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RESEARCH ARTICLE

Monitoring of the saproxylic beetle *Morimus asper funereus* (Coleoptera: Cerambycidae) in Măcin Mountains National Park, Romania

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Abstract

During 2014 and 2015, the species *Morimus asper funereus* Mulsant, 1862 was monitored in the Măcin Mountains National Park, Romania using the visual transect method. The studied was focused on two topics: to determine the numerical abundance of *Morimus asper funereus* populations and to identify the environmental variables which influenced them. Ten abiotic factors were analysed: altitude (A), exposition (Ex.), slope (S.a), forest coverage (F.c.), air temperature (A.t.), soil temperature (S.t.), air relative humidity (A.h.), cloud-cover (Nb.), wind speed (W.s.) and wind direction (W.d.). During the study period, 112 individuals were identified. The most favourable habitats for this species were Moesian silver lime woods (91Z0) and Pannonian-Balkanic Turkey oak – sessile oak forests (91M0). The main environmental variables that influenced the beetle population dynamics were the forest coverage and wind direction. Taking into account these two parameters, we concluded that *Morimus asper funereus* preferred semi-shaded and semi-open habitats, characteristic of mature, old, deciduous forests within the Măcin Mountains National Park. In order to protect this species, special attention must be given to the forest management measures, e.g. protection of fallen trees, abundant coarse woody debris and a dense canopy.

Keywords
*Morimus asper funereus***,** environment, habitat, monitoring, transect.

Introduction

The Măcin Mountains were designated as National Park in 2003 following the Government Decision no. 230. In 2007, when Romania joined the European Community, the protection and preservation objectives relating to fauna and flora with high conservative value became better defined for the Măcin Mountains National Park (MMNP). These objectives were legally supported through the Romanian Government Emergency Ordinance no. 57/2007 and law no. 49/2011, and further strengthened through a management plan for the MMNP, approved through Government Decision no. 1074/11.12.2013. According to this management plan, one of the species with conservation value was *Morimus asper funereus*, a large longhorn beetle included in Annex II of the Habitats Directive 92/43 EEC, the IUCN red list and also in the Bern Convention (EU code 6908).

Its presence in MMNP was confirmed by studies organised during June 2006 to December 2007, in order to asses the biodiversity of the invertebrate fauna and the influence of management practices (UNDP/GEF, 2006–2007) in this area.

Solano et al. (2013) and Leonarduzzi et al. (2017) mentioned that all European populations of the genus *Morimus* should be referred to as *Morimus asper*, a genetically and morphologically variable species. *Morimus asper funereus* Mulsant, 1862 is a stenotopic, silvicolous, xylo-detriticolous, xylophagous and saproxylic species. It lives in both deciduous and mixed forests, predominantly inhabiting old-growth forests. The favoured microhabitats are: the leaf litter decomposition layer, moist stumps, fallen wood, the soil surface and trunks with remaining bark of trees of *Fagus, Quercus, Populus, Castanea* and *Abies* (Jurc et al. 2008). According to Fusu et al. 2015, the conservation status of *Morimus asper funereus* in the steppic bioregion (where MMNP is located) is unfavourable-inadequate.

In order to bring information about the conservation status of the Natura 2000 invertebrates in MMNP, including *Morimus asper funereus*, a monitoring programme was developed during 2014 and 2015. According to Solano et al. 2013, this beetle represents a flagship species for old-growth forest saproxylic communities in E and SE Europe. Thus, monitoring programmes for *Morimus asper funereus* were initiated in Croatia, Slovenia, Bulgaria, Italy and Hungary (Merkl and Hegyessy 2008, Vrezec et al. 2012, Anonymous 2015, Hardersen et al. 2017a, b, Carpaneto et al. 2017, Leonarduzzi et al. 2017, Katušić et al. 2017). In Romania, a national monitoring protocol based on transect walks was designed by Fusu et al. 2015. Until very recently, the only studies made in Romania on *Morimus* and other Natura 2000 invertebrates were the faunistic inventories made in different protected areas (e.g. Nera Gorges-Beuşniţa National Park, Maramureş Mountains National Park, Defileul Jiului National Park, Nordul Gorjului de Est, Bârnova-Repedea forest, Muscelele Argeşului, Prigoria-Bengeşti forest, Buzău, Cândeşti Piedmont, Dumbrava Sibiului forest, Cheile Rudăriei and the Făgărăş Mountains), although any data were presented as the results of a monitoring project (Bussler et al. 2005, Ungureanu et al. 2008, Serafim 2008, Maican and Serafim 2012, Prunar et al. 2014, Stan and Nitzu 2013, Walentowski et al. 2013, Bărbuceanu et al. 2015, Stancă-Moise 2015, Manu et al. 2016, Olosutean et al. 2017, Bărbuceanu 2017).

