

Spatial niche partitioning of two saproxylic sibling species (Coleoptera, Cetoniidae, genus *Gnorimus*)

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Abstract. 1. Knowledge on ecological requirements of species is a focal point for their conservation, especially if they live in threatened habitat types such as old-growth forests.

2. We predict that habitat requirements shape the spatial niche partition of two sibling species of saproxylic beetles *Gnorimus nobilis* and *Gnorimus variabilis*.

3. To test our hypothesis, we conducted a comparative study on the presence and abundance of these chafer beetles in northern Apennines using air-trapping, exploring the effects of altitude and habitat type.

4. We performed our analyses in a study area of 268 800 ha, where we detected nine patches of putatively suitable habitat (13 347 ha), setting a total of 82 air-traps.

5. We collected an unexpected high number of specimens of both species, and found that *G. nobilis* and *G. variabilis* are rarely syntopic, having different ecological preferences influenced primarily by altitude, but also by forest type.

Key words. Autoecology, chafer beetles, habitat selection, old-growth forests, spatial niche.

Introduction

Knowledge of species-specific data on factors affecting abundance and distribution of insects, as well as the ecological requirements influencing habitat selection – often determined by a complex trade-off between several biotic and abiotic factors – are vital to ensure appropriate species and habitat management (Thomas *et al.*, 1998, 2001; New, 2009; Krämer *et al.*, 2012).

In Europe, as reported by several recent studies (Kaila *et al.*, 1997; Simila *et al.*, 2003; Arnan *et al.*, 2011), old-growth forests are one of the most threatened habitat types. This particular type of habitat is a source of biodiversity, providing different micro-habitat niches not found in other forest types, playing a key role for the presence of the associated fauna, primary the saproxylic species

(Esseen *et al.*, 1997; Audisio *et al.*, 2009; Arnan *et al.*, 2011; Blazyte-Cereskiene & Karalius, 2012).

Recent studies stated that the progressive decline of many saproxylic species could be related to loss and fragmentation of suitable old-growth forest habitats (McNeely, 2002; Horák *et al.*, 2010, 2012). Therefore, studies on autoecology, and in particular habitat selection, of saproxylic insects become more and more important.

Up to now, few studies about habitat selection of saproxylic insects have been conducted in Europe (Ranius & Jansson, 2000; Johansson, 2006; Tikkanen *et al.*, 2007; Vrezec *et al.*, 2007; Alexander, 2008; Pegola-Carte, 2010; Horák *et al.*, 2010, 2012; Harvey *et al.*, 2011), and just a small percentage of them has been realised in Italy (Mazzei *et al.*, 2011; Chiari *et al.*, 2013).

In this context, we carried out an ecological study focused on two sibling species of saproxylic Cetoniidae beetles: the noble chafer *Gnorimus nobilis* (Linnaeus, 1758) and the variable chafer *Gnorimus variabilis* (Linnaeus, 1758). They both spend the larval stage of their life cycle in decaying hollow trees in old-growth woods, whereas adults usually feed on nectar of flowers as catkins,

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meadowsweets, hogweeds and several species of Apiaceae (Dutto, 2005; Schenke, 2012; P. Audisio, pers. comm., 2013). The two studied species are both widespread in Europe, including Great Britain. *G. variabilis* is included in the European Red List of saproxylic beetles as Vulnerable in EU27 and Near Threatened in Europe.

The third European species of the genus, *G. decempunctatus* Helfer, 1834, is endemic to Sicily and was not considered in our study. In Italy, the two chafer species have been poorly studied and just few distributional data are available. Moreover, none of them is included in the most relevant Italian faunistic database (CKmap: Ruffo & Stoch, 2005).

Our study was focused on: (i) collecting data about distribution, abundance and detectability of chafer beetles within the study area, also in the light of the used sampling method (airtraps), and (ii) on investigating ecological factors associated to spatial niche partitioning between the two species. Spatial niche partitioning was explored in several studies on insects (Wassmer, 1995; Herz and Heitland, 2005; Friberg *et al.*, 2008a,b; Gilbert *et al.*, 2008), and in some cases has been considered as a key evolutionary phenomenon responsible for adaptive speciation (Friberg *et al.*, 2008a).

