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The effect of dominance rank on female reproductive success in social mammals

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ABSTRACT
Life in social groups, while potentially providing social benefits, inevitably leads to conflict among group members. In many social mammals, such conflicts lead to the formation of dominance hierarchies, where high-ranking individuals consistently outcompete other group members. Given that competition is a fundamental tenet of the theory of natural selection, it is generally assumed that high-ranking individuals have higher reproductive success than lower-ranking individuals. Previous reviews have indicated large variation across populations on the potential effect of dominance rank on reproductive success in female mammals. Here, we perform a meta-analysis based on 444 effect sizes from 187 studies on 86 mammal species to investigate how life-history, ecology and sociality modulate the relationship between female dominance rank and fitness. As predicted, we found that (1) dominance rank is generally positively associated with reproductive success, independent of the approach different studies have taken to answer this question; and that (2) the relationship between rank and reproductive success is conditional on life-history mechanisms, with higher effects of dominance rank on reproductive output than on survival, particularly in species with high reproductive investment. Contrary to our predictions, (3) the fitness benefits to high-ranking females appear consistent across ecological conditions rather than increasing when resources decrease. Instead, we found that the social environment consistently mitigates rank differences on reproductive success by modulating female competition, with, as predicted, (4) dominant females showing higher reproductive success than subordinates in two different types of societies: first, effect sizes are highest when females live in cooperatively breeding groups composed of a single dominant female and one or more subordinate females; second, they are also elevated when females form differentiated relationships which occurs when groups are composed of unrelated females. Our findings indicate that obtaining a high ranking position in a social group consistently provides female mammals with fitness benefits, even though future studies might show lower effects given various biases in the literature we were able to access, including, but not restricted to, a publication bias. They further draw a complex landscape of the level of social inequality across mammalian societies, reflected by variation in the benefits of social dominance, which appears to be shaped by reproductive and social competition more than by ecological competition.

Keywords: dominance hierarchy, female competition, meta-analysis

Background

In order for social groups to persist, group members need to find strategies to deal with the conflicts that inevitably occur (Ward and Webster (2016)). In many female social mammals, conflicts and aggressive interactions are associated with the formation of different types of hierarchies. How these hierarchies form and are expressed differs across societies (Tibbetts, Pardo-Sanchez, and Weise (2022)). In singular cooperative breeders, a single dominant breeding female suppresses reproduction in subordinate group members, who rarely fight amongst each other until an opportunity to become dominant opens (Solomon, French, et al. (1997)). In many species where multiple breeding females form stable groups, females can be arranged in stable linear hierarchies, where mothers help their daughters to inherit their rank in their matriline (Holekamp and Smale (1991)). In another set of species, hierarchies are more flexible as a female's rank depends on her body size, condition, or availability of coalition partners (Pusey (2012)). However, it has remained unclear whether and when dominant females gain substantial fitness benefits, indicating that there is selection on all females to compete for a high rank. Instead of direct selection on females to compete over high dominance rank because it provides substantial fitness benefits, selection might be on females to find a place in the hierarchy that maximizes their fitness based on their intrinsic qualities and access to social opportunities.

The prevailing assumption is that high ranking females benefit from their dominant status because outcompeting other females provides them with priority of access to resources (Ellis (1995), Pusey (2012)). Subordinates are expected to accept their status, because despite having lower reproductive success than dominants, they have few outside options and would presumably face high costs, or have even lower success if they tried to challenge for the dominant status or to reproduce independently (Alexander (1974), Vehrencamp (1983)). An alternative assumption however is that both dominants and subordinates gain from arranging themselves in a hierarchy to avoid the overt fighting that occurs whenever differentially aggressive individuals repeatedly interact (West (1967)). All individuals make a compromise, such that they all balance the potential benefits of their respective positions with the potential costs (Williams (1966)).

Previous reviews have found that while high ranking female mammals frequently appear to have higher reproductive success, there are many populations where such an association has not been found (Pusey (2012), T. Clutton-Brock and Huchard (2013)). Most studies that brought together such data have focused on primates and generally only provided qualitative summaries of the evidence, sometimes using a limited number of fitness proxies (Fedigan (1983), Ellis (1995), Paula Stockley and Bro-Jørgensen (2011)). One meta-analysis across primates investigated whether life history might mediate the strength of the association between dominance and reproductive success and found that high-ranking females had higher fecundity benefits in species with a longer lifespan (Majolo et al. (2012)). However, there has been no study simultaneously examining the effect of life-history, social and ecological factors in modulating the benefits of social dominance. Similarly, there has been no quantitative assessment of the potential factors that may mitigate the relationship between rank and reproductive success to explain those cases where high rank is not beneficial. Here, we investigate the extent and sources of variation in the effect of dominance rank on female reproductive success across social mammals. Our study builds on the long history of research on dominance interactions (Strauss et al. (2022)) by bringing together effect sizes of the relationship between rank and reproductive success from diverse mammalian societies, and we add socio-ecological predictor variables that have not been included in earlier analyses.

Objective

In this study, we present a quantitative assessment of the strength of the relationship between female dominance rank and reproductive success in social mammals and explore factors that might mediate this relationship. Our objective is to identify the ranges of variation in the relationship between rank and reproductive success and to investigate how this relationship is influenced by differences in life-history, ecology, and sociality. We addressed our objective through the following questions, by testing the corresponding four core predictions, which each break into a number of secondary predictions (see results):

1) Does high rank generally lead to higher reproductive success for females in social mammals? We expected that, overall, high dominance rank has a positive effect on reproductive success, based on the previously published reviews and meta-analyses.

2) What are the life history traits that mediate the benefits of rank on reproductive success? We expected that dominants have higher reproductive success predominantly in species in which females have the ability to quickly produce large numbers of offspring, because reproductive competition may be most intense in those species that invest heavily in reproduction, and the consequences of such competition may be more detectable due to the potential for large variance in reproductive success among females in such species

3) What are the ecological conditions that mediate the benefits of rank on reproductive success? We expected that differences in reproductive potential would be particularly marked where within-group contest competition for resources is expected to be largest, that is when resources are limited and monopolizable.

4) What are the social circumstances that mediate the benefits of rank? We expected that the association between dominance rank and reproduction is stronger in species living in more stable and structured social groups, where rank differences may be pronounced, and stable over long periods.

Methods

Literature search

The literature search was performed by S & DL. We started with the references in previous major reviews and meta-analyses on the association between dominance and reproduction in female mammals (see below for inclusion criteria): Fedigan (1983) (8 effect sizes on female primates entered), Ellis (1995) (16 effect sizes entered / 5 not entered on female non-primates, 38 effect sizes entered / 22 not entered on female primates), Brown and Silk (2002) (28 effect sizes entered / 7 not entered on female primates), Paula Stockley and Bro-Jørgensen (2011) (12 effect sizes entered / 2 not entered on female non-primates, 11 effect sizes entered / 1 not entered on female primates), Majolo et al. (2012) (26 effect sizes entered / 2 not entered on female primates), Pusey (2012) (45 effect sizes entered / 2 not entered on female primates), and T. Clutton-Brock and Huchard (2013) (8 effect sizes entered / 1 not entered on female primates, 6 effect sizes entered / 1 not entered on female non-primates) (some effect sizes appear in multiple studies, leading to a total of 136 effect sizes) (using Pubmed, 22 May 2019 - 13 June 2019). Next, we searched Google Scholar and Google Search with the following terms: “dominance AND female AND mammal AND reproductive success OR reproduction” (04 July 2019 - 31 July 2019; 143 additional effect sizes), “rank AND female AND mammal AND reproductive success OR reproduction” (14 September 2019 - 13 November 2019; 90 additional effect sizes), and “sex ratio AND dominance AND female AND mammal” (11 February 2020 - 06 March 2020; 75 additional effect sizes).

We checked the titles and abstracts to identify studies that observed dominance interactions and reproductive success in social groups of interacting female non-human mammals. We limited our checks to the first 1000 results for all searches as automatically sorted by the respective search engine (sorted by ‘relevance’ on Google Scholar). We selected studies that measured the association between dominance rank and at least one aspect of female reproductive success and reported the data or a test-statistic. For both dominance and reproductive success, we only included studies that had direct measures, not secondary indicators. For dominance, we excluded studies where authors did not explicitly determine dominance relationships and only assumed that traits such as size, presence in core areas, or reproductive success itself indicate dominance. We did however include studies where authors established dominance hierarchies, found that they are associated with some other trait such as size or condition, and subsequently used the other trait to rank individuals. For reproductive success, we similarly excluded studies that reported associations of dominance rank with traits whose links with reproductive success were indirect or had not been tested. Studies we excluded reported, for example, associations between dominance rank and mating frequency, priority of access to food resources, or differences in ranging behaviour. We included all kinds of academic publications, from primary articles published in peer-reviewed journals through reviews, books and book chapters, and unpublished PhD theses.

Variables, their definitions, and their sources

Variables coded directly from the relevant publications:

All data from the literature search on publications reporting the effect of dominance rank on reproductive success were entered prior to the first submission of the preregistration. S and DL performed the data extraction. We initially coded eight papers independently, for which we both extracted the same values and classified the approaches in the same way. S and DL also independently went through the studies included in Majolo et al. (2012) and agreed on which to include and which not. After this, S and DL independently identified and coded articles, with occasional cross-checks and discussions of any border line cases. We extracted the relevant information to calculate the effect sizes and their associated variance. In addition, we coded a set of variables to characterize the methodological approach. The dataset contains 444 effect sizes from 187 studies on 86 mammalian species.

Z-transformed effect size: we converted all effect sizes to Z-transformed correlation coefficients (Zr). In cases where articles reported a pairwise correlation coefficient, we directly use this value. In cases where authors had used alternative statistical approaches (e.g. t-test comparison between two groups of individuals), the test statistics were converted to the statistic 'r' using formulas provided by Lakens (2013), Lajeunesse et al. (2013), and Wilson (2019). In cases where authors reported individual-level data reflecting dominance rank and reproductive success (for example in the form of a table that listed for groups of dominants and subordinates their mean and deviation of reproductive success or for every individual their rank and reproductive success), we calculated correlation coefficients directly from a 2-by-2 frequency table (when comparing classes of high- to low-ranking individuals) or from linear regressions (when individuals had continuous ranks). In cases where studies simply stated that "all dominants bred but none of the subordinates" we assumed an error of 0.5% for both dominants not breeding and subordinates breeding to obtain the sampling variance estimates. We extracted separate effect sizes for each reported analysis: for example, if authors reported separately associations between dominance rank and mortality of offspring to 1 year and to independence, we obtained two effect sizes from this population reflecting infant survival. We Z-transformed all correlation coefficients to control for the asymptotic distribution of these values. We changed the sign of the effect sizes to make them consistent across studies. This was necessary because dominance rank was coded differently across studies, for example sometimes studies assigned dominant individuals the lowest value by starting a count from 1, whereas in other cases they were assigned the highest value to reflect the proportion of other females they are dominant over. We set the sign of effect sizes such that positive values mean that higher ranking individuals have shorter interbirth intervals, higher survival as adults and of their infants, higher infant production (e.g. larger litter sizes, higher probability of breeding), and higher lifetime reproductive success (e.g. higher total number of offspring weaned).

Sample size: we recorded the sample size for the relevant statistical comparison (number of females, number of offspring, number of matrilines etc.).

Sampling variance: we calculated the sampling variance of the effect sizes based on the correlation coefficient r and the sample size, using the formulas provided by Wilson (2019). The standard error, which is alternatively used in some approaches, is the square root of the sampling variance (Viechtbauer (2010)).

Species identity: we recorded the common name and the latin species name as listed by the authors. We referred to the Mammal Diversity Database (Burgin et al. (2018)) to resolve instances where species attributions had been changed since the publication of the original study.

Study site: we recorded the name of the study site as listed by the authors in the method section. The focus of this variable is to determine whether multiple observations are from the same species from the same study population, and we accordingly assigned different names for the study site label in case two or more different species had been studied at the same site.

Measure of reproductive success: we recorded which aspect of reproduction dominance rank was associated with. We classified reproductive traits into six classes: - age at first reproduction (includes age at first birth, age at first conception, age at first menstrual cycle); - infant survival (includes rates of mortality of offspring prior to their independence; proportion of pregnancies carried to birth); - survival (includes rates of mortality of females per year, age at death); - infant production (includes litter size, offspring weight, litter mass, number of offspring per year, probability of birth in a given year, number of surviving infants per year); - interbirth interval (includes time between live births, number of cycles to conception, number of litters per year); - lifetime reproductive success (includes total number of offspring born or surviving to independence for females who had been observed from first reproduction to death).

Classification of rank: we recorded the approach the authors had used to assign dominance positions to individuals, distinguishing between those based on aggressive/submissive interactions between pairs of individuals and those based on other traits such as age, size, or which female was the first to reproduce.

Scoring of rank: we recorded whether in the analyses individuals were assigned a specific, continuous rank position or whether individuals were classified into rank categories (dominant versus subordinates, high- versus middle- versus low-ranking).

Duration of study: we recorded the number of years that authors had observed the individuals (anything less than one year was assigned a value of 1).

Population type: we recorded whether the population was free-living, provisioned, or captive based on the authors descriptions.

Social group size: we recorded the average number of adult females per group in the study population, based on the information provided in the manuscripts. We relied on the definition of a social group as used by the respective authors, which might include associations of females in: singular-breeder cooperative groups (as in wolves or meerkats); stable groups of multiple breeding females (as in baboons or hyenas); or breeding associations defined by physical proximity (as in bighorn sheep or antelopes). We will have a separate coding of the social system (see below).

Variables extracted from the broader literature for each species/population:

The following data were added prior to the analyses. For most of these, we extracted information from the relevant papers or publications reporting on the same population. For some of these, we used previously published species' averages, because records from each population for each specific period during which the effect of dominance rank on reproductive success were measured were not available for a large enough sample. We list sources we used to obtain these data.

Litter size: the number of offspring per birth; data available for each population, we used the average as reported by the authors (based on the data in Jones et al. (2009)).

Interbirth interval: the time in months between consecutive births; data available for a limited set of populations, we used the average as reported by the authors. Given that population specific data was available for only a very limited subset, we added species-level averages (based on the data in Jones et al. (2009)).

Maximum lifespan: the maximum time in months that an individual of that species has been recorded to live for (based on the data in Jones et al. (2009)).

Cooperative breeding group: whether social groups usually contain a single breeding female and additional non-breeding adult females that help to raise the offspring of the breeding female. Group membership for females is usually closed and changes occur through birth and death or fissioning of existing groups. This classification is in contrast to plural breeding groups and breeding associations (see below); data available for each population, we used the description of the social system in the population as reported by the authors.

Plural breeding group: whether social groups usually contain multiple breeding females that remain together for extended periods of time. It includes both groups in which females are philopatric or disperse. Females form differentiated relationships with other group members. This classification is in contrast to cooperative breeding groups and breeding associations (see above/below); data available for each population, we used the description of the social system in the population as reported by the authors.

Breeding association: whether social groups consist of multiple breeding females that associate either in space or by mutual attraction. Group membership is fluid and associations among individuals can rapidly change. This classification is in contrast to cooperative breeding groups and plural breeding groups (see above); data available for each population, we will use the description of the social system in the population as reported by the authors.

Dominance system: whether dominance rank of females appears to depend primarily on (i) their age, (ii) their physical attributes such as body size, or (iii) nepotism in the form of support from their mother or from same-aged group members. Data available from a subset of populations, to which we added data from primary reports of species-level classifications from other populations assuming that this trait is usually stable across populations within species (references listed in the data file).

Philopatry: whether females have the majority of their offspring in the same social groups or in the same location in which they have been born or whether females disperse to other groups or locations to reproduce; data from species-level descriptions of female behaviour (based on the data in Barsbai, Lukas, and Pondorfer (2021)).

Monopolizable resources: whether the gross dietary category of a species is based on monopolizable resources (carnivory, frugivory), or non-monopolizable resources (herbivory, or omnivory) (based on the data in Wilman et al. (2014)).

Environmental harshness: whether the average climatic conditions experienced by the species are characterized by cold temperatures, low rainfall, and unpredictability (based on the data and principal components summarizing climate data in Botero et al. (2014)).

Population density: the average number of individuals per square kilometer for the species (based on the data in Jones et al. (2009)).

Average and variance in relatedness among group females: the average and variance in relatedness measured using genetic approaches among adult females within the same group as reported for this species; data available from a subset of the populations (references listed in the data file).

Coalition formation: whether adult females form coalitions with other female group members to support each other during within-group aggressive interactions; data from species-level descriptions of female behaviour (based on the data in Lukas and Clutton-Brock (2018)).

Sexual dimorphism in body weight: we calculated sexual dimorphism following the two step approach of Smith (1999) as the average weight of males divided by average weight of females if males are heavier than females and as 2 minus the average weight of females divided by the average weight of males otherwise (based on data in:Jarman (1983), Loison et al. (1999), Smith and Cheverud (2002), Isaac (2005), and Kappeler et al. (2019))

Male infanticide: whether adult males in that species kill offspring (based on the data in Lukas and Huchard (2014)).

Adult sex ratio: the ratio of the average number of adult males divided by the sum of the average number of females and males per social group of that species. We took species' averages to reflect adaptation to likely levels of potential sexual conflict because several of the studies from which we extracted effect sizes had captive or experimental settings or only reported the number of females that were included in the study (based on the data in Barsbai, Lukas, and Pondorfer (2021)).

Phylogeny

We generated a single consensus phylogeny for the mammalian species in our sample from the most recent complete mammalian time-calibrated phylogeny (Upham, Esselstyn, and Jetz (2019)). We downloaded a credible set of 1000 trees of mammalian phylogenetic history from vertlife.org/phylosubsets/ (July 2020) and used TreeAnnotator (version 1.8.2 in BEAST: Drummond et al. (2012)) to generate a maximum clade credibility (MCC) tree (median node heights and a burn in of 250 trees). We trimmed the tree to match the species in our sample (in one instance using a close relative, /Canis lupus/ instead of /Canis familiaris/) and converted branch lengths using functions of the package ape (Paradis and Schliep (2019)).

Analyses

We performed all analyses in the statistical software R (version 4.0.3; R Core Team (2020)). We built separate models for each prediction. For some predictor variables,we could not find data to match to all observed effect sizes, and excluded these cases with missing data from the respective analyses. We report the sample size for each analysis. To assess the robustness of the findings and whether modeling decisions might have an influence on our results, we used a frequentist and a Bayesian approach to build the statistical models. For the frequentist approach, we fit meta-analytic multilevel mixed-effects models with moderators via linear models using the function"rma.mv" in the package metafor (Viechtbauer (2010)), taking into account the sampling variance as measurement error and including models that account for the potential correlations among effect sizes due to shared phylogenetic history among species (Nakagawa and Santos (2012)). For the Bayesian approach, we estimated relationships as implemented in the package rethinking using the function "ulam" (McElreath (2020)) to fit with Markov chain Monte Carlo estimation in stan (Stan Development Team (2020)). We fit multilevel models that include the sampling variance as measurement error (Kurz (2019)) and the shared phylogenetic history as a covariance matrix. Weakly regularizing priors were used for all parameters. We drew 8000 samples from four chains, checking that for each the Gelman-Rubin convergence diagnostic 'R-hat' values are less than 1.01 indicating that the Markov chains have converged towards the final estimates. Visual inspection of trace plots and rank histograms were performed to ensure that they indicated no evidence of divergent transitions or biased posterior exploration. Posteriors from the model were used to generate estimates of the overall effect size and the influence of potential moderators. With both approaches, we determined whether a variable had a relationship with the variation in the effect of dominance rank on reproductive success when the interval (for metafor the 95% confidence interval of the estimate; for rethinking the 89% compatibility estimate of the posterior sample) of the estimated association did not cross zero (continuous variable) or of the contrast between levels did not cross zero (categorical variable), indicating that our data show a consistent positive/negative association.

In both approaches, the phylogenetic multilevel meta-analyses we used for most of our analyses takes as outcome the individual effect sizes, the z-transformed $ObservedFisherZr_i$ as the *i*-th effect size (with i = 1,...,$N_i = \sum_{j=1}^{N_{studies}} N_r$ where N_r is the number of effect sizes reported in the *j*-th study). They include the variance $Variance_i$, the sampling (measurement) error of the *i*-th effect; and the values for the respective predictor variables, $Explanatory_i$ associated with the *i*-th effect size. From this, we estimate μ as the meta-analytical mean (or intercept); and $\beta_{explanatory} * Explanatory$ as the slope β between the $Explanatory$ variable and the effect size values.

The meta-analysis in metafor takes the form:

$$ObservedFisherZr_i = \mu + \beta_{explanatory} * Explanatory_i + s_{k[i]} + p_{k[i]} + e_i$$
$$\mathbf{s} \sim Normal(0, \sigma_s^2 \mathbf{I})$$
$$\mathbf{p} \sim MVNormal(0, \sigma_p^2 \mathbf{D})$$
$$\mathbf{e} \sim Normal(0, \mathbf{V})$$

where

each effect size $ObservedFisherZr_i$ is assumed to reflect the overall mean μ and the relationship with the respective predictor variable $\beta_{explanatory} * Explanatory_i$, plus

s_k is the species-specific effect, which is not part of the phylogenetic effect with **s** as 1 by the number of species $N_{species}$ vector of the s_k values which are normally distributed around zero with species specific variance σ_s^2 and I has dimensions $N_{species}$ by $N_{species}$;

p_k is the phylogenetic effect for the *k*th species, with **p** as 1 by $N_{species}$ column vector with the p_k values which are assumed to follow a multivariate normal distribution with mean 0 and variance-covariance matrix $\sigma_p^2 K$, where σ_p^2 denotes between species variance due to phylogeny and **D** is the $N_{species}$ by $N_{species}$ distance matrix between species k and l from the phylogeny; and

e_i is the effect-size-specific residual term for the *i*-th effect size and **e** is a 1 by N_i vector of e_i which is normally distributed around zero with variance mean $Variance_i$, the sampling (measurement) error of the *i*-th effect, and **V** is an N_i by N_i matrix with the $Variance_i$ values along the diagonal.

The meta-analysis in rethinking takes the form:

$$ObservedFisherZr_i \sim Normal(TrueFisherZr_i, Variance_i)$$
$$TrueFisherZr_i \sim MVNormal(\alpha, K_{k[i],l[j]})$$
$$\alpha = \mu + \beta_{explanatory} * Explanatory_i$$
$$\mu \sim Normal(0, 1)$$
$$\beta_{explanatory} \sim Normal(0, 0.5)$$
$$\mathbf{K} = \eta^2 exp(-\rho^2 \mathbf{D}^2)$$
$$\eta^2 \sim Exponential(1)$$
$$\rho^2 \sim Exponential(1)$$

where

each effect size $ObservedFisherZr_i$ is assumed to reflect the true effect size of that relationship $TrueFisherZr_i$ that was measured with some error, with the extent of the error related to the observed $Variance_i$ of each effect size;

the $TrueFisherZr_i$ effect sizes come from an overall distribution, the mean α of which depends on μ and the relationship with the respective predictor variable $\beta_{explanatory} * Explanatory_i$, with the priors for μ and β centered around zero assuming the overall effect size mean is close to zero but might be smaller or larger than zero and that the predictor variable might have no, a negative, or a positive influence; and

$K_{k[i],l[j]}$ reflecting the similarity between the respective species k and l from which the effect sizes i and j have been reported, with **K** as the variance-covariance matrix of the $TrueFisherZr_i$ reflecting the similarity between all species k and l, where the same species k can appear in multiple rows/columns when there are multiple observed effect sizes from that species, that transforms the squared distance **D** among all species pairs k, l from the phylogeny according to a Gaussian process with a multinormal prior with the parameters η^2 (maximum covariance among closely related species) and ρ^2 (decline in covariance as phylogenetic distance increases), whose priors are constrained to be positive.

We provide all code showing the setup of the various models and the plots, the input files containing the data and phylogeny (see the "Data and Code Availability" section for the archived versions or the linked github repository. In addition, the github repository also contains a simulated dataset with the same structure as the actual data, which we used to assess the fit of our models in the preregistration.

Preregistration

We preregistered hypotheses, methods, and analysis plans: https://dieterlukas.github.io/Preregistration_MetaAnalysis_RankSuccess.html

The literature search was completed before the first submission of the preregistration. All variables that were coded directly from the source publications (Z transformed effect size, variance, sample size, species identity, aspect of reproductive success, classification of rank, duration of study, population type, and social group size) were also entered prior to the first submission. In July 2019, S worked with a preliminary subset of the data (143 effect sizes), and investigated publication bias, the overall mean and variance in effect sizes, and whether effect sizes differed according to which reproductive output was measured. We added the data on the following explanatory variables and started analyses in July 2020 after the preregistration passed pre-study peer review at *Peer Community In Ecology*: Paquet (2020) Peer Community in Ecology, 100056. [10.24072/pci.ecology.100056] (https://doi.org/10.24072/pci.ecology.100056)

- litter size, litters per year, and population density for the respective species
- cooperative vs plural vs associate breeding from the descriptions in the respective population from the articles from which we obtained the effect sizes
- dominance system from additional references on the species
- philopatry of the respective species
- diet category of the respective species
- environmental harshness across the range of the respective species
- coalition formation in the respective species
- sexual dimorphism in body weight
- male infanticide
- sex ratio among adult group members
- average relatedness from the articles from which we obtained the effect sizes or additional references matching the exact population
- we did not collect data on variance in relatedness because it was not possible to extract this information from most studies reporting relatedness levels

Changes from preregistration

Additional variables: We added data on the maximum lifespan of species to address Prediction 4.2. We realized that whether a study should be considered short- or long-term depends on the lifespan of the focal species. We used the information on the number of years a study had been conducted together with the maximum lifespan data to calculate the relative duration of a study as the number of years the study had lasted divided by the maximum lifespan of the species.

We added data on the dominance style of macaque species after noting that these species constitute a large proportion of our sample. Across macaque species, dominance interactions among females in a group have been assigned into one of four grades, ranging from egalitarian species in Grade 1 to highly despotic species in Grade 4 (Thierry (2007)). We were interested to assess the effect of dominance style on the benefits of dominance. We extracted the data on the dominance style for the species in our sample from Balasubramaniam et al. (2012)

We changed how we calculated sexual dimorphism in body weight. We had previously taken the ratio of male weight divided by female weight. A collaborator on a different project, in which we also use sexual dimorphism in body weight as a variable, alerted us to the article by Smith (1999) which shows that this simple ratio is biased because its distribution across species is non-linear resulting in asymmetries when females are the larger sex (as example, assume a species where individuals of one sex are 10kg and individuals of the other sex are 8kg; if males are the larger sex the simple ratio would indicate that the larger sex is 25% larger [10/8=1.25]; however, if females were the larger sex it would indicate that the larger sex is only 20% larger [8/10=0.80]). We therefore switched to formula provided in this article, calculating sexual dimorphism as the average weight of males divided by average weight of females if males are heavier than females and as two minus the average weight of females divided by the average weight of males otherwise.

Outlier check: Before running the analyses, we made a funnel plot of the standard error over the effect size, where we noticed three outlier data points. We realized that for these three entries (EffectRefs 425, 427, and 428) we had used the wrong formula to calculate the effect size and variance. All of these are studies of multiple groups of *Callithrix jacchus*, each with a small number of females. For these three studies, we had erroneously used the 2-by-2 frequency tables to calculate the standardized mean difference, not the correlation coefficient. We corrected the values for these three entries before performing any of the analyses.

Sampling bias: The funnel plot of the complete dataset showed a strong asymmetry, indicating that our sample is biased towards including many studies with low precision and high positive effect sizes. To better illustrate this sample bias, we used a different way to plot the data (Nakagawa, Lagisz, O'Dea, et al. (2021)) that was suggested after we had written our preregistration. We also added further analyses, based on functions in the packages 'metafor' (following Nakagawa, Lagisz, Jennions, et al. (2021)) and 'rethinking' (following McElreath (2020)), to determine the potential causes of the bias in our sample and the influence on what effects should be expected in new samples.

Multivariate analyses: We constructed the multivariate analyses after completing the univariate analyses. Specifically, one setof analyses investigates the potential difference between cooperative breeders and plural/associated breeders, and others more specific links between likely linked variables.

Results

We extracted 444 effect sizes of the relationship between dominance rank and reproductive success of female mammals from 187 studies on 86 species during our literature search (Figure 1). More than half of the effect sizes are from primate species (254 effect sizes), with macaques (109) and baboons (76) a particular focus for this research. About two thirds (283) of the reports are from wild populations; rank was predominantly determined on the basis of aggressive interactions (407) rather than on other measures such as age or size (37); and it was about equally frequent that researchers classified rank categorically as dominant versus subordinate (251) than continuously from highest to lowest (193). Most of the reported effects link dominance rank to infant production (198) followed by infant survival (113), with fewer effects reported on interbirth intervals (46), lifetime reproductive success (34), survival (30), or age at first reproduction (23).

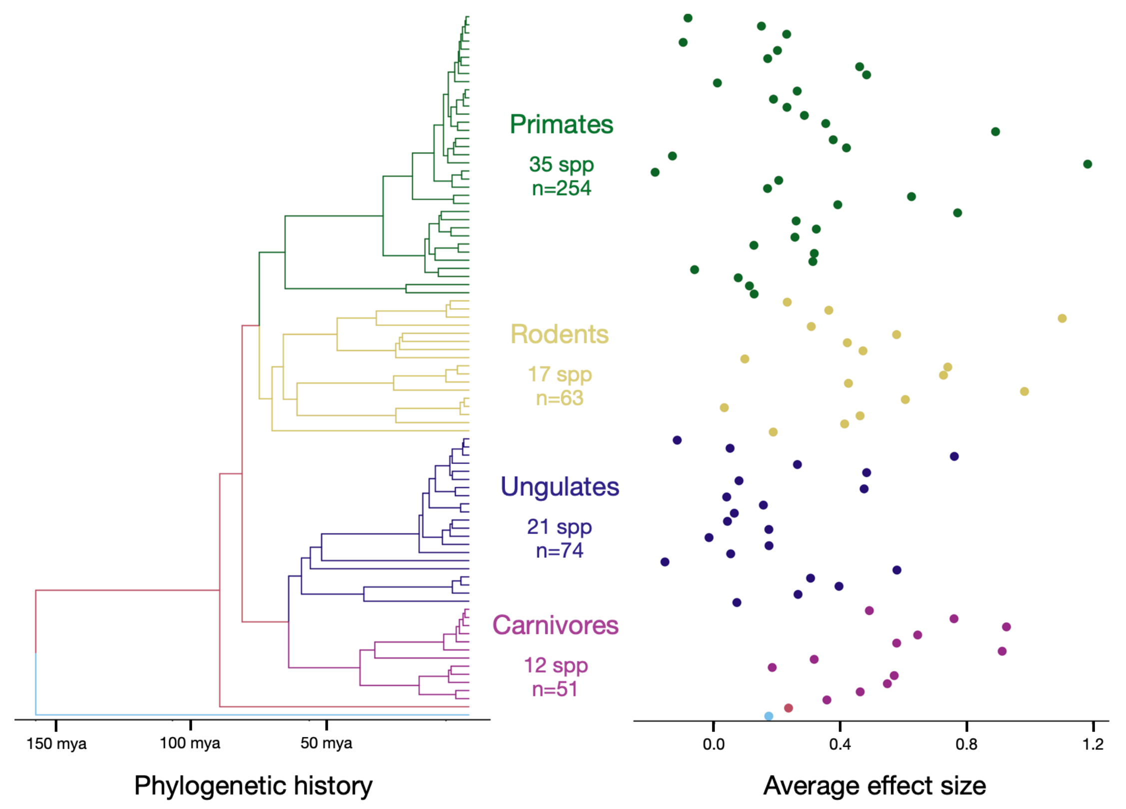

Figure 1. Phylogenetic distribution of the effect sizes in our dataset. Most effect sizes came from studies of primates (green: 254 effect sizes from 35 different species), followed by ungulates (blue: 74 effect sizes from 21 different species), rodents (yellow: 63 effect sizes from 17 species), and carnivores (purple: 51 effect sizes from 12 species), plus a single effect size each from hyraxes (red) and marsupials (aqua). Effect sizes (averaged when multiple values exist for a given species) vary even among closely related species, though there are slight differences among Orders (e.g. carnivores generally have high effect sizes, for more details see below).

1) Does high rank generally lead to higher reproductive success for females in social mammals?

Prediction 1.1: Publication bias does not influence our sample of effect sizes.

We did not predict a publication bias, and accordingly no relationship between effect sizes and sample size. A publication bias would be indicated if our sample does not contain many studies showing small effect sizes with small sample sizes. Most studies set out to test if high dominance might lead to both benefits and costs and therefore are likely to report also small effect sizes, and previous meta-analyses did not detect signals of publication bias (e.g. Majolo et al. (2012)).

Result 1.1: Our sample shows several biases
A visual inspection of an orchard plot of the raw data of the range of effect sizes indicates a sample bias, showing that extreme effect sizes tend to be of low precision and that there is an overrepresentation of positive effect sizes (Figure 2).

There are potentially (at least) three sources of sample bias, the first being 'publication bias' with studies with low effect sizes (not reaching traditional levels of significance) not ending-up in the published literature, the second being 'study system bias' with research focusing on populations where it is easy to detect effects (e.g. cooperative breeders), and the third being 'study time bias' with studies performed over shorter time frames generally being more imprecise. We added further post-hoc analyses to investigate these patterns individually here, and in combined models after identifying which study systems might show different effect sizes (section R5.1).

