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CONSERVATION STATUS ASSESSMENT OF THE ENDEMIC *HIERACIUM* S. STR. (ASTERACEAE) OCCURRING IN SICILY

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Abstract - The current status of the majority of apomictic taxa, and therefore their priorities for conservation, are poorly known, and consequently, they are neglected by conservationists. In Sicily 8 species and 4 subspecies of *Hieracium* s. str. occurs. Eleven taxa are endemic to the area, one has a wider distribution. These taxa were not evaluated within the recent project "Red List assessment of plants and fungi in Italy" because collectively considered with insufficient and unreliable distribution data. The global conservation status of the endemic *Hieracium* s. str. taxa occurring in Sicily was assessed here using the IUCN categories and criteria, on the basis of the data collected during field surveys over 10 years. Criteria A, B, C and D were used in assessments. The assessment of punctual endemic taxa considered the real threats to which populations are subjected. Overall, 6 Critically Endangered, 2 Endangered, 1 Vulnerable and 2 Least Concern taxa were assessed. The knowledge of taxa, currently small in size and isolated from each other, allows for the planning of differentiated conservation strategies.

Keywords: Apomictic taxa; endemic; conservation; criteria; fire; IUCN protocol; threat.

Introduction

The conservation of apomictic critical taxa has taken second place in the conservation of ordinary sexual species (Rich, 2006). Apomictic taxa have not been regarded as of the same status as classic sexually reproducing species because of their lower genetic diversity (Wigginton, 1999). Because of their perceived lower appreciation and often reputedly unclear taxonomy, the current status of the majority of these apomictic taxa, and therefore their priorities for conservation, are poorly known, and consequently, they are neglected by conservationists (Rich, 2006). The major problem for the conservation of critical species is the lack of knowledge about species delimitation, distribution, ecology and threats in Europe and Mediterranean countries (Tennant et al., 2002; Rich et al., 2008a, 2008b).

Among apomictic genera, *Hieracium* L. s. str. (Asteraceae) is probably the best known. *It* includes perennial herbs distributed mainly in temperate regions of Europe, Asia and North America (Chrtek et al., 2006), with a few sexual diploids, mostly distributed in South Europe (Merxmüller, 1975; Chrtek et al., 2004) and numerous apomictic polyploids (Pignatti, 1994; Gottschlich, 2009). According to Mráz & Zdvořák (2019), the diploid *Hieracium* taxa reproduce exclusively sexually, whereas asexual reproduction occurs only in polyploids.

The taxonomy and distribution of the genus *Hieracium* in southern Italy are currently under review. Recent studies have resulted in the description of new endemic taxa with very local

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distributions (Brullo et al., 2001; Raimondo & Di Gristina, 2004, 2007; Caldarella et al., 2013; Gottschlich et al., 2013, 2015; Di Gristina et al., 2013, 2014, 2015a, 2015b, 2016a, 2018, 2019). Additionally, little-known taxa were rediscovered (Di Gristina et al., 2016b; Gottschlich et al., 2017b) or reported as new to Italian flora (Gottschlich et al., 2017a).

In Sicily knowledge about *Hieracium* taxonomic delimitation, distribution, ecology and threats is suitable for studying the conservation of these taxa. *Hieracium* s. str. is thus represented by 12 taxa. Eleven of them (*H. busambarense* Caldarella, Gianguzzi & Gottschl., *H. hypochoeroides* subsp. *montis-scuderii* Di Grist., Gottschl., Galesi, Raimondo & Cristaudo, *H. lucidum* Guss. subsp. *lucidum*, *H. lucidum* subsp. *cophanense* (Lojac.) Greuter, *H. murorum* subsp. *atrovirens* (Froel.) Raimondo & Di Grist., *H. pallidum* Biv. subsp. *pallidum*, *H. pallidum* subsp. *aetnense* Gottschl., Raimondo & Di Grist., *H. racemosum* subsp. *pignattianum* (Raimondo & Di Grist.) Greuter, *H. schmidtii* subsp. *madoniense* (Raimondo & Di Grist.) Greuter, *H. schmidtii* subsp. *nebrodense* (Tineo ex Lojac.) Di Grist., Gottschl. & Raimondo and *H. symphytifolium* Froel.) are endemic to the island; the remaining (*H. racemosum* subsp. *crinitum* (Smith) Rouy) has a wider range. In addition, Bartolucci et al. (2018) reported *Hieracium racemosum* subsp. *alismatifolium* (Posp.) Zahn as doubtfully occurring; in our opinion, this taxon does not occur in Sicily. Most of these taxa are chasmophytes confined to vertical cliffs or rocky slopes. Among them, the diploid *H. lucidum* subsp. *lucidum*, according to Pignatti (1979, 1982, 1994), ascribes to Sicily the interesting role of the likely differentiation centre of the genus. Sicilian taxa have recently been revised for their nomenclature, taxonomy, and distribution (Aghababyan et al., 2008; Di Gristina et al., 2012, 2015c). Knowledge on their conservation status is not yet exhaustive and needs constant updating especially because the populations of the taxa are represented by a small number of individuals restricted to a few sites often subject to fire. Their phytogeographical and taxonomical relevance requires special protection measures. Unfortunately, the current status and priorities for conservation of the *Hieracium* taxa are poorly known, and consequently they are neglected by local administrations (Di Gristina et al., 2015c). *Hieracium* taxa considered with insufficient and unreliable distribution data were excluded from the recent contribution by Orsenigo et al. (2018) aimed at assessing the current risk of extinction of all the Italian endemic vascular plants. Consequently, we initiated extended work to assess the conservation status of the 11 Sicilian endemic *Hieracium* taxa. The results are reported in this paper to contribute to the conservation of this remarkable component of the Sicilian flora.