In this context, we predict that habitat requirements – specifically elevation and forest typology – shape the distribution of the two saproxylic beetles. To test our hypothesis, we conducted a comparative study on the distribution and abundance of these chafer beetles in a study area in northern Apennines using air-trapping, exploring the effects of altitude and habitat (forest) type.

Material and methods

Study area

Following the guidelines of Habitat Directive 1992/43/EEC, Sites of Community Importance (SCI) have been instituted in all the UE Countries with the aim of increasing conservation and management of endangered and threatened habitats, as old-growth forests, and species. Therefore, we performed our study in a 268 800 ha area (Modena province), where we detected nine patches of putatively suitable habitat (13 347 ha), corresponding to nine SCI (patch = SCI; Fig. 1).

Within each patch, putatively suitable habitat was estimated using a land cover map (Corine Land Cover anno 2000 – IV Livello), and consequently removing from each patch all the areas including definitely not suitable habitats (e.g. water bodies, grasslands, coniferous forests).

Collecting data

A total of 82 interception air-traps (Appendix 1) were used to collect *G. nobilis* and *G. variabilis* within the study area. A mixture of red wine and bananas was used as bait. This is usually the standard collecting method for

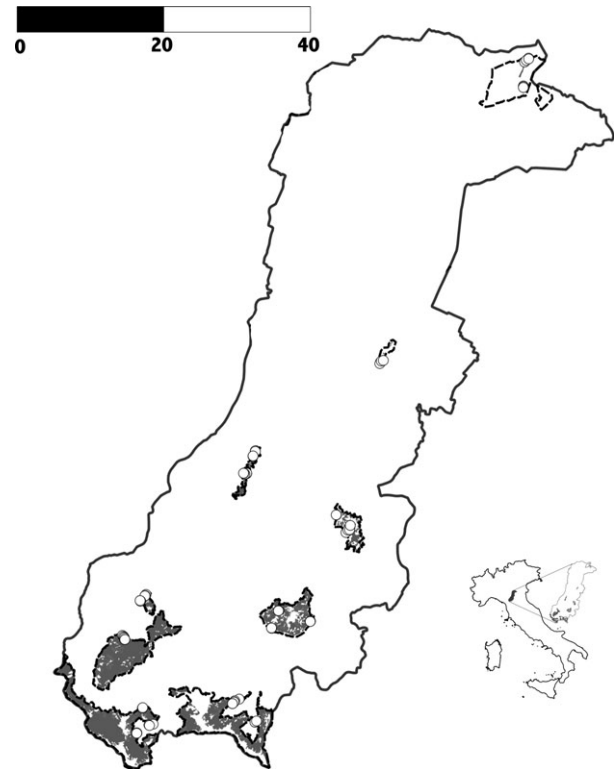


Fig. 1. Study area: Modena province. Sites of Community Importance (=patches): black dashed line; putatively suitable habitat: grey polygons; air-traps: white points. Scale bar in kilometres.

many Cetoniidae (Dutto, 2005) and it is not species specific; we therefore presumed that detectability did not differ between the two studied chafer species.

Captures were carried out between June and July 2012, for 20 days. Traps were placed in different habitat typologies [oak forests (35 traps), chestnut forests (16 traps), willow forests (17 traps) and mixed deciduous woods (14 traps)], at a broad altitude range (10–1250 m a.s.l.). The minimum distance among the traps within the same patch was 50 m. Presence (P) of the two species was computed as number of captured animals per trap.

Statistical analyses

All the statistical analyses were carried out in the R environment (R Core Team, 2012). Differences in presence were investigated using a generalised linear mixed model (GLMM) with patch added as a repeated measure to account for pseudo-replication. We used a GLMM with Poisson error distribution to assess the effect of habitat, species and altitude on capture success, starting with a model with all terms interactions, then terms were sequentially removed from the full model by step-wise deletion of the least significant terms. GLMM analysis was performed using R package lme4 (Bates *et al.*, 2011).

Results

Specimens of *Gnorimus* were captured in 31 of the 82 air-traps (Appendix 1); we collected a total of 88 individuals: 65 *G. variabilis* and 23 *G. nobilis*. The male/female sex ratio was 30/35 for *G. variabilis* and 5/18 for *G. nobilis*. In only one trap, the two species were collected together (trap no. 50, oak forest, 660 m a.s.l.).

