Detection of habitats colonized by *Omphiscola glabra* (Gastropoda: Lymnaeidae) on acid soils using indicator plants

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Abstract – The lymnaeid *Omphiscola glabra* is known to be an intermediate host in the life cycle of *Fasciola hepatica* and knowing its distribution in the field is important to determine that of the parasite. Looking at indicator plants has been proposed by several authors as one of the most practical ways of carrying out a malacological survey in pastures of a farm. Field investigations on 361 French farms breeding cattle or sheep on acid soils were thus carried out for 36 years in March or April to list indicator plant species in seven types of habitats colonized by *O. glabra*, and determine the characteristics of their habitats (area, snail density) for each indicator plant. Six plant species: *Agrostis stolonifera*, *Dactylis glomerata*, *Glyceria fluitans*, *Juncus acutiflorus*, *Juncus effusus* and *Lotus uliginosus*, were examined in 3137 snail habitats. *J. effusus* was the best indicator species to detect snail populations in five habitat types, while *J. acutiflorus* was the best indicator for snail populations living in spring heads. The other four plant species characterized only a few populations. Snail habitats detected with *J. acutiflorus*, *J. effusus* or *L. uliginosus* were significantly larger in area, while the density of overwintering snails was significantly lower in habitats with *G. fluitans*. These initial results suggest that *J. effusus* is a good indicator for the detection of *O. glabra* in the acid soils of central France. However, additional studies are required to test its limitations in the field.

Key words: Acid soil / habitat / indicator plant / Lymnaeidae / *Omphiscola glabra*

Introduction

The lymnaeid snails *Galba truncatula* (O.F. Müller) and *Omphiscola glabra* (O.F. Müller) act as intermediate hosts in the transmission of fasciolosis. The first species is known to be the main host snail of *Fasciola hepatica* (Linnaeus) in Western European countries (Torgerson and Claxton, 1999; Mas-Coma *et al.*, 2009). In contrast, *O. glabra* is only an occasional intermediate host whose role has been mainly demonstrated on the acid soils of central France (Abrous *et al.*, 1999, 2000). To control this parasitosis, it is necessary to treat livestock to eliminate adult flukes and also to control the host snail in its habitats. The search for *G. truncatula* and *O. glabra* populations in the field is always difficult because of the numerous temporary or permanent water bodies that these snails can colonize on acid soils. Looking at indicator plants was proposed by Over (1962, 1967) as one of the most practical ways to do a malacological survey in pastures of a farm with an animal fasciolosis problem. This idea was based on observations that De Brie (1379)

had made in French pastures. According to this author, there was a real danger for sheep to graze in a field with many buttercups of the species *Ranunculus flammula* (Linnaeus). The subsequent authors have provided contradictory results on the role of buttercups as indicator plants. Charlier *et al.* (2014) found a positive correlation between the presence of *Ranunculus* sp. and the abundance of *G. truncatula* on four Belgian farms. In contrast, Taylor (1965), in his review on fasciolosis, stated that the presence of these buttercups in a meadow did not mean that there was a real habitat for the snail. In central France, Guy *et al.* (1996) also found no relationship between the presence of these plants and the abundance of the snail in its habitats on acid soils.

In the swampy meadows and road ditches on the cristallophyllian soils of Limousin (central France), the populations of *G. truncatula* and *O. glabra* were often present in the same open drainage furrows: the peripheral extremity of these furrows was colonized by *G. truncatula*, while the middle part was occupied by the other lymnaeid (Vareille-Morel *et al.*, 1999, 2007; Rondelaud *et al.*, 2009). Given this situation, it was logical to assume that the indicator plants used for the detection of *G. truncatula*

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habitats could be the same to identify habitats where *O. glabra* lives. Several authors such as Patzer (1927) and Mehl (1932) in Germany or de Vries (1945) and Roberts (1950) in Great Britain have already provided several lists of indicator plants to identify the habitats of *G. truncatula*. According to Smith (1978) and Moens (1981), the habitats of this lymnaeid in Western Europe can be identified by associations of several helophytic plants. Among these, the presence of *Alopecurus geniculatus* (Linnaeus), *Glyceria sp.* and *Ranunculus repens* (Linnaeus) would be typical (Anderson, 2013). On the acid soils of Limousin, several species such as *Juncus acutiflorus* (Ehrhart, ex Hoffmann) or *Juncus effusus* (Linnaeus) have already been reported as indicator plants to detect the habitats of *G. truncatula* in swampy grasslands (Ghestem *et al.*, 1974; Gaultier *et al.*, 1994; Guy *et al.*, 1996). Several species of Poaceae also had indicator value on the banks of ponds and rivers (Dreyfuss *et al.*, 1997; Hourdin *et al.*, 2006). In view of these preliminary results, it was considered interesting to undertake large-scale malacological investigations in Limousin to verify whether the use of these indicator plants truly enabled detection of the habitats of *G. truncatula* and those of *O. glabra* on farms with an animal fasciolosis problem.

