Field studies need to report essential information on social organisation – independent of the study focus

Lindelani Makuya, Charlotte-anaïs Olivier, Carsten Schradin

► To cite this version:

Lindelani Makuya, Charlotte-anaïs Olivier, Carsten Schradin. Field studies need to report essential information on social organisation – independent of the study focus. *Ethology*, 2021, 10.1111/eth.13249 . hal-03457477

HAL Id: hal-03457477

<https://hal.science/hal-03457477>

Submitted on 30 Nov 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Field studies need to report essential information on social organization – independent of the study focus

Makuya, L.¹, Olivier, C.A.^{1,2} & Schradin, C.^{1,2}

¹ School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Private Bag 3, WITS 2050, Johannesburg, South Africa

² IPHC, UNISTRA, CNRS, 23 rue du Loess, 67200 Strasbourg, France

Published as

Makuya, L., Olivier, C.-A. & Schradin, C. 2022. Field studies need to report essential information on social organisation – independent of the study focus. *Ethology*, 128.

<https://doi.org/10.1111/eth.13249>

Abstract

Comparative studies on social evolution are ideally based on large datasets to ensure high statistical power, but their scientific validity also relies on the quality of the data. However, even though social organization, i.e., the composition of social units, is measured in many field studies testing specific hypotheses, these data are often not adequately reported. Here,

22 we summarise which data on social organization should always be reported regardless of the
23 study focus to make them available for comparative studies. As an example, we report data
24 from a literature survey on one of the four superorders of placental mammals, the Xenarthra
25 from South America (armadillos, anteaters and sloths), of which all 30 species are generally
26 assumed to be solitary living. In total we found 4510 articles. The titles and abstracts of 61
27 publications indicated that data on social organization were collected, but only 12
28 publications contained sufficient information for us to determine the social organization. We
29 found reliable information on nine species, of which seven were strictly solitary. Two species
30 showed a combination of solitary-living and pair-living with one including female groups. This
31 review therefore indicates that Xenarthra may not be exclusively solitary. Our literature
32 survey further shows that valuable data are often not reported even though it can be assumed
33 that these data had been collected. We report examples from 23 additional studies on
34 monotremes, marsupials, and two other placental superorders showing similar issues in
35 reporting data. It is important to make authors aware that this information would be valuable
36 for comparative studies. In sum, we recommend including data on the composition of social
37 units, sex of individuals, occupancy of sleeping sites, frequency of observations and trapping
38 events, home range overlap, and the proportion of the individuals in the study area,
39 independent of the study question in all publications.

40

41 **Keywords:** Comparative study; Field data; Intraspecific variation; Social organization; Social
42 system; Social structure

43

44

45 **Introduction**

46 Comparative studies yield significant insight into the evolution of social systems (Chak et al.,
47 2017; Cornwallis et al., 2017; Firman et al., 2020; Griesser et al., 2017; Lukas & Clutton-Brock,
48 2013). The quality of such comparisons has increased over the last decades due to significant
49 improvements in statistical methods that correct for phylogeny and enable us to include
50 ecological and life-history factors (Garamszegi, 2014). However, the quality of comparative
51 studies also depends on the quality of the used database (Schradin, 2017). Many researchers
52 focused on getting a large, instead of an accurate, database, for example by using
53 phylogenetic inferences to add species that had not been studied (birds: Cockburn, 2006;
54 used also by Gonzalez et al., 2013; Jetz & Rubenstein, 2011; mammals: Lukas & Clutton-Brock,
55 2013). There are now statistically sound methods to infer missing phylogenetic data points
56 (for example see Callaghan et al. (2021)), which are useful when the important life-history
57 and ecological data for a few species are known, so that one can include these species.
58 However, such inference should only be done if the social data are missing from just a few
59 but not the majority of species (Schradin, 2017). Furthermore, information assuming the
60 social system from anecdotal observations or expert opinion published in secondary and
61 tertiary sources has often been included for species that have never been studied in the field
62 (Schradin, 2017). This has been criticised and a more careful approach has been
63 recommended (Griesser & Suzuki, 2016; Huck et al., 2020), i.e. to only use data from studies
64 where animals have been studied in their natural environment (Schradin, 2017). However,
65 while the number of field studies has increased over the last decades (Schradin & Hayes,
66 2017), basic data on social systems are often not reported in a way that makes them useable
67 for comparative studies.