Materials and Methods

This study is based on data collected during field surveys over the last 10 years (2011–2020), from early spring to autumn. The 11 Sicilian *Hieracium* taxa considered are listed in Table 1. *H. racemosum* subsp. *crinitum* has been excluded from this account because we do not have data about this taxon outside Sicily and a regional assessment would be of local interest. The conservation status for each of the 11 considered taxa was assessed using IUCN criteria and guidelines (IUCN, 2012a, 2012b, 2019). Three main types of information were available for assessment: distribution, population sizes and threats. Four of the five IUCN criteria were employed. Criterion E was not used because there is insufficient information to assess population dynamics or estimate the minimum viable population.

The distribution information was used to compute the Extent of Occurrence (EOO) and Area of Occupancy (AOO) of each taxon, following the IUCN guidelines for applying criterion B (IUCN, 2019) using the Geospatial Conservation Assessment Tool (Bachman et al., 2011). The extent of Occurrence was obtained by delimiting a polygon that encompassed all the known localities of a taxon. The AOO was calculated by overlaying a 2 × 2 km grid cell and summing the areas in which each taxon was located. This was possible because of the narrow distributions of the taxa and the detail of the spatial information available. The EOO was often lower than the AOO for narrowly distributed species; in these cases, according to the guidelines (IUCN, 2019), EOO was changed to make it equal to AOO. To apply sub-criteria under criterion B, the number of locations for each taxon was calculated based on the main threat according to IUCN guidelines (IUCN, 2019).

Population sizes were estimated for the application of criteria C and D. All mature individuals were counted where the population was circumscribed and comprised a few individuals. Where this was infeasible the population was estimated.

Threats were categorized according to the IUCN threats classification scheme (IUCN, 2012b).

Results

Hieracium busambarense Caldarella, Gianguzzi & Gottschl., Pl. Biosyst., 148: 439. 2014.

Distribution and habitat. NW-facing carbonate-dolomitic vertical cliffs of Rocca Busambra (PA) (CW-Sicily), between 1500 and 1600 m a.s.l. (Table 1, Figure 1).

Threats. Threat 10.3: Avalanches/Landslides (Table 2). The natural evolution of the rock faces, subject to landslides and collapse, could reduce the number of individuals in the population.

Table 1. List of the 11 endemic Sicilian *Hieracium* taxa, with information on chorology, distribution, and habitat.

Taxon	Chorology	Locality	Habitat	Altitude (m a.s.l.)
Hieracium busambarense	Endemic	Rocca Busambra (PA)	Calcareous-dolomitic and vertical cliffs	1500-1600
Hieracium hypochoeroides subsp. *montis-scuderii*	Endemic	Mt Scuderi (ME)	Carbonate rocks	1140-1180
Hieracium lucidum subsp. *lucidum*	Endemic	Mt Gallo (PA)	Calcareous rocks and vertical cliffs	220-350
Hieracium lucidum subsp. *cophanense*	Endemic	Mt Cofano, Mt Passo del Lupo (TP)	Calcareous rocks and vertical cliffs	200-710
Hieracium murorum subsp. *atrovirens*	Endemic	Madonie Mountains (PA)	Carbonate rocky slopes	1350-1580
Hieracium pallidum subsp. *pallidum*	Endemic	Mt Etna (CT), Rocche Argimusco (ME)	Volcanic and quartzarenitic rocks	1200-2000
Hieracium pallidum subsp. *aetnense*	Endemic	Mt Etna (CT)	Volcanic stony slopes	1580-1650
Hieracium racemosum subsp. *pignattianum*	Endemic	Madonie Mountains (PA)	Carbonate rocks and rocky slopes	1300-1700
Hieracium schmidtii subsp. *madoniense*	Endemic	Madonie Mountains (PA)	Carbonate rocky slopes	1520-1700
Hieracium schmidtii subsp. *nebrodense*	Endemic	Madonie Mountains (PA)	Quartzarenitic rocks	1350-1450
Hieracium symphytifolium	Endemic	Madonie Mountains (PA)	Carbonate rocks and rocky slopes	1250-1800

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 60-80 mature individuals (Table 2).

