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Short Note

Presence of the hazel dormouse *Muscardinus avellanarius* at the limit of its altitudinal range

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Abstract

The hazel dormouse *Muscardinus avellanarius* is commonly considered a typical lowland species, though occasional observations have also been reported at higher altitudes in mountains. In this work, we checked the presence of this species at its altitudinal limits in the Alps. Summer nests were searched along two valley floors at progressively higher altitudes. Fifteen nests were found, 10 in Valsavarenche and 5 in Val di Rhêmes, from 1600 m up to the upper tree line at 2032 m, which represents the current altitudinal record for the species. All the nests were composed by layers of different plant matter. This structure may promote insulation and protection from wind and low temperatures, and is typical of reproductive females. Nests were also found in sites surrounded by few woody species, which hardly cover the food requirements of the dormice throughout their season of activity, suggesting the use of alternative resources such as insects or other invertebrates. The presence of hazel dormice at these altitudes indicates that this species can adapt to less diverse habitats and extreme climatic conditions.

The hazel dormouse *Muscardinus avellanarius* is generally considered as a typical lowland species, from Mediterranean habitats to low mountainous areas (Juškaitis and Büchner, 2013). Nonetheless, occasional sightings were also reported at high altitudes in Macedonia (1980 m, Kryštufek and Petkowski, 1990), in the Western Italian Alps (1950 m, Cantini et al., 1988), in the Austrian Alps (1920 m, Spitzenberger and Bauer, 2001) and in the Tatra Mountains (1750 m, Ważna et al., 2012). The most suitable habitats for this species are composed by a high diversity of tree and shrub species, which may ensure a continuity of food supplies throughout the year (Bright and Morris, 1996; Juškaitis, 2014). The hazel dormouse is considered to be a threatened species in Europe, especially because of forest management, fragmentation and reduction (Bright and Morris, 1996; Mortelliti et al., 2011; Bertolino et al., 2014); therefore, this species is listed within the Habitat Directive of the European Union and within the Bern Convention (Bertolino et al., 2015).

To date, the presence of the hazel dormouse in the Alps has been reported only through occasional observations (Patriarca and Debernardi, 1997; Spitzenberger and Bauer, 2001). Thus, it is still unclear whether its presence in altitude is exceptional, and if the species occupies the Alpine valleys with a spatial continuum or in single spots. Gorodkov (1986) proposed that a reliable definition of the distribution range of species, especially when rare or not continuously distributed, would also require altitude as a third dimension. Therefore, we investigated the presence of the hazel dormouse at the altitudinal limits of its range, to evaluate its distribution in the subalpine altitudinal zone characterized by the presence of mixed conifer forests.

The study was carried out in two valleys of the Gran Paradiso National Park (Western Italian Alps): Valsavarenche and Val di Rhêmes. Within the park, the hazel dormouse had sporadically been reported between 1120 and 1950 m a.s.l. (Cantini et al., 1988; Patriarca and Debernardi, 1997). The vegetation is similar throughout the two valleys, with deciduous woodlands dominant at low altitudes and conifer forests till the upper tree line.

We searched for summer nests of the hazel dormouse in the subalpine level, which is characterized by the presence of mixed conifer forests and shrublands, from about 1600 m up to the limit of the tree line at about 2100 m. During four days between October and December 2015, when dormice already left their summer nests and entered hibernation, we looked for nests at 13 sites, six in Valsavarenche and seven in Val di Rhêmes. At each site, woodland edges and shrub areas were systematically searched for hazel dormouse summer nests. Sites were located along the valley floors at progressively higher altitudes.

At every site with nests, the vegetation was described in an area of about a 50 m radius around the nest, identifying shrub and tree species. In the laboratory, nests were opened, and the plant parts were separated, according to their structure (see Tab. 1). Afterwards, all components were dried and weighed to evaluate their relative abundance.

