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Out of the shadows: rediscovery of the EU-protected beetle *Stephanopachys linearis* (Kugelann, 1792) in Italy and conservation implications (Coleoptera: Bostrichidae)

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SUMMARY

We report recent field records of the saproxylic beetle *Stephanopachys linearis* in Italy, observed in spring 2026 in the Western Alps. The species was found on fire-scorched living *Pinus sylvestris* (Scots pine) and *Larix decidua* (European larch) trees damaged by a wildfire nine years before the survey. Prior to this discovery, the species was known from Italy only through three museum specimens collected in the Eastern Alps nearly 90 years ago. Based on historical material alone and never confirmed by recent field observations, these records were insufficient to include *S. linearis* among the Italian species formally requiring protection under the EU Habitats Directive. The present rediscovery fills this gap and effectively adds *S. linearis* to the list of species for which member states are required to designate Special Areas of Conservation (SACs), ensure regular monitoring, and establish conservation measures where necessary. Notably, the species was found in co-occurrence with *S. substriatus* on some of the surveyed trees, a likewise protected congener and only recently reconfirmed in Italy. The new locality lies approximately 50 km from the nearest confirmed French occurrence in the Queyras massif (Hautes-Alpes). We discuss the biogeographical significance and conservation implications of the find and outline priorities for future research.

INTRODUCTION

The ongoing erosion of global biodiversity at an unprecedented rate represents one of the most pressing challenges for conservation science and policy (Barnosky et al. 2011, Ceballos et al. 2015). Insects are among the most severely affected groups, with widespread declines documented across taxonomic orders and geographic regions (Sánchez-Bayo and Wyckhuys 2019, Cardoso et al. 2020,

Wagner et al. 2021). However, effective conservation planning is frequently hampered by a critical lack of knowledge on species geographic distributions (Hortal et al. 2015). This knowledge gap is particularly acute for rare and elusive species, whose inherent biological traits often lead to chronic data deficiency (Cardoso et al. 2011, Bland et al. 2015, Bennett et al. 2024). Consequently, even when such species are formally included in well-established international protection frameworks, they may fail to benefit from meaningful conservation action due to a lack of basic distributional information.

Within Europe, Council Directive 92/43/EEC, the "Habitats Directive" (HD), establishes the primary legal framework for biodiversity conservation, obliging Member States to monitor and maintain a favourable conservation status for habitats and species of Community interest, including over a hundred arthropods (European Economic Community 1992). Among these, *Stephanopachys linearis* (Kugelann, 1792) and *Stephanopachys substriatus* (Paykull, 1800) are two elusive saproxylic beetles both listed in Annex II of the Habitats Directive. Their inclusion in Annex II requires Member States in which the species occur to consider them in the designation and management of Special Areas of Conservation (SACs), to monitor their conservation status, and to adopt conservation measures where necessary. This mismatch between formal protection and limited field knowledge is particularly evident in species that depend on rare, ephemeral microhabitats and require highly targeted survey methods.

S. linearis is distributed across the boreal and subalpine belt of the Palaearctic. Its range extends from Scandinavia and the Baltic region, across Siberia to the Russian Far East, with relict occurrences in the mountain ranges of central and southern Europe, as well as in the Caucasus (Borowski 2007, Borowski et al. 2018). Before the present study, according to the most recent IUCN Red List assessment, the species was considered extant in the European Alps only in south-eastern France (Dodelin et al. 2025), with records spanning from the 1950s (Leseigneur 1951, Simon 1952) to the present (Rousset 2009, Brustel et al. 2013, 2019, Braud et al. 2017, SILENE-Nature[1]). Its historical presence in Switzerland, previously assumed, is in fact undocumented and is now regarded only as potential (Chittaro and Sanchez 2019). In Austria, the species was historically recorded from a few Alpine localities (Franz 1974) but has not been subsequently reconfirmed and is now currently treated as extinct at the national level (Ellmauer et al. 2020). However, this status may partly reflect the elusiveness of the species combined with the need for intensive recent surveys. In Slovenia, similarly, the species is known only from records predating the mid-20th century and has not been recorded again since then (Vrezec et al. 2011). In Italy, the few confirmed records also date back almost a century (Nardi and Audisio 2016).