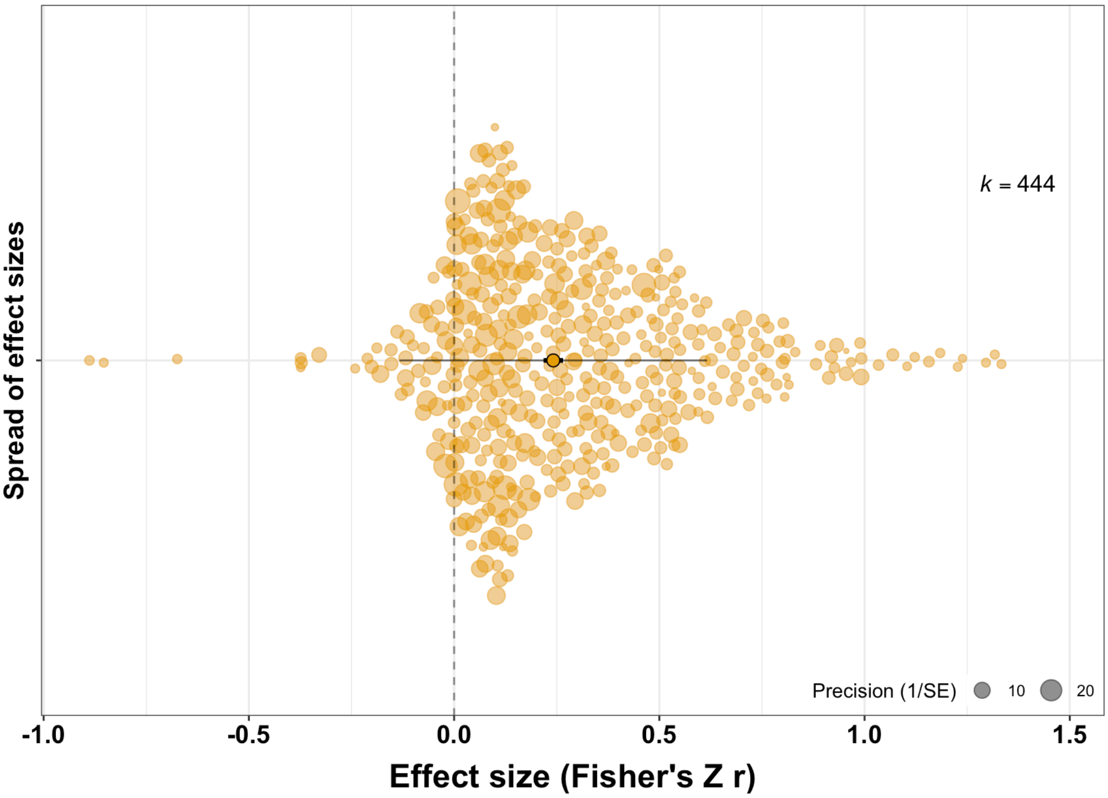

Figure 2. Orchard plot displaying the spread of the 444 effect sizes in our sample (each dot represents a single effect size, the size of the dot indicates the precision). Overall, most studies report a positive association between dominance rank and reproductive success (darker circle in the center indicates the mean, thick black edge right next to circle indicates precision interval, thin black lines extending from darker circle the confidence interval of the estimate). Our sample does show bias, with effect sizes not distributed symmetrically around the center but showing an overrepresentation of highly positive values.

We applied tests for 'publication bias' that expect a standard distribution of p-values (Preston, Ashby, and Smyth (2004)) to our data, which suggest that effect sizes with a p-value smaller than 0.05 are about four times more likely to be reported than effect sizes with a p-value larger than 0.50.

Studies with smaller sample sizes have a higher risk to report inflated effect sizes due to a higher likelihood of Type I and Type II errors. In our dataset, the average effect sizes at smaller sample sizes are more extreme than those at larger sample sizes (effect sizes range from -0.89 to +1.33 for studies with a sample size of 20 or smaller, while for studies with sample sizes larger than 20 they range from -0.37 to +1.24). However, it is not just that the spread of values is larger for studies with smaller sample sizes, but the positive bias in effect sizes we observe decreases with the sample size of studies (metafor estimate 95% confidence interval lower -0.03 to upper -0.02, rethinking estimate 89% compatibility estimate of posterior sample lower -0.09 to upper -0.04) (Figure 3). This supports a 'publication bias', where studies with small sample sizes that did not show a positive effect are missing from the literature. However, the estimate of the intercept and slope of this model linking effect size to sample size shows that, across the range of sample sizes, the estimate of the overall effect size does not go below zero (see line in Figure 3). This indicates that females with higher rank have higher reproductive success across the range of sample sizes.

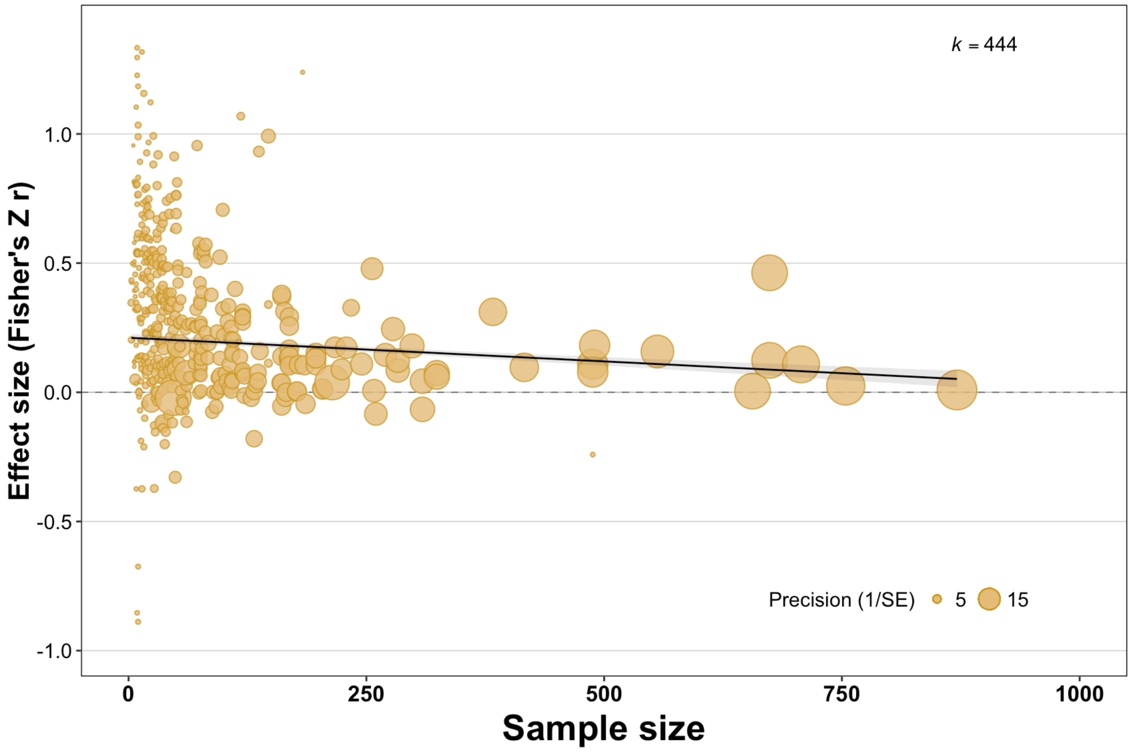

Figure 3. Relationship between the effect size of dominance rank on female reproductive success and the sample size of the study. Studies with smaller sample sizes show more extreme effect sizes, and also indications of potential publication bias as there are more extremely positive values than what would be expected based on the average effect sizes of studies with larger sample sizes.

The base analyses also indicate that at least part of the sample bias might result from 'study system bias', because they reveal substantially more differences (high heterogeneity) among studies than what would be expected by chance if all studies reflected a single underlying effect(total heterogeneity / total variability: 73.37%). Given the diversity of studies in our sample, we did not expect that the effect sizes represent a sample from a single distribution: for example, studies of offspring mortality tend to have larger sample sizes (because each mother can have multiple offspring) and we predict different effect sizes for these studies. Sections R2 - R4 present the specific analyses for each prediction to assess each of the factors potentially leading to differences between effect size estimates, and we combine them in section R5.1.

Finally, including the study duration (in years) as a predictor of the effect sizes also indicates that our sample shows 'study time bias'. Effect sizes are lower when studies have been conducted for longer (metafor estimate 95% confidence interval lower -0.01 to upper 0.00, rethinking estimate 89% compatibility estimate of posterior sample lower -0.05 to upper 0.00), but in particular the variance is reduced once a study has been running for 10 or more years (Figure 4).

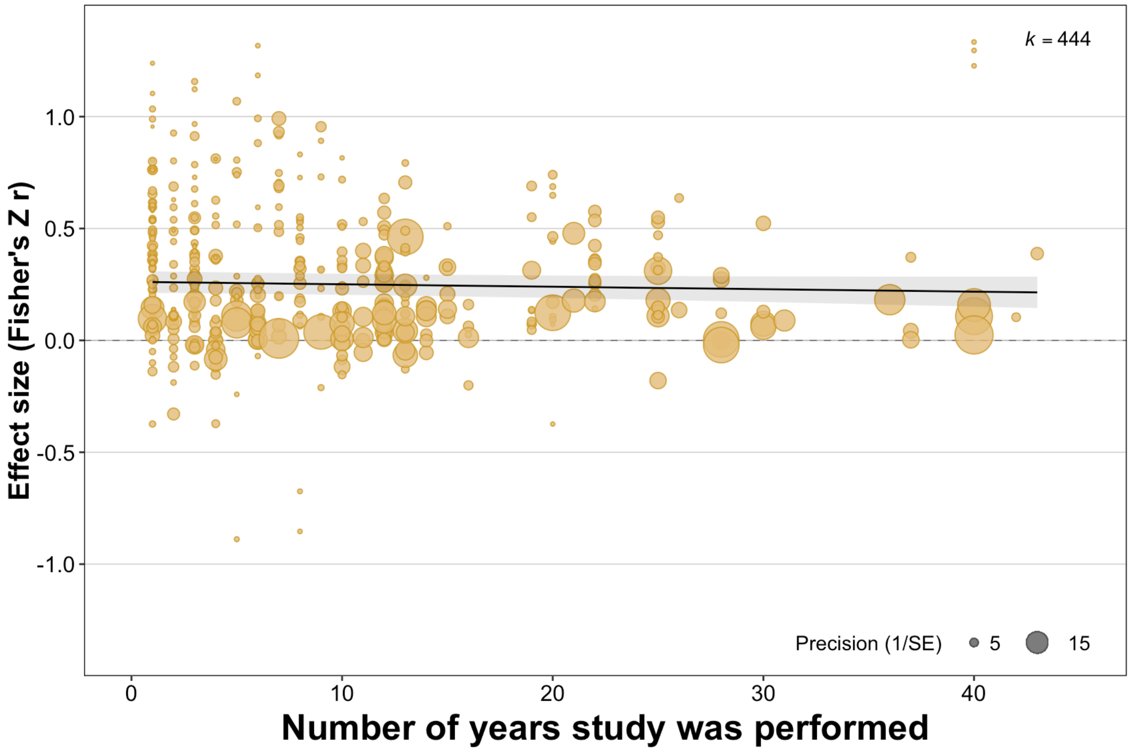

Figure 4. Relationship between the measured size of the effect of dominance rank on female reproductive success and study duration. Studies that have been conducted for 10 or more years tend to have higher precision (larger circle) and tend to be closer to the overall mean.

Prediction 1.2: Overall, high dominance rank will be associated with higher reproductive success.

We predicted that, taking into account the power of the different studies, the combined effect of high rank on reproductive success will be positive. Previous studies that summarized existing evidence (e.g. Majolo et al. (2012), Pusey (2012)) found that high ranking females generally have higher reproductive success than low ranking females.

Result 1.2: Positive overall effect of higher rank on reproductive success

We constructed an intercept-only meta-analytic base model to test for a general effect of dominance rank on reproductive success. Across our sample, there is consistent evidence that females with higher dominance rank have higher reproductive success (metafor estimate of overall effect size lower +0.22 to upper +0.27, rethinking estimate lower +0.26 to upper +0.30; the metafor estimate here and in the additional models is lower than the rethinking estimate because the statistical approach of the former expects the data to be more symmetrical than they are (see Figure 2 for the bias) while the rethinking approach pools information from the available heterogeneous data, such that the metafor estimate is closer to the median of the raw data of 0.23 and the rethinking estimate closer to the mean of 0.29). This overall effect means, for example, that in groups with two individuals dominants would have 0-6 offspring while subordinates would have 0-4 offspring (see Discussion). Yet there is large variation in our sample, with effect sizes ranging from -0.89 to +1.33 (Figure 2).

Prediction 1.3: Effect sizes from the same population and the same species will be similar.

We predicted that studies that have been conducted on the same species, and in particular at the same site, will report similar effects of dominance rank on reproductive success. For some long-term studies, multiple studies have been performed using slightly different methods and/or data from different years which might include the same set of individuals leading to very similar effect size estimates. For studies of the same species from different sites, we expected similarities because many aspects of the life-history and social system that will shape the relationship between rank and reproductive success will be conserved.

Result 1.3: Similarity of effect sizes from the same study and from the same species

To the base model, we added random effects to account for non-independence due to effect sizes originating from within the same study, from studies performed on the same population and on the same species. The estimate of the overall effect size did not change in this model accounting for non-independence (metafor estimate of overall effect size when accounting for non-independence lower +0.22 to upper +0.31, rethinking estimate lower +0.26 to upper +0.35) from the overall effect estimated in the base model. Effect sizes from the same species and the same study, but not from the same population, tend to be similar to each other. The absence of a population effect could be because the ‘study’ and ‘population’ effects are likely to be confounded, as there are very few observations of the same population but from different studies in our dataset. Alternatively, it could be that effects do not vary much across populations of the same species, which is also indicated by the absence of differences between wild and captive populations (see below), with differences among studies of the same species mostly due to differences in the choice of measurement.

Prediction 1.4: Closely related species will show similar effects of dominance rank on reproductive success.

We predicted that effect sizes of the relationship between dominance rank and reproductive success will be more similar among closely related species (Chamberlain et al. (2012)) because methodological approaches can be specific to specific Orders (e.g. ungulates are studied differently than primates) and because closely related species share life history, social and ecological traits that might shape the influence of rank on reproductive success.

Result 1.4: Effect sizes from species in the same Order are similar

To the random effects model, we added a covariance structure to reflect potential similarities in effect sizes arising from closely related species showing similar effects due to their shared phylogenetic history. Both statistical approaches indicate that closely related species tend to have effect sizes that are more similar than those of distantly related species. The metafor approach suggests that about 25% of the variation in effect sizes is associated with covariation among species. The rethinking approach shows high uncertainty in the estimates (Figure 5), reflecting the high heterogeneity in the underlying data with high variation within species and different measures taken among closely related species. It suggests that species of the same genus tend to have similar effect sizes and that shared phylogenetic history might also explain similarities in effect sizes among species in the same Order, but covariance estimates are close to zero for species pairs that are more distantly related (Figure 5; the highest standardized distance between any pair of species in the same Order is 0.40).

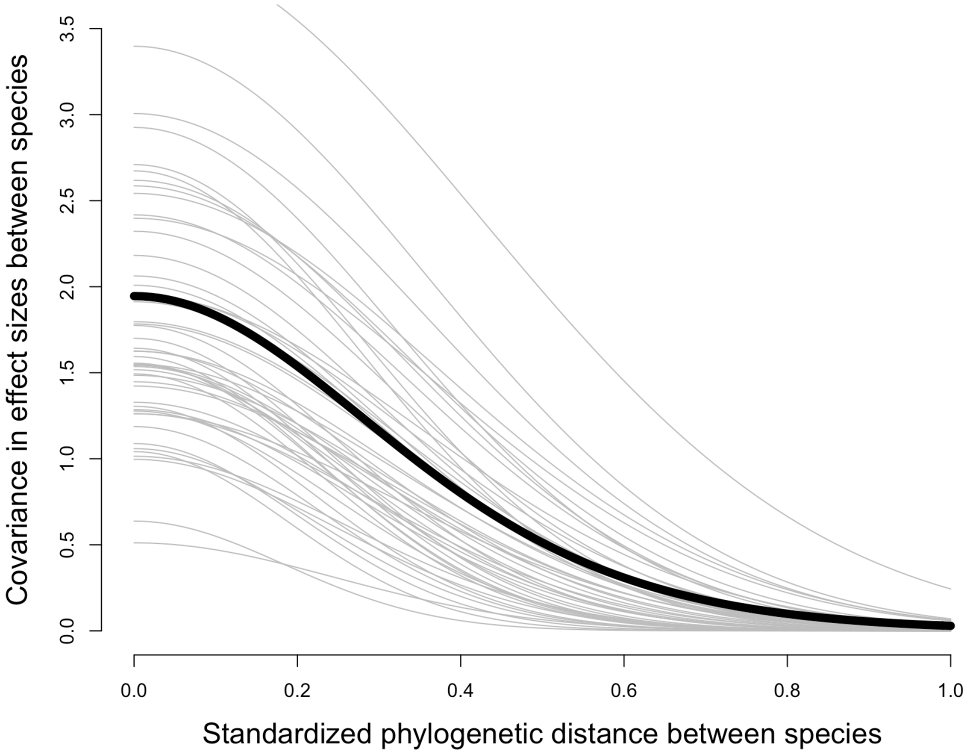

Figure 5. Relationship between the phylogenetic distance between pairs of species and the similarity of their effect sizes (solid black line represents mean estimate of rethinking model, grey lines represent variation in the estimate). Species that are closely related and share most of their phylogenetic history (standardized phylogenetic distance close to zero) show intermediate levels of covariance in their effect sizes of dominance rank on female reproductive success. The covariance drops to low values at a standardized phylogenetic distance of around 0.4, the level separating species that are part of the same Order.

Prediction 1.5: Effect sizes depend on the approach used (wild vs captive populations / agonistic interactions vs physical signs of rank / linear rank vs classes).

We expected that some of the variation in effect size across studies arises from methodological differences:

(i) we predicted lower effect sizes for studies of captive populations compared to wild populations: while the absence of stochastic events in captivity might mean that dominance is more consistently associated with certain benefits, the effects of high dominance rank on reproductive success will be reduced because of lower competition over resources;

(ii) we predicted lower effect sizes for studies where rank was measured based on agonistic interactions rather than on size or age because size and age are frequently directly associated with differences in female reproduction and clear differences between dominants and subordinates may indicate the existence of castes that tend to be associated with strong reproductive monopolization (Lukas and Clutton-Brock (2018)); and

(iii) we predicted different effect sizes for studies classifying individuals into two or three rank categories compared to linear ranking depending on the social system. In cases where there is usually a single dominant female (singular cooperative breeders, such as meerkats), using a linear regression between each individuals' rank and its reproductive success will likely estimate a lower effect size because such an approach assumes differences in rank or reproductive success among the subordinates when there are none. In contrast, grouping individuals into categories to compare dominants to subordinates will capture actual differences more accurately. In cases where several females breed (plural breeders, such as hyenas) and are ordered in a linear hierarchy, a linear regression will exploit the full information available on individual differences in rank and reproductive success, whereas grouping individuals will lead to a loss of resolution, at a risk of underestimating the differences between highest and lowest ranking individuals. We performed simulations to determine the extent to which this choice of approach skews the effect sizes and found that it can lead to differences of more than 35% between the true and the estimated effect sizes. For illustration, we include this simulation in our code.

Result 1.5: Effect sizes are higher when studies used physical signs to classify individuals into categorical rank categories, but do not depend on whether they were measured in captive or in wild populations

To the base model, we added random effects reflecting the differences in approaches across studies (dominance ranks classified continuous/categorical; dominance determined through agonism/correlate; population type wild/provisioned/captive).

(i) Effect sizes did not clearly differ depending on whether studies were conducted with captive (metafor estimate lower +0.24 to upper +0.30, rethinking estimate lower +0.27 to upper +0.37; n=138 effect sizes), provisioned (metafor estimate lower +0.21 to upper +0.33, rethinking estimate lower +0.14 to upper +0.41; n=23 effect sizes), or wild (metafor estimate lower +0.22 to upper +0.34; n=283 effect sizes) individuals, and this does not change when we nest the population type within species (indicating that effect sizes do not differ between captive, provisioned, and wild populations of the same species).

(ii) Studies which determined the rank of females based on agonistic interactions have lower effect sizes (metafor estimate lower +0.22 to upper +0.26, rethinking estimate lower +0.24 to upper +0.32; n=407 effect sizes) than studies which used other correlates (body size, age, etc.) to assign dominance ranks (metafor estimate lower +0.43 to upper +0.55, rethinking estimate lower +0.41 to upper +0.63; n=37 effect sizes). These 37 effect sizes where rank was assigned based on correlates are from cooperative breeders and/or studies in which groups consisted of mothers and their daughters.

(iii) Studies which measured dominance rank categorically by classifying individuals as either dominants or subordinates report higher effect sizes (metafor estimate lower +0.29 to upper +0.35, rethinking estimate lower +0.31 to upper +0.41; n=251 effect sizes) than studies assigning individuals continuous ranks (metafor estimate lower +0.16 to upper +0.22, rethinking estimate lower +0.17 to upper +0.28; n=193 effect sizes). In essentially all studies of cooperative breeders (31 of 32 effect sizes), comparisons were between the single dominant female and a class of the remaining subordinate females, which may contribute to higher effect sizes for studies using categorical measures of rank (see section R5.2.1).

2) What are the life history traits that mediate the benefits of rank on reproductive success?

Prediction 2.1: High dominance rank will benefit females more than their offspring.

We predicted that high rank is more likely to be associated with higher reproductive success in studies that measured female age at first reproduction, number of offspring born per year or across a lifetime, or female survival rather than the survival of their offspring. While in cooperatively breeding species reproductive suppression might impact offspring survival, in plural breeders offspring survival is more likely to be influenced by factors that are outside of the control of females, such as infanticide by new males (Cheney et al. (2004)).

Result 2.1: Dominance rank has weakest effects on offspring survival and highest effects on lifetime reproductive success

To the base model, we added a predictor variable reflecting the six classes of measures of reproductive success.

Dominance rank appears to have the highest effect on age at first conception (metafor estimate lower +0.32 to upper +0.43, rethinking estimate lower +0.33 to upper +0.52; n=23 effect sizes), followed by life time reproductive success (metafor estimate lower +0.27 to upper +0.40, rethinking estimate lower +0.31 to upper +0.47; n=34 effect sizes), interbirth interval (metafor estimate lower +0.25 to upper +0.37, rethinking estimate lower +0.28 to upper +0.37; n=46 effect sizes), infant production (metafor estimate lower +0.21 to upper +0.33, rethinking estimate lower +0.23 to upper +0.38; n=198 effect sizes), adult survival (metafor estimate lower +0.18 to upper +0.31, rethinking estimate lower +0.18 to upper +0.34; n=30 effect sizes), and the lowest effect on infant survival (metafor estimate lower +0.14 to upper +0.25, rethinking estimate lower +0.15 to upper +0.26; n=113 effect sizes). Effects of dominance rank on survival are lower than on other measures of female fitness (contrasts between infant survival and age at first conception/life time reproductive success/interbirth interval/infant production do not cross zero; contrasts between adult survival and age at first conception/life time reproductive success/interbirth interval do not cross zero). Effect sizes for life time reproductive success are slightly higher (but contrasts overlap zero) than for its components (adult survival, interbirth interval, infant production). However, there does not appear to be a straightforward additive (or multiplicative) combination of these individual effects (Figure 6).

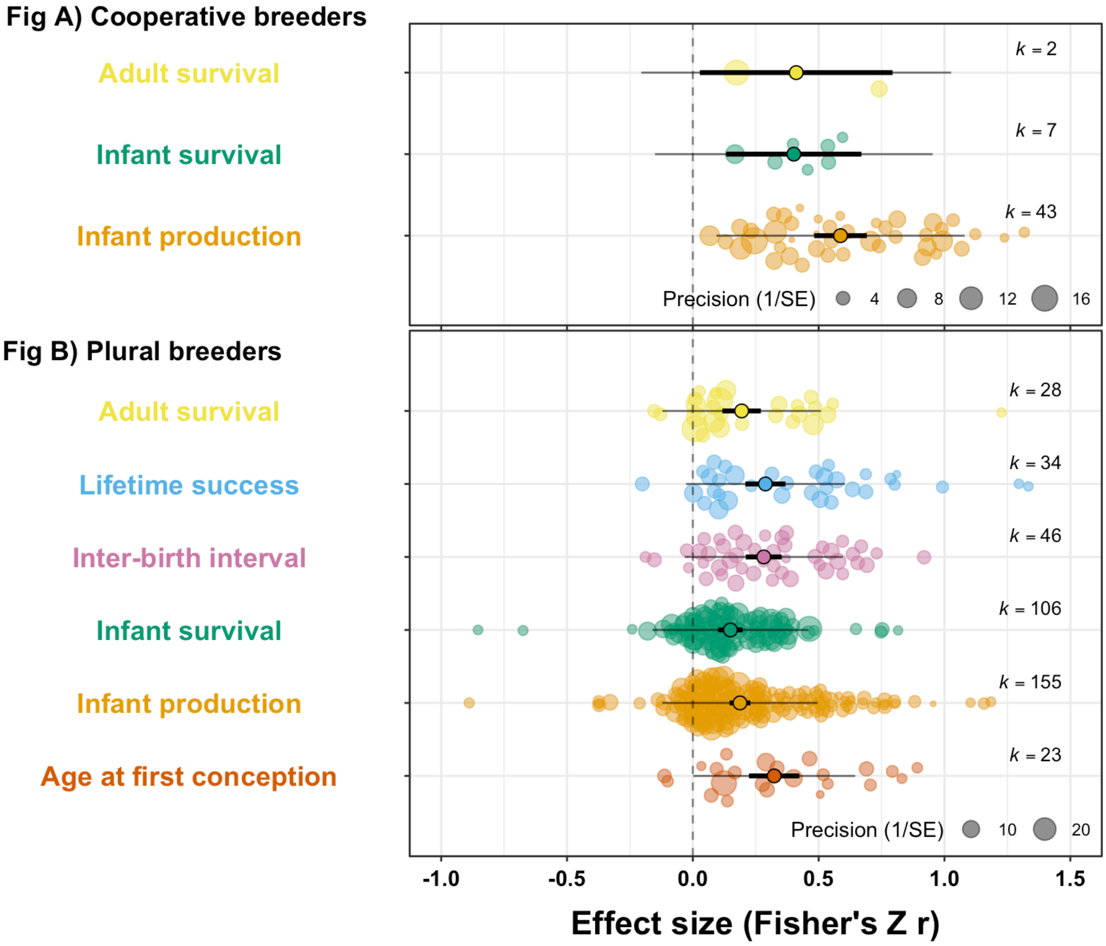

Figure 6. Raw effect sizes of dominance rank on reproductive success are generally higher for cooperative breeders (a) than for plural breeders (b), and differ according to the measure of reproductive success. In general, dominance appears to have stronger effects on reproductive output (lifetime reproductive success, age at first conception, infant production, inter-birth intervals) than on survival (both of the adult females themselves and of their infants). The differences between measures of reproductive success change slightly when accounting for similarity among observations from the same and related species, but the ordering remains the same. As in previous figures, each dot represents a single effect size, with the size of the dot indicating the precision (legend bottom right). For each measure of reproductive success, the darker circle in the middle represents the estimated mean effect, with the bold lines representing the confidence interval of the mean effect and the thinner lines the prediction estimate of the model.

Prediction 2.2: Dominance will have stronger effects on immediate reproductive success in species in which females produce many offspring over a short time period.

One key mechanism that has been proposed is that females with high dominance rank have priority of access to resources during periods when these resources are limited, which in turn can increase their reproductive success. Accordingly, we predicted stronger effects of rank on measures of immediate reproductive success in species in which females have higher energetic investment into reproduction, with larger litter sizes and shorter interbirth intervals (Lukas and Huchard (2019)), as there is a higher potential for variation in reproductive success (P. Stockley (2003)). In contrast, in long-lived species in which females produce only single offspring at long intervals, high-ranking females are expected to have less opportunity to translate short-term resource access into immediate reproductive success but might store energy to potentially increase their own survival or lifetime reproductive success (Lemaître, Ronget, and Gaillard (2020)).

Results 2.2: Stronger effects in species with larger litter sizes and more litters per year
Effects of dominance on reproductive success are higher in species with larger litter sizes (metafor estimate of litter size lower +0.03 to upper +0.05, rethinking estimate lower +0.05 to upper +0.09; n=444 effect sizes) and with more litters per year (metafor estimate of litters per year lower +0.04 to upper +0.08, rethinking estimate lower +0.06 to upper +0.11; n=444 effect sizes). Effect sizes in species where females produce single offspring are on average 0.25 while effect sizes in species where females produce litters are on average 0.34, and effect sizes in species where females produce one or fewer litters per year are on average 0.25 while effect sizes in species where females produce multiple litters each year are on average 0.45. The association of the effect sizes with the number of litters per year remained when accounting for the phylogenetic relatedness among species, but the association with litter size did not, suggesting that it might be influenced by other characteristics that differ among species with variable litter sizes.

3) What are the ecological conditions that mediate the benefits of rank on reproductive success?

Prediction 3.1: Positive effects of high dominance rank on reproductive success will be stronger in populations in which females feed on resources that are more monopolizable.

We predicted that high rank will have stronger effects on reproductive success in fruit- and meat-eaters compared to herbivores or omnivores. One of the main expected benefits of high rank is priority of access to resources, which should be more relevant in populations in which resources can be monopolized (Fedigan (1983)).

Result 3.1: Effects of dominance rank on reproductive are independent of diet
Effect sizes are larger in carnivores (0.35; n=72 effect sizes) than in omnivores (0.28; n=227 effect sizes), herbivores (0.25; n=117 effect sizes), or frugivores (0.21; n=28 effect sizes) (estimated difference carnivores versus omnivores rethinking lower -0.14 to upper -0.01, difference carnivores versus herbivores rethinking lower -0.16 to upper -0.03, difference carnivores versus frugivores rethinking lower -0.24 to upper -0.02; estimates for all other comparisons cross 0). Carnivores are no longer estimated to have different effect

sizes when the phylogenetic relatedness among species is taken into account, potentially due to the higher prevalence of cooperative breeding in carnivores.

Prediction 3.2: Effects of dominance rank on reproductive success will be more pronounced in populations living in harsher environments.

We predicted that the effect of rank on reproductive success will be stronger in populations in which resources are limited because they live in harsh and unpredictable environments. Previous studies have shown that cooperatively breeding species are more likely to occur in such environments (Lukas and Clutton-Brock (2017)), but we also expect stronger effects among plural breeding populations living in harsh environments.

Result 3.2: Effect sizes are not higher in harsher environments

We found no evidence for an association between environmental harshness and the effect of dominance rank on reproductive success (metafor estimate lower -0.3 to upper +0.4, rethinking estimate lower -0.6 to upper +0.1; no change when accounting for shared phylogenetic history; n=259 effect sizes).

Prediction 3.3: Effects of dominance rank on reproductive success will be more pronounced in populations with high densities of individuals.

We predicted that the effect of rank on reproductive success will be stronger in populations in which more individuals share a limited amount of space. At higher population densities, social groupings and interactions are more likely and competition over resources is expected to be stronger.

Results 3.3: Higher population density is associated with stronger effects of dominance rank on reproductive success

Effect sizes are higher in populations with higher densities of individuals (metafor lower +0.04 to upper +0.08, rethinking lower +0.05 to upper +0.10; n=346 effect sizes), even when including phylogenetic relatedness.

4) What are the social circumstances that mediate the benefits of rank?

Prediction 4.1: Benefits of rank will be most pronounced in cooperatively breeding species.

We predicted that rank effects on reproduction will be higher in cooperative breeders, where the dominant female is often the only breeding female because she suppresses the reproduction of subordinate females (Digby, Ferrari, and Saltzman (2006)), compared to plural breeders, where aggressive behaviour is more targeted and limited to access over specific resources.

Result 4.1: Cooperative breeders have larger effect sizes than plural breeders

Effect sizes of cooperative breeders (average 0.58; n=52 effect sizes) are higher than those observed in plural (average 0.25; n=324 effect sizes) or associated breeders (average 0.23; n=68 effect sizes) (estimates for difference cooperative breeder vs plural breeder metafor lower -0.40 to upper -0.30, rethinking lower -0.41 to upper -0.27; cooperative breeder vs associated breeder metafor lower -0.47 to upper -0.35, rethinking lower -0.45 to upper -0.26; plural breeder vs associated breeder metafor lower -0.07 to upper +0.05, rethinking lower -0.07 to upper +0.05). Cooperative breeders are still estimated to have higher effect sizes than species with other breeding systems when accounting for phylogenetic relatedness, but the differences are slightly reduced (Figure 6).

Prediction 4.2: For plural-breeders, the time-scales at which the reproductive benefits of dominance accrue depend on how individuals achieve high rank.

We predicted that in populations of plural breeders in which groups contain multiple breeding females, the way in which these females compete over dominance will influence the potential benefits of high rank. In populations in which female rank depends primarily on age, high ranking females will have higher reproductive success for short periods of time because changes in rank are expected to occur regularly, and because high rank may only be reached towards the end of their reproductive life (Thouless and Guinness (1986)). In societies in which female rank depends primarily on size or condition, rank effects on reproductive success are expected to be expressed on intermediate time frames, as individuals may not be able to maintain a larger relative size or condition over lifetime but they are expected to acquire rank relatively early in their reproductive life (Giles et al. (2015), Huchard et al. (2016)). In societies in which female rank primarily depends on nepotism, and ranks are often inherited and stable across a female's lifetime, we predicted that effects of rank on reproductive success will be strongest when measured over long periods because small benefits might add up to substantial differences among females (Frank (1986)) whereas stochastic events might reduce differences between females on shorter time scales (Cheney et al. (2004)).

Result 4.2: Overall, effect sizes do not differ according to how dominants achieve or maintain their high ranks

Effect sizes are higher in species in which condition plays a major role in determining which females are dominant rather than subordinate (average effect size 0.38; n=94 effect sizes), compared to species in which age (average effect size 0.31; n=100 effect sizes) or nepotism (average effect size 0.24; n=243 effect sizes) influence dominance rank (estimates for difference condition vs age: metafor lower +0.05 to upper +0.17, rethinking lower +0.01 to upper +0.16; condition vs nepotism: metafor lower +0.07 to +0.20, rethinking lower +0.08 to +0.20; age vs nepotism: metafor lower -0.07 to upper +0.03, rethinking lower -0.01 to upper +0.12). Species with different dominance systems are no longer estimated to be different when including the phylogenetic similarity.

