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Measuring personality traits in Eurasian red squirrels: a critical comparison of different methods

Running title: Measuring personality in red squirrels

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Conflict of interest

The authors declare no conflict of interest.

Authors' contributions

FS and LAW developed the hypotheses and study design; LAW and FS collected data. FS and SVD analysed data. FS led the writing of the manuscript. AM and DP contributed critically to the drafts. All authors gave final approval for publication.

Data Availability Statement

The data that support the findings of this study are openly available in Zenodo at https://doi.org/10.5281/zenodo.3889846

ABSTRACT

Animal personality, behavioural differences among individuals which are consistent through time and contexts, is generally described by one or more traits. Different methods are used to measure these traits, such as behavioural observations and trapping indices. Comparing several methods allows to validate different tests and to better identify which aspect of an animal's personality is being measured. Here we measured activity, exploration, and immobility of Eurasian red squirrels (*Sciurus vulgaris*) using observations from the open field test (OFT), and compared them with trappability and trap-diversity indices calculated from capture-mark-recapture data in six independent study sites. Trappability measures the willingness to enter a baited trap (boldness), while trap-diversity can be a proxy for exploration tendency. Our first aim was to test their repeatability, thus their appropriateness as candidate measures of personality traits. Next we explored the predictions that: (i) trappability, measuring boldness, does not correlate with any of the OFT personality traits, since risk-taking can not be expressed in our arena test; and (ii) trap-diversity correlates with exploration obtained from the OFT. Considering the species ecology and study design, we used multivariate Bayesian models based on different time-intervals (session/year) and habitat-types (alpine/plain). We found significant repeatabilities for trappability, for trap-diversity, and for most OFT personality traits, except exploration in the plain sites. Independently from habitat-type or time-interval, trappability did not correlate with either activity, exploration, or immobility from OFT, thus measuring a different personality axis, which we considered a proxy for boldness. Trap-diversity did not correlate with exploration from OFT, but seems related to a different aspect of red squirrels' exploration tendency. Our study emphasizes that caution is needed when using behaviours from OFT to measure multiple personality traits and that applying extra methods based on animals' responses to trapping can provide reliable proxies for boldness and exploration tendency.

KEYWORDS

Capture-mark-recapture, open field test, repeatability, *Sciurus vulgaris*, trappability, trap-diversity

INTRODUCTION

Animal personality is defined as consistent among-individual differences in behaviour which persist through time and in different contexts (Carter, Feeny, Marshall, Cowlishaw, & Heinsohn, 2013; Koski, 2014; Réale, Reader, Sol, McDougall, & Dingemanse, 2007) and is commonly described by several underlying personality traits, each of which reflects a particular aspect of an individual's behavioural repertoire (Carter et al., 2013; Réale et al., 2007). Personality has been documented across taxa in several recent studies (insects: Crall et al., 2018; fish: Barber, Mora, Payne, Weinersmith, & Sih, 2017; Jolles, Briggs, Araya-Ajoy, & Boogert, 2019; reptiles: Horváth, Rodríguez-Ruiz, Martín, López, & Herczeg, 2019; Michelangeli, Chapple, Goulet, Bertram, & Wong, 2019; birds: Morinay, Daniel, Gustafsson, & Doligez, 2019; Richardson et al., 2019; mammals: Brehm, Mortelliti, Maynard, & Zydlewski, 2019; DeRango et al., 2019; Petelle, Martin, & Blumstein, 2019) and personality traits such as activity (Michelangeli et al., 2019), exploration (Arvidsson, Adriaensen, Van Dongen, De Stobbeleere, & Matthysen, 2017) and boldness-shyness (Jolly, Webb, Gillespie, Hughes, & Phillips, 2019; Perals, Griffin, Bartomeus, & Sol, 2017) have been quantified using different methods under laboratory conditions and in free-living populations in the wild (Krebs, Linnenbrink, & Guenther, 2019; Réale et al., 2007; Slipogor, Burkart, Martin, Bugnyar, & Koski, 2020; Tkaczynski et al., 2019).

One of the most common assays used in behavioural ecology studies is the open field test (OFT, Walsh & Cummins, 1976; Carter et al., 2013; Montiglio, Garant, Pelletier, & Réale, 2012), where an animal's behaviour in a novel situation is observed. The OFT allows a relatively simple and rapid measurement of an animal's behaviour (Perals et al., 2017) and the quantification of a variety of different personality traits (i.e., boldness: Jolly et al., 2019; Yuen, Schoepf, Schradin, & Pillay, 2017; exploration: Montiglio et al., 2012; activity: Boon, Reale, & Boutin, 2008). Its effectiveness has been recently criticized for simultaneously measuring multiple traits (Carter et al., 2013; Réale et al., 2007), which could lead to difficulties in quantifying a targeted trait (Carter et al., 2013). Nevertheless, combined measures are usually more significant from an ecological perspective and allow to consider possible confounding effects of other traits (Jolly et al., 2019; Koski, 2014), and/or to look for behavioural syndromes (Sih, Bell, & Johnson, 2004; Sih, Cote, Evans, Fogarty, & Pruitt, 2012). Hence, a careful use of the OFT, also relying on biological knowledge and proper metric validation, is advocated (Carter et al., 2013; Krebs et al., 2019; Perals et al., 2017). In this light, measuring different traits with multiple tests increases the certainty of applying relevant tests and the understanding about what they are quantifying (i.e. multi-traits and multi-test approach, Carter et al., 2013; Koski, 2014; Krebs et al., 2019).

Studies in natural populations based on capture-mark-recapture of animals can rely on the sampling method itself to obtain measure of individual behaviour and/or personality. Indeed, individual differences in willingness to enter a baited trap (trappability) can be considered as a measure of an animal's propensity for risk-taking (Bisi et al., 2011; Boon et al., 2008; Boyer, Réale, Marmet, Pisanu, & Chapuis, 2010; Le Coeur et al., 2015; Montiglio et al., 2012; Réale, Gallant, Leblanc, & Festa-Bianchet, 2000; Santicchia et al., 2018a, 2019). Reactions to risky situations, excluding any component of novelty which is exclusively related to exploration propensity (Réale et al., 2007), have been identified in literature as a measure of individual boldness (Réale et al., 2007). Nevertheless, correlations between exploration and risk-taking behaviour have been found (van Oers, Drent, de Goede, & van Noordwijk, 2004) and some studies highlighted that exploration of new environments itself increases the risk of predation (Larsen & Boutin, 1994). Thus, the intrinsic relationship between boldness and exploration needs to be considered and accounted for to properly identify which aspect of an individual's behaviour or personality is measured (Carter et al., 2013; Koski, 2014).

Moreover, also the number of different traps visited (trap diversity) can give insights about an animal's movements in the wild (Boyer et al., 2010; Brehm & Mortelliti, 2018; Santicchia et al., 2018a, 2019; Vanden Broecke et al., 2018). This measure can be both informative of an individual's exploration tendency or its space use (Boyer et al., 2010; Réale et al., 2007). Indeed, in some studies individuals are defined as explorers when they move farther from their core-area in order to obtain information of nearby habitat quality or food resources (Bruinzeel & van de Pol, 2004; Fedy & Stutchbury, 2004; Fraser, Gilliam, Daley, Le, & Skalski, 2001; Tebbich, Fessl, & Blomqvist, 2009; Verbeek, Drent, & Wiepkema, 1994) or potential partners (Neudorf, Stutchbury, & Piper, 1997; Pedersen, Dunn, & Whittingham, 2006). Consequently, exploration has been found to be correlated with movements in the wild, such as dispersal distance (Dingemanse, Both, van Noordwijk, Rutten, & Drent, 2003; Fraser et al., 2001), home range size (Minderman et al., 2010; van Overveld, Adriaensen, & Matthysen, 2011) and number of foraging sites used (Herborn et al., 2010).

Personality trait differences between individuals, measured in studies which rely on the usage of passive trapping methods (Boon et al., 2008; Boyer et al., 2010; Carter, Heinsohn, Goldizen, & Biro, 2012; Michelangeli, Wong, & Chapple, 2016), have been suggested to influence their trappability resulting in a sampling biased towards 'trap-happy/trap-shy' animals (Brehm & Mortelliti, 2018; Carter et al., 2012). However, recent studies highlighted that this, apparently inevitable, bias can be overcome considering a study design and sampling methods based on the animal's ecology and on the assessment of measured traits though a multi-test approach (i.e. convergent/discriminant validity, Carter et al., 2013; Jolly et al., 2019; Michelangeli et al., 2016).

Here we used the OFT to measure activity, exploration and immobility in the Eurasian red squirrel (*Sciurus vulgaris*; Mazzamuto et al., 2019; Santicchia et al., 2020a; Wauters et al., 2019) and capture-mark-recapture data to calculate trappability and trap-diversity indices (Santicchia et al., 2018a, 2019). The main objective was to compare personality traits derived from different methodological approaches. For instance, in sciurid rodents, such methods comparisons have been carried out on the Siberian chipmunk (*Tamias sibiricus*; Boyer et al., 2010) and the North American red squirrel (*Tamiasciurus hudsonicus*; Boon et al., 2008; Brehm & Mortelliti, 2018). Both species are ecologically different from the Eurasian red squirrel. Indeed, North American red squirrels are strictly territorial and actively defend (with aggressive behaviours) a central larderhoard (Boon et al., 2008), while Siberian chipmunks spend most of their time foraging on the ground, caching food in their burrows, which are defended against conspecifics (Tsytsulina, Formozov, Shar, Lkhagvasuren, & Sheftel, 2016). Conversely, the Eurasian red squirrel has a sex-specific social organization with overlapping home ranges, and aggressive behavior and social status vary with body mass, age and ecological context (availability and predictability of food resources; e.g. Wauters & Dhondt, 1989; 1992). Therefore, comparison and validation of methods applied to measure personality traits are required, due to their high species-specificity in rodents (Brehm & Mortelliti, 2018 and references therein) as well as in other wild animals (Tkaczynski et al., 2019).

First, we investigated whether activity, exploration and immobility, as well as trappability and trap-diversity indices, were repeatable and, thus, could be considered as personality traits (Brehm & Mortelliti, 2018). Secondly, we tested if trappability correlates with personality traits from OFT. Since, trappability in our study system reflects risk-taking behaviour (boldness; Santicchia et al., 2018a, 2019), we predicted that it will not correlate with any of the personality traits measured in the OFT, since the arena test we performed is not designed to measure boldness (discriminant validity, Carter et al., 2013). Lack of correlation would indeed indicate that trappability measures a different axis of personality variation than either activity, exploration, or immobility from OFT, supporting the use of trappability as a proxy for boldness. Furthermore, we tested whether trap-diversity, which could reflect exploration tendency (Santicchia et al., 2018a, 2019), correlates with exploration obtained from the OFT, thus capturing the same axis of personality variation (convergent validity, Carter et al., 2013). Here, a lack of correlation would suggest that trap-diversity measures a different personality trait then exploration derived from OFT, possibly due to ecological factors (e.g., squirrel density, habitat patchiness) that might influence trap-diversity but not the behaviour in the arena.

MATERIALS AND METHODS

Study species

Male and female Eurasian red squirrel differ in social organization. Adult females have food-based home ranges and defend their core-areas (most intensively used parts in the home range) against other females (intrasexual territoriality; Wauters & Dhondt, 1992). Older, heavier males are dominant and use the largest home ranges, overlapping with more females than younger males of lower body mass (Romeo, Wauters, Preatoni, Tosi, & Martinoli, 2010; Wauters & Dhondt, 1992). The mating system is promiscuous, although most females only mate with a dominant male of high body mass (Wauters, Dhondt, & De Vos, 1990). Reproduction is seasonal, with one to two litters per year, and is strongly affected by the female's body condition, food availability and, in the mountains, elevation (Rodrigues et al., 2010; Wauters & Dhondt, 1995; Wauters et al., 2008). The species occupies a wide variety of forest types, occurring in both continuous forests and fragmented woodlands. Although red squirrels are well adapted to fragmented habitats and have good dispersal capacities (Thomas, Teich, Dausmann, Reher, & Turner, 2018; Wauters, Verbeylen, Preatoni, Martinoli, & Matthysen, 2010), populations inhabiting forest fragments have lower densities and reduced genetic diversity, and higher endoparasite loads than those in continuous forests (Santicchia et al., 2015;

Wauters, Hutchinson, Parkin, & Dhondt, 1994). Most animals disperse as juveniles and subadults (from 4 to 10 months old, Wauters et al., 2010).

Study sites, trapping and handling squirrels

We trapped red squirrels in three study sites in alpine habitat (Bormio, Cancano, Valfurva) and three in plain habitat (Castelbarco, Vanzago, Passatempo) between January 2016 and December 2019 (Supporting Information Table S1). In alpine habitat only red squirrels were present, while in the study sites in the plain habitat, red squirrels co-occurred with invasive alien grey squirrels (*Sciurus carolinensis*). Since the alien species was controlled for red squirrel conservation, its numbers were low throughout the study (Santicchia et al., 2018b; Wauters et al., 2019). In both habitats, two study sites were high-quality forests or woodlands, and one study site in each habitat-type was of lower quality (fewer food resources and/or extreme weather conditions in winter; Supporting Information S1). Capture-mark-recapture (CMR) sessions were carried out two times per year in the alpine sites and from two to six times per year in the plain sites, each session lasted from three to six days. Number of traps varied between study sites (Supporting Information Table S1). We used Tomahawk "squirrel" traps (Model 202, Tomahawk Live Trap Co., Hazelhurst, WI, USA), placed on the ground or at breast height against tree trunks. Traps were more or less homogeneously distributed over the study site, with distances of 50-150 m between them and average trap-density ranging from 0.29 to 1.05 traps ha^{-1} (details in Supporting Information Table S1). We pre-baited traps with hazelnuts three to four times over a 30 day period, then baited and set for capture session. We partly covered the traps with dark plastic bag to provide animals with shelter, and checked traps three times/day to minimize time in trap. Before handling, we completely covered the trap with a cloth to reduce stress. We flushed the trapped animal in a zipper-tube handling bag to reduce direct contact with the operator. At first capture, we marked each squirrel with a Monel 1005 1L1 ear-tag (size 2.3 – 10 mm, 0.2 g or less than 0.1% of squirrel's body mass; National Band & Tag Co. Newport, KY, USA), putting the tag near the base of the ear to reduce risk of injury. To reduce stress, only trained researchers handled the squirrels, and handling time was kept as short as possible (< 5 minutes). Each animal was weighed to the nearest 5 g using a spring-balance (Pesola AG, Baar, Switzerland) (Wauters et al., 2007). Sex and age class were determined from external genitalia and body mass, with juvenile red squirrels weighing less than 250 g (Wauters & Dhondt, 1989). Only two juveniles were included in our dataset.