In this context, the present research seeks to establish the presence and abundance of the saproxylic beetle *Morimus asper funereus* in MMNP, as well as the relevant environment variables and, for the first time in Romania, the correlation between these factors and the number of individuals. The overall aim is to provide some practical indications for the adequate monitoring and protection of this species. In addition, the study location itself is very important since the Măcin Mountains are the oldest geological features in Romania, dating from the second part of the Palaeozoic and comprising mostly volcanic rocks (Gavrilă and Anghel 2013).

Material and methods

The study area

The Măcin Mountains National Park is situated at 45°8´49”N and 28°19´51”E, in Romanian Dobruja, in Tulcea county. The whole area has 11151.82 hectares. Its climate is continental with some Sub-Mediterranean influences. More detailed description of the investigated area was provided by Manu et al. 2016.

The following Natura 2000 habitats were identified within MMNP (Fig. 1):

- Moesian silver lime woods (91Z0), representing 28.59% of the total area;
- Ponto-Sarmatic steppes (62C0*) - 22.60%;
- Pannonian-Balkanic Turkey oak – sessile oak forests (91M0) - 17.10%;
- Eastern white oak forests (91AA) - 9.85%;
- Ponto-Sarmatian deciduous thickets (40C0*) - 8.37%;
- Dacian oak and hornbeam forests (91Y0) - 5.88%;
- Euro-Siberian steppic woods with Quercus spp. (91I0*) – 4.08%;
- Dobrogean beech forests (91X0) - 1.25%;
- Pannonic salt steppes and salt marshes (1530) - 1.30%;
- Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi Veronicion dillenii* (8230) - 0.13%;
- Siliceous rocky slopes with chasmophytic vegetation (8220) - 0.84%.

Habitats

The monitoring programme for *Morimus asper funereus* was conducted from June to August, in 2014 and 2015, when the adults showe maximum activity (Vrezec et