Our initial prediction focused on whether the time-scales at which the reproductive benefits of dominance accrue depend on how individuals achieve high rank. However, we realized that there was no straightforward way to assess this prediction. The species in our dataset have vastly different lifespans and associated interbirth intervals, so the time-scale needs to be considered on a relative rather than an absolute scale. The values for the relative duration of a study (number of years studied divided by the maximum lifespan of the species) show that 90% of effect sizes are from studies that lasted less than 10% of the lifespan of the species (median 3%). In all of the 19 species in which studies spanned more than 10% of the lifespan, females acquire rank by nepotism. We did not find any consistent pattern of relationship between effect size and study duration dependent on the system of dominance acquisition.

Prediction 4.3: For plural-breeding macaques, effect sizes of dominance rank on reproductive success are larger in species characterized as more despotic than in species characterized as more egalitarian.
We added an analysis after the preregistration, focusing on variation in dominance style among macaques. Macaque species have been assigned to a four-grade social style according to the relationships among females. Grade 1 species, the most despotic, are characterized by steep dominance hierarchies and more asymmetries in social interactions among breeding females, whereas grade 4 species show more frequent counter-aggression from subordinates towards dominants and less bias in social interactions. We expected that the steeper hierarchies in more despotic species would lead to larger differences in access to resources, and accordingly higher reproductive success for dominant females.

Result 4.3: Among macaques, effect sizes do not differ according to how the dominance style among females has been characterized
Differences in dominance styles among macaques are not associated with the effect of dominance rank on reproductive success (metafor estimates effect sizes of species in Grade 1 to be different from species in Grade 2 lower +0.05 to upper +0.12 but no differences for the five other pairwise Grade comparisons; rethinking estimates for all comparisons overlap zero; n = 109 effect sizes from 9 species). Egalitarian species do not show lower effects of dominance rank on reproductive success than other species and the sample size is too small to determine whether despotic species differ from other species (Figure 7).

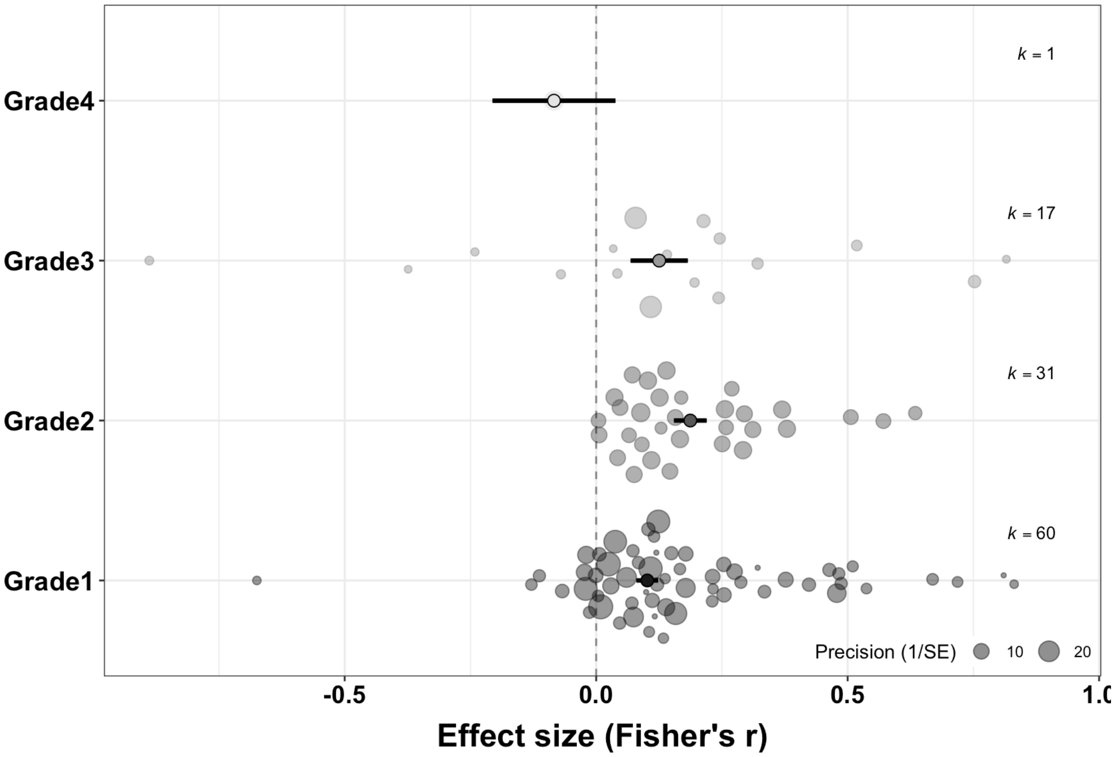

Figure 7. The effect of dominance rank on female reproductive success is similar across macaque species with different dominance styles. Relationships among female group members in species of grade 1 (bottom dark grey) are generally considered egalitarian, while grade 4 (top light grey) is assigned to species in which relationships are deemed highly despotic. Species with different dominance styles are not estimated to be different (all posterior contrasts overlap zero).

Prediction 4.4: Dominance rank will have stronger effects on reproductive success in populations in which females are philopatric in comparison to populations where females disperse to breed.

We predicted that effects of rank on reproductive success will be lower in populations in which adult females are able to leave their group and join other groups compared to populations in which females cannot breed outside their natal group. In populations in which females are philopatric, they are likely to have support from female kin which can strengthen dominance differences (Lukas and Clutton-Brock (2018)). In addition, in species where females can change group membership easily, females are expected to join those groups where they have the best breeding option available to them (Vehrencamp (1983)).

Result 4.4: Stronger effects in populations in which females disperse to breed rather than in which females are philopatric

The effects of dominance rank on reproductive success are higher in species in which females disperse and join new groups (average effect size 0.46; n=55 effect sizes) compared to species in which most females were born in the group where they breed (average effect size 0.26; n=360 effect sizes) (metafor estimate of difference lower -0.24 to upper -0.12, rethinking estimate lower -0.25 to upper -0.11), also when accounting for phylogenetic covariance (Figure 8).

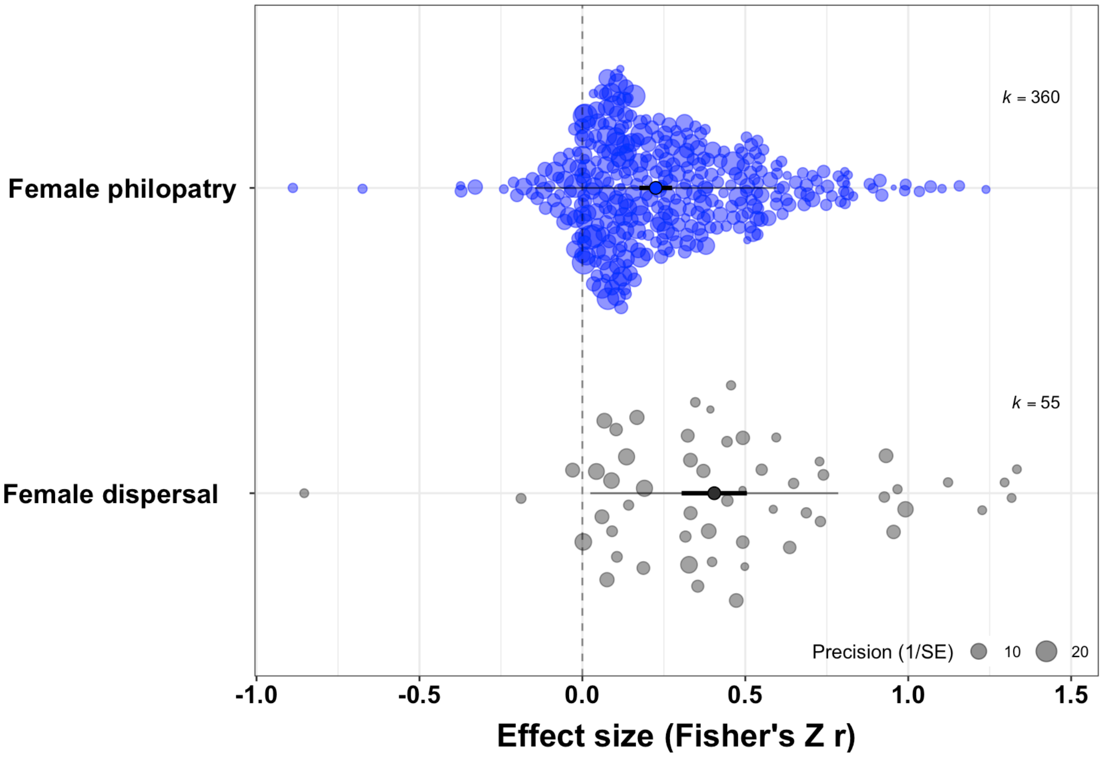

Figure 8. Effect sizes of dominance rank on female reproductive success are lower in species in which females are philopatric and remain in the group/area where they have been born (top, blue dots) than in species in which females disperse to breed (bottom, grey dots).

Prediction 4.5: In plural breeding species, dominance will have stronger effects on reproductive success when the number of females in the group is smaller.

We predicted that the effect of rank on reproductive success will be stronger in plural breeding populations in which there are fewer females per group, because dominant females will be more likely to interfere in reproductive attempts when there are fewer subordinates (T. H. Clutton-Brock et al. (2010)) and because increased competition in larger groups is expected to reduce reproductive success even among dominants (Van Noordwijk and Van Schaik (1988)).

Result 4.5: Effects of dominance rank on reproductive success are higher when groups contain fewer females
Both approaches detect a negative association between the effect sizes and group sizes (metafor estimate of log group size lower -0.099 to upper -0.678, rethinking estimate of standardized group size lower -0.10 to upper -0.05; n=444 effect sizes). Compared to groups of 2 females, groups of 10 females show ~10% lower effect sizes and groups of ~50 females show 50% lower effect sizes. The negative association between group size and the effect sizes remains when accounting for similarity among closely related species.

Prediction 4.6: Dominance rank will be more strongly associated with reproductive success in populations in which average relatedness among female group members is high.

We predicted that the relationship between dominance rank and reproductive success will be more pronounced in species in which social groups primarily consist of close kin compared to groups composed of unrelated females. Groups with high levels of average kinship among females are those where groups are small, females remain philopatric (Lukas et al. (2005)), and females have support to establish their positions (Lukas and Clutton-Brock (2018)), which all are expected to lead to higher benefits of high rank.

Result 4.6: No association between levels of relatedness and effects of dominance rank on reproductive success
Effect sizes of dominance rank on reproductive success increase with increasing levels of average relatedness among female group members (metafor estimate lower +0.31 to upper +0.59, rethinking estimate lower +0.31 to upper +0.71; n=288 effect sizes), though the association is no longer detected when including the shared phylogenetic history among species (metafor estimate lower -0.01 to upper +0.56; rethinking estimate lower -0.02 to upper +0.65).

Prediction 4.7: Dominance rank will be more strongly associated with reproductive success in populations in which variance in relatedness among female group members is high.

In addition to levels of average relatedness among group females, we also predicted that the relationship between dominance rank and reproductive success will be more pronounced in species in which there is high variance in relatedness, with females being closely related to some group members but not to others, as compared to species in which group females are either all related or all unrelated. In several species with female philopatry, groups are structured into matrilines (Fortunato (2019)). Members of the same matriline tend to support each other in interactions with unrelated females, likely reinforcing differences among females.

Result 4.7: Variance in relatedness
We could not assess this prediction because sufficient data was not available.

Prediction 4.8: The effect of dominance on reproductive success will be less pronounced in populations in which females regularly form coalitions.

We predicted that high ranking females will have less pronounced reproductive benefits in species in which females form strategic coalitions with others (Bercovitch (1991)). Individuals have been suggested to form strategic coalitions to level the reproduction of others (Pandit and Schaik (2003)) and these coalitions are less likely in cooperatively breeding species (Lukas and Clutton-Brock (2018)).

Result 4.8: No differences in effect sizes between species in which females form coalitions to those in which they do not

Species in which females form coalitions show only slightly lower effects of dominance rank on reproductive success (average 0.27; n=246 effect sizes) than species in which females do not have support during aggressive interactions (average 0.32; n=180 effect sizes) (estimate of difference metafor: lower -0.11 to upper -0.01, rethinking lower -0.09 to upper +0.01), with no difference in models accounting for similarity due to phylogenetic relatedness (metafor lower -0.10 to upper +0.07; rethinking lower -0.09 to upper +0.03).

Prediction 4.9: Dominance rank will have less effect on reproductive success in populations in which there is intense inter-sexual conflict.

We predicted that the association between high dominance rank and increased reproductive success of females will be lower in populations in which males compete intensely over reproductive opportunites because this leads to intersexual conflict that harms female fitness (Swedell et al. (2014)). In such populations, males tend to be aggressive towards females and males taking up tenure in a group tend to kill offspring indiscriminately or might even target offspring of high-ranking females (Cheney et al. (2004), Fedigan and Jack (2013)), reducing any potential differences between high- and low-ranking females. We assessed whether high ranking females benefit less from their positions in populations in which groups show strong female-biased sex composition, or in which males commit infanticide, or with strong sexual size dimorphism (with males being larger than females).

Result 4.9: Dominance rank has less effect on reproductive success in social groups with fewer males per female but not with sexual dimorphism and male infanticide

Effect sizes are larger in species in which sex ratios in social groups are more balanced and lower when there are fewer males per female (metafor estimate lower +0.55 to upper +1.25, rethinking estimate lower +0.07 to upper +0.11; n=328 effect sizes), and the association remains the same when accounting for shared phylogenetic history.

Effect sizes are lower in species in which males commit infanticide (metafor estimate lower -0.20 to upper 0.00; rethinking estimate lower -0.15 to upper -0.04; n=332 effect sizes), but the relationship does not hold when accounting for phylogenetic relatedness (metafor lower -0.13 to upper +0.07, rethinking lower -0.07 to upper +0.06).

Differences in effect sizes are not associated with the extent of sexual dimorphism in body size across species (metafor estimate lower -0.17 to upper +0.11; rethinking lower -0.05 to upper +0.01; similar estimates when accounting for sharerd phylogenetic history; n=334 effect sizes).

Summary of univariate analyses

Overall, our data indicate that females of higher rank generally have higher reproductive success than females of lower rank. In terms of the approach, effect sizes of dominance rank on reproductive success were higher (i) when individuals were assigned a rank category rather than a continuous position and (ii) when rank was determined using indirect measures rather than aggressive interactions, plus (iii) variation in effect size was also influenced by differences not captured by our variables, with measures reported in the same study or from species belonging to the same taxonomic Order being more similar than expected by chance. We found no differences in effect sizes when studies were conducted in a captive rather than a wild setting. Effect sizes of dominance rank were higher for measures of reproductive output than for measures of survival, and higher for measures of maternal than offspring fitness.

We found that effect sizes of dominance rank on reproductive success are associated with seven of our single predictor variables (one in the opposite direction from what we predicted), whereas we did not find an association with another eight of the single predictor variables (Table 1). Five of the six associated predictor variables reflect variation in the social environment, while we did not find any association with any of the predictor variables reflecting the ecological environment.

Table 1. Overview of our predictions and results of univariate analyses indicating whether **we did or did not find an association between individual variables with variation in effect sizes of dominance rank on female reproductive success**. The table presents, for each variable, which direction of association we predicted, the association we observed (estimates of the 95% confidence interval with the metafor approach and of the 89% posterior compatibility interval with the rethinking approach), and the respective estimates of the association when accounting for shared phylogenetic history among the species in our sample. Overall, our results align with 7 out of our 16 predictions.

Predictor variable	Predicted association	Observed association	Metafor 95% CI	Rethinking 89% PCI
P2.1 success measure	negative (survival lower)	negative	not available	-0.10 - -0.01
P2.2 litters per year	positive	positive	+0.03 - +0.05	+0.05 - +0.09
P2.2 litter size	positive	none	-0.01 - +0.03	-0.04 - +0.09
P3.1 diet	positive (carnivores higher)	none	-0.04 - +0.03	-0.10 - +0.06
P3.2 environmental harshness	positive	none	-0.30 - +0.40	-0.60 - +0.10
P3.3 population density	positive	positive	+0.04 - +0.08	+0.05 - +0.10
P4.1 cooperative breeding	positive	positive	+0.30 - +0.40	+0.27 - +0.41
P4.2 dominance acquisition	positive (condition higher)	none	-0.10 - +0.12	-0.02 - +0.03
P4.3 dominance style	positive (despotic higher)	none	-0.07 - +0.03	-0.01 - +0.12
P4.4 philopatry	positive	negative	-0.24 - -0.12	-0.25 - -0.11
P4.5 group size	negative	negative	-0.07 - -0.01	-0.10 - -0.05
P4.6 average relatedness	negative	none	-0.01 - +0.56	-0.01 - +0.12
P4.8 female coalitions	negative	none	-0.10 - +0.07	-0.09 - +0.07
P4.9 male infanticide	negative	none	-0.13 - +0.07	-0.07 - +0.06
P4.9 sexual dimorphism	negative	none	-0.17 - +0.11	-0.05 - +0.01
P4.9 sex ratio	positive	positive	+0.44 - +1.25	+0.07 - +0.11

5) Potential interactions among predictor variables

We expected potential interactions among the predictor variables because some of them might influence each other while others might potentially modulate the influence of another predictor variable on the dominance effects. Six predictions were added in the preregistration (P5.5-P5.9). We added further analyses based on the outcome of the single-factor analyses. These are listed in the changes from the preregistration section and their results are presented below.

Result 5.1: Heterogeneity and sample bias

The sample bias, namely the over-representation of extreme effect sizes, in our data likely results from all three influences of (i) publication bias, (ii) study system bias, and (iii) study time bias. In addition to the direct indications of publication and study time bias in our sample, our univariate analyses identified many factors that could lead to study system bias. For example, while less than 5% of all mammalian species are cooperative breeders, 12% of all effect sizes in our sample come from cooperative breeders which have high positive effect sizes.

To identify the potential interplay between the three biases, we built combined models. If biases occur because study systems with different effect sizes also have particular sample sizes and study duration (e.g. cooperative breeders tend to live in smaller groups), we should no longer detect an association between sample size, study duration and effect sizes when controlling for the different study systems. The combined models indicate that the study system factors identified in the univariate analyses are directly associated with variation in effect sizes (all their estimates do not overlap zero), as is sample size, but not the study duration. This indicates that our sample has both publication and study system bias. The lack of a direct influence of study time bias presumably occurs because sample size is associated with the number of years a study has been conducted for, indicating that large samples - both in terms of study duration and breadth - might reduce noise.

The reduction in publication bias when accounting for the study system bias is visible when comparing the funnel plot of the raw effect sizes in relation to their precision (Figure 9a), which shows a clear asymmetry, to the funnel plot of the effect sizes adjusted for known predictors (Figure 9b), which only indicates that some large effect sizes at small precision are not balanced.

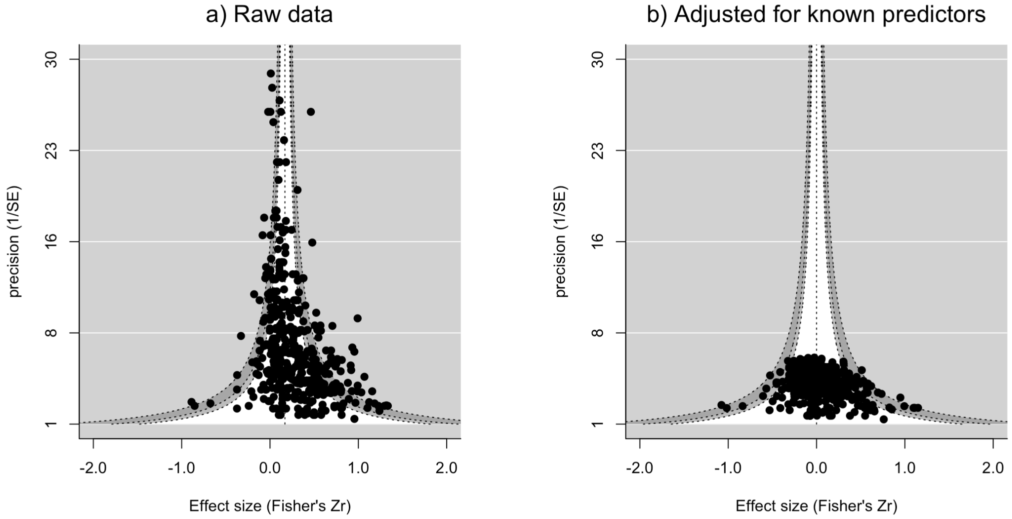

Figure 9. Funnel plots based on raw effect sizes (a) and effect sizes adjusted for known predictors (b). When accounting for the influence of which reproductive trait was measured, whether the species is a cooperative breeder or not, the number of litters per year the species produces, and the phylogenetic covariance among species, the distribution of the 444 effect sizes in our sample appears much less imbalanced (b) than the raw effect sizes (a). The mean effect size (grey dotted line in the center going upwards) is shifted close to zero when adjusting for known predictors because these predictors explain why some studies have positive effect sizes. Precision decreases for most estimates because they no longer represent the measured values, but incorporate the uncertainty as the values are inferred from the expected interaction of the predictors.

Results 5.2: Differences between cooperative and plural/associated breeders

In our preregistration, we had decided to first construct univariate models as reported above, testing the influence of a single variable at a time to assess support for the specific predictions. One of the main factors that we found to be associated with higher effect sizes is cooperative breeding. Cooperative breeders differ from other social organisms in many additional aspects, so we first checked whether any of the other associations we detect occur because they covary with cooperative breeding.

Result 5.2.1: Differences in approach to study cooperative breeders

Approaches of assigning rank depend on the breeding system of the study species, with many studies of cooperative breeders assigning rank into categories (98% categorical, 2% continuous) based on other measures (50% agonism, 50% other) while studies of plural and associated breeders often assign continuous ranks (51% categorical, 49% continuous) based on agonistic interactions (97% agonism, 3% other). Combining the variables representing the different study approaches with the variable representing the classification as cooperative breeder or not into single models indicates that the difference in effect sizes is primarily due to the stronger dominance effects in cooperative breeders (estimate of difference metafor lower +0.23 to upper +0.34, rethinking lower +0.23 to upper +0.37, n=444 effect sizes) and only very little due to the approaches the authors chose (other measure vs agonism estimate of difference metafor lower +0.02 to upper +0.15, rethinking lower -0.02 to upper +0.16; rank categorical vs continuous estimate of difference metafor lower -0.02 to upper -0.09, rethinking lower -0.07 to upper +0.03, n=444 effect sizes).

Result 5.2.2: Different life history measures and cooperative breeding

In cooperative breeders, effects of dominance rank were only assessed on three of the six life history traits. We therefore performed separate analyses for cooperative and for plural/associated breeders to identify the life history traits showing specific increases in higher ranking females compared to others.

In cooperative breeders, effect sizes are higher for infant production (metafor estimate lower +0.49 to upper +0.72, rethinking estimate lower +0.55 to upper +0.69, n=43 effect sizes), and lower for infant survival (metafor lower +0.13 to upper +0.54, rethinking lower +0.20 to upper +0.61, n=7 effect sizes) and adult survival (metafor estimate lower +0.02 to upper +0.59, rethinking estimate lower +0.12 to upper +0.73, n=2 effect sizes) (Figure 6).

In plural/associated breeders, effect sizes are (depending on the approach) highest for lifetime reproductive success (metafor estimate lower +0.19 to upper +0.29, rethinking estimate lower +0.33 to upper +0.47, n=34 effect sizes), age at first conception (metafor lower +0.27 to upper +0.36, rethinking lower +0.25 to upper +0.43, n=23 effect sizes) and interbirth interval (metafor lower +0.23 to upper +0.34, rethinking lower +0.25 to upper +0.38, n=46 effect sizes), followed by infant production (metafor lower +0.13 to upper +0.22, rethinking lower +0.19 to upper +0.27, n=155 effect sizes) and adult survival (metafor lower +0.14 to upper +0.24, rethinking lower +0.15 to upper +0.30, n=28 effect sizes), and are lowest for infant survival (metafor lower +0.11 to upper +0.20, rethinking lower +0.11 to upper +0.20, n=106 effect sizes) (Figure 6). The two methods give slightly different estimates because there is large variation among the effect sizes within each life history trait. In particular, effect sizes of dominance rank on lifetime reproductive success can be either low or high, often for the same population. For example, an experiment with house mice reported effect sizes ranging from 0.08 to 0.80, depending on the relatedness among the group members (König 1994). For mountain gorillas living in the Virungas, one study reported no effect of dominance rank on lifetime reproductive success (0.00) (Robbins et al. 2007) while another reported the highest effect size in our sample (1.33) after excluding major sources of environmental variability on reproductive success (Robbins et al. 2011).

Result 5.2.3: Litters per year and cooperative breeding

Cooperative breeders tend to have higher reproductive rates than species with other breeding systems. However, the association between reproductive rate and effect sizes of dominance rank on reproductive success remains across all breeding systems (metafor estimate of cooperative breeding lower +0.22 to upper +0.58, litters per year lower 0.00 to upper +0.07, interaction lower -0.10 to update +0.04), with larger effect sizes in species producing more litters per year in cooperative (rethinking estimate lower +0.02 to upper +0.20; n=52 effect sizes) and plural (rethinking lower +0.13 to upper +0.33; n=324 effect sizes), but not associated breeders (rethinking lower -0.08 to upper +0.23; n=68 effect sizes) (estimates take into account phylogenetic relatedness).

Result 5.2.4: Group size and cooperative breeding

In mammals, most groups of cooperative breeders have fewer females (in our data, median 2 females per group, n=52) than groups of plural/associated breeders (in our data, median 14 females per group, n=392), meaning that the negative relationship between group size and effect sizes that we describe above might arise because cooperative breeders have both smaller group sizes and larger effect sizes. In our data, both group size and cooperative breeding remain independently associated with the effect sizes of dominance rank on reproductive success. The analyses suggest an interaction (metafor estimate for cooperative breeding lower +0.16 to upper +0.39, for group size lower -0.01 to upper 0.00, interaction lower 0.00 to upper +0.03, n=444 effect sizes), with effect sizes increasing with group size in cooperative breeders (rethinking estimate lower +0.01 to upper +0.02), where a single dominant continues to monopolize reproduction as groups get larger, and declining with group sizes in other breeding systems (rethinking estimate lower -0.01 to upper 0.00), where dominants might be less able to control reproduction of other group members as groups grow larger (Figure 10).

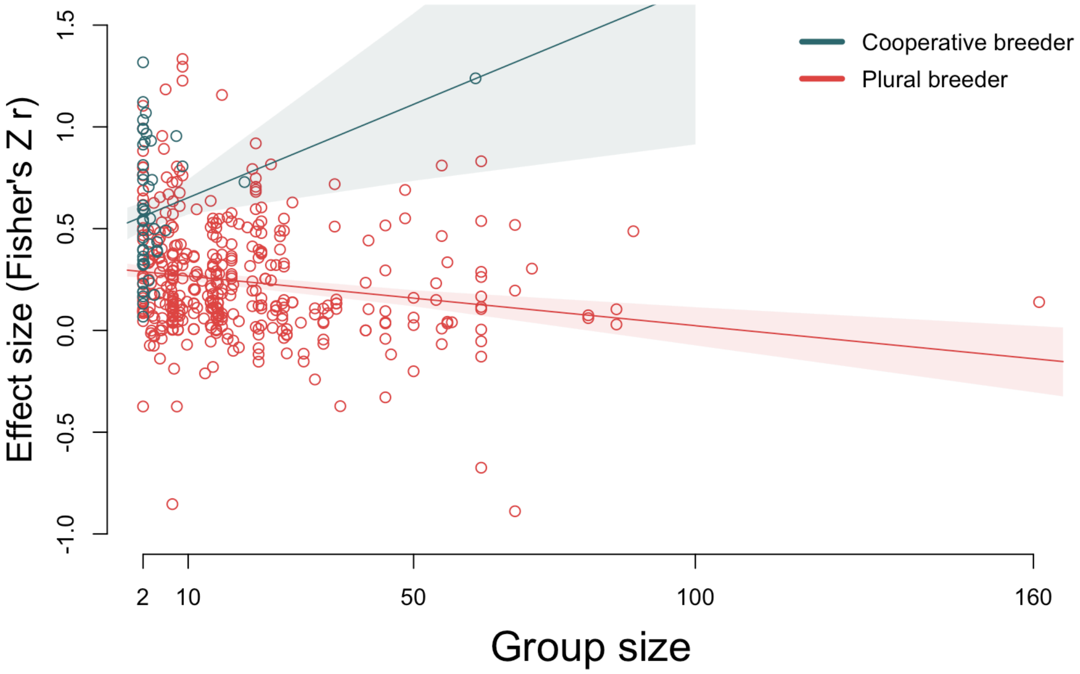

Figure 10. The relationship between the number of females in the group and the effect of dominance on reproductive success depends on whether the species is a cooperative (olive dots show data and olive line with shading shows estimate from rethinking model) or a plural breeder (red dots show data and red line with shading shows estimate from rethinking model). In cooperative breeders, effect sizes increase with

increasing group size as a single female continues to monopolize reproduction in the group, whereas effect sizes decrease with increasing group size as dominants can potentially no longer outcompete all other females.

Result 5.2.5: Average relatedness and cooperative breeding

Similarly, there appears to be an interaction between average relatedness and breeding systems (metafor estimate for cooperative breeding lower -0.06 to upper +0.44, for average relatedness lower -0.75 to upper +0.03, for interaction +0.10 - +1.51, n=288 effect sizes), with effect sizes increasing with higher levels of average relatedness in cooperative breeders (rethinking estimate lower 0.00 to upper +0.12, n=36 effect sizes) and decreasing with higher levels of average relatedness in plural/associate breeders (rethinking estimate lower -0.06 to upper 0.00, n=252 effect sizes)

Result 5.2.6: Philopatry and cooperative breeding

Female dispersal is more common in cooperative breeders (46%) than in plural/associated breeders (9%). Effect sizes are larger in species with female dispersal among the plural/associated breeders (rethinking estimate lower -0.19 to upper -0.02, n=363 effect sizes), but not in cooperative breeders (rethinking estimate lower -0.10 to upper +0.12, n=52 effect sizes) (metafor estimate for cooperative breeding lower +0.15 to upper +0.49, for philopatry lower -0.18 to upper +0.06, for interaction -0.18 - +0.26). This suggests that dominant females in cooperative breeders appear to maintain reproductive control independently of whether they obtained their position by queuing in the group or entering the position through immigration.

Result 5.2.7: Coalition formation and cooperative breeding

Coalition formation does not occur in cooperative breeders, leading to a potential confound. Restricting the analyses to plural/associated breeders, we found that effect sizes are higher in species in which females do form coalitions than in species where they do not (metafor estimate lower 0.00 to upper +0.14, rethinking estimate lower +0.01 to upper +0.11, n=374 effect sizes). This likely reflects the benefits of nepotism in matrilineal groups. For our analysis, we did not differentiate between stabilizing coalitions, which usually occur among kin to maintain matrilineal rank differences, and revolutionary coalitions, which usually occur among unrelated individuals to limit the power of others in the group.

Result 5.3: Philopatry and average relatedness

Among plural/associated breeders, average relatedness is lower in species in which females disperse (mean r 0.03, n=16) than in species in which females are philopatric (mean r 0.10, n=228), and differences in effect sizes are mainly associated with whether females disperse or are philopatric (higher effects when females disperse than when they are philopatric, metafor estimate lower -0.11 to upper -0.03, rethinking estimate lower -0.22 to upper -0.02) rather than levels of average relatedness (metafor estimate lower +0.03 to upper +0.10, rethinking estimate lower -0.04 to upper +0.01, n=242 effect sizes).

Prediction 5.4: Female philopatry [larger effect sizes predicted] might be associated with increased group *sizes [smaller effect sizes predicted]), leading to an interaction that might influence the estimation of their respective associations the effect sizes of dominance rank on reproductive success.*

Result 5.4: Philopatry and group size are both associated with variation effect sizes

Group sizes of species in which females disperse tend to be smaller than group sizes of species in which females are philopatric. Both philopatry and increasing group size independently lead to lower effect sizes, but the association of philopatry is reduced compared to the single factor analysis (metafor estimate philopatry lower -0.09 to upper -0.01 group size lower -0.07 to upper -0.01, rethinking estimate philopatry lower -0.16 to upper 0.00 group size lower -0.07 to upper -0.03, n=415 effect sizes).

Prediction 5.5: Higher population density [predicted to lead to larger effect sizes] might be associated with larger group sizes [smaller effect sizes predicted], leading to an interaction that might influence the estimation of their respective associations with the effect sizes of dominance rank on reproductive success.

Result 5.5: Population density and group size are both associated with variation in effect sizes

Population density and group size have independent influences on effect sizes, but both their associations are smaller, suggesting their roles can cancel each other out (population density estimate metafor lower 0.00 to upper +0.01, rethinking lower 0.00 to upper +0.01; group size estimate metafor lower -0.03 to upper 0.01, n=346 effect sizes).

Prediction 5.6: Smaller group sizes [larger effect sizes predicted) might be associated with more intense intersexual conflict [smaller effect sizes predicted], leading to an interaction that might influence the estimation of their respective associations with the effect sizes of dominance rank on reproductive success.

Result 5.6: Group size and sex ratio are both associated with variation in effect sizes

Group size and sex ratio have independent influences on effect sizes, with similar association as observed in the single factor analyses (group size estimate metafor lower -0.01 to upper 0.00, rethinking lower -0.07 to upper -0.02; sex ratio estimate metafor lower +0.53 to upper +1.18, rethinking lower +0.06 to upper +0.11; n=346 effect sizes), while there is no support for an interaction between the two (interaction estimate metafor lower -0.02 to upper +0.02, rethinking lower -0.03 to upper 0.04).

Prediction 5.7: Monopolizable resources [larger effect sizes predicted] might be associated with reduced population density [smaller effect sizes predicted]), leading to an interactive influence on the strength of the effect sizes of dominance rank on reproductive success.