Field investigations were thus carried out by our team on 361 cattle- or sheep-breeding farms located in Limousin to detect the habitats colonized by either lymnaeid, and to determine the characteristics of these habitats (surface area, snail density) in relation to each indicator plant species. The results obtained for *G. truncatula* have been published (Rondelaud *et al.*, 2011). We found that *J. acutiflorus* was the most frequent indicator plant to detect the habitats of this snail, as this rush was found in most sites at the peripheral extremity of open drainage furrows and also in spring heads, trampled areas and road ditches. *J. effusus* was the most indicative species for snail sites located along drainage ditches, while *Glyceria fluitans* (R. Brown) was the most representative species for sites along the banks of ponds and rivers. The present paper reports the results we obtained on the habitats of *O. glabra* on the same soil type.

Materials and methods

Study area

Snail investigations were carried out by our team on 361 farms located in the three departments of Limousin (Fig. 1), *i.e.* northern Corrèze (71 farms), Creuse (56) and Haute Vienne (234). These farms were located in an area with GPS coordinates ranging from 45°20′ N to 46°24′ N in latitude and from 0°37′ E to 2°8′ E in longitude. All these farms were on cristallophyllian or metamorphic soils and 97.5% of them ranged from 190 to 500 m in altitude. Permanent grasslands on these farms were hygromesophilous: the hygrophilous zone of each meadow mainly consisted of rushes or bulrushes and covered the bottom of a valley, while the mesophilous zone was peripheral and extended on the nearest slopes (Fig. 2). These meadows

were subject to an alternate regime of pasture and mowing. An open drainage network was generally present in these pastures. All these farms have a continental climate modulated by moist winds from the Atlantic Ocean. Depending on the year, average annual rainfall range from 800 to 1000 mm, while the average annual temperature was between 10.5 °C and 11.5 °C according to the altitude of farms (Fig. 3). Snail habitats were waterlogged from early October until late May or early June and were subject to drying out from early July to mid-September.

Two successive malacological surveys were carried out in March or April in each farm and its immediate vicinity. The first was carried out between 1970 and 1999 when one or more cases of fasciolosis were detected by the local veterinarians in cattle or sheep. A total of 11 992 water holes in the 361 farms were investigated during this survey to identify the presence/absence of an indicator plant species, determine lymnaeid species and specify habitat size when snails were present. The second survey was performed between 1976 and 2006 when new cases of fasciolosis were detected. The 3137 populations of *O. glabra* recorded on these 361 farms during the first survey were re-investigated to count overwintering snails and calculate the surface area of each habitat.

These investigations were carried out in permanent meadows and road or way ditches, which edged them. They were also done along the borders of evacuation systems, *i.e.* pond, stream and river banks. The total area investigated on these 361 farms was 385.7 km² (Vareille-Morel *et al.*, 2007). March and April were chosen because all snail sites were watered and vegetation was sufficient to identify the species of Poaceae.

Potential indicator plants

Six species: *J. acutiflorus*, *J. effusus*, *Lotus uliginosus* (Schkuhr), *Agrostis stolonifera* (Linnaeus), *Dactylis glomerata* (Linnaeus) and *G. fluitans*, were used as potential indicator plants. The first three were selected as they represented more than 75% of plant species found by Ghestem *et al.* (1974), Gaultier *et al.* (1994) or Guy *et al.* (1996) during their phytosociological studies in swampy pastures on acid soils. In road ditches, both rush species, *A. stolonifera* and *G. fluitans* were chosen according to their dominance in the study by Jourdin *et al.* (1985) on the habitats of these lymnaeids in northern Haute Vienne. The dominance of *D. glomerata* and *G. fluitans* over the other plant species in sites with *G. truncatula* along two rivers (Dreyfuss *et al.*, 1997; Hourdin *et al.*, 2006) was the reason for their selection as potential indicator plants on the pond and river banks.