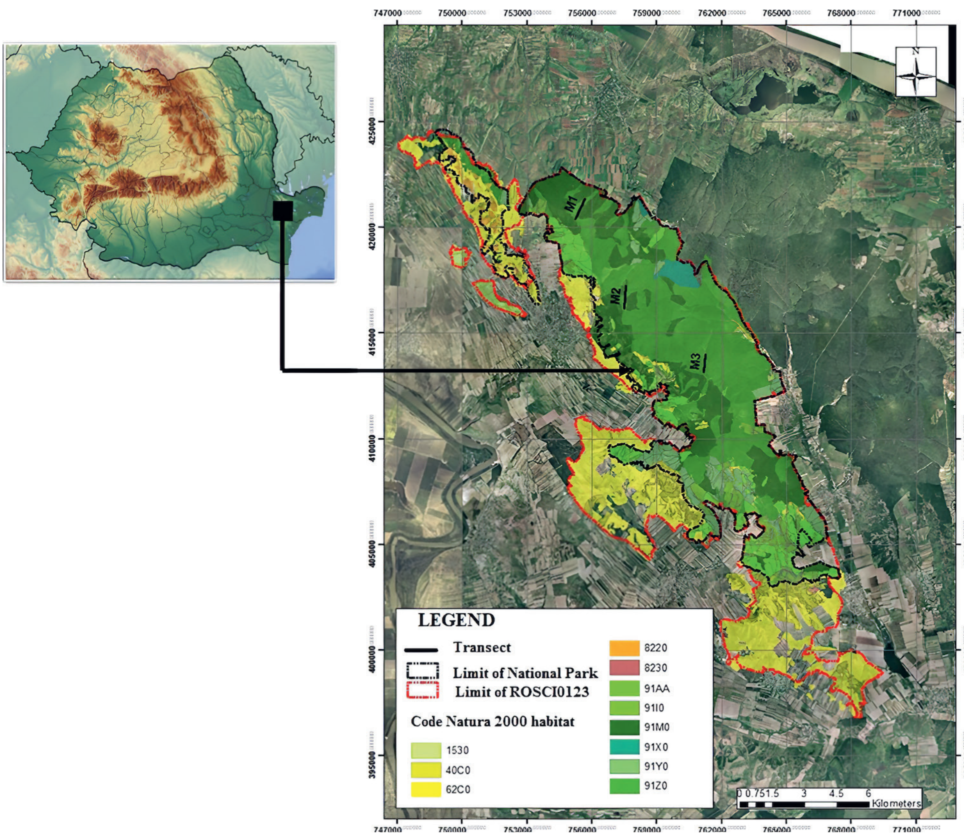

Figure 1. Monitoring transects for *Morimus asper funereus* in MMNP.

al. 2010, 2012). Two monitoring methods were proposed by the European researchers: a) searching/capturing adults which are attracted to freshly cut wood; and b) searching for adults along transect (Hardersen et al. 2017a). In our study we chose the second method, setting out three transects (M1, M2, M3), 1000 metres long and 50 metres wide. The locations and Natura 2000 habitats present were:

M1. Chițău forest (45 degrees 14 min 44.88 sec N; 28 degrees 15 min 21.70 sec E): Pannonian-Balkanic Turkey oak – sessile oak forests (91M0) and Moesian silver lime woods (91Z0);

M2. Seaca Valley (45 degrees 13 min 16.06 sec N; 28 degrees 17 min 19.71 sec E): Pannonian-Balkanic Turkey oak – sessile oak forests (91M0), Moesian silver lime woods (91Z0) and Dacian oak and hornbeam forests (91Y0);

M3. Teica Hill (45 degrees 10 min 39.10 sec N; 28 degrees 19 min 25.39 sec E): Moesian silver lime woods (91Z0) (Fig. 1).

These three transects were monitored, four times per year for two years in daylight, between 9:00 a.m. and 6:00 p.m. In order to avoid repetition, the position of transects was recorded with a Magellan Professional Mobile Mapper or/and Garmin 76CSx.

Our investigation mainly targeted large trees (both alive and degraded), stumps and fallen trunks, as the most favourable woody material to host individuals from the investigated species (Jurc et al. 2008, Fusu et al. 2015, Carpaneto et al. 2017) (Fig. 2).

Climate data

In order to establish correlations between numerical abundance and environmental variables, ten abiotic factors were analysed: altitude (A), exposition (Ex.), slope (S.a), forest coverage (F.c.), air temperature (A.t.), soil temperature (S.t.), air relative humidity (A.h.), cloud-cover (Nb.), wind speed (W.s.) and wind direction (W.d.) (Table 1). Air temperature and relative humidity were measured with a wireless thermohygrometer HTS55 Irox. Soil temperature was recorded with a Step System thermometer. Wind speed was quantified using the Beaufort scale (where numbers 0 to 12 indicate the strength of the wind from calm (force 0) to hurricane (force 12). The percentage of the sky covered by clouds (cloud-cover) is another environmental variable which was taken into consideration (Wikstrom et al. 2009). Climate data were recorded at the starting point of each monitored transect, on every occasion when we went in the field (Table 1). Correlations between the number of individuals observed and the environmental parameters were also considered, in order to provide some practical indications for the monitoring (Carpaneto et al. 2017).

The method used for study of climatic data is essentially the same as reported previously for monitoring of *Rosalia alpina*, in the same protected area, in 2016 (Manu et al. 2016).

Data analysis

All continuous variables were z-transformed (standardised to an average of zero and a standard deviation of one) to increase comparability of the effects of the variables. For this species, pairwise correlations were calculated among variables to evaluate the presence of multicollinearity. Strong pairwise correlations were found between variables Alt and Exp and Ta and Ts ($|r|>0.94$), indicating low multicollinearity (Berry and Feldman 1985).

An information-theoretic approach was used to identify the appropriate models for predicting the occurrence of each plant species (Generalised Linear Model (GLM), assuming a Poisson distribution and log link function). We designed 22 models representing different combinations of eleven variables: year (Y), habitat type (Ht), altitude (Alt), exposure (Exp), slope (Slp), forest coverage (Fc), air temperature (Ta), soil temperature (Ts), air relative humidity (Rha), wind speed (Ws) and direction (Wd) (Table 1).