Arena test personality measures

After checking a red squirrel's identity, we released it inside a portable arena by opening a sliding door and allowing the animal to move from the handling bag into the arena (Mazzamuto et al., 2019). The arena was placed within 20 m of the trap location. We performed the OFT (4 minutes) which serves to estimate activity, exploration and immobility in a novel environment (Mazzamuto et al., 2019; Santicchia et al., 2020a; Wauters et al., 2019; details in Supporting Information S2). At the end of the experiment, the squirrel was released by opening the sliding door. For each experiment we calculated the time that individuals spent in each behavioural state (behaviours defined in Table S2) using the CowLog 3.0.2 software (Hänninen & Pastell, 2009). To reduce the number of behaviours observed into few personality-linked variables we used the expert-based method (EB; Mazzamuto et al., 2019). The EB approach is a classification of behaviours into groups, summing the values of the single behaviours to obtain scores for few personality-linked variables, based on researchers' previous knowledge. This method was validated (Carter et al., 2013) for red squirrels by comparing its classification outcome and scores with those derived from PCA or Factor Analysis (Mazzamuto et al., 2019). Ethogram description and details in Supporting Information S2 and Table S2. To check the assumptions of repeatability of the OFT traits, the majority of squirrels were tested multiple times to have repeated measures for most individuals.

Ethical note

Trapping, marking and handling of red squirrels and arena test experiments were carried out in accordance with the Guidelines for the treatment of animals in behavioural research and teaching (Animal Behaviour, 2020, 159, I-XI; https://doi.org/10.1016/j.anbehav.2019.11.002). Approval and legal requirements according to the Italian Wildlife Protection and Hunting Law L.N. 157 from 1992 and authorizations N. 294-34626 of 12/09/2014 (2014-2016) from the Provincia di Torino and N. 62-3025 (2017-2019) from the Città Metropolitana di Torino, and Decreto N. 11190 (29/11/2013) and decrees N. 9523 of 15/10/2014 and N. 198 (13/01/2017) from Direzione Generale Agricoltura, Regione Lombardia; and the permission Protocol N. 414 of 28/02/2014 of the Stelvio National Park.

Trappability and trap-diversity indices

For each individual we calculated a trappability and a trap-diversity index, and investigated whether they can be considered personality-linked variables in our study species and populations. In previous studies trappability was considered a proxy of the tendency to take risks (boldness) and trap-diversity a proxy of the propensity to explore the environment (exploration) (Santicchia et al., 2018a). As outlined by Brehm and Mortelliti (2018), caution is necessary when considering these indices as proxies of personality. In effect, trappability has been demonstrated to differ between sexes, ages, study sites, seasons and years (see Brehm & Mortelliti, 2018 and references therein). Therefore, we calculated trappability and trap-diversity at different time-intervals; per trapping session and per year; as well as for both habitat-types (alpine and plain) separately. We included only individuals that were captured at least in two capture sessions, during the period of the study, to avoid sampling bias due to: (i) potential dispersers (i.e. animals that were captured only one time and dispersed away from the study site); (ii) old animals (i.e. animals that were captured only one time because they died at the start of the study period); and (iii) new animals caught only at the end of the study (i.e. animals that were captured only one time because settled in the study site at the end of the study period). Number of available traps per study site did not change during the study period (details in Supporting Information Table S1).

Trappability per session (TBs) was estimated from the ratio of number of captures in session *i* on the number of capture days in session *i*. Trap-diversity per session (TDs) was calculated from the ratio of the number of different traps an individual was captured in session *i* on the number of available traps.

TBs (trappability session *i*) = n. captures session *i* / n. capture days session *i*

TDs (trap-diversity session *i*) = n. different traps captured session *i* / n. available traps site

Trappability per year (TBy) was calculated from the ratio of the number of captures in year *i* on the number of capture days an individual was present in year *i*. Each individual was considered present in the study site, thus potentially catchable, from the first to the last session in which it was captured. Number of capture days an individual was present in the study site included all capture days of the first and the last session an animal was captured, and also all capture days of sessions in-between these two. This allowed us to estimate number of capture days an individual was present on a yearly basis. Trap-diversity per year (TDy) was estimated from the ratio of the number of different traps an individual was captured in year *i* on the number of available traps.

TBy (trappability year *i*) = n. captures year *i* / n. capture days presence year *i*

TDy (trap-diversity year *i*) = n. different traps captured year *i* / n. available traps site

Repeatability of OFT personality traits, trappability and trap-diversity

We estimated the repeatability of the OFT personality traits and of the trappability and trap-diversity indices for each habitat-type (alpine and plain) separately and for both session and year time-periods (Table 1). Repeatabilities were calculated with a Linear Mixed Model (LMM; Nakagawa & Schielzeth, 2010) using the R package 'rptR' v 0.9.22 (CI = 95%, number of parametric bootstraps for interval estimation = 2000, number of permutations used when calculating asymptotic p-values = 1000; Stoffel, Nakagawa, & Schielzeth, 2017) and estimates were considered significant based on confidence intervals and the p-value of a Likelihood Ratio Test (LRT), that compares the fit of a model with ID as random effect (estimating the within-individual variance) and the same model without the random effect (Nakagawa & Schielzeth, 2010; Table 1).

Each model with one of the OFT personality trait as dependent variable (activity, immobility, exploration) included study site, sex, year, arena test order (categorical factor: first [coded as 1] vs. subsequent ones [all coded as 0], based on results from earlier studies which showed that scores of OFT personality traits differed between the first arena and all the subsequent ones; Dingemanse et al., 2012; Santicchia et al., 2020a; Wauters et al., 2019), and number of days from the previous arena test as fixed effects. Squirrel identity (ID) was added as random effect. Arena test order and number of days from the previous test were included to account for habituation and temporal proximity between two tests (number of days between subsequent tests: alpine sites, median 132, mean ± SE = 185 ± 12, range 1 – 611 days; plain sites, median 146, mean ± SE = 157 ± 10, range 1 – 622 days; details in Supporting Information S3) (Mazzamuto et al., 2019; Montiglio, Garant, Thomas, & Réale, 2010; Dingemanse et al., 2012). All repeatabilities were calculated on squareroot transformed values of proportion time for each OFT personality trait and assumptions of normality of the residuals was confirmed by Shapiro-Wilk's test (W > 0.90). Also squirrels that had only one estimate for the OFT personality traits were included in the repeatability estimates (following Martin, Nussey, Wilson, & Réale, 2011).

We calculated repeatability of trappability and trap-diversity for individuals with at least one arena test (see Table 1). We run four separate models for these indices (TBs, TDs, TBy, TDy) with each of them as dependent variable and study site, sex, year as fixed effect, and squirrel identity as random effect. All repeatabilities were calculated on squareroot transformed values of trappability and trap-diversity, and assumptions of normality of the residuals was confirmed by Shapiro-Wilk's test (W > 0.90). Full model outputs are provided in Supporting Information, Tables S3 and S4.

Relationship between OFT personality traits, trappability and trap-diversity

Since we calculated trappability and trap-diversity both based on session and year, and since the relationship between them and the OFT personality traits can be influenced by differences in habitat-type (alpine or plain; see Brehm & Mortelliti, 2018), we performed four multivariate Bayesian generalized linear mixed effects models based on a Markov Chain Monte Carlo algorithm with the R package MCMCglmm version 2.29 (Hadfield, 2010). Before the analysis we selected our data including individuals that were present at least in two capture sessions to avoid any bias (as described above in '*Trappability and trap-diversity indices*') and excluding missing values for OFT personality traits and trappability, trap-diversity indices.

Models based on session were conducted on a subset (alpine sites: n = 182, ID = 69, males/females = 44/25; plain sites: n = 244, ID = 90, males/females = 51/39) which included personality traits derived from the first OFT of each session for each red squirrel and the relative TBs (trappability/session) and TDs (trap-diversity/session) value. While models based on year were conducted on another subset (alpine sites: n = 127, ID = 69, males/females = 44/25; plain sites: n = 165, ID = 90, males/females = 51/39) which included personality traits derived from the first OFT of each year for each red squirrel and the relative TBy (trappability/year) and TDy (trap-diversity/year) value.

The OFT personality traits squareroot transformed scores (immobility, activity and exploration) were treated as dependent variables after centering and scaling [(x_i – mean x)/SD x] with a Gaussian residual error distribution. In the plain sites exploration was not repeatable but was included in the models to allow comparisons between model outputs. Also squareroot transformed values of indices (TBs, TDs, TBy, TDy) were included as dependent variables after standardization within study site because of site-related differences in capture histories and available traps (details in Supporting Information Table S1). In addition, sex, year, arena test order (categorical factor: first [coded as 1] vs. subsequent ones [all coded as 0], see Santicchia et al., 2020a; Wauters et al., 2019), study site, and body mass (centered and scaled) were added as fixed effects. In all models, the effect of arena test order and study site was only estimated for the OFT personality traits. Models based on session included also season [winter (December to February); spring-summer (March to July); autumn (September to November)] as fixed effect, which was only estimated for trappability and trap-diversity indices, since variation in food availability across seasons could influence the attractiveness of the baited traps. As repeated observations were present, and to estimate both among-individual and within-individual variation of the dependent variables, individual (ID) was added as random effect. Assumption of normality of the dependent variables was supported by their QQ-plots.

For both the residual and between-individual variation, an unstructured variance-covariance matrix was modelled, allowing the estimation of correlations among the dependent variables (covariance divided by the square root of the product of the variances). Posterior distributions were based on 1050000 iterations with a burn-in of 50000 iterations and thinning of 400, such that 2500 iterations were used to obtain point estimates and 95% credibility intervals. For all fixed effects related parameters (i.e., intercept, slopes, differences), the prior distribution was Gaussian with zero mean and variance equal to 10^8 (default setting in MCMCglmm). We used non-informative (parameter-expanded) inverse Wishart prior [prior specifications: R structure degree of belief (nu) = 0.002; G structure degree of belief (nu) = 5, alpha.mu = rep (0, 5), alpha.V = diag (25^2, 5, 5); Houslay & Wilson, 2017]. We applied the Gelman-Rubin statistic (Gelman & Rubin, 1992) and Geweke diagnostic (Geweke, 1992) which confirmed model consistency and convergence. Full model outputs are provided in Supporting Information, Tables S5, S6, S7 and S8.

RESULTS

OFT personality traits

We performed 273 OFT on 144 different red squirrels (95 males, 49 females) in alpine sites and 309 OFT of 120 individuals (65 males, 55 females) in plain sites (Table 1). In the Alps, 68 animals were tested more than 1 time (197 arena tests) while 76 animals were tested only once. In the plain, 76 individuals were tested more than 1 time (265 arena tests) and 44 animals tested only once. During OFT, red squirrels in both habitat-types spent most time in behaviours related to activity and immobility and little time in exploration (Table 1). We found moderate repeatabilities ($R > 0.31$; see also Bell, Hankinson, & Laskowski, 2009) for activity and immobility in alpine and plain sites and low repeatabilities ($R < 0.20$; Bell et al., 2009) for exploration in alpine sites (Table 1). The repeatability of exploration in plain sites was low and not significant (Table 1).

Trappability and trap-diversity indices

We calculated trappability and trap-diversity per session and year on 70 red squirrels (45 males, 25 females) in alpine sites and on 90 red squirrels (51 males, 39 females) in plain sites (Table 1). Number of captures, number of different traps, and number of capture days, calculated for each individual, based on different habitat-types and time-intervals, are described in Table 2. Trappability and trap diversity reported a moderate repeatability (all $R > 0.30$) in alpine sites, but a lower repeatability in plain sites (all $R < 0.30$; Table 1). In both habitat-types, repeatability values of indices based on year are higher than those based on session, although confidence intervals largely overlap (see Table 1 for details).

OFT personality traits, trappability and trap-diversity relationships

Alpine sites

In alpine sites, the model with personality traits, trappability (TBs) and trap-diversity (TDs) indices based on session, reported a strong and negative correlation between immobility and activity ($r = -0.85$; 95% CI = -0.98 to -0.62; Figure 1, Table S9) and a strong positive correlation between TBs and TDs ($r = 0.82$; 95% CI

= 0.13 to 0.99; Figure 1, Table S9). Moreover, there was a positive correlation between immobility and TDs (r = 0.71; 95% CI = 0.09 to 0.99; Figure 1, Table S9). All the other correlations between immobility, activity and exploration, TBs and TDs had 95% CIs that included 0 and thus can be considered not significant (Figure 1). Males had higher TBs and TDs than females and squirrel body mass was positively related with exploration and TDs (details on the MCMCglmm output in Table S5).

In the model based on year, all correlations between the dependent variables included 0 in the 95% CIs (Figure 1). Males had a higher TBy than females, while there was no effect of sex on TDy or on any of the OFT personality traits. Body mass did not affect any of the dependent variables (details on the MCMCglmm output in S7).

Plain sites

For the plain sites, the model based on session reported only a strong and negative correlation between immobility and activity (r = -0.92; 95% CI = -0.99 to -0.81; Figure 1, Table S9). All the other correlations between immobility, activity and exploration and TBs and TDs were not significant (Figure 1, Table S9). Males had higher TBs and TDs than females but there was no significant relationship of body mass with any of the dependent variables (details on the MCMCglmm output in Table S6).

Similarly, the same model based on year had no significant correlations among the OFT personality traits (immobility, activity and exploration) or between OFT traits and TBy and/or TDy (Figure 1, Table S9). In this habitat-type, males had both higher TBy and higher TDy than females, while there was no relationship of body mass with any of the dependent variables (details on the MCMCglmm output in Table S8).

DISCUSSION

Through the use of the OFT we measured activity, exploration and immobility in the Eurasian red squirrel (*Sciurus vulgaris*), while capture-mark-recapture allowed us to estimate trappability and trap-diversity indices, which can be related to boldness and exploration, respectively. We tested their repeatability, thus their appropriateness as candidate variables of personality traits, and, to test our hypotheses, explored their posterior correlations derived from the multivariate MCMCglmm models. We found significant repeatabilities for all five variables, except for exploration from OFT in the plain habitat-type. Trappability did not correlate with any of the personality traits measured in the OFT, and trap-diversity did not correlate with exploration measured in the OFT.

Repeatability of OFT personality traits

Personality traits activity and immobility, measured in the OFT, had a moderate repeatability, suggesting they are reliable personality traits for red squirrels, in both alpine and plain sites (Brehm & Mortelliti, 2018; Carter et al., 2013). This is similar to other studies on the same species, where repeatabilities for activity and immobility were also moderate (Mazzamuto et al., 2019; Santicchia et al., 2020a; Wauters et al., 2019), and on other studies on rodents where repeatability of activity measured in the OFT were from moderate to high (*Tamiasciurus hudsonicus*: Boon et al., 2008; *Tamias striatus*: Montiglio et al., 2012; *Sciurus carolinensis:* Mazzamuto et al., 2019, Santicchia et al., 2020b; *Marmota flaviventer*: Petelle et al., 2019; *Peromyscus maniculatus*, *Myodes gapperi*, *Blarina brevicauda:* Brehm et al., 2019, Brehm, Tironi, & Mortelliti, 2020).