The dominance of one plant over the other species was determined according to the criteria used by the Zürich-Montpellier school of phytosociology (Becking, 1957). When the dominance of *J. acutiflorus* and that of *J. effusus* over the other plant species were the same in a snail habitat, these two rush species were considered as indicator plants for this habitat.
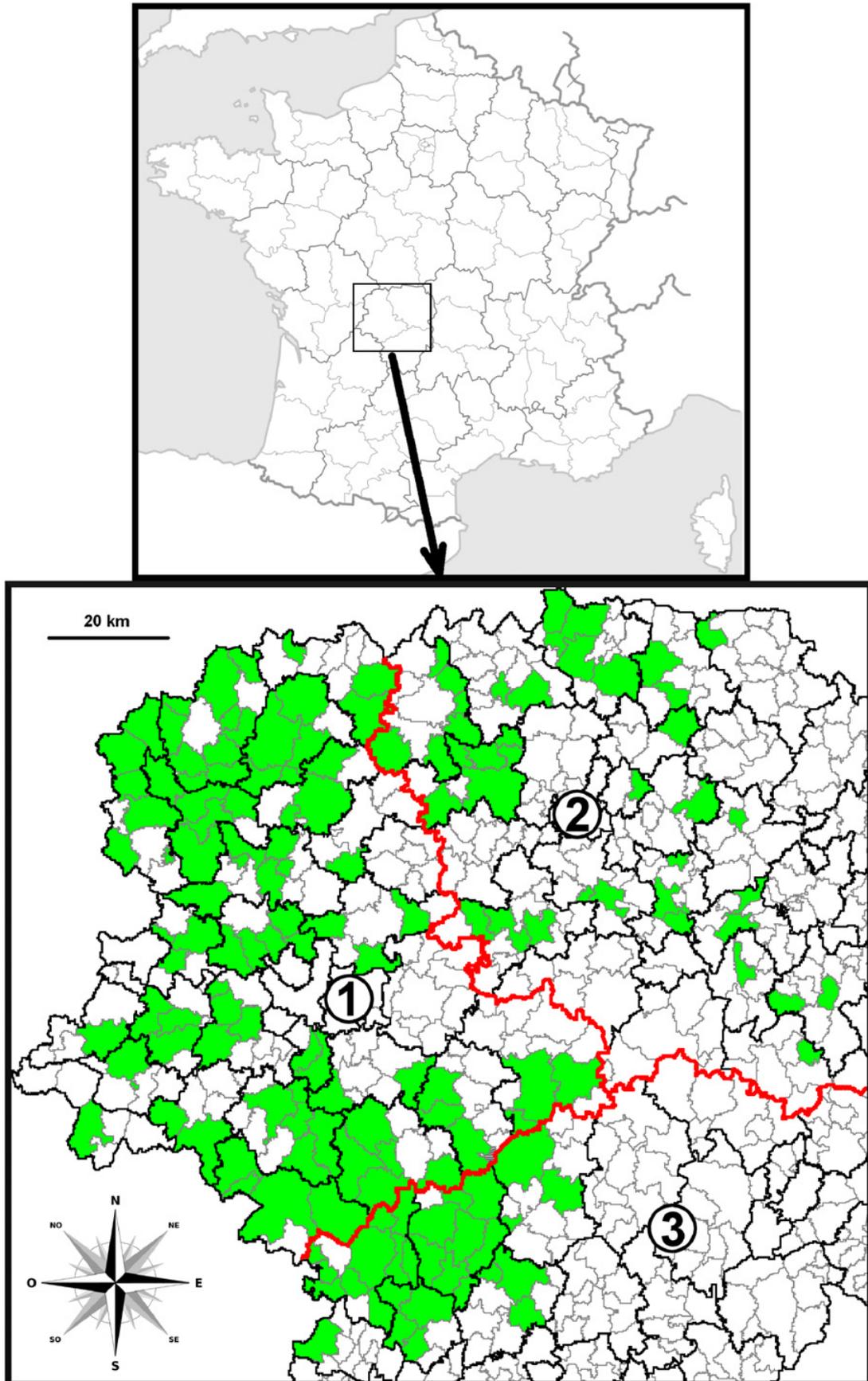
Fig. 1. Location of the Limousin region in France (upper map) and municipalities (in green) on which the 361 farms investigated are located (lower map): 1, Haute Vienne; 2, Creuse; 3, northern Corrèze. In red, the administrative limit between the three departments.
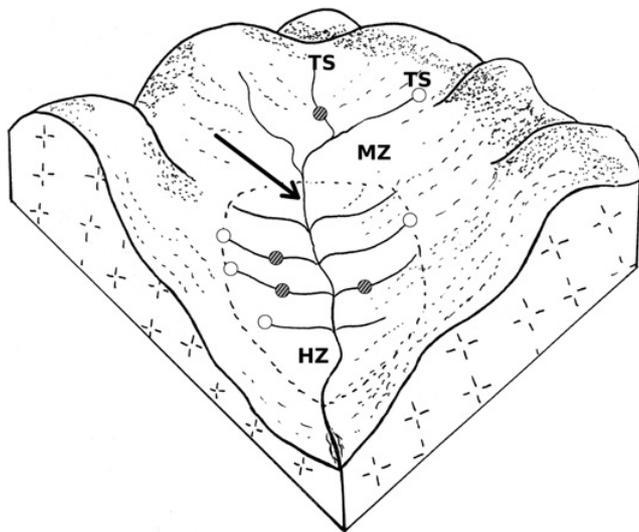
Fig. 2. Block diagram showing the location of *Omphiscola glabra* (•) and *Galba truncatula* (○) habitats along an open drainage network on the Limousin acid soils. The HZ in each meadow covers the bottom of the valley, while the MZ is peripheral and extends to the nearest slopes. The drainage ditch (arrow) receives water from several furrows. The snail habitats are located at the end of these furrows (*G. truncatula*) or in the middle part of their course (*O. glabra*). HZ, hygrophilous zone; MZ, mesophilous zone; TS, temporary spring.
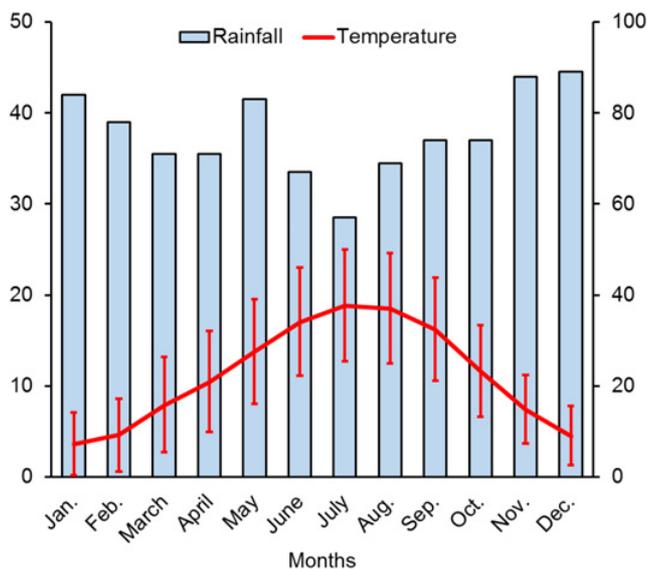