68 In the field of Behavioural Ecology, the focus on field studies is on theory-driven
69 research and not on describing the social system of species (Clutton-Brock & Janson, 2012).
70 Social organization, which means the sex and the composition of social units, is one of the
71 four key components of social systems (Kappeler & van Schaik, 2002). Social organization is
72 easier to observe and to record than the three other components of the social system
73 (Schradin et al., 2018), which are the mating system (who reproduces with whom), the social
74 structure (social interactions; social networks) and the parental care system (who takes care
75 of the offspring) (Kappeler, 2019). While field researchers often record the composition of
76 study groups, details of such basic data are often not reported in the arising publications that
77 test specific hypotheses.

78 The conclusions from hypothesis-driven research are important to test and develop
79 theory; however; conclusions can change and the main values of each study are the data that
80 were recorded. It is as important to include these data and the conclusions drawn from them.
81 The availability of published data has been recognised as being of crucial importance
82 (Ramachandran et al., 2021; Reichman et al., 2011). For comparative studies and for meta-
83 analyses data are more valuable than interpretations. This is demonstrated by the example
84 of intra-specific variation in social systems (Lott, 1984; Schradin et al., 2018). For example, if
85 a study population is reported to be pair-living because most animals live in pairs but some
86 populations or individuals also live solitarily or in groups, then biologically meaningful
87 variation might be missed. We have been building a database on mammalian social evolution
88 since 2015 (Agnani et al., 2018; Valomy et al., 2015). For this, we have searched more than
89 ten thousand peer-reviewed articles for information about the composition of social units,
90 focusing on data reported in the methods and results sections. We noticed that many field
91 studies that presumably collected such data did not report them, but instead assigned a

92 general form of social organization to the study population in the introduction and / or
93 discussion.

94 The aim of the current paper was to identify which data are often missing from
95 publications even though they probably had been collected and could have been used to
96 accurately assign social organization, including its variation. For this, we surveyed the
97 literature on one mammalian superorder as an example, the Xenarthra (armadillos, sloths and
98 ant-eaters), and added more examples from other mammalian taxa. We chose this
99 superorder as it is small, containing only 30 species, all of which had been assumed to live
100 solitary (Lukas & Clutton-Brock, 2013). Our aims were to (1) provide an overview of what is
101 known regarding the social organization of Xenarthra, (2) identify which information is
102 missing in published field studies on Xenarthra to correctly characterise their social
103 organization, (3) report additional examples from other mammalian taxa, and finally (4)
104 provide a template for field researchers on which data to provide in every published paper so
105 that they are available for comparative studies of social evolution.

106

107

108 **Methods**

109 *Xenarthra social organization*

110 The Xenarthra (armadillos, sloths and anteaters) is one of four superorders within the
111 placentals; with the other three being Afrotheria (elephants, sea cows and elephant-shrews),
112 Euarchontaglires (primates and rodents) and Laurasiatheria (bats, carnivores and ungulates)
113 (Wildman et al., 2007). Xenarthra mainly occur in South America, with one species ranging to

North America. They consist of 30 species of which 20 belong to the order Cingulata (armadillos) and 10 to the order Pilosa (six species of sloths and four species of anteaters). Xenarthra are typically considered to be solitary living (Lukas & Clutton-Brock (2013) categorised all 24 Xenarthrans in their database as solitary living), though it has been acknowledged that small groups might occur (Nowak & Wilson, 1999; Wilson & Mittermeier, 2018). Determining the social organization of species in this superorder is important for comparative studies regarding mammalian social evolution.