For each model, the Akaike information criterion (AICc) value was calculated using correction for small samples sizes (Burnham and Anderson 2002). The models were ranked according to their AICc and the best model has the smallest AICc

Figure 2. Investigated habitats for *Morimus asper funereus* in MMNP, 2014–2015.

value. Delta AICc (DAICc) was calculated to express the difference between each model and the best model. All statistical procedures were implemented in R 3.2.3

Table 1. Population parameters of *Morimus asper funereus* and environmental variables, recorded in MMNP (2014–2015). EJ = early June, EJy = early July, EdJy = end of July, EA = early August.

T	Ab.	P	A (m)	Ex.	S.a. (°)	F.c. (%)	A.t. (T°)	S.t. (T°)	A.h. (%)	Nb. (%)	W.s.	W.d.
		2014										
M1	6♂ + 5♀	EJ	212	SW/NE	28	50	27	22	69	90	1	SE
M2	3♂ + 2♀	EJ	173	SW/NE	35	60	27	22	63	60	3	NE
M3	5♂ + 5♀	EJ	181	SW/NE	25	30	18	16	59	60	1	NE
M1	3♂ + 5♀	EJy	183	SW/NE	28	60	28	24	62	5	1	SE
M2	2♂ + 4♀	EJy	304	NE	28	60	29	26	67	10	0	-
M3	3♂ + 4♀	EJy	220	SW/NE	30	65	31	25	60	15	0	-
M1	2♂ + 3♀	EdJy	183	SW/NE	28	60	28	24	69	20	1	SE
M2	2♂ + 2♀	EdJy	220	SW/NE	35	30	27	22	62	5	0	-
M3	1♂ + 2♀	EdJy	304	NE	28	60	21	16	83	100	1	NE
M1	2♂ + 3♀	EA	220	SW/NE	35	30	29	26	60	80	0	-
M2	2♂ + 4♀	EA	183	SW/NE	28	60	26	21	64	10	0	-
M3	3♂ + 2♀	EA	304	NE	28	60	25	20	64	85	0	-
		2015										
M1	3♂ + 4♀	EdJ	183	SW/NE	28	60	27	22	34	80	0	-
M2	2♂ + 3♀	EdJ	304	NE	28	62	20	17	74	50	2	SE
M3	1♂ + 4♀	EdJ	220	SW/NE	20	55	24	19	65	5	2	SE
M1	1♂ + 2♀	MJ	183	SW/NE	28	60	30	23	49	0	0	-
M2	2♂ + 2♀	MJ	304	NE	28	62	26	21	59	80	1	SE
M3	3♀	MJ	220	SW	20	55	23	18	75	0	0	-
M1	2♀	EdJy	183	SW/NE	28	60	21	19	59	0	1	SE
M2	2♀	EdJy	304	NE	28	62	27	22	49	0	2	SE
M3	1♂ + 2♀	EdJy	220	SW	20	55	25	19	43	0	1	SW
M1	1♀	EA	183	SW/NE	28	60	28	25	39	0	2	SW
M2	1♀	EA	304	NE	28	62	27	22	45	80	1	SE
M3	1♀	EA	220	SW	20	55	22	20	56	0	1	SE

A = altitude; Ab = numerical abundance; A.h. = air relative humidity; A.T. = air temperature; E = East; N = North; W = West; EJ = early June; EJy = early July; EdJ = end of June; EdJy = end of July; EA = early August; Ex = exposition; F.c. = forest coverage; Ht = habitat type; MJ = middle July; Nb = cloud-cover; P = period; S.a = average slope; S.T. = soil temperature; S = South; Y = year; T = transect; Top = toponym; Ws = wind speed; W.d = wind direction.

(R Development Core Team 2015). The model selection and model averaging were performed with the AICcmodavg package (Mazerolle 2009).

Results

During the two years of study, 112 individuals of *Morimus asper funereus* were identified, 75 in 2014 (with an average of 6.25 ± 2.3 per transect) and 37 in 2015 (with an average of 3.08 ± 1.88 per transect) (Fig. 3).

Table 2. Model selection results. LL Log-likelihood, K number of parameters, AICc corrected akaike information criterion value, Delta AICc difference between lowest AICc model and model AICc.