Like all *Stephanopachys* species, it is strictly associated with gymnosperms (Liu et al. 2008, Lawrence 2010). *S. linearis* feeds and develops specifically in the inner bark and cambium of damaged living or recently dead conifers (Brustel et al. 2013, Borowski et al. 2018). Its European host tree species include *Pinus sylvestris* L. (Scots pine), *Picea abies* (L.) H.Karst. (Norway spruce), *Abies alba* Mill. (European silver fir), *Larix decidua* Mill. (European larch), and likely *Pinus nigra* J.F.Arnold subsp. *laricio* Poir. (Corsican pine) in Corsica, where historical records are known (Brustel et al. 2013). In forest ecosystems, wildfires function as crucial ecological drivers by generating unique, temporary microhabitats characterized by reduced host defenses and lowered competition (Bell 2023). This post-disturbance environment provides a critical pulse of resources for specialized saproxylic and pyrophilous insects, whose regional populations depend on fire-created niches and surrounding landscape composition (Bell 2023, Ramberg et al. 2025). Within this context, *S. linearis* is regarded as an obligate pyrophile in its northern range, primarily colonising living Scots pines scorched by wildfires (Wikars 2006, Ranius et al. 2014, Borowski et al. 2018); in the Alps, fire-damaged trees appear to represent the main breeding substrate, although lightning-struck and mechanically-damaged trees can also serve as hosts (Brustel et al. 2013, 2019). According to Wikars (2006), suitable tree-related microhabitats remain available for 3–5 years after fire, occasionally up to a maximum of 15 years. This strict dependence on rare and ephemeral post-disturbance microhabitats makes the species inherently difficult to detect, explaining, at least in

[1] silene.eu, last accessed 18/02/2025

part, the historical scarcity of records across much of its southern distribution.

In Italy, early records from South Tyrol (northeastern Italy) cited in older literature were re-examined and shown by Nardi & Audisio (2016) to be erroneous. The same authors provided the first and hitherto only verified Italian record, based on three historical museum specimens collected in 1937 from the same locality "Tolmezzo", in Friuli-Venezia Giulia (northeastern Italy). While this finding established the historical presence of the species in the country, the lack of more recent data prevented *S. linearis* from being formally incorporated into the Italian national protected species list under the Habitats Directive — which was adopted more than five decades after the collection of these specimens. Consequently, the species remained excluded from the official Italian Habitats Directive Article 17 reporting (e.g. Ercole et al. 2021). Across the rest of its European range, according to the most recent reporting cycle available for the Habitats Directive (2019-2024), the species was assessed as Unfavourable-Inadequate (U1) in Finland, Favourable (FV) in Sweden, and Unknown in France. No assessment was carried out for Austria, where the species is listed as extinct in the national species checklist. According to IUCN criteria, the species was assessed as Endangered (EN) on the European Red List of Saproxylic Beetles (Cálix et al. 2018); however, the most recent assessment considers it Least Concern (LC) at the European level (Dodelin et al. 2025). In Italy, the species was assessed as Endangered (EN) on the Italian Red List of Saproxylic Beetles (Audisio et al. 2014) and subsequently suggested as Data Deficient (DD) by Nardi & Audisio (2016).

With this note, we report new field records confirming the current presence of *S. linearis* in Italy and highlight their implications for national conservation planning and Habitats Directive implementation.

MATERIALS AND METHODS

The study area is located in Western Alps, on the southern slope of Monte Rocciamelone, in the Susa Valley (Piedmont, northwestern Italy). The slope encompasses a broad elevational gradient, from approximately 500 m a.s.l. in the valley floor to the summit (3,538 m a.s.l.) and supports a full sequence of vegetation zones. The surveyed area falls within the subalpine conifer belt, dominated by Scots pine and European larch (Sindaco et al. 2008). In late October 2017, a major wildfire burned over 2,500 hectares of woodland across the middle and lower Susa Valley, severely affecting the study area (De Petris et al. 2020, Morresi et al. 2022, Mantero et al. 2023). The fire left standing living trees with varying degrees of bark scorching, representing the post-disturbance substrate targeted in the present study.

