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To link to this article DOI: http://dx.doi.org/10.1007/s10344-014-0838-8

Publisher: Springer

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1 **Activity and space patterns of Pyrenean desman (*Galemys pyrenaicus*) suggest non-**

2 **aggressive and non-territorial behaviour**

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12

13 **Abstract**

14 The Pyrenean desman is considered as a flag species of biodiversity and evolution. However,

15 its scientific knowledge is still under development and currently on debate, in special in

16 relation to the behavioural ecology and social organization. Based on the previous hypothesis

17 of individual desmans being solitary and territorial, activity and space patterns were

18 described as arranged to avoid conspecifics. However, recent new insights into the species

19 social behaviour revealed non-interspecific avoidance. With this study we provide novel

20 insights into their activity and space patterns and their relation to the social behaviour. A

21 total of 30 individuals were trapped of which 18 provided informative radiotracking data to

22 study (1) individuals activity behaviour, (2) proportion of home range utilised and movement

23 distances, and (3) movement directionality. Activity and space use patterns were affected by

24 daylight and seasonality but not by sex, age or number of other conspecifics sharing the home

25 range. In contrast to the previous observations, individuals did not show a pattern of

26 directionally in their movements. Noticeably, we observed encounters between individuals

27   without evidence of aggressive behaviour between them. Our results suggest that desmans do

28   not opposite their activity neither their spatial behaviour in order to avoid encounters with

29   conspecifics as previously suggested. These novel findings provide more evidences of a

30   social structure and organization with social interactions and non-aggressive behaviour. This

31   is of relevance for management actions and conservation purposes of this endemic mammal.

32

33

34   Authors declare no conflict of interest

Introduction

The Pyrenean desman (*Galemys pyrenaicus*; also known as Iberian desman) is a riparian species considered as a flag species of biodiversity and evolution because of its relic and narrow endemic character. Together with the Russian desman (*Desmana moschata*) represent the last two extant species of the Desmanini lineage of Soricomorpha (Nowak 1999) a mammalian taxa of extremely high biodiversity value. However, the species has been quite unknown to the general public due to its nocturnal elusive behaviour; and to the scientific community because the difficulty of its study (due to e.g. the few approved capture authorisations or the difficulty of scat identification using non-genetic methodologies since desman and shrew scats can easily be misidentified)

The first published information on its social and ecological behaviour was thanks to the novel studies carried by (Stone 1987b; Stone 1987a; Stone 1985; Stone and Gorman 1985), Stone (1987b; 1987a; 1985) in wild watercourses, and Richard and Michaud (1975) and Richard (1986; 1985) in captivity. Since then a few seminal studies have talked about its distribution, morphology and general biology (Aymerich and Gosàlbez 2013; Aymerich and Gosàlbez 2002; Bertrand 1993; Palomo et al. 2007; Queiroz and Almada 1993; Williams-Tripp et al. 2012) and most of them are grey literature and/or have low international repercussion. Nonetheless, in the recent years the interest on the species has increased notably by both the general public and the scientific community. Indeed, the Pyrenean desman recently became strictly protected under the Bern Convention (Appendix II) and the EU Habitats and Species Directive (Annexes II and IV). Notwithstanding, the scientific knowledge on its behaviour and ecology is still poorly developed.

One of the most unknown aspects of the species biology is its behavioural ecology and the reliability of little available information is currently on debate. The species was first observed as largely territorial and solitary or organised in couples in the wild (Stone 1987a;

60   Stone and Gorman 1985) and solitary in captivity (Richard and Viallard 1969). This

61   hypothesis was supported by observations that described the individuals as highly aggressive

62   with conspecifics independently of the sex even between couples, except for temporal mating

63   and transient individuals (Stone 1987a). Since these first studies, there has been no more

64   research on its social organization or behaviour, and these observations have been the

65   foundation for the knowledge on the species behavioural ecology. Consequently, many

66   studies were based on the aegis of desmans being aggressive with resident male and female

67   couples occupying an exclusive range in which the male's range encloses that of the female,

68   and individuals hold exclusive shelters (Richard and Valette Viallard 1969; Stone 1987b;

69   Stone 1987a; Stone 1985). Controversially, we recently observed a different social behaviour

70   with non-territoriality nor conspecific avoidance (Melero et al. 2012). More in detail, we

71   found that socio-spatial organization was community based with non-exclusive or permanent

72   territories and shared home ranges and resting sites (shelters used for more than 1h) between

73   two or more resident non-couple individuals of different and/or same sex. Our new findings

74   thus, recalled for a re-evaluation of the behavioural ecology of the species and the subsequent

75   related research and management actions.