Conversely, exploration had a low repeatability in alpine sites (R=0.18), and repeatability was not significant in plain sites. Recent studies on rodents measured exploration in the OFT using different variables, such as duration or frequency of behaviours observed, and reported repeatabilities from low to moderate (*Marmota flaviventer*: Petelle et al., 2019; *Myodes glareolus*: Schirmer, Herde, Eccard, & Dammhahn, 2019). Previous studies on the same species and on a different squirrel species also found low repeatability values for exploration measured in the OFT (*Sciurus vulgaris*: Santicchia et al., 2020a; Wauters et al., 2019; *Sciurus carolinensis*: Santicchia et al., 2020b) and among-individual variation in the duration of exploration behaviours in the OFT was low, compared to other behavioural measures taken during the same tests (see Table S2, Santicchia et al., 2020b; Table 1, Santicchia et al., 2020a; Table 2, Wauters et al., 2019). Hence, behaviours related to pure exploration by this species occur rarely in such tests.

Furthermore, studies on other squirrel species which measured personality in the OFT found that, when applying multivariate reduction techniques, behaviours related to activity and exploration grouped on the same component (*Tamias striatus*: Martin & Réale, 2008; *Tamiasciurus hudsonicus*: Boon et al., 2008), even when appropriate tests were designed to separate measures of the two personality traits (i.e. hole-board test: File & Wardill, 1975). Hence, separating exploration from activity is critical and not always possible, since they are strongly and positively associated in several squirrel species (Boon et al., 2008; Boyer et al., 2010; Martin & Réale, 2008; Patterson & Shulte-Hostedde, 2011). This highlights how, in different squirrel species, the OFT might not be the best way to measure exploration separately from activity (Boon et al., 2008; Boyer et al., 2010; Martin & Réale, 2008; Santicchia et al., 2020a,b; Wauters et al., 2019).

Moreover, aside this criticism, the low or even non-significant repeatability values of exploration found in the present study could also be related to high levels of plasticity in exploration behaviours (flexible component of personality, e.g., Dingemanse et al., 2012). This has been suggested, but on a different personality trait, in a previous study on the same species, which measured the personality trait "sociability" with and without an invasive competitor present (Wauters et al., 2019). In our plain study sites, red squirrels are in syntopy with the alien Eastern grey squirrel (*S. carolinensis*), contrary to alpine sites where they occur without other tree squirrels competitors, and it is not unlikely that the presence of the invasive species could advantage individual red squirrels with more flexible exploration behaviours (context related plasticity; see also Sih et al., 2012; Wauters & Dhondt, 1993).

Repeatability of trappability and trap-diversity

Trappability has been measured in several studies on animal personality and, as examined by Brehm and Mortelliti (2018), erroneously used as a proxy for personality traits based solely on its correlation with other traits without testing its own repeatability. Moreover, in their study, these authors highlighted how a trappability measure can be highly species specific and contingent on environmental factors. Hence, the need to estimate the repeatability of trappability, separately from other traits, before using it as a proxy for personality. This is paramount for every candidate personality variable, and should be common practice in animal personality studies (Brehm & Mortelliti, 2018; Carter et al., 2013).

Here we found moderate repeatabilities of trappability and trap-diversity in alpine sites [annual 0.33 and 0.50 respectively; Table 1], while in plain sites they were lower [annual 0.27 and 0.20 respectively; Table 1]. Both these indices have been found to measure individual differences in personality also in other studies on sciurid rodents, which reported moderate to high repeatabilities (*Tamias sibiricus*: Boyer et al., 2010; Le Coeur et al., 2015; *Sciurus vulgaris*: Santicchia et al., 2018a; *Sciurus carolinensis*: Santicchia et al., 2019).

Repeatabilities differences by habitat-type and time-intervals

In the present study, we measured personality traits in two different habitat types (alpine and plain) which differ in forest type, thus in resources availability (Supporting Information S1). Previous studies showed that spatio-temporal variation in habitat quality (in particular tree-seed availability) influences tree squirrel population dynamics, space use and behaviour (Boutin et al., 2006; Lurz, Garson, & Wauters, 2000; Thomas et al., 2018; Wauters & Dhondt, 1992; Zong et al., 2014). Hence, also the costs and benefits of certain personality traits may vary in space (habitat) and/or over time.

As far as habitat type was concerned, trappability and trap-diversity repeatabilities, as well as those calculated for activity, immobility and exploration measured in the OFT, seemed to be higher in alpine sites than in plain sites. Differences in behavioural consistency between habitat types have been investigated comparing urban and rural populations (Hardman & Dalesman, 2018) and individuals with a high behavioural flexibility have been suggested to adapt better to urban landscapes (Lowry, Lill, & Wong, 2013). This suggests that Eurasian red squirrels inhabiting plain sites, which are not urbanized but still more anthropogenically disturbed semi-natural sites, are likely to have higher flexibility in their behaviours compared to populations in alpine sites. However, this was not confirmed by our data since the confidence intervals of repeatability estimates partially overlap (see Table 1 for details; Hardman & Dalesman, 2018). Comparisons of personality traits repeatability across populations and/or habitat-types is beyond our scope, but future studies may wish to explore this, since it has been rarely investigated (Dingemanse et al., 2012; van Dongen, Maldonado, Sabat, & Vásquez, 2010; Hardman & Dalesman, 2018).

Moreover, our study has been conducted across four consecutive years, which allowed us to measure personality of red squirrels during the major part of their lifetime (average lifespan 3-4 years; Lurz, Gurnell, & Magris, 2005; Wauters & Dhondt, 1995). As detailed in methods section, we calculated trappability and trap-diversity for different time-intervals (session and year), where the short time-interval measure, allowed us to control for possible confounding effect due to seasonal variation in capture rates. Conversely, a long time-interval, covers a wider range of individual responses to trapping, and thus could allow to distinguish more clearly bold from shy animals and high from low explorers. Also, studies on other rodent species measured the repeatability of personality variables on an appropriate timescale based on study species lifespan: trappability on a yearly basis (Siberian chipmunk generation length 3-4 years; Boyer et al., 2010; Tsytsulina et al., 2016); or within a single capture session (several small rodent species that have a nearly complete population turnover from one year to the next, Brehm & Mortelliti, 2018). In red squirrels, we indeed found slightly higher year-based than session-based repeatabilities of trappability and trap-diversity, in both habitat-types, albeit with overlapping confidence intervals (Table 1). As mentioned above, this difference might be due to a higher among-individual variance in personality traits measured on a yearly than on a short-term (session) basis. A relatively higher variance accounted for by differences among individuals in relation to within-individual variance would indeed result in higher repeatability values (Bell et al., 2009; Brehm & Mortelliti, 2018; Carlson & Tetzlaff, 2020; Nakagawa & Schielzeth, 2010). This could be related to the relative stability of capture rates measured over a longer time-interval (year) compared to those based on shorter time-intervals (session). Indeed, a shorter time-interval measure (session) is more sensitive to stochastic (e.g. seasonal) factors affecting capture rates (e.g. Tkaczynski et al., 2020).

Bias of trappability and trap-diversity

In the present study, trappability and trap-diversity, for both habitat-types and based on session and year, has been found to be repeatable, thus a measure of personality traits. However, measures obtained from passive trapping methods, such as the baited traps that we used here, have been criticized for causing personality-biased sampling towards the boldest individuals in a population, leading to a lack of sampling on those animals that are hard to capture (Biro & Dingemanse, 2009; Jolly et al., 2019; Michelangeli et al., 2016). Recent studies on rodents explored this issue and highlighted how different aspects, mainly related to sampling design and species ecology, need to be accounted for in such studies (Brehm & Mortelliti, 2018; Jolly et al., 2019).

Studies on capture-mark-recapture of Eurasian red squirrels in alpine habitats found how in the same session recapture probabilities were high, suggesting that the probability to miss squirrels present in the study site were low (Wauters et al., 2008). Also, studies on the same species in lowland habitat detailed that after a certain number of days (five days) no additional new unmarked squirrels were trapped (Wauters & Dhondt, 1993; Wauters, Matthysen, Adriaensen, & Tosi, 2004). In general, in the present study, we observed that during the lasts days of capture in each session nearly all captures were related to already marked squirrels. Nevertheless, we cannot entirely rule out the possibility that we missed some extremely shy individuals, but at worst, this makes our data and comparisons more conservative. That we sampled a broad range of responses to the traps is further supported by the high variation in our trappability and trap-diversity measures (see Table 1 for details). Thus, we are confident that our measure of trappability and trap-diversity are only minimally biased towards bolder and more explorative animals (Biro & Dingemanse, 2009).

Also neophobia has to be considered in studies which rely on passive trapping methods (Jolly et al., 2019; Michelangeli et al., 2016). The capture-mark-recapture method applied on squirrels relies also on a pre-baiting phase, which consist in placing inactive baited traps at fixed points in the study sites and repeatedly replenish the bait over a 30 day period before each trapping sessions (Wauters et al., 2008). Therefore, a repeated exposure to the baited traps before capture sessions, along with increasing trapping success, decreases the possibility of rejection by neophobic/shy individuals (Michelangeli et al., 2016). Finally, a careful sampling design which provides an appropriate number of available traps to avoid trap saturation must be considered (Jolly et al., 2019). Indeed, the presence of alien species competitors, as in our plain sites, could decrease trap availability for the target species since in those sites there is no niche partitioning between the species (Santicchia et al., 2018b; Wauters, Gurnell, Martinoli, & Tosi, 2002; Wauters et al., 2019). In the present study this is unlikely since in the majority of trapping sessions less than 30% of the traps were occupied during a trap-control round [in alpine sites on average 30% (range 5-60% per trapping occassion) of traps were simultaneously unavailable, while in plain sites the average was 20% (range 2-46%)].

Relationships between OFT personality traits, trappability and trap-diversity

Among the three personality traits measured with OFT, activity and immobility were negatively correlated in both habitat types, but only when estimated in session. This was expected since these two traits are measured along a continuum of high to low time spent moving in the arena (Mazzamuto et al., 2019). That the correlations were stronger at the session rather than the annual level was probably due to having used more arena tests per individual at the session level. Therefore, it is likely we obtained more accurate estimates of traits measured in sessions, leading to greater statistical power to detect the correlations.

In the alpine sites, we found a positive correlation between immobility from OFT and trap-diversity. This correlation was evident only at session level, and only in this habitat-type; hence it could be a spurious result. In fact it is counter intuitive, since these squirrels with high trap-diversity were mostly males and/or animals of high body mass; hence individuals expected to use large home ranges (Romeo et al., 2010; Wauters & Dhondt, 1992). An alternative explanation is that squirrels show habituation to the OFT, indeed repeated exposition to the same test can cause a decrease in responses to novelty (Martin & Réale, 2008; Réale et al., 2007) as already observed in some traits (Dingemanse et al., 2012; Perals et al., 2017). Hence, this potential habituation, measured by an increase in expression of immobility-related behaviours (see Supporting Information Table S5), seems to be stronger in animals with high trap-diversity.

Following the general goal to capture a wide range of traits to increase awareness of what is actually measured (Carter et al., 2013; Koski, 2014), we compared personality traits obtained from the OFT with trappability and trap-diversity indices. Since the personality traits that we measured in the OFT were related to activity, immobility and exploration (Mazzamuto et al., 2019; Santicchia et al., 2020a; Wauters et al., 2019), we predicted that trappability (boldness; Santicchia et al., 2018a, 2019) would not correlate with any of them. Our results demonstrated that trappability, whether based on sessions or year, was not correlated with any of the personality traits measured in the OFT (Figure 1), thus measures a different axis of personality variation. These findings, found in both habitat types, support that trappability is a proxy for boldness in red squirrels (see Santicchia et al., 2018a, 2019). Moreover, this measure is based on the individual number of captures, thus the propensity of each animal to enter in a trap. Since entering a trap also results in the animal being handled, the entire process is likely to be stressful, but despite this, the animals overcome the fear in order to obtain the bait (i.e. bighorn sheep; Réale et al., 2000). Hence, we are confident that our trappability actually measures the willingness to take risks (boldness; Réale et al., 2007).

Previous studies on rodents explored the relationship between personality traits measured in the OFT and number of captures (trappability) reporting different results. Boon et al. (2008) found that activity-exploration of the North American red squirrel (*Tamiasciurus hudsonicus*) was positively related with the number of captures, but they did not test repeatability of the latter. Boyer et al. (2010), found a positive relationship between *Tamias sibiricus* activity-exploration in an arena test and trappability, both having significant repeatabilities. Also, they found a positive relationship between number of captures (trappability) and number of different traps (trap-diversity) used by an individual. Similarly, in this study, as in other studies on tree squirrels (Santicchia et al., 2018a, 2019), we found a strong and positive correlation between the two capture indices based on session, but only in alpine sites (Figure 1). That they are related to some degree is inherent to the estimates; a squirrel can not have a high trap-diversity index when trapped very few times (low trappability). In contrast, animals with high trappability might be captured nearly always in the same trap, hence having a low trap diversity score. The fact that we found a positive correlation only in one habitat-type and only when estimated per session, suggest that the two trapping indices indeed measure two different personality traits.

Some studies found contrasting results. In a large-scale experiment on four rodent species and a shrew, Brehm and Mortelliti (2018) found that number of captures in a session (trappability) was not repeatable and that there was no correlation between trappability and activity-exploration measured in an OFT. These examples highlight that trappability not always reflects a personality trait and its applicability is species-specific (Brehm & Mortelliti, 2018).

Finally, we predicted that trap-diversity (exploration; Santicchia et al., 2018a, 2019) would correlate with exploration measured in the OFT, capturing the same axis of personality variation. Our results did not confirmed our prediction, indeed we found that trap-diversity, albeit repeatable, was not correlated with exploration from OFT, for both habitat-types and time-intervals (Figure 1). Similarly, in introduced Siberian chipmunks (*Tamias sibiricus*) there was no association between trap-diversity and exploration measured with arena-tests (Boyer et al., 2010). They suggested that trap-diversity was mainly a proxy for space use, which apparently was independent from activity-exploration propensity of chipmunks. In contrast, in territorial American red squirrels (*Tamiasciurus hudsonicus*), activity-exploration was positively related with the number of different trapping locations (Boon et al., 2008), suggesting that a high number of different trapping locations was positively related to a high number of extra-territorial exploratory movements.

Our alternative prediction included the possibility that trap-diversity measures a different axis of personality variation than exploration obtained from the OFT. In this study, trap-diversity measures were based on capture-mark-recapture data that rely on how squirrels move inside their home ranges and visit the available traps. Therefore, it is likely that trap-diversity actually measures an individual's exploration in a known environment (its home range). Conversely, exploration in the OFT was measured in a context different from the natural environment, probably mainly related to the novelty aspect of exploration as defined by Réale et al. (2007). It is likely that these intrinsic differences between the two measures of exploration are responsible for the lack of correlation between trap-diversity and exploration derived from the OFT; in other words they are measuring different personality traits. That estimates of exploration behaviour in a species can be highly context (test situation) specific was also demonstrated by Arvidsson et al. (2017) who found that an activity-exploration score of individual great tits (*Parus major*) derived from the classical arena design was not correlated with scores obtained from tests in a different, much larger arena structure. Furthermore, in our species and study design, both the expression of exploration-linked behaviours in the OFT and the repeatability of exploration itself where low. Hence, the OFT does not seem a reliable method to quantify exploration tendency in Eurasian red squirrels. Finally, for several of our correlations the CI's are wide, in particular for variables with low repeatabilities (Bell et al., 2009). In such instances among-individual variation may be insufficient to detect the covariations reducing the biological meaning of the non-significant correlations.