Fig. 3. Ombrothermic diagram showing the monthly variations of rainfall (histograms) and temperature (continuous line) throughout the year in northern Haute Vienne. Mean values of temperature are given with their range. All data came from records noted from 1981 to 2010 by the meteorological station at Le Dorat, department of Haute Vienne. Temperature in °C, rainfall in mm.

Snail investigations

When an indicator plant, either in monospecific stands, or as the dominant species in multi-species assemblages, was found near a water hole, the corresponding area was investigated for the presence of the snail. Seven types of habitats were considered for *O. glabra*. The first four were located in meadows: (i) surface drainage furrows, (ii) temporary or permanent spring heads on hillsides, (iii) surface drainage ditches and (iv) trampled areas when they were covered by a water layer of at least 5 cm in depth. The other three types were (v) road or way ditches when they are waterlogged during winter and spring, (vi) small streams and (vii) ponds.

In each habitat, the abundance of the *O. glabra* population was evaluated by counting overwintering snails because this generation consisted mostly of adult snails (> 12 mm shell height) in March or April that had not yet laid their egg masses at that time. Depending of the water level, these snails were counted on sight or after collection with a sieve (3 mm mesh size) on the entire body of water. When the habitat was located on a meadow, the snails were counted by two people for 30–40 min. In contrast, the snail count was performed by a single person for 15–20 min when the habitat was in a road ditch, on a pond bank or a stream bank. The surface area of each habitat was then determined. Measuring of areas occupied by snails was not difficult in the case of furrows, ditches, ponds and streams. Snail habitats located in spring heads and trampled areas were mapped and their areas were determined according to their geometric shape and size.