76   Under the observations of Stone (1985; 1987a;b) individual behaviour was observed

77   to be arranged to avoid conspecifics. It was described as a bimodal activity rhythm with one

78   diurnal and one nocturnal activity bout during which the whole riparian territory was seen to

79   be patrolled on a 48h basis if solitary and 24h basis in the case of mating couples sharing the

80   territory. In this patrolling, males were more frequently found in the border areas of the river

81   sections included in their territories to protect the territory and mating couples avoiding

82   encounters between them. In addition, individuals had fixed directional up or downstream

83   movements that were organised between individuals to avoid encounters, including couples

84   except for mating encounters. However, under the novel recent observations of the species

85   not being territorial or aggressive (Melero et al. 2012), individual activity and space use

86   might not follow the previously postulated objective of avoidance.

87   In this study, we investigated the activity and space use patterns of a local population

88   of Pyrenean desman. We hypothesised that individual activity and space use patterns were

89   not organised to avoid conspecific encounters. To test our hypothesis we studied (1)

90   individuals activity behaviour (active versus inactive), (2) proportion of home range utilised

91   and movement distances during the activity bouts, and (3) directionality of individual

92   desmans. We also state several observed spatiotemporal encounters between individuals. Our

93   overall aim was to increase the scarce research and knowledge on the behaviour of the

94   species. We believe that clarifying the scientific knowledge on the species behaviour is

95   crucial for the understanding of the species biology and its conservation. This will contribute

96   to the awareness of the species and, ultimately, to improve design of on-going and future

97   research, management and conservation actions.

98

99   **Material and methods**

100

101   The study area and the methodology for trapping and radiotracking was previously described

102   in the in Melero et al. (2012) because the data used in this study was a subset of the data used

103   in the preceding publication consisting of individuals captured between 2002 and 2004 in the

104   river Tor.

105

106   Study area

107

108   The study was conducted in the river Tor, located in the Eastern Pyrenees (UTM 31TCH61).

109   We selected 2 km of the river Tor which presented 4 m of mean width, 0.1-0.4 m of mean

110   depth, and 6.5% of mean slope, rocky river-bed and rocky shorelines covered by dense

111 vegetation. The river Tor is a well preserved river without anthropogenic pressures. Winter

112 snowfalls and their subsequent spring thaws maintain a constant high river flow with a peak

113 in April-May but without significant seasonal differences. Mean altitude of the area ranges

114 between 1200 and 1400 m and precipitation falls regularly along the year within a range of

115 800-1000 mm being the highest between May and September. Temperatures in the area range

116 from an average of 20 ℃ in summer to -2 ℃ in winter.

117   Other aquatic and semiaquatic vertebrates sharing the habitat with the Pyrenean

118 desman are the brown trout *Salmo trutta*, viperine snake *Natrix Maura*, White-throated

119 Dipper *Cinclus cinclus*, the Eurasian Water Shrew *Neomys fodiens*, the water vole *Arvicola*

120 *sapidus* and the Eurasian otter *Lutra lutra*. The river provides availability of a diverse

121 invertebrate fauna such as caddisflies (Trichoptera) and mayflies (ephemeroptera) among

122 others.

123

124 Trapping and radiotracking

125

126 Two trapping sessions of 5 to 7 days each were conducted annually with 28-35 trap nights per

127 session between 2002 and 2004. The sessions were set each year in April to June (spring-

128 summer, spring hereafter) and in September-October (autumn) to cover both the expected

129 reproductive and the non-reproductive seasons (Castién 1994). Animals were live trapped at

130 night in partially submerged unbaited mesh traps designed for trapping the species and based

131 on the designs of eel traps. Traps were located inside the rivers in adequate places for

132 trapping (i.e. narrow pathways) maintaining a separation of 30-300 m between them and

133 checked every 3 hours during the night every day (traps were open during daylight hours).