Result 5.7: As in the individual analyses, population density but not diet is associated with differences in the effect sizes

Population density but not the diet category are associated with variation in the effect of dominance rank on reproductive success (population density estimate metafor lower 0.00 to upper +0.01, rethinking lower +0.05 to upper +0.11; diet category estimate metafor lower -0.31 to upper +0.21, rethinking lower -0.40 to upper +0.69; n=346 effect sizes), while there is no support for an interaction between the two (interaction estimate metafor lower -0.02 to upper +0.02, rethinking lower -0.03 to upper +0.04).

Prediction 5.8: Environmental harshness [larger effect sizes predicted] might be associated with reduced population density [smaller effect sizes predicted]), leading to an interactive influence on the strength of the effect sizes of dominance rank on reproductive success.

Result 5.8: Population density but not environmental harshness remains associated with variation in effect sizes

Population density but not environmental harshness are associated with variation in the effect of dominance rank on reproductive success (population density estimate metafor lower 0.00 to upper +0.01, rethinking lower +0.04 to upper +0.11; environmental harshness estimate metafor lower -0.10 to upper +0.07, rethinking lower -0.08 to upper +0.01; n=214 effect sizes), and there is no support for an interaction between the two (interaction estimate metafor lower -0.001 to upper +0.001, rethinking lower -0.09 to upper +0.01).

Prediction 5.9: Studies performed on wild versus captive individuals and using different measures of reproductive success might not only differ in the overall strength of the effect of rank on reproductive success, but also in how other variables influence this effect.

Result 5.9: No different influences in captive and wild populations

Models in which both the intercept and the slopes can vary according to whether studies were performed in the wild or in captivity also showed that there are no detectable differences of the effects of dominance rank on reproductive success between populations in these settings (for the different life history measurements and for cooperative breeding).

Summary of combined analyses

The analyses of combinations of predictors of the effect size of dominance rank on reproductive success indicate that many predictors may have a direct influence. Regarding the potential influence of the study approach on inferences, we find that specific approaches are more common in some study systems, but that using different approaches does not lead to different estimates of the effect size. We also find that average relatedness might not directly mitigate effect sizes, but that it is a co-variate of the breeding system and whether females are philopatric or disperse. In addition, we find that all cooperative breeders have large effect sizes independent of further social variation, while differences in social factors, including philopatry, group size, average relatedness, and coalition formation, further mitigate effect sizes among plural breeders.

Discussion

Our results provide support for three of our four pre-registered objectives. First, we find that in social mammals, dominant females have higher reproductive success than lower-ranking females. While there appears to be a publication bias in the dataset we put together, the overall positive effect of higher rank on reproductive success is strong, thus unlikely to result only from such bias, and instead reflects a genuine biological phenomenon. Second, positive effects of dominance rank are present across all life history measures and among plural breeders, where data for all measures of reproductive success exist, are highest for life-time reproductive success. This suggests that even if dominants might face some trade-offs (e.g. higher stress levels Cavigelli et al. (2003)), obtaining a high ranking position in a social group generally leads to fitness benefits, though how females obtain these benefits (e.g. shorter interbirth intervals versus larger offspring) differs between populations. Effects are particularly pronounced in species in which females produce large numbers of offspring at once. Third, and against our predictions, we did not find that ecological factors play a major role in mediating the benefits of rank on reproduction. Fourth, the types of society females live in appear to have a particular modulating influence. Strong associations between dominance rank and reproductive success are consistently found among cooperative breeders, they are intermediate in stable groups with small numbers of unrelated breeding females, and lowest when large numbers of females associate.

Despite a consistently positive relationship between higher dominance rank and higher reproductive success, the data show some biases, namely a combination of publication bias, study system bias, and study time bias. Unlike often claimed for meta-analyses, the over-representation of positive findings in our case appears not to be primarily due to a file-drawer problem of unpublished negative findings but due to researchers targeting their efforts on particular systems. Studies of the potential mechanisms of female competition and reproductive suppression appear to have focused on societies where there are clear differences in rank and in reproductive success between dominants and subordinates. Additional studies on (or publication of existing results from) societies in which hierarchies might not be as obvious could be revealing to understand how generally selection shapes female competition. In addition, obtaining reliable reproductive success data in long-lived mammals takes particular effort, again likely limiting the systems that have been studied to investigate the effects of dominance rank. We did find that studies conducted for longer time periods, and specifically for more than 10 years, show less variance in their estimates, potentially because they also have larger sample sizes. Alternatively, or in addition, studies conducted across longer time frames might be less likely to show extreme effect size estimates because natural changes in dominance rank and events that affect all females equally (e.g. droughts or infanticide Cheney et al. (2004)) occur relatively regularly across a multi-year study, while estimates derived over short time frames may over-estimate effect sizes. For future studies, detailed long-term investigations are not only relevant to understand the long-term consequences of the effect of dominance rank on reproduction, but also to infer the multiple mechanisms that can link rank to reproductive output (e.g. Fedigan (1983), Pusey, Williams, and Goodall (1997), Tibbetts, Pardo-Sanchez, and Weise (2022)). Tracing such differences in reproductive success over multiple generations will also be important to determine the selection processes shaping social evolution.

Overall, we estimated an average effect of 0.28 of rank on reproductive success. What does this mean? First, it is important to highlight that this effect size reflects how well rank predicts reproductive success, but the effect size does not directly indicate how different the reproductive success of high-ranking females is from that of low-ranking females. While the effect of dominance has to be zero in groups where all females have exactly the same reproductive success, an effect of zero is also found in a group where there are large differences in reproductive success across females which do not align with the females' dominance rank. Just by chance, we would expect differences in reproductive success among females in a social group and these differences could be associated with traits that might be used to classify social rank. To assess whether the effects we detect are higher than such random variation, we performed simulations. For this, we simulated artificial groups of female macaques, the genus most common in our sample. We assumed that each female in each group might have an average of 2 offspring, following a Poisson distribution, so most females have 1 or 2 offspring and very few more than 8 offspring. We performed 10,000 simulations of six groups of twelve females each (the median group size in our data). When we set no association between rank and reproductive success, less than 0.1% of simulations showed an effect size as high or higher than the 0.28 we observe in the data (Figure 11). Effect sizes for a perfect association between each female's rank and her reproductive success ranged between 0.75-0.95 (mean 0.88), lower than 1 because some females of different rank will have the same number of offspring. Simulations in which the two highest ranking females always have the highest reproductive success, while rank among lower ranking females is no longer associated with success, produces effect sizes close to what we observe (mean 0.32), whereas values tend to be slightly lower if only the highest ranking female consistently has the highest success (mean 0.18). The value of the overall effect size we observe compared to those under random expectations indicates that social rank has a particular association with reproductive success beyond the random variation we expect in social groups.

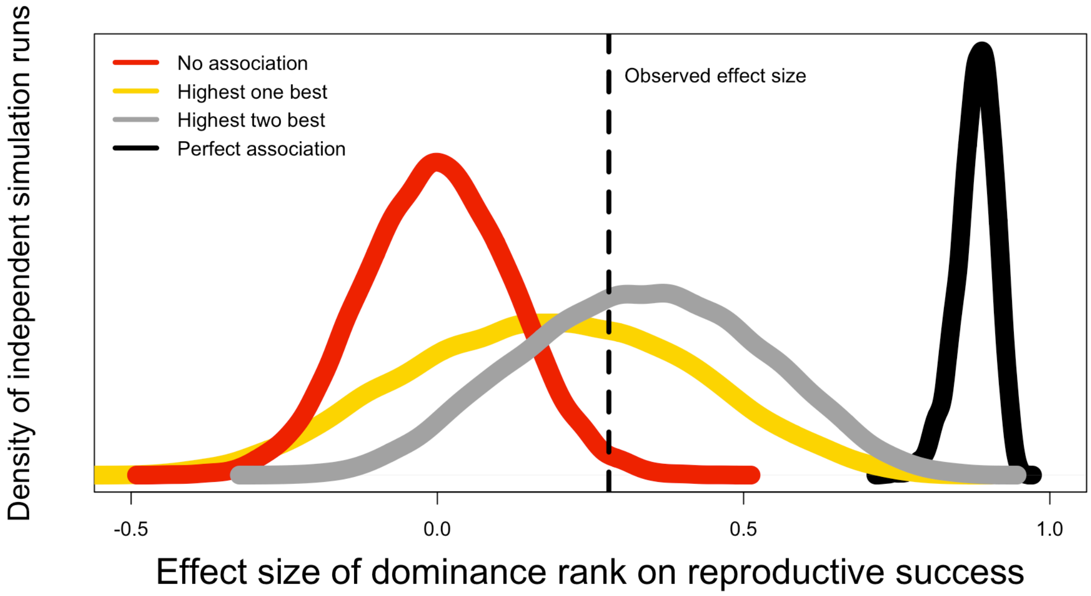

Figure 11. The average effect size of dominance rank on female reproductive success we observe in our

sample (0.28; dotted vertical line) is in between the effect sizes expected for social groups in which there is either no (grey line) or a perfect association (black line) between each rank and the reproductive success of females. The observed value is close to a situation in which the two highest ranking females (red line) or only the highest ranking female (yellow line) always have the highest success in a group of twelve females. Lines represent the densities of 10,000 simulated samples showing the respective effect size for each of the four associations.

Among the social traits we investigated, the highest difference in the effect of rank on reproductive success was between cooperative breeders and plural/associated breeders. This result was expected given the higher reproductive skew that has been found among females in cooperative breeders (Lukas and Clutton-Brock (2012)). The contrast between breeding systems appears due to the degree of reproductive control that dominants in cooperative breeders have. Our results also show that other social factors, in particular the number of females in the group and their relatedness, influence effect sizes in opposite directions in cooperative breeders than in plural breeders. The observation that in cooperative breeders reproductive success is shared less in species with larger numbers of subordinates and higher relatedness among them is in line with theoretical predictions that complete monopolization of reproduction can be stable if subordinates are queuing to inherit the dominant position themselves (Kokko and Johnstone (1999)). The likely importance of reproductive control of dominant females in cooperative breeders compared to plural/associated breeders is also reflected in the effect of group size on the benefits of dominance in the different breeding systems. Similar to what has also been found in eusocial insects (Rubenstein, Botero, and Lacey (2016)) and cooperatively breeding birds (Riehl (2017)), among cooperatively breeding mammals there usually is a single breeding dominant female and large groups occur when her reproductive output is high without loss of reproductive control. In contrast, among plural/associated breeding mammals groups grow large as more females/matrilines join a group leading to reduced reproductive control of dominants. In this context, it is important to again bear in mind that we only look at the association between rank and the variation in reproductive success within groups. In cooperative breeders, increases in group size might reduce the reproductive output of dominant females even if they still monopolize reproduction (T. H. Clutton-Brock et al. (2010)). In plural breeders, even though the relative difference between dominant and subordinate females might be lower in larger groups, in terms of overall fitness it might still be better to be dominant in a group of the optimal size than in a smaller group (e.g. small group where dominant has 3 versus subordinate has 2 offspring, i.e. 50% higher fitness, compared to a group where dominant has 4 while all other females have 3 offspring, i.e. 33% higher fitness).

Among plural and associated breeders, effects of dominance rank on female reproductive success are higher when (i) females disperse, (ii) groups are smaller, and (iii) females form coalitions. These observations are somewhat opposite to the processes presumably linked to reproductive suppression in cooperative breeders. In addition, these findings also do not support accounts that focus on nepotism as a primary factor in leading to social groups with large differences among females. It appears that in situations of strong nepotism females in a group might have more similar reproductive success, with patterns such as youngest sister ascendancy potentially reducing differences among kin (Datta (1988), Bergstrom and Fedigan (2010), Lea et al. (2014)), as predicted when offspring production is costly (Cant and Johnstone (1999)). In species with high nepotism, differences might be predominantly among matrilines (Holekamp et al. (2012)) rather than among individuals, which our study focused on. In our sample we observe relatively strong effects of high dominance rank in plural breeders when females form social bonds with unfamiliar/unrelated individuals they encounter when joining new breeding units upon reaching maturity (e.g. Cameron, Setsaas, and Linklater (2009)), such as among equids and gorillas. Groups in which females compete with and form complex bonds with unrelated females tend to be characterized by high relationship complexity (Lukas and Clutton-Brock (2018)). Rates of aggression tend to be high and dominance relationships are often based on age differences (Rutberg and Greenberg (1990)) with rare changes in the hierarchy, such that females who obtain high ranking positions in these units are likely to gain fitness benefits for extended periods of time. Overall though, effect sizes can be high independent of how females acquire and maintain rank, as also highlighted by the similarity in effect sizes across macaque species with different dominance styles. It thus sounds as if social inequality, regardless of its sources and forms, has broadly similar consequences on the variance of reproductive success.

Of the ecological variables we investigated, only population density was associated with differences in effect sizes of dominance rank on reproductive success, again supporting the role of social interactions in shaping fitness outcomes of dominance interactions. The observation that other ecological factors do not mitigate the strength of the fitness benefit dominant females receive might suggest that dominants are consistently able to outcompete other females in the group rather than dominance only being important under challenging conditions. While local ecological conditions, rather than the coarse species-level traits we used here, might modulate fitness benefits of high dominance rank for females, it seems unlikely that there would be a strong directional influence given that effect sizes from the same species tend to be similar, even in captive conditions. In line with this, previous work has shown that subordinate females may not always be the first to suffer under limiting conditions (Fedigan (1983)). Instead, a number of ecological challenges, such as for example predation or drought (Cheney et al. (2004)), particularly affect pregnant or lactating females. Accordingly, these costs are mainly carried by those females that have high reproductive output, thereby reducing variance in reproductive success and diminishing the relative benefits dominant females acquire (Altmann and Alberts (2003)).

The overall effect size of dominance rank on female reproductive success across the species in our sample is slightly higher than that reported in a previous study, though we find a similar value when we restrict our sample to primate species, the focus of the previous study (the average in our sample is 0.28 across all species, and 0.23 across primates only, versus 0.20 in a previous report for primates Majolo et al. (2012)). These estimates of the effects of female dominance rank are lower than those previously reported for males. The previous study on primates reports an effect of male dominance rank on fecundity of 0.71 (Majolo et al. (2012)), and estimates in a different study of the effect of dominance rank on males' mating success are ~0.6 (Cowlishaw and Dunbar (1991)). Do these different estimates reflect that males benefit more from high dominance rank than females? We think that we cannot make such an inference at this stage. Measures of mating success might not necessarily translate in equally high skew in reproductive success (Fedigan (1983)). Studies measuring male reproductive success also tend to cover even shorter time periods than the studies that identify female reproductive success; when sampled over similar time frame, in particular when sampled across the whole lifespan, the variances in reproductive success of males and females appear more similar (Lukas and Clutton-Brock (2014)). This is partly because mammalian males often move between groups, thus are only sampled for a subset of their reproductive career. Several factors identified here as modulating the effect of dominance rank on reproductive success may also be linked to differences between females and males. For example, the benefits of dominance may be mostly reproductive in males, while they may affect both reproduction and survival in females, again potentially leading to more similar values when measured across the whole lifespan. It could be expected that sex differences in the benefits of dominance on lifetime reproductive success are largely modulated by the mating system, where males may benefit more than females in polygynous species, but not in promiscuous or monogamous ones. Overall, the benefits of rank differ qualitatively and quantitatively between males and females and only additional symmetrical meta-analyses in males can answer such a question.

Our findings highlight that social factors can have important influences on demography and genetic evolution by leading to systematic differences in reproductive success. The effect of high dominance rank on reproductive success influences the growth and composition of social groups across generations. In particular when social rank is heritable, long-term changes are visible in the few studies which have been able to track reproductive success across multiple generations. For example, among spotted hyenas, the highest ranking female in 1979 is the ancestor of more than half of the females in the clan in 2009 (Holekamp et al. (2012)). This perspective also nicely highlights how small differences in reproductive success can add up over long time frames. While in the case of this hyena clan the highest ranking female gained the benefits, chance variation might also reduce such differences. For most populations, the effect sizes we reported are far from perfect such that dominants do not consistently have the highest reproductive success. Our data cannot resolve whether there is phenotypic selection to gain high rank (Huchard et al. (2016)), or whether high ranking females have higher reproductive success because they obtained this position by chance (Snyder and Ellner (2018)) in particular during extreme conditions where only few females might survive or reproduce (Lewontin and Cohen (1969)), or whether there are some traits that lead to both higher rank and higher reproductive success (Fedigan (1983)).

Our focus in this study was on the consequences of competition among females within groups, highlighting that some females (the subordinates) have a reduced fitness. It is important to bear in mind that such an approach outlooks selection that operates on competition between groups, which may be substantial in cooperative breeders where a single female mothers all offspring in a group, such that only one of her daughters can inherit the highest rank. Accordingly, living in social groups might not necessarily maximize fitness differences among females compared to a situation where they would all be solitary. Instead, the fitness benefits of social life may outweigh its costs for most females, such that even subordinates have a higher relative fitness when group-living compared to living alone. Nevertheless, our findings clearly show that these benefits are unequally shared, and that this is true across environmental conditions. They draw a complex landscape of the level of social inequality across mammalian societies, where the benefits of social dominance are modulated by aspects of life-history, demography and sociality that affect the form and intensity of reproductive and social competition, more than by ecological competition.

Ethics

Our study relies on previously published data and did not involve working directly with animals.

Author contributions

Shivani: Hypothesis development, data collection, data analysis and interpretation, revising/editing.

Huchard: Hypothesis development, data analysis and interpretation, write up, revising/editing.

Lukas: Hypothesis development, data collection, data analysis and interpretation, write up, revising/editing, materials/funding.

Data and code availability

The dataset has been published at KNB doi:10.5063/F1PZ578P. The code of the current version is archived at Edmond doi:10.17617/3.80

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Conflict of interest disclosure

We, the authors, declare that we have no conflicts of interest relating to the content of this article. Elise Huchard and Dieter Lukas are Recommenders at PCI Ecology.

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References

Alexander, R. D. (1974). The evolution of social behavior. Annual review of ecology and systematics, 325-383. https://doi.org/10.1146/annurev.es.05.110174.001545

Altmann, J., & Alberts, S. C. (2003). Variability in reproductive success viewed from a life-history perspective in baboons. American Journal of Human Biology, 15(3), 401-409. https://doi.org/10.1002/ajhb.10157

Balasubramaniam, K. N., Dittmar, K., Berman, C. M., Butovskaya, M., Cooper, M. A., Majolo, B., ... & De Waal, F. B. (2012). Hierarchical steepness, counter-aggression, and macaque social style scale. American journal of primatology, 74(10), 915-925. https://doi.org/10.1002/ajp.22044

Barsbai, T., Lukas, D., & Pondorfer, A. (2021). Local convergence of behavior across species. Science, 371(6526), 292-295. https://doi.org/10.1126/science.abb7481

Bercovitch, F. B. (1991). Social stratification, social strategies, and reproductive success in primates. Ethology and Sociobiology, 12(4), 315-333. https://doi.org/10.1016/0162-3095(91)90023-J

Fedigan, L., & Bergstrom, M. (2010). Dominance among female white-faced capuchin monkeys (Cebus capucinus): hierarchical linearity, nepotism, strength and stability. Behaviour, 147(7), 899-931. https://doi.org/10.1163/000579510X497283

Botero, C. A., Dor, R., McCain, C. M., & Safran, R. J. (2014). Environmental harshness is positively correlated with intraspecific divergence in mammals and birds. Molecular ecology, 23(2), 259-268. https://doi.org/10.1111/mec.12572

Brown, G. R., & Silk, J. B. (2002). Reconsidering the null hypothesis: Is maternal rank associated with birth sex ratios in primate groups?. Proceedings of the National Academy of Sciences, 99(17), 11252-11255. https://doi.org/10.1073/pnas.162360599

Burgin, C. J., Colella, J. P., Kahn, P. L., & Upham, N. S. (2018). How many species of mammals are there?. Journal of Mammalogy, 99(1), 1-14. https://doi.org/10.1093/jmammal/gyx147

Cameron, E. Z., Setsaas, T. H., & Linklater, W. L. (2009). Social bonds between unrelated females increase reproductive success in feral horses. Proceedings of the National Academy of Sciences, 106(33), 13850-13853. https://doi.org/10.1073/pnas.0900639106

Cant, M. A., & Johnstone, R. A. (1999). Costly young and reproductive skew in animal societies. Behavioral Ecology, 10(2), 178-184. https://doi.org/10.1093/beheco/10.2.178

Cavigelli, S. A., Dubovick, T., Levash, W., Jolly, A., & Pitts, A. (2003). Female dominance status and fecal corticoids in a cooperative breeder with low reproductive skew: ring-tailed lemurs (Lemur catta). Hormones and Behavior, 43(1), 166-179. https://doi.org/10.1016/S0018-506X(02)00031-4

Chamberlain, S. A., Hovick, S. M., Dibble, C. J., Rasmussen, N. L., Van Allen, B. G., Maitner, B. S., ... & Whitney, K. D. (2012). Does phylogeny matter? Assessing the impact of phylogenetic information in ecological meta-analysis. Ecology Letters, 15(6), 627-636. https://doi.org/10.1111/j.1461-0248.2012.01776.x

Cheney, D. L., Seyfarth, R. M., Fischer, J., Beehner, J., Bergman, T., Johnson, S. E., ... & Silk, J. B. (2004). Factors affecting reproduction and mortality among baboons in the Okavango Delta, Botswana. International Journal of Primatology, 25(2), 401-428. https://doi.org/10.1023/B:IJOP.0000019159.75573.13

Clutton-Brock, T., & Huchard, E. (2013). Social competition and its consequences in female mammals. Journal of Zoology, 289(3), 151-171. https://doi.org/10.1111/jzo.12023

Clutton-Brock, T. H., Hodge, S. J., Flower, T. P., Spong, G. F., & Young, A. J. (2010). Adaptive suppression of subordinate reproduction in cooperative mammals. The American Naturalist, 176(5), 664-673. https://doi.org/10.1086/656492

Cowlishaw, G., & Dunbar, R. I. (1991). Dominance rank and mating success in male primates. Animal Behaviour, 41(6), 1045-1056. https://doi.org/10.1016/S0003-3472(05)80642-6

Datta, S. (1988). The acquisition of dominance among free-ranging rhesus monkey siblings. Animal Behaviour, 36(3), 754-772. https://doi.org/10.1016/S0003-3472(88)80159-3

Digby, L. J., Ferrari, S. F., & Saltzman, W. (2006). The role of competition in cooperatively breeding species. Primates in Perspective. Oxford University Press, New York, 85-106.

Drummond, A. J., Suchard, M. A., Xie, D., & Rambaut, A. (2012). Bayesian phylogenetics with BEAUti and the BEAST 1.7. Molecular biology and evolution, 29(8), 1969-1973. https://doi.org/10.1093/molbev/mss075

Ellis, L. (1995). Dominance and reproductive success among nonhuman animals: a cross-species comparison. Ethology and sociobiology, 16(4), 257-333. https://doi.org/10.1016/0162-3095(95)00050-U

Fedigan, L. M. (1983). Dominance and reproductive success in primates. American Journal of Physical Anthropology, 26(S1), 91-129. https://doi.org/10.1002/ajpa.1330260506

Fedigan, L. M., & Jack, K. M. (2013). Sexual conflict in white-faced capuchins. Evolution's Empress, eds Fisher ML, Garcia JR (Oxford Univ Press, New York), 281-303. https://doi.org/10.1093/acprof:oso/9780199892747.003.0014

Fortunato, L. (2019). Lineal kinship organization in cross-specific perspective. Philosophical Transactions of the Royal Society B, 374(1780), 20190005. https://doi.org/10.1098/rstb.2019.0005

Frank, L. G. (1986). Social organization of the spotted hyaena Crocuta crocuta. II. Dominance and reproduction. Animal Behaviour, 34(5), 1510-1527. https://doi.org/10.1016/S0003-3472(86)80221-4

Giles, S. L., Nicol, C. J., Harris, P. A., & Rands, S. A. (2015). Dominance rank is associated with body condition in outdoor-living domestic horses (Equus caballus). Applied animal behaviour science, 166, 71-79. https://doi.org/10.1016/j.applanim.2015.02.019

Holekamp, K. E., & Smale, L. (1991). Dominance acquisition during mammalian social development: the "inheritance" of maternal rank. American Zoologist, 31(2), 306-317. https://doi.org/10.1093/icb/31.2.306

Holekamp, K. E., Smith, J. E., Strelioff, C. C., Van Horn, R. C., & Watts, H. E. (2012). Society, demography and genetic structure in the spotted hyena. Molecular Ecology, 21(3), 613-632. https://doi.org/10.1111/j.1365-294X.2011.05240.x

Huchard, E., English, S., Bell, M. B., Thavarajah, N., & Clutton-Brock, T. (2016). Competitive growth in a cooperative mammal. Nature, 533(7604), 532-534. https://doi.org/10.1038/nature17986

Isaac, J. L. (2005). Potential causes and life-history consequences of sexual size dimorphism in mammals. Mammal review, 35(1), 101-115. https://doi.org/10.1111/j.1365-2907.2005.00045.x

Jarman, P. (1983). Mating system and sexcul dimorphism in large terrestrial, mammalian herbivores. Biological Reviews, 58(4), 485-520. https://doi.org/10.1111/j.1469-185X.1983.tb00398.x

Jones, K. E., Bielby, J., Cardillo, M., Fritz, S. A., O'Dell, J., Orme, C. D. L., ... & Purvis, A. (2009). PanTHERIA: a species-level database of life history, ecology, and geography of extant and recently extinct mammals: Ecological Archives E090-184. Ecology, 90(9), 2648-2648. https://doi.org/10.1890/08-1494.1

Kappeler, P. M., Nunn, C. L., Vining, A. Q., & Goodman, S. M. (2019). Evolutionary dynamics of sexual size dimorphism in non-volant mammals following their independent colonization of Madagascar. Scientific reports, 9(1), 1-14. https://doi.org/10.1038/s41598-018-36246-x

Kokko, H., & Johnstone, R. A. (1999). Social queuing in animal societies: a dynamic model of reproductive skew. Proceedings of the Royal Society of London. Series B: Biological Sciences, 266(1419), 571-578. https://doi.org/10.1098/rspb.1999.0674

Kurz, S. (2019). Statistical Rethinking with Brms, Ggplot2, and the Tidyverse. available at: https://solomonkurz.netlify.com/post/bayesian-meta-analysis/.

Lajeunesse, M. J., Koricheva, J., Gurevitch, J., & Mengersen, K. (2013). Recovering missing or partial data from studies: a survey of conversions and imputations for meta-analysis. Handbook of meta-analysis in ecology and evolution, 195-206. https://doi.org/10.23943/princeton/9780691137285.003.0013

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. Frontiers in psychology, 4, 863. https://doi.org/10.3389/fpsyg.2013.00863

Lea, A. J., Learn, N. H., Theus, M. J., Altmann, J., & Alberts, S. C. (2014). Complex sources of variance in female dominance rank in a nepotistic society. Animal behaviour, 94, 87-99. https://doi.org/10.1016/j.anbehav.2014.05.019

Lemaître, J. F., Ronget, V., & Gaillard, J. M. (2020). Female reproductive senescence across mammals: a high diversity of patterns modulated by life history and mating traits. Mechanisms of Ageing and Development, 192, 111377. https://doi.org/10.1016/j.mad.2020.111377

Lewontin, R. C., & Cohen, D. (1969). On population growth in a randomly varying environment. Proceedings of the National Academy of sciences, 62(4), 1056-1060. https://doi.org/10.1073/pnas.62.4.1056

Loison, A., Gaillard, J. M., Pélabon, C., & Yoccoz, N. G. (1999). What factors shape sexual size dimorphism in ungulates?. Evolutionary Ecology Research, 1(5), 611-633.

Lukas, D., & Clutton-Brock, T. (2012). Cooperative breeding and monogamy in mammalian societies. Proceedings of the Royal Society B: Biological Sciences, 279(1736), 2151-2156. https://doi.org/10.1098/rspb.2011.2468

Lukas, D., & Clutton-Brock, T. (2014). Costs of mating competition limit male lifetime breeding success in polygynous mammals. Proceedings of the Royal Society B: Biological Sciences, 281(1786), 20140418. https://doi.org/10.1098/rspb.2014.0418

Lukas, D., & Clutton-Brock, T. (2017). Climate and the distribution of cooperative breeding in mammals. Royal Society open science, 4(1), 160897. https://doi.org/10.1098/rsos.160897

Lukas, D., & Clutton-Brock, T. (2018). Social complexity and kinship in animal societies. Ecology letters, 21(8), 1129-1134. https://doi.org/10.1111/ele.13079

Lukas, D., & Huchard, E. (2014). The evolution of infanticide by males in mammalian societies. Science, 346(6211), 841-844. https://doi.org/10.1126/science.1257226

Lukas, D., & Huchard, E. (2019). The evolution of infanticide by females in mammals. Philosophical Transactions of the Royal Society B, 374(1780), 20180075. https://doi.org/10.1098/rstb.2018.0075

Lukas, D., Reynolds, V., Boesch, C., & Vigilant, L. (2005). To what extent does living in a group mean living with kin?. Molecular Ecology, 14(7), 2181-2196. https://doi.org/10.1111/j.1365-294X.2005.02560.x

Majolo, B., Lehmann, J., de Bortoli Vizioli, A., & Schino, G. (2012). Fitness-related benefits of dominance in primates. American journal of physical anthropology, 147(4), 652-660. https://doi.org/10.1002/ajpa.22031

McElreath, R. (2020). Statistical rethinking: A Bayesian course with examples in R and Stan. Chapman and Hall/CRC. https://doi.org/10.1201/9780429029608

Nakagawa, S., Lagisz, M., Jennions, M. D., Koricheva, J., Noble, D. W., Parker, T. H., ... & O'Dea, R. E. (2022). Methods for testing publication bias in ecological and evolutionary meta-analyses. Methods in Ecology and Evolution, 13(1), 4-21. https://doi.org/10.1111/2041-210X.13724

Nakagawa, S., Lagisz, M., O'Dea, R. E., Rutkowska, J., Yang, Y., Noble, D. W., & Senior, A. M. (2021). The orchard plot: cultivating a forest plot for use in ecology, evolution, and beyond. Research Synthesis Methods, 12(1), 4-12. https://doi.org/10.1002/jrsm.1424

Nakagawa, S., & Santos, E. S. (2012). Methodological issues and advances in biological meta-analysis. Evolutionary Ecology, 26(5), 1253-1274. https://doi.org/10.1007/s10682-012-9555-5

Pandit, S. A., & van Schaik, C. P. (2003). A model for leveling coalitions among primate males: toward a theory of egalitarianism. Behavioral Ecology and Sociobiology, 55(2), 161-168. https://doi.org/10.1007/s00265-003-0692-2

Paradis, E., & Schliep, K. (2019). ape 5.0: an environment for modern phylogenetics and evolutionary analyses in R. Bioinformatics, 35(3), 526-528. https://doi.org/10.1093/bioinformatics/bty633

Preston, C., Ashby, D., & Smyth, R. (2004). Adjusting for publication bias: modelling the selection process. Journal of Evaluation in Clinical Practice, 10(2), 313-322. https://doi.org/10.1111/j.1365-2753.2003.00457.x

Pusey, A. (2012). Magnitude and sources of variation in female reproductive performance. The evolution of primate societies, 343-366.

Pusey, A., Williams, J., & Goodall, J. (1997). The influence of dominance rank on the reproductive success of female chimpanzees. Science, 277(5327), 828-831. https://www.jstor.org/stable/2893132

R Core Team (2020). R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Riehl, C. (2017). Kinship and incest avoidance drive patterns of reproductive skew in cooperatively breeding birds. The American Naturalist, 190(6), 774-785. https://doi.org/10.1086/694411

Rubenstein, D. R., Botero, C. A., & Lacey, E. A. (2016). Discrete but variable structure of animal societies leads to the false perception of a social continuum. Royal Society open science, 3(5), 160147. https://doi.org/10.1098/rsos.160147

Rutberg, A. T., & Greenberg, S. A. (1990). Dominance, aggression frequencies and modes of aggressive competition in feral pony mares. Animal Behaviour, 40(2), 322-331. https://doi.org/10.1016/S0003-3472(05)80927-3

Smith, R. J. (1999). Statistics of sexual size dimorphism. Journal of Human Evolution, 36(4), 423-458. https://doi.org/10.1006/jhev.1998.0281

Smith, R. J., & Cheverud, J. M. (2002). Scaling of sexual dimorphism in body mass: a phylogenetic analysis of Rensch's rule in primates. International Journal of Primatology, 23(5), 1095-1135. https://doi.org/10.1023/A:1019654100876

Snyder, R. E., & Ellner, S. P. (2018). Pluck or luck: does trait variation or chance drive variation in lifetime reproductive success?. The American Naturalist, 191(4), E90-E107. https://doi.org/10.1086/696125

Solomon, N. G., & French, J. A. (Eds.). (1997). Cooperative breeding in mammals. Cambridge University Press.

Stan Development Team (2020). Stan Modeling Language Users Guide and Reference Manual. https://mc-stan.org.