Parameters studied

The first parameter was the number of snail populations for each habitat type and each indicator species. The differences between the numbers recorded for the different plant species within the same habitat type were analyzed using Fisher's exact test. The fisher.multcomp function of the RVAideMemoire package (R Core Team, 2016) was used as a *post hoc* test to perform pairwise comparisons. The other two parameters were the surface area of each habitat and the number of overwintering snails per m^2 of habitat. Individual values noted for either parameter were averaged and standard deviations were established, taking into account the indicator plant. Normality of these values was analyzed using a Shapiro–Wilk normality test (Shapiro and Wilk, 1965). As the distributions of these values were not normal, a Kruskal–Wallis test was used to establish levels of significance. All the statistical analyses were performed using R 3.3.0 software (R Core Team, 2016).

The surface areas of snail habitats and snail densities shown in Table 3 correspond to the set of results for each indicator plant and do not take into account the habitat type. Figures 4 and 5 show the frequencies of habitats colonized by *G. truncatula* and *O. glabra* in relation to their surface area or their snail density, respectively, and the presence of four indicator plants (*G. fluitans*, *J. acutiflorus*, *J. effusus* and *L. uliginosus*). As the data reported by Rondelaud *et al.* (2011) for *G. truncatula* were given using classes for habitat areas or snail densities, the areas of *O. glabra* habitats were presented using the
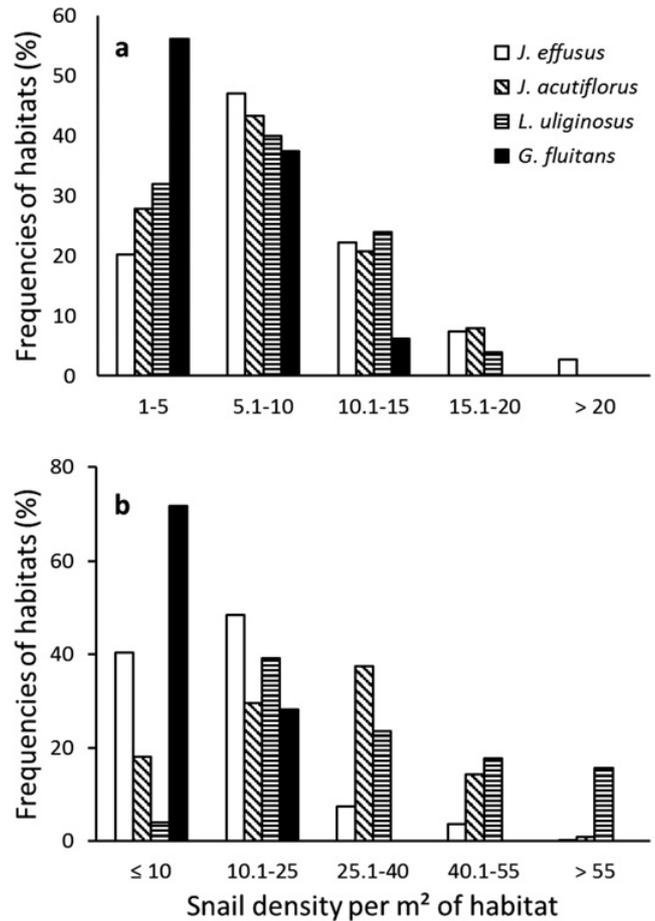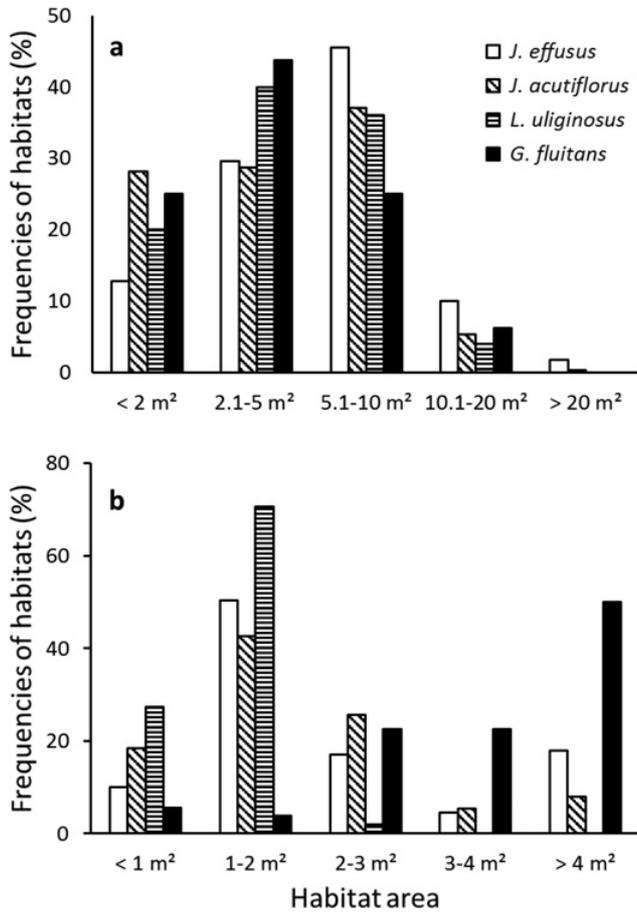
Fig. 4. Frequency of habitats colonized by *Omphiscola glabra* (a) and *Galba truncatula* (b) in relation to their area in March or April and the presence of four indicator species on the Limousin acid soils. Total number of habitats identified with *Juncus effusus*, *Juncus acutiflorus*, *Lotus uliginosus* and *Glyceria fluitans*: *O. glabra*, 2784, 585, 25 and 16, respectively; *G. truncatula*, 538, 6541, 51 and 357. The data used for *G. truncatula* came from the report by Rondelaud *et al.* (2011).