Field surveys were initially designed to validate a species distribution model for *S. substriatus* in the Alps developed in a companion study (L. Anselmo, E. Caprio, L. Valladares et al. unpublished). Surveys were conducted in March 2026, between roughly 1650 and 1800 m a.s.l., by inspecting around ten fire-damaged coniferous trees within the same stand. During these surveys, adults of *S. linearis* were encountered on fire-scorched trees. Subsequent targeted searches were extended to the adjacent Natura 2000 site 'Rocciamelone' (IT1110039) to assess the presence of the species within a Habitats Directive-designated protected area, where a further ten fire-damaged trees were inspected. The survey method consisted of visual inspection of the bark surface and subcortical layer of fire-damaged coniferous trees showing signs consistent with *Stephanopachys* activity, including characteristic exit holes, galleries, and frass (Ehnström and Axelsson 2002, Brustel et al. 2013, Ranius et al. 2014, Borowski et al. 2018). Trees were selected opportunistically based on visible fire damage and external signs of possible colonisation. Individuals were photographed in the field and identified following Brustel et al. (2013). A small number of voucher specimens (n = 3) were collected and deposited in the Museo Regionale di Scienze Naturali di Torino. Locality data are reported at the 10×10 km ETRS89 grid cell level, in accordance with the Article 17 Habitats Directive reporting protocol (DG Environment 2017).

RESULTS

In March 2026, at least ten adult individuals of *S. linearis* were observed under the bark of three Scots pine trees at approximately 1,700 m a.s.l. (Fig. 1A). During subsequent targeted surveys, the species was confirmed also within the adjacent Natura 2000 site "Rocciamelone" (IT1110039), where additional several adults were found on both Scots pine and European larch. Adults of *S. substriatus* were recorded co-occurring on some of the same inspected trees (Fig. 1b; Anselmo et al., in preparation). All

host trees were living and showed bark scorching consistent with fire damage (Fig. 2). Characteristic subcortical galleries, exit holes, and numerous larvae — not identifiable to species level on morphological grounds (Brustel et al. 2013) — were also observed. The occurrence data fall within the 10×10 km Habitats Directive reporting grid cells E408N245 and E409N245 (Fig. 3). Because the surveys were exploratory and targeted to apparently suitable trees, no detection rate is reported. Structured surveys aimed at obtaining ecological data are currently underway, and their results will be reported separately (L. Anselmo, E. Caprio, P. Audisio and S. Bonelli, in preparation).

DISCUSSION

The present record of *S. linearis* constitutes the first recent field observation of the species in Italy, and the first record of any kind from the Italian Western Alps. This finding provides the evidence of the occurrence of this EU-protected species in Italy and has direct implications for its inclusion in national conservation planning, monitoring, and Habitats Directive reporting. As an Annex II species, *S. linearis* should now be considered in the assessment of the adequacy of the Italian Natura 2000 network and, where appropriate, in the designation or management of Special Areas of Conservation. The species was recorded both within and in the immediate vicinity of the Natura 2000 site 'Rocciamelone' (IT1110039), which is therefore particularly relevant for its conservation. Combined with the recent reconfirmation of the congener *S. substriatus* in the same mountain range (Anselmo 2023), this finding makes the Italian Western Alps of exceptional importance for the conservation of EU-protected saproxylic beetles belonging to this genus in Italy.