134 After immobilization with anaesthetic (isoflurane), animals were measured, weighted, sexed,

135 aged and classified as either a new capture or a recapture. Animals were classified by sex and

136 age based on the data of Peyre (1961), González-Esteban et al. (2003) and González-Esteban

137 et al. (2002) respectively. The captured animals were marked with a subcutaneous

138 transponder (PIT; ID K162 FDX-B; AEG ID; Trovan Ltd., Madrid, Spain) and

139 radiotransmitter (frequency 150-151, Pip model, BioTrack, Ltd., Wareham, Dorset, UK and

140 Tinyloc Ltd., Mataró, Spain). Transponders weighted approximately 0.95mg < 1.7‰ of the

141 lightest individuals (M16 and F11, weight = 54g). Radiotransmitters weighted approximately

142 2.5-3g < 5.5% of the weight of the lightest individuals and < 4.4% of the heaviest individual

143 (F8, weight = 70g). All manipulated animals were released in the capture area once fully

144 recovered. None of the captured individuals died during the procedures. Trapping was carried

145 out by three accredited biologist and one accredited veterinary, but animal manipulation was

146 carried out only by the accredited veterinary. Research permit and accreditations were

147 provided by the Scientific Ethical Committee of the Department of Environment and Housing

148 of the Catalonian Government (Spain). Our methods followed the "Guidelines for the Use of

149 Animals in Research" (Association for the Study of Animal Behaviour and Animal Behavior

150 Society 2012). All recaptured animals showed a good condition with no effects by the

151 manipulation, the transponder or the transmitter. Failed radiotransmitters of recaptured

152 individuals were removed following procedures explained above.

153 Radiotracking was done with a RX-8910HE (Televilt International AB) and three

154 multidirectional and bidirectional antennas (for long, medium and short distances) with a

155 mean precision of 0.2 and 0.1m respectively. Radiolocations were recorded by homing to the

156 animals without triangulation as desman movements follow the river course. The study area

157 did not have proper coverage for GPS systems. Therefore, animal position was recorded and

158 mapped following as reference the 100 m signals of the road that flows parallel to the river (1

159 – 10m distance, mean = 7m). This and the narrow width of the river facilitated the location of

160 the individuals with the precision of the bidirectional antennas being the limiting factor

161 (0.1m).

162

163   Radiotracking was started five-seven days after the animal was released to avoid bias

164 due to recovery from manipulation. Animal location was made daily; during night each

165 individual was radiotracked every 1-2 h ($\breve{x} = 1.2$, SD = 0.3) when they were active and

166 every 10-20 min when inactive to detect the re-start of the activity. During daylight

167 radiotracking was made every 30-60 min. All individuals were tracked for 10-15min after

168 located.

169

170 Activity patterns

171

172 Activity and inactivity behaviour was defined based on time spent outside (activity) or inside

173 (inactivity) the resting site. Diurnal time was set between dawn and dusk for each day and

174 nocturnal between dusk and dawn. Activity (n = 589) versus inactivity (n = 1024) was

175 studied using only radiolocations separated at least 1h to reduce temporal autocorrelation

176 except when individuals changed their behaviour leading to n = 559 and 977 respectively.

177 The influence of sex, age, daylight (diurnal and nocturnal), season (spring-autumn) and

178 number of conspecifics sharing the home range were analysed by means of generalised lineal

179 mixed models (GLMM). Activity was fitted as to a binary distribution, and best model fit was

180 selected based on AIC. Factors were set as fixed effects except for individual that was set as

181 random effect. By considering individual as random effect, we tested individual variation and

182 avoided the problem of different number of repeated measures per individual.

183   For conspecific sharing the territory that also had concurrently radiolocations we

184 analysed if their frequencies of activity per hour were correlated with the activity of the other

185 individual by means of a Pearson correlation. Overall, we had enough concurrently

186 information for two pairs of individuals sharing the space: F1-F3 and M6-M15, and one pair

187 of individuals captured together F10-M11. Radiotracking did not show space overlap

188 between the pair F10-M11 but included it based on the fact that at some point the did share it.