Other cetonid species collected with the two *Gnorimus* were as follows: *Cetonia aurata* (Linnaeus, 1761), *Protaetia cuprea* (Fabricius, 1775), *P. aeruginosa* (Linnaeus, 1767), *P. opaca* (Fabricius, 1787) and *Oxythyrea funesta* (Poda, 1761). We sampled also several species of longhorn beetles: *Cerambyx scopolii* Fuessly, 1775, *Certallum ebulinum* (Linnaeus, 1767), *Leptura aurulenta* (Fabricius, 1792), *Xylotrechus antilope* (Schonner, 1817), *Rhagium mordax* (De Geer, 1775), *Axinopalpis gracilis* (Krynicky, 1832), *Purpuricenus kaehleri* (Linnaeus, 1758), *Rutpela maculata* (Poda, 1761) and *Stictoleptura cordigera* (Fuessly, 1775).

Furthermore, a relatively high number of Hymenoptera Vespoidae (with a prevalence of *Vespa crabro* Linnaeus, 1758) and different moth species have been found within the airtraps.

Gnorimus variabilis was captured in 20 traps: 3 in chestnut, 2 in willow, 11 in oak and 4 in mixed deciduous forests. *G. nobilis* was captured in 12 traps: 4 in chestnut forests, 2 in oak forests and 6 in mixed woods. No specimens of *G. nobilis* were collected in willows. *G. variabilis* was collected from 180 to 840 m a.s.l., *G. nobilis* from 660 to 1250 m a.s.l. *G. variabilis* was captured with a maximum of 22 specimens/trap, *G. nobilis* with a maximum of 8 specimens/trap.

Captures were affected by habitat category ($F_{3,148} = 2.72$, $P = 0.05$). The interaction of the factors species $\times$ altitude ($F_{1,148} = 3.83$, $P = 0.05$) was significant (Tables 1 and 2).

Discussion

Abundance versus detectability

The first relevant result of our study was the relatively high number of captured specimens for both species. Such abundance could support the hypothesis that the lack of knowledge for these species is likely due to low detectability

Table 1. Generalised linear mixed model testing the effect of habitat, species and altitude on capture success. Capture success as dependent variable and trap as repeated measures.

Model parameters	Statistics
Species	$F_{1,157} = 2.40$, $P = 0.12$
Habitat	$F_{3,157} = 2.72$, $P = 0.05$
Elevation	$F_{1,157} = 0.46$, $P = 0.50$
Species $\times$ Elevation	$F_{1,157} = 3.83$, $P = 0.05$

Table 2. Model estimates.

	Estimates	SE	Z value
Intercept	-7.084741	1.741959	-4.067
<i>Gnorimus variabilis</i>	8.536168	1.622658	5.261
Chestnut	-2.252038	0.899351	-2.504
Oak	-1.611746	0.308211	-5.229
Willow	-3.902683	0.788765	-4.948
Elevation	0.007890	0.001946	4.054
<i>Gnorimus variabilis</i> : elevation	-0.010272	0.002047	-5.018

that depends on type of monitoring used to detect these insects, rather than to their effective rarity. In fact, direct-count collecting methods, that are commonly used for these chafer, take less field effort, but are likely less efficient than air-trapping. A similar pattern has been recently argued for another saproxylic species, the endangered hermit beetle *Osmoderma eremita* (Scopoli, 1763): direct-count methods (Audisio *et al.*, 2009; Chiari *et al.*, 2013) in Central Apennines resulted markedly less successful than collecting methods based on pitfall traps or black cross-window air-traps activated with a specific pheromone (Chiari *et al.*, 2013).

However, our capture rates for *G. nobilis* and *G. variabilis*, although higher than expected, were consistently lower compared to data for closely related species of saproxylic beetles in northern Europe (including *O. eremita*), within study areas of similar size and with comparable collecting efforts (Ranius, 2000, 2001, 2007; Larsson & Svensson, 2009, 2011). Such different trends of saproxylic abundances between northern and southern Europe may be only partially due to different climatic conditions as a consequence of different latitudes. In fact, differences in abundance could be better explained focusing on the structure of deciduous old forests and on the conservation status of hollow trees: in northern Europe old deciduous woods are generally better preserved than in the South, and hollow trees are usually more abundant and aggregated in stands, so that the status of several saproxylic beetles species seems to be markedly less threatened than in southern European regions (Chiari *et al.*, 2013).