The exclusion of *S. linearis* from Italian conservation frameworks was not an oversight but reflected the limited and exclusively historical evidence available at the time. The three museum specimens from Friuli-Venezia Giulia reported by Nardi & Audisio (2016), collected more than half a century before the adoption of the Habitats Directive, were never confirmed by subsequent field records. As a result, *S. linearis* was not included in the national monitoring programmes or in the Italian reporting under Article 17. This partly mirrors the case of *S. substriatus* which had initially been included in the checklist of Italian protected species before being considered absent owing to the lack of occurrence records for approximately 25 years (Anselmo 2023). Given the far longer data gap, the solely historical nature of the few available records, and the fact that it was never listed among protected species in Italy, the present rediscovery of *S. linearis* is particularly relevant for Italian biodiversity conservation. Furthermore, this case highlights a practical tension between the operational frameworks applied to national reporting (DG Environment 2017, 2023) and the precautionary principle underpinning EU environmental policy (Art. 191 TFEU[2]). While this principle implies that scientific uncertainty should not prevent protective actions, the reporting protocols necessarily rely on recent empirical evidence to assign active presence codes such as Present regularly (PRE) or Occasional (OCC). Consequently, in the absence of targeted surveys, small and elusive species such as *S. linearis* and *S. substriatus* may be treated as absent or extinct in national assessments based solely on historical records, even though this may reflect survey deficiency rather than genuine absence. With the present finding, *S. linearis* can now be incorporated into the official national Article 17 checklist, enabling its formal inclusion in the upcoming reporting cycles.

Biogeographically, the find is highly coherent. The Western Italian Alps form a continuous mountain system with the French Queyras massif, where the species has been repeatedly recorded, only ca. 50 km west of the new site, on the other side of the same mountain group (Leseigneur 1951, Simon 1952, Brustel et al. 2013, Braud et al. 2017, SILENE-Nature database[3]). The complete absence of records from the Italian Western Alps until now may therefore reflect a lack of targeted surveys rather than an effective range boundary. The elusive nature and small size of *S. linearis* make its detection inherently challenging and strongly method-dependent. Like *S. substriatus*, this species develops within the inner bark and cambium of damaged living or recently dead conifers, leaving external signs — exit holes and

[2] https://eur-lex.europa.eu/eli/treaty/tfeu_2016/art_191/oj/eng, last accessed 07/07/2026