Data collection and literature review Xenarthra

Literature research was done from the 27th July 2020 until the 30th June 2021. During this period a species list of the extant members of the superorder Xenarthra was compiled using the IUCN Red List of Threatened Species (www.iucnredlist.org). Using this list, a search was conducted on the primary literature on social organization in Web of Science and Google Scholar. The search string used to assemble this information consisted initially of the term social in conjunction with the species scientific name or common name. For example, the search string used for the Northern long-nosed armadillo *Dasypus sabanicola* was ("*Dasypus sabanicola*" OR "Northern long-nosed armadillo" AND "*social*"). If no records were found with the initial search string, then a second search string was used that consisted only of the scientific species name (e.g., "*Dasypus sabanicola*"). If the second search string still yielded no results, then the final search string used was just the genus name and the term social (e.g., "*Dasypus*" AND social). Within the search results from Web of Science, the following research areas were selected to refine the results – "*zoology*", "*behavioural science*" and "*environmental science/ecology*" – and the document type - "*article*". All publication titles

that were not applicable to the topic were removed from the generated database. From the remaining articles the abstracts were read and reviews not reporting primary data or studies done on captive animals were excluded from the database. The PDFs of the remaining publications were then obtained and searched for the following terms related to social organization: “social,” “group,” “territorial,” “solitary,” “bachelor,” “plural,” “aggregation,” “gregarious,” “pair” and “singular.” The figures, tables and supplementary materials were also checked for information that may not have been recorded in the main text. The same process was applied in Google scholar to search for additional articles.

The social organization described in the primary literature for each of the species was recorded according to the following categories (for details see (Agnani et al., 2018; Valomy et al., 2015): “solitary,” “pair,” “one male multiple females,” “one female multiple males,” “multiple males and multiple females.”

Data from other mammalian taxa

We are in the process of building a database on mammalian social organization reported from field studies using the same methods as described above. In addition to the detailed case study on Xenarthra, we also reported examples from several other mammalian taxa, but without the claim to cover all species in these taxa.

Data analysis

The following variables were calculated from the information provided from the literature. The total number of social units observed per population and per species was summed up.

Then the main social organization was determined by the most commonly observed social organization. Following this, the percentage of main social organization was calculated by dividing the number of social units of the main social organization by the total number of social units multiplied by 100. Finally, intra-specific variation in social organization (IVSO) was determined as within population when variation occurred only within a population, among populations when variation occurred among populations only, both if variation occurred within and among populations, and none if there was no variation reported.

Results

Xenarthra

We found 4510 articles (1801 for Pilosa and 2709 for Cingulata). The titles from 61 articles (30 for Pilosa and 31 for Cingulata) indicated that information on social organization was collected. These articles were searched in detail for information. Twelve publications provided information on social organization for 15 populations of nine of the 30 Xenarthran species. From these nine species, the following seven species were reported to be exclusively solitary: southern naked-tailed armadillo, *Cabassous unicinctus* (Desbiez et al., 2018), giant armadillo, *Priodontes maximus* (Desbiez et al., 2019), nine-banded armadillo, *Dasypus novemcinctus*, (McDonough, 2000), maned three-toed sloth, *Bradypus torquatus* (Falconi et al., 2015), Hoffmann's two-toed sloth, *Choloepus hoffmanni* (Vaughan et al., 2007), southern tamandua, *Tamandua tetradactyla* (Rodrigues et al., 2001) and giant anteater, *Myrmecophaga tridactyla* (Di Blanco et al., 2017; Medri & Mourão, 2005; Shaw et al., 1987). Two Pilosa species showed intra-specific variation in social organization. In the pale-throated three-toed sloth, *Bradypus tridactylus* (Taube et al., 1999), solitary living (of both sexes), pair-

living, and multi-female groups were reported. In the brown-throated sloth, *Bradypus variegatus*, solitary living (of both sexes) and pair-living was reported (Garcés-Restrepo et al., 2017; Pauli & Perry, 2012).

While the title and abstract of 61 publications indicated that data on social organization was collected, only 12 publications contained useable information. Most of the 49 remaining studies focussed on population dynamics (N=14), habitat use (N=12), or other ecological aspects such as conservation, spatial ecology, or monitoring via camera traps (see ESM 1). Most studies could not be used to correctly determine social organization because they either did not report the sex of individuals or state the composition of the social units they observed (for example they observed / trapped / tracked individuals but did not present data whether they were solitary or not; Table 1). Studies using radio-tracking often failed to report whether or not individuals shared home ranges and sleeping sites (Table 1). One study had information we could use for our database for one species (*Bradypus tridactylus*) and missing information for the other species (*Choloepus didactylus*) (Taube et al., 1999).