Finally, our captures suggest that there could be a sex-bias: excluding trap no. 24, where 16 males of *G. variabilis* were collected together, we found that approximately 72% of captured *G. variabilis* and 78% of *G. nobilis* were females. Our study was primarily designed to get some findings about species niche partitioning and habitat selection, and not about sex ratio. However, we believe that this could be a useful starting point for further analyses. In fact, similar female-biased results were obtained for *O. eremita* by Chiari *et al.* (2013) and they argued that these differences could reflect an uneven predation risk by sex, possibly related to sexually specific behavioural differences, with males occurring more frequently on the ground level to search for females and being more active on the wood mould surface into the cavities (Chiari, 2011; Chiari *et al.*, 2013). Anyway, we believe that such

explanation is not applicable to chafer beetles, because adult of these species usually spend less time within the cavities, and are commonly found feeding on flowers.

Alternatively, the reported female-biased pattern for *G. variabilis* and *G. nobilis* could be explained by post-reproductive behaviour: after mating, males disperse searching for food on flowers, thus leaving the reproductive sites; on the opposite, females usually remain near hollow trees for oviposition.

Habitat selection and spatial niche partitioning

Gnorimus variabilis was captured in more sites than *G. nobilis* (20 traps vs. 12 traps) and with a larger number of specimens (65 *G. variabilis* vs. 23 *G. nobilis*). Furthermore, excluding a single record (trap no. 50, in an oak tree, 660 m a.s.l.), the two species were never collected syntopically, showing a clearly non-overlapping distributional pattern.

At least two different explanations could justify the observed patterns of capture rates and distributional ranges of the studied taxa: (i) *G. variabilis* is more common and widespread than *G. nobilis*, (ii) differences in distribution and detectability are chiefly shaped by ecological factors.

Our data seem to be partially compatible to the latter scenario: some of the considered ecological interactions were significant (species-elevation, species-habitat-elevation). We found that, although elevation is definitely the primary factor shaping the distribution of the two *Gnorimus* species (Fig. 2), the interactions between this ecological covariate and wood type must be considered when

designing a distributional model for these saproxylic species. Our data showed that the species *G. variabilis* is generally associated to low and middle altitudes (from ca. 10 to ca. 800 m a.s.l.), whereas *G. nobilis* prefers higher altitudes (ca. 700–1250 m a.s.l.); hence, the two chafer species have a restricted range of altitude where they overlap, between ca. 700 and 800 m a.s.l. The importance of altitude as a factor shaping species distribution has been previously documented by several studies, both specifically on insects and on animals in general, pinpointing how features related to altitude affect the proportion of suitable habitat (Valladares *et al.*, 1990; Marszałek, 2002; Giordano *et al.*, 2007; De Liberato *et al.*, 2010).

The correlation between altitude and the considered wood types resulted not statistically significant ($P = 0.90$), suggesting that the importance of altitude in affecting chafers distribution is not directly related to different vegetational assemblages that can be found at different altitudes. Mixed deciduous forests were the habitat type preferred by species of the genus *Gnorimus* (we collected at least one chafer beetle specimen in 10 of the 14 airtraps sited within mixed deciduous woods). In our study (Fig. 3), *G. nobilis* seemed more strictly associated to this heterogeneous habitat type (found in only 2 of the 16 traps in chestnut forests and in 3 of the 35 traps in oak forests, never in willows), whereas *G. variabilis*, despite showing a slight preference for heterogeneous plant associations, is found with a good consistency within the other woods types, especially in oak forests where it was captured in 11 of the 35 traps.