189

190   Space use patterns

191

192   Space use was evaluated based on the home range use in terms of the percentage of the home

193   range utilised during the individuals' daily activity as calculated as lineal meters of river

194   section utilised. Home range size was obtained and exposed in our previously study (Melero

195   et al. 2012). In relation to the movement patterns, we studied the distances travelled during

196   the activity periods per day and the direction of the movement (upstream and downstream)

197   using all radiolocations (n= 1613). Distance travelled per activity bout was defined as the

198   sum of the distances from the resting site to the distal location points without counting

199   sections travelled more than once (because e.g. of forward and backward movements).

200   Percentage of home range used and direction of movement were set to binomial distributions,

201   and distances travelled to a Gaussian distribution. All three variables were tested against the

202   influence of sex, age, daylight (diurnal and nocturnal), season (spring-autumn) and number of

203   conspecifics sharing the home range by means of GLMMs and linear mixed model (LMM)

204   for distances travelled. We followed the same procedure as in the activity analyses for the

205   fixed and random effects.

206   All models were fit in package lme4 and based on Restricted Maximum Likelihood

207   (REML) and package lme done in R. Model selection was based on AIC criteria.

208

209   **Results**

210

211   We obtained the most completed radiotracking and trapping dataset up to date. A total of 30

212   individuals were trapped of which 18 provided enough radiotracking data to study their

213   activity and home range (ten males and eight females). Individuals were tracked for at least 2

214   days and for a maximum of 33 days ($\breve{x} = 25.3$, SD = 10.5; Table 1). The remaining

215   individuals were not radiotracked due to transmitter failure before 2 days of radiotracking.

216

217   Activity pattern

218

219   On average, individuals spent more time inactive than active with 36.51% (SD = 23%) of

220   active radiolocations, 9-10 h of activity per day. In general, the activity of desman was

221   mainly nocturnal although the activity pattern differed between autumn and spring. During

222   autumn, individuals presented two nocturnal, or exceptionally three, activity bouts with an

223   average duration of 5 hours (SD = 1.5) each separated by one (exceptionality 2) inactive

224   period of 100 minutes of average duration (SD = 57.81) commonly happening at 2pm

225   approximately, and a single diurnal activity bout of 73.75 minutes of average (SD = 45.69;

226   Fig. 1a). In spring, however, nocturnal activity was reduced to a single bout ($\breve{x} = 8h$, SD =

227   1.6) without any inactive period but diurnal activity was longer ($\breve{x} = 102$ min, SD = 52.51;

228   Fig. 1b).

229   Best model fit included season and daylight but dismissed sex, age and number of

230   conspecifics in the home range as factors influencing the activity pattern (in addition, in all

231   models $p > 0.1$ for dismissed factors). Both season and daylight had a significant effect on

232   activity ($F = 10.51$, $df = 1$, $p < 0.0001$ and $F = 2.61$, $df = 1$, $p = 0.009$ respectively) although

233   their interaction was not significant ($F = -0.25$, $df = 3$, $p = 0.79$). Overall, individuals

234   presented higher probability of being active at spring nights, followed by autumn nights;

235   however, variability was also highest in them nocturnal spring activity (Fig. 2). Variance due

236   to the random effect was low (7%) indicating low individual variability.

237   All cases where we had enough data on conspecifics sharing the territory showed a

238   significant correlation between their frequencies of activity per hour. This correlation was

239   high in the case of F1 and F3 ($r^2 = 0.83$, $df = 22$, $p < 0.0001$), and lower in the case of M6 and

240   M15 ($r^2 = 0.48$, $df = 18$, $p = 0.001$); similar to the pair trapped together F10 and M11 ($r^2 = $

241   0.31, $df = 21$, $p = 0.006$) (Fig. 3).

242

243   Space use pattern

244

245   Home range was almost completely utilised during their total nocturnal movements in

246   autumn (average percentatge of utilisation $\breve{x} = 76.03\%$, SD = 24.09) with a slightly

247   significant reduction in spring ($\breve{x} = 58.55\%$, SD = 17.10; $F = -2.65$, $df = 1$, $p = 0.01$; Fig.