IUCN categories. Despite having a low number of mature individuals *H. busambarense* is not subject to human activities or stochastic events capable of making it VU or EN within a very short time. The threat 10.3 "Avalanches / Landslides" is more potential than real and the population size is stable. Consequently, according to IUCN guidelines (2019), *H. busambarense* has to be listed as LC (Table 2).

Hieracium hypochoeroides subsp. ***montis-scuderii*** Di Grist., Gottschl., Galesi, Raimondo & Cristaudo, Fl. Medit., 23: 49. 2013.

Distribution and habitat. NW-facing carbonate rocks of Mt Scuderi (Peloritani Mountains, NE-Sicily), between 1140 and 1180 m a.s.l. (Table 1, Figure 1).

Threats. Threat 10.3: Avalanches/Landslides (Table 2). The natural evolution of the rock faces, subject to landslides and collapse, could reduce the number of individuals in the population.

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 30-35 mature individuals (Table 2).

IUCN categories. On the base of criterion D, due to the low number of mature individuals (< 50), *H. hypochoeroides* subsp. *montis-scuderii* should be classified as *Critically Endangered* (CR): D (Table 2). Despite having a low number of mature individuals *H. hypochoeroides* subsp. *montis-scuderii* is not subject to human activities or stochastic events capable of making it VU or EN within a very short time. The threat 10.3 "Avalanches / Landslides" is more potential than real and the population size is stable. Consequently, according to IUCN guidelines (2019) *H. hypochoeroides* subsp. *montis-scuderii* has to be listed as LC (Table 2).

The conservation status "Critically Endangered" (CR): B1a+2a; C2a(ii) reported by Di Gristina et al. (2013) has to be corrected on the basis of a deeper knowledge of the taxon and on the strict application of the guidelines by IUCN (2019).

Hieracium lucidum Guss., Index Seminum [Boccadifalco], 1825: 6. 1825 subsp. ***lucidum***

Distribution and habitat. NW-facing calcareous rocks and vertical cliffs of Mt Gallo (NW-Sicily), between 150 and 400 m a.s.l. (Table 1, Figure 1).

Threats. Threat 7.1: Fire & Fire Suppression (Table 2). Although the plants grow on rocks and vertical cliffs, the recurrent presence of fire is progressively reducing the number of individuals. We can estimate a 70% reduction in the number of mature individuals over the past 15 years. Threat 8.2: Problematic Native Species/Diseases (Table 2). The cliffs of Mt Gallo are being colonized by the invasive alien *Pennisetum setaceum* (Forssk.) Chiov. which competes with native species. The occurrence of recurring fire and of alien invasive species caused the decline of the quality of Habitat.

In addition, the monitoring carried out in recent years showed that the plants of *H. lucidum* subsp. *lucidum* are particularly appetizing for gastropods, in particular by *Erctella mazzullii* (De Cristofori & Jan, 1832) (Pulmonata, Stylommatophora, Helicidae), an endemic, rupicolous, saxicalous taxon of northwestern Sicily (Colomba et al., 2011) (Figure 2).

IUCN criteria applied. Criterion A, sub-criterion A2, Population reduction observed of 70% in the last 15 years and the causes of reduction are not ceased. Criterion B, sub-criterion B1, Extent of Occurrence (EOO): 12 km^2; sub-criterion B2, Area of Occupancy (AOO): 12 km^2 (Table 2); condition a) number of locations: 1; condition b) Continuing decline observed, inferred or projected in the quality of habitat (iii) and number of mature individuals (v) (Table 2). Criterion C, number of mature individuals: the single known population consists of 80-100 mature individuals; sub-criterion C2, an observed, estimated, projected, or inferred continuing decline in the number of mature individuals (Table 2); condition a) number of mature individuals in each subpopolation (i): the taxon is represented by one population that includes 80-100 mature individuals (Table 2). Criterion D, sub-criterion D, Number of mature individuals: 80-100 mature individuals (Table 2).