Preference of *G. nobilis* for mixed deciduous forests could be due to adult feeding strategies: they feed from

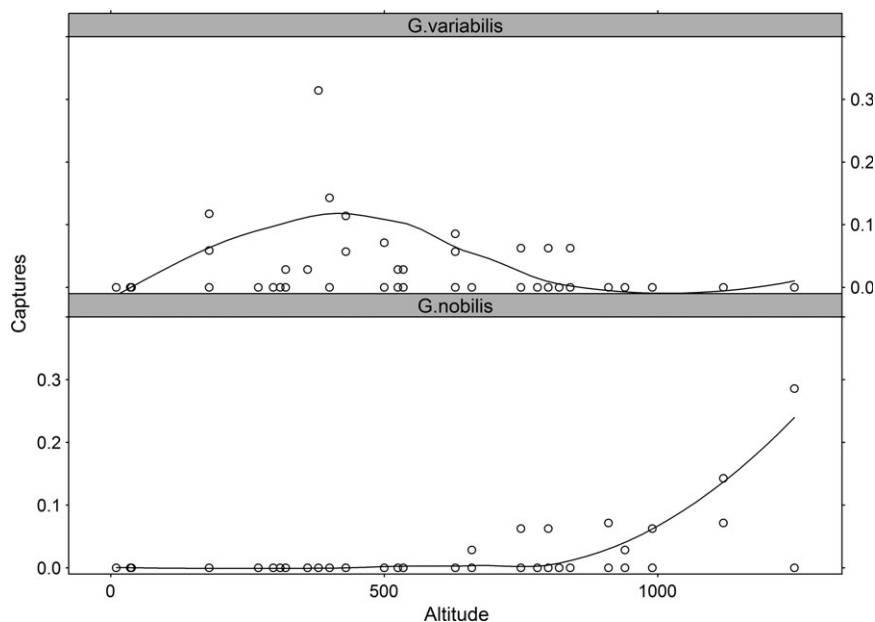


Fig. 2. Different patterns of distribution for the two species along altitude.

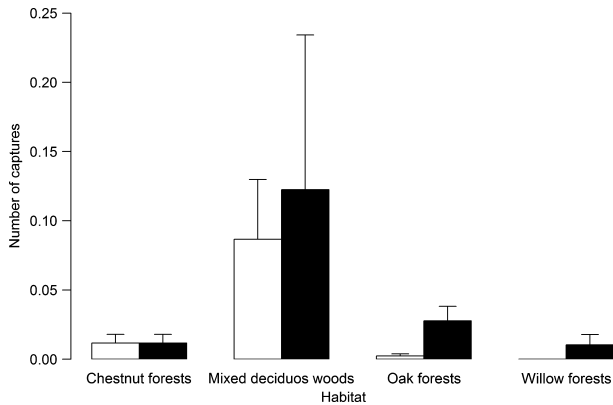


Fig. 3. Different rates of captures (with standard error) for the two species, in different forest typologies. Black = *Gnorimus variabilis*; White = *Gnorimus nobilis*.

nectars upon pale/white flowers such as hogweed and meadowsweet, within riparian humid environments (Schenke, 2012; P. Audisio, unpubl. data). In contrast, *G. variabilis* adult specimens usually feed on catkin flowering plants, which are frequently found both in humid environments but even in dry ones, such as sunny oak, willow and chestnut forests. In a study on *G. nobilis* in the United Kingdom, Schenke (2012) highlighted that conversely to that usually reported for saproxylic invertebrates, where dry climates and sun exposure of the host wood substrate are known to positively influence saproxylic species presence, providing a warmer larval pabulum (Ranius & Nilsson, 1997; Lindhe & Lindelöw, 2004; Lindhe *et al.*, 2005; Buse *et al.*, 2007; Djupström *et al.*, 2008; Dubois *et al.*, 2009), *G. nobilis* in England was found to prefer more riparian habitats. Furthermore, even larval ecology could influence the host choice. As evidenced by Schenke (2012), preferences for certain host plant species may be explained by differences in microhabitat dynamics, like amount of wood mould, aspects of rot-holes growth speed, wood quality and wood management (Ranius & Nilsson, 1997; Ranius, 2002; Lachat *et al.*, 2006; Dubois *et al.*, 2009).

We conclude that the observed differences in altitudinal range and ecological specialisation between the two species suggest differences in habitat suitability within our study area, indicating spatial-niche partitioning between the two species. This does not mean necessarily that *G. variabilis* is more common than *G. nobilis* (proposed scenario no. 1), but, more likely, the patches of suitable habitat for *G. variabilis* in the study area are more extended and widespread than the patches of suitable habitat for *G. nobilis* (scenario no. 2). To definitely exclude the first proposed scenario (*G. variabilis* more common than *G. nobilis*) further researches on population size and dynamics by capture-mark-recapture are required.