248   4). During the daylight activity bouts home range was only partially utilised (11.6 % in

249   autumn and 6.2 % in spring with not significant differences, $p > 0.1$; Fig. 4). Best model fit

250   included season and daylight but dismissed sex, age and number of conspecifics in the home

251   range as factors influencing the movement distances (in addition, in all models $p > 0.1$ for

252   dismissed factors). There was no significant variability between individuals (variance due to

253   random effect = 0.9%).

254   Distances travelled by the individuals at each activity bout were highest at night and

255   in autumn (268.5 ± 123.9 m), with significant differences between seasons ($F = 13.77$, $df = 1$,

256     $p < 0.0001$) and daylight ($F = 140.89$, $df = 1$, $p < 0.0001$; Fig. 5

257   ) but not with other factors. As before, best model fit all other factors (in all models $p > 0.07$

258   for dismissed factors). Variability due to individuals was again low (13%). During these

259   displacement movements, individuals were observed to frequently travel from the resting site

260   to the distal site of their home range and afterwards either rest in the same or different resting

261   site or travel to the opposite distal point before resting. In relation to the direction of the

262   movement, best model fit included all factors but there were no differences in the direction of

263   the movement (up or downstream) for any of the models (all p-values > 0.4). Diurnal

264   movements were always one way movement from the resting site and return to the same or,

265   exceptionally, a different resting site. In all cases, individuals' movement was straight

266   forward, without forward and backward movements.

267

268   Spatio-temporal encounters

269

270   Several individuals were found to share the home range for 1- to 24- days (Table 1) and, of

271   them the pairs F1 and F3, and M6 and M15 were both found together in the same location in

272   eight occasions during six and three days of radiotracking respectively. In all the cases did

273   not seem to alter their behaviour for conspecific avoidance. Encounters last from 10 seconds

274   to up 10 min, but no longer than 5 minutes when all individuals were actively moving.

275

276   **Discussion**

277

278   This study provides evidence of the non-avoidance behaviour among individuals of Pyrenean

279   desman. The individual activity and space use patterns of the studied population were not

280   organised to avoid conspecifics. Indeed, we could directly observe encounters between

281   individuals of different or same sex.

282   As previously described by Stone (1987b; 1987a), individuals presented a bimodal

283   activity pattern in spring consisting of primary nocturnal activity bout ($\breve{x} = 8h$) of average

284   and a short activity bout during daylight ($\breve{x} = 102min$). However, we observed a shift from

285   this bimodal activity rhythm to a trimodal and exceptionally tetramodal in autumn. At this

286   time individuals included 1 or 2 nocturnal resting bouts ($\breve{x} = 100min$) and reduced their

287   diurnal activity to a single and shorter bout ($\breve{x} = 73.75min$) without resting time. This

288   activity rhythm was never observed before, probably to the fact that Stone´s previous studies

289   were always done in spring time. This shift in their rhythm is probably related to the

290   individuals' ability to adapt their behaviour to the duration of the night at different seasons.

291 Indeed, the only factors affecting their activity pattern were seasonality and daylight. It is

292 possible that there is also relation between the duration of the diurnal and nocturnal activity

293 and the biomass intake and/or the individuals' energetic requirements. The probability of

294 activity during spring nights increased because there is not resting period and, thus, the

295 probability of finding an individual active was higher, but the duration of the total nocturnal

296 activity is shorter in spring when nights are also shorter than in the studied months of autumn.

297 However, the duration of the diurnal activity bout increases in this spring, which might be

298 related to a necessity of feeding to maintain its energetic requirements. Unfortunately, our

299 data did not provide information to test this hypothesis.

300 Coinciding with Stone's previous studies, individual variation in the activity pattern

301 was very low (7% variation due to individual effect) and independent of their sex, age and,

302 more interesting of the number of conspecifics sharing the home range with them. These

303 results support the previous hypothesis of a common activity pattern between individuals. In

304 fact, for those cases sharing the home range where we had enough data, the activity of the

305 individuals was significant correlated; information that, together with the model, supports the

306 idea of a similar activity pattern between individuals.