Nests were detected in all investigated sites except one in Valsavarenche and two in Val di Rhêmes (Fig. 1). In Valsavarenche, ten nests were found at 1600, 1689, 1864, 1874, and 1923 m a.s.l. (Tab. 2). At 1600 m, two groups of four and two nests, respectively, were clustered closely in two shrubby areas. The nest at 1923 m was near (74 m) the site where an animal was trapped the previous September (SB and EM unpublished data). In Val di Rhêmes, nests were detected at 1681 and 1790 m a.s.l. and in a large shrubby area at altitudes of 1930, 1962, and 2032 m a.s.l. (Fig. 2). The height where nests were located varied from 0.3 m to 1.5 m (Tab. 2). The diversity of tree and shrub species at the nest sites (Fig. 3) ranged from five woody plant species in the surrounding area up to 14 shrub species and some scattered trees (Tab. 2). The periods of flowering and fructification of tree and shrub species found around the nests are reported in Fig. 4.

All the nests may be classified as "layered" according to Wachtendorf (1951). Nests generally showed an external layer composed of small twigs and/or large fibres, which covered a further layer of leaves and then an innermost layer of thin materials (e.g. grass, moss, Tab. 1).

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Table 1 – Materials used by the hazel dormice to build their nests and relative percentages in weight.

Nest ID	Altitude	Dry weight (%)			
		Leaves	Twigs/cones	Large fibres	Thin fibres/ grass/moss
A1	1600	65.7	0.0	4.0	30.3
A2	1600	78.6	0.0	0.0	21.4
A3	1600	62.5	0.0	0.0	37.5
A4	1600	85.7	0.0	0.0	14.3
A5	1600	44.4	0.0	25.0	30.6
A6	1600	9.1	0.0	0.0	90.9
B	1689	75.0	6.3	0.0	18.8
C	1864	78.6	0.0	0.0	21.4
D	1874	85.1	0.0	0.0	14.9
E	1923	29.0	0.0	39.0	32.0
F	1681	78.5	0.0	0.0	21.5
G	1790	25.0	0.0	43.8	31.3
H1	1930	75.0	0.0	0.0	25.0
H2	1962	19.8	20.2	0.0	60.0
H3	2032	63.6	0.0	0.0	36.4

Notably, in one case, the nest was additionally densely covered by the soft silky fluff of the hairy plume of *Epilobium angustifolium* seeds, acting as a sort of separate roof cover (Fig. 3). The same silky fluff was found inside four other nests and, in traces, outside another one.

During our survey, we detected for the first time a continuous presence of the hazel dormouse in subalpine mixed conifer forests and shrublands, from 1600 m up to the tree line at over 2000 m; the nest located at 2032 m is the current altitudinal record for this species. Spitzenberger and Bauer (2001) stated that the frequency of hazel dormouse recordings in the mountainous regions of Austria rapidly decreased with increasing altitude, resulting in only a few sightings in the subalpine area. Our data clearly suggest that there are, at least in some Alpine valleys, suitable habitats for hazel dormice even up to the limit of scattered trees. The detection of nests along the two valley floors in nearly all monitored sites showed that the presence of the species is not occasional. Spitzenberger and Bauer (2001) did not furtherly describe the area where they found the hazel dormice, however showing a photograph of the habitat; this was characterized by scattered larches, shrubs and scree, thus being very similar to the places where we recorded the occurrence of this species.

Although some authors have shown divergent results (e.g., completely vegetarian dormice in Central Russia: Likhachev, 1971; low importance of acorns in the diet in UK: Bright and Morris, 1993; high prevalence of seeds in Northern Russia: Airapetyans, 1983; significant presence of insects in the diet in late summer in Southern England: Richards et al., 1984), the diet of the hazel dormouse follows a similar pattern in most of the species range, with flowers being a predominant food source in spring, insects and bird eggs in early summer, berries in late summer and autumn and seeds in autumn (Juškaitis, 2014). Usually, generative parts of plants (flower-buds, catkins, flowers, berries, and seeds) are preferred to vegetative parts (leaf-buds, leaves, and shoots) (Juškaitis, 2014).

According to Bright and Morris (1996) and several other authors (see Juškaitis and Büchner, 2013, for a review), an optimal hazel dormouse habitat is determined by a high diversity of tree and shrub species, which could provide animals with food resources during the active season (Fig. 4). In fact, most of the shrub species found around the nests bloom between May and July and fruit from July/August until at least late autumn (Pignatti, 1982), covering most of the activity period of the hazel dormouse. By contrast, in some cases only few woody species were observed in nesting sites. In such a situation, the availability of plant matter (e.g. flowers, berries and seeds) hardly covers all months of dormouse activity. Other resources, such as insects or other invertebrates, should therefore be used by dormice to supplement their diet.