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Author contributions

MT: project design, field work, data analysis, paper writing. FB: data analysis, paper writing. CM: field work, project design. DP: data analysis, project design, manuscript revision. LW: project coordinator, manuscript revision. AM: project coordinator, manuscript revision.

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Appendix

Table A1. Captures database

Patch	ID_ Trap	Altitude a.s.l.	Habitat type	Presence	Species
IT4040001	1	750	Chestnut	1	N
IT4040001	2	750	Chestnut	0	N
IT4040001	3	750	Chestnut	0	N
IT4040001	4	780	Chestnut	0	N
IT4040001	5	780	Chestnut	0	N
IT4040001	6	780	Chestnut	0	N
IT4040001	7	800	Chestnut	0	N
IT4040001	8	800	Chestnut	0	N
IT4040001	9	800	Chestnut	1	N
IT4040002	10	990	Chestnut	0	N
IT4040002	11	990	Chestnut	0	N

Table A1. (Continued)

Patch	ID_ Trap	Altitude a.s.l.	Habitat type	Presence	Species
IT4040002	12	990	Chestnut	1	N
IT4040002	13	1250	Mixed forest	0	N
IT4040002	14	1250	Mixed forest	8	N
IT4040002	15	1250	Mixed forest	4	N
IT4040002	16	1120	Mixed forest	1	N
IT4040002	17	1120	Mixed forest	1	N
IT4040002	18	1120	Mixed forest	2	N
IT4040003	19	180	Willow	0	N
IT4040003	20	180	Willow	0	N
IT4040003	21	180	Willow	0	N
IT4040003	22	430	Oak	0	N
IT4040003	23	430	Mixed forest	0	N
IT4040003	24	430	Oak	0	N
IT4040003	25	380	Oak	0	N
IT4040003	26	360	Oak	0	N
IT4040003	27	310	Oak	0	N
IT4040004	28	297	Willow	0	N
IT4040004	29	297	Willow	0	N
IT4040004	30	297	Willow	0	N
IT4040004	31	400	Oak	0	N
IT4040004	32	400	Oak	0	N
IT4040004	33	840	Chestnut	0	N
IT4040004	34	840	Chestnut	0	N
IT4040004	35	840	Chestnut	0	N
IT4040004	36	840	Chestnut	0	N
IT4040005	37	820	Oak	0	N
IT4040005	38	820	Oak	0	N
IT4040005	39	820	Oak	0	N
IT4040005	40	910	Mixed forest	0	N
IT4040005	41	910	Mixed forest	1	N
IT4040005	42	910	Mixed forest	0	N
IT4040005	43	940	Oak	1	N
IT4040005	44	940	Oak	0	N
IT4040005	45	940	Oak	0	N
IT4040006	46	630	Oak	0	N
IT4040006	47	630	Oak	0	N
IT4040006	48	630	Oak	0	N
IT4040006	49	630	Oak	0	N
IT4040006	50	660	Oak	1	N
IT4040006	51	660	Oak	1	N
IT4040006	52	660	Oak	0	N
IT4040011	53	36	Willow	0	N
IT4040011	54	36	Willow	0	N
IT4040011	55	36	Willow	0	N
IT4040011	56	38	Willow	0	N
IT4040011	57	38	Willow	0	N
IT4040011	58	38	Willow	0	N
IT4040013	59	500	Mixed forest	0	N
IT4040013	60	500	Mixed forest	0	N
IT4040013	61	500	Mixed forest	0	N
IT4040013	62	525	Oak	0	N
IT4040013	63	525	Oak	0	N
IT4040013	64	525	Oak	0	N
IT4040013	65	535	Oak	0	N
IT4040013	66	535	Oak	0	N
IT4040013	67	535	Oak	0	N
IT4040013	68	270	Oak	0	N

Table A1. (Continued)