Other mammalian taxa

Examples from other mammalian taxa show that the same information to determine social organization is often missing, just as for Xenarthra (Table 1; ESM 2). For example, in Perissodactyla, groups have been observed in onagers (*Equus hemionus*) and kiangs (*E. kiang*) without the sex of the individuals being reported (ESM2), which would be essential to determine the sex composition of the social units, i.e., whether it is one male with several females, multi-male multi-female groups, or all male and all female groups. The same problem occurred in several species of kangaroos (ESM2). In platypus (*Ornithorhynchus*

anatinus), which are typically regarded to be solitary living (Wilson & Mittermeier, 2015), den sharing has been reported repeatedly, but not whether the same individuals permanently share one den and home range, or whether such associations were short lived, representing random aggregations at preferred resting sites (ESM 2).

Discussion

It is mandatory to have access to reliable field data of animal social systems if one wants to do comparative studies on social evolution (Schradin, 2017). Conducting field studies is costly in time and funding (Clutton-Brock & Sheldon, 2010; Schradin & Hayes, 2017). It is, therefore, both surprising and frustrating when such valuable data are collected but not reported. Here we report in detail for one superorder of placentals, the Xenarthra, that most conducted field studies do not report data essential to accurately determine social organization. We further add examples from other mammalian taxa indicating similar problems. Data on social organization are valuable and difficult to collect; therefore, we give advice on how to report such data in the future, independent of the study focus.

So far, Xenarthrans, which represents sloths, anteaters and armadillos, have been believed to live solitarily (Wilson & Mittermeier, 2018). This might be the reason why most field studies on Xenarthrans did not report the composition of social units: possibly the authors were assuming that it is clear that they are solitary. However, in our literature survey we found some indication that some species of Xenarthrans show intra-specific variation in social organization, including pair-living and female groups. The Xenarthra represent one of four mammalian superorders, such that the social organization of these species might have a

significant impact on comparative studies regarding mammalian social evolution. From our point of view, while solitary living is the most common form of social organization in Xenarthra, ignoring other possible forms of social organization in this taxon could lead to mistakes in comparative studies of mammals. To prevent such mistakes from occurring, field data from long-term monitoring of natural populations is essential; however, this data is often missing.

In another database, all Xenarthra were classified as solitary living (Lukas & Clutton-Brock, 2013). It is important to note that there is agreement that comparative studies need clear definitions (Lukas & Clutton-Brock, 2017; Schradin, 2017). For example, Lukas & Clutton-Brock (2013) had a more stringent definition to classify species as pair-living than we had: pairs had to be together for more than one breeding season (Lukas & Clutton-Brock, 2013). Whereas we recorded pairs in pale-throated three-toed sloths (*Bradypus tridactylus*; Taube et al. (1999)) even though it was unknown for which time they stayed together. In contrast, using radio-tracking in brown-throated sloths (*Bradypus variegatus*), the authors indicate mate fidelity of one female remaining in the home range of one male for 3 years (Fig 3a in Garcés-Restrepo et al. (2017)), and the female mated only with this male, such that it can be regarded as a pair (Garcés-Restrepo et al., 2017). We did not consider observed pairs in nine-banded armadillos (*Dasypus novemcinctus*) as indication for pair-living, because pairs were only present during courtship and mating, indicating a solitary form of social organization (McDonough, 2000). The secondary literature also reports some degree of sociality for some Xenarthra, for example female groups in Hoffmann's two-toed sloth (*Choloepus hoffmanni*; Nowak & Wilson (1999)), groups in pale-throated three-toed sloths (*Bradypus tridactylus*, Wilson & Mittermeier (2018)), and groups of adult offspring staying together in nine-banded armadillos (*Dasypus novemcinctus*, Nowak & Wilson (1999)). In sum, some data from the

primary literature (Garcés-Restrepo et al., 2017; McDonough, 2000; Taube et al., 1999) and reports from secondary literature (Nowak & Wilson, 1999; Wilson & Mittermeier, 2018) indicate that Xenarthra might be less asocial than generally assumed. Whether to score these species as solitary, variable in their social organization, or excluding them due to uncertainties from further comparative analysis will have to depend on the specific study objective.