Stockley, P. (2003). Female multiple mating behaviour, early reproductive failure and litter size variation in mammals. Proceedings of the Royal Society of London. Series B: Biological Sciences, 270(1512), 271-278. https://www.jstor.org/stable/3558691

Stockley, P., & Bro-Jørgensen, J. (2011). Female competition and its evolutionary consequences in mammals. Biological Reviews, 86(2), 341-366. https://doi.org/10.1111/j.1469-185X.2010.00149.x

Strauss, E. D., DeCasien, A. R., Galindo, G., Hobson, E. A., Shizuka, D., & Curley, J. P. (2022). DomArchive: a century of published dominance data. Philosophical Transactions of the Royal Society B, 377(1845), 20200436. https://doi.org/10.1098/rstb.2020.0436

Swedell, L., Leedom, L., Saunders, J., & Pines, M. (2014). Sexual conflict in a polygynous primate: costs and benefits of a male-imposed mating system. Behavioral ecology and sociobiology, 68(2), 263-273. https://doi.org/10.1007/s00265-013-1641-3

Thierry, B. (2007). Unity in diversity: lessons from macaque societies. Evolutionary Anthropology: Issues, News, and Reviews: Issues, News, and Reviews, 16(6), 224-238. https://doi.org/10.1002/evan.20147

Thouless, C. R., & Guinness, F. E. (1986). Conflict between red deer hinds: the winner always wins. Animal Behaviour, 34(4), 1166-1171. https://doi.org/10.1016/S0003-3472(86)80176-2

Tibbetts, E. A., Pardo-Sanchez, J., & Weise, C. (2022). The establishment and maintenance of dominance hierarchies. Philosophical Transactions of the Royal Society B, 377(1845), 20200450. https://doi.org/10.1098/rstb.2020.0450

Upham, N. S., Esselstyn, J. A., & Jetz, W. (2019). Inferring the mammal tree: species-level sets of phylogenies for questions in ecology, evolution, and conservation. PLoS biology, 17(12), e3000494. https://doi.org/10.1371/journal.pbio.3000494

Van Noordwijk, M. A., & Van Schaik, C. P. (1988). Scramble and contest in feeding competition among female long-tailed macaques (Macaca fascicularis). Behaviour, 105(1-2), 77-98. https://doi.org/10.1163/156853988X00458

Vehrencamp, S. L. (1983). A model for the evolution of despotic versus egalitarian societies. Animal Behaviour, 31(3), 667-682. https://doi.org/10.1016/S0003-3472(83)80222-X

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. Journal of statistical software, 36(3), 1-48. https://doi.org/10.18637/jss.v036.i03

Ward, A., & Webster, M. (2016). Sociality: the behaviour of group-living animals. Springer, pp. 276 https://doi.org/10.1007/978-3-319-28585-6

West, M. J. (1967). Foundress associations in polistine wasps: dominance hierarchies and the evolution of social behavior. Science, 157(3796), 1584-1585. https://doi.org/10.1126/science.157.3796.1584

Williams, G. C. (2018). Adaptation and natural selection: A critique of some current evolutionary thought (Vol. 75). Princeton university press. https://doi.org/10.2307/j.ctv39x5jt

Wilman, H., Belmaker, J., Simpson, J., de la Rosa, C., Rivadeneira, M. M., & Jetz, W. (2014). EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals: Ecological Archives E095-178. Ecology, 95(7), 2027-2027. https://doi.org/10.1890/13-1917.1

Wilson, D. B. (2019). Practical Meta-Analysis Effect Size Calculator [Online Calculator]. Retrieved from: https:/www.campbellcollaboration.org/research-resources/research-for-resources/effect-sizecalculator.html

Supplement: The effect of dominance rank on female reproductive success in social mammals

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07/10/2021

Supplementary data

Data Table. References for the effect sizes of dominance rank on female reproductive success, for the dominance system in a given population, and for the average relatedness among females in social groups in a given population.

Id	Species	Reference effect size	Reference dominance system	Reference relatedness
1	Cervus_elaphus	(Clutton-Brock, et al. 1984)	(HALL, 2010)	(Nussey, et al., 2005)
2	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
3	Macaca_arctoides	(Nieuwenhuijsen, et al., 1985)	(HOLEKAMP and SMALE, 1991)	NA
4	Macaca_fuscata	(Gouzoules, et al. 1982)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
5	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
6	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
7	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
8	Macaca_mulatta	(Drickamer, 1974)	(Deutsch and Lee, 1991)	NA
9	Mandrillus_sphinx	(Setchell, et al. 2005)	(Setchell et al. 2002)	NA
10	Papio_cynocephalus	(, 2021)	(Packer, et al., 1995)	NA
11	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, et al., 1995)	(Wasser and Starling, 1988)
12	Rangifer_tarandus	(Holand, et al., 2004)	(Holand, et al., 2004)	(Djakovifa et al., 2011)
13	Callithrix_jacchus	(Sousa, et al., 2005)	(Digby, 1995)	(Nievergelt et al. 2009)
14	Chlorocebus_aethiops	(Fairbanks and McGuire, 1984)	(HOLEKAMP and SMALE, 1991)	(Fairbanks, et al., 2011)
15	Chlorocebus_aethiops	(Fairbanks and McGuire, 1984)	(HOLEKAMP and SMALE, 1991)	(Fairbanks, et al., 2011)
16	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
17	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
18	Lemur_catta	(Takahata, et al., 2007)	(Taylor and Sussman, 1985)	(Parga, et al., 2015)
19	Macaca_fuscata	(Gouzoules,et al. 1982)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
20	Macaca_fuscata	(Gouzoules,et al. 1982)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
21	Macaca_fuscata	(Wolfe, 1984)	(Koyama et al. 2003)	(Koyama et al. 2003)
22	Macaca_sylvanus	(Kümmerli and Martin, 2005)	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
23	Macaca_sylvanus	(Kümmerli and Martin, 2005)	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
24	Mesocricetus_auratus	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)
25	Mesocricetus_auratus	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)

26	Mesocricetus_auratus	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)	(Huck, Lisk, and McKay, 1988)
27	Oreamnos_americanus	(Cote and Festa-Bianchet, 2001)	(Cote, 2000)	(Shafer, et al., 2012)
28	Oryctolagus_cuniculus	(von Holst, et al., 2002)	(von Holst, et al., 2002)	(Surrridge, et al., 1999)
29	Oryctolagus_cuniculus	(von Holst, et al., 2002)	(von Holst, et al., 2002)	(Surrridge, et al., 1999)
30	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
31	Semnopithecus_entellus	(Borries, et al. 1991)	(Borries, Sommer, and Srivastava, 1991)	NA
32	Rangifer_tarandus	(Holand, et al., 2004)	(Holand, Gjonstein, Losvar, et al., 2004)	(Djakovifa et al., 2011)
33	Sciurus_vulgaris	(Wauters and Dhondt, 1989)	(Wauters and Dhondt, 1989)	NA
34	Sciurus_vulgaris	(Wauters and Dhondt, 1989)	(Wauters and Dhondt, 1989)	NA
35	Theropithecus_gelada	(DUNBAR and DUNBAR, 1977)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
36	Papio_ursinus	(Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, Cheney, and Seyfarth, 1999)
37	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, Cheney, and Seyfarth, 1999)
38	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, Cheney, and Seyfarth, 1999)
39	Cervus_elaphus	(Clutton-Brock, et al., 1984)	(HALL, 2010)	(Nussey, et al., 2005)
40	Crocuta_crocuta	(Holekamp, et al. 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
41	Gorilla_beringei	(Robbins, et al., 2007)	(Robbins, et al., 2007)	(Watts, 1994)
42	Lemur_catta	(Takahata, et al., 2007)	(Taylor and Sussman, 1985)	(Parga, et al., 2015)
43	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
44	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
45	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
46	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
47	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
48	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
49	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
50	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
51	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
52	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
53	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
54	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
55	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
56	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
57	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
58	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
59	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
60	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
61	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
62	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
63	Macaca_fascicularis	(VanNoordwijk & VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
64	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
65	Macaca_mulatta	(Meikle and Vessey, 1988)	(Deutsch and Lee, 1991)	NA
66	Oreamnos_americanus	(Cote and Festa-Bianchet, 2001)	(Fa, 2000)	(Shafer, et al., 2012)
67	Oreamnos_americanus	(Cote and Festa-Bianchet, 2001)	(Fa, 2000)	(Shafer, et al., 2012)
68	Oryctolagus_cuniculus	(von Holst, et al., 2002)	(von Holst, et al., 2002)	(Surrridge, et al., 1999)
69	Pan_troglodytes	(Pusey, 1997)	(Wittig et al. 2003)	(Vigilant, et al., 2001)

70	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
71	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
72	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
73	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
74	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
75	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
76	Papio_cynocephalus	(Silk, 2003)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
77	Papio_cynocephalus	(Silk, 2003)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
78	Semnopithecus_entellus	(Borries, et al., 1991)	(Borries, Sommer, and Srivastava, 1991)	NA
79	Semnopithecus_entellus	(Borries, et al., 1991)	(Borries, Sommer, and Srivastava, 1991)	NA
80	Crocuta_crocuta	(Hofer and East, 2003)	(Hofer and East, 2003)	NA
81	Papio_ursinus	Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
82	Papio_ursinus	(Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
83	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
84	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
85	Macaca_fuscata	(Gouzoules, et al., 1982)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
86	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
87	Mandrillus_sphinx	(Setchell et al. 2002)	(Setchell et al. 2002)	NA
88	Papio_anubis	(Cheney et al. 2006)	(Johnson, 1987)	NA
89	Papio_ursinus	NA	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
90	Papio_ursinus	(Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
91	Chlorocebus_aethiops	(Fairbanks and McGuire, 1984)	(HOLEKAMP and SMALE, 1991)	(Fairbanks, et al., 2011)
92	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
93	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
94	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
95	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
96	Crocuta_crocuta	(Holekamp, et al., 1996)	(Hofer and East, 2003)	(Horn, et al., 2004)
97	Gorilla_beringei	(Robbins, et al., 2007)	(Robbins, et al., 2005)	(Watts, 1994)
98	Macaca_arctoides	(Nieuwenhuijsen, et al., 1985)	(HOLEKAMP and SMALE, 1991)	NA
99	Mandrillus_sphinx	(Setchell et al. 2002)	(Setchell et al. 2002)	NA
100	Mandrillus_sphinx	(Setchell et al. 2002)	(Setchell et al. 2002)	NA
101	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	NA
102	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
103	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	NA
104	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
105	Papio_anubis	(Garcia, Lee, and Rosetta, 2006)	(Johnson, 1987)	NA
106	Papio_anubis	(Garcia, Lee, and Rosetta, 2006)	(Johnson, 1987)	NA
107	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
108	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
109	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
110	Papio_anubis	(Barton and Whiten, 1993)	(Johnson, 1987)	(Lynch 2016)
111	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
112	Papio_ursinus	(Bulger and Hamilton, 1987)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
113	Gorilla_beringei	(Robbins, et al., 2007)	(Robbins, et al., 2005)	(Watts, 1994)

114	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
115	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
116	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
117	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
118	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
119	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
120	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
121	Macaca_fascicularis	(VanNoordwijk VanSchaik, 1999)	(van Noordwijk and van Schaik, 1987)	(Ruiter and Geffen, 1998)
122	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
123	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
124	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
125	Macaca_fuscata	(Takahata, et al., 1998)	(Koyama et al. 2003)	(Nakagawa, et al., 2015)
126	Mandrillus_sphinx	(Setchell, et al., 2005)	(Setchell et al. 2002)	NA
127	Ovis_canadensis	(Festa-Bianchet, 1991)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
128	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
129	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
130	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
131	Crocuta_crocuta	(Hofer and East, 2003)	(Hofer and East, 2003)	NA
132	Macaca_fuscata	(Takahata, 1980)	(Koyama et al. 2003)	(Koyama)2003
133	Oryctolagus_cuniculus	(von Holst, Hutzelmeyer, Kaetzke, et al., 2002)	(von Holst, Hutzelmeyer, Kaetzke, et al., 2002)	(Surrridge, et al., 1999)
134	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
135	Papio_anubis	(Packer, et al., 1995)	(Johnson, 1987)	(Kopp 2015)
136	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
137	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
138	Papio_cynocephalus	(Wasser, et al., 2004)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser and Starling, 1988)
139	Crocuta_crocuta	(Hofer and East, 2003)	(Hofer and East, 2003)	NA
140	Papio_ursinus	(Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
141	Papio_ursinus	(Cheney et al. 2006)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
142	Cervus_elaphus	(Clutton-Brock, et al., 1984)	(HALL, 2010)	(Nussey, et al., 2005)
143	Cervus_elaphus	(Clutton-Brock, et al., 1984)	(HALL, 2010)	(Nussey, et al., 2005)
144	Macaca_mulatta	(Wilson, et al., 1978)	(Deutsch and Lee, 1991)	(Bernstein and Ehardt, 1986)
145	Macaca_mulatta	(Wilson, et al., 1978)	(Deutsch and Lee, 1991)	(Bernstein and Ehardt, 1986)
146	Macaca_sinica	(Dittus, 1979)	(Dittus, 1986)	NA
147	Macaca_sinica	(Dittus, 1979)	(Dittus, 1986)	NA
148	Lycaon_pictus	(Creel, et al., 1997)	(Spiering, et al., 2009)	(Girman, et al., 1997)
149	Fukomys_damarensis	(Burland, et al., 2004)	(Gaylard, Harrison, and Bennett, 1998)	(Burland, et al., 2002)
150	Macaca_fuscata	(Fedigan, et al., 1986)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
151	Macaca_fuscata	(Fedigan, et al., 1986)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
152	Macaca_fuscata	(Fedigan, et al., 1986)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
153	Macaca_fuscata	(Fedigan, et al., 1986)	(Koyama et al. 2003)	(Baxter and Fedigan, 1979)
154	Helogale_parvula	(Keane, et al., 1994)	(Creel, 2005)	(Creel and Waser, 1994)
155	Helogale_parvula	(Keane, et al., 1994)	(Creel, 2005)	(Creel and Waser, 1994)
156	Helogale_parvula	(Keane, et al., 1994)	(Creel, 2005)	(Creel and Waser, 1994)
157	Marmota_caligata	(Wasser and Barash, 1983)	(Patil, Karels, and Hik, 2015)	NA

158	Marmota_caligata	(Wasser and Barash, 1983)	(Patil, Karels, and Hik, 2015)	NA
159	Marmota_caligata	(Wasser and Barash, 1983)	(Patil, Karels, and Hik, 2015)	NA
160	Marmota_caligata	(Wasser and Barash, 1983)	(Patil, Karels, and Hik, 2015)	NA
161	Macaca_radiata	(Silk, et al., 1981)	(HOLEKAMP and SMALE, 1991)	NA
162	Macaca_radiata	(Silk, et al., 1981)	(HOLEKAMP and SMALE, 1991)	NA
163	Macaca_radiata	(Silk, et al., 1981)	(HOLEKAMP and SMALE, 1991)	NA
164	Marmota_flaviventris	(Huang, et al., 2011)	(Huang, Wey, and Blumstein, 2011)	(Armitage, et al., 2011)
165	Marmota_flaviventris	(Huang, et al., 2011)	(Huang, Wey, and Blumstein, 2011)	(Armitage, et al., 2011)
166	Marmota_flaviventris	(Huang, et al., 2011)	(Huang, Wey, and Blumstein, 2011)	(Armitage, et al., 2011)
167	Marmota_flaviventris	(Huang, et al., 2011)	(Huang, Wey, and Blumstein, 2011)	(Armitage, et al., 2011)
168	Alouatta_palliata	(Glander, 1980)	(Jones, 1980)	NA
169	Alouatta_palliata	(Glander, 1980)	(Jones, 1980)	NA
170	Equus_quagga	(Pluhacek, and Plausik, 2006)	(Lloyd and Rasa, 1994)	NA
171	Equus_quagga	(Pluhacek, and Plausik, 2006)	(Lloyd and Rasa, 1994)	NA
172	Equus_zebra	(Lloyd and Rasa, 1989)	(Lloyd and Rasa, 1994)	NA
173	Equus_zebra	(Lloyd and Rasa, 1989)	(Lloyd and Rasa, 1994)	NA
174	Equus_zebra	(Lloyd and Rasa, 1989)	(Lloyd and Rasa, 1994)	NA
175	Equus_zebra	(Lloyd and Rasa, 1989)	(Lloyd and Rasa, 1994)	NA
176	Equus_zebra	(Lloyd and Rasa, 1989)	(Lloyd and Rasa, 1994)	NA
177	Equus_caballus	(Rubenstein et al. 2009)	(Sinderbrand 2011)	NA
178	Equus_caballus	(Rubenstein et al. 2009)	(Sinderbrand 2011)	NA
179	Equus_caballus	(Rubenstein et al. 2009)	NA	NA
180	Mirounga_angustirostris	(Cheney et al. 1988)	(Christenson and Boeuf, 1978)	NA
181	Ovis_canadensis	(Hass, 1991)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
182	Ovis_canadensis	(Hass, 1991)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
183	Ovis_canadensis	(Hass, 1991)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
184	Hyaena_brunnea	(Owens and Owens, 1996)	(OWENS and OWENS, 1996)	(Knowles, et al., 2009)
185	Hyaena_brunnea	(Owens and Owens, 1996)	(OWENS and OWENS, 1996)	(Knowles, et al., 2009)
186	Mus_musculus	(Rusu and Krackow, 2004)	(Rusu and Krackow, 2004)	(Rusu and Krackow, 2004)
187	Mus_musculus	(Koenig, 1994)	(Rusu and Krackow, 2004)	(Koenig, 1994)
188	Mus_musculus	(Koenig, 1994)	(Rusu and Krackow, 2004)	(Koenig, 1994)
189	Mus_musculus	(Koenig, 1994)	(Rusu and Krackow, 2004)	(Koenig, 1994)
190	Mus_musculus	(Koenig, 1994)	(Rusu and Krackow, 2004)	(Koenig, 1994)
191	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
192	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
193	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
194	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
195	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
196	Rhabdomys_pumilio	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)	(Kinahan and Pillay, 2007)
197	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
198	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
199	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
200	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
201	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)

202	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
203	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
204	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
205	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
206	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
207	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
208	Apodemus_sylvaticus	(Gerlach, 2002)	(Gerlach, 2002)	(Gerlach, 2002)
209	Rattus_norvegicus	(Schultz and Lore, 1993)	(Ziporyn and McClintock, 1991)	(Schultz and Lore, 1993)
210	Marmota_marmota	(Hacklaender, et al., 2003)	(Lardy, and Cohas, 2013)	(Hacklaender, et al. 2003)
211	Heterocephalus_glaber	(Faulkes and Bennett, 2001)	(Clarke and Faulkes, 1997)	NA
212	Fukomys_damarensis	(Faulkes and Bennett, 2001)	(Gaylard, Harrison, and Bennett, 1998)	(Burland, et al., 2002)
213	Cryptomys_hottentotus	(Faulkes and Bennett, 2001)	(Gaylard, Harrison, and Bennett, 1998)	NA
214	Suricata_suricatta	(Griffin, 2003)	(Russell, et al., 2004)	(Griffin, 2003)
215	Leontopithecus_rosalia	(Henry, et al., 2013)	(Baker et al. 2002)	NA
216	Leontopithecus_rosalia	(Henry, et al., 2013)	(Baker et al. 2002)	NA
217	Leontopithecus_rosalia	(Henry, et al., 2013)	(Baker et al. 2002)	NA
218	Leontopithecus_rosalia	(Dietz and Baker, 1993)	NA	NA
219	Leontocebus_fuscicollis	(Goldizen, et al., 1996)	(Goldizen, et al., 1996)	NA
220	Saguinus_mystax	(Garber, et al., 1993)	(Smith 2000)	NA
221	Cebus_capucinus	(Fedigan, et al, 2008)	(Fedigan and Bergstrom, 2010)	NA
222	Cebus_capucinus	(Fedigan, et al, 2008)	(Fedigan and Bergstrom, 2010)	NA
223	Cercopithecus_mitis	(Cords, 2002)	(Klass and Cords, 2015)	NA
224	Chlorocebus_aethiops	NA	(HOLEKAMP and SMALE, 1991)	NA
225	Chlorocebus_aethiops	(Cheney et al. 1988)	(HOLEKAMP and SMALE, 1991)	NA
226	Chlorocebus_aethiops	(Cheney et al. 1988)	(HOLEKAMP and SMALE, 1991)	NA
227	Chlorocebus_aethiops	(Whitten et al. 1983)	(HOLEKAMP and SMALE, 1991)	NA
228	Chlorocebus_aethiops	(Whitten et al. 1983)	(HOLEKAMP and SMALE, 1991)	NA
229	Chlorocebus_aethiops	(Whitten et al. 1983)	(HOLEKAMP and SMALE, 1991)	NA
230	Chlorocebus_aethiops	(Whitten et al. 1983)	(HOLEKAMP and SMALE, 1991)	NA
231	Pan_troglodytes	(Jones, et al., 2010)	(Wittig et al. 2003)	(Vigilant, et al., 2001)
232	Papio_anubis	(Smuts and Nicolson, 1989)	(Johnson, 1987)	NA
233	Papio_anubis	(Smuts and Nicolson, 1989)	(Johnson, 1987)	NA
234	Macaca_fuscata	(Itoigawa,et al. 1992)	(Koyama et al. 2003)	NA
235	Macaca_fuscata	(Itoigawa, et al., 1992)	(Koyama et al. 2003)	NA
236	Macaca_fuscata	(Itoigawa, et al., 1992)	(Koyama et al. 2003)	NA
237	Macaca_fuscata	(Itoigawa, et al., 1992)	(Koyama et al. 2003)	NA
238	Macaca_fuscata	(Itoigawa, et al., 1992)	(Koyama et al. 2003)	NA
239	Macaca_fuscata	(Itoigawa, et al., 1992)	(Koyama et al. 2003)	NA
240	Ovis_canadensis	(Eccles and Shackleton, 1986)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
241	Ovis_canadensis	(Eccles and Shackleton, 1986)	(Festa-Bianchet, 1991)	(Fournier & Festa-Bianchet, 1995)
242	Ammotragus_lervia	(Cassinello and Alados, 1996)	(Cassinello, 1995)	NA
243	Ammotragus_lervia	(Cassinello and Alados, 1996)	(Cassinello, 1995)	NA
244	Ammotragus_lervia	(Cassinello and Alados, 1996)	(Cassinello, 1995)	NA
245	Ammotragus_lervia	(Cassinello and Alados, 1996)	(Cassinello, 1995)	NA

246	Antilocapra_americana	(Clancey and Byers, 2015)	(Dennehy, 2001)	(Carling, et al., 2003)
247	Antilocapra_americana	(Clancey and Byers, 2015)	(Dennehy, 2001)	(Carling, et al., 2003)
248	Antilocapra_americana	(Clancey and Byers, 2015)	(Dennehy, 2001)	(Carling, et al., 2003)
249	Nanger_dama	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
250	Gazella_cuvieri	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
251	Gazella_cuvieri	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
252	Gazella_cuvieri	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
253	Gazella_cuvieri	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
254	Nanger_dama	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
255	Nanger_dama	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
256	Nanger_dama	(Alados and Escez, 1992)	(Alados and Escvez, 2021)	NA
257	Capra_nubiana	(Shargal, et al., 2008)	(Greenberg-Cohen, et al., 2010)	NA
258	Ozotoceros_bezoarticus	(Morales-Picerva, et al., 2014)	(Morales-Pisterva, et al., 2014)	NA
259	Ozotoceros_bezoarticus	(Morales-Picerva, et al., 2014)	(Morales-Pisterva, et al., 2014)	NA
260	Mus_musculus	(Drickamer, 1985)	(Rusu and Krackow, 2004)	(Drickamer, 1985)
261	Mus_musculus	(Drickamer, 1985)	(Rusu and Krackow, 2004)	(Drickamer, 1985)
262	Mus_musculus	(Drickamer, 1985)	(Rusu and Krackow, 2004)	(Drickamer, 1985)
263	Helogale_parvula	(Rood, 1980)	(Creel, 2005)	(Creel and Waser, 1994)
264	Macaca_mulatta	(Gomendio, et al. 1990)	(Deutsch and Lee, 1991)	NA
265	Macaca_mulatta	(Gomendio, et al. 1990)	(Deutsch and Lee, 1991)	NA
266	Cervus_elaphus	(Gomendio, et al. 1990)	(HALL, 2010)	(Nussey, et al., 2005)
267	Cervus_elaphus	(Gomendio, et al. 1990)	(HALL, 2010)	(Nussey, et al., 2005)
268	Macaca_mulatta	(Gomendio, et al. 1990)	(Deutsch and Lee, 1991)	NA
269	Crocuta_crocuta	(Frank et al. 1995)	(Hofer and East, 2003)	(Horn, et al., 2007)
270	Crocuta_crocuta	(Frank et al. 1995)	(Hofer and East, 2003)	(Horn, et al., 2007)
271	Crocuta_crocuta	(Frank et al. 1995)	(Hofer and East, 2003)	(Horn, et al., 2007)
272	Crocuta_crocuta	(Frank et al. 1995)	(Hofer and East, 2003)	(Horn, et al., 2007)
273	Crocuta_crocuta	(Frank et al. 1995)	(Hofer and East, 2003)	(Horn, et al., 2007)
274	Ateles_paniscus	(Symington, 1987)	(van Roosmalen 1980)	NA
275	Crocuta_crocuta	(White, 2005)	(Hofer and East, 2003)	(Horn, et al., 2007)
276	Crocuta_crocuta	(White, 2005)	(Hofer and East, 2003)	(Horn, et al., 2007)
277	Crocuta_crocuta	(White, 2005)	(Hofer and East, 2003)	(Horn, et al., 2007)
278	Petrogale_concinna	(Nelson and Goldstone, 1986)	(Nelson and Goldstone, 1986)	NA
279	Macaca_assamensis	(Heesen, et al., 2013)	(Fuertbauerr 2011)	(Moor, et al., 2020)
280	Papio_ursinus	(Busse 1982)	(HOLEKAMP and SMALE, 1991)	(Silk, et al. 1999)
281	Macaca_fuscata	(Wolfe, 1984)	(Koyama et al. 2003)	(Koyama et al. 2003)
282	Macaca_fuscata	(Wolfe, 1984)	(Koyama et al. 2003)	(Koyama et al. 2003)
283	Macaca_fuscata	(Wolfe, 1984)	(Koyama et al. 2003)	(Koyama et al. 2003)
284	Theropithecus_gelada	(le Roux, et al., 2010)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
285	Theropithecus_gelada	(le Roux, et al., 2010)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
286	Marmota_marmota	(King and Cote, 2002)	(Lardy, and Cohas, 2013)	NA
287	Marmota_marmota	(King and Cote, 2002)	(Lardy, and Cohas, 2013)	NA
288	Papio_cynocephalus	(Beehner, et al., 2006)	(Packer, et al., 1995)	(Horn, et al., 2007)
289	Papio_cynocephalus	(Beehner, et al., 2006)	(Packer, et al., 1995)	(Horn, et al., 2007)

290	Papio_cynocephalus	NA	(Packer, et al., 1995)	(Horn, et al., 2007)
291	Papio_cynocephalus	(Altmann & Alberts 2003)	(Packer, et al., 1995)	(Horn, et al., 2007)
292	Papio_ursinus	(Baniel et al. 2021)	(Holekamp and Smale, 1991)	(Baniel, et al. 2018)
293	Vulpes_vulpes	(Baker, et al., 1998)	(Baker et al., 1998)	(Iossa, et al., 2008)
294	Semnopithecus_entellus	(Dolhinow, et al., 1979)	(Borries, Sommer, and Srivastava, 1991)	NA
295	Sapajus_apella	(DiBitetti et al. 2001)	(Welker, et al., 1990)	NA
296	Miopithecus_talapoin	(Abbott, 1987)	(Abbott, 1987)	NA
297	Mungos_mungo	(Nichols,et al., 2010)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
298	Mungos_mungo	(Nichols,et al., 2010)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
299	Mungos_mungo	(Nichols,et al., 2010)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
300	Mungos_mungo	(Nichols,et al., 2010)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
301	Mungos_mungo	(de Luca and Ginsberg, 2001)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
302	Canis_simensis	(Randall, et al., 2007)	(HOLEKAMP and SMALE, 1991)	(Randall, et al., 2007)
303	Procavia_capensis	(Koren and Geffen, 2009)	(Visser, Robinson, and van Vuuren, 2020)	(Visser 2013)
304	Bison_bison	(Vervaecke, Roden, and de Vries, 2005)	(Vervaecke, Roden, and de Vries, 2005)	NA
305	Bison_bison	(Vervaecke, Roden, and de Vries, 2005)	(Vervaecke, Roden, and de Vries, 2005)	NA
306	Capra_pyrenaica	(Santiago-Moreno, et al., 2007)	(Santiago et al. 2013)	NA
307	Sus_scrofa	(Meikle, et al., 2010)	(Gaillard et al. 1993)	(Meikle, et al., 2010)
308	Papio_cynocephalus	(Altmann et al. 1988)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
309	Macaca_sylvanus	(Paul & Kuester 1996)	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
310	Macaca_sylvanus	(Paul & Kuester 1996)	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
311	Macaca_sylvanus	NA	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
312	Papio_ursinus	(Baniel et al. 2021)	(HOLEKAMP and SMALE, 1991)	(Baniel, et al., 2018)
313	Papio_ursinus	(Baniel et al. 2021)	(HOLEKAMP and SMALE, 1991)	(Baniel, et al., 2018)
314	Papio_ursinus	(McFarland, et al., 2017)	(HOLEKAMP and SMALE, 1991)	NA
315	Papio_ursinus	(McFarland, et al., 2017)	(HOLEKAMP and SMALE, 1991)	NA
316	Papio_cynocephalus	(McFarland, et al., 2017)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
317	Lama_guanicoe	(Correa, et al., 2013)	(Correa, et al., 2013)	NA
318	Bos_taurus	(Hohenbrink et al., 2012)	(Spinka et al., 2013)	NA
319	Capra_hircus	(Barroso, et al., 2000)	(Barroso, Alados, and Boza, 2000)	NA
320	Sus_scrofa	(Mendl, et al. 1995)	(Cappa, Lombardini, and Meriggi, 2021)	NA
321	Bison_bison	(Green and Rothstein, 1991)	(Vervaecke, Roden, and de Vries, 2005)	NA
322	Bison_bison	(Green and Rothstein, 1991)	(Vervaecke, Roden, and de Vries, 2005)	NA
323	Antilocapra_americana	(Byers 1997)	(Dennehy, 2001)	(Carling, et al., 2003)
324	Antilocapra_americana	(Byers 1997)	(Dennehy, 2001)	(Carling, et al., 2003)
325	Antilocapra_americana	(Byers 1997)	(Dennehy, 2001)	(Carling, et al., 2003)
326	Antilocapra_americana	(Byers 1997)	(Dennehy, 2001)	(Carling, et al., 2003)
327	Suricata_suricatta	(MacLeod & Clutton-Brock, 2013)	(Russell, Carlson, McIlrath, et al., 2004)	(Griffin, 2003)
328	Suricata_suricatta	(MacLeod & Clutton-Brock, 2013)	(Russell, Carlson, McIlrath, et al., 2004)	(Griffin, 2003)
329	Mesocricetus_auratus	(Pratt and Lisk, 1989)	(Huck, Lisk, and McKay, 1988)	(Huck, et al. 1988)
330	Mesocricetus_auratus	(Pratt and Lisk, 1989)	(Huck, Lisk, and McKay, 1988)	(Huck, et al. 1988)
331	Gorilla_beringei	(Robbins, et al., 2011)	(Robbins, Gerald-Steklis, Robbins, et al., 2005)	(Watts, 1994)
332	Gorilla_beringei	(Robbins, et al., 2011)	(Robbins, Gerald-Steklis, Robbins, et al., 2005)	(Watts, 1994)
333	Gorilla_beringei	(Robbins, et al., 2011)	(Robbins, Gerald-Steklis, Robbins, et al., 2005)	(Watts, 1994)

334	Papio_anubis	(Smuts and Nicolson, 1989)	(Johnson, 1987)	NA
335	Papio_anubis	(Smuts and Nicolson, 1989)	(Johnson, 1987)	NA
336	Papio_anubis	(Smuts and Nicolson, 1989)	(Johnson, 1987)	NA
337	Macaca_mulatta	(Small and Hrdy, 1986)	(Deutsch and Lee, 1991)	NA
338	Cercopithecus_mitis	(Roberts and Cords, 2013)	(Klass and Cords, 2015)	NA
339	Suricata_suricatta	(Macdonald and Doolan, 1997)	(Russell, Carlson, McIlrath, et al., 2004)	NA
340	Microtus_arvalis	(Dobly, 2008)	(Dobly, 2008)	(Dobly, 2008)
341	Microtus_ochrogaster	(Wolff, et al., 2001)	(Wolff, Dunlap, and Ritchhart, 2001)	(Wolff, et al., 2001)
342	Microtus_pinetorum	(Wolff, et al., 2001)	(Wolff, Dunlap, and Ritchhart, 2001)	(Wolff, et al., 2001)
343	Macaca_mulatta	(Meikle, et al. 1984)	(Deutsch and Lee, 1991)	NA
344	Macaca_sylvanus	(Paul and Thommen, 1984)	(Paul and Kuester, 1987)	NA
345	Macaca_sylvanus	(Paul and Thommen, 1984)	(Paul and Kuester, 1987)	NA
346	Macaca_sylvanus	(Paul and Thommen, 1984)	(Paul and Kuester, 1987)	NA
347	Equus_quagga	(Schilder and Boer, 1987)	(Lloyd and Rasa, 1994)	NA
348	Equus_quagga	(Schilder and Boer, 1987)	(Lloyd and Rasa, 1994)	NA
349	Macaca_mulatta	(Berman, 1988)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
350	Macaca_arctoides	(Rhine, 1994)	(HOLEKAMP and SMALE, 1991)	NA
351	Papio_cynocephalus	(Rhine, et al., 1992)	(Packer, Collins, Sindimwo, et al., 1995)	(Wasser & Starling, 1988)
352	Canis_latrans	(Gese 2004)	(Gese 2004)	NA
353	Canis_latrans	(Gese 2004)	(Gese 2004)	NA
354	Macaca_mulatta	(Brent, et al. 2017)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
355	Suricata_suricatta	(Cram,et al., 2018)	(Russell, Carlson, McIlrath, et al., 2004)	(Griffin, 2003)
356	Fukomys_mechowi	(Dammann, et al., 2011)	(Wallace and Bennett, 1998)	(Dammann, et al., 2011)
357	Papio_ursinus	(Silk, et al. 2010)	(HOLEKAMP and SMALE, 1991)	(Silk, et al., 1999)
358	Papio_cynocephalus	(Archie, et al., 2014)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
359	Crocuta_crocuta	(Watts, et al., 2009)	(Hofer and East, 2003)	(Horn, et al., 2007)
360	Crocuta_crocuta	(Strauss and Holekamp, 2019)	(Hofer and East, 2003)	(Horn, et al., 2007)
361	Propithecus_verreauxi	(Kubzdela 1998)	(Kubzdela 1998)	(Lawler, et al. 2003)
362	Propithecus_verreauxi	(Kubzdela 1998)	(Kubzdela 1998)	(Lawler, et al. 2003)
363	Propithecus_verreauxi	(Kubzdela 1998)	(Kubzdela 1998)	(Lawler, et al. 2003)
364	Macaca_mulatta	(Blomquist, et al., 2010)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
365	Macaca_mulatta	(Blomquist, et al., 2010)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
366	Macaca_mulatta	(Blomquist, et al., 2010)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
367	Papio_ursinus	(Ron, Henzi, and Motro, 1996)	(HOLEKAMP and SMALE, 1991)	NA
368	Papio_ursinus	(Ron, Henzi, and Motro, 1996)	(HOLEKAMP and SMALE, 1991)	NA
369	Papio_ursinus	(Ron, Henzi, and Motro, 1996)	(HOLEKAMP and SMALE, 1991)	NA
370	Macaca_mulatta	(Simpson and Simpson, 1982)	(Deutsch and Lee, 1991)	NA
371	Macaca_fuscata	(Koyama, et al. 1992)	(Koyama et al. 2003)	(Koyama et al. 2003)
372	Macaca_fuscata	(Koyama, et al. 1992)	(Borries, Sommer, and Srivastava, 1991)	(Koyama et al. 2003)
373	Macaca_mulatta	(Maestripieri, 2001)	(Deutsch and Lee, 1991)	(Bernstein & Ehardt, 1986)
374	Macaca_mulatta	(Maestripieri, 2001)	(Deutsch and Lee, 1991)	(Bernstein & Ehardt, 1986)
375	Semnopithecus_schistaceus	(Vries et al., 2016)	(VRIES, KOENIG, and BORRIES, 2016)	NA
376	Semnopithecus_schistaceus	(Vries et al., 2016)	(VRIES, KOENIG, and BORRIES, 2016)	NA
377	Semnopithecus_schistaceus	(Vries et al., 2016)	(VRIES, KOENIG, and BORRIES, 2016)	NA