IUCN categories. On the basis of criteria A and B, due to the observed 70% reduction in the number of mature individuals over the past 15 years and the causes of reduction are not ceased, due to its restricted area (EOO < 100 km^2), a single location (1), observed declining of the quality of habitat and number of mature individuals, *H. lucidum* subsp. *lucidum* can be classified as *Critically Endangered* (CR): B1ab(iii,v) (Table 2). According to criteria A, B2, C and D, due to low number of mature individuals (< 2.500 and < 250 respectively), declining observed of the number of mature individuals (70% in the last 15 years), number of mature individuals in each subpopolation < 250, and AOO < 500 km^2, *H. lucidum* subsp. *lucidum* can be classified as *Endangered* (EN): A2ace, B2ab(iii,v), C2a(i), D. Consequently, the highest category of threat proposed is CR: B1ab(iii,v) (Table 2).

Hieracium lucidum subsp. ***cophanense*** (Lojac.) Greuter, Willdenowia, 37: 164. 2007.

Distribution and habitat. NW-facing calcareous rocks and vertical cliffs of Mt Cofano and Mt Passo del Lupo (Natural Reserve of Zingaro) (NW-Sicily), between 180-300 and 650-720 m a.s.l. respectively (Table 1, Figure 1).

Threats. Threat 7.1: Fire & Fire Suppression (Table 2). Although the plants grow on rocks and vertical cliffs, the recurrent presence of fire of high intensity is progressively reducing the number of individuals.

IUCN criteria applied. Criterion A, sub-criterion A2, Population reduction observed of 60% in the last 15 years and the causes of reduction are not ceased. Criterion B, sub-criterion B1, Area of Occupancy (AOO): 8 km^2 (Table 2); condition a) number of locations: 1; condition b) continuing decline observed, inferred or projected in the quality of habitat (iii) and number of mature individuals (v) (Table 2). Criterion C, Number of mature individuals: the population size, occurring in Mt Cofano and Mt Passo del Lupo, consists overall of 65-75 mature individuals (Table 2); sub-criterion C2, an observed, estimated, projected or inferred continuing decline in the number of mature individuals (Table 2); condition a) number of mature individuals in the population (i): in Mt Cofano and in Mt Passo del Lupo consists of 25-30 and 40-45 respectively. Criterion D, sub-criterion D, Number of mature individuals: 70-90 mature individuals (Table 2).

IUCN categories. On the basis of criteria A, B and D, due to its restricted area (EOO < 5.000 km^2 and AOO < 500 km^2), number of locations (< 5), low number of mature individuals (< 250), declining observed of the quality of habitat and number of mature individuals (60% in the last 15 years), *H. lucidum* subsp. *cophanense* can be classified as *Endangered* (E): A2ac, B1ab(iii,v) + 2ab(iii,v), D (Table 2). According to criteria C, due to the low number of mature individuals (< 250), declining observed of the number of mature individuals, and number of mature individuals in each subpopulation < 50, *H. lucidum* subsp. *cophanense* can be classified as *Critically Endangered* (CR): C2a(i). Consequently, the highest category of threat proposed is *Critically Endangered* (CR): C2a(i) (Table 2).

Hieracium murorum subsp. ***atrovirens*** (Froel.) Raimondo & Di Grist., Willdenowia, 37: 165. 2007.

Chorology. Sicilian endemic (Tab. 1).

Distribution and habitat. NW-facing carbonate rocky slopes from Passo della Botte to Rocca di Mele (Madonie Mountains, PA) (N-Sicily), between 1350 and 1580 m a.s.l. (Table 1, Figure 3).

Threats. Threats 2.3.1, 2.3.2: Nomadic Grazing and Smallholder Grazing, Ranching or Farming. 8.1.2 Named species: Wild boars and, since the last 10 years, Fallow deer, whose population on the Madonie has grown from a few hundreds to about 5,000 individuals (Silveira Bueno et al., 2020), constituting a serious threat to all plant species of the high mountain belt that grow in places accessible by animals (Table 2).

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 35-40 mature individuals; Wild boars and Fallow deer are a significant threat for the population (Table 2).

IUCN categories. On the basis of criterion D, due to the low number of mature individuals (< 50), and to the occurrence of a significant threat *H. murorum* subsp. *atrovirens* can be classified as *Critically Endangered* (CR): D (Table 2).

Hieracium pallidum Biv., in Bivona-Bernardi, Nuove piante inedite: 11. 1838 subsp. ***pallidum***

Chorology. Sicilian endemic (Table 1).