A similar problem as in Xenarthra exists for monotremes, which are all generally believed to be solitary living (Wilson & Mittermeier, 2015). However, numerous reports of den sharing in the platypus (*Ornithorhynchus anatinus*), covering decades of studies (Grant et al. 1992; Serena 1994; Serena et al. 1998 and older reports cited within), indicate that this general assumption might not cover the full range of social organization occurring in this species.

While in Xenarthra and monotremes, the general assumption that they live solitarily might explain why researchers are reluctant to report data on social organization. Alternatively, in group-living species we found that the correct group composition could often not be determined as no information about the sexes was given such as in Perissodactyla, Carnivora, Rodentia, and Marsupialia. However, whether the social organization consists of one male with multiple females or multiple males and multiple females, has a significant influences on other aspects of the social system, for example the mating system and the social structure (Kappeler, 2019). In sum, we found throughout the mammalian taxa, examples of field studies that likely collected data on social organization without reporting it. This can lead to the misclassification and ignorance of important variation (Schradin et al., 2018), therefore affecting the outcome of comparative studies (Schradin, 2017).

274 To compensate for missing data, others solved this by using phylogenetic
275 interferences (assuming closely related species have the same social system), included data
276 from captive studies, and expert opinions, with the risk of coming to wrong conclusions
277 (Schradin et al., 2018). Here we argue for field researchers to report life-history data in a
278 precise way, making it possible to accurately determine the social organization and especially
279 the composition of social units, one of the key components of social systems (Kappeler, 2019).
280 Sometimes it is impossible for researchers to give the correct information about the sex
281 composition of social units, especially in species forming large herds (Moehlman 1998;
282 Rudman 1998) or when individuals are not captured, sexed, and individually marked.
283 However, when such information is routinely collected, it should also be reported. In
284 Xenarthra, this problem exists for studies published during the last 4 decades and was even
285 dominant during the last decade (ESM1); indicating that it is not a problem of research
286 methodology, but of publishing culture. We argue that in future, it is important to report such
287 data even if the study focus is on a different topic.

288 Kappeler (2019) defined the social organization as the composition of social units,
289 which was inferred by previous comparative studies from direct observations (Jaeggi et al.,
290 2020), trapping data (Valomy et al., 2015) and from sleeping sites (Agnani et al., 2018). Table
291 1 states the information which every study on wild living animals should report in their
292 methods and results section, to make information about the social organization of the study
293 population available for comparative studies, even when the study focus is on something else.
294 While Table 1 lists this information in the order of missing information, in any publication it
295 should typically be reported as: (1) proportion of individuals within the study area trapped,
296 marked, radio-tracked, and observed, (2) frequency of trapping / observation event, (3) sex
297 of individuals studied, (4) composition of social units, (5) in studies using radio-tracking the

home range overlap with all individuals should be stated, and (6) which individuals shared nesting / sleeping / resting sites and how regularly. It is very important that all of this information is also reported for species which are believed to live solitarily, because as demonstrated here for *Xenarthra*, important deviation from this main form of social organization might occur. Furthermore, it has been empirically demonstrated that many species that were believed to be solitary living in fact live in pairs or groups (Agnani et al., 2018; Valomy et al., 2015).

Similar considerations as for reporting data on social organization may also apply to the three other components of the social system. For the mating system, it is now common that the number of extra-pair paternities are reported, how many offspring each male sired in a group, and the frequency of multiple paternities, which can then be used in comparative studies (Dobson et al., 2018). For the social structure, different measures of the social networks must be reported in a way that they can be used for comparative studies (see <https://github.com/bansallab/asnr>). For the parental care system, it is important to report not only whether maternal, paternal and allo-parental care by breeders and non-breeders occurs, but also how commonly parental behaviour is shown by the different group members, and how many social units show which category of parental care system (Griesser et al., 2017; Griesser & Suzuki, 2016). Therefore, our demand to accurately report data on social organization can be extended to the other components of the social system.