Fig. 5. Frequency of habitats colonized by *Omphiscola glabra* (a) and *Galba truncatula* (b) in relation to their density of overwintering snails in March or April and the presence of four indicator species on the Limousin acid soils. The total number of habitats identified with these indicator plants is given in the caption of Figure 4. The data used for *G. truncatula* came from the report by Rondelaud *et al.* (2011).

following five categories: < 2 m^2, from 2.1 to 5 m^2, from 5.1 to 10 m^2, from 10.1 to 20 m^2 and > 20 m^2. A similar protocol was used for the density of overwintering snails but with the following five categories: < 5 snails/m^2, from 5.1 to 10/m^2, from 10.1 to 15/m^2, from 15.1 to 20/m^2 and $> 20/$m^2. The percentages presented in the histograms of each graph are expressed in relation to the total number of snail populations noted for each indicator plant species (*i.e.* 100%).

Results

Table 1 shows the distribution of the 3137 snail populations according to the type of habitat colonized by this species. The most numerous populations (> 20% of water holes studied) were located in open drainage furrows and road or way ditches. Intermediate values were recorded for snail colonies that lived in springs, drainage ditches and along pond banks, while the populations colonizing stream banks and trampled areas were less common (< 10%).

Frequency of snail populations for each indicator plant

The most frequent indicator species characterizing these snail populations was *J. effusus* (Table 2) because this rush was noted in the seven habitat types. Compared with the other indicator plants, the number of snail populations identified with *J. effusus* was significantly higher in drainage furrows ($P < 0.001$), road or way ditches ($P < 0.001$), drainage ditches ($P < 0.001$), pond banks ($P < 0.001$) and stream banks ($P < 0.001$). In the case of spring heads, the number of snail populations was significantly higher ($P < 0.001$) when the indicator plant was *J. acutiflorus*. Lastly, no significant difference between the numbers of populations identified with either rush species in trampled areas was noted. If we consider the

Table 1. Water holes studied on the 361 farms on the Limousin acid soils, with indication of the number of habitats colonized by *Omphiscola glabra*.

Type of water hole	Number of water points investigated	Number of habitats with *O. glabra* (%)
Open drainage furrows	5546	2165 (39.0)
Road ditches	1934	498 (25.7)
Spring heads (meadows)	1454	195 (13.4)
Open drainage ditches	1287	134 (10.4)
Pond banks	811	53 (6.5)
Stream banks	727	87 (11.9)
Trampled areas	233	5 (2.1)
Total	11 992	3137 (26.1)

Table 2. Distribution of the 3137 populations of *Omphiscola glabra* on the Limousin acid soils in relation to the habitat type and presence of the indicator plant species.

Type of water point (total number)	Indicator plant	Populations of *O. glabra*	
		Number	Frequency (%)
Open drainage furrows (2165)	*Juncus acutiflorus*	354	16.3
	Juncus effusus	2044	94.4
	Lotus uliginosus	17	0.7
Road or way ditches (498)	*J. acutiflorus*	33	6.6
	J. effusus	387	77.7
	Agrostis stolonifera	75	15.0
	Glyceria fluitans	3	0.6
Spring heads in meadows (195)	*J. acutiflorus*	171	87.6
	J. effusus	127	65.1
	L. uliginosus	1	0.5
Drainage ditches (134)	*J. acutiflorus*	21	15.6
	J. effusus	106	79.1
	L. uliginosus	7	5.2
Pond banks (53)	*J. acutiflorus*	3	5.6
	J. effusus	39	73.5
	G. fluitans	11	20.7
Stream banks (87)	*J. effusus*	76	87.3
	Dactylis glomerata	9	10.3
	G. fluitans	2	2.2
Trampled areas (5)	*J. acutiflorus*	3	60.0
	J. effusus	5	100

other indicator species within the same habitat type, the second plant dominating by the number of identified populations was *J. acutiflorus* in drainage furrows ($P < 0.001$), *A. stolonifera* in road or way ditches ($P < 0.001$), *J. acutiflorus* in drainage ditches ($P < 0.01$), *J. effusus* in spring heads ($P < 0.001$) and *G. fluitans* on pond banks ($P < 0.05$).