CONCLUSIONS

We conclude that activity and immobility obtained from the OFT are reliable measures of red squirrel's personality, as well as trappability and trap-diversity indices derived from capture-mark-recapture data. These personality traits are consistent in different habitat-types (alpine and plain) and when measured over different time-periods (per session or per year). In contrast, exploration measured in the OFT, occurred at low frequencies and had poor (alpine habitat-type) or even non-significant repeatabilities (plain habitat-type). Based on our findings we are confident that trappability is indeed an appropriate measure of boldness, while, contrary to our expectation, trap-diversity does not reflect exploration obtained from the OFT but seems to be related to a different aspect of red squirrels' exploration tendency. Albeit our hypotheses were mainly focused on exploring relationships between different methods to measure personality traits (testing convergent/discriminant validity, Carter et al., 2013), this study underscores that careful application is needed when using OFTs or animals’ responses to traps in studies of personality, and that it is paramount to consider the environmental context in which the species is studied, and its social organization and life-history.

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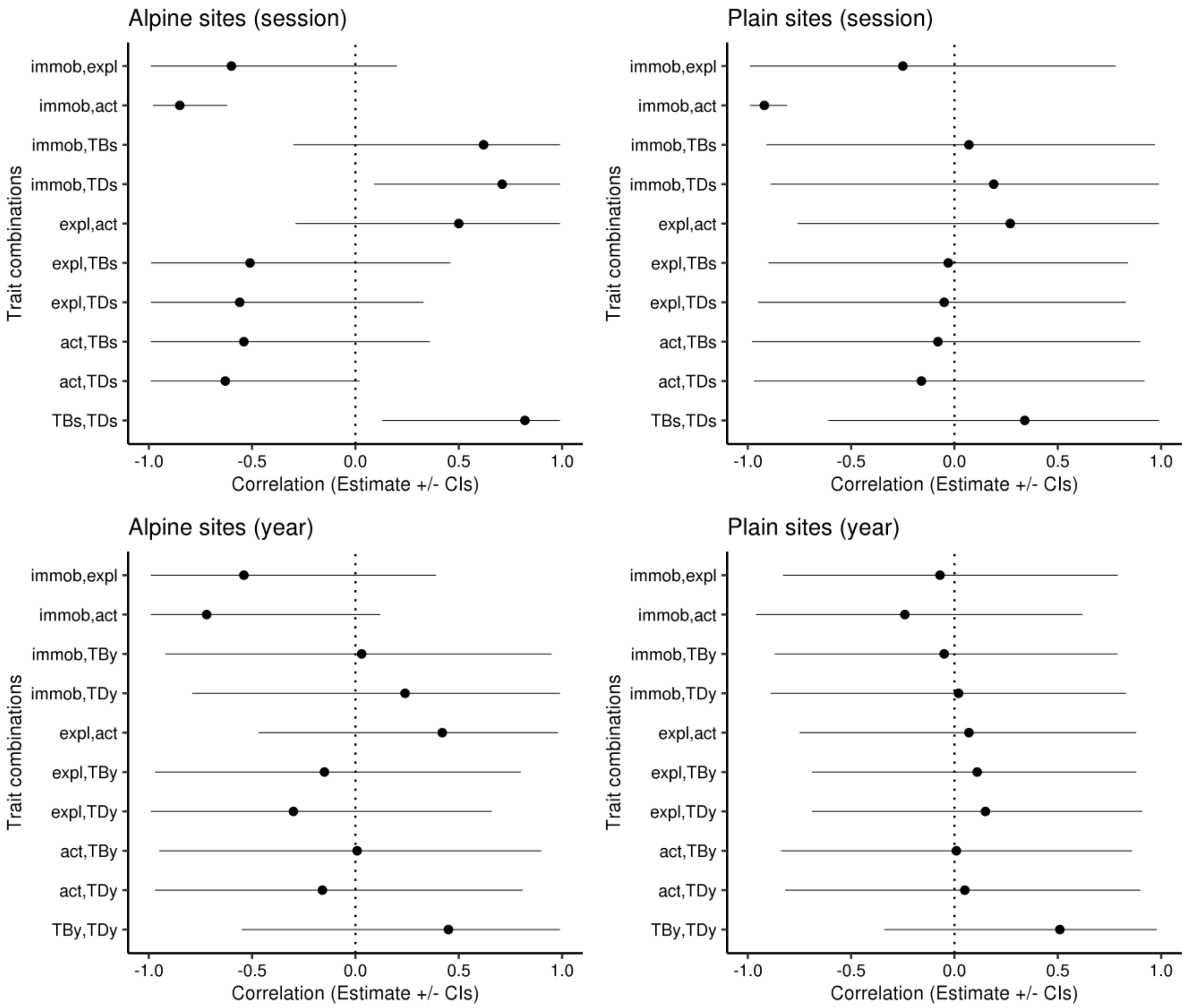
Table 1. The average proportion of time (raw data), red squirrels were engaged in behaviours related to the different OFT personality traits (see Table S2 for details). Followed by the average (raw data) trappability (TB) and trap-diversity (TD) calculated for each session and each year. Data grouped by habitat-type (alpine and plain). Each type of different personality measure reported the sample sizes (n) and the relative number of different squirrels (ID). Data shown are the minimum and maximum values, mean with standard deviation (SD) and the 95% confidence intervals. Repeatability (R), confidence intervals (95% CI) and likelihood ratio test (LRT; df; p) were estimated on squareroot transformed personality measures.

Personality measure	**Habitat-type**	**Personality trait**						**Repeatability**				
			min	max	Mean	SD	95% CI	R	95% CI	LRT	df	p
Open Field Test	**Alpine** (n=273; ID=144)	Activity	0.004	0.92	0.33	0.19	0.19 – 0.44	0.47	0.34 – 0.62	34.3	1	<0.001
		Immobility	0.01	0.99	0.60	0.22	0.46 – 0.77	0.46	0.34 – 0.62	23.4	1	<0.001
		Exploration	0	0.31	0.05	0.05	0.01 – 0.07	0.18	0.04 – 0.37	5.2	1	0.01
	Plain (n=309; ID=120)	Activity	0.03	0.97	0.36	0.23	0.17 – 0.52	0.35	0.22 – 0.49	36.5	1	<0.001
		Immobility	0	0.95	0.54	0.28	0.34 – 0.78	0.31	0.18 – 0.45	25.1	1	<0.001
		Exploration	0	0.42	0.07	0.08	0.02 – 0.09	0.10	3.3e-16 – 0.25	2.15	1	0.07
TB, TD indices session	**Alpine** (n=203; ID=70)	TBs	0.17	1.33	0.44	0.25	0.25 – 0.50	0.33	0.18 – 0.50	20.4	1	<0.001
		TDs	0.05	0.22	0.08	0.05	0.05 – 0.10	0.41	0.26 – 0.56	28.7	1	<0.001
	Plain (n=452; ID=90)	TBs	0.20	2	0.53	0.32	0.25 – 0.75	0.17	0.07 – 0.26	22.2	1	<0.001
		TDs	0.03	0.29	0.07	0.05	0.03 – 0.08	0.18	0.09 – 0.28	23.6	1	<0.001
TB, TD indices Year	**Alpine** (n=138; ID=70)	TBy	0.11	1	0.39	0.23	0.25 – 0.50	0.33	0.13 – 0.56	8.28	1	0.002
		TDy	0.05	0.44	0.10	0.07	0.05 – 0.10	0.55	0.38 – 0.73	19.6	1	<0.001
	Plain (n=186; ID=90)	TBy	0.07	1.67	0.49	0.30	0.25 – 0.66	0.27	0.11 – 0.48	10.3	1	<0.001
		TDy	0.03	0.43	0.12	0.09	0.05 – 0.17	0.20	0.03 – 0.41	4.67	1	0.02

Table 2. Description of factors used to calculate individual trappability and trap-diversity indices. Data grouped by time-interval and habitat-type.

Time-interval	**Session**						**Year**					
Habitat-type	**Alpine**			**Plain**			**Alpine**			**Plain**		
Range of presence in the study sites	2–6 sessions			2–9 sessions			1–3 years			1–4 years		
	median	mean ± SE	range	median	mean ± SE	range	median	mean ± SE	range	median	mean ± SE	range
n. captures	1	1.69 ± 0.07	1–4	2	2.15 ± 0.06	1–7	2	2.49 ± 0.15	1–8	4	5.22 ± 0.28	1–16
n. different traps captured	1	1.57 ± 0.06	1–4	2	1.99 ± 0.05	1–6	2	1.94 ± 0.11	1–8	3	3.57 ± 0.17	1–11
n. capture days	4	3.97 ± 0.05	3–6	4	4.20 ± 0.04	3–5	7	6.38 ± 0.17	3–9	9	11.68 ± 0.54	3–28

Figure 1. Correlations (estimate ± 95% credibility intervals) between the dependent variables derived from the MCMCglmm models per trapping session and per year, and for each habitat-type (alpine and plain). Significant results (0 not included in the 95% CIs).



Measuring personality traits in Eurasian red squirrels: a critical comparison of different methods

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Supporting Information

Table S1. Location of study sites in Lombardy and Piedmont, North Italy. Sample size refers to capture-mark-recaptures, number of different squirrels (ID) and sexes (M, F). Data are presented for each habitat-type (alpine or plain).

Site (size ha)	Coordinates	Sample size CMR (ID, M, F)	Sessions				N traps	Trap density (ha^{-1})
			2016	2017	2018	2019		
Alps								
Bormio (70 ha)	46°27′N, 10°30′E	84 (41, 33, 8)	june sept	june sept	june sept	june	20	0.29
Cancano (55 ha)	46°33′N, 10°15′E	103 (29, 17, 12)	june sept	june sept	may sept	june sept	18	0.33
Valfurva (70 ha)	46°27′N, 10°31′E	277 (87, 52, 35)	may sept	may sept	may sept	may	20	0.29
Plain								
Castelbarco (65 ha)	45°35′N, 9°31′E	551 (82, 45, 37)	jan apr sept oct	feb[1] apr may oct dec	mar july	mar june	40	0.62
Vanzago (60 ha)	45°31′N, 8°58′E	287 (34, 20, 14)	jan mar may oct	feb june nov	mar nov	feb apr oct	28	0.47
Passatempo (20 ha)	45°00′N, 7°78′E	218 (30, 13, 17)	mar may oct	mar may oct dec	apr nov	mar apr dec	21	1.05

[1] two capture sessions were carried out in February 2017.

S1. Details on study sites

The alpine sites are mixed conifer forests dominated by either Norway spruce (*Picea abies*), Arolla pine (*Pinus cembra*) or mountain pine (*Pinus mugo*) (Wauters et al., 2008; Rodrigues et al., 2010). The lowland (plain) sites are mature mixed broadleaf-conifer woods dominated by oaks (*Quercus robur, Q. petraea*) and hornbeam (*Carpinus betulus*) with different proportions of conifers, and high proportions of strongly preferred tree seeds [hazel (*Corylus avellana*) and walnut (*Juglans regia*) in Passatempo; sweet chestnut (*Castanea sativa*), hazel and hornbeam in Castelbarco; hazel and hornbeam in Vanzago]. Based on the availability of preferred tree seeds (Wauters et al., 2001; Molinari et al., 2006; Rodrigues et al., 2010) and red squirrel densities, Valfurva, Bormio (alpine) and Castelbarco and Passatempo (plain) are considered high-quality habitats, while Cancano (alpine) and Vanzago (plain) are habitats of poorer quality.

S2. Details on arena test to measure personality

The arena is a white extruded polycarbonate box of 50 × 51 × 51 cm; the floor of the arena consists of a panel with four blind holes (7 cm diameter × 4 cm deep), that allow to differentiate between exploration and activity behaviours (hole board test, Martin & Réale, 2008; Mazzamuto et al., 2019). In the lid of the arena (inside a 5 cm diameter hole) we fit a web camera (Drift, Professional HD Action Camera, model: FD9960, Ghost S) to record the animal's behaviour. We placed the arena on the ground near the trap where the squirrel was caught and started recording before we released the animal inside the arena (Mazzamuto et al., 2019; Wauters et al., 2019; Santicchia et al., 2020). After each experiment we cleaned the arena with 90% ethyl alcohol to eliminate urine and faecal pellets when present and to eliminate effects of squirrel's scent on behaviour of the next animal and to prevent transmission of infections. The protocol of the experiments and test duration validation are reported by Mazzamuto et al. (2019). Procedures to define the expert-based (EB) personality traits are explained in detail in previous papers (Mazzamuto et al., 2019; Wauters et al., 2019; Santicchia et al., 2020).

S3. Temporal difference between consecutive arena tests

Number of days from the previous arena test were included in models testing for repeatabilities of the OFT personality traits to account for the possible effect of temporal proximity between two tests. In details, in alpine sites 8 arena tests were conducted after 1 day from the previous test on the same individual, 7 arena tests after 2 days and 1 arena test after 3 days. Hence, 16 arena tests on a total of 273 were conducted in close temporal proximity (same capture session). In plain sites 14 arena tests were conducted after 1 day from the previous test on the same individual, 13 arena tests after 2 days and 7 arena tests after 3 days. Thus, 34 arena tests on a total of 309 were conducted in close temporal proximity (same capture session).

Table S2. Ethogram for the open field test (OFT). Description of the single behaviours and indication of the expert-based grouping into categories that represent personality traits (after Mazzamuto et al., 2019; Wauters et al., 2019; Santicchia et al., 2020).

Open Field Test

Behaviour	**Behaviour description**	**Personality traits**
Locomotion	Jump, walk	**Activity**
Rise	Rise up on hind legs	
Scan	Head moving	
Scratch	Scratch or chew floors/walls	**Exploration**
Sniff	Sniff the corner of arena	
Head dip	Put head in holes in the floor	
Hang	Hang on walls	**Immobility**
Immobile	No movement	

Table S3. Repeatabilities of OFT personality traits, by each habitat-type (alpine and plain), estimated with *rptR* function and relative linear mixed-effects models fitted by *lmer* function in *lmerTest* package.