[3] silene.eu, last accessed 18/02/2025

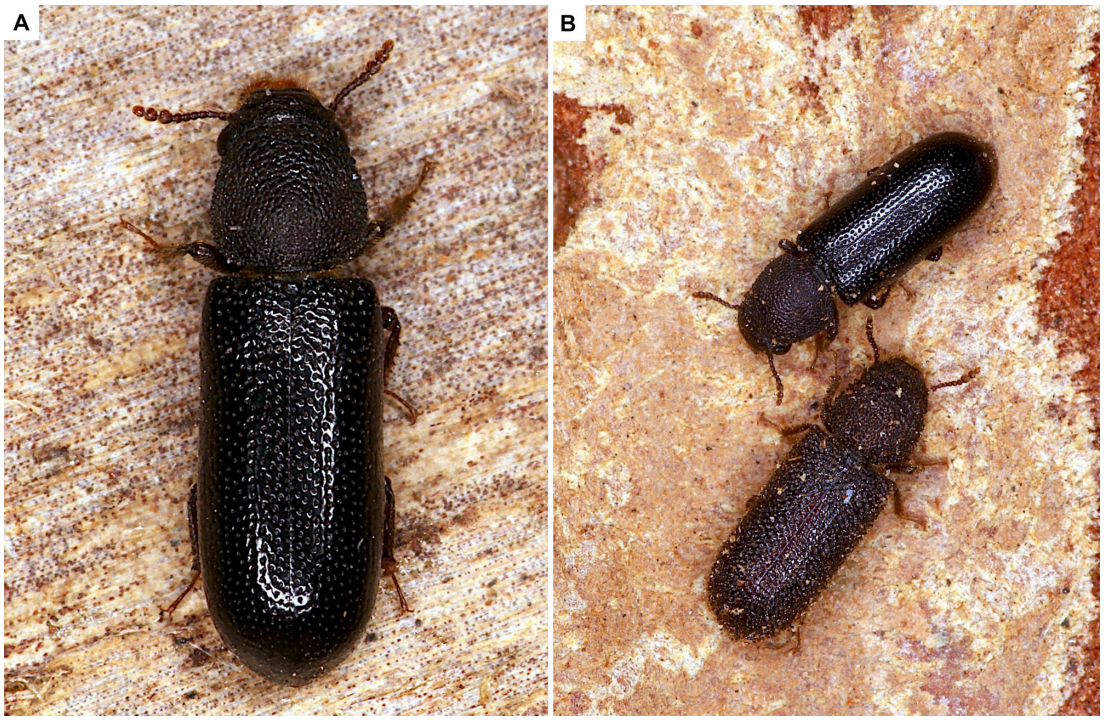

Figure 1. Live individuals of *Stephanopachys linearis* recorded at the study area (Susa Valley, Piedmont, northwestern Italy; ca. 1,700 m a.s.l.). (A) Adult *S. linearis* observed under the bark of a fire-scorched European larch tree. (B) Co-occurrence of *S. linearis* (top) and *S. substriatus* (bottom) within the same microhabitat.

Figure 2. Habitat and tree-related microhabitat of *S. linearis* in the study area. (A) A mixed coniferous stand of European larch and Scots pine affected by wildfire, where several individuals of both *S. linearis* and *S. substriatus* were recorded on fire-scorched but living trees during bark inspection. (B) Bark loss, partly caused by woodpecker foraging, exposing signs of saproxylic insect activity on a fire-scorched European larch; bark inspection of this tree yielded adults of both species. (C) Similar bark loss and insect activity on a fire-scorched Scots pine; inspection of this tree yielded adults of *S. linearis* only.