Wachtendorf (1951) described layered nests composed by two distinct layers, the inner one with fine material (e.g. grass, thin fibres, fluff) and the outer layer usually made of tree or shrub leaves. Layered nests are generally built by females during the reproductive period (Juškaitis, 2014). In our study, we identified even three layers, to indicate that most of the nests were of reproductive females. Layered nests do not provide a better insulation per se, in comparison to foliage nests without a second inner layer, but ensure stability, softness and durability (Sury, 1985).

The distribution of the hazel dormouse in the Western Italian Alps overlaps with that of the fat dormouse *Glis glis* in deciduous forests and with that of the garden dormouse *Eliomys quercinus* at the highest altitudes, mainly in coniferous forests (Patriarca and Debernardi, 1997; Bertolino et al., 2001; Negro et al., 2013). These species are characterized by different ecological requirements, e.g. different diet and three-

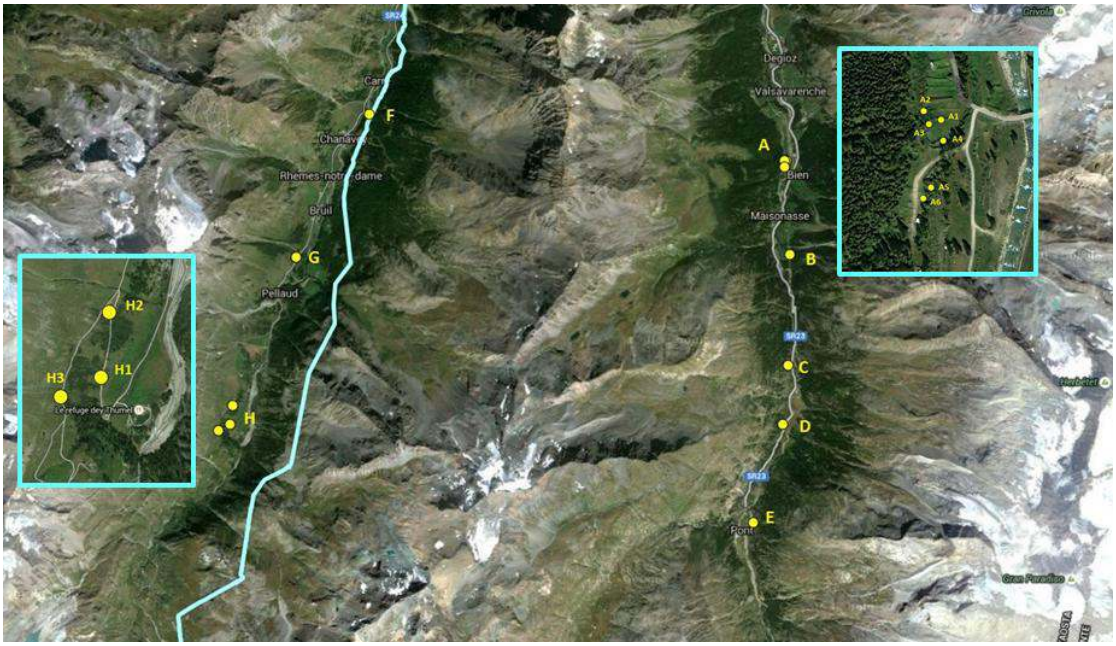

Figure 1 – Location of hazel dormouse nests in Valsavarenche (right) and Val di Rhêmes (left). The continuous line in Val di Rhêmes is the border of the Gran Paradiso National Park.

Figure 2 – Location of three hazel dormouse nests found in Val di Rhêmes at 1930 (H1), 1962 (H2), and 2032 m a.s.l. (H3); the area at the limit of the tree line was covered by at least 17 shrub species (see Tab. 2) and scattered larches.

Figure 3 – Nests found in Valsavarenche at 1600 m (up) and in Val di Rhêmes at 1962 m (middle, with *Epilobium angustifolium* silky fluff) and 2032 m (down).

dimensional space use, and could coexist in the same areas, though the level of syntopy and niche partitioning is yet to be investigated.