Distribution and habitat. Shaded volcanic rocks and rocky slopes of Mt Pomiciaro, Mt Zoccolaro and Serra del Salifizio facing the Valle del Bove (Mt Etna, CT) (E-Sicily), between 1550 and 2000 m a.s.l. (Table 1, Figure 1); NW-facing quartzarenitic rocks of Rocche dell'Argimusco (Peloritani Mountains, ME) (NE Sicily), between 1200 and 1250 m a.s.l. (Table 1, Fig. 1).

Threats. Threat 2.3.2: Small-holder Grazing, Ranching or Farming (Table 2). The population of Rocche dell'Argimusco is threatened by goat grazing.

Threats. Threats 10.1 Volcanoes (Table 2). The eruptions of the Etna volcano are the main threat for the population of Mt Zoccolaro and Serra del Salifizio which are located on the edge of the Valle del Bove, a preferential channel for the lava flow.

IUCN criteria applied. Criterion D, Number of mature individuals: the two populations, consist overall of 180-200 mature individuals (Table 2).

IUCN categories. On the basis of criterion D, due to the low number of mature individuals (< 250) and the direct threats to which it is subject, *H. pallidum* subsp. *pallidum* can be classified as *Endangered* (EN): D (Table 2).

Hieracium pallidum subsp. ***aetnense*** Gottschl., Raimondo & Di Grist., Pl. Biosyst., 147: 826. 2013.

Distribution and habitat. Volcanic stony slope in a very restricted area on Mt Pomiciaro (Mt Etna, CT) (E-Sicily), between 1580 and 1650 m a.s.l. (Table 1, Figure 3).

Threats. Threats 10.1 Volcanoes (Table 2). The eruptions of the Etna volcano are the main threat to the population. But Mt Pomiciaro is not on the usual path of lava flows.

IUCN criteria applied. Criterion B, sub-criterion B1, Area of Occupancy (AOO): 4 km^2; condition a) number of locations: 1; condition b) Continuing decline observed, inferred, or projected in the number of mature individuals (v) (Table 2). Criterion C, Number of mature individuals: the single known population consists of 20-25 mature individuals; sub-criterion C2, an observed, estimated, projected, or inferred continuing decline in the number of mature individuals (Table 2); condition a) number of mature individuals in the population (i): the taxon is represented by one population that includes 20-25 mature individuals (Table 2). Criterion D, Number of mature individuals: 20-25 mature individuals (Table 2).

IUCN categories. On the basis of criteria B, C and D, due to its restricted area (EOO < 100 km^2 and AOO < 10 km^2), a single location, number of mature individuals (< 50), declining observed of the number of mature individuals, and number of mature individuals in each subpopolation < 50, *H. pallidum* subsp. *aetnense* can be classified as *Critically Endangered* (CR): B1ab(v) + 2ab(v), C2a(i), D (Table 2).

Hieracium racemosum subsp. ***pignattianum*** (Raimondo & Di Grist.) Greuter, Willdenowia, 37: 171. 2007

Distribution and habitat. NW-facing carbonate rocks, rocky slopes, and in clearings of beech woods of Mt Mufara, Mt Quacella, Mt Daino, Cozzo del Filatore, Rocca di Mele, Stretto Canna, (Madonie Mountains, PA) (N-Sicily), between 1300 and 1700 m a.s.l. (Table 1, Figure 4).

Threats. Threats 2.3.1, 2.3.2: Nomadic Grazing and Small-holder Grazing, Ranching or Farming. 8.1.2 Named species: Wild boars and, since the last 10 years, Fallow deer, whose population on the Madonie has grown from a few hundreds to about 5,000 individuals (Silveira Bueno et al., 2020), constituting a serious threat to all plant species of the high mountain belt that grow in places accessible by animals (Table 2).

IUCN criteria applied. Criterion D, Number of mature individuals: the population consists of 800-900 mature individuals (Table 2); sub-criterion D2, Area of Occupancy (AOO): 20 km^2 and a single location (Table 2).

IUCN categories. On the base of criterion D, due to the number of mature individuals (< 1.000), the number of locations (< 5), *H. racemosum* subsp. *pignattianum* can be classified as *Vulnerable* (VU): D1+ D2 (Table 2).

Hieracium schmidtii subsp. ***madoniense*** (Raimondo & Di Grist.) Greuter, Willdenowia, 37: 173. 2007.

Distribution and habitat. NW-facing carbonate rocky slopes of Rocca di Mele (Madonie Mountains) (N-Sicily), between 1520 and 1700 m a.s.l. (Table 1, Figure 4).

Threats. Threats 2.3.1, 2.3.2: Nomadic Grazing and Small-holder Grazing, Ranching or Farming. 8.1.2 Named species: Wild boars and, since the last 10 years, Fallow deer, whose population on the Madonie has grown from a few hundreds to about 5,000 individuals (Silveira Bueno et al., 2020), constituting a serious threat to all plant species of the high mountain belt that grow in places accessible by animals (Table 2).