378	Mungos_mungo	(Sanderson, et al. 2015)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
379	Mungos_mungo	(Sanderson, et al. 2015)	(de Luca and Ginsberg, 2001)	(Nichols, et al., 2012)
380	Mesocricetus_auratus	(Chelini, et al., 2011)	(Huck, Lisk, and McKay, 1988)	(Pratt and Lisk, 1989)
381	Mesocricetus_auratus	(Chelini, et al., 2011)	(Huck, Lisk, and McKay, 1988)	(Pratt and Lisk, 1989)
382	Mesocricetus_auratus	(Chelini, et al., 2011)	(Huck, Lisk, and McKay, 1988)	(Pratt and Lisk, 1989)
383	Macaca_mulatta	(Liu, et al. 2018)	(Deutsch and Lee, 1991)	NA
384	Macaca_mulatta	(Liu, et al. 2018)	(Deutsch and Lee, 1991)	NA
385	Macaca_mulatta	(Liu, et al. 2018)	(Deutsch and Lee, 1991)	NA
386	Macaca_mulatta	(Liu, et al. 2018)	(Deutsch and Lee, 1991)	NA
387	Ceratotherium_simum	(Metrione and Harder, 2011)	(Metrione, Penfold, and Waring, 2007)	(Metrione and Harder, 2011)
388	Cebus_capucinus	(Kalbitzer, et al. 2017)	(Fedigan and Bergstrom, 2010)	NA
389	Canis_lupus	(Cafazzo,et al., 2014)	(Cafazzo, Valsecchi, Bonanni, and Natoli, 2010)	NA
390	Macaca_nigra	(Kerhoas, et al., 2014)	(Duboscq, et al., 2017)	NA
391	Equus_caballus	(Cameron, et al., 2009)	(Sinderbrand 2011)	(Cameron, et al., 2009)
392	Equus_caballus	(Cameron, et al., 2009)	(Sinderbrand 2011)	(Cameron, et al., 2009)
393	Odocoileus_virginianus	(Michel, et al., 2015)	(Townsend and Bailey, 1981)	NA
394	Papio_cynocephalus	(Archie, et al., 2014)	(Packer, Collins, Sindimwo, et al., 1995)	(Horn, et al., 2007)
395	Macaca_mulatta	(Ellis, et al., 2019)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
396	Cervus_elaphus	(Ceacero, et al., 2018)	(HALL, 2010)	(Ceacero, et al., 2018)
397	Cervus_elaphus	(Ceacero, et al., 2018)	(HALL, 2010)	(Ceacero, et al., 2007)
398	Cervus_elaphus	(Ceacero, et al., 2018)	(HALL, 2010)	(Ceacero, et al., 2007)
399	Cervus_elaphus	(Ceacero, et al., 2018)	(HALL, 2010)	(Ceacero, et al., 2007)
400	Bos_taurus	(Spinka, and Ceacero, 2017)	(Spinka, et al., 2013)	NA
401	Bos_taurus	(Spinka, and Ceacero, 2017)	(Spinka, et al., 2013)	NA
402	Bos_taurus	(Spinka, and Ceacero, 2017)	(Spinka, et al., 2013)	NA
403	Bos_taurus	(Spinka, and Ceacero, 2017)	(Spinka, et al., 2013)	NA
404	Bos_taurus	(Spinka, and Ceacero, 2017)	(Spinka, et al., 2013)	NA
405	Oryctolagus_cuniculus	(Mykytowycz, 1959)	(von Holst, Hutzelmeyer, Kaetzke, et al., 2002)	NA
406	Oryctolagus_cuniculus	(Mykytowycz, 1959)	(von Holst, Hutzelmeyer, Kaetzke, et al., 2002)	NA
407	Heterocephalus_glaber	(Jarvis, 1981)	(Clarke and Faulkes, 1997)	NA
408	Canis_rufus	(Zimen, 2010)	(Sparkman, et al. 2010)	NA
409	Canis_rufus	(Zimen, 2010)	(Sparkman, et al. 2010)	NA
410	Lycaon_pictus	(Malcolm and Marten, 1982)	(Spiering, Somers, Maldonado, et al., 2009)	(Girman, et al., 1997)
411	Lycaon_pictus	(Malcolm and Marten, 1982)	(Spiering, Somers, Maldonado, et al., 2009)	(Girman, et al., 1997)
412	Macaca_mulatta	(Anderson and Simpson, 1979)	(Deutsch and Lee, 1991)	NA
413	Macaca_fuscata	(Sugiyama and Ohsawa, 1982)	(Koyama et al. 2003)	NA
414	Macaca_fuscata	(Sugiyama and Ohsawa, 1982)	(Koyama et al. 2003)	NA
415	Macaca_fuscata	(Sugiyama and Ohsawa, 1982)	(Koyama et al. 2003)	NA
416	Macaca_fuscata	(Sugiyama and Ohsawa, 1982)	(Koyama et al. 2003)	NA
417	Macaca_mulatta	(Stucki, Dow, and Sade, 1991)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
418	Macaca_mulatta	(Bercovitch and Berard, 1993)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
419	Theropithecus_gelada	(Dunbar, 1980)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
420	Theropithecus_gelada	(Dunbar, 1980)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
421	Theropithecus_gelada	(Dunbar, 1980)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)

422	Theropithecus_gelada	(Dunbar, 1980)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
423	Theropithecus_gelada	(Dunbar, 1980)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
424	Theropithecus_gelada	(Dunbar, 1985)	(Dunbar, 1980)	(Snyder-Mackler, et al., 2014)
425	Callithrix_jacchus	(Rothe, 2010)	(Digby, 1995)	(Rothe, 2010)
426	Callithrix_jacchus	(Arruda, et al., 2005)	(Digby, 1995)	(Nievergelt et al. 2000)
427	Callithrix_jacchus	(Arruda, et al., 2005)	(Digby, 1995)	(Nievergelt et al. 2000)
428	Callithrix_jacchus	(Abbott, et al., 1981)	(Digby, 1995)	(Abbott, et al., 1981)
429	Erythrocebus_patas	(Loy, 1981)	(Isbell & Pruetz 1988)	NA
430	Saimiri_sciureus	(Coe, et al., 1981)	(Mitchell, Boinski, and van Schaik, 1991)	NA
431	Saimiri_sciureus	(Coe, et al., 1981)	(Mitchell, Boinski, and van Schaik, 1991)	NA
432	Saimiri_sciureus	(Coe, et al., 1981)	(Mitchell, Boinski, and van Schaik, 1991)	NA
433	Chlorocebus_aethiops	(Wrangham, 1981)	(HOLEKAMP and SMALE, 1991)	NA
434	Macaca_mulatta	(Blomquist, 2009)	(Deutsch and Lee, 1991)	(Chepko-Sade & Olivier, 1979)
435	Pan_troglodytes	(Boesch, 1997)	(Wittig et al. 2003)	(Lukas et al., 2005)
436	Pan_troglodytes	(Boesch, 1997)	(Wittig et al. 2003)	(Lukas et al., 2005)
437	Lemur_catta	(Nunn and Pereira, 2000)	(Taylor and Sussman, 1985)	(Taylor and Sussman, 1985)
438	Macaca_fascicularis	(Schaik, et al., 1989)	(Wittig et al. 2003)	NA
439	Pan_troglodytes	(Stanton, et al., 2017)	NA	(Vigilant, et al., 2001)
440	Pan_troglodytes	(Stanton, et al., 2017)	(Wittig et al. 2003)	(Vigilant, et al., 2001)
441	Gorilla_beringei	(Eckardt, et al., 2016)	(Robbins, Gerald-Steklis, Robbins, et al., 2005)	(Watts, 1994)
442	Macaca_sylvanus	(Modolo and Martin, 2007)	(Paul and Kuester, 1987)	(Kuemmerli and Martin, 2008)
443	Lophocebus_albigena	(Arlet, et al., 2014)	(Arlet, et al., 2014)	NA
444	Trachypithecus_phayrei	(Borries, et al., 2004)	(Koenig, Larney, Lu, and Borries, 2004)	(Larney 2013)

Supplementary references

[1] Nievergelt, C.M., Digby, L.J., “Ramakrishnan, U. and Woodruff, D.S., 2000. Genetic analysis of group composition and breeding system in a wild common marmoset (Callithrix jacchus) population”. In: International Journal of Primatology, 21(1), pp.1-20.

[2] R. Spinka, et al. “Pay respect to the elders: age, more than body mass, determines dominance in female beef cattle”. In: Animal Behaviour 86.6 (Dec. 2013), pp. 1315-1323. DOI: 10.1016/j.anbehav.2013.10.002. <URL: https://doi.org/10.1016/j.anbehav.2013.10.002>.

[3] R. Spinka, et al., and F. Ceacero. “Higher dominance position does not result in higher reproductive success in female beef cattle1,2”. In: Journal of Animal Science 95.8 (Aug. 2017), pp. 3301-3309. DOI: 10.2527/jas.2017.1415. <URL: https://doi.org/10.2527/jas.2017.1415>.

[4] D. H. Abbott. “Behaviourally mediated suppression of reproduction in female primates”. In: Journal of Zoology 213.3 (Nov. 1987), pp. 455-470. DOI: 10.1111/j.1469-7998.1987.tb03720.x. <URL: https://doi.org/10.1111/j.1469-7998.1987.tb03720.x>.

[5] D. H. Abbott, A. S. McNeilly, S. F. Lunn, et al. “Inhibition of ovarian function in subordinate female marmoset monkeys (Callithrix jacchus jacchus)”. In: Reproduction 63.2 (Nov. 1981), pp. 335-345. DOI: 10.1530/jrf.0.0630335. <URL: https://doi.org/10.1530/jrf.0.0630335>.

[6] C. Alados and J. Escós. “The determinants of social status and the effect of female rank on reproductive success in Dama and Cuvier’s gazelles”. In: Ethology Ecology & Evolution 4.2 (2021), pp. 151-164. ISSN: 0394-9370. DOI: 10.1080/08927014.1992.9525336. <URL: http://dx.doi.org/10.1080/08927014.1992.9525336>.

[7] C. Alados and J. Escós. “The determinants of social status and the effect of female rank on reproductive success in Dama and Cuvier’s gazelles”. In: Ethology Ecology & Evolution 4.2 (2021), pp. 151-164. ISSN: 0394-9370. DOI: 10.1080/08927014.1992.9525336. <URL: http://dx.doi.org/10.1080/08927014.1992.9525336>.

[8] C. Alados and J. Escós. “The determinants of social status and the effect of female rank on reproductive success in Dama and Cuvier’s gazelles”. In: Ethology Ecology & Evolution 4.2 (2021), pp. 151-164. ISSN: 0394-9370. DOI: 10.1080/08927014.1992.9525336. <URL: http://dx.doi.org/10.1080/08927014.1992.9525336>.

[9] C. Alados and J. Escós. “The determinants of social status and the effect of female rank on reproductive success in Dama and Cuvier’s gazelles”. In: Ethology Ecology & Evolution 4.2 (Apr. 1992), pp. 151-164. DOI: 10.1080/08927014.1992.9525336. <URL: https://doi.org/10.1080/08927014.1992.9525336>.

[10] D. M. Anderson and M. J. A. Simpson. “Breeding Performance of a Captive Colony of Rhesus Macaques (Macaca Mulatto)”. In: Laboratory Animals 13.3 (Jul. 1979), pp. 275-282. DOI: 10.1258/002367779780937834. <URL: https://doi.org/10.1258/002367779780937834>.

[11] E. A. Archie, J. Tung, M. Clark, et al. “Social affiliation matters: both same-sex and opposite-sex relationships predict survival in wild female baboons”. In: Proceedings of the Royal Society B: Biological Sciences 281.1793 (Oct. 2014), p. 20141261. DOI: 10.1098/rspb.2014.1261. <URL: https://doi.org/10.1098/rspb.2014.1261>.

[12] M. E. Arlet, L. A. Isbell, A. Kaasik, et al. “Determinants of Reproductive Performance Among Female Gray-Cheeked Mangabeys (Lophocebus albigena) in Kibale National Park, Uganda”. In: International Journal of Primatology 36.1 (Dec. 2014), pp. 55-73. DOI: 10.1007/s10764-014-9810-4. <URL: https://doi.org/10.1007/s10764-014-9810-4>.

[13] K. B. Armitage, D. H. V. Vuren, A. Ozgul, et al. “Proximate causes of natal dispersal in female yellow-bellied marmots, Marmota flaviventris”. In: Ecology 92.1 (Jan. 2011), pp. 218-227. DOI: 10.1890/10-0109.1. <URL: https://doi.org/10.1890/10-0109.1>.

[14] M. Arruda, A. Araújo, M. Sousa, et al. “Two Breeding Females within Free-Living Groups May Not Always Indicate Polygyny: Alternative Subordinate Female Strategies in Common Marmosets (Callithrix jacchus)”. In: Folia Primatologica 76.1 (2005), pp. 10-20. DOI: 10.1159/000082451. <URL: https://doi.org/10.1159/000082451>.

[15] P. J. BAKER, C. P. ROBERTSON, S. M. FUNK, et al. “Potential fitness benefits of group living in the red fox,Vulpes vulpes”. In: Animal Behaviour 56.6 (Dec. 1998), pp. 1411-1424. DOI: 10.1006/anbe.1998.0950. <URL: https://doi.org/10.1006/anbe.1998.0950>.

[16] A. Baniel, G. Cowlishaw, and E. Huchard. “Context dependence of female reproductive competition in wild chacma baboons”. In: Animal Behaviour 139 (May. 2018), pp. 37-49. DOI: 10.1016/j.anbehav.2018.03.001. <URL: https://doi.org/10.1016/j.anbehav.2018.03.001>.

[17] F. Barroso, C. Alados, and J. Boza. “Social hierarchy in the domestic goat: effect on food habits and production”. In: Applied Animal Behaviour Science 69.1 (Aug. 2000), pp. 35-53. DOI: 10.1016/s0168-1591(00)00113-1. <URL: https://doi.org/10.1016/s0168-1591(00)00113-1>.

[18] R. A. Barton and A. Whiten. “Feeding competition among female olive baboons, Papio anubis”. In: Animal Behaviour 46.4 (Oct. 1993), pp. 777-789. DOI: 10.1006/anbe.1993.1255. <URL: https://doi.org/10.1006/anbe.1993.1255>.

[19] M. J. Baxter and L. M. Fedigan. “Grooming and consort partner selection in a troop of Japanese monkeys (Macaca fuscata)”. In: Archives of Sexual Behavior 8.5 (Sep. 1979), pp. 445-458. DOI: 10.1007/bf01541200. <URL: https://doi.org/10.1007/bf01541200>.

[20] J. C. Beehner, D. A. Onderdonk, S. C. Alberts, et al. “The ecology of conception and pregnancy failure in wild baboons”. In: Behavioral Ecology 17.5 (Jun. 2006), pp. 741-750. DOI: 10.1093/beheco/arl006. <URL: https://doi.org/10.1093/beheco/arl006>.

[21] F. B. Bercovitch and J. D. Berard. “Life history costs and consequences of rapid reproductive maturation in female rhesus macaques”. In: Behavioral Ecology and Sociobiology 32.2 (Feb. 1993), pp. 103-109. DOI: 10.1007/bf00164042. <URL: https://doi.org/10.1007/bf00164042>.

[22] C. M. Berman. “Maternal Condition and Offspring Sex Ratio in a Group of Free-Ranging Rhesus Monkeys: An Eleven-Year Study”. In: The American Naturalist 131.3 (Mar. 1988), pp. 307-328. DOI: 10.1086/284792. <URL: https://doi.org/10.1086/284792>.

[23] I. S. Bernstein and C. Ehardt. “The influence of kinship and socialization on aggressive behaviour in rhesus monkeys (Macaca mulatta)”. In: Animal Behaviour 34.3 (Jun. 1986), pp. 739-747. DOI: 10.1016/s0003-3472(86)80057-4. <URL: https://doi.org/10.1016/s0003-3472(86)80057-4>.

[24] G. E. Blomquist. “Environmental and genetic causes of maturational differences among rhesus macaque matrilines”. In: Behavioral Ecology and Sociobiology 63.9 (May. 2009), pp. 1345-1352. DOI: 10.1007/s00265-009-0792-8. <URL: https://doi.org/10.1007/s00265-009-0792-8>.

[25] G. E. Blomquist, D. S. Sade, and J. D. Berard. “Rank-Related Fitness Differences and Their Demographic Pathways in Semi-Free-Ranging Rhesus Macaques (Macaca mulatta)”. In: International Journal of Primatology 32.1 (Nov. 2010), pp. 193-208. DOI: 10.1007/s10764-010-9461-z. <URL: https://doi.org/10.1007/s10764-010-9461-z>.

[26] C. BOESCH. “Evidence for dominant wild female chimpanzees investing more in sons”. In: Animal Behaviour 54.4 (Oct. 1997), pp. 811-815. DOI: 10.1006/anbe.1996.0510. <URL: https://doi.org/10.1006/anbe.1996.0510>.

[27] C. Borries, E. Larney, A. Derby, et al. “Temporary Absence and Dispersal in Phayre’s Leaf Monkeys (Trachypithecus phayrei)”. In: Folia Primatologica 75.1 (Jan. 01, 2004), pp. 27-30. ISSN: 0015-5713. DOI: 10.1159/000073428. <URL: http://dx.doi.org/10.1159/000073428>.

[28] C. Borries, V. Sommer, and A. Srivastava. “Dominance, age, and reproductive success in free-ranging female hanuman langurs (Presbytis entellus)”. In: International Journal of Primatology 12.3 (Jun. 1991), pp. 231-257. DOI: 10.1007/bf02547586. <URL: https://doi.org/10.1007/bf02547586>.

[29] L. J. N. Brent, A. Ruiz-Lambides, and M. L. Platt. “Family network size and survival across the lifespan of female macaques”. In: Proceedings of the Royal Society B: Biological Sciences 284.1854 (May. 2017), p. 20170515. DOI: 10.1098/rspb.2017.0515. <URL: https://doi.org/10.1098/rspb.2017.0515>.

[30] J. Bulger and W. J. Hamilton. “Rank and density correlates of inclusive fitness measures in a natural chacma baboon (Papio ursinus) troop”. In: International Journal of Primatology 8.6 (Dec. 1987), pp. 635-650. DOI: 10.1007/bf02735781. <URL: https://doi.org/10.1007/bf02735781>.

[31] T. M. Burland, N. C. Bennett, J. U. M. Jarvis, et al. “Eusociality in African mole-rats: new insights from patterns of genetic relatedness in the Damaraland mole-rat (Cryptomys damarensis)”. In: Proceedings of the Royal Society of London. Series B: Biological Sciences 269.1495 (May. 2002), pp. 1025-1030. DOI: 10.1098/rspb.2002.1978. <URL: https://doi.org/10.1098/rspb.2002.1978>.

[32] T. M. BURLAND, N. C. BENNETT, J. U. M. JARVIS, et al. “Colony structure and parentage in wild colonies of co-operatively breeding Damaraland mole-rats suggest incest avoidance alone may not maintain reproductive skew”. In: Molecular Ecology 13.8 (Jul. 2004), pp. 2371-2379. DOI: 10.1111/j.1365-294x.2004.02233.x. <URL: https://doi.org/10.1111/j.1365-294x.2004.02233.x>.

[33] S. Cafazzo, R. Bonanni, P. Valsecchi, et al. “Social Variables Affecting Mate Preferences, Copulation and Reproductive Outcome in a Pack of Free-Ranging Dogs”. In: PLoS ONE 9.6 (Jun. 2014). Ed. by C. Wicker-Thomas, p. e98594. DOI: 10.1371/journal.pone.0098594. <URL: https://doi.org/10.1371/journal.pone.0098594>.

[34] S. Cafazzo, P. Valsecchi, R. Bonanni, et al. “Dominance in relation to age, sex, and competitive contexts in a group of free-ranging domestic dogs”. In: Behavioral Ecology 21.3 (2010), pp. 443-455. DOI: 10.1093/beheco/arq001. <URL: https://doi.org/10.1093/beheco/arq001>.

[35] E. Z. Cameron, T. H. Setsaas, and W. L. Linklater. “Social bonds between unrelated females increase reproductive success in feral horses”. In: Proceedings of the National Academy of Sciences 106.33 (Aug. 2009), pp. 13850-13853. DOI: 10.1073/pnas.0900639106. <URL: https://doi.org/10.1073/pnas.0900639106>.

[36] F. Cappa, M. Lombardini, and A. Meriggi. “Influence of seasonality, environmental and anthropic factors on crop damage by wild boar Sus scrofa”. In: Folia Zoologica 68.4 (2021), p. 261. ISSN: 0139-7893. DOI: 10.25225/fozo.015.2019. <URL: http://dx.doi.org/10.25225/fozo.015.2019>.

[37] M. D. Carling, P. A. Wiseman, and J. A. Byers. “MICROSATELLITE ANALYSIS REVEALS MULTIPLE PATERNITY IN A POPULATION OF WILD PRONGHORN ANTELOPES (ANTILOCAPRA AMERICANA)”. In: Journal of Mammalogy 84.4 (Nov. 2003), pp. 1237-1243. DOI: 10.1644/brb-116. <URL: https://doi.org/10.1644/brb-116>.

[38] J. Cassinello. “Factors modifying female social ranks in Ammotragus”. In: Applied Animal Behaviour Science 45.1-2 (Oct. 1995), pp. 175-180. DOI: 10.1016/0168-1591(95)00583-e. <URL: https://doi.org/10.1016/0168-1591(95)00583-e>.

[39] J. Cassinello and C. L. Alados. “Female reproductive success in captiveAmmotragus lervia(Bovidae, Artiodactyla). Study of its components and effects of hierarchy and inbreeding”. In: Journal of Zoology 239.1 (May. 1996), pp. 141-153. DOI: 10.1111/j.1469-7998.1996.tb05442.x. <URL: https://doi.org/10.1111/j.1469-7998.1996.tb05442.x>.

[40] F. Ceacero, M. K. á, A. J. Garc, et al. “Different maternal investment strategies for male and female calves in a polygynous mammal”. In: Current Zoology 65.3 (Jun. 2018). Ed. by Z. Jia, pp. 269-277. DOI: 10.1093/cz/zoy049. <URL: https://doi.org/10.1093/cz/zoy049>.

[41] F. Ceacero, T. Landete-Castillejos, A. J. Garc, et al. “Kinship Discrimination and Effects on Social Rank and Aggressiveness Levels in Iberian Red Deer Hinds”. In: Ethology 113.12 (Dec. 2007), pp. 1133-1140. DOI: 10.1111/j.1439-0310.2007.01427.x. <URL: https://doi.org/10.1111/j.1439-0310.2007.01427.x>.

[42] M. O. M. Chelini, R. Palme, and E. Otta. “Social stress and reproductive success in the female Syrian hamster: Endocrine and behavioral correlates”. In: Physiology & Behavior 104.5 (Oct. 2011), pp. 948-954. DOI: 10.1016/j.physbeh.2011.06.006. <URL: https://doi.org/10.1016/j.physbeh.2011.06.006>.

[43] B. D. Chepko-Sade and T. J. Olivier. “Coefficient of genetic relationship and the probability of intragenealogical fission in Macaca mulatta”. In: Behavioral Ecology and Sociobiology 5.3 (1979), pp. 263-278. DOI: 10.1007/bf00293675. <URL: https://doi.org/10.1007/bf00293675>.

[44] T. Christenson and B. L. Boeuf. “Aggression in the Female Northern Elephant Seal, Mirounga Angustirostris”. In: Behaviour 64.1-2 (1978), pp. 158-171. DOI: 10.1163/156853978x00495. <URL: https://doi.org/10.1163/156853978x00495>.

[45] E. Clancey and J. A. Byers. “A comprehensive test of the Trivershypothesis in pronghorn (Antilocapra americana)”. In: Journal of Mammalogy 97.1 (Oct. 2015), pp. 179-186. DOI: 10.1093/jmammal/gyv168. <URL: https://doi.org/10.1093/jmammal/gyv168>.

[46] F. M. Clarke and C. G. Faulkes. “Dominance and queen succession in captive colonies of the eusocial naked mole, Heterocephalus glaber”. In: Proceedings of the Royal Society of London. Series B: Biological Sciences 264.1384 (Jul. 1997), pp. 993-1000. DOI: 10.1098/rspb.1997.0137. <URL: https://doi.org/10.1098/rspb.1997.0137>.

[47] T. H. Clutton-Brock, S. D. Albon, and F. E. Guinness. “Maternal dominance, breeding success and birth sex ratios in red deer”. In: Nature 308.5957 (Mar. 1984), pp. 358-360. DOI: 10.1038/308358a0. <URL: https://doi.org/10.1038/308358a0>.

[48] C. L. Coe, J. Chen, E. L. Lowe, et al. “Hormonal and behavioral changes at puberty in the squirrel monkey”. In: Hormones and Behavior 15.1 (Mar. 1981), pp. 36-53. DOI: 10.1016/0018-506x(81)90033-7. <URL: https://doi.org/10.1016/0018-506x(81)90033-7>.

[49] M. Cords. “Friendship among adult female blue monkeys (Cercopithecus mitis)”. In: Behaviour 139.2 (2002), pp. 291-314. DOI: 10.1163/156853902760102681. <URL: https://doi.org/10.1163/156853902760102681>.

[50] L. A. Correa, B. Zapata, H. Samaniego, et al. “Social structure in a family group of Guanaco (Lama guanicoe, Ungulate): Is female hierarchy based on prior attributes’ orsocial dynamics’?” In: Behavioural Processes 98 (Sep. 2013), pp. 92-97. DOI: 10.1016/j.beproc.2013.05.003. <URL: https://doi.org/10.1016/j.beproc.2013.05.003>.

[51] D. L. Cram, P. Monaghan, R. Gillespie, et al. “Rank-Related Contrasts in Longevity Arise from Extra-Group Excursions Not Delayed Senescence in a Cooperative Mammal”. In: Current Biology 28.18 (Sep. 2018), pp. 2934-2939.e4. DOI: 10.1016/j.cub.2018.07.021. <URL: https://doi.org/10.1016/j.cub.2018.07.021>.

[52] S. Creel. “DOMINANCE, AGGRESSION, AND GLUCOCORTICOID LEVELS IN SOCIAL CARNIVORES”. In: Journal of Mammalogy 86.2 (Apr. 2005), pp. 255-264. DOI: 10.1644/bhe-002.1. <URL: https://doi.org/10.1644/bhe-002.1>.

[53] S. R. Creel and P. M. Waser. “Inclusive fitness and reproductive strategies in dwarf mongooses”. In: Behavioral Ecology 5.3 (1994), pp. 339-348. DOI: 10.1093/beheco/5.3.339. <URL: https://doi.org/10.1093/beheco/5.3.339>.

[54] S. Creel, N. M. Creel, M. G. L. Mills, et al. “Rank and reproduction in cooperatively breeding African wild dogs: behavioral and endocrine correlates”. In: Behavioral Ecology 8.3 (1997), pp. 298-306. DOI: 10.1093/beheco/8.3.298. <URL: https://doi.org/10.1093/beheco/8.3.298>.

[55] P. Dammann, R. Šumbera, C. Maßmann, et al. “Extended Longevity of Reproductives Appears to be Common in Fukomys Mole-Rats (Rodentia, Bathyergidae)”. In: PLoS ONE 6.4 (Apr. 2011). Ed. by G. G. de Polavieja, p. e18757. DOI: 10.1371/journal.pone.0018757. <URL: https://doi.org/10.1371/journal.pone.0018757>.

[56] J. J. Dennehy. “Influence of social dominance rank on diet quality of pronghorn females”. In: Behavioral Ecology 12.2 (Mar. 2001), pp. 177-181. DOI: 10.1093/beheco/12.2.177. <URL: https://doi.org/10.1093/beheco/12.2.177>.

[57] J. C. Deutsch and P. C. Lee. “Dominance and feeding competition in captive rhesus monkeys”. In: International Journal of Primatology 12.6 (Dec. 1991), pp. 615-628. DOI: 10.1007/bf02547673. <URL: https://doi.org/10.1007/bf02547673>.

[58] J. M. Dietz and A. J. Baker. “Polygyny and female reproductive success in golden lion tamarins, Leontopithecus rosalia”. In: Animal Behaviour 46.6 (Dec. 1993), pp. 1067-1078. DOI: 10.1006/anbe.1993.1297. <URL: https://doi.org/10.1006/anbe.1993.1297>.

[59] L. J. Digby. “Social organization in a wild population ofCallithrix jacchus: II. Intragroup social behavior”. In: Primates 36.3 (Jul. 1995), pp. 361-375. DOI: 10.1007/bf02382859. <URL: https://doi.org/10.1007/bf02382859>.

[60] W. P. Dittus. “The Evolution of Behaviors Regulating Density and Age-Specific Sex Ratios in a Primate Population”. In: Behaviour 69.3-4 (1979), pp. 265-301. DOI: 10.1163/156853979x00511. <URL: https://doi.org/10.1163/156853979x00511>.

[61] W. P. J. Dittus. “Sex differences in fitness following a group take-over among Toque macaques: testing models of social evolution”. In: Behavioral Ecology and Sociobiology 19.4 (Sep. 1986), pp. 257-266. DOI: 10.1007/bf00300640. <URL: https://doi.org/10.1007/bf00300640>.

[62] N. Djaković, Ø. Holand, A. L. Hovland, et al. “Association patterns and kinship in female reindeer (Rangifer tarandus) during rut”. In: acta ethologica 15.2 (Dec. 2011), pp. 165-171. DOI: 10.1007/s10211-011-0121-x. <URL: https://doi.org/10.1007/s10211-011-0121-x>.

[63] A. Dobly. “Breeding suppression between two unrelated and initially unfamiliar females occurs with or without social tolerance in common voles (Microtus arvalis)”. In: Journal of Ethology 27.3 (Oct. 2008), pp. 299-306. DOI: 10.1007/s10164-008-0118-8. <URL: https://doi.org/10.1007/s10164-008-0118-8>.

[64] P. Dolhinow, J. J. McKenna, and J. V. H. Laws. “Rank and reproduction among female langur monkeys: Aging and improvement (They’re not just getting older, they’re getting better)”. In: Aggressive Behavior 5.1 (1979), pp. 19-30. DOI: 10.1002/1098-2337(1979)5:1<19::aid-ab2480050104>3.0.co;2-7. <URL: https://doi.org/10.1002/1098-2337(1979)5:1<19::aid-ab2480050104>3.0.co;2-7>.

[65] L. C. Drickamer. “A Ten-Year Summary of Reproductive Data for Free-Ranging Macaca mulatta”. In: Folia Primatologica 21.1 (1974), pp. 61-80. DOI: 10.1159/000155596. <URL: https://doi.org/10.1159/000155596>.

[66] L. C. Drickamer. “Social dominance, reproduction, and release of the maturation-delaying chemosignal in the urine of female house mice (Mus musculus).” In: Journal of Comparative Psychology 99.4 (Dec. 1985), pp. 411-419. DOI: 10.1037/0735-7036.99.4.411. <URL: https://doi.org/10.1037/0735-7036.99.4.411>.

[67] J. Duboscq, C. Neumann, M. Agil, et al. “Degrees of freedom in social bonds of crested macaque females”. In: Animal Behaviour 123 (Jan. 2017), pp. 411-426. DOI: 10.1016/j.anbehav.2016.11.010. <URL: https://doi.org/10.1016/j.anbehav.2016.11.010>.

[68] R. Dunbar. Reproductive Decisions. Princeton University Press, Dec. 1985. DOI: 10.1515/9781400853847. <URL: https://doi.org/10.1515/9781400853847>.

[69] R. I. M. Dunbar. “Determinants and evolutionary consequences of dominance among female gelada baboons”. In: Behavioral Ecology and Sociobiology 7.4 (Nov. 1980), pp. 253-265. DOI: 10.1007/bf00300665. <URL: https://doi.org/10.1007/bf00300665>.

[70] R. I. M. DUNBAR and E. P. DUNBAR. “Dominance and reproductive success among female gelada baboons”. In: Nature 266.5600 (Mar. 1977), pp. 351-352. DOI: 10.1038/266351a0. <URL: https://doi.org/10.1038/266351a0>.