Patch	ID_ Trap	Altitude a.s.l.	Habitat type	Presence	Species
IT4040013	69	270	Oak	0	N
IT4040013	70	270	Oak	0	N
IT4040013	71	320	Oak	0	N
IT4040013	72	320	Oak	0	N
IT4040013	73	320	Oak	0	N
IT4040014	74	10	Oak	0	N
IT4040014	75	10	Oak	0	N
IT4040014	76	10	Oak	0	N
IT4040014	77	10	Willow	0	N
IT4040014	78	10	Willow	0	N
IT4040014	79	10	Mixed forest	0	N
IT4040014	80	10	Willow	0	N
IT4040014	81	10	Willow	0	N
IT4040014	82	10	Willow	0	N
IT4040001	1	750	Chestnut	0	V
IT4040001	2	750	Chestnut	0	V
IT4040001	3	750	Chestnut	1	V
IT4040001	4	780	Chestnut	0	V
IT4040001	5	780	Chestnut	0	V
IT4040001	6	780	Chestnut	0	V
IT4040001	7	800	Chestnut	1	V
IT4040001	8	800	Chestnut	0	V
IT4040001	9	800	Chestnut	0	V
IT4040002	10	990	Chestnut	0	V
IT4040002	11	990	Chestnut	0	V
IT4040002	12	990	Chestnut	0	V
IT4040002	13	1250	Mixed forest	0	V
IT4040002	14	1250	Mixed forest	0	V
IT4040002	15	1250	Mixed forest	0	V
IT4040002	16	1120	Mixed forest	0	V
IT4040002	17	1120	Mixed forest	0	V
IT4040002	18	1120	Mixed forest	0	V
IT4040003	19	180	Willow	2	V
IT4040003	20	180	Willow	0	V
IT4040003	21	180	Willow	1	V
IT4040003	22	430	Oak	2	V
IT4040003	23	430	Mixed forest	22	V
IT4040003	24	430	Oak	4	V
IT4040003	25	380	Oak	11	V
IT4040003	26	360	Oak	1	V
IT4040003	27	310	Oak	0	V
IT4040004	28	297	Willow	0	V
IT4040004	29	297	Willow	0	V
IT4040004	30	297	Willow	0	V
IT4040004	31	400	Oak	0	V
IT4040004	32	400	Oak	5	V
IT4040004	33	840	Chestnut	0	V
IT4040004	34	840	Chestnut	1	V
IT4040004	35	840	Chestnut	0	V
IT4040004	36	840	Chestnut	0	V
IT4040005	37	820	Oak	0	V
IT4040005	38	820	Oak	0	V
IT4040005	39	820	Oak	0	V
IT4040005	40	910	Mixed forest	0	V
IT4040005	41	910	Mixed forest	0	V

Table A1. (Continued)

Patch	ID_ Trap	Altitude a.s.l.	Habitat type	Presence	Species
IT4040005	42	910	Mixed forest	0	V
IT4040005	43	940	Oak	0	V
IT4040005	44	940	Oak	0	V
IT4040005	45	940	Oak	0	V
IT4040006	46	630	Oak	3	V
IT4040006	47	630	Oak	0	V
IT4040006	48	630	Oak	3	V
IT4040006	49	630	Oak	2	V
IT4040006	50	660	Oak	0	V
IT4040006	51	660	Oak	0	V
IT4040006	52	660	Oak	0	V
IT4040011	53	36	Willow	0	V
IT4040011	54	36	Willow	0	V
IT4040011	55	36	Willow	0	V
IT4040011	56	38	Willow	0	V
IT4040011	57	38	Willow	0	V
IT4040011	58	38	Willow	0	V
IT4040013	59	500	Mixed forest	1	V
IT4040013	60	500	Mixed forest	1	V
IT4040013	61	500	Mixed forest	0	V
IT4040013	62	525	Oak	1	V
IT4040013	63	525	Oak	0	V
IT4040013	64	525	Oak	0	V
IT4040013	65	535	Oak	0	V
IT4040013	66	535	Oak	1	V
IT4040013	67	535	Oak	0	V
IT4040013	68	270	Oak	0	V
IT4040013	69	270	Oak	0	V
IT4040013	70	270	Oak	0	V
IT4040013	71	320	Oak	1	V
IT4040013	72	320	Oak	0	V
IT4040013	73	320	Oak	0	V
IT4040014	74	10	Oak	0	V
IT4040014	75	10	Oak	0	V
IT4040014	76	10	Oak	0	V
IT4040014	77	10	Willow	0	V
IT4040014	78	10	Willow	0	V
IT4040014	79	10	Mixed forest	0	V
IT4040014	80	10	Willow	0	V
IT4040014	81	10	Willow	0	V
IT4040014	82	10	Willow	0	V

