Assessment of male reproductive skew via highly polymorphic STR markers in wild vervet monkeys, *Chlorocebus pygerythrus*

Running title: Male reproductive skew in wild vervet monkeys

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Abstract

Male reproductive strategies have been well-studied in primate species where males' ability to monopolize reproductive access is high. Less is known about species where males cannot monopolize mating access. Vervet monkeys (*Chlorocebus pygerythrus*) are interesting in this regard as female co-dominance reduces the potential for male monopolization. Under this condition, we assessed whether male dominance rank still influences male mating and reproductive success, by assigning paternities to infants in a population of wild vervets in the Eastern Cape, South Africa. To determine paternity, we established microsatellite markers from non-invasive fecal samples via cross-species amplification. In addition, we evaluated male mating and reproductive success for three groups over four mating seasons. We identified 21 highly polymorphic microsatellites (number of alleles = 7.5±3.1 (mean±SD), observed heterozygosity = 0.691±0.138 (mean±SD)) and assigned paternity to 94 of 97 sampled infants (96.9%) with high confidence. Matings pooled over four seasons were significantly skewed across three groups, although skew indices were low (*B* index = 0.023 to 0.030) and mating success did not correlate with male dominance. Paternities pooled over four seasons were not consistently significantly skewed (*B* index = 0.005 to 0.062), with high-ranking males siring more offspring than subordinates only in some seasons. We detected six cases of extra-group paternity (6.4%), and four cases of natal breeding (4.3%). Our results suggest that alternative reproductive strategies besides priority of access for dominant males are likely to affect paternity success, warranting further investigation into the determinants of paternity among species with limited male monopolization potential.

Keywords: Microsatellites, mating skew, non-invasive sampling, extra-group paternity, natal breeding.

Introduction

Early work in evolutionary biology argued that males and females have evolved different reproductive strategies due to differential investment in their gametes (i.e., egg and sperm cells, respectively). Females typically invest more time and resources into large egg cells, produced in small quantities, while males invest relatively little in their smaller sperm cells, but produce these in large quantities (Trivers, 1972). This sex difference was suggested to be particularly pronounced in mammals where gestation and lactation place a substantial energetic burden on females, while males usually contribute little to offspring care (Kleiman and Malcolm, 1981; Trivers, 1972). As a consequence, females were thought to be mainly limited by access to food (Trivers, 1972), whereas males were limited by access to fertile females (Kappeler and van Schaik, 2004). More recent theoretical developments, however, suggest that males and females can be both choosy or indiscriminate with respect to mating partners (Gowaty, 2003) emphasizing that both sexes are under selection with respect to offspring viability (Gowaty, 2004). Given the varying investment in offspring, males and females have developed differential reproductive strategies to maximize their reproductive output.

Among social mammals living in multi-male, multi-female groups (Clutton-Brock, 1989), as seen in many primates (Alberts et al., 2006), a common male strategy is to monopolize reproductive access to females around the time of likely conception. While this strategy is mainly restricted to more dominant males who can guard females from subordinate males, other males can also increase their mating and reproductive success via opportunistic copulations (e.g., Coltman et al., 1999; Gibson, 2010), coalition formation (e.g., Feh, 1999; Young et al., 2013), or investment in friendships with females (e.g., Kulik et al., 2012).

Given that the majority of mammal and particularly primate species are characterized by promiscuous mating systems, genetic analyses are required to assess male paternity success in order to study male reproductive success. In mammals, male reproductive success mostly depends on male monopolization potential, i.e., where males are dominant over females and fight other males to obtain high dominance status which regulates access to fertile females (e.g. soay sheep, *Ovis aries*, Coltman et al., 1999; Preston et al., 2005; eastern grey kangaroo, *Macropus giganteus*, Miller et al., 2010; reindeer, *Rangifer tarandus*, Roed et al., 2002). Within the primate taxon, the majority of studies on male reproductive success have focused on species with high male monopolization potential, were mate-guarding is mainly used to monopolize fertile females (savannah baboons, *Papio cynocephalus*, Alberts et al., 2006;

chimpanzees, *Pan troglodytes*, Boesch et al., 2006; crested macaques, *Macaca nigra*, Engelhardt et al., 2017). Most of these studies have shown that male reproductive output is biased towards more dominant males (Alberts et al., 2006; Ellis, 1995; Engelhardt et al., 2006). However, there is wide inter-specific variation in alpha male paternity (Ostner et al., 2008), with dominance rank being a poor predictor of male reproductive success in some primate species (Dewsbury, 1982; Ellis, 1995). One explanation for this could be that females developed strategies to reduce male monopolization potential, confuse paternity and/or to reduce the risk of infanticide. Females may therefore mate with as many males as possible, as well as concealing ovulation and synchronizing or extending their receptive period, such that monopolization becomes prohibitively costly for males with respect to both time and energy (reviewed in Zinner et al., 2004). For example, in rhesus macaques (*Macaca mulatta*), a species with limited male monopolization potential, males have restricted information about the exact time of female ovulation (Dubuc et al., 2012). As a consequence, mate-guarding by top-ranking males accounted for only 30 to 40% of all fertilizations (Dubuc et al., 2012), suggesting that male dominance has a limited influence on male reproductive success and that females may pursue their own reproductive interests (Dubuc et al., 2011). In a mammal species with limited male monopolization potential, the spotted hyena, *Crocuta crocuta,* male reproductive success is not linked to dominance (Engh et al., 2002), however, in primate species with limited male monopolization potential, the link can be surprisingly strong (e.g., bonobos, *Pan paniscus*, Gerloff et al., 1999; sifakas, *Propithecus verreauxi*, Kappeler and Schäffler, 2008). This is particularly interesting, as males are not dominant over females in these species (females are co-dominant to males in bonobos, Vervaecke et al., 2000; while females dominate males in sifakas, Richard and Nicoll, 1987). These studies question any notion of a general influence of male dominance on reproductive success and call for more studies that can help unravel the factors that determine male reproductive success, especially when females are not dominated by males.

The successful monopolization of fertile females by one or a few males is a general characteristic of many primate species (Kutsukake and Nunn, 2009). Accordingly, the majority of offspring are produced by one or few males, while most males sire few or no offspring (reviewed in Kutsukake and Nunn, 2009; Widdig, 2013), even across their lifetime (Dubuc et al., 2014a). However, the degree of reproductive skew, commonly assessed by the Nonacs' binomial skew index (hereafter *B* index, Nonacs, 2000), varies widely across species and can even be independent of male monopolization potential (high potential: chimpanzees, Surbeck et al., 2017; crested macaques, Engelhardt et al., 2017; limited potential: rhesus macaques, Widdig et al., 2004; ring-tailed lemurs, *Lemur catta*, Parga et al., 2016). In fact, the highest level of reproductive skew is found in species with either male or female dominance, respectively (Engelhardt et al., 2017; Parga et al., 2016).

Another important consequence when male monopolization potential is limited is that females are better able to mate with males outside their group (van Noordwijk and van Schaik, 2004), such that a proportion of offspring can result from extra-group paternities (hereafter: EGPs). Previous studies on primate species with high male monopolization potential revealed lower incidences of observed EGPs (0 to 7%, Alberts et al., 2006; Engelhardt et al., 2017; Vigilant et al., 2001) than in species with limited male monopolization potential (16 to 40%, Lawler et al., 2003; Parga et al., 2016; Ruiz-Lambides et al., 2017).

Similarly, a delay in natal dispersal should provide opportunities for natal breeding, particularly with limited male monopolization potential, although mechanisms of inbreeding avoidance would be expected to reduce the probability of this occurring (cf. Widdig et al., 2017). Natal breeding is generally rare or seems to be absent in primate species with high male monopolization potential (Wikberg et al., 2017; Engelhardt et al., 2017), while evidence on natal breeding is mixed in species with limited male monopolization potential (0 to 16%, Kappeler and Schäffler, 2008; Widdig et al., 2017). Consequently, studies to date have presented mixed results with respect to whether natal breeding represents a potential male strategy to improve reproductive success.

Chlorocebus spp. live in multi-male, multi-female groups, where males disperse from their natal group at the time of sexual maturation and subsequently change groups on average every two years (Henzi and Lucas, 1980). After immigration, males achieve and maintain their rank through frequent agonistic interactions (Struhsaker, 1967a). Females can win encounters against males, both at the dyadic level or in coalitions (Cheney et al., 1988), and their consequent ability to reject male mating attempts underpins male mating access (Freeman, 2012; Keddy, 1986). *Chlorocebus spp.* and especially vervet monkeys (*Chlorocebus pygerythrus*) are therefore an ideal genus and species to investigate male reproductive success, being characterized by female co-dominance (Young et al., 2017), limited male monopolization potential (Cheney et al., 1988; Weingrill et al., 2011), breeding seasonality (Cheney et al., 1988), moderate sexual dimorphism (Cheney et al., 1988) and the possibility of concealed ovulation (Andelman, 1987).

The first aim of the present study was to develop a sufficient number of polymorphic microsatellite markers to allow genetic paternity analysis from non-invasive fecal samples of wild vervet monkeys. Our second aim was to assign paternities across our three study groups over four breeding seasons, in order to assess the degree of both mating and reproductive skew, along with the relationship between male dominance and skew. Our final aim is to describe the extent of extra-group paternity and natal breeding.

Materials & Methods

Study population and study period

Data were collected from three groups of wild vervet monkeys living on the Samara Private Game Reserve, Eastern Cape, South Africa (32°22'S, 24°52'E). The three study groups (RST, RBM, PT) are habituated to close range observation and all animals are individually identifiable (Pasternak et al., 2013). Between 2013 and 2016, the number of adult males (m) and females (f) differed across groups, RST: m=12±2, f=16±2, RBM: m=11±3, f=11±1 and PT: m=7±1, f=7±1 (mean ± SD).

Vervet monkeys are seasonal breeders and the mating season at the study site extends from April to July (Freeman et al., 2012). Genetic and behavioral data for this study were collected between April 2013 and July 2017. Individual records of the date of birth and death, days of group residency, date of male migration, identity of behavioral mother (based on nursing and association) and sex of individuals were noted immediately or within two days of the event. Dates of birth and the identities of behavioral mothers were not available for some individuals born before 2012.

Sample collection and DNA extraction

For the development of a microsatellite panel, we used 18 blood samples previously collected during a thermoregulation study for which animals were immobilized via darts containing an anesthetic (mixture of midazolam, 2.5mg, and ketamine, 50mg, for on average weight of 4.4kg per monkey, McFarland et al., 2013, 2015). From each animal, 2ml blood samples were taken, which were immediately frozen as EDTA-blood (anticoagulant). Additionally, for non-invasive paternity analyses, we collected 620 fecal samples from a total of 197 individuals. Samples were collected immediately after defecation of known individuals. 605 fecal samples were stored with the 'two-step' storage procedure (Nsubuga et al., 2004) and additional 15 fecal samples were frozen (see supplemental material for 'Fecal sample storing procedures'). In total, we collected up to three independent fecal samples (2.93±1.20, mean±SD) for each individual. Finally, we collected small tissue samples (1x1cm, N=12) from miscarriages and deceased individuals, which were frozen immediately after collection and stored at -20°C until extraction. Of 111 infants born during our study period, we lack genetic samples for 14, as they died before potential sample collection, leading to an infant sampling success of 87.4% (2013: 96.7% with 1 infant dying, 2014: 94.3% with 2 infants dying, 2015: 88.0% with 3 infants dying and 2016: 61.9% with 8 infants dying during an extreme drought). For the 2013 season, it was not possible to sample three potential sires in PT and two potential sires in RST. For all other seasons, we were able to sample all potential sires across the three groups. In total, we sampled 51 out of 56 potential sires across groups and seasons considered (i.e., 91.1% male sampling success over all cohorts). This included all natal males and immigrants, together with a few males from unhabituated neighboring groups that were opportunistically sampled.

DNA isolation for blood and tissue samples was performed with the *QIAamp® DNeasy® Blood & Tissue Kit* (Qiagen, Hilden, Germany) and both dried and frozen fecal samples with the *QIAamp® Fast DNA Stool Mini Kit* (Qiagen, Hilden, Germany), respectively. We modified the provided protocol by incubating the samples in 1.2ml InhibitEX buffer overnight and adding 0.5ml of InhibitEX buffer after 24 hours. Isolated DNA was diluted and stored at 8°C.