		Morimus asper funereus			
	Model	LL	K	AICc	ΔAICc
1	Y	2	-49.95	103.9	35.53
2	Ht	2	-56.42	116.84	48.47
3	Alt	2	-55.32	114.65	46.28
4	Exp	2	-55.43	114.86	46.49
5	Slp	2	-56.06	116.12	47.75
6	F.c	2	-55.21	114.43	46.06
7	Ta	2	-56.47	116.94	48.57
8	Ts	2	-56.46	116.92	48.55
9	Rha	2	-55.31	114.63	46.26
10	Ws	2	-55.99	115.98	47.61
11	Wd	2	-36.6	77.2	8.83
12	Wd+Ws	3	-36.15	78.29	9.92
13	Ht+Alt	3	-55.31	116.62	48.25
14	Exp+Slp	3	-54.98	115.96	47.59
15	Rha+Ts	3	-54.91	115.82	47.46
16	Y+F.c	3	-49.85	105.71	105.71
17	Ws+Wd+Y	4	-31.13	70.26	1.89
18	Ws+Wd+Y+Fc	5	-29.18	68.37	0
19	Ws+Wd+Y+Rha	5	-30.96	71.91	3.54
20	Ws+Wd+Y+Alt	5	-31.07	72.13	3.77
21	Ws+Wd+Y+Ht	5	-31.13	72.26	3.89
22	Ws+Wd+Y+Exp	5	-31.07	72.14	3.77

"+" = the additive effect, Y = year, Ht = habitat type, Alt = altitude, Exp = exposure, F.c. = Forest coverage, Slp = slope, Ta = air temperature, Ts = soil temperature, Rha = air relative humidity, Ws = wind speed, Wd = wind direction.

The highest numbers of individuals were found in June and early July of each year, taking into account that in the latter month two observations were made (Table 1). According to other studies, there is a second peak in numerical abundance of *Morimus asper funereus* at the end of June and beginning of July, due to emergence of the second generation. This peak is strongly influenced by altitude and environmental conditions (Vrezec et al. 2010, 2012, Rossi de Gasperis et al. 2016, Hardersen et al. 2017a). The values obtained from our study are consistent with results reported in the literature on the dynamics of this species (Chiari et al. 2013, Fusu et al. 2015, Katušić et al. 2017).

The dry period of 2015, when the air humidity had decreased to 34%, influenced the activity of the adults, especially of males. This phenomenon was highlighted by the decreased value of the sex ratio (0.37), 72.97% of the total number of specimens found being females. In comparison, in 2014, the ratio between the two sexes was 0.82, a relatively balanced ratio, and the proportion of females was 54.66% (Table 2). The average value of the sex ratio over the two years of study was 0.64, and the proportion of females was 60.71%. These results contrast with those from other researchers, who registered a male-biased sex ratio in captures (Chiari et al. 2013, Bărbuceanu et al. 2015, Manu et al. 2017, Hardersen et al. 2017b). There are two possible explanations: a) that in the MMNP a warmer climate with Mediterranean influence affects the population dynamics, favouring females; or b) the climate during the monitoring period (from June to August during both years) was not so proper for the investigated species, in this southern area the males having the peak in May probably, and after this their numbers diminish.

Analysing the preference of *Morimus asper funereus* for habitat type, we observed that 48.21% of individuals were found in Moesian silver lime woods (91Z0). The remaining individuals were recorded in mixed habitats between Moesian silver lime woods (91Z0) and Pannonian-Balkanic Turkey oak – sessile oak forests (91M0) (38.39%). This preference remained essentially unchanged between the two years. In 2015, the proportion of individuals in habitat 91Z0 increased, apparently due to the dry weather. The Moesian silver lime woods usually occur in sheltered

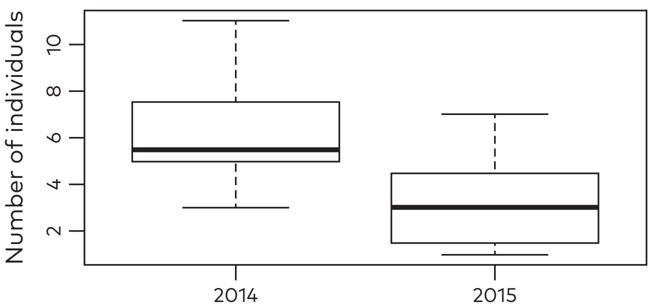

Figure 3. Average number of individuals of *Morimus asper funereus*, from 2014 and 2015.

valleys, where the average forest coverage was 60% ± 2.89%, protecting the beetles from the dry weather.