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 35-40 mature individuals; the population is subject to a real threat (Table 2).

IUCN categories. On the base of criterion D, due to the low number of mature individuals (< 50), *H. schmidtii* subsp. *madoniense* can be listed as *Critically Endangered* (CR): D (Table 2).

Hieracium schmidtii subsp. ***nebrodense*** (Tineo ex Lojac.) Di Grist., Gottschl. & Raimondo, Phytotaxa, 265: 59. 2016.

Distribution and habitat. NW-facing quartzarenitic rocks of Mt Cavallo (Madonie Mountains, PA) (N-Sicily), between 1350 and 1450 m a.s.l. (Table 1, Figure 4).

Threats. Threats 2.3.1, 2.3.2: Nomadic Grazing and Smallholder Grazing, Ranching or Farming. 8.1.2 Named species: Wild boars and, since the last 10 years, Fallow deer, whose population on the Madonie has grown from a few hundreds to about 5,000 individuals (Silveira Bueno et al., 2020), constituting a serious threat to all plant species of the high mountain belt that grow in places accessible by animals (Table 2).

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 30-35 mature individuals; the population is subject to a real threat (Table 2).

IUCN categories. On the base of criterion D, due to the low number of mature individuals (< 50), *H. schmidtii* subsp. *nebrodense* can be listed as *Critically Endangered* (CR): D (Table 2).

Hieracium symphytifolium Froel., in Candolle, Prodr. 7: 232. 1838.

Distribution and habitat. NW-facing carbonate rocks and rocky slopes of the highest reliefs of the Madonie Mountains (PA) (N-Sicily), between 1250 and 1800 m a.s.l. (Table 1, Figure 1).

Threats. Threats 2.3.1, 2.3.2: Nomadic Grazing and Smallholder Grazing, Ranching or Farming. 8.1.2 Named species: Wild boars and, since the last 10 years, Fallow deer, whose population on the Madonie has grown from a few hundred to about 5,000 individuals (Silveira Bueno et al., 2020), constituting a serious threat to all plant species of the high mountain belt that grow in places accessible by animals (Table 2).

IUCN criteria applied. Criterion D, Number of mature individuals: the single known population consists of 180-200 mature individuals; the population is subject to a real threat (Table 2).

IUCN categories. On the basis of criterion D, due to the low number of mature individuals (< 250), *H. synphytifolium* can be classified as *Endangered* (EN): D (Table 2).

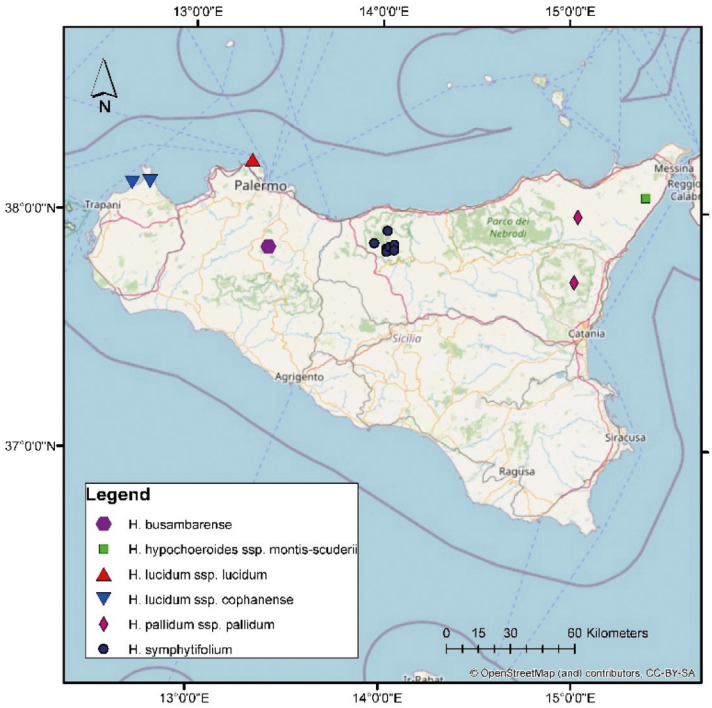

Figure 1. Distribution map of *Hieracium busambarense*, *H. hypochoeroides* subsp. *montis-scuderii*, *H. lucidum* subsp. *lucidum*, *H. lucidum* subsp. *cophanense*, *H. pallidum* subsp. *pallidum* and *H. symphytifolium*.

Figure 2. *Hieracium lucidum* subsp. *lucidum* eaten by *Erctella mazzullii*.