Establishment of a microsatellite panel and genotyping

Using DNA extracted from 18 blood samples, we investigated 45 microsatellite loci that have been found to be highly polymorphic in other primate species (for details on investigated markers see supplemental material Tab. S1). We followed the two-step multiplex approach by running two successive polymerase chain reaction (PCR) (Arandjelovic et al., 2009) to increase the amount of the PCR amplification. The first PCR (multiplex PCR) comprised up to 15 primer pairs simultaneously (15µl approach) followed by a singleplex PCR (i.e. PCR for each locus) containing diluted multiplex-products as amplification templates (10µl approach) (see supplemental material 'PCR protocol and sequencing'). All reactions were performed in a *Mastercycler® Pro* thermal cycler (Eppendorf, Hamburg, Germany). Following Engelhardt et al. (2017), the protocols were later optimized for fecal samples in order to work non-invasively (see supplemental material 'PCR protocol and sequencing'). For fragment analysis, PCR products of different allele ranges and/or different fluorescent labels were combined for cost efficiency. The sequencing was performed by using an *ABI 3730* sequencer (see supplemental material ‘PCR protocol and sequencing’). For determination of the allele sizes, the sequencing output was imported into PeakScanner software (Applied Biosystems®).

Selection of markers

We selected a total of 21 markers for genotyping (see Tab. 1). First, we chose 15 core markers genotyped for all 197 individuals with an average of 14.56±0.79 (mean±SD) marker typed per individual (see supplemental material Tab. S2a, b) and tested for marker suitability (see below). Later, we added six additional markers for 59 out of 197 individuals, to improve a given paternity exclusion rule or confirm unsolved paternities (see supplemental material ‘Additional six marker’). We used the following criteria for marker selection based on blood samples: preference was given to 1) tetra-nucleotide repeat markers, 2) markers with at least four unique alleles, 3) markers with reliable allele size scoring (no or few stutters/multiple peaks) and 4) highly polymorphic markers based on standard population genetic parameters. To test the latter, we calculated the probability that an individual would be heterozygous at a given locus (expected heterozygosity, H_{exp}), determined the actual observed heterozygosity (H_{obs}), determined the polymorphic information content (PIC), tested for any deviation from Hardy-Weinberg equilibrium (HWE) and estimated the frequency of null alleles (F(Null)) (see supplemental material for ‘Criteria thresholds’). All parameters were calculated from allele frequencies in *Cervus 3.0* (Kalinowski et al., 2007). For a heterozygous genotype to be approved, we aimed to confirm both alleles via two amplifications of two independent samples (mean number ±SD of confirmation=4.09±2.21, mean number of amplification= 4.76), while for a homozygous genotype we aimed to confirm the one allele on average four times using two independent samples (mean number ±SD of confirmation=4.40±2.26, mean number of amplification= 4.43). This approach was shown to produce reliable genotypes without DNA quantification (Bellemain et al., 2005; Piggott et al., 2005).

We also tested the marker suitability by confirming the Mendelian inheritance of the markers in mother-offspring pairs. Behavioral mothers were identified from long-term observations (nursing and association). To confirm them as genetic mothers, we tested Mendelian inheritance of 97 mother-offspring pairs by matching their genotypes using the 15 core markers.

[Table 1]

Paternity assignment

We typed our 197 individuals at an average of 15.59±1.92 loci (mean±SD) when including all 21 markers. However, in order to be included in a paternity analysis, mother-offspring-putative father trios required genotypes at 12 common markers. We assigned paternity using a combination of an exclusion and likelihood approach. We used the program *Findsire* (http://www.uni-kiel.de/medinfo/mitarbeiter/krawczak/download/) to exclude potential sires mismatching a given mother-offspring pair at a particular locus. While spermatogenesis starts at 3.5 years of age (Whitten and Turner, 2009), males tend to disperse from their natal group at around four to five years (Henzi and Lucas, 1980). However, given the ability to reproduce, we considered males above 1250 days at the beginning of the mating season in question as potential sires. We usually knew the age of natal males from demographic records, except for seven subjects emigrating into our study groups before the start of the systematic data collection, which we therefore also included as potential sires. Our paternity assignment followed a conservative approach by considering paternity as established only if i) paternity exclusion of all other potential sires was based at least on the 'best match' criteria *and* ii) paternity likelihood for a given parent-offspring trio was at the 95% confidence level, as calculated in *Cervus 3.0* (for details see supplemental material 'Paternity criteria' and Engelhardt et al., 2017; Widdig et al., 2017).

Behavioral observations

During our study period (2013 to 2017), we collected mating interactions (i.e., genital sniff, grab, female refusal, mount, ejaculation) and dominance interactions (i.e., submission, displace, supplant, facial threat, vocal threat, lunge, physical contact) (cf. Freeman, 2012). Up to two observers on each group collected data for 10 hours on a near daily basis (see supplemental material 'field site'). Given the relative low frequency of mating and dominance interactions known for this species (Struhsaker, 1967b), we applied the method of *ad libitum* sampling (Altmann, 1974) with a resulting mean±SD of 2.24±1.46 mating events and 14.18±12 dominance interactions per day and group over four mating seasons. While we cannot exclude that we missed some interactions it is likely that we recorded most or all of them as the habitat of our vervet population has a good visibility and the group spread is small.

Establishing male dominance hierarchy

To establish a male dominance hierarchy per group and season, we used decided dyadic agonistic interactions of males older than approximately 3.5 years. Dominance ranks were calculated in R version 3.2.3 (R Core Team, 2013) with the package 'EloRating' (Neumann et al., 2011) using standardized Elo-ratings averaged over each four month mating season to allow for the comparison of ratings between groups of different sizes. For 12 potential sires in 2013 and for two each in 2014, 2015 and 2016, it was not possible to calculate a rank position, as they resided only a few days within the groups and no agonistic interactions were observed. Similarly, we did not observe agonistic interactions for extra-group males mating or reproducing in one of our study groups. Therefore, these males had to be excluded from investigations of the relationship between mating/paternity success and dominance rank.

Mating and reproductive skew

To determine the mating and reproductive skew for each group and season, we calculated the Nonacs' *B* index (Nonacs, 2003, 2000) using the Skew Calculator 2013 (https://www.eeb.ucla.edu/Faculty/Nonacs/pi.html). The *B* index specifies whether a given distribution is significantly different from random, with positive values up to 1 indicating a higher skew than expected, negative values down to -1 indicating a more equal distribution of reproduction, and values around 0 indicating a random distribution. Additionally, the program calculates the lower and upper confidence intervals (CI, 95%), the minimum *B* value (equal*B*) and the maximum *B* value (monopol*B*) via simulations which further help to interpret the results. When the CIs include zero, the distribution is not significantly different from random. In cases where the lower CI is smaller than the minimum *B* value, we cannot reject the possibility of an equal distribution. In cases where the upper CI is larger than the maximum *B* value, then a complete monopolization by one individual cannot be excluded (cf. Strier et al., 2011). As the *B* index accounts for the time spent within a group, we included information of male group residency based on existing demographic data of our study population (Henzi and Barrett, unpublished data). To calculate the mating skew, we used the number of successful matings per male observed relative to his tenure for the respective season in a given group (April to July between 2013 and 2016, respectively). We defined male reproductive success as the number of genetically assigned born or miscarried offspring per male. To compute reproductive skew, we used the number of offspring sired per male relative to his tenure for the respective season in the birth group of the respective offspring. For certain groups and seasons it was not reasonable to calculate the reproductive skew as the number of infants or potential sires were too low to produce a meaningful *B* index.

To investigate the influence of dominance rank on mating and paternity success, respectively, we ran Spearman rank correlations per group and season in R (R Core Team, 2013). As some males were included in multiple groups and seasons, skew data were not entirely independent, hence, we adjusted the α-levels (α') for the mating and reproductive skew as well as for the correlations between dominance rank vs. mating or paternity success respectively based on the number of carried out tests and the number of significant tests (Cross and Chaffin, 1982) and only considered p values as significant when they were smaller than the adjusted α-level.

Extra-group paternity and natal breeding

Although we have no data on group compositions before 2008, we assessed group membership and immigration on a near daily basis from collected demographic data (2008 to 2017) with young males (below 3.5 years of age) generally considered as natal males unless we observed a migratory event.

To assess the degree of EGPs, we confirmed group membership of the assigned sires around the time of conception of the infant under consideration. In the case of a migratory event, we considered males as immigrated when they constantly resided for at least 14 days in a new group, and noted the first day seen on the new group as immigration date. A conception window was estimated by subtracting 161 and 165 days, respectively from the date of birth of a given infant (163±2 days, *Chlorocebus* gestation length according to Bramblett et al., 1975), resulting in a 5-day conception window. To avoid assigning an EGP to a possible migratory event, we set a window of 14 days prior and 14 days after the conception window, in total a 33-day window for the assignment of EGPs (adapted from Ruiz-Lambides et al., 2017). Infants sired by males who were members of a different social group than the infants' birth group outside of the above defined 33-day window were assigned as EGPs.

Based on demographic data, we were also able to estimate whether sires were natal to the infants' birth group or not. Breeding events in which infants were sired by males still residing within their natal group (i.e. prior to natal dispersal) were defined as natal breeding.

Results

Marker characteristics

Table 1 presents the 15 best markers (core markers) selected by confirming all criteria described above together with the 6 additional markers we used to enhance paternity exclusion for some trios. Based on the 197 individuals genotyped, alleles per marker ranged from 4 to 15 and the observed mean heterozygosity was similar to the expected mean heterozygosity (0.691 vs. 0.708, see Tab. 1). The mean PIC of 0.661 indicated a high power for discrimination of our microsatellites; we also found no signs of null alleles (mean F(Null)=0.015). There was no significant deviation from Hardy-Weinberg equilibrium, except for one marker (D6S501). However, we can exclude the possibility of a segregating null allele for this locus (see Tab. 1, F(Null)=-0.066) and a failure to distinguish alleles, therefore we still included this locus in our parental assignment.

We further tested marker suitability by confirming Mendelian inheritance of markers for putative mother-offspring pairs based on observations. We confirmed 95 of the 97 behavioral mothers by matching genotypes of mother-infant pairs. The two remaining infants were adopted for unknown reasons by different females, while the genetic mother was still alive in the same group. All genetically determined maternities were used for the following paternity analysis.

Paternity analysis

From a total of 51 potential sampled sires, 29 males were assigned as fathers to at least one offspring born during our study period. Over three groups and four birth seasons, we determined paternities for 94 of 97 infants (96.91%) with high confidence using both exclusion and likelihood methods (for details see supplemental material ‘Paternity results’ and Tab. S3). The remaining three infants, typed on 15 to 19 markers, could not be assigned to any of the males we sampled indicating that we probably lack a sample of the actual sire. For the 2013 cohort, we have two unsolved paternities, with missing samples from two within-group males. For the 2015 cohort, we collected samples of all potential sires within the groups, hence the unsolved paternity is most likely due to an EGP.

Mating and reproductive skew *vs.* dominance

When we pooled the observed matings over the four seasons, all three groups showed a significantly mating skew, although *B* indices were consistently small (mating skew per group, considering males present in several seasons only once, $\alpha'=0.05$, *B* index: PT = 0.023, $p<0.001$, $N_{males}=22$; RBM = 0.030, $p<0.001$, $N_{males}=30$; RST = 0.030, $p<0.001$, $N_{males}=31$). A similar picture emerged when looking at groups and seasons separately: mating was significantly skewed for the groups PT and RBM in all seasons and for RST in 2 of 4 seasons after α-level adjustment (see Tab. 2). However, the interpretation of these results need to be treated with caution as for all groups and seasons (except for PT in 2014), the *B* indices were close to zero suggesting a random distribution. In addition, for RBM 2014 to 2016 and RST 2013 to 2014, the CIs included zero, and the lower CIs were equal to the equal*B* values indicating that, in some seasons and groups, mating either occurred at random or was equally distributed (Tab. 2).

Furthermore, over all groups and all seasons, male mating success was not significantly correlated with male dominance rank after α-level adjustment (see Tab. 2). Across all groups and mating seasons, the mating success of the alpha male ranged from 0% to 57.8% (20.3±18.5%, mean±SD), which confirms the limited potential of male monopolization in vervet monkeys, at least in some seasons and groups.

Paternity was not consistently skewed across groups when pooled across all four seasons, and all groups showed *B* indices close to zero (reproductive skew per group, considering males present in several seasons only once, α'=0.025, *B* index: PT = 0.062, $p<0.007$, $N_{males}=23$; RBM = 0.061, $p<0.001$, $N_{males}=30$; RST = 0.005, $p=0.248$, $N_{males}=30$). When we considered groups and seasons separately, paternity was not skewed for eight of a total of nine groups and seasons. In five of those, CIs indicated no significant deviation from a random distribution, and the lower CIs were the same as the equal*B*s indicating that an equal distribution of paternities cannot be excluded. After α-level adjustment, only the paternity distribution of PT in 2013 remained significantly skewed (see Tab. 3).