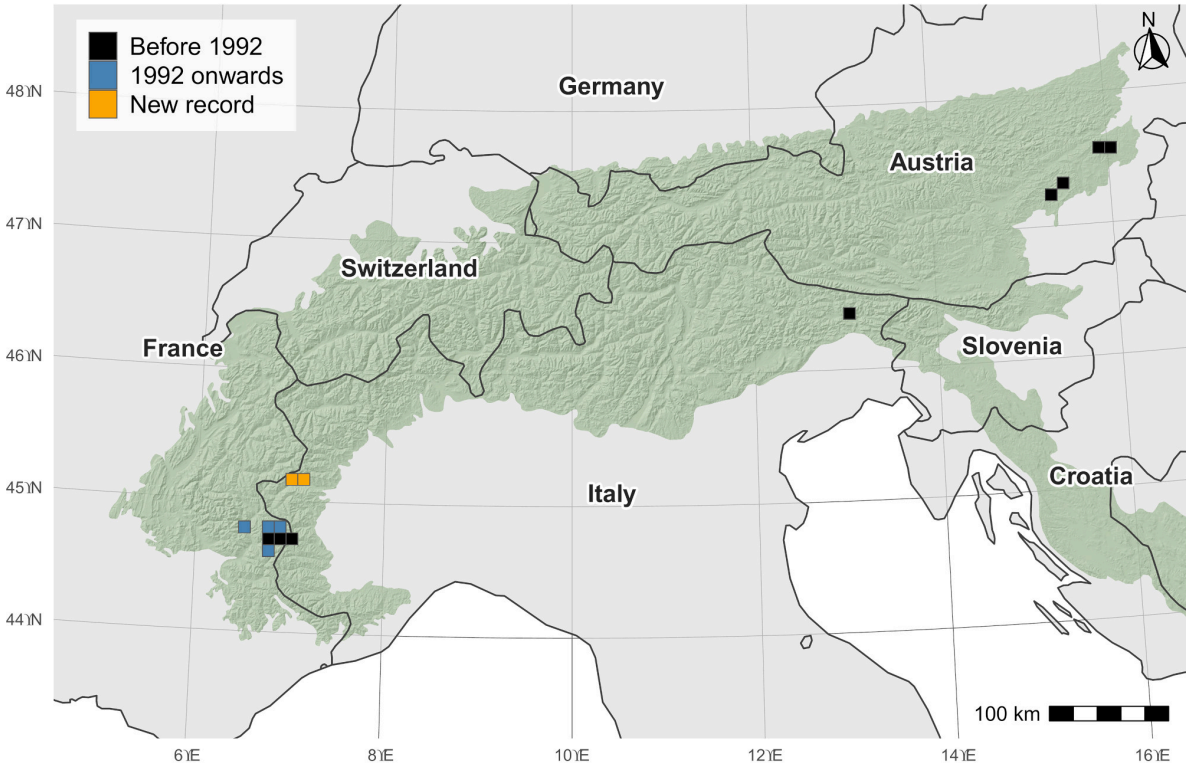

Figure 3. Updated distribution of *S. linearis* in the European Alps. Black grid cells indicate localities with records exclusively predating the adoption of the Habitats Directive (21 May 1992): the historical Italian collected specimens from 1937 (Friuli Venezia-Giulia, north-eastern Italy; Nardi and Audisio 2016), older records from the Queyras Massif (Hautes-Alpes, south-eastern France; Leseigneur 1951, Simon 1952, Brustel et al. 2013), and records four localities from Styria and Lower Austria (eastern Austria; Franz 1974). One black grid cell straddles the France–Italy border; its records originate entirely from the French side. Blue cells include records from the adoption of the HD onwards, all falling within the Hautes-Alpes (southeastern France; Rousset 2009, Brustel et al. 2013, Braud et al. 2017, SILENE-Nature database[4]). Orange cells indicate the new Italian records from the Susa Valley (Piedmont, north-western Italy; this study). Occurrence data are reported at the 10×10 km ETRS89 grid cell level, in accordance with the Article 17 reporting protocol (DG Environment 2017). Green relief shading represents the EU Alpine biogeographical region (EEA 2016).

frass — that are inconspicuous and easily overlooked without careful inspection (Ehnström & Axelsson 2002, Brustel et al. 2013, 2019). Passive interception traps, the standard survey method for many saproxylic beetle communities (Wikars et al. 2005, Alinvi et al. 2007, Bouget et al. 2008), are poorly effective for *Stephanopachys* spp. (Brustel et al. 2013). Direct visual search for adults and their remains on bark surfaces and within feeding galleries currently represents the most effective detection approach, though it demands considerable targeted effort and specialist experience, and is partly destructive when bark removal is required (Brustel et al. 2013, 2019, Borowski et al. 2018). While citizen science platforms have proven valuable to obtain occurrence data for more visually distinctive beetles (Zapponi et al. 2017), this group is generally underrepresented in such databases, with most records deriving from academic research (Díaz-Calafat et al. 2024). The present discovery of the species in Western Italian Alps should therefore be interpreted as the outcome of applying an appropriate, species-specific survey method in a forest where the species was actually present, rather than as evidence of absence until now. A directly comparable case is that of Poland — the country from which the species was originally described by Kugelann in 1792 — it went unrecorded for over 200 years before being rediscovered on a burned Scots pine site in Białowieża Primaeval Forest through targeted surveys (Borowski et al. 2018). That find closely parallels the present one: both were made possible by targeted search effort in suitable habitat, and both resulted in the species being recovered after

[4] silene.eu, last accessed 18/02/2025

a gap that reflected survey deficiency rather than genuine extinction or absence. Dedicated surveys using the same approach should therefore be extended to other potentially suitable subalpine conifer forest across the Alps with a recent fire history.

The specific origin of the newly discovered population raises several questions that cannot be resolved from present data alone — including whether it reflects natural dispersal, passive transport via timber trade, or long-term local persistence. The distance to the nearest known occurrence in the French Queyras massif (~50 km) considerably exceeds the colonisation range of around 10 km tentatively attributed to the species (Bohman et al. 2004, Wikars 2006), raising the question of how the new population became established. However, pyrophilous insects are generally characterised by notable dispersal capacity, driven by the need to rapidly locate rare and ephemeral post-disturbance microhabitats across landscapes (Bell 2023). Furthermore, some bark-associated saproxylic beetles are known to exploit wind-assisted dispersal over several tens of kilometres under favourable conditions (Sauvard 2004, Feldhaar and Schauer 2018). Notably, in the French population, *S. linearis* has been recorded not only on fire-scorched standing trees but also on trees damaged by lightning strike and mechanical injury (Brustel et al. 2013), suggesting that these may provide functionally important alternative microhabitats, facilitating persistence and dispersal even in the absence of fire. Taken together, these considerations suggest that the effective dispersal range of *S. linearis* may exceed current expectations, and that the near-continuous subalpine conifer forest of the Western Alps — with its scattered occurrence of fire-damaged, lightning-struck, and logging-disturbed standing trees — may have served as a connectivity corridor between the French and Italian sides. The study area also has a fire history predating the 2017 event: a wildfire of approximately 45 hectares of woodland occurred in late winter 2000, suggesting that the species may have persisted in the area since that earlier disturbance.