307 In concordance with the observed activity pattern, seasonality and daylight were also

308 the only factors influencing the range use and movement pattern of the studied population. In

309 both cases, individual desmans utilised higher percentage of their home ranges and travelled

310 longer distances at night and in autumn (76.03% versus 58.55% in spring nights). During the

311 daylight activity bouts home range was only partial utilised (11.6 % in autumn and 6.2 % in

312 spring with not significant differences, $p > 0.1$; Fig. 4). In addition, individual variation was

313 again low (only 0.9% in the case of the home range use and 13% for travelled distances)

314 which indicated a common pattern with independence of the sex, age or number of

315 conspecifics sharing the home range. This findings, contradict the previous view that

316 described their spatial behaviour based on sexual differences and conspecifics avoidance

317 (Stone 1987a; Stone 1985). Under the hypothesis of individuals being solitary and aggressive,

318 the spatial behaviour of males and females was suggested to differ in order to maintain a

319 mutual avoidance. This was based on the observations that the direction of the movements

320 (upstream or downstream) seemed to differ between sexes which was explained as a pattern

321 to avoid encounters with conspecifics occurring even in paired individuals (Stone 1987a;

322 Stone 1985). In addition, males were observed to travel further distances than female while

323 females mainly stayed in the neighbourhood of the resting site. Controversially, our results

324 support a common spatial pattern for both females and males and a lack of mutual avoidance.

325 Indeed, we observed no differences in the direction of the movement (up or downstream)

326 between sexes, ages, daylight (diurnal and nocturnal), season (spring-autumn) or in relation

327 to the number of conspecifics sharing the home range.

328   Our results indicate a general common behavioural pattern between individual

329 desmans with a lack of mutual avoidance. This is supported by our previous findings were

330 individuals on individuals concurrently sharing resting sites with independence of their sex or

331 age (Melero et al. 2012). Activity and space patterns were previously explained based on the

332 hypothesis of conspecific avoidance. However, our results suggest that individuals of

333 Pyrenean desman do not organise their activity neither opposite their spatial behaviour in

334 order to avoid encounters with conspecifics as previously suggested (Stone 1987b; Stone

335 1987a). Indeed, we could directly observe encounters with individuals without evidence of

336 aggressive behaviour between them. The reasons for the differences between our studies and

337 those by Stone are yet unknown. Differences in prey availability could be the first suggestion;

338 however, there is not available data to test this hypothesis and both rivers seem to present

339 similar resources and conditions. Notwithstanding, our current and previous findings are

340 consistent with the behaviour of the most similar species, the Russian desman (Onufrenya

341 and Onufrenya 1993). This species has similar ecological to the desman but it is considered a

342   semi nomadic and non-territorial (Nowak 1999; Onufrenya and Onufrenya 1993) with social

343   interactions between conspecifics.

344   Overall, based on our current observation and our previous study on the shelter use

345   behaviour, we recall for a new understanding on the species behaviour based on a social

346   organization hypothesis where individuals are non-aggressive neither territorial.

347

348   Management and conservation implications

349

350   Our findings are of significant relevance for management and conservation purposes of the

351   species. The species distribution and status is currently being monitored by several national

352   and international projects in Spain, France and Portugal (e.g. LIFE+ Desmania) mostly by

353   means of indirect signs surveys consisting on annual scat surveys to map its distribution and

354   potential expansion/contraction. In the past, the species distribution has also been mapped

355   using other indirect signs that included not only scats but also interview to local residents.

356   This type of information is, however, less reliable than the current methodology based on scat

357   surveys. None of these methodologies allow identifying individuals and thus, estimating the

358   density. Genetic monitoring using the collected scats will allow identifying individual. Until

359   this is achieved, density estimations could be wrongly estimated if the surveys are based on

360   the previous hypothesis. First, under the hypothesis of desmans being solitary and territorial,

361   density has been calculated assuming a maximum of two (mating couple) individuals per

362   mean home range (e.g. two individuals per 200-500m). However, based on our results there

363   could be more than two individuals in the same home range length and thus, density would be

364   underestimated. Estimation of population density based on presence absence data should be

365   thus updated and used with criticism since until now they were done on the basis of

366   individuals being in couples and maintaining fixed territories (e.g. Nores et al. 1998).