In contrast to mating success, however, paternity success was at least partly determined by male dominance. For RBM and RST in mating season 2014, we found a significant positive correlation between dominance rank and paternity success, which remained after α-level adjustment (see Tab. 3). This suggests that males of higher dominance rank produced more offspring than males of lower dominance rank, which seems not to be the case for other groups and seasons. Across all groups and seasons, alpha share of paternity success ranged from 0% to 66.7% (23.7±20.0%, mean±SD) indicating that, on average, alpha males had a limited ability to monopolize paternities across seasons and groups.

Extra-group paternity and natal breeding

Among our 94 infants with assigned paternities, we detected six offspring assigned as EGPs (6.4%) and four offspring sired by natal males (4.3%). However, due to the lack of DNA samples for some potential sires, we could have actually missed one additional EGP (see above). Note that the degree of EGP partly depends on how it was defined; if we apply a more conservative EGP assignment rule with a 30-day window before and after the conception window (data not shown), the number of EGPs would have been reduced to four EGPs (4.3%). For two of our six EGP offspring, the sires never resided in the group of their offspring, two sires had emigrated from the infant's group before conception, and two sires moved afterwards into the group (19 and 50 days after end of conception window, respectively). For the three natal breeders, the date of birth was unknown, however, genetic analysis revealed that two males were still residents in the group of their mother, confirming genetically that three infants were sired via natal breeding.

[Table 2]

[Table 3]

Discussion

After successful establishment of our marker panel, we were able to determine the paternity of 94 out of 97 sampled infants sired between 2013 and 2016 in our study population. Our study confirmed previous observations (Cramer, 2012; Struhsaker, 1967b), that the mating frequency in vervet monkeys is relatively low. Furthermore, matings in our study population were consistently skewed over four seasons and three groups, but always of low magnitude. Male mating success was not significantly influenced by male dominance rank, with males of different ranks mating equally often (over four mating seasons: mean±SE: PT: 8.3±1.4; RBM: 7.2±1.1; RST: 7.2±1.1 successful matings per male observed). However, inspection of the data revealed that for most seasons and groups, the relationship between male dominance and mating success was positive (i.e., more matings by higher-ranking males), with only RST in three out of four seasons deviating from this pattern. RST was the largest group and showed a slightly female-biased sex ratio, which might have enabled females to better exert mate choice in this group. The alpha males' share of matings was restricted to a mean of 20.3% over four seasons and three groups, which is rather low when compared to other primate species. For example, in bonobos, a species with limited male monopolization potential, the highest-ranking male in a party accounted for 40.8% of matings (Surbeck et al., 2011). However, when compared to another mammal, the spotted hyena (5% alpha male share of matings, Engh et al., 2002) in which males also have a limited male monopolization potential, the vervet alpha males' share of matings is four-fold greater. Over our study period, matings were predominately initiated by males, but females resisted male mating attempts in approximately 28.6% of all sexual interactions observed (Minkner, unpublished data). This implies the possibility that mating success, but also paternity output, can be affected by female mate choice, including cryptic choice (Kappeler and van Schaik, 2004). In vervet monkeys, the equal distribution of matings across the male hierarchy, together with the potentially concealed ovulation (Andelman, 1987) could therefore be due to females trying to confuse paternity (reviewed in Kappeler and van Schaik, 2004). Interestingly, refusals of mating attempts by females may even be more frequent around ovulation (Andelman, 1987; Young, unpublished data). Hence, females may be able to use different strategies to select the best sires for their offspring. In contrast to our results, mating seems to be skewed in favor of high-ranking and central males in other species with female co-dominance or female dominance (Surbeck et al., 2011; Sauther, 1991). This difference could be due to bonobo females advertising ovulation via sexual swellings and ring-tailed lemur females behaviorally advertising ovulation, both of which facilitate male monopolization potential. In addition, recent work revealed that male vervets being well integrated in the female networks tend to achieve higher dominance ranks (Young et al., 2017) which suggests males could gain mating access to females through positive associations rather than monopolization. This is also supported by the fact that we found no relationship between male dominance and mating success.

With respect to paternity success, our data revealed that paternity is not consistently skewed. This is in contrast to previous studies in species with limited male monopolization potential, where high-ranking males tend to gain a higher reproductive success than low-ranking males (Kappeler and Schäffler, 2008; Surbeck et al., 2017; see below). Over four cohorts and three groups, reproductive skew was generally low and varied across seasons and groups. In comparison to mating success, we found a consistent positive relationship between male dominance and reproductive success, although this only reached statistical significance in two groups for one season. However, similarly to the monopolization potential, reproductive skew may be affected by several key variables, such as the stability of male hierarchy (Alberts et al., 2006), the degree of female synchrony, the number of within-group competitors (Ostner et al., 2008) and the number of females within a group (Kappeler and Port, 2008) as discussed below.

Our paternity findings contrast with results from the closely related green monkey (*Chlorocebus sabaeus*), a species in which females can also reject male mating attempts (Keddy, 1986). In a study of captive green monkeys, Weingrill and colleagues (2011) demonstrated that the alpha male was able to sire 76% of all infants within the group. However, the captive setting and artificial group composition (three young males, aged three to five years and a nine-year old alpha male) may explain this difference. In captivity the male hierarchy is likely to be more stable compared to wild populations, where male emigration and immigration is frequent. In fact, in wild Hanuman langurs (*Semnopithecus entellus*) 93% of rank changes were due to immigration of males (Borries, 2000). Hierarchy instability might explain the low alpha male share of paternity in the group PT in 2013, as the alpha male received two injuries during this mating season and died soon after the last injury. Similarly, just before the mating season 2016, the alpha male in PT dispersed and eight new males immigrated. The subsequent instability in the group hierarchy most likely served to reduce the reproductive skew.

Overall, the average reproductive skew was rather low (B = 0.051), compared to other studies on species with limited male monopolization potential. For example, in bonobos, a species with female co-dominance, the average reproductive skew varied (over 7 years: B=0.22, over 12 years: B=0.08, Surbeck et al., 2017), with high-ranking males siring more offspring than low-ranking males. Ring-tailed lemurs, which perform female dominance and behaviorally advertise ovulation, showed a rather high reproductive skew (B=0.423, mean calculated from B indices of Parga et al., 2016), while Assamese macaques (*Macaca assamensis*), which have a concealed ovulation, had a low paternity skew (B=0.087, Sukmak et al., 2014). Interestingly, there were only two studies with a comparable low reproductive skew (B=0.012, Strier et al., 2011; B=0.014, Dubuc et al., 2014a). The first one was conducted on a group of egalitarian, male philopatric northern muriquis (*Brachyteles hypoxanthus*). This study suggested that the low skew was caused by maternal kin networks between males, reducing individual reproductive success while related males benefited from shared paternities (Strier et al., 2011). The second study was conducted on rhesus macaques, where low reproductive skew was suggested to be due to the reduced male-male competition levels typical of this species (Dubuc et al., 2014a). As male vervets disperse from their natal group, networks between related males are less likely to explain our findings unless males emigrate with relatives of similar age. Additionally, low male-male competition is an unlikely explanation for the low skew found in our population, as vervet males tend to be involved in severe fights during the mating season (Freeman, 2012). Although a severe drought reduced the number of infants in RBM and PT in 2016, it is unlikely that this event explains the pattern we have found, as we find consistent results for RST over all four seasons including the year of the drought.

Furthermore, the number of EGPs in our vervet population was low (6.4%) compared to other studies. For example, in ring-tailed lemurs, a species with a similar sex ratio and limited male monopolization potential, the number of EGPs was high (21 to 33% EGPs, Parga et al., 2016).

However, the high number of EGPs in the study of Parga et al. (2016) might be misleading, as their sample size was relatively small (N=14 and 9 offspring, respectively) and residency data of some males was missing. The low number of EGPs in our vervet population could be due to the fact that males change groups frequently (every two years, Young, unpublished data) making outbreeding less advantageous for females, given that seeking matings outside the group exposes females to both predation risk (Kappeler, 1999) and inter-group aggression (Nichols et al., 2015). In addition, primate groups with a female-biased sex ratio show higher numbers of EGPs (Lawler et al., 2003; Ruiz-Lambides et al., 2017), suggesting that in groups with a balanced (our population) to male-biased sex ratio, the number of EGPs is likely to be smaller as males should be able to exclude extra-group males from mating. Furthermore, group instability is linked to higher numbers of EGPs (Isvaran and Clutton-Brock, 2007), which may explain four out of six EGP offspring in our population which were sired during change-overs of alpha-males.

Finally, the level of natal breeding in our population was also low (four infants or 4.3%). Of these four offspring, three were still alive in July 2018 (969 to 1354 days old). It has been suggested that mortality due to inbreeding depression is still possible until maturation (Widdig et al., 2017), which suggests that these individuals are unlikely to be subject of close inbreeding as they reach reproductive age (1250 days). Hence mating partners of our natal breeding males seem to be descended from differing maternal families. In addition all four mothers were multiparous, rejecting the possibility that females, breeding with a natal male, might have been inexperienced with reproduction. In other mammal populations, natal breeding was rare (spotted hyenas, Engh et al., 2002; Japanese macaques, Inoue and Takenaka, 2008; capuchin monkeys, Wikberg et al., 2017) and the scarcity was most likely due to inbreeding avoidance. Male vervet monkeys tend to disperse for the first time around the age of maturation (Henzi and Lucas, 1980). We rarely observed matings involving natal males or even observed aggressive refusals of natal males' mating attempts in our population (Minkner, pers. observations), which is in line with the theory of inbreeding avoidance. In rhesus macaques, late dispersing males had higher life-time reproductive success probably because they started reproducing in their natal groups (Weiß et al., 2016). Consequently, late dispersal and natal breeding could be a reproductive strategy to accomplish high life-time reproductive success. However, more data are needed to assess whether this is indeed the case.

Overall, while male dominance seems to be an important factor influencing mating access and paternity success in other primates with limited male monopolization potential, male dominance in our vervet population seems to be a poor predictor of the variation in mating and reproductive skew. This suggests that other factors might influence male fitness in vervet monkeys. To better understand male reproductive strategies in species with limited male monopolization potential, future studies should investigate other male characteristics such as social abilities (male care, Langos et al., 2013; Ostner et al., 2013; male-female friendship, Kulik et al., 2012; Smuts, 1985; male-male coalitions, Young et al., 2013) and proxies of health (e.g., secondary sexual traits in form of ornaments, Dixson et al., 2005; Dubuc et al., 2014b) and their impact on male reproductive success.

Conclusions

The genetic analysis based on 21 highly polymorphic markers in our population of vervet monkeys exceeded that of previous studies (Newman et al., 2002; Weingrill et al., 2011) and revealed new insights into reproductive strategies of a species with female co-dominance. Overall, mating and paternity skew was generally of low magnitude. Furthermore, while the mating success was not related to male dominance, paternity success was partly predicted by male dominance, suggesting that female choice may play a role in male vervet reproductive success. The successful cross-species amplification for the vervet monkey suggests that the proposed markers could be helpful for further investigations of other *Chlorocebus* species, e.g., to benefit conservation efforts in closely related species (e.g., vulnerable bale monkey, *Chlorocebus djamdjamensis*, Butynski et al., 2008), or to investigate determinants of male reproductive success in the light of female choice, as well as the interplay between female and male reproductive strategies in vervet monkeys.

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Data availability

Details on tested markers, individual genotypes and paternities will be available online within the supplemental material.

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Supplemental material

Assessment of male reproductive skew via highly polymorphic STR markers in wild vervet monkeys, *Chlorocebus pygerythrus*

Running title: Male reproductive skew in wild vervet monkeys

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Field site

The field site was established in 2008 and census data are recorded on a near daily basis (for RST and RBM collected since 2008 and for PT collected since 2012). During winter data were collected from 0730 to 1730 and during summer the data collection was evenly distributed with days starting at 0400 for the following 10 hours (early days) or latest ending at 1900 and beginning 10 hours earlier (late days).

Fecal sample storing procedure

We collected 620 fecal samples of which 605 were dried and 15 were frozen samples. To dry the fecal samples we followed the 'two-step' storage procedure (Nsubuga et al., 2004) by immediately transferring the fresh sample into a tube containing 40ml of 95% ethanol. After ethanol treatment of 24 to 36 hours, we transferred the samples into 50ml tubes filled with approximately 20g of silica beads and stored them at room temperature until extraction. In addition to the 605 dried samples, we used 15 fecal samples of potential sires and mothers, collected for other purposes that were immediately frozen at -20°C until extraction.