In our study, the hazel dormouse was mainly searched and detected in shrubby areas, but previous reports suggested that the species may also be present inside coniferous forests (Patriarca and Debernardi, 1997). These areas represent the altitudinal limit of the species distribution and are characterized by short summers and demanding climatic conditions. Therefore, studying the adaptation strategies of the hazel dormouse to such extreme conditions could help in understanding the ecological plasticity of the species, a necessary knowledge for its conservation. Considering the presence of nests in most of the monitored sites, the fact that nearly all of them were of reproductive females, and that the hazel dormouse has been periodically captured or observed in owl nest-boxes (E. Patriarca, pers. com.), we could suppose that the species is present in these valleys with reproductive populations and not only occasionally; this however, should be better investigated.

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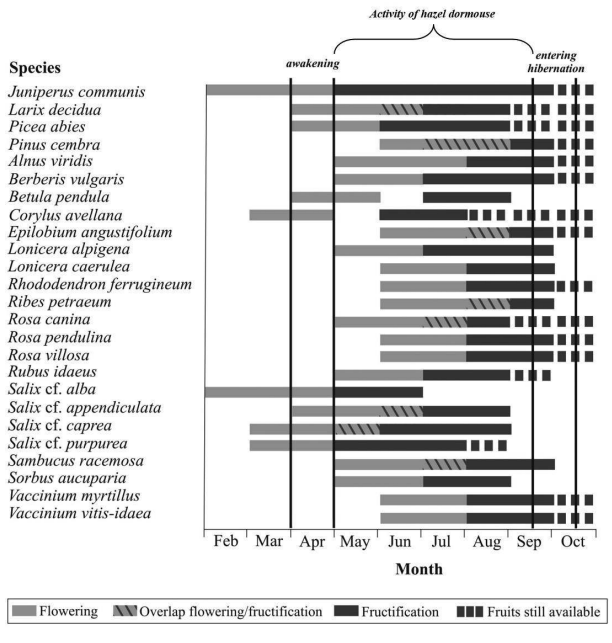

Figure 4 – Period of flowering and fructification of the tree and shrub species found around nests; periods are from Pignatti, 1982.

Table 2 – Tree and shrub species present in the sites where nests were found; nests A1-A4 and A5-A6 were found in the same shrublands therefore the lists of the plant species are referred to the two groups of nests. *Epilobium* was added because of its obvious presence as nest material.

	VALSAVARENCHE										VAL DI RHÊMES				
ID	A_1	A_2	A_3	A_4	A_5	A_6	B	C	D	E	F	G	H_1	H_2	H_3
Altitude (m)	1600	1600	1600	1600	1600	1600	1689	1864	1874	1923	1681	1790	1930	1962	2032
Nest built on	*Berberis vulgaris*	*Rosa villosa*	*Berberis vulgaris*	*Rosa pendulina*	*Salix alba*	*Berberis vulgaris*	*Salix alba*	*Alnus viridis*	*Salix alba*	Gras	*Alnus viridis*	*Lonicera caerulea*	*Alnus viridis*	*Alnus viridis*	*Alnus viridis*
Nest height above ground (m)	1.5	1.0	1.5	1.5	1.5	1.5	1.5	0.7	0.5	0.3	0.30	1	0.5	0.7	1.5
Number of plant species*			10			12	7	8	7	8	7	11	15	5	6
Larix decidua			x			x	x	x		x	x	x	x		
Picea abies			x			x	x			x	x	x			
Pinus cembra											x				
Betula pendula			x									x	x		
Alnus viridis						x									
Corylus avellana							x	x	x		x		x	x	x
Sorbus aucuparia									x				x		
Juniperus communis						x	x	x	x	x		x	x		
Vaccinium myrtillus													x	x	
Vaccinium vitis-idaea							x			x					
Berberis vulgaris			x			x		x	x			x	x		
Rubus idaeus			x			x				x		x	x		
Sambucus racemosa			x			x						x	x		x
Lonicera alpigena										x					
Lonicera caerulea						x					x	x			
Ribes petraeum												x	x		x
Rosa villosa			x			x							x		
Rosa canina						x					x				
Rosa pendulina			x				x	x	x			x	x		
Salix caprea			x										x		x
Salix appendiculata														x	x
Salix alba			x			x	x	x	x				x		
Salix purpurea						x		x						x	x
Epilobium angustifolium								x	x	x		x	x	x	
Rhododendron ferrugineum										x	x				