Summarising the influence of environmental factors, we observed that the majority of the investigated habitats had South-West/North-East, North-East and South-West exposure. Over half of the total number of individuals (53.57%) preferred habitats with a South-West/North-East (28.57%) and South-West exposure (25%). This phenomenon was consistent over the two years of study.

Analysing the forest coverage, the percentages varied little between the two years of study (52.08% ± 13.72 in 2014 and 59% ± 3.07 in 2015). A similar trend was observed for air and soil temperatures. In the first year of research, the average air temperature was 26.31°C ± 3.54 and, in 2015, 24.89°C ± 2.99. Average soil temperature also did vary in the two years was 21.96°C ± 3.37 in 2014 and 20.49°C ± 2.32, in 2015. However, air humidity did show a clear difference between years, being higher in 2014 (65.16% ± 6.53) than in 2015 (53.90% ± 13.15). Cloud-cover also affected the numerical abundance of *Morimus asper funereus*, the highest number of individuals being recorded for the interval 0–50% cover (54.46%). When cloud-cover increased (over 50%), there was an observed decline in numerical abundance (Table 3).

The best model supported by the data included year, wind speed and direction, and percent of forest coverage (Table 2).

Considering the best model, *Morimus asper funereus* showed a higher abundance in transects with a NE rather than a SW wind direction (Fig. 4), and higher in 2014 than in 2015 (Fig. 3). The abundance decreased significantly with increased forest coverage (Fig. 5) (Table 3).

Considering the species independently and the best model, *Morimus asper funereus* showed higher abundance in transects with a NE than a SV wind direction and the abundance decreased significantly with the increase of the percent of forest coverage (Figs 4, 5) (Table 3).

Table 3. Results of the best models relating the abundance of the *Morimus asper funereus* with year, percentage of forest coverage (FC), wind speed (Ws) and wind direction (Wd).

	Estimate	SE	Z	P
Intercept	1.133	0.430	2.635	0.008
Ws	0.292	0.226	1.290	0.197
WdSE	0.931	0.456	2.044	0.041
WdSV	0.475	0.699	0.679	0.497
Year2015	-1.044	0.323	-3.227	0.001
F.c.	-0.459	0.182	-2.529	0.011

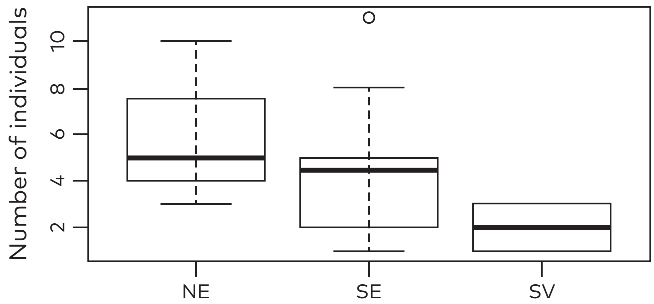

Figure 4. The effect of wind direction on *Morimus asper funereus* abundance.

Discussion

The beetle was observed more frequently in 2014 than in 2015. The second year of study was characterised by low values of atmospheric humidity (34% in June and 39% in August) and fewer periods with extensive cloud-cover 50–80% (Table 1). Comparing the MMNP results with other studies, the number of individuals of *Morimus asper funereus* recorded in Măcin is similar to those obtained in protected areas in Italy (113 individuals) or in Croatia at Međimurje, Nedelišće (140 individuals), Spain (73 individuals), but higher than those from Hungary (14 individuals), Serbia (9 individuals), Belgium, Bulgaria, Austria, Turkey (1–2 individuals), Macedonia (5 individuals), Spain (1–7 individuals) (Schuh et al. 1992, Romero-Samper and Bahülo 1993, Migliaccio et al. 2004, Nataša and Stojanović 2005, Özdikmen 2007, Chiari et al. 2013, Ilić et al. 2013, Georgiev et al. 2013, Keszthelyi 2015, Plewa et al. 2015, Katušić et al. 2017, Thomaes et al. 2017, Castro and Perez 2018).