PCR protocol and sequencing

The multiplex reaction for DNA isolated from tissue and fecal samples contained 2.25µl distilled water, 7.5µl *MyTaq^{TM} HS Mix* (*Bioline*) and 2.25µl primer-mix (all 15 unlabelled primer pairs) as a 12µl master-mix. PCR reagents such as buffer, dNTPs, $MgCl_2$, Taq polymerase and enhancers are included in the *MyTaq^{TM} HS Mix*. Finally, 3.0µl of diluted DNA (1:100) was added into each well. The cycling protocol included a hot start at 94°C for two minutes followed by 30 cycles with denaturation at 94°C for 20 seconds, annealing temperature at 56°C for 30 seconds and elongation at 72°C for 30 seconds and ended with 10 minutes at 72°C for final elongation. The extracts were stored at 8°C. The multiplex PCR products were diluted 1:100.

The singleplex reaction for DNA of tissue and fecal samples was done in a 10µl approach, containing 3.4 or 3.2µl distilled water, 5.0µl MyTaq, and 0.6 or 0.8µl of primer mix with 3 or 4 reverse and labeled forward primer pairs (10pmol). Finally, 1.0µl of diluted multiplex PCR product was added into each well. The singleplex reaction protocol was the same as for the multiplex PCR for tissue and fecal samples, except that the annealing temperature was executed at 58°C. Again, the PCR products were stored at 8°C.

The sequencing plates for fragment analysis were prepared with 0.5µl combined PCR product of each singleplex and 0.1µl Rox (HD400 from Applied Biosystems®) as a size standard.

Criteria thresholds for highly polymorphic marker

For selection of highly polymorphic marker, we calculated the probability that an individual would be heterozygous at a given locus (expected heterozygosity, H_{exp}), determined the actual observed heterozygosity (H_{obs}) and selected only markers with an $H_{exp}>0.5$ (Botstein et al., 1980). Furthermore, we determined the polymorphic information content (PIC) and selected markers with PIC>0.5 as they are highly informative for marker discrimination (Botstein et al., 1980). Moreover, we tested for any deviation from Hardy-Weinberg equilibrium (HWE) with a significant deviation from HWE suggesting genotyping problems, e.g. segregating null alleles or incorrectly distinguished alleles. Finally, we estimated the frequency of null alleles (F(Null)), with values <0.05 indicating a negligible frequency of null alleles (Chapuis and Estoup, 2007).

Paternity criteria

Paternities were considered as i) strictly solved cases if the parent-offspring trio had no mismatches in all common markers, while all other potential sires had at least two mismatches, (ii) relaxed solved cases if the parent-offspring trio had no mismatch in all common markers, while the next putative sire had one mismatch or (iii) best match cases, if we determined one mismatch between parent-offspring trio and the next putative father had at least two mismatches (cf. Widdig et al., 2017). In addition, we used *Cervus 3.0* (Kalinowski et al., 2007) to determine paternity using the likelihood approach by selecting the most likely parent-offspring trio based on the 95% confidence level. Paternities were only considered as assigned when criteria of both, exclusion and likelihood approach, were fulfilled. We used the following parameters for calculation: proportion of potential sires sampled 0.80, proportion loci typed 0.98 and the proportion loci mistyped 0.01.

Additional six markers

All paternities were solved based on the 15 core markers, but for some infants the paternity exclusion rule was improved (N=3) or confirmed (N= 4) with six additional markers. For example when a paternity was solved based on the 'relaxed rule' only (i.e. parent-offspring trio had no mismatch in all common markers, while the next putative sire had one mismatch), the added six markers would confirm this case now with the strict rule (i.e. parent-offspring trio had no mismatches in all common markers, while all other potential sires had at least two mismatches). Furthermore, we confirmed the results of paternity analyses for the three unsolved cases (no father found within our sample of potential sires). For the conformation of these six markers, we applied more relaxed rules for cost efficiency (amplifications of heterozygous genotypes 1.25±0.43; homozygous genotypes 1.21±0.41, mean±SD).

Paternity results

Of 94 assigned paternities, we were able to solve paternity of 84 infants applying our strict exclusion criteria and 1 infant applying our relaxed criteria. Furthermore, we assigned 9 paternities to the male providing the best match as defined above. Again, all paternities were additionally confirmed at the 95% confidence level.

Table S1: 45 tested microsatellite markers (primer), 15 core markers highlighted in dark grey and 6 additional markers highlighted in light grey used for paternity analysis with used dye, reference species, annealing temperature [°C] and reference study

Primer	dye	species	annealing [°C]	reference
D1S518	Fam	*Ch. sabaeus*	58	(Almeida et al., 2011; Jasinska et al., 2007; Newman et al., 2002; Weingrill et al., 2011)
D1S548	Hex	*Macaca mulatta;* *M. nigra*	58	(Engelhardt et al., 2017; Widdig et al., 2017)
D4S2408	Hex	*Ch. sabaeus*	58	(Almeida et al., 2011)
D4S243	Fam	*Ch. sabaeus*	58	(Newman et al., 2002)
D5S1457	Fam	*M. mulatta; M. nigra*	58	(Engelhardt et al., 2017; Kanthaswamy et al., 2010; Widdig et al., 2017)
D5S1467	Hex	*Ch. sabaeus*	58	(Almeida et al., 2011)
D6S474	Fam	*M. mulatta*	58	(Nürnberg et al., 1998)
D6S501	Fam	*M. nigra; M. mulatta*	59	(Engelhardt et al., 2017; Widdig et al., 2017)
D7S2204	Fam	*M. nigra*	58	(Engelhardt et al., 2017)
D8S1106	Ned	*Ch. sabaeus*	58	(Almeida et al., 2011; Jasinska et al., 2007;

				Widdig et al., 2017)
D10S1432	Hex	Ch. sabaeus	58	(Jasinska et al., 2012)
D10S611	Hex	*Papio cynocephalus*	58	(Bayes et al., 2000)
D13S765	Fam	*M. mulatta M. nigra;*	57	(Engelhardt et al., 2017; Kanthaswamy et al., 2010; Widdig et al., 2017)
D17S1304	Hex	*Chlorocebus sabaeus*	58	(Almeida et al., 2011)
D19S245	Hex	*Ch. sabaeus*	58	(Almeida et al., 2011)
D2S1333	Hex	*M. mulatta*	58	(Rogers et al., 2005)
D6S1017	Fam	*Ch. sabaeus*	58	(Almeida et al., 2011)
D6S493	Fam	*M. nigra*	58	(Engelhardt et al., 2017)
D11S2002	Hex	*Pan troglodytes*	58	(Bradley et al., 2000)
D12S67	Fam	*M. nigra*	58	(Engelhardt et al., 2017)
D18S536	Hex	*M. nigra*	58	(Engelhardt et al., 2017)
D1S415	Fam	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D2S1326	Hex	*Gorilla gorilla*	58	(Zhang et al., 2001)
D2S135	Fam	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D2S367	Fam	*Human*	58	(Gyapay et al., 1994)
D3S1312	Fam	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D3S1768	Fam	*Human*	58	(Pokorny et al., 1997)
D4S1645	Fam	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D5S1466	Hex	*Ch. sabaeus*	58	(Newman et al., 2002)
D5S1470	Hex	*Human*	58	(Xu et al., 1996)
D5S820	Fam	*M. mulatta*	58	(Kayser et al., 1996)
D6S1705	Hex	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D6S266	Fam	*Human*	58	(Weissenbach et al., 1992)
D6S405	Hex	*Ch. sabaeus*	58	(Jasinska et al., 2007)
D6S493	Fam	*M. mulatta*	58	(Nürnberg et al., 1998)
D8S271	Fam	*Human*	58	(Weissenbach et al., 1992)
D8S601	Fam	*Human*	58	(Xu et al., 1996)
D11S925	Fam	*M. nigra*	60	(Engelhardt et al., 2017)
D12S67	Fam	*M. mulatta*	58	(Kayser et al., 1995)
D14S255	Fam	*M. mulatta*	58	(Kayser et al., 1996)
D15S823	Fam	*M. mulatta*	60	(Rogers et al., 2005)
D16S403	Hex	*M. mulatta*	60	(Kanthaswamy et al., 2010)
D20S206	Fam	*M. mulatta*	58	(Nürnberg et al., 1998)
D20S484	Fam	*Ch. sabaeus*	58	(Jasinska et al., 2007)
SCA1REP	Hex	*Human*	58	(Orr et al., 1993)

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Table S2a: Genotypes of 211 individuals for marker D10s1432, D10s611, D13s765, D17s1304, D19s245, D1s518, D1s548, D4s2408, D4s243, D5s1457 and D5s1467 with 'number'/'number' indicating two alleles of genotype and 0/0 indicating no genotype available. Individual identifier with S= potential sire, M= potential mother, O= offspring (ID), birth cohort year with unkn= unknown birth cohort (cohort), number of typed marker per individual (# typed)

ID	cohort	# typed	D10S1432	D10S611	D13S765	D17S1304	D19S245	D1S518	D1S548	D4S2408	D4S243	D5S1457	D5S1467
S1	unkn	19	155/163	158/162	236/240	207/211	241/257	190/194	216/216	362/362	243/263	122/130	184/184
S2	unkn	17	171/175	154/158	194/194	187/211	221/229	194/198	212/220	366/366	231/235	126/126	184/188
S3	unkn	15	163/175	154/158	186/186	187/187	209/233	178/178	216/216	354/354	243/251	130/130	184/192
O1	2013	15	155/171	150/150	194/240	207/211	221/241	186/190	212/220	362/366	235/235	126/130	184/188
O2	2015	14	171/179	150/158	0/0	187/207	217/241	186/190	220/220	362/366	235/235	122/130	188/188
M1	unkn	15	171/171	150/158	236/240	187/211	221/241	186/194	212/220	362/366	235/243	130/130	188/188
O3	2014	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O4	2013	14	155/175	154/158	0/0	187/211	217/257	182/190	212/216	366/370	247/251	118/130	184/188
S4	unkn	15	171/183	150/158	232/236	207/207	217/253	182/194	212/220	362/362	231/239	122/126	188/188
O5	2014	13	155/175	154/154	0/0	207/207	0/0	182/194	216/216	366/366	235/239	118/126	188/192
S5	2009	15	171/175	150/150	194/236	211/219	217/221	182/190	212/212	366/370	235/251	122/122	184/188
M2	unkn	16	155/171	154/162	186/190	207/211	209/241	182/186	216/216	366/366	235/251	118/130	188/192
O6	2015	15	155/175	162/162	0/0	0/0	217/221	182/194	216/216	362/362	231/247	122/126	184/188
O7	2014	15	155/167	154/158	198/232	207/211	225/229	190/198	216/224	362/366	243/251	126/126	184/188
M3	unkn	15	155/167	154/154	198/232	207/207	217/229	190/198	212/216	362/362	243/251	126/126	184/188
O8	2015	14	155/155	154/162	0/0	207/211	221/229	190/194	216/216	362/362	239/243	126/126	184/196
S6	unkn	15	155/155	154/158	194/236	187/207	221/225	182/194	212/216	366/370	235/251	118/126	184/188
S7	unkn	15	155/179	154/154	236/236	207/219	221/221	182/190	216/220	362/362	239/243	126/126	184/188
O9	2013	15	155/171	150/154	232/236	207/211	229/241	190/194	212/216	362/378	251/251	126/126	188/188
S8	unkn	15	155/159	158/158	236/236	207/207	209/229	190/190	216/224	362/362	243/243	122/122	184/188
M4	2010	18	155/175	154/162	232/236	187/207	217/229	182/186	212/216	362/362	243/247	118/122	184/188
O10	2016	14	155/175	158/162	0/0	207/207	217/221	186/194	216/216	362/362	239/243	122/126	184/196
O11	2014	15	155/171	154/158	232/236	187/207	217/229	182/194	212/220	362/362	247/251	118/130	184/184

