue it is affirmed ‘Unter dem Namen Onosma stellulatum erhielt ich 1830 von Petter eine bei Spalato in Dalmatien gesammelte neue Art:...’, we checked also for Petter’s material in Tübingen (TUB) and Wien (W) herbaria. While we were not able to trace any appropriate specimen in the latter, we found in the former (TUB) one herbarium specimen which can possibly be considered as a duplicate of original material, even if it lacks the date and bears only the indication ‘Dalmatien’.


≡ *O. javorvae* Simontik, Magyar Bot. Lap. 5: 385 (1906)

Lectotypus (here designated): In agro Tergestino, in declivibus apricis montis Spaccato prope Tergestim; solo calcareo, s.d., Marchesetti (BP!).


Distribution: endemic to Karst (Trieste area – NE Italy, Dalmatia – Croatia). One disjunct isolated relic population in Veneto (var. *veronensis*).

≡ *O. canescens* J. et C. Presl, Fl. Sicula: 34 (1826)

Lectotypus (here designated): *Onosma canescens*, Presl (PR!).

Distribution: endemic to Sicily

**IDENTIFICATION KEY FOR O. ECHIOIDES COMPLEX**

1. Plants very hispid because of whitish hairs > 2 mm, generally not adpressed to the stem, which cover the leaves almost totally; corolla (22/25–29.1/32) mm long, 8–10 mm wide.............. *O. echioides* subsp. *canescens*
1. Plants hispid to strigose because of whitish–grey hairs <2 mm, ± adpressed to the stem, which cover up to ¾ of the leaves; corolla (13/15–25.5/26) mm long, (5)/6–8.5/11) mm wide 2
2. Corolla (13)/14.6–20 mm long, (5)/5.40–8 mm wide.......................... *O. echioides* subsp. *dalmatica*
2. Corolla (19)/21–25.5/26 mm long, (6)/7–8.5/11) mm wide 3
3. Leaves greenish–grey, 1–3 mm wide, highly revolute at margins, asterosetae generally overlapping; asterosetae completely adpressed to the leaves; corolla infundibuliform to urceolate........... *O. echioides* subsp. *angustifolia*
3. Leaves greenish, 2–5 mm wide, less revolute at margins, asterosetae generally not overlapping; asterosetae patent; corolla almost always urceolate.............. *O. echioides* subsp. *echioides*
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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** Specimens seen.

**Appendix S2.** Source of living plant material investigated.

**Appendix S3.** Statistical values for the measured characters. Characters are grouped according to their typology (binary, semiquantitative, continuous). Test statistic at population level (population) and subspecific level (taxa) shows the degree of freedom (d.f.), the test type (Test: P, Pearson $\chi^2$ statistic; K, Kruskal–Wallis; F, F statistic) and the statistic significance level (p). Univariate statistic values ($\mu$, mean; $\sigma$, standard deviation; percentile 10, lower, middle and upper values) are reported with exclusion of constant characters and characters with $P > 0.001$ at population level.

**Appendix S4.** Spearman rho correlation of characters measured in different part of the plant. lt, lower third; mt, medium third; ut, upper third; S, stem; L, leaf; Ca, calix. Test of significance level (p) is always lower than 0.01 except: *$P > 0.05$; **$P > 0.1$; ***$P > 0.5$.

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