Activity alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = act ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname =
c("ID"), data = dfalp, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, rat
io = TRUE, adjusted = TRUE)

Data: 273 observations
----------------------------------------

ID (144 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
   0.47  0.071  0.335  0.622    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.4909 0.4952  0.335  0.622
permut   1000 0.0396 0.0168  0.000  0.167

Likelihood ratio test:
logLik full model = 168.9909
logLik red. model = 151.8655
D  = 34.3, df = 1, P = 2.42e-09



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: act ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfalp

REML criterion at convergence: -272.8

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.83984 -0.54740 -0.02662  0.57639  2.04106

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.009596 0.09796
 Residual             0.010813 0.10398
Number of obs: 273, groups:  ID, 144

Fixed effects:
               Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   4.169e-01  3.768e-02  2.229e+02  11.066  < 2e-16 ***
SEXM         -1.232e-02  2.350e-02  1.296e+02  -0.524  0.60100
order011      1.687e-01  2.055e-02  1.705e+02   8.210 5.25e-14 ***
AREAFRA       9.501e-02  3.304e-02  1.315e+02   2.876  0.00470 **
AREAVAL       4.097e-02  2.674e-02  1.427e+02   1.532  0.12766
YEAR2017      3.350e-02  2.046e-02  2.490e+02   1.637  0.10282
YEAR2018     -7.464e-02  2.514e-02  2.635e+02  -2.969  0.00326 **
YEAR2019     -3.335e-02  2.874e-02  2.567e+02  -1.160  0.24702
ndayprevtest  2.412e-04  7.966e-05  1.719e+02   3.028  0.00284 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Immobility alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = immob ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname
= c("ID"), data = dfalp, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, r
atio = TRUE, adjusted = TRUE)

Data: 273 observations
----------------------------------------

ID (144 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.464 0.0699  0.344  0.612    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.4852 0.4872  0.344  0.612
permut   1000 0.0414 0.0136  0.000  0.194

Likelihood ratio test:
logLik full model = 148.8642
logLik red. model = 137.154
D  = 23.4, df = 1, P = 6.51e-07



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: immob ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfalp

REML criterion at convergence: -233.8

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.3138 -0.3390  0.0550  0.5414  2.2229

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.01094  0.1046
 Residual             0.01262  0.1123
Number of obs: 273, groups:  ID, 144

Fixed effects:
               Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   8.944e-01  4.050e-02  2.133e+02  22.084  < 2e-16 ***
SEXM          3.305e-03  2.522e-02  1.126e+02   0.131  0.89597
order011     -1.730e-01  2.217e-02  1.553e+02  -7.803 8.31e-13 ***
AREAFRA      -8.358e-02  3.545e-02  1.145e+02  -2.358  0.02008 *
AREAVAL      -3.661e-02  2.870e-02  1.257e+02  -1.276  0.20441
YEAR2017     -3.164e-02  2.204e-02  2.455e+02  -1.435  0.15247
YEAR2018      5.384e-02  2.706e-02  2.633e+02   1.989  0.04768 *
YEAR2019      5.437e-02  3.092e-02  2.540e+02   1.758  0.07992 .
ndayprevtest -2.499e-04  8.597e-05  1.566e+02  -2.907  0.00418 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Exploration alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = expl ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname
= c("ID"), data = dfalp, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, r
atio = TRUE, adjusted = TRUE)

Data: 273 observations
----------------------------------------

ID (144 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.182 0.0834 0.0396  0.372    0.019  0.011

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.2072 0.2080 0.0396  0.372
permut   1000 0.0378 0.0144 0.0000  0.172

Likelihood ratio test:
logLik full model = 272.9636
logLik red. model = 270.3625
D  = 5.2, df = 1, P = 0.0113



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: expl ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfalp

REML criterion at convergence: -473

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.32728 -0.54581 -0.06242  0.55428  2.94454

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.001530 0.03911
 Residual             0.006866 0.08286
Number of obs: 273, groups:  ID, 144

Fixed effects:
               Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   1.381e-01  2.420e-02  2.224e+02   5.706 3.66e-08 ***
SEXM         -5.248e-03  1.372e-02  1.168e+02  -0.383 0.702721
order011      1.030e-01  1.544e-02  2.131e+02   6.667 2.20e-10 ***
AREAFRA      -8.037e-03  1.935e-02  1.206e+02  -0.415 0.678604
AREAVAL      -3.261e-02  1.590e-02  1.356e+02  -2.051 0.042145 *
YEAR2017      3.448e-02  1.435e-02  2.620e+02   2.403 0.016947 *
YEAR2018      2.241e-02  1.685e-02  2.508e+02   1.330 0.184706
YEAR2019     -6.362e-02  1.881e-02  2.233e+02  -3.383 0.000848 ***
ndayprevtest  2.338e-04  5.986e-05  2.134e+02   3.906 0.000126 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Activity plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = act ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname =
c("ID"), data = dfpla, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, rat
io = TRUE, adjusted = TRUE)

Data: 309 observations
----------------------------------------

ID (120 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.345 0.0689  0.218  0.482    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.3549 0.3554  0.218  0.482
permut   1000 0.0289 0.0102  0.000  0.124

Likelihood ratio test:
logLik full model = 197.9881
logLik red. model = 179.7631
D  = 36.5, df = 1, P = 7.83e-10



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: act ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfpla

REML criterion at convergence: -329.5

Scaled residuals:
     Min       1Q   Median       3Q      Max
-3.13805 -0.55426 -0.01489  0.56940  2.61264

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.006498 0.08061
 Residual             0.012329 0.11104
Number of obs: 309, groups:  ID, 120

Fixed effects:
                 Estimate Std. Error         df t value Pr(>|t|)
(Intercept)     4.047e-01  2.687e-02  2.176e+02  15.058  < 2e-16 ***
SEXM           -1.594e-02  2.080e-02  1.120e+02  -0.766   0.4452
order011        1.594e-01  1.861e-02  2.478e+02   8.569 1.14e-15 ***
AREAC06-04      1.259e-01  2.543e-02  1.022e+02   4.951 2.93e-06 ***
AREASal-Passat  5.206e-02  2.684e-02  1.088e+02   1.940   0.0550 .
YEAR2017        4.685e-02  2.196e-02  2.999e+02   2.133   0.0337 *
YEAR2018       -1.051e-01  2.409e-02  2.993e+02  -4.365 1.75e-05 ***
YEAR2019        2.643e-01  2.547e-02  2.545e+02  10.378  < 2e-16 ***
ndayprevtest    1.719e-04  7.236e-05  2.458e+02   2.375   0.0183 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Immobility plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = immob ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname
= c("ID"), data = dfpla, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, r
atio = TRUE, adjusted = TRUE)

Data: 309 observations
----------------------------------------

ID (120 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.309 0.0721   0.18  0.462    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.3244 0.3254   0.18  0.462
permut   1000 0.0284 0.0103   0.00  0.121

Likelihood ratio test:
logLik full model = 117.9232
logLik red. model = 105.3577
D  = 25.1, df = 1, P = 2.68e-07


Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: immob ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfpla

REML criterion at convergence: -173.9

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.98194 -0.42839  0.04519  0.50227  3.13872

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.00956  0.09777
 Residual             0.02137  0.14619
Number of obs: 309, groups:  ID, 120

Fixed effects:
                 Estimate Std. Error         df t value Pr(>|t|)
(Intercept)     8.356e-01  3.437e-02  2.092e+02  24.310  < 2e-16 ***
SEXM            1.715e-02  2.622e-02  1.020e+02   0.654 0.514515
order011       -1.491e-01  2.435e-02  2.458e+02  -6.124 3.59e-09 ***
AREAC06-04     -1.184e-01  3.198e-02  9.129e+01  -3.703 0.000365 ***
AREASal-Passat -4.227e-02  3.380e-02  9.881e+01  -1.251 0.214064
YEAR2017        4.315e-02  2.845e-02  2.996e+02   1.517 0.130405
YEAR2018        1.278e-01  3.118e-02  2.982e+02   4.100 5.33e-05 ***
YEAR2019       -3.374e-01  3.269e-02  2.411e+02 -10.321  < 2e-16 ***
ndayprevtest   -2.504e-04  9.472e-05  2.439e+02  -2.643 0.008748 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Exploration plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = expl ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID), grname
= c("ID"), data = dfpla, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, r
atio = TRUE, adjusted = TRUE)

Data: 309 observations
----------------------------------------

ID (120 groups)

Repeatability estimation overview:
      R     SE     2.5%  97.5% P_permut  LRT_P
  0.102 0.0637 1.19e-16  0.245    0.052  0.071

Bootstrapping and Permutation test:
            N   Mean  Median     2.5%  97.5%
boot     2000 0.1160 0.11337 1.19e-16  0.245
permut   1000 0.0273 0.00797 0.00e+00  0.124

Likelihood ratio test:
logLik full model = 237.4557
logLik red. model = 236.382
D  = 2.15, df = 1, P = 0.0714


Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: expl ~ SEX + order01 + AREA + YEAR + ndayprevtest + (1 | ID)
   Data: dfpla

REML criterion at convergence: -404.7

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.93072 -0.57473 -0.09505  0.50439  3.09174

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.001343 0.03664
 Residual             0.011791 0.10859
Number of obs: 309, groups:  ID, 120

Fixed effects:
                 Estimate Std. Error         df t value Pr(>|t|)
(Intercept)     2.701e-01  2.161e-02  2.009e+02  12.499  < 2e-16 ***
SEXM           -1.205e-02  1.504e-02  8.801e+01  -0.801   0.4251
order011        3.738e-02  1.738e-02  2.694e+02   2.150   0.0324 *
AREAC06-04     -4.726e-05  1.794e-02  6.750e+01  -0.003   0.9979
AREASal-Passat -3.267e-02  1.931e-02  8.525e+01  -1.691   0.0944 .
YEAR2017       -1.294e-01  1.915e-02  2.937e+02  -6.757 7.57e-11 ***
YEAR2018       -1.090e-01  2.085e-02  2.864e+02  -5.226 3.34e-07 ***
YEAR2019        4.696e-02  2.069e-02  1.907e+02   2.270   0.0243 *
ndayprevtest    7.339e-05  6.767e-05  2.692e+02   1.085   0.2791
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table S4. Repeatabilities of trappability (TB) and trap-diversity (TD), per session and year, by each habitat-type (alpine and plain), estimated with *rptR* function and relative linear mixed-effects models fitted by *lmer* function in *lmerTest* package.

Trappability/session (TBs) alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trappsesstrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), data
= dfalprep, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRUE,
adjusted = TRUE)

Data: 203 observations
----------------------------------------

ID (70 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
   0.33 0.0839  0.174  0.503    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.3442 0.3475  0.174  0.503
permut   1000 0.0361 0.0117  0.000  0.168

Likelihood ratio test:
logLik full model = 87.1323
logLik red. model = 76.92647
D  = 20.4, df = 1, P = 3.12e-06



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trappsesstrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfalprep

REML criterion at convergence: -137.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.0532 -0.6750 -0.1793  0.5910  2.5208

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.009413 0.09702
 Residual             0.019081 0.13813
Number of obs: 203, groups:  ID, 70

Fixed effects:
             Estimate Std. Error        df t value Pr(>|t|)
(Intercept)   0.55547    0.04664  86.09489  11.911   <2e-16 ***
SEXM          0.04981    0.03327  69.03769   1.497   0.1390
AREAFRA       0.12640    0.04831  71.76228   2.616   0.0108 *
AREAVAL       0.04459    0.04037  69.66446   1.105   0.2732
YEAR2017     -0.01561    0.02740 179.77209  -0.570   0.5697
YEAR2018     -0.01380    0.03185 195.59112  -0.433   0.6652
YEAR2019      0.01863    0.04395 186.71480   0.424   0.6721
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trap-diversity/session (TDs) alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trapdivsesstrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), da
ta = dfalprep, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRU
E, adjusted = TRUE)

Data: 203 observations
----------------------------------------

ID (70 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.406 0.0798  0.254  0.572    0.001      0

Bootstrapping and Permutation test:
            N   Mean  Median   2.5%  97.5%
boot     2000 0.4189 0.42141  0.254  0.572
permut   1000 0.0337 0.00776  0.000  0.147

Likelihood ratio test:
logLik full model = 285.942
logLik red. model = 271.6149
D  = 28.7, df = 1, P = 4.33e-08



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trapdivsesstrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfalprep

REML criterion at convergence: -522.1

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.9608 -0.5562 -0.1835  0.6364  3.0624

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.001717 0.04143
 Residual             0.002514 0.05014
Number of obs: 203, groups:  ID, 70

Fixed effects:
              Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   0.260545   0.018469  80.947113  14.107  < 2e-16 ***
SEXM          0.016944   0.013312  65.895916   1.273 0.207550
AREAFRA       0.073470   0.019297  67.799708   3.807 0.000305 ***
AREAVAL       0.002125   0.016146  66.260461   0.132 0.895672
YEAR2017     -0.026690   0.010124 173.698173  -2.636 0.009142 **
YEAR2018     -0.015633   0.011901 193.195578  -1.314 0.190536
YEAR2019     -0.004567   0.016290 180.756499  -0.280 0.779539
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trappability/session (TBs) plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trappsesstrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), data
= dfplarep, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRUE,
adjusted = TRUE)

Data: 452 observations
----------------------------------------

ID (90 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.169 0.0498 0.0799  0.273    0.001      0

Bootstrapping and Permutation test:
            N   Mean   Median   2.5%  97.5%
boot     2000 0.1727 1.72e-01 0.0799 0.2730
permut   1000 0.0126 1.98e-09 0.0000 0.0658

Likelihood ratio test:
logLik full model = 123.4903
logLik red. model = 112.38
D  = 22.2, df = 1, P = 1.22e-06



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trappsesstrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfplarep

REML criterion at convergence: -207.3

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.1737 -0.7740 -0.0105  0.7155  2.8621

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.006118 0.07822
 Residual             0.030129 0.17358
Number of obs: 452, groups:  ID, 90

Fixed effects:
                Estimate Std. Error        df t value Pr(>|t|)
(Intercept)      0.57422    0.02562 141.84278  22.411  < 2e-16 ***
SEXM             0.03673    0.02438  86.43539   1.507   0.1355
AREAC06-04       0.15826    0.02975  94.24153   5.320 6.97e-07 ***
AREASal-Passat   0.18042    0.03109  94.87407   5.802 8.60e-08 ***
YEAR2017         0.02344    0.02100 444.72538   1.116   0.2650
YEAR2018         0.01973    0.02962 444.99273   0.666   0.5058
YEAR2019         0.07327    0.03247 365.29382   2.257   0.0246 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trap-diversity/session (TDs) plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trapdivsesstrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), da
ta = dfplarep, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRU
E, adjusted = TRUE)

Data: 452 observations
----------------------------------------

ID (90 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.175 0.0497 0.0829  0.278    0.001      0

Bootstrapping and Permutation test:
            N   Mean   Median   2.5%  97.5%
boot     2000 0.1792 1.78e-01 0.0829  0.278
permut   1000 0.0133 2.52e-19 0.0000  0.070

Likelihood ratio test:
logLik full model = 602.0758
logLik red. model = 590.2882
D  = 23.6, df = 1, P = 6.01e-07



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trapdivsesstrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfplarep

REML criterion at convergence: -1149.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.2213 -0.6636 -0.1184  0.5961  3.0755

Random effects:
 Groups   Name        Variance  Std.Dev.
 ID       (Intercept) 0.0007679 0.02771
 Residual             0.0036089 0.06007
Number of obs: 452, groups:  ID, 90