Discussion

This work provides the first comprehensive conservation status assessment of the 11 endemic *Hieracium* s. str. taxa occurring in Sicily. The application of the current IUCN Red List categories and criteria (IUCN, 2012a, 2012b, 2019) reveals that six are Critically Endangered (*Hieracium lucidum* subsp. *lucidum, H. lucidum* subsp. *cophanense, H. murorum* subsp. *atrovirens; H. pallidum* subsp. *aetnense, H. schmidtii* subsp. *madoniense, H. schmidtii* subsp. *nebrodense*), two are Endangered (*H. pallidum* subsp. *pallidum, H. symphytifolium*), one Vulnerable (*H. racemosum* subsp. *pignattianum*) and two Least Concern (*H. busambarense* and *H. hypochoeroides* subsp. *montis-scuderii*) (Table 2). Our study, therefore, fills a knowledge gap, as it represents the first thorough assessment of the conservation status of the Sicilian *Hieracium* taxa and provides an important step towards the recognition and conservation of this remarkable component of the Sicilian flora.

From the methodological point of view, for punctual endemic species, the EOO, measured by a minimum convex polygon could have a value less than AOO, measured using the 2×2 km grids. In these cases EOO should be changed to make it equal to AOO to ensure consistency with the definition of AOO as an area within EOO (IUCN, 2019).

The assessment of punctual endemic taxa must consider real threats to which populations are subjected. In fact, even if a taxon is represented by a small number of mature individuals but there is no reduction in the quality or in the surface of the habitat or in the number of individuals, and there are no concrete threats, nothing suggests that the population cannot live, with this small number of individuals, for many generations to come. Thus, according to IUCN (2019) guidelines it has to be listed as LC. This is the basis of the assessment of *H. busambarense* and *H. hypochoeroides* subsp. *montis-scuderii.* In contrast, the occurrence of real threats such as overgrazing due to wild animals present in large numbers in the Madonie mountains led to taxa being listed at higher threat categories.

The most relevant conservation approach for these taxa seems to be the conservation of the habitats they occupy. All taxa investigated fall within protected areas (Regional parks or Nature reserves), but this does not exclude the presence of significant threats; for example, fire is a constant presence in the coastal belt of Sicily and in the Madonie, in the mountain belt and wild animals are constantly increasing.

The knowledge of taxa, currently small in size and isolated from each other, allows for very detailed data on the biology, distribution and consistency of populations. This allows for the planning of differentiated conservation strategies. As suggested by Rich et al. (2008a), the maintenance of *ex-situ* collections

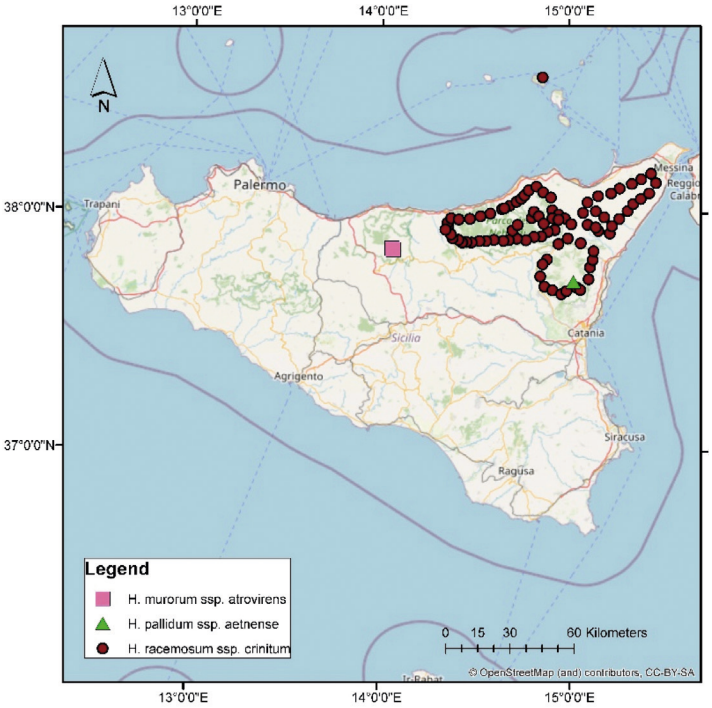

Figure 3. Distribution map of *Hieracium murorum* subsp. *atrovirens* and *H. pallidum* subsp. *aetnense*.