O12	2014	15	155/171	150/158	194/194	187/211	221/221	198/202	212/220	366/378	235/239	122/126	184/184
M5	unkn	15	155/179	150/158	194/236	187/211	221/241	190/202	212/216	370/378	239/239	122/126	184/184
O13	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O14	2016	15	171/179	150/158	194/194	211/211	221/221	190/190	212/212	370/378	239/251	122/126	184/184
O15	2014	15	155/175	158/162	232/236	203/215	221/241	178/190	212/216	362/362	235/239	118/122	184/188
M6	unkn	15	155/155	154/158	194/236	219/223	221/241	190/198	212/216	358/370	239/239	126/126	188/188
O16	2014	15	155/171	150/158	194/236	207/219	221/241	194/198	216/216	370/370	239/251	126/126	188/188
S9	unkn	14	171/179	150/154	232/232	203/207	221/221	182/190	220/220	0/0	239/239	126/126	184/184
O17	2013	15	171/179	158/158	194/236	203/207	217/257	190/194	212/216	366/370	235/239	122/126	184/188
O18	2014	15	175/179	158/158	194/236	203/211	221/241	186/194	212/216	362/374	227/239	126/130	184/188
S10	unkn	13	155/171	158/162	0/0	0/0	221/229	182/202	212/224	370/374	227/243	118/126	184/192
O19	2015	15	171/175	158/158	194/194	187/187	221/221	190/194	212/212	366/370	231/251	126/126	184/188
O20	2015	15	155/171	154/158	186/236	203/207	217/221	178/190	216/216	362/370	239/243	126/126	184/188
O21	2013	15	155/171	154/158	194/236	207/223	241/241	190/194	212/216	370/370	239/239	126/126	188/188
S11	unkn	15	155/163	150/154	194/232	207/211	221/237	194/202	216/216	362/378	239/243	122/126	184/188
M7	unkn	15	155/155	154/158	236/236	207/215	221/225	178/190	212/216	362/362	239/243	122/126	184/184
O22	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
M8	unkn	15	175/179	154/158	194/236	187/203	217/221	190/194	212/216	362/370	239/251	118/126	188/188
O23	2016	14	155/175	158/158	0/0	187/215	221/229	190/194	216/216	362/370	231/239	126/126	188/188
S12	unkn	12	0/0	154/154	194/194	207/207	221/221	178/178	216/216	0/0	239/239	122/126	188/188
S13	unkn	15	175/175	150/158	194/228	207/207	217/221	182/186	220/220	366/370	239/239	122/126	184/188
S14	unkn	15	167/179	150/154	228/228	203/211	221/225	190/194	216/220	366/370	239/247	118/130	184/188
M9	unkn	21	171/171	154/158	232/236	187/215	209/221	182/194	212/220	362/362	243/243	118/122	188/188
O24	2016	19	155/171	154/154	0/0	187/187	217/221	194/194	212/220	362/370	243/247	118/122	188/188
O25	2014	20	155/171	150/154	194/236	207/215	221/229	182/190	212/220	362/366	231/243	118/126	184/188
O26	2015	14	171/171	150/154	0/0	187/211	217/221	182/182	212/220	362/366	243/251	122/122	184/188
S15	unkn	13	155/155	158/162	194/206	203/207	209/221	186/202	212/220	0/0	235/251	118/126	188/196
O27	2013	13	159/171	154/158	236/236	211/215	0/0	182/190	212/212	0/0	235/243	122/126	188/188
S16	unkn	15	155/163	154/158	198/232	211/215	225/225	186/198	216/224	366/366	239/243	126/126	184/188

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M10	unkn	15	0/0	158/162	236/236	187/211	221/229	178/182	216/216	362/370	235/239	126/130	188/188
O28	2013	15	155/171	158/162	236/236	203/211	221/241	178/190	216/216	362/370	231/235	122/126	188/188
O29	2013	19	171/171	154/158	232/236	207/207	221/225	190/194	216/216	354/362	235/239	122/130	192/196
M11	unkn	18	155/171	154/154	232/236	187/207	229/229	186/190	212/216	354/370	235/247	122/130	192/196
O30	2014	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O31	2015	16	171/171	154/158	0/0	207/207	221/229	190/194	212/216	354/362	231/247	122/126	188/196
S17	unkn	19	155/171	158/162	194/232	207/211	221/221	190/194	216/216	362/362	231/239	122/126	188/196
O32	2014	15	159/175	150/158	232/236	187/211	221/229	182/202	212/216	362/362	239/239	126/130	188/188
O33	2014	15	155/171	150/158	228/236	211/211	221/221	190/194	216/220	362/362	239/247	126/130	184/184
S18	unkn	15	155/175	150/158	194/236	203/211	241/241	178/194	212/216	362/370	239/263	122/130	188/188
M12	unkn	15	155/171	150/162	236/236	207/211	209/221	190/206	212/216	362/362	239/247	122/130	184/184
O34	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O35	2013	14	155/163	150/150	236/236	187/211	221/221	190/202	212/212	362/366	239/247	122/130	184/188
O36	2014	15	171/179	154/154	186/236	207/207	217/229	190/198	212/212	370/370	231/251	122/126	184/188
M13	unkn	15	171/183	154/154	236/236	203/207	217/217	194/198	212/216	366/370	231/243	122/126	184/184
M14	unkn	15	163/179	158/158	194/194	203/203	229/241	190/190	216/220	366/378	231/239	122/126	184/184
O37	2013	15	171/179	150/158	194/236	203/203	229/241	190/194	212/220	362/366	231/235	126/130	184/188
O38	2013	15	175/183	154/154	236/236	187/207	217/229	194/198	212/212	366/366	231/239	118/122	184/184
O39	2014	15	155/163	158/158	194/240	203/203	241/241	190/194	212/216	362/378	231/231	122/122	184/188
O40	2015	13	171/171	150/162	0/0	207/211	209/221	190/194	216/220	366/366	239/251	122/130	184/184
S19	unkn	17	171/179	158/162	194/232	207/211	217/221	190/194	220/220	0/0	231/235	122/130	184/188
O41	2013	15	155/183	150/162	194/194	187/203	217/229	190/194	216/216	362/370	231/239	126/126	184/184
O42	2013	15	171/171	150/154	232/236	187/211	217/221	186/190	212/216	370/378	239/251	122/126	188/192
M15	unkn	19	155/175	150/158	236/236	203/211	229/229	190/194	216/224	362/370	239/251	118/126	184/184
O43	2014	19	163/171	150/150	232/236	187/211	233/237	186/190	212/212	366/366	235/239	126/130	184/188
M16	unkn	17	155/171	154/158	194/232	187/215	217/229	190/198	216/220	354/370	239/239	126/130	188/192
O44	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O45	2015	16	0/0	154/158	194/228	187/215	217/229	190/194	216/220	362/370	239/251	126/130	184/192
O46	2014	18	167/175	150/158	0/0	203/207	229/237	190/194	212/224	370/370	239/243	118/122	184/184

S20	unkn	17	155/167	150/154	186/186	207/207	237/241	194/194	212/216	370/370	243/247	118/126	184/188
O47	2016	14	171/171	150/158	194/236	187/207	221/241	0/0	216/216	366/366	0/0	126/126	184/188
M17	unkn	20	171/179	150/158	194/194	187/211	221/229	194/198	212/216	362/366	227/251	118/126	184/188
O48	2015	17	171/175	154/158	0/0	211/211	221/221	198/198	212/220	366/366	227/231	126/126	188/188
O49	2013	19	171/171	154/154	186/236	211/215	229/241	182/194	212/212	366/370	235/239	126/130	184/188
S21	unkn	18	155/175	154/158	0/0	187/207	217/229	190/194	212/216	366/370	239/247	118/126	184/188
M18	unkn	14	171/179	150/158	194/194	207/219	229/229	194/202	216/220	0/0	227/239	126/126	188/188
S22	unkn	9	155/171	158/162	194/194	203/219	0/0	0/0	216/216	362/362	0/0	122/126	184/188
M19	unkn	19	171/183	154/158	194/236	215/219	225/229	182/190	212/212	370/370	235/239	126/130	184/188
O50	2014	14	0/0	150/158	194/232	203/207	229/257	190/194	212/216	366/366	239/243	126/126	184/188
O51	2015	13	163/171	154/158	0/0	187/215	0/0	182/202	212/224	362/370	239/239	122/126	188/188
S23	unkn	19	159/171	150/158	228/236	207/211	221/221	190/194	220/220	362/374	239/247	126/126	184/188
M20	unkn	14	155/175	150/154	206/214	207/211	209/241	186/198	216/216	0/0	239/243	122/130	180/184
O52	2015	13	171/175	150/158	0/0	187/207	221/241	186/198	216/220	366/366	231/239	126/130	184/188
O53	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
M21	unkn	15	171/171	154/158	194/236	187/219	217/257	190/194	212/216	362/370	235/243	118/126	184/192
O54	2015	15	155/171	150/158	194/236	207/207	221/257	194/202	212/216	370/378	235/239	118/126	184/192
S24	unkn	15	167/171	150/158	194/194	187/211	221/241	182/202	212/220	366/370	239/243	126/130	184/188
S25	unkn	15	155/179	154/154	186/206	207/215	221/229	190/194	212/216	362/370	235/251	122/126	188/188
O55	2013	15	171/171	150/158	194/194	211/219	217/221	190/190	212/212	362/366	235/243	126/126	184/188
O56	2013	15	171/179	150/150	194/194	187/203	221/241	186/194	212/216	362/370	235/239	122/126	188/188
O57	2014	15	155/163	150/154	206/232	207/211	221/241	198/202	216/216	366/378	239/243	122/126	180/188
M22	unkn	19	171/179	150/158	194/244	187/203	217/221	186/186	212/216	362/362	235/243	122/126	184/188
O58	2014	19	179/179	150/158	194/236	187/211	221/221	186/186	212/216	362/362	235/235	122/130	184/188
S26	unkn	15	155/155	154/158	236/240	203/219	241/253	190/194	212/220	350/362	231/243	122/122	188/188
O59	2013	14	155/163	150/154	194/206	207/211	221/241	186/194	216/216	0/0	239/243	122/130	180/188
O60	2014	15	171/175	150/158	236/236	187/219	217/221	178/194	212/220	366/370	231/239	122/130	184/188
S27	unkn	15	155/175	150/150	236/236	187/215	217/217	186/198	216/216	362/362	231/235	118/130	184/184
M23	2010	18	155/175	150/158	194/236	207/219	221/221	178/186	212/212	366/370	231/235	118/130	188/188

O61	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O62	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O63	2015	13	0/0	150/158	0/0	187/211	221/221	186/186	212/216	362/362	235/235	122/130	184/188
S28	2011	14	0/0	154/154	194/194	219/219	209/221	194/194	220/220	362/366	231/251	122/126	188/192
S29	unkn	15	171/179	158/162	186/236	211/211	221/221	194/194	216/220	370/374	235/239	122/130	184/184
S30	unkn	15	163/163	154/158	186/206	211/215	229/233	194/194	212/216	366/370	227/235	122/130	184/184
S31	unkn	15	155/179	150/162	194/198	187/187	217/237	194/194	216/216	362/374	231/243	122/126	184/184
M24	unkn	15	155/183	150/154	194/236	207/219	217/221	182/194	212/220	362/362	239/251	122/126	188/188
O64	2016	14	155/171	150/154	0/0	207/219	221/221	182/194	212/212	362/362	235/239	126/126	188/188
S32	unkn	15	155/179	158/158	190/202	207/211	237/237	190/190	216/220	374/374	243/247	122/126	184/196
S33	2008	18	155/175	158/162	232/240	187/203	221/241	186/190	216/216	362/370	231/235	118/122	184/188
M25	unkn	15	155/179	154/162	194/236	203/207	221/241	190/194	212/216	362/370	231/239	126/130	188/196
M26	unkn	14	155/171	150/154	194/236	203/211	221/221	194/198	212/216	0/0	239/239	122/126	188/188
O65	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O66	2014	14	155/179	150/154	0/0	203/211	221/221	190/198	212/212	362/362	235/247	122/122	184/188
S34	unkn	15	171/175	150/154	194/232	187/187	237/257	194/194	212/216	362/366	231/251	118/126	188/192
M27	unkn	15	155/179	150/158	194/236	207/219	217/225	190/194	212/220	362/374	231/243	122/130	184/188
O67	2014	14	155/183	150/162	0/0	203/211	221/221	190/194	212/216	362/362	239/243	126/130	184/196
S35	unkn	20	159/171	154/158	186/236	203/211	217/241	190/194	212/216	366/370	235/243	118/126	188/188
M28	unkn	20	155/155	154/158	232/236	207/207	209/217	178/178	216/216	362/362	231/235	126/130	184/184
O68	2015	16	0/0	154/158	194/232	0/0	209/229	178/190	216/220	362/362	235/239	122/126	184/188
S36	unkn	14	171/171	150/154	202/236	207/211	0/0	186/194	212/216	366/378	247/251	122/126	188/188
O69	2014	18	0/0	150/154	0/0	207/207	217/221	178/194	216/220	362/374	239/247	126/126	184/188
O70	2013	15	155/171	158/158	232/236	207/211	209/221	178/190	216/220	362/374	239/247	126/130	184/188
S37	unkn	18	155/171	158/162	232/236	187/207	217/221	194/194	212/220	362/366	239/251	122/130	184/192
S38	unkn	15	155/175	150/162	194/236	187/215	217/217	182/186	212/216	362/362	243/247	118/130	184/184
O71	2014	15	155/183	150/158	232/232	207/211	217/245	182/190	212/212	362/370	231/239	122/122	188/188
O72	2013	15	179/179	150/154	194/194	187/211	229/257	190/194	212/212	362/366	235/251	122/126	188/188
M29	unkn	15	167/175	150/158	194/244	207/219	241/245	186/202	212/212	366/370	227/239	126/126	184/188