CONCLUSIONS

During the process of building a database on mammalian social organization we came across several peer-reviewed publications that indicated that they had collected data we

could use for the database, but this information was not presented in a way that we could reliably determine the composition of social units. Here we argue for field researchers to always report life history data, making it possible to accurately determine the social organization; especially to report the proportion of population studied, frequency of trapping / observation events, sex of individuals studied, the composition of social units and sharing of home ranges and sleeping sites. These recommendations are not only important for mammals, but also for databases in other taxa, such as fish (Tanaka et al., 2018) and birds (Griesser & Suzuki, 2016).

Acknowledgements

We are grateful for the help of several interns in extracting data on social organization. Comments by W. Goymann, M. Griesser and one anonymous referee significantly improved the manuscript. We are also grateful to E. Kudze and T. Godding for helping to edit the grammar and language. This study was supported by the CNRS and the University of Strasbourg.

References

Agnani, P., Kauffmann, C., Hayes, L. D., & Schradin, C. (2018). Intra-specific variation in social organization of Strepsirrhines. *American Journal of Primatology*, 80(5), e22758. doi:doi:10.1002/ajp.22758

341 Callaghan, C. T., Nakagawa, S., & Cornwell, W. K. (2021). Global abundance estimates for
 342 9,700 bird species. *Proceedings of the National Academy of Sciences*, 118(21),
 343 e2023170118. doi:10.1073/pnas.2023170118

344 Chak, S. T. C., Duffy, J. E., Hultgren, K. M., & Rubenstein, D. R. (2017). Evolutionary transitions
 345 towards eusociality in snapping shrimps. *Nature Ecology & Evolution*, 1(4), 1-7.

346 Clutton-Brock, T., & Janson, C. (2012). Primate socioecology at the crossroads: Past, present,
 347 and future. *Evolutionary Anthropology: Issues, News, and Reviews*, 21(4), 136-150.
 348 doi:<https://doi.org/10.1002/evan.21316>

349 Clutton-Brock, T., & Sheldon, B. C. (2010). Individuals and populations: the role of long-term,
 350 individual-based studies of animals in ecology and evolutionary biology. *Trends in*
 351 *Ecology & Evolution*, 25(10), 562-573.

352 Cockburn, A. (2006). Prevalence of different modes of parental care in birds. *Proceedings of*
 353 *the Royal Society B: Biological Sciences*, 273(1592), 1375-1383.

354 Cornwallis, C. K., Botero, C. A., Rubenstein, D. R., Downing, P. A., West, S. A., & Griffin, A. S.
 355 (2017). Cooperation facilitates the colonization of harsh environments. *Nature*
 356 *Ecology & Evolution*, 1(3), 1-10.

357 Desbiez, A., Kluyber, D., Massocato, G., Oliveira-Santos, L., & Attias, N. (2019). Spatial ecology
 358 of the giant armadillo *Priodontes maximus* in Midwestern Brazil. *Journal of*
 359 *Mammalogy*, 101(1), 151-163.

360 Desbiez, A. L. J., Massocato, G. F., Kluyber, D., & Santos, R. C. F. (2018). Unraveling the cryptic
 361 life of the southern naked-tailed armadillo, *Cabassous unicinctus squamicaudis* (Lund,
 362 1845), in a Neotropical wetland: home range, activity pattern, burrow use and
 363 reproductive behaviour. *Mammalian Biology*, 91(1), 95-103.

364 Di Blanco, Y. E., Jiménez Pérez, I., & Di Bitetti, M. S. (2017). Habitat selection in reintroduced
 365 giant anteaters: the critical role of conservation areas. *Journal of Mammalogy*, 96(5),
 366 1024-1035.

367 Dobson, F. S., Abebe, A., Correia, H. E., Kasumo, C., & Zinner, B. (2018). Multiple paternity and
 368 number of offspring in mammals. *Proceedings of the Royal Society B*, 285(1891),
 369 20182042.

370 Falconi, N., Vieira, E. M., Baumgarten, J., Faria, D., & Giné, G. A. F. (2015). The home range
 371 and multi-scale habitat selection of the threatened maned three-toed sloth (*Bradypus*
 372 *torquatus*). *Mammalian Biology*, 80(5), 431-439.