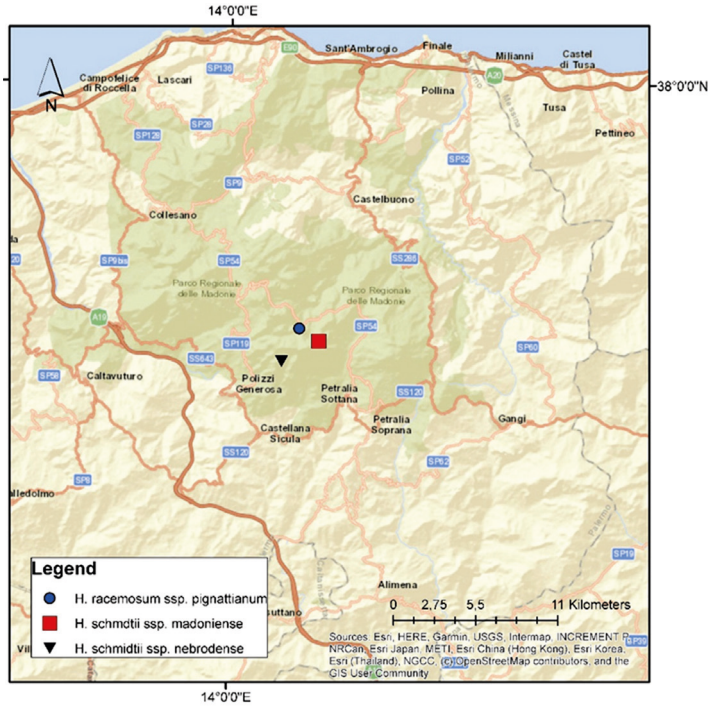

Figure 4. Distribution map of *Hieracium racemosum* subsp. *pignattianum*, *H. schmidtii* subsp. *madoniense* and *H. schmidtii* subsp. *nebrodense*.

Table 2. Extent of Occurrence (EOO), Area of Occupancy (AOO), number of locations (No. loc.), number of mature individuals (No. ind.), demographic trend: s = stable, d = declining, major threats and proposed IUCN Category of the endemic Sicilian *Hieracium* taxa.

Taxa	EOO (km²)	AOO (km²)	No. loc.	No. ind.	Trend	Threats	Proposed IUCN Category
Hieracium busambarense	4	4	1	60-80	stable	10.3 avalanches/landslides	LC: D
Hieracium hypochoeroides subsp. *montis-scuderi*i	4	4	1	30-35	stable	10.3 avalanches/landslides	LC: D
Hieracium lucidum subsp. *lucidum*	12	12	1	80-100	declining	7.1 fire & fire suppression 8.2 problematic native species/diseases 10.3 avalanches/landslides	CR: B1ab(iii,v)
Hieracium lucidum subsp. *cophanense*	8	8	1	70-90	declining	7.1 fire & fire suppression 10.3 avalanches/landslides	CR: C2a(i)
Hieracium murorum subsp. *atrovirens*	4	4	1	35-40	stable	2.3.1 nomadic grazing 2.3.2 small-holder grazing, ranching or farming 8.1.2 *Dama dama*, *Sus scrofa*	CR: D
Hieracium pallidum subsp. *pallidum*	16,179	8	2	180-200	stable	2.3.2 small-holder grazing, ranching or farming 10.1 volcanoes	EN: D
Hieracium pallidum subsp. *aetnense*	4	4	1	20-25	declining	10.1 volcanoes	CR: B1ab(v) + 2ab(v) CR: C2a(i) CR: D
Hieracium racemosum subsp. *pignattianum*	12,499	20	1	800-900	stable	2.3.1 nomadic grazing 2.3.2 small-holder grazing, ranching or farming 8.1.2 *Dama dama*, *Sus scrofa*	VU: D1+ D2
Hieracium schmidtii subsp. *madonien*se	4	4	1	35-40	stable	2.3.1 nomadic grazing 2.3.2 small-holder grazing, ranching or farming	CR: D
Hieracium schmidtii subsp. *nebrodense*	4	4	1	30-35	stable	2.3.1 nomadic grazing 8.1.2 *Dama dama*, *Sus scrofa*	CR: D
Hieracium symphytifolium	31,964	28	1	180-200	stable	2.3.1 nomadic grazing 8.1.2 *Dama dama*, *Sus scrofa*	EN: D

in Botanic Gardens and Seed Banks supports the conservation of apomictic taxa with small population sizes. Therefore, the plant material used for *ex situ* conservation should match the variability found *in situ*. The general rule for apomictic taxa has been to collect a few seeds under the assumption that they are clonal. However, facultative apomixis can generate new variation through residual sexuality (Mráz & Zdvořák, 2019). Therefore, the *ex situ* protocols should, therefore, take this into account by sampling from a much wider range of plants and populations to encompass the genetic variation (Rich et al., 2008a).

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