[71] S. Cote. “DOMINANCE HIERARCHIES IN FEMALE MOUNTAIN GOATS: STABILITY, AGGRESSIVENESS AND DETERMINANTS OF RANK”. In: Behaviour 137.11 (2000), pp. 1541-1566. DOI: 10.1163/156853900502718. <URL: https://doi.org/10.1163/156853900502718>.

[72] S. Cote and M. Festa-Bianchet. “Reproductive success in female mountain goats: the influence of age and social rank”. In: Animal Behaviour 62.1 (Jul. 2001), pp. 173-181. DOI: 10.1006/anbe.2001.1719. <URL: https://doi.org/10.1006/anbe.2001.1719>.

[73] T. Eccles and D. Shackleton. “Correlates and consequences of social status in female bighorn sheep”. In: Animal Behaviour 34.5 (Oct. 1986), pp. 1392-1401. DOI: 10.1016/s0003-3472(86)80210-x. <URL: https://doi.org/10.1016/s0003-3472(86)80210-x>.

[74] W. Eckardt, K. Fawcett, and A. W. Fletcher. “Weaned age variation in the Virunga mountain gorillas (Gorilla beringei beringei): influential factors”. In: Behavioral Ecology and Sociobiology 70.4 (Feb. 2016), pp. 493-507. DOI: 10.1007/s00265-016-2066-6. <URL: https://doi.org/10.1007/s00265-016-2066-6>.

[75] S. Ellis, N. Snyder-Mackler, A. Ruiz-Lambides, et al. “Deconstructing sociality: the types of social connections that predict longevity in a group-living primate”. In: Proceedings of the Royal Society B: Biological Sciences 286.1917 (Dec. 2019), p. 20191991. DOI: 10.1098/rspb.2019.1991. <URL: https://doi.org/10.1098/rspb.2019.1991>.

[76] L. A. Fairbanks, M. J. Jorgensen, J. N. Bailey, et al. “Heritability and genetic correlation of hair cortisol in vervet monkeys in low and higher stress environments”. In: Psychoneuroendocrinology 36.8 (Sep. 2011), pp. 1201-1208. DOI: 10.1016/j.psyneuen.2011.02.013. <URL: https://doi.org/10.1016/j.psyneuen.2011.02.013>.

[77] L. A. Fairbanks and M. T. McGuire. “Determinants of fecundity and reproductive success in captive vervet monkeys”. In: American Journal of Primatology 7.1 (1984), pp. 27-38. DOI: 10.1002/ajp.1350070106. <URL: https://doi.org/10.1002/ajp.1350070106>.

[78] C. G. Faulkes and N. C. Bennett. “Family values: group dynamics and social control of reproduction in African mole-rats”. In: Trends in Ecology & Evolution 16.4 (Apr. 2001), pp. 184-190. DOI: 10.1016/s0169-5347(01)02116-4. <URL: https://doi.org/10.1016/s0169-5347(01)02116-4>.

[79] L. M. Fedigan, S. D. Carnegie, and K. M. Jack. “Predictors of reproductive success in female white-faced capuchins (Cebus capucinus)”. In: American Journal of Physical Anthropology 137.1 (Sep. 2008), pp. 82-90. DOI: 10.1002/ajpa.20848. <URL: https://doi.org/10.1002/ajpa.20848>.

[80] L. M. Fedigan, L. Fedigan, S. Gouzoules, et al. “Lifetime Reproductive Success in Female Japanese Macaques”. In: Folia Primatologica 47.2-3 (1986), pp. 143-157. DOI: 10.1159/000156271. <URL: https://doi.org/10.1159/000156271>.

[81] L. Fedigan and M. Bergstrom. “Dominance among female white-faced capuchin monkeys (Cebus capucinus): hierarchical linearity, nepotism, strength and stability”. In: Behaviour 147.7 (2010), pp. 899-931. DOI: 10.1163/000579510x497283. <URL: https://doi.org/10.1163/000579510x497283>.

[82] M. Festa-Bianchet. “The social system of bighorn sheep: grouping patterns, kinship and female dominance rank”. In: Animal Behaviour 42.1 (Jul. 1991), pp. 71-82. DOI: 10.1016/s0003-3472(05)80607-4. <URL: https://doi.org/10.1016/s0003-3472(05)80607-4>.

[83] F. Fournier and M. Festa-Bianchet. “Social dominance in adult female mountain goats”. In: Animal Behaviour 49.6 (Jun. 1995), pp. 1449-1459. DOI: 10.1016/0003-3472(95)90066-7. <URL: https://doi.org/10.1016/0003-3472(95)90066-7>.

[84] P. A. Garber, F. E. On, L. Moya, et al. “Demographic and reproductive patterns in moustached tamarin monkeys (Saguinus mystax): Implications for reconstructing platyrrhine mating systems”. In: American Journal of Primatology 29.4 (1993), pp. 235-254. DOI: 10.1002/ajp.1350290402. <URL: https://doi.org/10.1002/ajp.1350290402>.

[85] C. Garcia, P. Lee, and L. Rosetta. “Dominance and reproductive rates in captive female olive baboons,Papio anubis”. In: American Journal of Physical Anthropology 131.1 (2006), pp. 64-72. DOI: 10.1002/ajpa.20405. <URL: https://doi.org/10.1002/ajpa.20405>.

[86] A. Gaylard, Y. Harrison, and N. C. Bennett. “Temporal changes in the social structure of a captive colony of the Damaraland mole-rat, Cryptomys damarensis: the relationship of sex and age to dominance and burrow-maintenance activity”. In: Journal of Zoology 244.3 (Mar. 1998), pp. 313-321. DOI: 10.1111/j.1469-7998.1998.tb00035.x. <URL: https://doi.org/10.1111/j.1469-7998.1998.tb00035.x>.

[87] G. Gerlach. “Reproductive skew, costs, and benefits of cooperative breeding in female wood mice (Apodemus sylvaticus)”. In: Behavioral Ecology 13.3 (May. 2002), p. 408–418. ISSN: 1465-7279. DOI: 10.1093/beheco/13.3.408. <URL: http://dx.doi.org/10.1093/beheco/13.3.408>.

[88] G. Gerlach. “Reproductive skew, costs, and benefits of cooperative breeding in female wood mice (Apodemus sylvaticus)”. In: Behavioral Ecology 13.3 (May. 2002), pp. 408-418. DOI: 10.1093/beheco/13.3.408. <URL: https://doi.org/10.1093/beheco/13.3.408>.

[89] L. R. Gesquiere, J. Altmann, E. A. Archie, et al. “Interbirth intervals in wild baboons: Environmental predictors and hormonal correlates”. In: American Journal of Physical Anthropology 166.1 (Feb. 2018), pp. 107-126. DOI: 10.1002/ajpa.23407. <URL: https://doi.org/10.1002/ajpa.23407>.

[90] D. J. Girman, M. G. L. Mills, E. Geffen, et al. “A molecular genetic analysis of social structure, dispersal, and interpack relationships of the African wild dog (Lycaon pictus 1mu)”. In: Behavioral Ecology and Sociobiology 40.3 (Mar. 1997), pp. 187-198. DOI: 10.1007/s002650050332. <URL: https://doi.org/10.1007/s002650050332>.

[91] K. E. Glander. “Reproduction and population growth in free-ranging mantled howling monkeys”. In: American Journal of Physical Anthropology 53.1 (Jul. 1980), pp. 25-36. DOI: 10.1002/ajpa.1330530106. <URL: https://doi.org/10.1002/ajpa.1330530106>.

[92] A. W. Goldizen, J. Mendelson, M. van Vlaardingen, et al. “Saddle-back tamarin (Saguinus fuscicollis) reproductive strategies: Evidence from a thirteen-year study of a marked population”. In: American Journal of Primatology 38.1 (1996), pp. 57-83. DOI: 10.1002/(sici)1098-2345(1996)38:1<57::aid-ajp6>3.0.co;2-s. <URL: https://doi.org/10.1002/(sici)1098-2345(1996)38:1<57::aid-ajp6>3.0.co;2-s>.

[93] M. Gomendio. “The influence of maternal rank and infant sex on maternal investment trends in rhesus macaques: birth sex ratios, inter-birth intervals and suckling patterns”. In: Behavioral Ecology and Sociobiology 27.5 (1990), pp. 365-375. DOI: 10.1007/bf00164008. <URL: https://doi.org/10.1007/bf00164008>.

[94] M. Gomendio, T. H. Clutton-Brock, S. D. Albon, et al. “Mammalian sex ratios and variation in costs of rearing sons and daughters”. In: Nature 343.6255 (Jan. 1990), pp. 261-263. DOI: 10.1038/343261a0. <URL: https://doi.org/10.1038/343261a0>.

[95] H. Gouzoules, S. Gouzoules, and L. Fedigan. “Behavioural dominance and reproductive success in female Japanese monkeys (Macaca fuscata)”. In: Animal Behaviour 30.4 (Nov. 1982), pp. 1138-1150. DOI: 10.1016/s0003-3472(82)80204-2. <URL: https://doi.org/10.1016/s0003-3472(82)80204-2>.

[96] W. C. Green and A. Rothstein. “Sex bias or equal opportunity? Patterns of maternal investment in bison”. In: Behavioral Ecology and Sociobiology 29.5 (Dec. 1991), pp. 373-384. DOI: 10.1007/bf00165963. <URL: https://doi.org/10.1007/bf00165963>.

[97] D. Greenberg-Cohen, P. U. Alkon, and Y. Yom-Tov. “A Linear Dominance Hierarchy in Female Nubian Ibex”. In: Ethology 98.3-4 (Apr. 2010), pp. 210-220. DOI: 10.1111/j.1439-0310.1994.tb01072.x. <URL: https://doi.org/10.1111/j.1439-0310.1994.tb01072.x>.

[98] A. S. Griffin. “A genetic analysis of breeding success in the cooperative meerkat (Suricata suricatta)”. In: Behavioral Ecology 14.4 (Jul. 2003), pp. 472-480. DOI: 10.1093/beheco/arg040. <URL: https://doi.org/10.1093/beheco/arg040>.

[99] K. Hackländer, E. Möstl, and W. Arnold. “Reproductive suppression in female Alpine marmots, Marmota marmota”. In: Animal Behaviour 65.6 (Jun. 2003), pp. 1133-1140. DOI: 10.1006/anbe.2003.2159. <URL: https://doi.org/10.1006/anbe.2003.2159>.

[100] M. J. HALL. “Social Organization in an Enclosed Group of Red Deer (Cervus elaphus L.) on Rhum. I. The Dominance Hierarchy of Females and their Offspring”. In: Zeitschrift für Tierpsychologie 61.3 (Apr. 2010), pp. 250-262. DOI: 10.1111/j.1439-0310.1983.tb01341.x. <URL: https://doi.org/10.1111/j.1439-0310.1983.tb01341.x>.

[101] C. C. Hass. “Social status in female bighorn sheep (Ovis canadensis): expression, development and reproductive correlates”. In: Journal of Zoology 225.3 (Nov. 1991), pp. 509-523. DOI: 10.1111/j.1469-7998.1991.tb03832.x. <URL: https://doi.org/10.1111/j.1469-7998.1991.tb03832.x>.

[102] M. Heesen, S. Rogahn, J. Ostner, et al. “Food abundance affects energy intake and reproduction in frugivorous female Assamese macaques”. In: Behavioral Ecology and Sociobiology 67.7 (Apr. 2013), pp. 1053-1066. DOI: 10.1007/s00265-013-1530-9. <URL: https://doi.org/10.1007/s00265-013-

1530-9>.

[103] M. D. Henry, S. J. Hankerson, J. M. Siani, et al. “High rates of pregnancy loss by subordinates leads to high reproductive skew in wild golden lion tamarins (Leontopithecus rosalia)”. In: Hormones and Behavior 63.5 (May. 2013), pp. 675-683. DOI: 10.1016/j.yhbeh.2013.02.009. <URL: https://doi.org/10.1016/j.yhbeh.2013.02.009>.

[104] H. Hofer and M. L. East. “Behavioral processes and costs of co-existence in female spotted hyenas: a life history perspective”. In: Evolutionary Ecology 17.4 (Jul. 2003), pp. 315-331. DOI: 10.1023/a:1027352517231. <URL: https://doi.org/10.1023/a:1027352517231>.

[105] S. Hohenbrink and S. Meinecke-Tillmann. “Influence of social dominance on the secondary sex ratio and factors affecting hierarchy in Holstein dairy cows”. In: Journal of Dairy Science 95.10 (Oct. 2012), pp. 5694-5701. DOI: 10.3168/jds.2011-5281. <URL: https://doi.org/10.3168/jds.2011-5281>.

[106] O. Holand, H. Gjostein, A. Losvar, et al. “Social rank in female reindeer (Rangifer tarandus): effects of body mass, antler size and age”. In: Journal of Zoology 263.4 (Aug. 2004), pp. 365-372. DOI: 10.1017/s0952836904005382. <URL: https://doi.org/10.1017/s0952836904005382>.

[107] O. Holand, R. B. Weladji, H. Gjostein, et al. “Reproductive effort in relation to maternal social rank in reindeer (Rangifer tarandus)”. In: Behavioral Ecology and Sociobiology 57.1 (Jul. 2004), pp. 69-76. DOI: 10.1007/s00265-004-0827-0. <URL: https://doi.org/10.1007/s00265-004-0827-0>.

[108] K. E. HOLEKAMP and L. SMALE. “Dominance Acquisition During Mammalian Social Development: The of Maternal Rank”. In: American Zoologist 31.2 (Apr. 1991), pp. 306-317. DOI: 10.1093/icb/31.2.306. <URL: https://doi.org/10.1093/icb/31.2.306>.

[109] K. E. Holekamp, L. Smale, and M. Szykman. “Rank and reproduction in the female spotted hyaena”. In: Reproduction 108.2 (Nov. 1996), pp. 229-237. DOI: 10.1530/jrf.0.1080229. <URL: https://doi.org/10.1530/jrf.0.1080229>.

[110] D. von Holst, H. Hutzelmeyer, P. Kaetzke, et al. “Social rank, fecundity and lifetime reproductive success in wild European rabbits (Oryctolagus cuniculus)”. In: Behavioral Ecology and Sociobiology 51.3 (Feb. 2002), pp. 245-254. DOI: 10.1007/s00265-001-0427-1. <URL: https://doi.org/10.1007/s00265-001-0427-1>.

[111] R. C. V. Horn, J. C. Buchan, J. Altmann, et al. “Divided destinies: group choice by female savannah baboons during social group fission”. In: Behavioral Ecology and Sociobiology 61.12 (Jun. 2007), pp. 1823-1837. DOI: 10.1007/s00265-007-0415-1. <URL: https://doi.org/10.1007/s00265-007-0415-1>.

[112] R. C. V. Horn, A. L. Engh, K. T. Scribner, et al. “Behavioural structuring of relatedness in the spotted hyena (Crocuta crocuta) suggests direct fitness benefits of clan-level cooperation”. In: Molecular Ecology 13.2 (Jan. 2004), pp. 449-458. DOI: 10.1046/j.1365-294x.2003.02071.x. <URL: https://doi.org/10.1046/j.1365-294x.2003.02071.x>.

[113] B. Huang, T. W. Wey, and D. T. Blumstein. “Correlates and Consequences of Dominance in a Social Rodent”. In: Ethology 117.7 (May. 2011), pp. 573-585. DOI: 10.1111/j.1439-0310.2011.01909.x. <URL: https://doi.org/10.1111/j.1439-0310.2011.01909.x>.

[114] U. Huck, R. D. Lisk, and M. V. McKay. “Social dominance and reproductive success in pregnant and lactating golden hamsters (Mesocricetus auratus) under seminatural conditions”. In: Physiology & Behavior 44.3 (Jan. 1988), pp. 313-319. DOI: 10.1016/0031-9384(88)90031-5. <URL: https://doi.org/10.1016/0031-9384(88)90031-5>.

[115] G. Iossa, C. D. Soulsbury, P. J. Baker, et al. “Behavioral changes associated with a population density decline in the facultatively social red fox”. In: Behavioral Ecology 20.2 (Dec. 2008), pp. 385-395. DOI: 10.1093/beheco/arn149. <URL: https://doi.org/10.1093/beheco/arn149>.

[116] N. Itoigawa, T. Tanaka, N. Ukai, et al. “Demography and reproductive parameters of a free-ranging group of Japanese macaques (Macaca fuscata) at Katsuyama”. In: Primates 33.1 (Jan. 1992), pp. 49-68. DOI: 10.1007/bf02382762. <URL: https://doi.org/10.1007/bf02382762>.

[117] J. Jarvis. “Eusociality in a mammal: cooperative breeding in naked mole-rat colonies”. In: Science 212.4494 (May. 1981), pp. 571-573. DOI: 10.1126/science.7209555. <URL: https://doi.org/10.1126/science.7209555>.

[118] J. A. Johnson. “Dominance rank in juvenile olive baboons, Papio anubis: the influence of gender, size, maternal rank and orphaning”. In: Animal Behaviour 35.6 (Dec. 1987), pp. 1694-1708. DOI: 10.1016/s0003-3472(87)80062-3. <URL: https://doi.org/10.1016/s0003-3472(87)80062-3>.

[119] C. B. Jones. “The functions of status in the mantled howler monkey,Alouatta palliata Gray: Intraspecific competition for group membership in a folivorous neotropical primate”. In: Primates 21.3 (Jul. 1980), pp. 389-405. DOI: 10.1007/bf02390468. <URL: https://doi.org/10.1007/bf02390468>.

[120] J. H. Jones, M. L. Wilson, C. Murray, et al. “Phenotypic quality influences fertility in Gombe chimpanzees”. In: Journal of Animal Ecology 79.6 (Apr. 2010), pp. 1262-1269. DOI: 10.1111/j.1365-2656.2010.01687.x. <URL: https://doi.org/10.1111/j.1365-2656.2010.01687.x>.

[121] U. Kalbitzer, M. L. Bergstrom, S. D. Carnegie, et al. “Female sociality and sexual conflict shape offspring survival in a Neotropical primate”. In: Proceedings of the National Academy of Sciences 114.8 (Feb. 2017), pp. 1892-1897. DOI: 10.1073/pnas.1608625114. <URL: https://doi.org/10.1073/pnas.1608625114>.

[122] B. Keane, P. Waser, S. Creel, et al. “Subordinate reproduction in dwarf mongooses”. In: Animal Behaviour 47.1 (Jan. 1994), pp. 65-75. DOI: 10.1006/anbe.1994.1008. <URL: https://doi.org/10.1006/anbe.1994.1008>.

[123] D. Kerhoas, D. Perwitasari-Farajallah, M. Agil, et al. “Social and ecological factors influencing offspring survival in wild macaques”. In: Behavioral Ecology 25.5 (2014), pp. 1164-1172. DOI: 10.1093/beheco/aru099. <URL: https://doi.org/10.1093/beheco/aru099>.

[124] A. A. Kinahan and N. Pillay. “Dominance status influences female reproductive strategy in a territorial African rodent Rhabdomys pumilio”. In: Behavioral Ecology and Sociobiology 62.4 (Sep. 2007), pp. 579-587. DOI: 10.1007/s00265-007-0482-3. <URL: https://doi.org/10.1007/s00265-007-0482-3>.

[125] W. J. King and D. A. é. “Social, maternal, and environmental influences on reproductive success in female Alpine marmots (Marmota marmota)”. In: Canadian Journal of Zoology 80.12 (Dec. 2002), pp. 2137-2143. DOI: 10.1139/z02-205. <URL: https://doi.org/10.1139/z02-205>.

[126] K. Klass and M. Cords. “Agonism and dominance in female blue monkeys”. In: American Journal of Primatology 77.12 (Sep. 2015), pp. 1299-1315. DOI: 10.1002/ajp.22481. <URL: https://doi.org/10.1002/ajp.22481>.

[127] J. C. Knowles, P. J. V. C. de Groot, I. Wiesel, et al. “Microsatellite Variation in Namibian Brown Hyenas (Hyaena brunnea): Population Structure and Mating System Implications”. In: Journal of Mammalogy 90.6 (Dec. 2009), pp. 1381-1391. DOI: 10.1644/08-mamm-a-298r1.1. <URL: https://doi.org/10.1644/08-mamm-a-298r1.1>.

[128] A. Koenig, E. Larney, A. Lu, et al. “Agonistic behavior and dominance relationships in female phayre’s leaf monkeys - preliminary results”. In: American Journal of Primatology 64.3 (2004), pp. 351-357. DOI: 10.1002/ajp.20084. <URL: https://doi.org/10.1002/ajp.20084>.

[129] B. König. “Fitness effects of communal rearing in house mice: the role of relatedness versus familiarity”. In: Animal Behaviour 48.6 (Dec. 1994), pp. 1449-1457. DOI: 10.1006/anbe.1994.1381. <URL: https://doi.org/10.1006/anbe.1994.1381>.

[130] L. Koren and E. Geffen. “Androgens and social status in female rock hyraxes”. In: Animal Behaviour 77.1 (Jan. 2009), pp. 233-238. DOI: 10.1016/j.anbehav.2008.09.031. <URL: https://doi.org/10.1016/j.anbehav.2008.09.031>.

[131] N. Koyama, Y. Takahata, M. A. Huffman, et al. “Reproductive parameters of female Japanese macaques: Thirty years data from the arashiyama troops, Japan”. In: Primates 33.1 (Jan. 1992), pp. 33-47. DOI: 10.1007/bf02382761. <URL: https://doi.org/10.1007/bf02382761>.

[132] R. Kümmerli and R. D. Martin. “Male and Female Reproductive Success in Macaca sylvanus in Gibraltar: No Evidence for Rank Dependence”. In: International Journal of Primatology 26.6 (Dec. 2005), pp. 1229-1249. DOI: 10.1007/s10764-005-8851-0. <URL: https://doi.org/10.1007/s10764-005-8851-0>.

[133] R. Kümmerli and R. D. Martin. “Patterns of infant handling and relatedness in Barbary macaques (Macaca sylvanus) on Gibraltar”. In: Primates 49.4 (Sep. 2008), pp. 271-282. DOI: 10.1007/s10329-008-0100-7. <URL: https://doi.org/10.1007/s10329-008-0100-7>.

[134] S. Lardy, and A. Cohas. “Intrasexual competition and female dominance in a singular breeding mammal, the Alpine marmot”. In: Animal Behaviour 86.6 (Dec. 2013), pp. 1155-1163. DOI: 10.1016/j.anbehav.2013.09.017. <URL: https://doi.org/10.1016/j.anbehav.2013.09.017>.

[135] R. R. Lawler, A. F. Richard, and M. A. Riley. “Genetic population structure of the white sifaka (Propithecus verreauxi verreauxi) at Beza Mahafaly Special Reserve, southwest Madagascar (1992)”. In: Molecular Ecology 12.9 (Jul. 2003), pp. 2307-2317. DOI: 10.1046/j.1365-294x.2003.01909.x. <URL: https://doi.org/10.1046/j.1365-294x.2003.01909.x>.

[136] B. Liu, C. Wu, P. A. Garber, et al. “Effects of group size and rank on mother-infant relationships and reproductive success in rhesus macaques (Macaca mulatta)”. In: American Journal of Primatology 80.7 (Jun. 2018), p. e22881. DOI: 10.1002/ajp.22881. <URL: https://doi.org/10.1002/ajp.22881>.

[137] P. H. Lloyd and O. A. E. Rasa. “Status, reproductive success and fitness in Cape mountain zebra (Equus zebra zebra)”. In: Behavioral Ecology and Sociobiology 25.6 (Dec. 1989), pp. 411-420. DOI: 10.1007/bf00300187. <URL: https://doi.org/10.1007/bf00300187>.

[138] P. Lloyd and O. Rasa. “Incest Avoidance and Attainment of Dominance By Females in a Cape Mountain Zebra (Equus Zebra Zebra) Population”. In: Behaviour 128.3-4 (1994), pp. 169-188. DOI: 10.1163/156853994x00253. <URL: https://doi.org/10.1163/156853994x00253>.

[139] J. Loy. “The reproductive and heterosexual behaviours of adult patas monkeys in captivity”. In: Animal Behaviour 29.3 (Aug. 1981), pp. 714-726. DOI: 10.1016/s0003-3472(81)80006-1. <URL: https://doi.org/10.1016/s0003-3472(81)80006-1>.

[140] D. de Luca and J. Ginsberg. “Dominance, reproduction and survival in banded mongooses: towards an egalitarian social system?” In: Animal Behaviour 61.1 (Jan. 2001), pp. 17-30. DOI: 10.1006/anbe.2000.1559. <URL: https://doi.org/10.1006/anbe.2000.1559>.

[141] D. LUKAS, V. REYNOLDS, C. BOESCH, et al. “To what extent does living in a group mean living with kin?” In: Molecular Ecology 14.7 (Apr. 2005), pp. 2181-2196. DOI: 10.1111/j.1365-294x.2005.02560.x. <URL: https://doi.org/10.1111/j.1365-294x.2005.02560.x>.

[142] D. W. Macdonald and S. P. Doolan. “Band Structure and Failures of Reproductive Suppression in a Cooperatively Breeding Carnivore, the Slender-Tailed Meerkat (Suricata Suricatta)”. In: Behaviour 134.11-12 (1997), pp. 827-848. DOI: 10.1163/156853997x00179. <URL: https://doi.org/10.1163/156853997x00179>.

[143] K. MacLeod and T. Clutton-Brock. “No evidence for adaptive sex ratio variation in the cooperatively breeding meerkat, Suricata suricatta”. In: Animal Behaviour 85.3 (Mar. 2013), pp. 645-653. DOI: 10.1016/j.anbehav.2012.12.028. <URL: https://doi.org/10.1016/j.anbehav.2012.12.028>.

[144] D. Maestripieri. “Female-Biased Maternal Investment in Rhesus Macaques”. In: Folia Primatologica 72.1 (2001), pp. 44-47. DOI: 10.1159/000049920. <URL: https://doi.org/10.1159/000049920>.

[145] J. R. Malcolm and K. Marten. “Natural selection and the communal rearing of pups in African wild dogs (Lycaon pictus)”. In: Behavioral Ecology and Sociobiology 10.1 (Feb. 1982), pp. 1-13. DOI: 10.1007/bf00296390. <URL: https://doi.org/10.1007/bf00296390>.

[146] R. McFarland, D. Murphy, D. Lusseau, et al. “The ‘strength of weak ties’ among female baboons: fitness-related benefits of social bonds”. In: Animal Behaviour 126 (Apr. 2017), pp. 101-106. DOI: 10.1016/j.anbehav.2017.02.002. <URL: https://doi.org/10.1016/j.anbehav.2017.02.002>.

[147] D. B. Meikle, L. C. Drickamer, S. H. Vessey, et al. “Dominance Rank and Parental Investment in Swine (Sus scrofa domesticus)”. In: Ethology 102.8 (Apr. 2010), pp. 969-978. DOI: 10.1111/j.1439-0310.1996.tb01174.x. <URL: https://doi.org/10.1111/j.1439-0310.1996.tb01174.x>.

[148] D. B. Meikle, B. L. Tilford, and S. H. Vessey. “Dominance Rank, Secondary Sex Ratio, and Reproduction of Offspring in Polygynous Primates”. In: The American Naturalist 124.2 (Aug. 1984), pp. 173-188. DOI: 10.1086/284262. <URL: https://doi.org/10.1086/284262>.

[149] D. B. Meikle and S. H. Vessey. “Maternal dominance rank and lifetime survivorship of male and female rhesus monkeys”. In: Behavioral Ecology and Sociobiology 22.6 (Jun. 1988), p. 379–383. ISSN: 1432-0762. DOI: 10.1007/bf00294974. <URL: http://dx.doi.org/10.1007/BF00294974>.

[150] M. Mendl, A. J. Zanella, D. M. Broom, et al. “Maternal social status and birth sex ratio in domestic pigs: an analysis of mechanisms”. In: Animal Behaviour 50.5 (1995), pp. 1361-1370. DOI: 10.1016/0003-3472(95)80051-4. <URL: https://doi.org/10.1016/0003-3472(95)80051-4>.

[151] L. C. Metrione and J. D. Harder. “Fecal corticosterone concentrations and reproductive success in captive female southern white rhinoceros”. In: General and Comparative Endocrinology 171.3 (May. 2011), pp. 283-292. DOI: 10.1016/j.ygcen.2011.02.010. <URL: https://doi.org/10.1016/j.ygcen.2011.02.010>.

[152] L. C. Metrione, L. M. Penfold, and G. H. Waring. “Social and spatial relationships in captive southern white rhinoceros (Ceratotherium simum simum)”. In: Zoo Biology 26.6 (Jul. 2007), pp. 487-502. DOI: 10.1002/zoo.20143. <URL: https://doi.org/10.1002/zoo.20143>.

[153] E. S. Michel, S. Demarais, B. K. Strickland, et al. “Contrasting the Effects of Maternal and Behavioral Characteristics on Fawn Birth Mass in White-Tailed Deer”. In: PLOS ONE 10.8 (Aug. 2015). Ed. by T. Mappes, p. e0136034. DOI: 10.1371/journal.pone.0136034. <URL: https://doi.org/10.1371/journal.pone.0136034>.

[154] C. L. Mitchell, S. Boinski, and C. P. van Schaik. “Competitive regimes and female bonding in two species of squirrel monkeys (Saimiri oerstedi and S. sciureus)”. In: Behavioral Ecology and Sociobiology 28.1 (Jan. 1991), pp. 55-60. DOI: 10.1007/bf00172139. <URL: https://doi.org/10.1007/bf00172139>.

[155] L. Modolo and R. D. Martin. “Reproductive success in relation to dominance rank in the absence of prime-age males in Barbary macaques”. In: American Journal of Primatology 70.1 (2007), pp. 26-34. DOI: 10.1002/ajp.20452. <URL: https://doi.org/10.1002/ajp.20452>.

[156] D. D. Moor, C. Roos, J. Ostner, et al. “Female Assamese macaques bias their affiliation to paternal and maternal kin”. In: Behavioral Ecology 31.2 (Jan. 2020). Ed. by L. Barrett, pp. 493-507. DOI: 10.1093/beheco/arz213. <URL: https://doi.org/10.1093/beheco/arz213>.

[157] J. T. Morales-Pineyrua, G. Ciappesoni, and R. Ungerfeld. “Social rank and reproductive performance of pampas deer females (Ozotoceros bezoarticus, Linnaeus, 1758)”. In: Behavioural Processes 105 (Jun. 2014), pp. 49-52. DOI: 10.1016/j.beproc.2014.03.004. <URL: https://doi.org/10.1016/j.beproc.2014.03.004>.

[158] R. Mykytowycz. “Social behaviour of an experimental colony of wild rabbits, Oryctolagus cuniculus (L.) II. First breeding season”. In: CSIRO Wildlife Research 4.1 (1959), p. 1. DOI: 10.1071/cwr9590001. <URL: https://doi.org/10.1071/cwr9590001>.

[159] N. Nakagawa, M. Matsubara, Y. Shimooka, et al. “Embracing in a Wild Group of Yakushima Macaques (Macaca fuscata yakui) as an Example of Social Customs”. In: Current Anthropology 56.1 (Feb. 2015), pp. 104-120. DOI: 10.1086/679448. <URL: https://doi.org/10.1086/679448>.

[160] J. Nelson and A. Goldstone. “Reproduction in Peradorcas-Concinna (Marsupialia, Macropodidae)”. In: Wildlife Research 13.4 (1986), p. 501. DOI: 10.1071/wr9860501. <URL: https://doi.org/10.1071/wr9860501>.

[161] H. J. Nichols, W. Amos, M. A. Cant, et al. “Top males gain high reproductive success by guarding more successful females in a cooperatively breeding mongoose”. In: Animal Behaviour 80.4 (Oct. 2010), pp. 649-657. DOI: 10.1016/j.anbehav.2010.06.025. <URL: https://doi.org/10.1016/j.anbehav.2010.06.025>.

[162] H. J. Nichols, M. B. V. Bell, S. J. Hodge, et al. “Resource limitation moderates the adaptive suppression of subordinate breeding in a cooperatively breeding mongoose”. In: Behavioral Ecology 23.3 (Feb. 2012), pp. 635-642. DOI: 10.1093/beheco/ars008. <URL: https://doi.org/10.1093/beheco/ars008>.

[163] H. J. Nichols, N. R. Jordan, G. A. Jamie, et al. “Fine-scale spatiotemporal patterns of genetic variation reflect budding dispersal coupled with strong natal philopatry in a cooperatively breeding mammal”. In: Molecular Ecology 21.21 (Sep. 2012), pp. 5348-5362. DOI: 10.1111/mec.12015. <URL: https://doi.org/10.1111/mec.12015>.

[164] K. Nieuwenhuijsen, A. J. J. C. Lammers, K. J. de Neef, et al. “Reproduction and social rank in female stumptail Macaques (Macaca arctoides)”. In: International Journal of Primatology 6.1 (Feb. 1985), pp. 77-99. DOI: 10.1007/bf02693697. <URL: https://doi.org/10.1007/bf02693697>.

[165] M. A. van Noordwijk and C. P. van Schaik. “Competition among female long-tailed macaques, Macaca fascicularis”. In: Animal Behaviour 35.2 (Apr. 1987), pp. 577-589. DOI: 10.1016/s0003-3472(87)80284-1. <URL: https://doi.org/10.1016/s0003-3472(87)80284-1>.

[166] M. A. van Noordwijk and C. P. van Schaik. “The effects of dominance rank and group size on female lifetime reproductive success in wild long-tailed macaques,Macaca fascicularis”. In: Primates 40.1 (Jan. 1999), pp. 105-130. DOI: 10.1007/bf02557705. <URL: https://doi.org/10.1007/bf02557705>.

[167] M. A. van Noordwijk and C. P. van Schaik. “The effects of dominance rank and group size on female lifetime reproductive success in wild long-tailed macaques,Macaca fascicularis”. In: Primates 40.1 (Jan. 1999), p. 105–130. ISSN: 1610-7365. DOI: 10.1007/bf02557705. <URL: http://dx.doi.org/10.1007/BF02557705>.

[168] C. L. Nunn and M. E. Pereira. “Group histories and offspring sex ratios in ringtailed lemurs (Lemur catta)”. In: Behavioral Ecology and Sociobiology 48.1 (Jun. 2000), pp. 18-28. DOI: 10.1007/s002650000206. <URL: https://doi.org/10.1007/s002650000206>.