Fixed effects:
                Estimate Std. Error        df t value Pr(>|t|)
(Intercept)    1.831e-01  8.949e-03 1.404e+02  20.460  < 2e-16 ***
SEXM           1.693e-02  8.539e-03 8.607e+01   1.983   0.0506 .
AREAC06-04     7.134e-02  1.041e-02 9.371e+01   6.851 7.62e-10 ***
AREASal-Passat 1.180e-01  1.088e-02 9.425e+01  10.842  < 2e-16 ***
YEAR2017       8.618e-03  7.283e-03 4.446e+02   1.183   0.2374
YEAR2018       1.301e-02  1.027e-02 4.450e+02   1.267   0.2060
YEAR2019       1.491e-02  1.129e-02 3.665e+02   1.321   0.1872
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trappability/year (TBy) alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trappyeartrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), data
= dfalprepy, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRUE,
adjusted = TRUE)

Data: 138 observations
----------------------------------------

ID (70 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
   0.33  0.109  0.141  0.564    0.008  0.002

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.3619 0.3641  0.141  0.564
permut   1000 0.0675 0.0357  0.000  0.272

Likelihood ratio test:
logLik full model = 57.73423
logLik red. model = 53.59558
D  = 8.28, df = 1, P = 0.00201
```

```
Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trappyeartrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfalprepy

REML criterion at convergence: -80.5

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.8961 -0.6418 -0.1019  0.6242  2.6627

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.009407 0.09699
 Residual             0.019110 0.13824
Number of obs: 138, groups:  ID, 70

Fixed effects:
             Estimate Std. Error        df t value Pr(>|t|)
(Intercept)   0.50369    0.05333  91.98205   9.445 3.37e-15 ***
SEXM          0.05395    0.03648  66.68717   1.479  0.14384
AREAFRA       0.14557    0.05509  78.89117   2.642  0.00993 **
AREAVAL       0.02495    0.04583  76.52664   0.544  0.58771
YEAR2017      0.01477    0.03281  91.51174   0.450  0.65356
YEAR2018      0.01685    0.03761 113.51521   0.448  0.65504
YEAR2019      0.09017    0.04752 108.59805   1.897  0.06043 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trap-diversity/year (TDy) alpine sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trapdivyeartrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), da
ta = dfalprepy, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TR
UE, adjusted = TRUE)

Data: 138 observations
----------------------------------------

ID (70 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.548  0.086   0.39  0.721    0.001      0

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.5756 0.5841   0.39  0.721
permut   1000 0.0635 0.0255   0.00  0.276

Likelihood ratio test:
logLik full model = 157.6368
logLik red. model = 147.8494
D  = 19.6, df = 1, P = 4.84e-06



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trapdivyeartrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfalprepy

REML criterion at convergence: -270.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.9838 -0.5315 -0.0547  0.5573  3.9264

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.004174 0.06461
 Residual             0.003446 0.05870
Number of obs: 138, groups:  ID, 70

Fixed effects:
            Estimate Std. Error       df t value Pr(>|t|)
(Intercept)  0.31341    0.02829 81.47352  11.079  < 2e-16 ***
SEXM         0.01160    0.02012 62.17859   0.577 0.566331
AREAFRA      0.10426    0.02984 69.55651   3.493 0.000834 ***
AREAVAL     -0.02038    0.02491 67.95019  -0.818 0.416093
YEAR2017    -0.03167    0.01446 79.50517  -2.191 0.031406 *
YEAR2018    -0.02282    0.01709 97.03169  -1.335 0.184875
YEAR2019    -0.02402    0.02138 89.64081  -1.123 0.264246
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Trappability/year (TBy) plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trappyeartrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), data
= dfplarepy, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TRUE,
adjusted = TRUE)

Data: 186 observations
----------------------------------------

ID (90 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.271 0.0928  0.106  0.471    0.004  0.001

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.2947 0.2981  0.106  0.471
permut   1000 0.0487 0.0218  0.000  0.213

Likelihood ratio test:
logLik full model = 69.06984
logLik red. model = 63.94264
D  = 10.3, df = 1, P = 0.000682


Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trappyeartrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfplarepy

REML criterion at convergence: -101.2

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.38693 -0.64732  0.02389  0.54025  2.75486

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.00825  0.09083
 Residual             0.02216  0.14885
Number of obs: 186, groups:  ID, 90

Fixed effects:
                 Estimate Std. Error         df t value Pr(>|t|)
(Intercept)      0.525746   0.031191 129.478160  16.855  < 2e-16 ***
SEXM             0.042769   0.030220  88.655131   1.415  0.16050
AREAC06-04       0.197763   0.036487  89.022331   5.420 5.04e-07 ***
AREASal-Passat   0.213801   0.038187  94.003182   5.599 2.13e-07 ***
YEAR2017        -0.005114   0.028406 133.002423  -0.180  0.85741
YEAR2018         0.056819   0.032854 150.725656   1.729  0.08578 .
YEAR2019         0.110025   0.039569 168.006800   2.781  0.00605 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Trap-diversity/year (TDy) plain sites

```
Repeatability estimation using the lmm method

Call = rpt(formula = trapdivyeartrans ~ SEX + AREA + YEAR + (1 | ID), grname = c("ID"), da
ta = dfplarepy, datatype = "Gaussian", CI = 0.95, nboot = 2000, npermut = 1000, ratio = TR
UE, adjusted = TRUE)

Data: 186 observations
----------------------------------------

ID (90 groups)

Repeatability estimation overview:
      R     SE   2.5%  97.5% P_permut  LRT_P
  0.198  0.095 0.0279    0.4    0.041  0.015

Bootstrapping and Permutation test:
            N   Mean Median   2.5%  97.5%
boot     2000 0.2195 0.2190 0.0279  0.400
permut   1000 0.0492 0.0162 0.0000  0.217

Likelihood ratio test:
logLik full model = 168.3561
logLik red. model = 166.019
D  = 4.67, df = 1, P = 0.0153



Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: trapdivyeartrans ~ SEX + AREA + YEAR + (1 | ID)
   Data: dfplarepy

REML criterion at convergence: -292.1

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.30036 -0.60114 -0.09387  0.58574  2.07227

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 0.002024 0.04499
 Residual             0.008197 0.09054
Number of obs: 186, groups:  ID, 90

Fixed effects:
                 Estimate Std. Error         df t value Pr(>|t|)
(Intercept)      0.247890   0.017816 129.200567  13.914  < 2e-16 ***
SEXM             0.034807   0.016950  83.436832   2.054   0.0432 *
AREAC06-04       0.098376   0.020464  82.820790   4.807 6.75e-06 ***
AREASal-Passat   0.146058   0.021482  90.394891   6.799 1.10e-09 ***
YEAR2017         0.027251   0.017098 132.767764   1.594   0.1134
YEAR2018        -0.049914   0.019633 153.223521  -2.542   0.0120 *
YEAR2019         0.003565   0.023462 170.242499   0.152   0.8794
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table S5. Multivariate MCMCglmm model for alpine sites: prior, model parameters and outputs. immob = centered and scaled immobility score, expl = centered and scaled exploration score, act = centered and scaled activity score, TBstd = trappability per session, standardized within study site; TDstd = trap-diversity per session, standardized within study site, BMs = centered and scaled body mass value, AREA = study site (FRA = Cancano; VAL = Valfurva; BOR = Bormio). (sex, year, season, order: as described in methods).

```
burnin <- 50000
iterations <- 1050000
thinning <- 400

prior2 <- list(R = list(V = diag(5), nu = 0.002),
               G = list(G1 = list(V = diag(5), nu = 5, alpha.mu = rep(0,5), alpha.V = diag(25^2,5,5))))

formula = cbind (immob,expl,act,TBstd,TDstd) ~ trait-1 +
                     trait:SEX + trait:BMs + trait:YEAR +
                     at.level(trait,c(4,5)):season + at.level(trait,c(1,2,3)):order + at.level(trait,c(1,2,3)):AREA

mcmc3 <- MCMCglmm(fixed=formula,
                  random = ~ us(trait):ID,
                  rcov = ~ us(trait):units,
                  data=alp,
                  family=c(rep('gaussian',5)),
                  prior=prior2,
                  nitt=iterations,
                  burnin=burnin,
                  thin=thinning,
                  verbose=TRUE)


Iterations = 50001:1049601
 Thinning interval  = 400
 Sample size  = 2500

 DIC: 1798.701
```

G-structure: ~us(trait):ID (among-individual variance covariance)

```
                         post.mean   l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.ID       0.18942  1.353e-05 0.386799     2500
traitexpl:traitimmob.ID     -0.06842 -1.941e-01 0.013269     2500
```

```
traitact:traitimmob.ID      -0.18171 -3.743e-01 0.003539     2754
traitTBstd:traitimmob.ID     0.08673 -3.330e-02 0.213871     2027
traitTDstd:traitimmob.ID     0.11604 -1.155e-02 0.253555     2500
traitexpl:traitexpl.ID     0.06227  2.684e-07 0.166140     2500
traitact:traitexpl.ID      0.06200 -2.895e-02 0.178326     2500
traitTBstd:traitexpl.ID   -0.04237 -1.314e-01 0.024799     2500
traitTDstd:traitexpl.ID   -0.05432 -1.526e-01 0.025805     2500
traitact:traitact.ID       0.22424  2.629e-02 0.423729     2500
traitTBstd:traitact.ID    -0.08177 -2.053e-01 0.041613     1919
traitTDstd:traitact.ID    -0.11180 -2.493e-01 0.021920     2500
traitTBstd:traitTBstd.ID   0.13017  5.981e-07 0.309363     2254
traitTDstd:traitTBstd.ID   0.13909 -4.523e-03 0.326151     2281
traitTDstd:traitTDstd.ID   0.18067  1.946e-07 0.386222     2358
```

R-structure: ~us(trait):units (within-individual variance covariance)

```
                            post.mean l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.units       0.64535  0.45269  0.84923     2500
traitexpl:traitimmob.units     -0.38612 -0.54863 -0.24053     2500
traitact:traitimmob.units      -0.56929 -0.75609 -0.38306     2500
traitTBstd:traitimmob.units    -0.10784 -0.26589  0.04799     2080
traitTDstd:traitimmob.units    -0.13553 -0.28576  0.04025     1949
traitexpl:traitexpl.units     0.77477  0.59367  0.97224     2500
traitact:traitexpl.units      0.30847  0.17134  0.46120     2500
traitTBstd:traitexpl.units    0.02316 -0.14874  0.17549     2500
traitTDstd:traitexpl.units    0.04514 -0.11276  0.20951     2500
traitact:traitact.units       0.60201  0.41988  0.80235     2500
traitTBstd:traitact.units     0.11260 -0.04494  0.25530     2207
traitTDstd:traitact.units     0.13897 -0.02536  0.28633     2125
traitTBstd:traitTBstd.units   0.84703  0.60480  1.09495     2500
traitTDstd:traitTBstd.units   0.72190  0.49658  0.98356     2335
traitTDstd:traitTDstd.units   0.85912  0.60859  1.14457     2311
```

Location effects: cbind(immob, expl, act, TBstd, TDstd) ~ trait - 1 + trait:SEX + trait:BMs + trait:YEAR + at.level(trait, c(4, 5)):season + at.level(trait, c(1, 2, 3)):order + at.level(trait, c(1, 2, 3)):AREA

```
                                     post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
traitimmob                             -0.417455 -0.893182  0.087909     2226 0.0992 .
traitexpl                             0.314259 -0.158766  0.746419     2500 0.1672
traitact                              0.443121 -0.050921  0.921020     2350 0.0832 .
traitTBstd                            0.206456 -0.250473  0.609736     2500 0.3384
traitTDstd                            0.078458 -0.366507  0.499873     2500 0.7232
```

```
traitimmob:SEXM                         -0.042501 -0.389003  0.318366     2500 0.8240
traitexpl:SEXM                         0.011771 -0.304555  0.322435     2530 0.9592
traitact:SEXM                         -0.084776 -0.447263  0.278113     2777 0.6544
traitTBstd:SEXM                        0.434522  0.072597  0.792529     2500 0.0216 *
traitTDstd:SEXM                        0.485710  0.105070  0.865130     2500 0.0168 *
traitimmob:BMs                          -0.097352 -0.238474  0.053231     2500 0.2168
traitexpl:BMs                          0.194407  0.047517  0.339730     2500 0.0136 *
traitact:BMs                           0.082317 -0.077296  0.223312     2326 0.2784
traitTBstd:BMs                         0.146982 -0.009056  0.306380     2500 0.0664 .
traitTDstd:BMs                         0.185248  0.026405  0.342832     2500 0.0192 *
traitimmob:YEAR2017                     -0.059443 -0.395990  0.262703     2180 0.7224
traitexpl:YEAR2017                     0.453400  0.123514  0.805232     2500 0.0104 *
traitact:YEAR2017                      0.098897 -0.238710  0.408398     2221 0.5472
traitTBstd:YEAR2017                   -0.221272 -0.590141  0.107504     2355 0.1968
traitTDstd:YEAR2017                   -0.523581 -0.911621 -0.191178     2500 0.0072 **
traitimmob:YEAR2018                       0.444858  0.102738  0.867172     2500 0.0296 *
traitexpl:YEAR2018                     0.345434 -0.076107  0.706482     2500 0.0856 .
traitact:YEAR2018                     -0.594243 -0.975513 -0.231069     2500 0.0032 **
traitTBstd:YEAR2018                   -0.290915 -0.698898  0.108008     2500 0.1504
traitTDstd:YEAR2018                   -0.422033 -0.824803 -0.005656     2500 0.0472 *
traitimmob:YEAR2019                       0.532624 -0.033646  1.059617     2500 0.0608 .
traitexpl:YEAR2019                    -0.506106 -1.059647  0.079802     2377 0.0920 .
traitact:YEAR2019                     -0.421933 -0.979537  0.111878     2531 0.1224
traitTBstd:YEAR2019                   -0.249522 -0.832611  0.331049     2500 0.4000
traitTDstd:YEAR2019                   -0.258205 -0.864536  0.337672     2500 0.3960
at.level(trait, c(4, 5))1:seasonaut  -0.412240 -0.738706 -0.127629     2500 0.0136 *
at.level(trait, c(4, 5))2:seasonaut   0.054607 -0.242390  0.362141     2500 0.7120
at.level(trait, c(1, 2, 3))1:order0   0.801755  0.515731  1.077561     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))2:order0  -0.720191 -1.005373 -0.413668     2328 <4e-04 ***
at.level(trait, c(1, 2, 3))3:order0  -0.731374 -1.012369 -0.459744     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))1:AREAFRA -0.330212 -0.873026  0.144594     2200 0.1920
at.level(trait, c(1, 2, 3))2:AREAFRA  0.119708 -0.338767  0.558285     2500 0.5808
at.level(trait, c(1, 2, 3))3:AREAFRA  0.394465 -0.102318  0.909941     2500 0.1128
at.level(trait, c(1, 2, 3))1:AREAVAL -0.226737 -0.657508  0.176120     2282 0.2976
at.level(trait, c(1, 2, 3))2:AREAVAL -0.178046 -0.560415  0.240457     2213 0.3768
at.level(trait, c(1, 2, 3))3:AREAVAL  0.252343 -0.200062  0.664126     2259 0.2424
```

Description of fixed effects results

Males had higher trappability and trap-diversity than females. Red squirrels with a higher body mass were more explorative and had a higher trap-diversity than animals that weighed less. Trappability was lower in autumn than in spring, while there were no seasonal differences in trap-diversity. Immobility was expressed less strongly during the first arena test than subsequent ones, while exploration and activity were expressed more strongly during the first arena test than subsequent ones. There was no difference between study sites in the expression of OFT personality traits.

Table S6. Multivariate MCMCglmm model for plain sites: prior, model parameters and outputs. immob = centered and scaled immobility score, expl = centered and scaled exploration score, act = centered and scaled activity score, TBstd = trappability per session, standardized within study site; TDstd = trap-diversity per session, standardized within study site, BMs = centered and scaled body mass value, AREA = study site (C06-04 = Vanzago; Sal-Passat = Passatempo; C03-17 = Castelbarco). (sex, year, season, order: as described in methods).