Comparing our data for one year of study with the numerical abundances recorded elsewhere in Romania, we observed that the results in MMNP are similar to those recorded from Muscelele Argeşului (97 individuals), Platoul Cândeşti (59 individuals) and Prigoria-Bengeşti forest (47 individuals), but the values are higher than those obtained in Nordul Gorjului de Est (27 individuals), Nera Gorges-Beuşnița National Park (10 individuals), Bârnova-Repedea forest (3 individuals), Buzău area (6 individuals) and Defileul Jiului National Park (5 individuals) (Bussler et al. 2005, Ungureanu et al. 2008, Prunar et al. 2013, Stan and Nițu 2013, Bărbuceanu et al. 2015, Olosutean et al. 2017, Manu et al. 2017).

There are two possible explanations for these values. On one hand, in the small protected areas that are more accessible compared to the big ones (as Nera Gorges-Beuşnița National Park or Defileul Jiului National Park), finding the beetles may be easier. On the other hand, the protected areas such as Platoul Cândeşti, Prigoria-Bengeşti forest or Măcin Mountains National Park (according to its management plan) are characterised by dense forest ecosystems, which provide favourable environmental conditions for these beetles (Bărbuceanu et al. 2015, Bărbuceanu 2017, Manu et al. 2017).

Examining the habitat type, we observed that in two years of study *Morimus asper funereus*, a thermophilous species, especially preferred the Moesian silver lime woods (91Z0), characterised by a diverse tree flora including *Quercus petraea, Q. dalechampii, Q. polycarpa, Tilia cordata, T. tomentosa, T. platyphyllos, Fraxinus excelsior, F. ornus, Carpinus betulus* and *C. orientalis* (Doniță et al. 2005). These results concur with those obtained elsewhere in Europe and in Romania (Table 4).

According to Donița et al. 2005, Moesian silver lime woods are situated in shaded places, being characterised by an average annual air temperature of 9°C–10.5°C, higher in comparison with those of Dacian oak and hornbeam forests (7.5°C–9°C), or Euro-Siberian steppic woods with *Quercus* spp. (8°C–9°C). At the same time, both these two last habitats and the Eastern white oak forests (91AA) occur there where a summer period with a marked moisture deficit is. It must be also remembered that the Moesian silver lime woods habitats occupy the largest area in the MMNP (28.59%) (Fig. 1).

Applying statistical analysis and considering the best model, we found that the environmental variables with the clearest influence on the numerical abundance of *Morimus asper funereus* were wind direction and forest coverage. MMNP is characterised by a continental climate with some Sub-Mediterranean influences. This climate is characterised by an increased dryness with hot and arid summers, long autumns and snowless winters. The Măcin Mountains are the most arid mountains in Romania, with an annual average air temperature of 10°C–11°C and annual average precipitation of 400 mm (http://www.parcmacin.ro/plan-management). In the East and South-East parts of Romania, were MMNP is located, the dominant wind direction is North-East. This wind has continental influences determined by the East-European Anticyclone, especially in winter when it pumps in cold air (Rusan 2010). Climatological studies revealed that there is a strong relationship between wind, air temperature and humidity, where cold air provides a cooler climate and more humid atmosphere (Njau 1995, Marin et al. 2014). Hence, this cold air is a favourable environmental factor that positively influences populations of *Morimus asper funereus*, countering the arid summers of MMNP.

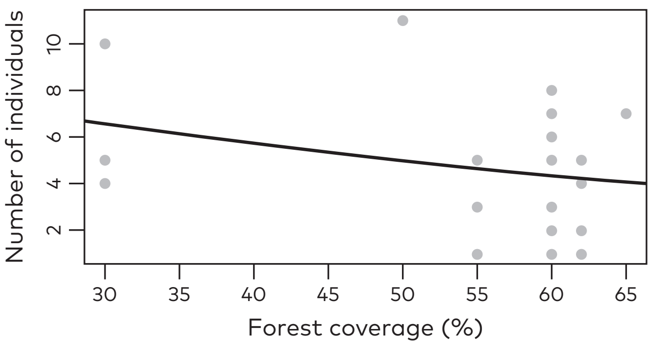

Figure 5. The effect of forest coverage on *Morimus asper funereus* abundance.

Table 4. The tree species preferred by *Morimus asper funereus* in Europe.