[169] D. H. NUSSEY, D. W. COLTMAN, T. COULSON, et al. “Rapidly declining fine-scale spatial genetic structure in female red deer”. In: Molecular Ecology 14.11 (Oct. 2005), pp. 3395-3405. DOI: 10.1111/j.1365-294x.2005.02692.x. <URL: https://doi.org/10.1111/j.1365-294x.2005.02692.x>.

[170] D. OWENS and M. OWENS. “Social dominance and reproductive patterns in brown hyaenas,Hyaena brunnea, of the central Kalahari desert”. In: Animal Behaviour 51.3 (Mar. 1996), pp. 535-551. DOI: 10.1006/anbe.1996.0058. <URL: https://doi.org/10.1006/anbe.1996.0058>.

[171] C. Packer, D. A. Collins, A. Sindimwo, et al. “Reproductive constraints on aggressive competition in female baboons”. In: Nature 373.6509 (Jan. 1995), pp. 60-63. DOI: 10.1038/373060a0. <URL: https://doi.org/10.1038/373060a0>.

[172] J. A. Parga, M. L. Sauther, F. P. Cuozzo, et al. “Genetic Evidence for Male and Female Dispersal in Wild Lemur catta”. In: Folia Primatologica 86.1-2 (May. 2015), pp. 66-75. DOI: 10.1159/000369386. <URL: https://doi.org/10.1159/000369386>.

[173] V. P. Patil, T. J. Karels, and D. S. Hik. “Ecological, Evolutionary and Social Constraints on Reproductive Effort: Are Hoary Marmots Really Biennial Breeders?” In: PLOS ONE 10.3 (Mar. 2015). Ed. by J. M. Waterman, p. e0119081. DOI: 10.1371/journal.pone.0119081. <URL: https://doi.org/10.1371/journal.pone.0119081>.

[174] A. Paul and J. Kuester. “Dominance, kinship and reproductive value in female Barbary macaques (Macaca sylvanus) at Affenberg Salem”. In: Behavioral Ecology and Sociobiology 21.5 (Nov. 1987), pp. 323-331. DOI: 10.1007/bf00299970. <URL: https://doi.org/10.1007/bf00299970>.

[175] A. Paul and D. Thommen. “Timing of Birth, Female Reproductive Success and Infant Sex Ratio in Semifree-Ranging Barbary Macaques (Macaca sylvanus)”. In: Folia Primatologica 42.1 (1984), pp. 2-16. DOI: 10.1159/000156140. <URL: https://doi.org/10.1159/000156140>.

[176] J. Pluhacek, L. B. š, and L. Cul’. “High-ranking mares of captive plains zebra Equus burchelli have greater reproductive success than low-ranking mares”. In: Applied Animal Behaviour Science 99.3-4 (Sep. 2006), pp. 315-329. DOI: 10.1016/j.applanim.2005.11.003. <URL: https://doi.org/10.1016/j.applanim.2005.11.003>.

[177] N. C. Pratt and R. D. Lisk. “Effects of social stress during early pregnancy on litter size and sex ratio in the golden hamster (Mesocricetus auratus)”. In: Reproduction 87.2 (Nov. 1989), pp. 763-769. DOI: 10.1530/jrf.0.0870763. <URL: https://doi.org/10.1530/jrf.0.0870763>.

[178] A. Pusey. “The Influence of Dominance Rank on the Reproductive Success of Female Chimpanzees”. In: Science 277.5327 (Aug. 1997), p. 828–831. ISSN: 1095-9203. DOI: 10.1126/science.277.5327.828. <URL: http://dx.doi.org/10.1126/science.277.5327.828>.

[179] D. A. Randall, J. P. Pollinger, R. K. Wayne, et al. “Inbreeding is reduced by female-biased dispersal and mating behavior in Ethiopian wolves”. In: Behavioral Ecology 18.3 (Mar. 2007), pp. 579-589. DOI: 10.1093/beheco/arm010. <URL: https://doi.org/10.1093/beheco/arm010>.

[180] R. J. Rhine. “A twenty-one-year study of maternal dominance and secondary sex ratio in a colony group of stumptailed macaques (Macaca arctoides)”. In: American Journal of Primatology 32.2 (1994), pp. 145-148. DOI: 10.1002/ajp.1350320207. <URL: https://doi.org/10.1002/ajp.1350320207>.

[181] R. J. Rhine, G. W. Norton, J. Rogers, et al. “Secondary sex ratio and maternal dominance rank among wild yellow baboons (Papio cynocephalus) of Mikumi National Park, Tanzania”. In: American Journal of Primatology 27.4 (1992), pp. 261-273. DOI: 10.1002/ajp.1350270404. <URL: https://doi.org/10.1002/ajp.1350270404>.

[182] A. M. Robbins, T. Stoinski, K. Fawcett, et al. “Lifetime reproductive success of female mountain gorillas”. In: American Journal of Physical Anthropology 146.4 (Oct. 2011), pp. 582-593. DOI: 10.1002/ajpa.21605. <URL: https://doi.org/10.1002/ajpa.21605>.

[183] M. M. Robbins, N. Gerald-Steklis, A. M. Robbins, et al. “Long-term dominance relationships in female mountain gorillas: strength, stability and determinants of rank”. In: Behaviour 142.6 (2005), pp. 779-809. DOI: 10.1163/1568539054729123. <URL: https://doi.org/10.1163/1568539054729123>.

[184] M. M. Robbins, A. M. Robbins, N. Gerald-Steklis, et al. “Socioecological influences on the reproductive success of female mountain gorillas (Gorilla beringei beringei)”. In: Behavioral Ecology and Sociobiology 61.6 (Jan. 2007), pp. 919-931. DOI: 10.1007/s00265-006-0321-y. <URL: https://doi.org/10.1007/s00265-006-0321-y>.

[185] M. M. Robbins, A. M. Robbins, N. Gerald-Steklis, et al. “Socioecological influences on the reproductive success of female mountain gorillas (Gorilla beringei beringei)”. In: Behavioral Ecology and Sociobiology 61.6 (Jan. 2007), p. 919–931. ISSN: 1432-0762. DOI: 10.1007/s00265-006-0321-y.

<URL: http://dx.doi.org/10.1007/s00265-006-0321-y>.

[186] S. Roberts and M. Cords. “Group size but not dominance rank predicts the probability of conception in a frugivorous primate”. In: Behavioral Ecology and Sociobiology 67.12 (Jul. 2013), pp. 1995-2009. DOI: 10.1007/s00265-013-1607-5. <URL: https://doi.org/10.1007/s00265-013-1607-5>.

[187] T. Ron, S. P. Henzi, and U. Motro. “Do Female Chacma Baboons Compete for a Safe Spatial Position in a Southern Woodland Habitat?” In: Behaviour 133.5-6 (1996), pp. 475-490. DOI: 10.1163/156853996x00549. <URL: https://doi.org/10.1163/156853996x00549>.

[188] J. P. Rood. “Mating relationships and breeding suppression in the dwarf mongoose”. In: Animal Behaviour 28.1 (Feb. 1980), pp. 143-150. DOI: 10.1016/s0003-3472(80)80019-4. <URL: https://doi.org/10.1016/s0003-3472(80)80019-4>.

[189] H. Rothe. “Some Aspects of Sexuality and Reproduction in Groups of Captive Marmosets (Callithrix jacchus)”. In: Zeitschrift für Tierpsychologie 37.3 (Apr. 2010), pp. 255-273. DOI: 10.1111/j.1439-0310.1975.tb00880.x. <URL: https://doi.org/10.1111/j.1439-0310.1975.tb00880.x>.

[190] A. le Roux, J. C. Beehner, and T. J. Bergman. “Female philopatry and dominance patterns in wild geladas”. In: American Journal of Primatology 73.5 (Dec. 2010), pp. 422-430. DOI: 10.1002/ajp.20916. <URL: https://doi.org/10.1002/ajp.20916>.

[191] J. Ruiter and E. Geffen. “Relatedness of matrilines, dispersing males and social groups in longmacaques (Macaca fascicularis)”. In: Proceedings of the Royal Society of London. Series B: Biological Sciences 265.1391 (Jan. 1998), pp. 79-87. DOI: 10.1098/rspb.1998.0267. <URL: https://doi.org/10.1098/rspb.1998.0267>.

[192] A. F. Russell, A. A. Carlson, G. M. McIlrath, et al. “ADAPTIVE SIZE MODIFICATION BY DOMINANT FEMALE MEERKATS”. In: Evolution 58.7 (Jul. 2004), pp. 1600-1607. DOI: 10.1111/j.0014-3820.2004.tb01739.x. <URL: https://doi.org/10.1111/j.0014-3820.2004.tb01739.x>.

[193] A. Rusu and S. Krackow. “Kin-preferential cooperation, dominance-dependent reproductive skew, and competition for mates in communally nesting female house mice”. In: Behavioral Ecology and Sociobiology 56.3 (Apr. 2004). DOI: 10.1007/s00265-004-0787-4. <URL: https://doi.org/10.1007/s00265-004-0787-4>.

[194] J. L. Sanderson, H. J. Nichols, H. H. Marshall, et al. “Elevated glucocorticoid concentrations during gestation predict reduced reproductive success in subordinate female banded mongooses”. In: Biology Letters 11.10 (Oct. 2015), p. 20150620. DOI: 10.1098/rsbl.2015.0620. <URL: https://doi.org/10.1098/rsbl.2015.0620>.

[195] J. Santiago-Moreno, A. Gómez-Brunet, A. Toledano-D’, et al. “Social dominance and breeding activity in Spanish ibex (Capra pyrenaica) maintained in captivity”. In: Reproduction, Fertility and Development 19.3 (2007), p. 436. DOI: 10.1071/rd06122. <URL: https://doi.org/10.1071/rd06122>.

[196] C. P. V. Schaik, W. J. Netto, A. J. J. V. Amerongen, et al. “Social rank and sex ratio of captive long-tailed macaque females (Macaca fascicularis)”. In: American Journal of Primatology 19.3 (1989), pp. 147-161. DOI: 10.1002/ajp.1350190303. <URL: https://doi.org/10.1002/ajp.1350190303>.

[197] M. B. Schilder and P. L. Boer. “Ethological investigations on a herd of plains zebra in a safari park: Time-budgets, reproduction and food competition”. In: Applied Animal Behaviour Science 18.1 (Jul. 1987), pp. 45-56. DOI: 10.1016/0168-1591(87)90253-x. <URL: https://doi.org/10.1016/0168-1591(87)90253-x>.

[198] L. A. Schultz and R. K. Lore. “Communal reproductive success in rats (Rattus norvegicus): Effects of group composition and prior social experience.” In: Journal of Comparative Psychology 107.2 (1993), pp. 216-222. DOI: 10.1037/0735-7036.107.2.216. <URL: https://doi.org/10.1037/0735-7036.107.2.216>.

[199] J. M. Setchell, M. Charpentier, and E. J. Wickings. “Sexual selection and reproductive careers in mandrills (Mandrillus sphinx)”. In: Behavioral Ecology and Sociobiology 58.5 (May. 2005), pp. 474-485. DOI: 10.1007/s00265-005-0946-2. <URL: https://doi.org/10.1007/s00265-005-0946-2>.

[200] A. B. A. Shafer, J. M. Northrup, K. S. White, et al. “Habitat selection predicts genetic relatedness in an alpine ungulate”. In: Ecology 93.6 (Jun. 2012), pp. 1317-1329. DOI: 10.1890/11-0815.1. <URL: https://doi.org/10.1890/11-0815.1>.

[201] D. Shargal, L. Shore, N. Roteri, et al. “Fecal testosterone is elevated in high ranking female ibexes (Capra nubiana) and associated with increased aggression and a preponderance of male offspring”. In: Theriogenology 69.6 (Apr. 2008), pp. 673-680. DOI: 10.1016/j.theriogenology.2007.11.017. <URL: https://doi.org/10.1016/j.theriogenology.2007.11.017>.

[202] J. B. Silk. “Social Bonds of Female Baboons Enhance Infant Survival”. In: Science 302.5648 (Nov. 2003), pp. 1231-1234. DOI: 10.1126/science.1088580. <URL: https://doi.org/10.1126/science.1088580>.

[203] J. B. Silk, J. C. Beehner, T. J. Bergman, et al. “Strong and Consistent Social Bonds Enhance the Longevity of Female Baboons”. In: Current Biology 20.15 (Aug. 2010), pp. 1359-1361. DOI: 10.1016/j.cub.2010.05.067. <URL: https://doi.org/10.1016/j.cub.2010.05.067>.

[204] J. B. Silk, C. B. Clark-Wheatley, P. S. Rodman, et al. “Differential reproductive success and facultative adjustment of sex ratios among captive female bonnet macaques (Macaca radiata)”. In: Animal Behaviour 29.4 (Nov. 1981), pp. 1106-1120. DOI: 10.1016/s0003-3472(81)80063-2. <URL: https://doi.org/10.1016/s0003-3472(81)80063-2>.

[205] J. Silk, D. Cheney, and R. Seyfarth. “THE STRUCTURE OF SOCIAL RELATIONSHIPS AMONG FEMALE SAVANNA BABOONS IN MOREMI RESERVE, BOTSWANA”. In: Behaviour 136.6 (1999), pp. 679-703. DOI: 10.1163/156853999501522. <URL: https://doi.org/10.1163/156853999501522>.

[206] M. J. A. Simpson and A. E. Simpson. “Birth sex ratios and social rank in rhesus monkey mothers”. In: Nature 300.5891 (Dec. 1982), pp. 440-441. DOI: 10.1038/300440a0. <URL: https://doi.org/10.1038/300440a0>.

[207] M. F. Small and S. B. Hrdy. “Secondary sex ratios by maternal rank, parity, and age in captive rhesus macaques (Macaca mulatta)”. In: American Journal of Primatology 11.4 (1986), pp. 359-365. DOI: 10.1002/ajp.1350110406. <URL: https://doi.org/10.1002/ajp.1350110406>.

[208] B. Smuts and N. Nicolson. “Reproduction in wild female olive baboons”. In: American Journal of Primatology 19.4 (1989), pp. 229-246. DOI: 10.1002/ajp.1350190405. <URL: https://doi.org/10.1002/ajp.1350190405>.

[209] N. Snyder-Mackler, S. C. Alberts, and T. J. Bergman. “The socio-genetics of a complex society: female gelada relatedness patterns mirror association patterns in a multilevel society”. In: Molecular Ecology 23.24 (Nov. 2014), pp. 6179-6191. DOI: 10.1111/mec.12987. <URL: https://doi.org/10.1111/mec.12987>.

[210] M. B. C. Sousa, A. C. S. da Rocha Albuquerque, F. da Silva Albuquerque, et al. “Behavioral strategies and hormonal profiles of dominant and subordinate common marmoset (Callithrix jacchus) females in wild monogamous groups”. In: American Journal of Primatology 67.1 (2005), pp. 37-50. DOI: 10.1002/ajp.20168. <URL: https://doi.org/10.1002/ajp.20168>.

[211] A. M. Sparkman, J. R. Adams, T. D. Steury, et al. “Direct fitness benefits of delayed dispersal in the cooperatively breeding red wolf (Canis rufus)”. In: Behavioral Ecology 22.1 (Dec. 2010), pp. 199-205. DOI: 10.1093/beheco/arq194. <URL: https://doi.org/10.1093/beheco/arq194>.

[212] P. A. Spiering, M. J. Somers, J. E. Maldonado, et al. “Reproductive sharing and proximate factors mediating cooperative breeding in the African wild dog (Lycaon pictus)”. In: Behavioral Ecology and Sociobiology 64.4 (Nov. 2009), pp. 583-592. DOI: 10.1007/s00265-009-0875-6. <URL: https://doi.org/10.1007/s00265-009-0875-6>.

[213] M. A. Stanton, E. V. Lonsdorf, A. E. Pusey, et al. “Do juveniles help or hinder? Influence of juvenile offspring on maternal behavior and reproductive outcomes in wild chimpanzees (Pan troglodytes)”. In: Journal of Human Evolution 111 (Oct. 2017), pp. 152-162. DOI: 10.1016/j.jhevol.2017.07.012. <URL: https://doi.org/10.1016/j.jhevol.2017.07.012>.

[214] E. D. Strauss and K. E. Holekamp. “Social alliances improve rank and fitness in convention-based societies”. In: Proceedings of the National Academy of Sciences 116.18 (Mar. 2019), pp. 8919-8924. DOI: 10.1073/pnas.1810384116. <URL: https://doi.org/10.1073/pnas.1810384116>.

[215] B. R. Stucki, M. M. Dow, and D. S. Sade. “Variance in intrinsic rates of growth among free-ranging rhesus monkey groups”. In: American Journal of Physical Anthropology 84.2 (Feb. 1991), pp. 181-191. DOI: 10.1002/ajpa.1330840208. <URL: https://doi.org/10.1002/ajpa.1330840208>.

[216] Y. Sugiyama and H. Ohsawa. “Population Dynamics of Japanese Monkeys with Special Reference to the Effect of Artificial Feeding”. In: Folia Primatologica 39.3-4 (1982), pp. 238-263. DOI: 10.1159/000156080. <URL: https://doi.org/10.1159/000156080>.

[217] A. K. SURRIDGE, K. M. IBRAHIM, D. J. BELL, et al. “Fine-scale genetic structuring in a natural population of European wild rabbits (Oryctolagus cuniculus)”. In: Molecular Ecology 8.2 (Feb. 1999), pp. 299-307. DOI: 10.1046/j.1365-294x.1999.00570.x. <URL: https://doi.org/10.1046/j.1365-294x.1999.00570.x>.

[218] M. M. Symington. “Sex ratio and maternal rank in wild spider monkeys: when daughters disperse”. In: Behavioral Ecology and Sociobiology 20.6 (Jun. 1987), pp. 421-425. DOI: 10.1007/bf00302985. <URL: https://doi.org/10.1007/bf00302985>.

[219] Y. Takahata. “The reproductive biology of a free-ranging troop of Japanese monkeys”. In: Primates 21.3 (Jul. 1980), pp. 303-329. DOI: 10.1007/bf02390462. <URL: https://doi.org/10.1007/bf02390462>.

[220] Y. Takahata, N. Koyama, S. Ichino, et al. “The relationship between female rank and reproductive parameters of the ringtailed lemur: a preliminary analysis”. In: Primates 49.2 (Dec. 2007), pp. 135-138. DOI: 10.1007/s10329-007-0076-8. <URL: https://doi.org/10.1007/s10329-007-0076-8>.

[221] Y. Takahata, S. Suzuki, N. Agetsuma, et al. “Reproduction of wild Japanese macaque females of Yakushima and Kinkazan Islands: A preliminary report”. In: Primates 39.3 (Jul. 1998), pp. 339-349. DOI: 10.1007/bf02573082. <URL: https://doi.org/10.1007/bf02573082>.

[222] L. Taylor and R. W. Sussman. “A preliminary study of kinship and social organization in a semi-free-ranging group ofLemur catta”. In: International Journal of Primatology 6.6 (Dec. 1985), pp. 601-614. DOI: 10.1007/bf02692291. <URL: https://doi.org/10.1007/bf02692291>.

[223] T. W. Townsend and E. D. Bailey. “Effects of Age, Sex and Weight on Social Rank in Penned White-tailed Deer”. In: American Midland Naturalist 106.1 (Jul. 1981), p. 92. DOI: 10.2307/2425138. <URL: https://doi.org/10.2307/2425138>.

[224] R. C. Van Horn, J. C. Buchan, J. Altmann, et al. “Divided destinies: group choice by female savannah baboons during social group fission”. In: Behavioral Ecology and Sociobiology 61.12 (Jun. 2007), p. 1823–1837. ISSN: 1432-0762. DOI: 10.1007/s00265-007-0415-1. <URL: http://dx.doi.org/10.1007/s00265-007-0415-1>.

[225] H. Vervaecke, C. Roden, and H. de Vries. “Dominance, fatness and fitness in female American bison, Bison bison”. In: Animal Behaviour 70.4 (Oct. 2005), pp. 763-770. DOI: 10.1016/j.anbehav.2004.12.018. <URL: https://doi.org/10.1016/j.anbehav.2004.12.018>.

[226] L. Vigilant, M. Hofreiter, H. Siedel, et al. “Paternity and relatedness in wild chimpanzee communities”. In: Proceedings of the National Academy of Sciences 98.23 (Oct. 2001), pp. 12890-12895. DOI: 10.1073/pnas.231320498. <URL: https://doi.org/10.1073/pnas.231320498>.

[227] J. Visser, T. Robinson, and B. J. van Vuuren. “Spatial genetic structure in the rock hyrax (Procavia capensis) across the Namaqualand and western Fynbos areas of South Africa — a mitochondrial and microsatellite perspective”. In: Canadian Journal of Zoology 98.8 (Aug. 2020), pp. 557-571. DOI: 10.1139/cjz-2019-0154. <URL: https://doi.org/10.1139/cjz-2019-0154>.

[228] D. D. VRIES, A. KOENIG, and C. BORRIES. “Female reproductive success in a species with an age-inversed hierarchy”. In: Integrative Zoology 11.6 (Nov. 2016), pp. 433-446. DOI: 10.1111/1749-4877.12201. <URL: https://doi.org/10.1111/1749-4877.12201>.

[229] E. D. Wallace and N. C. Bennett. “The colony structure and social organization of the giant Zambian mole-rat, Cryptomys mechowi”. In: Journal of Zoology 244.1 (Jan. 1998), pp. 51-61. DOI: 10.1111/j.1469-7998.1998.tb00006.x. <URL: https://doi.org/10.1111/j.1469-7998.1998.tb00006.x>.

[230] S. K. Wasser and D. P. Barash. “Reproductive Suppression Among Female Mammals: Implications for Biomedicine and Sexual Selection Theory”. In: The Quarterly Review of Biology 58.4 (Dec. 1983), pp. 513-538. DOI: 10.1086/413545. <URL: https://doi.org/10.1086/413545>.

[231] S. K. Wasser and A. K. Starling. “Proximate and ultimate causes of reproductive suppression among female yellow baboons at Mikumi National Park, Tanzania”. In: American Journal of Primatology 16.2 (1988), p. 97–121. ISSN: 1098-2345. DOI: 10.1002/ajp.1350160202. <URL: http://dx.doi.org/10.1002/ajp.1350160202>.

[232] S. K. Wasser and A. K. Starling. “Proximate and ultimate causes of reproductive suppression among female yellow baboons at Mikumi National Park, Tanzania”. In: American Journal of Primatology 16.2 (1988), pp. 97-121. DOI: 10.1002/ajp.1350160202. <URL: https://doi.org/10.1002/ajp.1350160202>.

[233] S. Wasser, G. Norton, S. Kleindorfer, et al. “Population trend alters the effects of maternal dominance rank on lifetime reproductive success in yellow baboons (Papio cynocephalus)”. In: Behavioral Ecology and Sociobiology 56.4 (May. 2004). DOI: 10.1007/s00265-004-0797-2. <URL: https://doi.org/10.1007/s00265-004-0797-2>.

[234] D. P. Watts. “Social relationships of immigrant and resident female mountain gorillas, II: Relatedness, residence, and relationships between females”. In: American Journal of Primatology 32.1 (1994), pp. 13-30. DOI: 10.1002/ajp.1350320103. <URL: https://doi.org/10.1002/ajp.1350320103>.

[235] H. E. Watts, J. B. Tanner, B. L. Lundrigan, et al. “Post-weaning maternal effects and the evolution of female dominance in the spotted hyena”. In: Proceedings of the Royal Society B: Biological Sciences 276.1665 (Mar. 2009), pp. 2291-2298. DOI: 10.1098/rspb.2009.0268. <URL: https://doi.org/10.1098/rspb.2009.0268>.

[236] L. Wauters and A. A. Dhondt. “Body Weight, Longevity and Reproductive Success in Red Squirrels (Sciurus vulgaris)”. In: The Journal of Animal Ecology 58.2 (Jun. 1989), p. 637. DOI: 10.2307/4853. <URL: https://doi.org/10.2307/4853>.

[237] C. Welker, H. H&ouml, and C. Sch&auml-Witt. “Significance of Kin Relations and Individual Preferences in the Social Behaviour of Cebus apella”. In: Folia Primatologica 54.3-4 (1990), pp. 166-170. DOI: 10.1159/000156440. <URL: https://doi.org/10.1159/000156440>.

[238] P. A. White. “Maternal rank is not correlated with cub survival in the spotted hyena, Crocuta crocuta”. In: Behavioral Ecology 16.3 (Feb. 2005), pp. 606-613. DOI: 10.1093/beheco/ari033. <URL: https://doi.org/10.1093/beheco/ari033>.

[239] M. E. Wilson, T. P. Gordon, and I. S. Bernstein. "Timing of Births and Reproductive Success in Rhesus Monkey Social Groups". In: Journal of Medical Primatology 7.4 (1978), pp. 202-212. DOI: 10.1159/000459880. <URL: https://doi.org/10.1159/000459880>.

[240] L. D. Wolfe. "Female rank and reproductive success among arashiyama B Japanese macaques (Macaca fuscata)". In: International Journal of Primatology 5.2 (Apr. 1984), pp. 133-143. DOI: 10.1007/bf02735737. <URL: https://doi.org/10.1007/bf02735737>.

[241] J. O. Wolff, A. S. Dunlap, and E. Ritchhart. "Adult female prairie voles and meadow voles do not suppress reproduction in their daughters". In: Behavioural Processes 55.3 (Sep. 2001), pp. 157-162. DOI: 10.1016/s0376-6357(01)00176-0. <URL: https://doi.org/10.1016/s0376-6357(01)00176-0>.

[242] R. Wrangham. "Drinking competition in vervet monkeys". In: Animal Behaviour 29.3 (Aug. 1981), pp. 904-910. DOI: 10.1016/s0003-3472(81)80027-9. <URL: https://doi.org/10.1016/s0003-3472(81)80027-9>.

[243] E. Zimen. "On the Regulation of Pack Size in Wolves". In: Zeitschrift für Tierpsychologie 40.3 (Apr. 2010), pp. 300-341. DOI: 10.1111/j.1439-0310.1976.tb00939.x. <URL: https://doi.org/10.1111/j.1439-0310.1976.tb00939.x>.

[244] T. Ziporyn and M. K. McClintock. "Passing as an Indicator of Social Dominance Among Female Wild and Domestic Norway Rats". In: Behaviour 118.1-2 (1991), pp. 26-41. DOI: 10.1163/156853991x00184. <URL: https://doi.org/10.1163/156853991x00184>.

[245] Altmann, Hausfater, J. 1988. "Determinants of Reproductive Success in Savannah Baboons, Papio Cynocephalus." In Reproductive Success: Studies of Individual Variation in Contrasting Breeding Systems, edited by T. H. Clutton-Brock, 403–18. Princeton University Press.

[246] Altmann J, Alberts SC. 2003. "Intraspecific Variability in Fertility and Offspring Survival in a Nonhuman Primate: Behavioral Control of Ecological and Social Sources." In Offspring: Human Fertility Behavior in Biodemographic Perspective, edited by Bulatao RA Wachter KW, 6. ashington (DC): National Academies Press (US).

[247] Baker AJ, Dietz JM, Bales K. 2002. "Mating System and Group Dynamics in Lion Tamarins." In Lion Tamarins: Biology and Conservation, edited by Rylands AB Kleiman DG, 188–212. Washington, Smithsonian Institution Press.

[248] Baniel A, Huchard E, Carter AJ. in press. "Exploring Environmental and Social Predictors of Reproductive Pace in a Desert-Dwelling Baboon," in press. Busse, C. 1982. "Social Dominance and Offspring Mortality Among Female Chacma Baboons." Int J Primatol 3: 267.

[249] Byers, John A. 1997. American Pronghorn: Social Adaptations and the Ghosts of Predators Past. University of Chicago Press.

[250] Cheney, Dorothy L, Robert M Seyfarth, Julia Fischer, Jacinta C Beehner, Thore J Bergman, Sara E Johnson, Dawn M Kitchen, Ryne A Palombit, Drew Rendall, and Joan B Silk. 2006. "Reproduction, Mortality, and Female Reproductive Success in Chacma Baboons of the Okavango Delta, Botswana." In Reproduction and Fitness in Baboons: Behavioral, Ecological, and Life History Perspectives, 147–76. Springer.

[251] Cheney, R. M. Seyfarth, D. L., and P. C. Lee. 1988. "Reproductive Success in Vervet Monkeys." In Reproductive Success: Studies of Individual Variation in Contrasting Breeding Systems, edited by T. H. Clutton-Brock, 384–402. Princeton University Press.

[252] Di Bitetti, Mario S, and Charles H Janson. 2001. "Reproductive Socioecology of Tufted Capuchins (Cebus Apella Nigritus) in Northeastern Argentina." International Journal of Primatology 22 (2): 127–42.

[253] Frank, Laurence G, Kay E Holekamp, and Laura Smale. 1995. "Dominance, Demography, and Reproductive Success of Female Spotted Hyenas." Serengeti II: Dynamics, Management, and Conservation of an Ecosystem, 364–84.

[254] Fürtbauer, Ines. 2011. “The Socio-Endocrinology of Female Reproductive Strategies in Wild Assamese Macaques (Macaca Assamensis).” PhD thesis, Göttingen University.

[255] Gaillard, J-M, Serge Brandt, and J-M Jullien. 1993. “Body Weight Effect on Reproduction of Young Wild Boar (Sus Scrofa) Females: A Comparative Analysis.” Folia Zoologica (Brno) 42 (3): 204–12.

[256] Gese, Eric M. 2004. “Coyotes in Yellowstone National Park: The Influence of Dominance on Foraging, Territoriality, and Fitness.” Biology and Conservation of Wild Canids. Oxford University Press, New York, New York, USA, 271–83.

[257] Isbell, Lynne A, and Jill D Pruetz. 1998. “Differences Between Vervets (Cercopithecus Aethiops) and Patas Monkeys (Erythrocebus Patas) in Agonistic Interactions Between Adult Females.” International Journal of Primatology 19 (5): 837–55.

[258] Kopp, Gisela. 2015. “Gene Flow Dynamics in Baboons-the Influence of Social Systems.” PhD thesis, Göttingen University.

[259] Koyama, Nicola F. 2003. “Matrilineal Cohesion and Social Networks in Macaca Fuscata.” International Journal of Primatology 24 (4): 797–811.

[260] Kubzdela, Katarzyna Stefania. 1998. “Sociodemography in Diurnal Primates: The Effects of Group Size and Female Dominance Rank on Intragroup Spatial Distribution, Feeding Competition, Female Reproductive Success, and Female Dispersal Patterns in White Sifaka, Propithecus Verreauxi Verreauxi.” PhD thesis, University of Chicago.

[261] Larney, Eileen. 2013. “The Influence of Genetic and Social Structure on Reproduction in Phayre’s Leaf Monkeys (Trachypithecus Phayrei Crepusculus).” PhD thesis, State University of New York at Stony Brook.

[262] Lynch, Emily Claire. 2016. “Paternal Kinship in a Matrilocal Society of Olive Baboons (Papio Hamadryas Anubis) in Laikipia District, Kenya.” PhD thesis, Rutgers The State University of New Jersey-New Brunswick.

[263] Nievergelt, Caroline M, Leslie J Digby, Uma Ramakrishnan, and David S Woodruff. 2000. “Genetic Analysis of Group Composition and Breeding System in a Wild Common Marmoset (Callithrix Jacchus) Population.” International Journal of Primatology 21 (1): 1–20.

[264] Paul, Kuester, A. 1996. “Differential Reproduction in Male and Female Barbary Macaques.” In Evolution and Ecology of Macaque Societies, edited by Lindburg D. G. Fa J. E., 293–317. Cambridge University Press.

[265] Roosmalen, Marc GM van. 1980. “Habitat Preferences, Diet, Feeding Strategy and Social Organization of the Black Spider Monkey (Ateles Paniscus Paniscus Linnaeus 1758) in Surinam.” PhD thesis, Roosmalen.

[266] Rubenstein, Daniel I, and CASSANDRA M Nuñez. 2009. “Sociality and Reproductive Skew in Horses and Zebras.” Reproductive Skew in Vertebrates: Proximate and Ultimate Causes, 196–226.

[267] Santiago-Moreno, Julián, Amelia Gómez-Brunet, Antonio González-Bulnes, Benoit Malpaux, Philippe Chemineau, Antonio Pulido-Pastor, and Antonio López-Sebastián. 2003. “Seasonal Ovulatory Activity and Plasma Prolactin Concentrations in the Spanish Ibex (Capra Pyrenaica Hispanica) Maintained in Captivity.” Reproduction Nutrition Development 43 (3): 217–24.

[268] Setchell, Joanna M, Phyllis C Lee, E Jean Wickings, and Alan F Dixson. 2002. “Reproductive Parameters and Maternal Investment in Mandrills (Mandrillus Sphinx).” International Journal of Primatology 23 (1): 51–68.

[269] Sinderbrand, Carly Anne. 2011. “The Relationship of Dominance, Reproductive State and Stress in a Non-Cooperative Breeder, the Domestic Horse (Equus Caballus).” PhD thesis, Western Kentucky University. Smith, Andrew C, ER Tirado Herrera, Hannah M Buchanan-Smith, and Eckhard W Heymann. 2001. “Multiple Breeding Females and Allo-Nursing in a Wild Group of Moustached Tamarins (Saguinus Mystax).” Neotropical Primates 9 (2): 67–69.

[270] Visser, Jacobus Hendrik. 2013. “Gene-Flow in the Rock Hyrax (Procavia Capensis) at Different Spatial Scales.” PhD thesis, Stellenbosch: Stellenbosch University.

[271] Whitten, Patricia L. 1983. “Diet and Dominance Among Female Vervet Monkeys (Cercopithecus Aethiops).” American Journal of Primatology 5 (2): 139–59.

[272] Wittig, Roman M, and Christophe Boesch. 2003. “Food Competition and Linear Dominance Hierarchy Among Female Chimpanzees of the Tai National Park.” International Journal of Primatology 24 (4): 847–67.