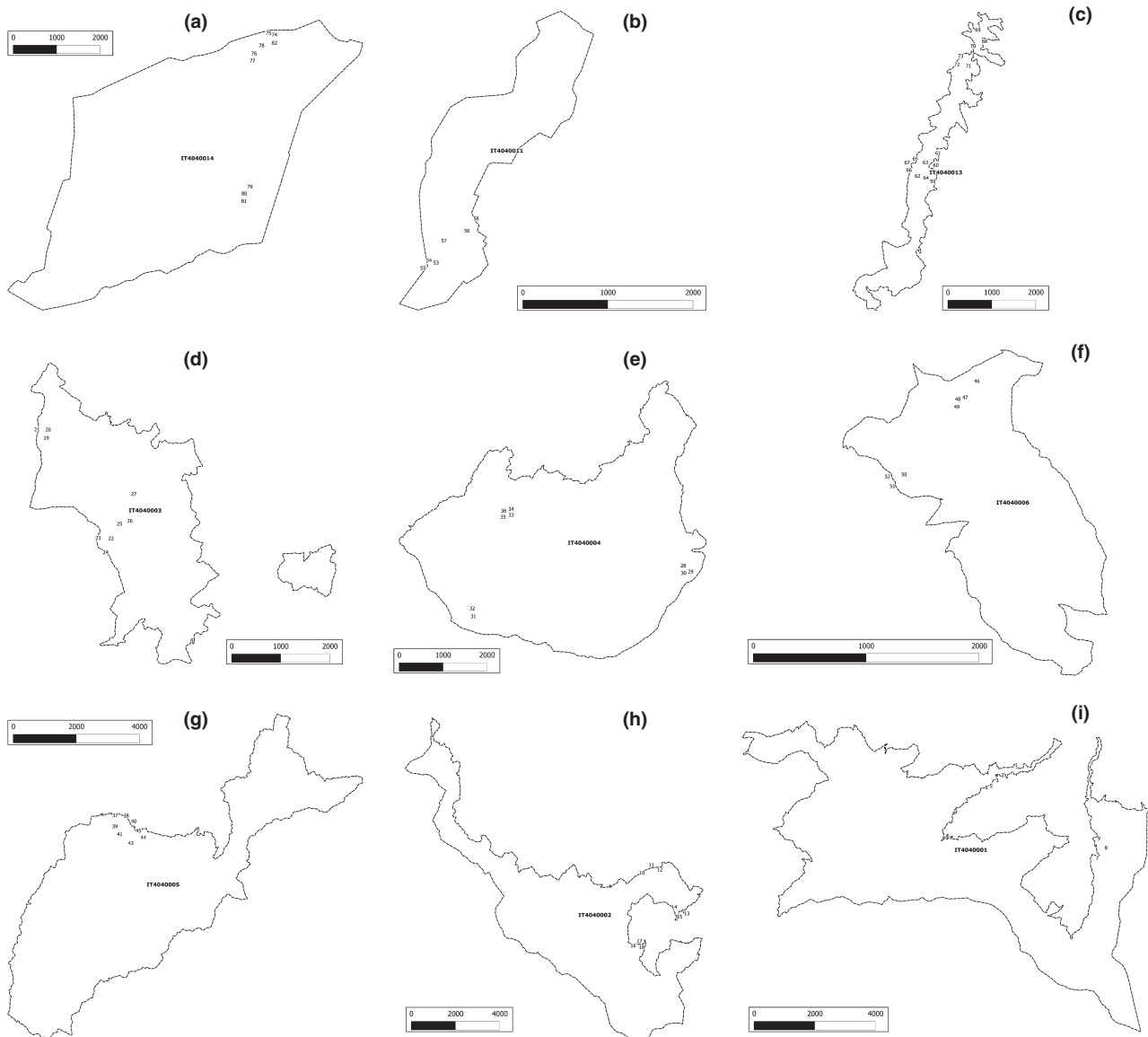


Fig. A2 (a-i). Traps positioning within each one of the nine patches (from North to South of the study area, see also Fig. 1). The ID-numbers of the database reported in Appendix 1.