Country	Tree species	Reference
Italy	*Fagus sylvatica, Carpinus betulus, Quercus robur, Q. cerris, Q. rubra, Picea abies, Fraxinus excelsior*	Chiari et al. 2013, Carpaneto et al. 2017, Leonarduzzi et al. 2017
Slovenia	*Fagus sp., Quercus sp., Populus sp., Castanea sp., Abies alba, Picea abies.*	Jurc et al. 2008, Vrezec et al. 2010
Bulgaria	*Fagus sylvatica, Carpinus betulus, Quercus spp., Q. pubescens, Castanea sativa, Populus detoides, Populus x euramericana, Pseudotsuga menziesii*	Georgiev et al. 2013, Doychev et al. 2017
Croatia	*Quercus cerris, Q. robur, Q. ilex, Q. petraea, Q. pubescens, Fagus sylvatica, Carpinus betulus, C. orientalis, Populus alba, Acer pseudoplatanus, Betula pendula, Prunus sp., Corylus avellana, Salix alba, Fraxinus sp., Ostrya carpinifolia.*	Katušić et al. 2017
Serbia	*Quercus petraea, Q. cerris, Q. frainetto, Fagus sp., Carpinus sp., Fraxinus sp.*	Ilić et al. 2013
Hungary	*Quercus sp., Fagus sp., Carpinus sp., Fraxinus sp.*	Merkl and Hegyessy 2008, Keszthelyi 2015
Macedonia	*Fagus sylvatica, Salix sp.*	Plewa et al. 2015
Czech Republic	*Quercus sp.*	Kozel 2015
Iberian Peninsula	*Quercus faginea, Q. robur, Alnus glutinosa, Pinus nigra, Fagus sylvatica, Cedrus libani, Populus nigra, Pinus radiata, Salix sp.*	Romero-Samper and Bahülo 1993
Romania	*Quercus cerris, Q. petraea, Carpinus betulus, Fagus sylvatica, Picea abies, Abies alba.*	Stan and Nitzu 2013, Máthé et al. 2013, Bărbuceanu et al. 2015, Stan et al. 2016, Manu et al. 2017

Forest cover is another environmental factor with an important indirect influence on the abundance of this species. Our results indicate a preference for habitats where forest coverage was at least 50–60%, or higher still when the atmospheric humidity is low, as in 2015 (Fig. 5).

At a European level, it has been shown that this silvicolous species prefers semi-shaded and semi-open habitats characteristic of mature and old forests (Jurc et al. 2008, Solano et al. 2013, Carpaneto et al. 2017). According to Rossi de Gasperis et al. 2016, this species showed a preference for huge fallen trees, branches on the ground, a low percentage of debarked surface and high canopy closure. Trees lying on the ground (habitats for *Morimus asper funereus*) do not have their own canopy, exposing part of the trunk to the sun, while a high canopy cover in the surroundings probably maintains the preferred range of daily temperature favouring daily adult activity. In Romania, different specialists have demonstrated that *Morimus asper funereus* not only prefers forests with higher density of trees and shrubs, but also fringe areas (Prunar et al. 2013, Bărbuceanu et al. 2015, Manu et al. 2017, Olosutean et al. 2017).

Conclusions

The monitoring of *Morimus asper funereus* in MMNP on three transects from June to August, in 2014 and 2015, four times per year, revealed the presence of 112 individuals. The results obtain during the two years of study strongly support the need for a longer monitoring programme in future, at very least three years but preferably five years or more. During this study, the clearest trend was the inversion of the sex ratio in 2015, with a decreased male activity, apparently due to the drought conditions of that year. Such modification of the sex ratio, due to natural causes, should be temporary and does not affect the long-term viability of the beetle populations. The most favourable habitats for this species were Moesian silver lime woods (91Z0) and Pannonian-Balkanic Turkey oak – sessile oak forests (91M0). Statistical analysis indicates that the main environmental variables influencing the population dynamics of this beetle were forest coverage and wind direction. In terms of forest coverage, we observed that *Morimus asper funereus* preferred semi-shaded and semi-open habitats, characteristic of mature, old, deciduous forests. Such "cooler" habitats were also further maintained by the prevalence of North-East winds, producing a favourable climate for *Morimus asper funereus*.

In order to protect this species, special attention must be given to forest management measures. Although forest cutting has a low intensity in MMNP, this anthropic activity remains the main threat for the xylophagous, saproxylic beetles, since such management involves the removal of the old, dead trees, fallen or standing. Trees lying on the ground, abundant coarse woody debris and a dense canopy provide a cooler habitat, favouring *Morimus asper funereus* development and its conservation.

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