```
burnin <- 50000
iterations <- 1050000
thinning <- 400

prior2 <- list(R = list(V = diag(5), nu = 0.002),
               G = list(G1 = list(V = diag(5), nu = 5, alpha.mu = rep(0,5), alpha.V = diag(25^2,5,5))))

formula = cbind (immob,expl,act,TBstd,TDstd) ~ trait-1 +
                     trait:SEX + trait:BMs + trait:YEAR +
                     at.level(trait,c(4,5)):season + at.level(trait,c(1,2,3)):order + at.level(trait,c(1,2,3)):AREA

mcmc4 <- MCMCglmm(fixed=formula,
                  random = ~ us(trait):ID,
                  rcov = ~ us(trait):units,
                  data=pla,
                  family=c(rep('gaussian',5)),
                  prior=prior2,
                  nitt=iterations,
                  burnin=burnin,
                  thin=thinning,
                  verbose=TRUE)

Iterations = 50001:1049601
 Thinning interval  = 400
 Sample size  = 2500

 DIC: 2157.401
```

G-structure: ~us(trait):ID (among-individual variance covariance)

	post.mean	l-95% CI	u-95% CI	eff.samp
traitimmob:traitimmob.ID	0.1151020	3.129e-02	0.20247	2500
traitexpl:traitimmob.ID	-0.0146754	-6.771e-02	0.02900	2532
traitact:traitimmob.ID	-0.1156960	-2.033e-01	-0.03142	2500

```
traitTBstd:traitimmob.ID    0.0034595 -3.988e-02  0.05037     2500
traitTDstd:traitimmob.ID    0.0079466 -3.295e-02  0.05780     2500
traitexpl:traitexpl.ID    0.0241233  4.106e-11  0.08133     2500
traitact:traitexpl.ID     0.0166267 -3.222e-02  0.07171     2500
traitTBstd:traitexpl.ID  -0.0007762 -1.703e-02  0.01620     2500
traitTDstd:traitexpl.ID  -0.0014897 -1.968e-02  0.01319     2500
traitact:traitact.ID      0.1365980  5.212e-02  0.24511     2500
traitTBstd:traitact.ID   -0.0038198 -5.342e-02  0.04414     2500
traitTDstd:traitact.ID   -0.0071402 -6.359e-02  0.03443     2500
traitTBstd:traitTBstd.ID  0.0109458  4.190e-09  0.04348     2500
traitTDstd:traitTBstd.ID  0.0071596 -3.120e-03  0.03676     2500
traitTDstd:traitTDstd.ID  0.0108689  2.168e-09  0.04425     2500
```

R-structure: ~us(trait):units (within-individual variance covariance)

```
                            post.mean  l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.units       0.35671  0.270500  0.44232     2500
traitexpl:traitimmob.units     -0.18905 -0.274385 -0.11415     2500
traitact:traitimmob.units      -0.27872 -0.363574 -0.20411     2500
traitTBstd:traitimmob.units     0.04321 -0.046231  0.12696     2500
traitTDstd:traitimmob.units     0.05446 -0.034889  0.13972     2500
traitexpl:traitexpl.units     0.65161  0.528639  0.77715     2500
traitact:traitexpl.units      0.08034  0.006163  0.15557     2040
traitTBstd:traitexpl.units   -0.01308 -0.112908  0.09278     2500
traitTDstd:traitexpl.units   -0.02548 -0.136697  0.07369     2500
traitact:traitact.units       0.34419  0.265703  0.43787     2500
traitTBstd:traitact.units    -0.01094 -0.094743  0.08571     2500
traitTDstd:traitact.units    -0.03022 -0.121767  0.05857     2500
traitTBstd:traitTBstd.units   0.86874  0.707000  1.04903     2500
traitTDstd:traitTBstd.units   0.80802  0.645627  0.97385     2500
traitTDstd:traitTDstd.units   0.90043  0.731700  1.07644     2500
```

```
 Location effects: cbind(immob, expl, act, TBstd, TDstd) ~ trait - 1 + trait:SEX + trait:BMs + trait:YEAR + at.level(trait, c(4,
5)):season + at.level(trait, c(1, 2, 3)):order + at.level(trait, c(1, 2, 3)):AREA
```

```
                                            post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
traitimmob                                    -0.091664 -0.334449  0.158610     2500 0.4704
traitexpl                                   0.579951  0.298069  0.869187     2500 <4e-04 ***
traitact                                    0.059693 -0.199177  0.324811     2500 0.6496
traitTBstd                                 -0.635819 -1.263882 -0.011034     2500 0.0520 .
traitTDstd                                 -0.559435 -1.205549  0.070755     2500 0.0888 .
traitimmob:SEXM                               0.198036 -0.023876  0.421227     2645 0.0840 .
traitexpl:SEXM                               -0.112003 -0.333757  0.140796     2500 0.3312
traitact:SEXM                                -0.199143 -0.416391  0.034510     2500 0.0896 .
traitTBstd:SEXM                               0.271701  0.018920  0.514033     2500 0.0328 *
traitTDstd:SEXM                               0.292362  0.018189  0.528057     2500 0.0224 *
```

```
traitimmob:BMs                                0.054622 -0.043629  0.149946     2500 0.2672
traitexpl:BMs                                -0.097362 -0.216694  0.015088     2657 0.0952 .
traitact:BMs                                 -0.033497 -0.132160  0.060389     2500 0.4720
traitTBstd:BMs                                0.065181 -0.062902  0.187636     2500 0.3064
traitTDstd:BMs                                0.075068 -0.056066  0.201390     2434 0.2464
traitimmob:YEAR2017                           0.091042 -0.143202  0.306840     2359 0.4216
traitexpl:YEAR2017                           -0.949750 -1.223902 -0.686813     2365 <4e-04 ***
traitact:YEAR2017                             0.322678  0.082209  0.534106     2295 0.0040 **
traitTBstd:YEAR2017                           0.213724 -0.145730  0.562653     2500 0.2408
traitTDstd:YEAR2017                           0.293716 -0.051419  0.652372     2140 0.1104
traitimmob:YEAR2018                           0.512266  0.233353  0.785308     2500 0.0008 ***
traitexpl:YEAR2018                           -0.888342 -1.235651 -0.585222     2500 <4e-04 ***
traitact:YEAR2018                            -0.528897 -0.812584 -0.249426     2500 0.0008 ***
traitTBstd:YEAR2018                          -0.107126 -0.446921  0.275174     2591 0.5520
traitTDstd:YEAR2018                          -0.008724 -0.384843  0.337620     2500 0.9536
traitimmob:YEAR2019                          -1.686343 -2.016665 -1.396611     2500 <4e-04 ***
traitexpl:YEAR2019                            0.620515  0.231049  0.976946     2500 0.0008 ***
traitact:YEAR2019                             1.500674  1.191365  1.826204     2500 <4e-04 ***
traitTBstd:YEAR2019                           0.273116 -0.147319  0.681338     2500 0.1920
traitTDstd:YEAR2019                           0.134879 -0.276191  0.547680     2500 0.5168
at.level(trait, c(4, 5))1:seasonaut           0.475000 -0.215121  1.230820     2500 0.2040
at.level(trait, c(4, 5))2:seasonaut           0.647048 -0.063734  1.401226     2500 0.0824 .
at.level(trait, c(4, 5))1:seasonspr-sum       0.554503 -0.130543  1.184975     2500 0.1056
at.level(trait, c(4, 5))2:seasonspr-sum       0.377767 -0.318705  1.015214     2500 0.2600
at.level(trait, c(1, 2, 3))1:order0           0.369707  0.177240  0.565452     1749 0.0008 ***
at.level(trait, c(1, 2, 3))2:order0          -0.012487 -0.258807  0.232415     2500 0.9232
at.level(trait, c(1, 2, 3))3:order0          -0.635534 -0.832405 -0.448026     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))1:AREAC06-04      -0.427858 -0.712765 -0.170090     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))2:AREAC06-04      -0.049143 -0.335657  0.204281     2788 0.7312
at.level(trait, c(1, 2, 3))3:AREAC06-04       0.629534  0.349477  0.899524     2999 <4e-04 ***
at.level(trait, c(1, 2, 3))1:AREASal-Passat -0.207497 -0.484789  0.067026     2036 0.1528
at.level(trait, c(1, 2, 3))2:AREASal-Passat -0.233719 -0.531522  0.019624     2750 0.0896 .
at.level(trait, c(1, 2, 3))3:AREASal-Passat  0.333089  0.051728  0.604527     2004 0.0232 *
```

Description of fixed effects results

Male red squirrels had higher trappability and trap-diversity than females. In the plain habitat-type, we found no relationship of body mass with immobility, exploration, activity or trappability and trap-diversity. There was no difference in trappability or trap diversity between the seasons. Immobility was expressed less strongly during the first arena test than subsequent ones, while activity was expressed more strongly during the first arena test than subsequent ones. The amount of exploration, which was always low, did not vary with arena test order. We found differences in the OFT personality traits among study sites: squirrels had lower immobility in Vanzago than in Castelbarco, while, in contrast, activity expression was higher. Squirrels had also higher activity in Passatempo than in Castelbarco.

Table S7. Multivariate MCMCglmm model for alpine sites: prior, model parameters and outputs. immob = centered and scaled immobility score, expl = centered and scaled exploration score, act = centered and scaled activity score; TBstdy = trappability per year, standardized within study site; TDstdy = trap-diversity per year, standardized within study site, BMs = centered and scaled body mass value, AREA = study site (FRA = Cancano; VAL = Valfurva; BOR = Bormio). (sex, year, order: as described in methods).

```
burnin <- 50000
iterations <- 1050000
thinning <- 400

prior2 <- list(R = list(V = diag(5), nu = 0.002),
               G = list(G1 = list(V = diag(5), nu = 5, alpha.mu = rep(0,5), alpha.V = diag(25^2,5,5))))

formula2 = cbind (immob,expl,act,TBstdy,TDstdy) ~ trait-1 +
                     trait:SEX + trait:BMs + trait:YEAR +
                     at.level(trait,c(1,2,3)):order + at.level(trait,c(1,2,3)):AREA

mcmc3a <- MCMCglmm(fixed=formula2,
                  random = ~ us(trait):ID,
                  rcov = ~ us(trait):units,
                  data=alpy,
                  family=c(rep('gaussian',5)),
                  prior=prior2,
                  nitt=iterations,
                  burnin=burnin,
                  thin=thinning,
                  verbose=TRUE)


Iterations = 50001:1049601
 Thinning interval  = 400
 Sample size  = 2500

 DIC: 1313.824
```

G-structure: ~us(trait):ID (among-individual variance covariance)

```
                            post.mean   l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.ID        0.2955177  2.368e-07  0.72111     2500
traitexpl:traitimmob.ID      -0.1536869 -4.349e-01  0.03127     2500
```

```
traitact:traitimmob.ID       -0.2467083 -6.250e-01  0.01868     2341
traitTBstdy:traitimmob.ID     0.0063634 -1.522e-01  0.17922     2500
traitTDstdy:traitimmob.ID     0.0406356 -1.265e-01  0.21424     2500
traitexpl:traitexpl.ID      0.1896397  5.424e-07  0.44947     2500
traitact:traitexpl.ID       0.1200155 -6.983e-02  0.35921     2500
traitTBstdy:traitexpl.ID   -0.0202183 -1.567e-01  0.07755     2500
traitTDstdy:traitexpl.ID   -0.0422554 -1.887e-01  0.06889     2500
traitact:traitact.ID        0.2711169  5.035e-07  0.60801     2312
traitTBstdy:traitact.ID    -0.0001003 -1.450e-01  0.14961     2500
traitTDstdy:traitact.ID    -0.0261500 -1.853e-01  0.12773     2500
traitTBstdy:traitTBstdy.ID  0.0754674  4.043e-09  0.29389     2500
traitTDstdy:traitTBstdy.ID  0.0632689 -1.378e-02  0.28591     1600
traitTDstdy:traitTDstdy.ID  0.1016116  3.365e-08  0.35326     2500
```

R-structure: ~us(trait):units (within-individual variance covariance)

```
                              post.mean l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.units        0.748946  0.38268  1.15319     2500
traitexpl:traitimmob.units      -0.351362 -0.64238 -0.09931     2500
traitact:traitimmob.units       -0.622226 -0.99076 -0.30890     2355
traitTBstdy:traitimmob.units    -0.031586 -0.24341  0.19651     2261
traitTDstdy:traitimmob.units     0.055190 -0.16589  0.28825     2500
traitexpl:traitexpl.units      0.726119  0.46066  1.02390     2500
traitact:traitexpl.units       0.219411 -0.01499  0.45671     2500
traitTBstdy:traitexpl.units    0.136826 -0.04734  0.32331     2500
traitTDstdy:traitexpl.units    0.055579 -0.14644  0.25610     2500
traitact:traitact.units        0.611125  0.31372  0.93488     2310
traitTBstdy:traitact.units     0.006056 -0.18821  0.20431     2312
traitTDstdy:traitact.units    -0.020486 -0.22341  0.18601     2500
traitTBstdy:traitTBstdy.units  0.942931  0.61863  1.24200     2500
traitTDstdy:traitTBstdy.units  0.730565  0.44186  1.03304     2500
traitTDstdy:traitTDstdy.units  0.894159  0.54856  1.20597     2500
```

Location effects: cbind(immob, expl, act, TBstdy, TDstdy) ~ trait - 1 + trait:SEX + trait:BMs + trait:YEAR + at.level(trait, c(1, 2, 3)):order + at.level(trait, c(1, 2, 3)):AREA

```
                                   post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
traitimmob                           -0.452812 -1.060580  0.220345     2500 0.1760
traitexpl                           0.411724 -0.185252  0.996589     2500 0.1816
traitact                            0.495802 -0.142438  1.069808     2500 0.1192
traitTBstdy                        -0.358417 -0.828821  0.084862     2320 0.1032
traitTDstdy                         0.120878 -0.334245  0.574454     2291 0.5880
```