Minkner _SupMat_detailed_methods_Male_reproductive_skew_in_wild_vervet_monkeys_ JHered

M30	unkn	15	155/175	154/158	232/236	207/211	241/245	182/190	212/220	370/374	239/243	122/126	184/188
O73	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O74	2015	14	171/175	150/154	236/236	203/207	217/225	186/190	216/216	362/366	0/0	118/130	184/188
O75	2015	14	155/155	150/154	0/0	211/223	233/245	190/190	220/220	362/370	239/239	126/126	184/184
O76	2014	15	163/179	150/150	194/232	207/207	237/253	194/202	216/220	362/362	235/239	122/126	188/188
O77	2014	20	171/171	154/158	194/236	203/207	217/253	186/190	212/216	362/366	235/243	122/126	184/188
M31	unkn	13	0/0	150/154	194/232	187/207	229/253	194/202	212/220	362/366	235/251	122/126	188/188
O78	2016	14	175/179	150/154	0/0	207/211	221/253	190/194	212/220	362/370	235/251	122/126	188/188
O79	2013	15	171/175	150/154	194/236	211/219	217/241	186/190	212/212	366/370	235/239	126/126	188/188
O80	2013	15	159/175	154/158	232/236	187/211	221/245	190/202	212/224	362/374	239/239	122/126	184/188
O81	2013	15	171/175	150/154	236/236	207/207	225/229	186/190	216/216	362/366	239/243	122/126	184/188
O82	2014	16	0/0	150/154	194/232	207/211	241/241	198/202	212/220	0/0	227/231	126/126	188/188
M32	unkn	19	171/179	150/158	236/244	203/207	217/225	186/194	216/224	362/362	0/0	122/130	184/188
S39	unkn	15	163/167	154/162	232/232	203/207	217/225	182/186	220/224	362/374	239/243	122/130	188/188
S40	2008	20	155/171	154/158	198/236	211/219	217/229	182/186	216/216	362/370	231/235	122/130	184/188
S41	unkn	17	155/155	154/158	198/232	211/223	221/221	178/178	220/220	370/370	227/251	130/130	192/192
S42	unkn	16	171/171	154/158	232/236	203/207	241/257	190/190	212/212	366/366	235/243	122/126	184/184
S43	unkn	19	155/175	154/158	236/236	203/211	209/229	190/190	216/220	362/370	231/235	122/126	188/188
S44	2012	15	171/179	150/154	194/236	187/207	217/229	186/190	216/220	366/370	239/247	130/130	184/184
M33	unkn	15	155/171	150/158	194/198	207/207	229/229	190/190	212/220	362/366	239/243	130/130	184/188
O83	2013	15	155/163	150/154	236/236	187/207	221/253	186/202	212/224	362/366	231/251	126/130	184/188
O84	2016	15	163/171	150/158	236/236	203/207	221/241	190/202	212/224	362/366	243/251	126/126	184/184
O85	2015	18	163/175	150/158	0/0	207/207	0/0	182/190	212/216	362/366	235/263	122/130	184/188
M34	unkn	19	171/175	150/158	194/236	207/211	0/0	182/190	212/212	366/370	231/235	122/130	184/188
O86	2016	15	155/171	158/162	194/236	207/211	221/237	190/190	212/216	362/370	235/239	122/126	184/188
M35	unkn	15	155/175	150/154	194/236	207/211	221/253	186/190	212/216	362/366	235/239	122/130	184/184
S45	unkn	15	155/155	154/158	236/236	207/215	217/229	190/194	212/216	362/362	231/231	126/130	184/188
O87	2013	15	175/179	154/158	194/236	211/211	229/241	198/198	212/220	366/370	239/239	126/126	184/188
M36	unkn	15	175/179	158/158	194/236	207/211	221/241	186/198	212/216	362/370	239/239	126/130	184/188

O88	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O89	2014	15	155/159	158/158	194/236	187/187	229/233	186/198	216/224	362/370	239/251	126/130	188/192
O90	2013	15	159/175	150/150	228/236	207/211	221/221	182/190	212/220	366/374	235/247	126/130	184/188
O91	2014	15	175/179	158/158	194/194	211/211	221/241	198/198	216/224	366/370	239/239	126/126	184/184
O92	2014	15	171/175	150/158	236/236	211/211	221/253	186/194	212/220	362/362	235/239	122/126	184/188
S46	unkn	18	155/155	154/162	194/236	215/215	229/229	190/198	216/220	362/370	239/243	122/126	184/188
O93	2013	15	155/155	154/162	194/236	187/215	217/221	190/194	212/216	362/370	239/259	118/122	184/188
M37	unkn	15	155/175	150/158	214/244	203/207	241/241	186/190	212/216	366/366	235/239	122/126	180/188
O94	2016	14	155/175	154/158	0/0	187/203	229/241	186/194	212/216	366/366	231/235	122/126	184/188
O95	2013	15	155/155	154/162	236/236	203/211	221/241	194/194	212/216	362/370	239/251	126/130	184/188
S47	unkn	15	163/179	158/158	194/194	187/211	233/241	186/186	216/216	366/374	227/231	118/130	184/184
S48	2009	15	163/179	154/158	194/236	203/203	229/241	186/190	212/216	366/366	231/239	122/126	184/188
O96	2013	15	155/175	158/158	236/244	203/203	229/241	186/202	212/216	366/370	235/251	122/126	184/188
O97	2014	18	167/179	150/154	0/0	203/207	221/237	194/194	212/216	362/362	239/243	126/130	184/188
O98	2015	14	171/175	154/158	186/206	207/211	217/241	190/194	212/216	0/0	235/235	118/126	188/188
M38	unkn	15	155/155	158/162	194/232	207/215	221/257	186/190	216/216	362/370	239/251	122/126	188/196
O99	2014	15	155/175	154/162	194/194	207/215	229/257	190/190	212/216	362/366	239/247	126/126	184/196
S49	unkn	19	179/183	150/158	206/236	211/211	221/221	186/190	212/216	362/366	235/243	122/130	184/188
O100	2014	15	155/175	150/154	194/194	207/211	229/241	190/194	212/220	366/366	231/235	122/126	180/184
O101	2014	15	155/155	154/158	232/236	187/223	229/241	190/190	212/220	362/370	243/247	118/126	184/184
M39	unkn	15	155/171	150/154	206/236	207/223	217/241	190/194	216/220	362/370	227/243	122/126	184/188
S50	unkn	20	155/175	150/154	194/236	207/223	209/233	182/190	220/220	362/366	231/239	122/126	184/184
M40	unkn	19	179/191	154/162	232/236	203/211	221/221	186/194	212/216	362/366	239/239	130/130	188/188
O102	2016	14	171/179	154/158	0/0	211/223	221/229	186/190	212/216	362/362	231/239	126/130	188/188
M41	2010	15	179/179	154/158	194/236	203/207	221/221	186/190	216/216	366/370	243/243	126/130	188/188
M42	unkn	14	171/179	150/154	0/0	203/207	221/229	190/190	216/220	362/366	243/243	126/130	184/188
O103	2015	14	155/155	154/158	0/0	207/215	217/221	186/190	212/216	362/370	231/243	130/130	184/188
O104	2016	18	171/179	154/162	194/194	203/211	221/221	190/194	216/220	362/370	231/243	130/130	184/188
S51	unkn	15	155/171	150/154	194/236	203/207	217/241	186/194	216/216	362/370	239/251	118/126	184/188

M43	unkn	15	167/171	150/154	194/232	211/215	217/241	182/202	216/220	362/378	231/243	122/126	184/188
O105	2015	14	155/171	150/154	0/0	211/215	229/241	182/190	212/216	362/362	231/231	122/126	188/188
O106	2016	14	163/167	150/158	0/0	187/215	217/233	182/202	216/224	366/378	231/251	122/126	188/188
O107	2013	15	167/171	154/154	194/236	211/211	217/241	182/190	212/220	362/370	243/243	126/126	188/188
S52	unkn	19	171/179	150/154	194/236	207/211	0/0	190/194	212/212	362/366	231/235	126/126	184/188
M44	unkn	15	155/175	158/158	232/236	207/211	225/245	186/190	216/220	366/374	235/239	126/126	184/192
O108	2013	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O109	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O110	2014	14	155/159	158/158	232/232	187/211	0/0	190/202	216/224	362/366	235/251	126/126	184/188
O111	2015	19	155/171	154/158	0/0	203/211	221/229	182/190	212/216	362/366	235/251	126/130	184/188
S53	unkn	20	155/171	150/158	194/194	207/223	229/241	190/194	212/216	362/366	231/235	126/126	184/188
S54	unkn	14	0/0	150/154	0/0	207/211	253/257	178/190	220/224	362/370	243/251	122/130	184/188
S55	unkn	15	159/179	154/158	194/232	203/211	225/241	182/198	220/224	362/366	231/239	126/126	184/188
S56	unkn	19	159/163	150/158	232/236	187/187	221/233	186/202	212/224	362/366	239/251	122/126	188/188

Table S2b: Genotypes of 211 individuals for marker, D6s474, D6s501, D7s2204, D8s1106, D11s2002, D12s67nigra, D18s536, D2s1333, D6s1017 and D6s493nigra with 'number'/'number' indicating two alleles of genotype and 0/0 indicating no genotype available. Individual identifier with S= potential sire, M= potential mother, O= offspring (ID), birth cohort year with unkn= unknown birth cohort (cohort), number of typed marker per individual (# typed)

ID	Cohort	# typed	D6S474	D6S501	D7S2204	D8S1106	D11S2002	D12S67nigra	D18S536	D2S1333	D6S1017	D6S493nigra
S1	unkn	19	194/194	118/126	231/235	127/135	0/0	234/234	0/0	273/329	355/355	144/152
S2	unkn	17	194/194	122/130	239/239	127/131	222/262	118/122	0/0	0/0	0/0	0/0
S3	unkn	15	198/198	134/142	239/239	131/139	0/0	0/0	0/0	0/0	0/0	0/0
O1	2013	15	198/206	118/122	231/235	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O2	2015	14	210/210	122/134	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M1	unkn	15	206/210	122/134	231/231	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O3	2014	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O4	2013	14	122/206	122/122	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0

S4	unkn	15	190/198	126/126	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O5	2014	13	122/122	126/130	0/0	131/135	0/0	118/146	0/0	0/0	0/0	0/0
S5	2009	15	202/214	126/142	235/235	131/131	0/0	0/0	0/0	0/0	0/0	0/0
M2	unkn	16	122/206	122/130	235/239	127/131	0/0	122/146	0/0	0/0	0/0	0/0
O6	2015	15	206/206	122/134	231/235	127/131	222/222	0/0	186/190	0/0	0/0	0/0
O7	2014	15	198/202	118/122	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M3	unkn	15	198/202	118/122	223/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O8	2015	14	198/206	122/122	223/231	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S6	unkn	15	202/206	122/134	235/243	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S7	unkn	15	206/206	118/122	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O9	2013	15	190/202	118/122	231/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S8	unkn	15	190/206	122/122	231/231	135/135	0/0	0/0	0/0	0/0	0/0	0/0
M4	2010	18	202/202	122/134	231/235	127/135	222/262	122/122	186/190	0/0	0/0	0/0
O10	2016	14	202/206	122/142	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O11	2014	15	190/202	122/122	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O12	2014	15	194/222	122/130	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
M5	unkn	15	198/222	122/130	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O13	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O14	2016	15	198/202	122/142	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O15	2014	15	202/206	126/130	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M6	unkn	15	194/230	126/130	239/243	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O16	2014	15	194/202	126/130	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
S9	unkn	14	194/202	122/122	231/231	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O17	2013	15	122/206	122/126	235/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O18	2014	15	202/206	122/126	231/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S10	unkn	13	198/210	122/126	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O19	2015	15	194/206	122/142	239/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O20	2015	15	194/206	126/130	239/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O21	2013	15	202/230	126/130	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0