The post-disturbance microhabitats in which *S. linearis* was recorded are entirely consistent with the known ecology of the species. In its northern range, *S. linearis* is regarded as an obligate pyrophile tightly linked to fire-scorched Scots pine (Borowski et al. 2018; Ranius et al. 2014; Wikars 2006), while in the French alpine populations Scots pine and European larch both serve as the primary host trees (Brustel et al. 2013), a pattern mirrored at the study site. The record of subcortical galleries, exit holes, and numerous larvae on the same trees where adults of *S. linearis* were found strongly suggests successful *in situ* reproduction, though larval identification from *S. substriatus* is not possible on morphological grounds (Brustel et al. 2013). However, the combination of molecular diagnostic techniques and more in-depth morphological analyses will certainly make it possible in the future to distinguish between the pre-imaginal stages of the two species.

The nine-year interval between the local wildfire and the present record is at the upper end of the range of microhabitat availability for the species (Wikars 2006). However, the actual timing of colonisation cannot be established from the available data. It is worth noting that occasional and unsystematic visits to the site between 2018 and 2024 failed to detect the species (L. Anselmo, personal observation); given the low detection probability of *S. linearis* and the considerable effort required for systematic surveys, these negative observations carry very limited inferential weight. The advanced post-fire age of the scorched standing trees at the site, however, suggests that the available tree-related microhabitat is likely approaching the end of its window of suitability. This temporal constraint highlights a broader conceptual challenge: while all Annex II species are primarily conserved through the designation of protected areas, those that track disturbance events may require conservation strategies operating at a larger spatial scale than individual Natura 2000 sites—a question that deserves dedicated attention in future research. Specifically, prescribed burning in pine-dominated stands at intervals of 3–6 years (up to 15), within landscape units of several tens of km² and with burned patches in close proximity to facilitate colonisation, has been proposed as a practical conservation strategy for *S. linearis* in boreal forests (Wikars 2006, Metsähallitus 2021). Whether analogous approaches are feasible in Alpine environments, where ecological, logistical, and regulatory conditions differ substantially, remains to be assessed. In this context, the present record raises several research and conservation priorities. The first priority is to establish the distribution and habitat requirements of *S. linearis* at the study site. This will inform the most urgent local conservation measures, support an update of the national extinction risk assessment according to IUCN criteria, and

contribute to the future Article 17 Habitats Directive reporting cycle. It will also help evaluate how well the population is covered by the Natura 2000 network. The second priority is to compare the ecological niche of *S. linearis* with that of the co-occurring congener *S. substriatus*, an opportunity offered by their documented co-occurrence at the study site; such comparison could provide a valuable basis for species-specific conservation planning. Both of these priorities are already being addressed within an ongoing study (L. Anselmo, E. Caprio, P. Audisio and S. Bonelli, in preparation). A further priority concerns long-term conservation planning, namely defining management measures adequate to achieve and maintain a favourable conservation status for *S. linearis* in Italy, including the feasibility of landscape-scale approaches such as those proposed for boreal populations. This will require further research and stakeholder engagement. Future surveys should therefore be extended to other coniferous forests affected by fire across the Italian Alps.

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AUTHOR CONTRIBUTIONS

LA conceived and carried out the study, conducted the fieldwork, and wrote the first draft of the manuscript. PA, SB and EC contributed to and revised the manuscript. SB and EC supervised the project. All authors have read and approved the final version of the manuscript before submission.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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