367 In addition, as observed in our previous study Melero et al. (2012) home ranges might not be

368 fixed over the seasons and/or years. Thus, density could also be overestimated based when

369 working with the hypothesis of fixed territories. Furthermore, this hypothesis of fixed

370 territories can overestimate the species distribution, and connectivity between populations.

371 This is due because, as with the density, distribution and connectivity are estimated based on

372 presence absence data (direct captures or presence – absence of signs consisting mainly of

373 scat surveys) assuming desmans do not change their territories. However, we have provided

374 evidences of individuals with passing areas and temporal displaced home ranges.

375   Hence, we recommend population monitoring include shared territories and social

376 interactions that allow more than two desmans per home range. In addition, based on our

377 current and previous results (Melero et al. 2012) we also recommend to include the existence

378 of passing areas and temporal home ranges (individuals changing the size and location of

379 their home ranges) and to prioritize those river sections that are permanently occupied versus

380 those temporally occupied.

381

391

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449

450

451   **Table 1** Radiotracked individuals, number of tracked days and of radiolocations, season,

452   percentage of active radiolocations, size of the home range (meters of river section),total

453   number of conspecifics in their home range for 2- to 24- days and season Adapted from

454   Melero el at. (2012).

Indiv.	Sex	Age at capture	No. of tracked days	No. radiolocations	Season	% active radiolocations	Home range (m)	Conspecifics in home range
F1	Female	Adult	25	111	Autumn	42.34	570	F3
F2	Female	Adult	21	126	Autumn	37.30	520	-
F3	Female	Adult	24	130	Autumn	41.54	430	F1
F4	Female	Adult	9	37	Autumn	35.13	530	M2*
F6	Female	Adult	8	64	Autumn	57.81	450	M5
F9	Female	Juvenile	3	11	Autumn	45.45	-	-
F10	Female	Juvenile	17	136	Spring	42.65	350	-
F11	Female	Adult	19	117	Autumn	19.66	660	-
M1	Male	Adult	34	206	Spring	34.95	530 – 2300[†]	-
M4	Male	Adult	20	112	Spring	40.18	620	F5*
M5	Male	Adult	2	6	Autumn	0	-	F6
M6	Male	Adult	33	232	Spring & Autumn	31.03	550- 1350[†]	F7*, F8, M* M15
M7	Male	Adult	4	20	Spring	30	670	M10*, M12*, M8
M8	Male	Juvenile	16	134	Autumn	35.07	650	M10*, M12*, M7

M9	Male	Juvenile	3	4	Spring	0	-	-
M11	Male	Juvenile	7	48	Spring	41.67	320	-
M15	Male	Adult	7	37	Autumn	37.83	450	M6
M16	Male	Adult	8	75	Autumn	37.33	510	-

455 *marked individuals that did not provide enough information for the analyses.

456 †Outliers due to exceptional one day long movements. Outliers were not taken into account in

457 the analyses.

458

459 **Figure 1** Percentage and standard error of activity per hour of the studied population of

460 Pyrenean desman in (a) autumn (n = 994) and (b) spring (n = 669) seasons. Data was

461 gathered by means of radiolocation.

462

463 **Figure 2** Estimated probability of being active for the studied population of Pyrenean

464 accordingly to daylight (diurnal and nocturnal) and season (autumn and spring). Values are

465 given as mean and their standard error calculated from the GLMM.

466

467 **Figure 3** Estimated activity correlation between pairs of the studied population of Pyrenean

468 desman F3-F1, M15-M6 and F10-M11. Values are given as between percentage of active

469 radiolocations per hour (%). Dotted lines stand for the estimated correlation.

470

471 **Figure 4** Estimated percentage of home range utilised of the studied population of Pyrenean

472 desman accordingly to daylight (diurnal and nocturnal) and season (autumn and spring).

473 Values are given as mean and their standard error calculated from the GLMM.

474

475 **Figure 5** Estimated total distance travelled during the activity bouts of the studied population

476 of Pyrenean desman accordingly to daylight (diurnal and nocturnal) and season (autumn and

477 spring). Values are given as mean and their standard error calculated from the GLMM.

478