373 Firman, R. C., Rubenstein, D. R., Moran, J. M., Rowe, K. C., & Buzatto, B. A. (2020). Extreme
 374 and variable climatic conditions drive the evolution of sociality in Australian rodents.
 375 *Current Biology*, 30(4), 691-697. e693.

376 Garamszegi, L. Z. (2014). *Modern phylogenetic comparative methods and their application in*
 377 *evolutionary biology*. Berlin: Springer.

378 Garcés-Restrepo, M. F., Peery, M. Z., Reid, B., & Pauli, J. N. (2017). Individual reproductive
 379 strategies shape the mating system of tree sloths. *Journal of Mammalogy*, 98(5), 1417-
 380 1425.

381 Gonzalez, J.-C. T., Sheldon, B. C., & Tobias, J. A. (2013). Environmental stability and the
 382 evolution of cooperative breeding in hornbills. *Proceedings of the Royal Society B:*
 383 *Biological Sciences*, 280(1768), 20131297.

384 Griesser, M., Drobniak, S. M., Nakagawa, S., & Botero, C. A. (2017). Family living sets the stage
 385 for cooperative breeding and ecological resilience in birds. *PLoS biology*, 15(6),
 386 e2000483.

387 Griesser, M., & Suzuki, T. N. (2016). Occasional cooperative breeding in birds and the
 388 robustness of comparative analyses concerning the evolution of cooperative breeding.
 389 *Zoological Letters*, 2, 7. doi:10.1186/s40851-016-0041-8

390 Huck, M., Di Fiore, A., & Fernandez-Duque, E. (2020). Of apples and oranges? The evolution
 391 of “monogamy” in non-human primates. *Frontiers in Ecology and Evolution*, 7(472).
 392 doi:10.3389/fevo.2019.00472

393 Jaeggi, A. V., Miles, M. I., Festa-Bianchet, M., Schradin, C., & Hayes, L. D. (2020). Variable social
 394 organization is ubiquitous in Artiodactyla and probably evolved from pair-living
 395 ancestors. *Proceedings of the Royal Society B: Biological Sciences*, 287(1926),
 396 20200035. doi:doi:10.1098/rspb.2020.0035

397 Jetz, W., & Rubenstein, D. R. (2011). Environmental uncertainty and the global biogeography
 398 of cooperative breeding in birds. *Current Biology*, 21(1), 72-78.

399 Kappeler, P. M. (2019). A framework for studying social complexity. *Behavioral Ecology and*
 400 *Sociobiology*, 73(1), 13. doi:10.1007/s00265-018-2601-8

401 Kappeler, P. M., & van Schaik, C. P. (2002). Evolution of primate social systems. *International*
 402 *Journal of Primatology*, 23(4), 707-740.

403 Lott, D. F. (1984). Intraspecific variation in the social systems of wild vertebrates. *Behaviour*,
 404 88, 266-325.

405 Lukas, D., & Clutton-Brock, T. (2017). Comparative studies need to rely both on sound natural
 406 history data and on excellent statistical analysis. *Royal Society open science*, 4(11),
 407 171211.

408 Lukas, D., & Clutton-Brock, T. H. (2013). The evolution of social monogamy in mammals.
 409 *Science*, 341(6145), 526-530. doi:10.1126/science.1238677

410 McDonough, C. M. (2000). Social organization of nine-banded armadillos (*Dasypus*
411 *novemcinctus*) in a riparian habitat. *The American Midland Naturalist*, 144(1), 139-151.

412 Medri, Í. M., & Mourão, G. (2005). Home range of giant anteaters (*Myrmecophaga tridactyla*)
413 in the Pantanal wetland, Brazil. *Journal of Zoology*, 266(4), 365-375.

414 Nowak, R. M., & Wilson, E. (1999). *Walker's Mammals of the World* (6th ed.). Baltimore: John
415 Hopkins University Press.