The two rushes were found with the same dominance in three types of snail habitats located in pastures: 250 open drainage furrows, 104 springs and three trampled areas. In contrast, in the other habitats, only one indicator species (among the six mentioned above) was dominant in the surrounding vegetation (data not shown).

Area of snail habitats for each indicator plant

Table 3 shows the distribution of the 3137 snail habitats in relation to their surface area (measured in March or April) and the presence of each indicator species. The mean areas noted in the habitats with *J. acutiflorus* or *J. effusus* were significantly larger ($P < 0.01$) than those identified with any of the other three indicator plants, whatever the mode of comparison. The differences between the areas of habitats identified with *L. uliginosus* and those of sites with *D. glomerata* or *G. fluitans* were also significant ($P < 0.05$). In contrast, the differences between the values for *J. acutiflorus*, *J. effusus* and *L. uliginosus* were not significant. The values found in habitats with *A. stolonifera*, *D. glomerata* or *G. fluitans* also did not significantly differ from each other.

Density in snail habitats for each indicator plant

The densities of overwintering snails noted in these habitats in March or April are also shown in Table 3 for each indicator plant. The values recorded in snail habitats

Table 3. Distribution of 3137 habitats colonized by *Omphiscola glabra* in relation to their surface area or their density of overwintering snails in March or April and the presence of indicator plant species on the Limousin acid soils.

Indicator plant	Total number of snail habitats	Habitat area (m^2)*	Snail density.m^{-2}*
Juncus effusus	2784	7.8 ± 5.0	10.0 ± 4.4
Juncus acutiflorus	585	6.9 ± 4.4	7.9 ± 2.1
Lotus uliginosus	25	6.2 ± 3.5	8.8 ± 4.3
Glyceria fluitans	16	3.6 ± 2.4	4.1 ± 2.9
Agrostis stolonifera	75	4.5 ± 3.0	9.5 ± 3.2
Dactylis glomerata	9	3.0 ± 1.8	8.6 ± 4.5

*Mean value $\pm$ S.D.

identified with *G. fluitans* were significantly lower ($P < 0.01$) than those with any of the other five indicator plants. In contrast, the differences between the densities of snails in sites with *A. stolonifera*, *D. glomerata*, *J. acutiflorus*, *J. effusus* or *L. uliginosus* were not significant.

Discussion

The high frequencies noted in six habitat types of *O. glabra* identified with *J. effusus* show that this species is a good indicator for snail populations on the Limousin acid soils. Its presence near a water point often allows us to find *O. glabra*. However, *J. effusus* is often associated in the present study with *J. acutiflorus* in the same plant assemblages in meadows and road ditches. Under these conditions, further studies are needed to determine whether *J. effusus* can be used as the type indicator plant to detect any snail population in the other Western European countries on acid soils. Among the other five plants, *J. acutiflorus* was the best indicator species for snail populations living in spring heads. In these grasslands on acid soils, the variations noted in the frequencies of snail populations identified with *J. acutiflorus* or with *J. effusus* as indicator species can easily be explained by (i) the largest requirements of *J. effusus* towards moisture conditions in the soil (Botineau, 1985; Crowley *et al.*, 2003), (ii) the need for packed soils for the growth of *J. effusus* (Brugel *et al.*, 2001), and (iii) the fact that most springs in meadows were located in the mesophilous zone or at the boundary between the mesophilous and hygrophilous zones, as shown in Figure 2. In road ditches as on stream or pond banks, the presence of *J. effusus* indicates the existence of sufficient conditions for the development of *O. glabra* populations.

