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

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

KEYWORDS
comparative study, field data, intra-specific variation, social organisation, social structure, social system

1 | INTRODUCTION

Comparative studies yield significant insight into the evolution of social systems (Chak et al., 2017; Cornwallis et al., 2017; Firman et al., 2020; Griesser et al., 2017; Lukas & Clutton-Brock, 2013).

The quality of such comparisons has increased over the last decades due to significant improvements in statistical methods that correct for phylogeny and enable us to include ecological and life-history factors (Garamszegi, 2014). However, the quality of comparative studies also depends on the quality of the used database (Schradin,

2017). Many researchers focused on getting a large, instead of an accurate, database, for example by using phylogenetic inferences to add species that had not been studied (birds: Cockburn, 2006; used also by Gonzalez et al., 2013; Jetz & Rubenstein, 2011; mammals: Lukas & Clutton-Brock, 2013). There are now statistically sound methods to infer missing phylogenetic data points (for example see Callaghan et al. (2021)). This can be important to include species into the database for which information on the social system is missing, but for which important life-history and ecological data are available. However, such inference should only be done if the social data are missing from just a few but not the majority of species (Schradin, 2017). Furthermore, information assuming the social system from anecdotal observations or expert opinion published in secondary and tertiary sources has often been included for species that have never been studied in the field (Schradin, 2017). This has been criticised and a more careful approach has been recommended (Griesser & Suzuki, 2016; Huck et al., 2020), that is to only use data from studies where animals have been studied in their natural environment (Schradin, 2017). However, while the number of field studies has increased over the last decades (Schradin & Hayes, 2017), basic data on social systems are often not reported in a way that makes them useable for comparative studies.

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

The conclusions from hypothesis-driven research are important to test and develop theory; however; conclusions can change and the main values of each study are the data that were recorded. It is as important to include these data and the conclusions drawn from them. The availability of published data has been recognised as being of crucial importance (Ramachandran et al., 2021; Reichman et al., 2011). For comparative studies and for meta-analyses, data are more valuable than interpretations. This is demonstrated by the example of intra-specific variation in social systems (Lott, 1984; Schradin et al., 2018). For example, if a study population is reported to be pair-living because most animals live in pairs but some individuals also live solitarily or in groups, then biologically meaningful variation might be missed. We have been building a database on mammalian social evolution since 2015 (Agnani et al., 2018; Valomy et al., 2015). For this, we have searched more than ten thousand peer-reviewed articles for information about the composition of social units, focusing on data reported in the methods and results

sections. We noticed that many field studies that presumably collected such data did not report them, but instead assigned a general form of social organisation to the study population in the introduction and/or discussion.

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

2 | METHODS

2.1 | Xenarthra social organisation

Xenarthra (armadillos, sloths and anteaters) is one of four superorders within the placentals; with the other three being Afrotheria (elephants, sea cows and elephant-shrews), Euarchontaglires (primates and rodents) and Laurasiatheria (bats, carnivores and ungulates) (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 and 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 organisation of species in this superorder is important for comparative studies regarding mammalian social evolution.

2.2 | Data collection and literature review Xenarthra

Literature research was done from July 27, 2020 until June 30, 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 organisation 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 organisation: "*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 organisation 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*."

2.3 | Data from other mammalian taxa

We are in the process of building a database on mammalian social organisation 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.

2.4 | 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 organisation was determined by the most commonly observed social organisation. Following this, the percentage of main social organisation was calculated by dividing the number of social units of the main social organisation by the total number of social units multiplied by 100. Finally, intra-specific variation in social organisation (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.

3 | RESULTS

3.1 | 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 organisation was collected. These articles were searched in detail for information. Twelve publications provided information on social organisation 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 organisation. 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 organisation 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 organisation 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).

3.2 | Other mammalian taxa

Examples from other mammalian taxa show that the same information to determine social organisation 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 (ESM 2), which would be essential to determine the sex composition of the social units, that is 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 (ESM 2). In

TABLE 1 Reasons why field studies could not be used to determine the social organisation of the study population

Missing information to determine social organisation	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.	24	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	

Note: 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.

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).

4 | 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 organisation. We further add examples from other mammalian taxa indicating similar problems. Data on social organisation 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 organisation, including pair-living and female groups. The Xenarthra represent one of four mammalian superorders, such that the social organisation 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 organisation in Xenarthra, ignoring other possible forms of social organisation 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 are essential; however, these data are 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 and 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 organisation (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 and Wilson (1999)), groups in pale-throated three-toed sloths (*Bradypus tridactylus*, Wilson and Mittermeier (2018)) and groups of adult offspring staying together in nine-banded armadillos (*Dasypus novemcinctus*, Nowak and 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 organisation 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 organisation occurring in this species.

In Xenarthra and monotremes, the general assumption that they live solitarily might explain why researchers are reluctant to report data on social organisation. 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 organisation consists of one male with multiple females or multiple males and multiple females, has 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 organisation 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).

To compensate for missing data, others solved this by using phylogenetic interferences (assuming closely related species have the same social system), included data from captive studies and expert opinions, with the risk of coming to wrong conclusions (Schradin et al., 2018). Here, we argue for field researchers to report life-history data in a precise way, making it possible to accurately determine the social organisation and especially the composition of social units, one of the key components of social systems (Kappeler, 2019). Sometimes, it is impossible for researchers to give the correct information about the sex composition of social units, especially in species forming large herds (Moehlman 1998; Rudman 1998) or when individuals are not captured, sexed and individually marked. However, when such information is routinely collected, it should also be reported. In Xenarthra, this problem exists for studies published during the last 4 decades and was even dominant during the last decade (ESM 1); indicating that it is not a problem of research methodology, but of publishing culture. We argue that in future, it is important to report such data even if the study focus is on a different topic.

Kappeler (2019) defined the social organisation as the composition of social units, which was inferred by previous comparative studies from direct observations (Jaeggi et al., 2020), trapping data (Valomy et al., 2015) and from sleeping sites (Agnani et al., 2018). Table 1 states the information which every study on wild living animals should report in their methods and results section, to make information about the social organisation of the study population available for comparative studies, even when the study focus is on

something else. While Table 1 lists this information in the order of missing information, in any publication it should typically be reported as: (1) proportion of individuals within the study area trapped, marked, radio-tracked and observed, (2) frequency of trapping/observation event, (3) sex 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 organisation 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 organisation 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 alloparental care by breeders and non-breeders occurs, but also how commonly this 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 organisation can be extended to the other components of the social system.

5 | CONCLUSIONS

During the process of building a database on mammalian social organisation, 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 organisation; 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).

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