```
traitimmob:SEXM                        -0.073720 -0.503704  0.383542     2335 0.7184
traitexpl:SEXM                        -0.026043 -0.431059  0.420398     2500 0.9176
traitact:SEXM                         -0.060571 -0.464081  0.374081     2500 0.7864
traitTBstdy:SEXM                       0.490190  0.092677  0.857622     2500 0.0160 *
traitTDstdy:SEXM                       0.300582 -0.104819  0.706558     2500 0.1472
traitimmob:BMs                         -0.039382 -0.245579  0.145409     2672 0.6896
traitexpl:BMs                          0.129765 -0.058695  0.293132     2500 0.1568
traitact:BMs                           0.003903 -0.176389  0.181266     2652 0.9520
traitTBstdy:BMs                        0.069181 -0.113791  0.249549     2500 0.4440
traitTDstdy:BMs                        0.064000 -0.117028  0.242631     2991 0.4816
traitimmob:YEAR2017                    -0.048479 -0.555261  0.408987     2679 0.8472
traitexpl:YEAR2017                     0.626639  0.149485  1.053826     2500 0.0080 **
traitact:YEAR2017                      0.038504 -0.384711  0.500389     2631 0.8648
traitTBstdy:YEAR2017                   0.023727 -0.411505  0.493412     2500 0.9016
traitTDstdy:YEAR2017                  -0.434004 -0.887352 -0.011657     2500 0.0520 .
traitimmob:YEAR2018                     0.447028 -0.149922  1.051973     2681 0.1520
traitexpl:YEAR2018                     0.537805  0.006631  1.080540     2500 0.0512 .
traitact:YEAR2018                     -0.567169 -1.105758 -0.005505     2660 0.0496 *
traitTBstdy:YEAR2018                  -0.021273 -0.502243  0.479670     2937 0.9224
traitTDstdy:YEAR2018                  -0.376224 -0.835631  0.107218     2500 0.1168
traitimmob:YEAR2019                     0.680271 -0.134944  1.482008     2500 0.0992 .
traitexpl:YEAR2019                    -0.573717 -1.383572  0.148655     2500 0.1384
traitact:YEAR2019                     -0.592778 -1.300615  0.184131     2500 0.1200
traitTBstdy:YEAR2019                   0.331401 -0.229845  1.043843     2305 0.3120
traitTDstdy:YEAR2019                  -0.527690 -1.191160  0.113903     2028 0.1112
at.level(trait, c(1, 2, 3))1:order0   0.489631  0.027376  0.975773     2500 0.0472 *
at.level(trait, c(1, 2, 3))2:order0  -0.423077 -0.863644  0.020121     2308 0.0632 .
at.level(trait, c(1, 2, 3))3:order0  -0.376185 -0.832681  0.035268     2500 0.0864 .
at.level(trait, c(1, 2, 3))1:AREAFRA -0.201879 -0.870983  0.397028     2500 0.5432
at.level(trait, c(1, 2, 3))2:AREAFRA -0.163269 -0.735919  0.452196     2361 0.5920
at.level(trait, c(1, 2, 3))3:AREAFRA  0.294984 -0.289701  0.884237     2500 0.3392
at.level(trait, c(1, 2, 3))1:AREAVAL -0.111748 -0.670458  0.440078     2500 0.6888
at.level(trait, c(1, 2, 3))2:AREAVAL -0.412619 -0.885128  0.114234     2500 0.1160
at.level(trait, c(1, 2, 3))3:AREAVAL  0.112326 -0.399343  0.618745     2500 0.6768
```

Description of fixed effects results

Males had higher trappability than females. There was no effect of sex on trap-diversity or on any of the OFT personality traits. Also a squirrel’s body mass was not related with any of the dependent variables. Immobility was expressed less strongly during the first arena test than subsequent ones. The difference in amount of exploration or activity was slightly higher in first arena test, but 95% CI overlapped 0 ($p = 0.063$ and 0.086, respectively). There was no difference between study sites in the expression of OFT personality traits.

Table S8. Multivariate MCMCglmm model for plain sites: prior, model parameters and outputs. immob = centered and scaled immobility score, expl = centered and scaled exploration score, act = centered and scaled activity score; TBstdy = trappability per year, standardized within study site; TDstdy = trap-diversity per year, standardized within study site, BMs = centered and scaled body mass value, AREA = study site (C06-04 = Vanzago; Sal-Passat = Passatempo; C03-17 = Castelbarco). (sex, year, order: as described in methods).

```
burnin <- 50000
iterations <- 1050000
thinning <- 400

prior2 <- list(R = list(V = diag(5), nu = 0.002),
               G = list(G1 = list(V = diag(5), nu = 5, alpha.mu = rep(0,5), alpha.V = diag(25^2,5,5))))

formula2 = cbind (immob,expl,act,TBstdy,TDstdy) ~ trait-1 +
                     trait:SEX + trait:BMs + trait:YEAR +
                     at.level(trait,c(1,2,3)):order + at.level(trait,c(1,2,3)):AREA

mcmc4a <- MCMCglmm(fixed=formula2,
                  random = ~ us(trait):ID,
                  rcov = ~ us(trait):units,
                  data=play,
                  family=c(rep('gaussian',5)),
                  prior=prior2,
                  nitt=iterations,
                  burnin=burnin,
                  thin=thinning,
                  verbose=TRUE)



Iterations = 50001:1049601
 Thinning interval  = 400
 Sample size  = 2500

 DIC: 1665.632
```

G-structure: ~us(trait):ID (among-individual variance covariance)

```
                           post.mean   l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.ID       0.011622  3.743e-09  0.04487     2500
```

```
traitexpl:traitimmob.ID      -0.003296 -3.234e-02  0.01974     2500
traitact:traitimmob.ID       -0.005011 -2.944e-02  0.00450     2280
traitTBstdy:traitimmob.ID    -0.002302 -4.759e-02  0.04512     2500
traitTDstdy:traitimmob.ID     0.000556 -3.403e-02  0.03061     2500
traitexpl:traitexpl.ID      0.063772  3.965e-08  0.17579     2500
traitact:traitexpl.ID       0.002680 -1.872e-02  0.02735     2315
traitTBstdy:traitexpl.ID    0.013615 -6.524e-02  0.09522     2500
traitTDstdy:traitexpl.ID    0.012517 -4.211e-02  0.07894     2500
traitact:traitact.ID        0.009135  5.142e-09  0.03566     2500
traitTBstdy:traitact.ID     0.001260 -4.181e-02  0.04421     2500
traitTDstdy:traitact.ID     0.001740 -2.654e-02  0.03326     2500
traitTBstdy:traitTBstdy.ID  0.184765  1.053e-04  0.38179     2621
traitTDstdy:traitTBstdy.ID  0.075304 -1.856e-02  0.22306     2500
traitTDstdy:traitTDstdy.ID  0.074941  9.832e-09  0.21693     2500
```

R-structure: ~us(trait):units (within-individual variance covariance)

```
                              post.mean l-95% CI u-95% CI eff.samp
traitimmob:traitimmob.units         0.47632  0.36925  0.60399     2500
traitexpl:traitimmob.units       -0.20804 -0.31729 -0.10934     2500
traitact:traitimmob.units        -0.40519 -0.51497 -0.30143     2500
traitTBstdy:traitimmob.units      0.05971 -0.04797  0.18175     2500
traitTDstdy:traitimmob.units      0.04697 -0.06938  0.15478     2682
traitexpl:traitexpl.units       0.66376  0.48291  0.83325     2500
traitact:traitexpl.units        0.11419  0.01266  0.21208     2500
traitTBstdy:traitexpl.units     0.03879 -0.10873  0.17314     2500
traitTDstdy:traitexpl.units     0.10623 -0.02573  0.24025     2500
traitact:traitact.units         0.48228  0.36875  0.59515     2500
traitTBstdy:traitact.units     -0.05808 -0.16623  0.06344     2500
traitTDstdy:traitact.units     -0.09397 -0.21051  0.01020     2500
traitTBstdy:traitTBstdy.units   0.76905  0.52696  1.01898     2500
traitTDstdy:traitTBstdy.units   0.56886  0.36424  0.77365     2282
traitTDstdy:traitTDstdy.units   0.79877  0.58787  1.02791     2253
```

Location effects: cbind(immob, expl, act, TBstdy, TDstdy) ~ trait - 1 + trait:SEX + trait:BMs + trait:YEAR + at.level(trait, c(1, 2, 3)):order + at.level(trait, c(1, 2, 3)):AREA

```
                                            post.mean  l-95% CI  u-95% CI eff.samp  pMCMC
traitimmob                                    -0.064947 -0.348925  0.224557     3016 0.6536
traitexpl                                    0.416012  0.073907  0.770748     2500 0.0200 *
traitact                                     0.039249 -0.251684  0.316235     2500 0.7816
traitTBstdy                                 -0.341597 -0.720294 -0.022806     2500 0.0504 .
```

```
traitTDstdy                              -0.034705 -0.381028  0.306382     2500 0.8296
traitimmob:SEXM                           0.182442 -0.035301  0.413970     2500 0.1088
traitexpl:SEXM                           -0.047145 -0.322596  0.257278     2500 0.7544
traitact:SEXM                            -0.158753 -0.382033  0.074498     2648 0.1824
traitTBstdy:SEXM                          0.383944  0.002525  0.701124     2500 0.0336 *
traitTDstdy:SEXM                          0.419926  0.105644  0.767188     2334 0.0128 *
traitimmob:BMs                            0.031770 -0.078661  0.154137     2330 0.5832
traitexpl:BMs                            -0.054316 -0.194583  0.084086     2500 0.4424
traitact:BMs                             -0.019007 -0.143522  0.094450     2403 0.7408
traitTBstdy:BMs                           0.038985 -0.103535  0.193385     2500 0.5952
traitTDstdy:BMs                           0.069315 -0.070904  0.208599     2500 0.3384
traitimmob:YEAR2017                       0.159022 -0.158964  0.468797     2500 0.3216
traitexpl:YEAR2017                       -0.752672 -1.146213 -0.381388     2645 <4e-04 ***
traitact:YEAR2017                         0.234352 -0.064823  0.543055     2500 0.1336
traitTBstdy:YEAR2017                     -0.092952 -0.468268  0.275746     2498 0.6240
traitTDstdy:YEAR2017                      0.063898 -0.293056  0.435708     2500 0.7096
traitimmob:YEAR2018                       0.562989  0.181700  0.960957     2500 0.0056 **
traitexpl:YEAR2018                       -0.580922 -1.089140 -0.118400     2830 0.0208 *
traitact:YEAR2018                        -0.565525 -0.930647 -0.158819     2500 0.0040 **
traitTBstdy:YEAR2018                      0.182313 -0.196246  0.626397     2500 0.3784
traitTDstdy:YEAR2018                     -0.861104 -1.289866 -0.476146     2500 <4e-04 ***
traitimmob:YEAR2019                      -1.561646 -1.993471 -1.147556     2500 <4e-04 ***
traitexpl:YEAR2019                        0.696541  0.201999  1.209853     2652 0.0072 **
traitact:YEAR2019                         1.495922  1.042524  1.892902     2500 <4e-04 ***
traitTBstdy:YEAR2019                      0.596203  0.083887  1.054142     2500 0.0224 *
traitTDstdy:YEAR2019                     -0.269199 -0.732464  0.163840     2500 0.2440
at.level(trait, c(1, 2, 3))1:order0       0.344356  0.022922  0.646887     2795 0.0328 *
at.level(trait, c(1, 2, 3))2:order0      -0.293097 -0.649403  0.065852     2500 0.1104
at.level(trait, c(1, 2, 3))3:order0      -0.607272 -0.901893 -0.272259     3230 0.0008 ***
at.level(trait, c(1, 2, 3))1:AREAC06-04  -0.596911 -0.860847 -0.325350     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))2:AREAC06-04   0.146638 -0.177590  0.492197     2500 0.3936
at.level(trait, c(1, 2, 3))3:AREAC06-04   0.680817  0.415682  0.957268     2500 <4e-04 ***
at.level(trait, c(1, 2, 3))1:AREASal-Passat -0.248044 -0.545412  0.017274  2500 0.0912 .
at.level(trait, c(1, 2, 3))2:AREASal-Passat -0.225374 -0.591369  0.133502  2500 0.2224
at.level(trait, c(1, 2, 3))3:AREASal-Passat  0.334672  0.057856  0.601331  2500 0.0216 *
```

Description of fixed effects results

Males had higher trappability and trap-diversity than females. There was no relationship of body mass with any of the dependent variables. Squirrels had lower values for immobility during the first than subsequent arena tests, while activity was expressed more strongly during the first arena test than in subsequent ones. There was no difference in exploration in relation to arena test order. Squirrels were less immobile and more active in Vanzago than in Castelbarco, and also the individuals from Passatempo had higher activity than those from Castelbarco. Hence, patterns analysed at annual level were similar to those from the session-based model.

Table S9. Correlations (95% credibility intervals between brackets) between the dependent variables derived from the MCMCglmm models per trapping session and per year, as well as for both habitat-types (alpine and plain; Figure 1). Estimates of the between-individual and within-individual variances for the three OFT personality traits, trappability and trap-diversity per session and per year in alpine and plain sites are detailed in the Supporting Information (Table S5, S6, S7 and S8). Significant results (0 not included in the 95% CIs) in bold.

Session			**Year**		
Variables	**Alpine sites**	**Plain sites**	**Variables**	**Alpine sites**	**Plain sites**
immob - expl	-0.60 (-0.99 – 0.20)	-0.25 (-0.99 – 0.78)	immob - expl	-0.54 (-0.99 – 0.39)	-0.07 (-0.83 – 0.79)
immob – act	**-0.85 (-0.98 – -0.62)**	**-0.92 (-0.99 – -0.81)**	immob - act	-0.72 (-0.99 – 0.12)	-0.24 (-0.96 – 0.62)
immob – TBs	0.62 (-0.30 – 0.99)	0.07 (-0.91 – 0.97)	immob - TBy	0.03 (-0.92 – 0.95)	-0.05 (-0.87 – 0.79)
immob - TDs	**0.71 (0.09 – 0.99)**	0.19 (-0.89 – 0.99)	immob - TDy	0.24 (-0.79 – 0.99)	0.02 (-0.89 – 0.83)
expl – act	0.50 (-0.29 – 0.99)	0.27 (-0.76 – 0.99)	expl - act	0.42 (-0.47 – 0.98)	0.07 (-0.75 – 0.88)
expl - TBs	-0.51 (-0.99 – 0.46)	-0.03 (-0.90 – 0.84)	expl - TBy	-0.15 (-0.97 – 0.80)	0.11 (-0.69 – 0.88)
expl - TDs	-0.56 (-0.99 – 0.33)	-0.05 (-0.95 – 0.83)	expl - TDy	-0.30 (-0.99 – 0.66)	0.15 (-0.69 – 0.91)
act – TBs	-0.54 (-0.99 – 0.36)	-0.08 (-0.98 – 0.90)	act - TBy	0.008 (-0.95 – 0.90)	0.009 (-0.84 – 0.86)
act - TDs	-0.63 (-0.99 – 0.02)	-0.16 (-0.97 – 0.92)	act - TDy	-0.16 (-0.97 – 0.81)	0.05 (-0.82 – 0.90)
TBs -TDs	**0.82 (0.13 – 0.99)**	0.34 (-0.61 – 0.99)	TBy -TDy	0.45 (-0.55 – 0.99)	0.51 (-0.34 – 0.98)

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