416 Pauli, J. N., & Perry, M. Z. (2012). Unexpected strong polygyny in the brown-throated three-
417 toed sloth. *PLoS ONE*, 7(12), e51389. doi:10.1371/journal.pone.0051389

418 Ramachandran, R., Bugbee, K., & Murphy, K. (2021). From open data to open science. *Earth*
419 *and Space Science*, 8. doi:10.1029/2020EA001562

420 Reichman, O., Jones, M., & Schildhauer, M. (2011). Challenges and opportunities of open data
421 in ecology. *Science (New York, N.Y.)*, 331, 703-705. doi:10.1126/science.1197962

422 Rodrigues, F. H., Marinho-Filho, J., & Dos Santos, H. G. (2001). Home ranges of translocated
423 lesser anteaters *Tamandua tetradactyla* in the cerrado of Brazil. *Oryx*, 35(2), 166-169.

424 Schradin, C. (2017). Comparative studies need to rely both on sound natural history data and
425 on excellent statistical analysis. *Royal Society open science*, 4(9), 170346.

426 Schradin, C., & Hayes, L. D. (2017). A synopsis of long-term field studies of mammals:
427 achievements, future directions, and some advice. *Journal of Mammalogy*, 98(3), 670-
428 677. doi:10.1093/jmammal/gyx031

429 Schradin, C., Hayes, L. D., Pillay, N., & Bertelsmeier, C. (2018). The evolution of intraspecific
430 variation in social organization. *Ethology*, 124, 527-536. doi:doi:10.1111/eth.12752

431 Shaw, J. H., Machado-Neto, J., & Carter, T. S. (1987). Behavior of free-living giant anteaters
432 (*Myrmecophaga tridactyla*). *Biotropica*, 255-259.

433 Tanaka, H., Frommen, J. G., Koblmüller, S., Sefc, K. M., McGee, M., Kohda, M., . . . Taborsky,
 434 M. (2018). Evolutionary transitions to cooperative societies in fishes revisited.
 435 *Ethology*, 124(11), 777-789.

436 Taube, E., Vié, J. C., Fournier, P., Genty, C., & Duplantier, J. M. (1999). Distribution of Two
 437 Sympatric Species of Sloths (*Choloepus didactylus* and *Bradypus tridactylus*) along the
 438 Sinnamary River, French Guiana 1. *Biotropica*, 31(4), 686-691.

439 Valomy, M., Hayes, L. D., & Schradin, C. (2015). Social organization in Eulipotyphla: evidence
 440 for a social shrew. *Biology Letters*, 11(11), doi:10.1098/rsbl.2015.0825.

441 Vaughan, C., Ramírez, O., Herrera, G., & Guries, R. (2007). Spatial ecology and conservation of
 442 two sloth species in a cacao landscape in Limón, Costa Rica. *Biodiversity and*
 443 *Conservation*, 16(8), 2293-2310.

444 Wildman, D. E., Uddin, M., Opazo, J. C., Liu, G., Lefort, V., Guindon, S., . . . Goodman, M. (2007).
 445 Genomics, biogeography, and the diversification of placental mammals. *Proceedings*
 446 *of the National Academy of Sciences*, 104(36), 14395-14400.

447 Wilson, D. E., & Mittermeier, R. A. (2015). *Handbook of the Mammals of the World Volume 5:*
 448 *Monotremes and Marsupials*. Lynx Edicions, Barcelona.

449 Wilson, D. E., & Mittermeier, R. A. (2018). *Handbook of the Mammals of the World Volume 8:*
 450 *Insectivores, Sloths and Colugos*. Lynx Edicions, Barcelona.

451
 452
 453

Table 1 Reasons why field studies could not be used to determine the social organization of the study population. For Xenarthra, data from a detailed literature survey trying to identify all published field studies are reported. Additional examples from other mammalian taxa are also reported.

Missing information to determine social organization	Total number of field studies on Xenarthra (ESM1)	Examples from other mammalian taxa (ESM2)
Composition of social units not stated.	29	Carnivora: 1 Chiroptera: 2 Marsupialia: 1 Monotremes: 3
Sex of individuals not stated.	23	Perissodactyla: 6 Carnivora: 2 Chiroptera: 2 Rodents: 2 Marsupialia: 4 Monotremes: 1
Occupancy of sleeping sites.	6	Monotremes: 1
Home range overlap not stated.	3	Monotremes: 1
Frequency of trapping events not stated.	2	Monotremes: 1
Not stated what proportion of the population was studied.	1	