The mean areas noted in the snail habitats with *J. acutiflorus* or *J. effusus* were significantly larger than those identified with any of the other three indicator plants. This difference can be explained by the characteristics of each habitat type that the snail colonizes. Indeed, the most numerous areas identified in habitats with these rushes were noted in open drainage furrows and springs. As no information on the areas of habitats colonized by *O. glabra* in relation to the other indicator plant species is available in the literature, the values recorded for *O. glabra* in this study were compared

with those that Rondelaud *et al.* (2011) have reported for some *G. truncatula* habitats located on the same farms and investigated during the same years. Figure 4 shows the distribution of areas recorded for snail habitats identified with *G. fluitans*, *J. acutiflorus, J. effusus* or *L. uliginosus* because these values are the most numerous among those that our team recorded during the habitat detection using indicator plants. Surface areas noted for *O. glabra* were clearly higher than those of *G. truncatula*, whatever the area class considered. Two perhaps complementary explanations can be proposed to interpret this difference. The first is to relate it to the ecological requirements of each lymnaeid for water. *G. truncatula* is known to be an amphibious species and is commonly seen on emerged areas in spring and summer, while *O. glabra* is more aquatic with rare emergences from the water (Vignoles *et al.*, 2017). This is supported by the location of both lymnaeid habitats in the same open drainage furrows, *e.g.* as shown in Figure 2. The second explanation is to consider that *G. truncatula* and *O. glabra* would tend to be mutually exclusive and that the former species would be a poor competitor compared with the latter. Økland (1990) reported that *G. truncatula* was seldom observed coexisting with another lymnaeid and that *O. glabra* showed increased frequency when no other freshwater gastropod species occurred in ditches and mires. Two other arguments support this hypothesis. The first is the competition between the two species for food acquisition when they are in the same breeding dishes in the laboratory, often resulting in the rapid death of *G. truncatula* when this snail grows in size (Dreyfuss *et al.*, 2006). The second argument comes from observations reported by Dreyfuss *et al.* (2014) in several mixed communities with *G. truncatula* and *O. glabra* on acid soils. Compared with control habitats with either lymnaeid, the zone where *G. truncatula* lived in these mixed habitats was always reduced in area, while that with *O. glabra* did not show any significant difference. The behaviour of *G. truncatula* as a poor competitor could be related to its pioneering life history strategy (Taylor, 1965).

The density of overwintering *O. glabra* was significantly lower in habitats with *G. fluitans* than in those identified with any of the other five indicator species. This low number of adult individuals was also observed in *G. truncatula* habitats identified with *G. fluitans* (Fig. 5), as 77% were colonized by < 10 snails/m^2 in March

or April (Rondelaud *et al.*, 2011). These results suggest that conditions in a habitat identified with *G. fluitans* are not favourable for the development of a lymnaeid population. Again, two potentially complementary hypotheses can be proposed to explain this situation. The first relates to the quantity of food available for *G. truncatula* or *O. glabra*, which would probably be lower in the habitats identified with *G. fluitans* than in the other sites where either lymnaeid can live. The other hypothesis is to consider that this low density of snails would be due to the secondary metabolites that *G. fluitans*, like other submerged plants (Wetzel, 1969), can excrete through its submerged leaves and that these toxic substances would have a negative impact on snails and/or their food. Comparison of *O. glabra* densities was also performed with those reported by Rondelaud *et al.* (2011) for *G. truncatula* in the same farms on acid soils and during the same period of time (Fig. 5). The number of overwintering snails per m^2 of habitat was clearly higher for *G. truncatula* than for the other lymnaeid, whatever the density class considered. Several hypotheses can be proposed to explain this difference between the densities of both lymnaeids. In our opinion, the most reliable explanation is to relate it to the characteristics of snail habitats and the ecology of each lymnaeid species. The amphibious behaviour of *G. truncatula* (Taylor, 1965) allows it to leave the water when living conditions are favourable and to move in search of food in a film of water (Moens, 1991). This feature would allow it to escape most of its terrestrial or aquatic predators and to take refuge in one or more environments depending on the nature of the predator. This would explain the high densities of overwintering *G. truncatula* found in March or April in its habitats. Conversely, the more aquatic behaviour of *O. glabra* would require it to live in deeper water collections than *G. truncatula* and to undergo greater predation with aquatic predators. This will result in lower densities of *O. glabra* in its habitats, even though the masses laid by this species are more numerous and contain more eggs than those of *G. truncatula* (Vareille-Morel *et al.*, 1998; Titi *et al.*, 2017).

In conclusion, *J. effusus* was the best indicator plant to detect the populations of *O. glabra* in most habitats on acid soils in central France. Larger snail habitats were noted in water points identified with either rush or *L. uliginosus*, while snail densities in March or April were lower in those identified with *G. fluitans*. However, the use of *J. effusus* as an indicator plant cannot be generalized to the other countries on acid soils because the conformation of meadows and pasture management vary with the breeding region and type of ruminants. Other investigations in the other areas on acid soils are still needed to determine whether there are limits before using this method in the field.

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