S11	unkn	15	198/202	122/130	231/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
M7	unkn	15	206/230	126/130	231/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O22	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
M8	unkn	15	206/206	122/142	239/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O23	2016	14	206/222	118/122	239/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S12	unkn	12	0/0	126/134	235/235	131/131	0/0	0/0	0/0	0/0	0/0	0/0
S13	unkn	15	198/206	118/134	235/235	131/131	0/0	0/0	0/0	0/0	0/0	0/0
S14	unkn	15	198/206	122/126	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M9	unkn	21	202/206	122/126	239/251	127/135	222/262	118/122	186/190	329/329	355/355	144/152
O24	2016	19	202/202	126/126	231/231	0/0	222/222	118/118	190/230	329/329	355/355	144/144
O25	2014	20	206/214	122/126	235/239	127/135	222/222	118/118	186/186	0/0	355/355	144/148
O26	2015	14	202/206	122/142	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S15	unkn	13	198/206	0/0	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O27	2013	13	194/206	126/126	235/251	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S16	unkn	15	198/226	122/130	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M10	unkn	15	130/202	118/122	239/239	131/131	0/0	0/0	0/0	0/0	0/0	152/152
O28	2013	15	202/206	118/122	231/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O29	2013	19	198/222	122/126	231/235	131/131	222/262	130/142	0/0	293/297	355/359	0/0
M11	unkn	18	198/206	122/126	235/235	131/135	262/262	138/142	0/0	0/0	355/359	0/0
O30	2014	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O31	2015	16	206/222	122/122	231/235	131/135	0/0	0/0	0/0	0/0	355/355	152/152
S17	unkn	19	206/222	122/142	231/231	131/135	222/254	130/138	190/190	0/0	355/359	0/0
O32	2014	15	130/198	118/122	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O33	2014	15	130/190	118/122	235/239	135/135	0/0	0/0	0/0	0/0	0/0	0/0
S18	unkn	15	130/214	118/126	235/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
M12	unkn	15	130/206	122/134	235/235	135/135	0/0	0/0	0/0	0/0	0/0	0/0
O34	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O35	2013	14	0/0	122/134	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O36	2014	15	190/210	122/122	227/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0

Minkner _SupMat_detailed_methods_Male_reproductive_skew_in_wild_vervet_monkeys_ JHered

M13	unkn	15	206/210	122/126	231/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M14	unkn	15	190/206	122/134	235/235	135/135	0/0	0/0	0/0	0/0	0/0	0/0
O37	2013	15	190/198	122/134	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O38	2013	15	202/206	126/126	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O39	2014	15	190/206	122/122	235/235	135/135	0/0	0/0	0/0	0/0	0/0	0/0
O40	2015	13	0/0	122/134	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S19	unkn	17	206/210	122/134	231/235	131/135	222/222	0/0	190/226	0/0	0/0	148/148
O41	2013	15	198/198	122/130	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O42	2013	15	190/198	122/126	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M15	unkn	19	198/206	118/122	235/235	131/135	0/0	118/122	0/0	317/329	355/355	144/148
O43	2014	19	202/226	122/122	235/239	131/135	262/262	118/122	0/0	0/0	355/355	144/152
M16	unkn	17	198/198	122/126	235/235	131/131	0/0	118/122	0/0	0/0	359/363	0/0
O44	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O45	2015	16	198/222	122/134	231/235	131/135	0/0	118/138	0/0	0/0	359/375	0/0
O46	2014	18	198/206	122/130	235/235	135/135	0/0	118/122	0/0	317/317	355/355	148/152
S20	unkn	17	0/0	122/130	235/235	127/135	0/0	118/122	0/0	317/317	0/0	152/152
O47	2016	14	122/222	122/130	239/239	127/131	0/0	0/0	0/0	0/0	0/0	144/144
M17	unkn	20	202/222	122/126	235/239	127/135	222/242	122/270	0/0	293/297	355/359	144/148
O48	2015	17	194/222	122/122	239/239	127/135	222/222	118/270	0/0	0/0	0/0	144/144
O49	2013	19	206/214	118/130	231/239	127/135	222/242	0/0	0/0	329/329	355/355	148/152
S21	unkn	18	122/202	122/126	231/239	135/135	0/0	118/122	174/230	329/329	0/0	144/144
M18	unkn	14	190/198	122/126	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S22	unkn	9	0/0	0/0	0/0	131/131	0/0	0/0	0/0	0/0	0/0	0/0
M19	unkn	19	214/222	118/130	231/231	131/135	242/242	0/0	0/0	329/329	355/355	152/152
O50	2014	14	122/198	122/130	231/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O51	2015	13	198/222	122/130	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S23	unkn	19	190/206	118/122	235/239	131/135	0/0	118/122	0/0	289/329	355/355	140/144
M20	unkn	14	198/206	122/134	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O52	2015	13	194/206	0/0	239/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0

O53	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
M21	unkn	15	206/222	122/122	231/239	135/135	0/0	0/0	0/0	0/0	0/0	0/0
O54	2015	15	202/222	122/130	231/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S24	unkn	15	190/222	122/126	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S25	unkn	15	190/206	122/130	227/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O55	2013	15	198/206	122/130	235/239	135/135	0/0	0/0	0/0	0/0	0/0	0/0
O56	2013	15	202/206	122/130	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O57	2014	15	198/198	122/134	231/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M22	unkn	19	206/210	122/126	235/235	131/135	222/262	138/138	178/198	0/0	355/359	0/0
O58	2014	19	206/206	122/122	235/239	127/131	222/262	138/142	186/198	0/0	355/355	0/0
S26	unkn	15	198/206	122/122	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O59	2013	14	198/206	122/134	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O60	2014	15	190/214	122/122	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S27	unkn	15	122/230	122/122	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M23	2010	18	202/214	122/122	235/235	131/131	262/306	122/122	0/0	321/329	0/0	0/0
O61	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O62	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O63	2015	13	206/206	122/122	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S28	2011	14	190/190	126/134	227/231	131/139	0/0	0/0	0/0	0/0	0/0	0/0
S29	unkn	15	194/198	122/126	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S30	unkn	15	202/206	118/122	227/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S31	unkn	15	198/198	122/130	235/235	127/135	0/0	0/0	0/0	0/0	0/0	0/0
M24	unkn	15	190/198	126/134	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O64	2016	14	198/206	122/126	231/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S32	unkn	15	206/206	118/122	235/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S33	2008	18	202/206	122/126	231/235	131/131	222/222	118/118	186/190	0/0	0/0	0/0
M25	unkn	15	206/210	118/122	231/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
M26	unkn	14	194/206	122/126	235/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O65	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

O66	2014	14	206/206	118/122	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S34	unkn	15	130/198	122/130	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M27	unkn	15	206/210	118/122	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O67	2014	14	206/206	122/122	231/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
S35	unkn	20	194/206	126/130	235/239	127/127	222/222	130/130	0/0	273/329	355/355	148/148
M28	unkn	20	190/202	118/122	231/239	127/135	222/306	118/122	0/0	289/309	355/355	148/148
O68	2015	16	198/202	118/118	231/235	127/135	190/306	118/122	0/0	0/0	0/0	148/148
S36	unkn	14	134/190	122/142	231/231	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O69	2014	18	190/202	118/122	231/235	127/131	222/222	118/122	0/0	289/289	355/355	144/148
O70	2013	15	190/202	118/118	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S37	unkn	18	190/222	122/134	231/235	131/135	262/262	138/142	186/186	0/0	0/0	0/0
S38	unkn	15	122/230	122/130	235/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O71	2014	15	198/198	122/126	231/235	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O72	2013	15	130/198	122/130	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M29	unkn	15	198/222	122/122	231/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M30	unkn	15	198/206	122/130	227/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O73	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O74	2015	14	122/122	122/126	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O75	2015	14	198/214	122/122	227/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O76	2014	15	198/210	122/122	235/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O77	2014	20	122/206	122/130	235/239	131/135	222/222	118/122	0/0	317/329	355/355	140/156
M31	unkn	13	0/0	122/130	235/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O78	2016	14	130/202	122/142	235/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O79	2013	15	194/198	122/126	231/235	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O80	2013	15	206/226	122/130	235/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O81	2013	15	202/210	122/126	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O82	2014	16	198/222	122/130	239/239	127/131	190/222	118/118	0/0	0/0	0/0	148/152
M32	unkn	19	122/210	126/130	235/239	131/131	222/222	118/118	0/0	317/317	355/355	140/152
S39	unkn	15	210/222	122/126	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0

S40	2008	20	130/198	118/122	231/239	127/131	250/258	142/142	174/186	289/297	355/355	0/0
S41	unkn	17	202/202	118/118	243/243	135/135	222/226	118/142	0/0	0/0	0/0	0/0
S42	unkn	16	122/202	126/130	235/239	131/135	222/222	0/0	0/0	0/0	0/0	0/0
S43	unkn	19	198/238	118/126	235/239	127/135	266/270	118/118	0/0	329/329	0/0	144/144
S44	2012	15	198/206	126/134	239/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
M33	unkn	15	198/206	134/134	239/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O83	2013	15	202/226	122/122	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O84	2016	15	202/226	122/130	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O85	2015	18	194/202	122/126	235/239	127/131	270/274	118/234	0/0	329/329	355/355	144/144
M34	unkn	19	130/202	122/126	235/239	131/135	262/270	118/122	0/0	329/329	355/355	144/152
O86	2016	15	202/222	122/122	231/239	135/135	0/0	0/0	0/0	0/0	0/0	0/0
M35	unkn	15	198/202	122/134	231/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S45	unkn	15	198/222	118/118	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O87	2013	15	194/206	122/122	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
M36	unkn	15	198/206	122/126	235/239	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O88	2015	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O89	2014	15	198/226	122/126	235/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O90	2013	15	130/190	122/122	239/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O91	2014	15	198/198	122/126	239/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O92	2014	15	190/202	118/122	231/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
S46	unkn	18	198/202	118/122	235/235	127/131	190/262	118/118	0/0	0/0	0/0	148/152
O93	2013	15	122/202	126/130	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M37	unkn	15	198/202	122/122	231/235	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O94	2016	14	194/202	122/122	235/239	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O95	2013	15	202/218	122/130	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S47	unkn	15	198/202	126/130	227/231	131/135	0/0	0/0	0/0	0/0	0/0	0/0
S48	2009	15	198/206	122/130	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O96	2013	15	198/198	118/122	231/235	131/131	0/0	0/0	0/0	0/0	0/0	0/0
O97	2014	18	198/218	122/130	235/235	131/135	258/258	122/122	0/0	317/317	0/0	144/152

O98	2015	14	202/206	122/130	235/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
M38	unkn	15	122/206	122/130	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O99	2014	15	202/206	126/130	231/239	135/135	0/0	0/0	0/0	0/0	0/0	0/0
S49	unkn	19	206/206	118/122	231/239	127/131	222/222	138/142	186/186	0/0	355/355	0/0
O100	2014	15	194/198	122/122	231/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
O101	2014	15	122/206	122/130	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M39	unkn	15	206/230	126/130	231/235	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S50	unkn	20	214/222	122/122	235/239	127/131	222/222	118/122	186/186	0/0	355/359	144/156
M40	unkn	19	206/218	122/122	231/231	131/131	222/258	122/126	0/0	317/317	0/0	144/152
O102	2016	14	198/218	118/122	231/235	131/135	0/0	0/0	0/0	0/0	0/0	0/0
M41	2010	15	206/214	118/126	231/235	127/127	0/0	0/0	0/0	0/0	0/0	0/0
M42	unkn	14	202/206	118/122	231/235	127/127	0/0	0/0	0/0	0/0	0/0	0/0
O103	2015	14	198/206	118/118	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O104	2016	18	206/214	122/126	231/235	127/131	190/222	0/0	186/190	0/0	0/0	144/148
S51	unkn	15	198/202	122/130	231/235	127/135	0/0	0/0	0/0	0/0	0/0	0/0
M43	unkn	15	198/202	122/122	239/251	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O105	2015	14	202/222	118/122	235/251	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O106	2016	14	198/198	122/122	235/251	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O107	2013	15	194/202	122/126	239/243	127/135	0/0	0/0	0/0	0/0	0/0	0/0
S52	unkn	19	198/206	122/130	235/239	127/135	222/306	122/122	0/0	289/329	355/355	144/156
M44	unkn	15	198/206	122/122	231/239	131/135	0/0	0/0	0/0	0/0	0/0	0/0
O108	2013	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O109	2016	0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
O110	2014	14	206/226	122/122	235/239	127/135	0/0	0/0	0/0	0/0	0/0	0/0
O111	2015	19	194/202	122/126	235/239	127/131	266/274	118/122	0/0	293/329	355/355	144/152
S53	unkn	20	198/214	118/126	231/235	135/135	222/262	118/118	186/186	0/0	355/359	144/148
S54	unkn	14	198/206	122/134	231/231	131/135	0/0	0/0	0/0	0/0	0/0	144/152
S55	unkn	15	198/206	122/130	239/239	127/131	0/0	0/0	0/0	0/0	0/0	0/0
S56	unkn	19	198/226	122/122	235/235	127/131	222/262	118/118	0/0	0/0	355/355	144/152

92 *Table S3: 111 infants (infantID) their birth cohort year (cohort), genetic mother (genMomID),birthgroup (bgrp), genetic sire (sireID), the paternity criteria (patCrit) with which sire was assigned, paternity likelihood confidence level of parent-offspring trio (patLike) with which sire was confirmed, comments for certain samples (comment)* 95

infantID	cohort	genMomID	bgrp	sireID	patCrit	patLike	comment
O1	2013	M1	RST	S53	strict	0.95	
O2	2015	M1	RST	S19	strict	0.95	
O3	2014		RST				no sample
O4	2013	M2	PT	S21	strict	0.95	
O5	2014	M2	PT	S21	strict	0.95	
O6	2015	M4	RBM	S17	strict	0.95	
O7	2014	M3	RBM	S16	strict	0.95	
O8	2015	M3	RBM	S17	strict	0.95	
O9	2013	M3	RBM	S36	strict	0.95	
O10	2016	M4	RBM	S17	strict	0.95	
O11	2014	M4	RBM	S37	strict	0.95	
O12	2014	M5	RST	S2	strict	0.95	
O13	2015		RST				no sample
O14	2016	M5	RST	S5	strict	0.95	
O15	2014	M7	RBM	S33	strict	0.95	
O16	2014	M6	PT	S51	strict	0.95	
O17	2013	M8	RST	S42	strict	0.95	
O18	2014	M8	RST	S47	strict	0.95	
O19	2015	M8	RST	S2	strict	0.95	
O20	2015	M7	RBM	S35	strict	0.95	
O21	2013	M6	PT	S51	strict	0.95	
O22	2016		RBM				no sample
O23	2016	M8	RST	S45	strict	0.95	
O24	2016	M9	RST	S21	strict	0.95	
O25	2014	M9	RST	S53	strict	0.95	
O26	2015	M9	RST	S5	strict	0.95	
O27	2013	M9	RST	S35	strict	0.95	
O28	2013	M10	RBM	S33	best match	0.95	
O29	2013	M11	RBM	S17	strict	0.95	
O30	2014		RBM				no sample
O31	2015	M11	RBM	S17	strict	0.95	
O32	2014	M10	RBM	S56	strict	0.95	
O33	2014	M12	RBM	S23	strict	0.95	
O34	2016		RBM				no sample
O35	2013	M12	RBM	S56	strict	0.95	
O36	2014	M13	PT	S25	strict	0.95	
O37	2013	M14	RST				no match
O38	2013	M13	PT	S21	strict	0.95	
O39	2014	M14	RST	S26	strict	0.95	
O40	2015	M12	RBM	S37	relaxed	0.95	

O41	2013	M15	PT	S31	best match	0.95	
O42	2013	M16	RBM	S36	strict	0.95	
O43	2014	M34	RBM	S56	strict	0.95	
O44	2016		RBM				no sample
O45	2015	M16	RBM	S37	best match	0.95	
O46	2014	M15	PT	S20	best match	0.95	
O47	2016	M17	RST	S42	best match	0.95	
O48	2015	M17	RST	S2	strict	0.95	
O49	2013	M19	RST	S35	strict	0.95	
O50	2014	M18	RST	S42	strict	0.95	
O51	2015	M19	RST	S56	strict	0.95	
O52	2015	M20	RST	S2	strict	0.95	
O53	2016		RST				no sample
O54	2015	M21	RST	S11	strict	0.95	
O55	2013	M21	RST	S52	strict	0.95	
O56	2013	M22	PT	S51	strict	0.95	
O57	2014	M20	RST	S11	strict	0.95	
O58	2014	M22	PT	S49	strict	0.95	
O59	2013	M20	RST	S11	strict	0.95	
O60	2014	M23	RBM	S37	strict	0.95	
O61	2015		RBM				no sample
O62	2016		RBM				no sample
O63	2015	M22	PT	S49	strict	0.95	
O64	2016	M24	RST	S52	strict	0.95	
O65	2016		PT				no sample
O66	2014	M26	PT	S49	strict	0.95	
O67	2014	M25	PT	S49	strict	0.95	
O68	2015	M28	RBM	S46	strict	0.95	
O69	2014	M28	RBM	S23	strict	0.95	
O70	2013	M28	RBM	S23	strict	0.95	
O71	2014	M30	RBM	S4	strict	0.95	
O72	2013	M31	RST	S52	strict	0.95	
O73	2016		RBM				no sample
O74	2015	M32	PT	S21	strict	0.95	
O75	2015	M30	RBM	S50	strict	0.95	
O76	2014	M31	RST	S11	strict	0.95	
O77	2014	M32	PT	S52	strict	0.95	
O78	2016	M31	RST	S5	strict	0.95	
O79	2013	M29	RST	S35	strict	0.95	
O80	2013	M30	RBM	S56	strict	0.95	
O81	2013	M32	PT	S21	strict	0.95	
O82	2014	M29	RST	S55	strict	0.95	
O83	2013	M35	RBM	S56	strict	0.95	
O84	2016	O83	RBM	S42	strict	0.95	
O85	2015	M34	RBM	S1	strict	0.95	

O86	2016	M34	RBM	S17	strict	0.95	
O87	2013	M36	RST	S2	best match	0.95	
O88	2015		RST				no sample
O89	2014	M16	RBM	S56	strict	0.95	
O90	2013	M34	RBM	S23	strict	0.95	
O91	2014	M36	RST	S55	strict	0.95	
O92	2014	M35	RBM	S23	strict	0.95	
O93	2013	M38	PT	S21	best match	0.95	
O94	2016	M37	RST	S2	strict	0.95	
O95	2013	M40	PT	S51	strict	0.95	
O96	2013	M37	RST				no match
O97	2014	M40	PT	S20	best match	0.95	
O98	2015	M37	RST	S35	strict	0.95	
O99	2014	M38	PT	S21	strict	0.95	
O100	2014	M37	RST	S2	strict	0.95	
O101	2014	M39	PT	S21	strict	0.95	
O102	2016	M40	PT	S53	strict	0.95	
O103	2015	M41	RST	S45	strict	0.95	
O104	2016	M41	RST	S19	strict	0.95	
O105	2015	M43	RST	S45	strict	0.95	
O106	2016	M43	RST	S56	strict	0.95	
O107	2013	M43	RST	S35	best match	0.95	
O108	2013		RBM				no sample
O109	2016		RBM				no sample
O110	2014	M44	RBM	S56	strict	0.95	
O111	2015	M10	RBM				no match

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Table captions

Assessment of male reproductive skew via highly polymorphic STR markers in wild vervet monkeys, *Chlorocebus pygerythrus*

Running title: Male reproductive skew in wild vervet monkeys

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Table 1: Overview of microsatellites (core markers 1-15, additional markers 16-21). Name of locus with indication if modified for Macaca nigra (locus), number of alleles at locus (k), number of individuals typed at locus (N), observed heterozygosity (H_{obs}), expected heterozygosity (H_{exp}), polymorphic information content (PIC), estimated null allele frequency (F(Null)), and nucleotide motif repeats for each locus (repeat). Note that the last 6 marker were used on a limited number of specific trios only to enhance paternity exclusion, leading to different genetic parameters.

Table 2: Mating skew over three groups and four mating seasons. Number of potential males (troop + extra-group males) for skew calculation and number of males used for Spearman rank correlation (in parenthesis) (Np), number of observed mating males (Nb), alpha male share of mating (% α-mat), alpha male tenure share of four month mating season (% α-tenure), the observed B value (B index), corresponding p value of the B index (p (B index)), B index for an equal sharing of mating (equalB), B index for complete monopolization of mating (monopolB), lower confidence interval (lCI: .95 %), upper confidence interval (uCI: .95 %), correlation coefficient for Spearman rank correlation (rho) between dominance rank and mating success, corresponding p value of rho (p (rho), p values (for B index and rho) are in **bold** *when remaining significant (i.e. when smaller than the adjusted α-level (α')), in gray shading when lCI and uCI included zero and when equalB and lCI are equal.*

Table 3: Reproductive skew over three groups and four mating seasons. Number of potential sires (troop + extra group sires) for skew calculation and number of potential sires used for Spearman rank correlation (in parenthesis) (Np), number of observed sires (Nb), number infants sampled (InfS), number infants not sampled (InfnS), alpha male share of paternity (% α-pat), the observed B value (B index), corresponding p value of the B index (p (B index)), B index for an equal sharing of paternity (equalB), B index for complete monopolization of paternity (monopolB), lower confidence interval (lCI: .95 %), upper confidence interval (uCI: .95 %), correlation coefficient for Spearman rank correlation (rho) between dominance rank and paternity success, corresponding p value of rho (p (rho)), p values (for B index and rho) are in **bold** *when remaining significant (i.e. when smaller than the adjusted α-level (α')), in gray shading when lCI and uCI included zero and when equalB and lCI are equal.*

No.	**locus**	**k**	**N**	**H_{Obs}**	**H_{Exp}**	**PIC**	**F(Null)**	**repeat**
1	D1S518	8	195	0.821	0.799	0.770	-0.020	tetra
2	D1S548	4	197	0.680	0.671	0.605	-0.010	tetra
3	D4S2408	8	186	0.672	0.706	0.655	0.025	tetra
4	D4S243	9	193	0.845	0.815	0.788	-0.019	tetra
5	D5S1457	4	197	0.736	0.684	0.627	-0.037	tetra
6	D5S1467	5	197	0.604	0.580	0.491	-0.023	tetra
7	D6S474	15	191	0.859	0.854	0.836	-0.006	tetra
8	D6S501	6	194	0.768	0.696	0.660	-0.066	tetra
9	D7S2204	7	195	0.667	0.692	0.629	0.016	tetra
10	D8S1106	4	196	0.735	0.664	0.590	-0.053	tetra
11	D10S1432	9	186	0.812	0.790	0.758	-0.015	tetra
12	D10S611	4	197	0.807	0.713	0.655	-0.065	tetra
13	D13S765	12	163	0.699	0.737	0.695	0.023	tetra
14	D17S1304	7	194	0.789	0.792	0.760	-0.001	tetra
15	D19S245	11	188	0.787	0.817	0.793	0.020	tetra
16	D2S1333	8	26	0.462	0.725	0.677	0.225	tetra
17	D6S1017	4	33	0.273	0.291	0.260	0.082	tetra
18	D6S493nigra	5	38	0.632	0.711	0.646	0.049	tetra
19	D11S2002	12	43	0.581	0.708	0.673	0.098	tetra
20	D12S67nigra	9	47	0.638	0.735	0.689	0.057	tetra
21	D18S536	7	17	0.647	0.688	0.625	0.029	tetra
Mean		**7.5**	**146.3**	**0.691**	**0.708**	**0.661**	**0.015**	
SD		**3.1**	**73.4**	**0.138**	**0.115**	**0.122**	**0.065**	

Group-Season	Np	Nb	% α-mat	% α-tenure	*B* index	p (*B* index) *α'=0.017*	equal*B*	monopol*B*	lCI	uCI	rho	p (rho) *α'=0.0045*
PT-13	13 (10)	9	20.6	69.7	0.040	**<0.001**	-0.012	0.932	0.019	0.078	-0.103	0.776
PT-14	6 (6)	6	50	97.6	0.130	**<0.001**	-0.023	0.808	0.053	0.248	0.174	0.742
PT-15	4 (4)	4	57.8	98.6	0.073	**<0.001**	-0.010	0.607	0.019	0.168	[a]	[a]
PT-16	10 (10)	9	24.5	70.5	0.032	**<0.001**	-0.009	0.879	0.012	0.064	0.300	0.400
RBM-13	24 (19)	13	12.9	100.0	0.055	**<0.001**	-0.013	1.036	0.031	0.769	0.052	0.832
RBM-14	21 (20)	15	6.4	100.0	0.017	**0.016**	-0.020	0.921	-0.020	0.046	0.189	0.425
RBM-15	14 (12)	10	16.2	98.7	0.031	**<0.001**	-0.006	0.878	-0.006	0.055	0.348	0.268
RBM-16	8 (6)	4	34.4	100.0	0.048	**0.002**	-0.012	1.090	-0.012	0.147	0.580	0.228
RST-13	20 (14)	6	0	95.2	0.026	0.242	-0.132	0.922	-0.132	0.657	-0.162	0.581
RST-14	14 (13)	10	5	97.3	0.016	0.186	-0.046	0.875	-0.046	0.085	-0.573	0.041[b]
RST-15	17 (17)	13	4.2	100.0	0.020	**<0.001**	-0.007	0.913	0.010	0.037	-0.124	0.634
RST-16	19 (17)	15	11.6	100.0	0.047	**<0.001**	-0.006	1.066	0.030	0.109	0.160	0.538
Mean	14.2 (12.3)	9.5	20.3	94. 0	0.045							
SD	6.3 (5.3)	3.9	18.5	11.3	0.032							

[a] Spearman rank test for groups and seasons with less than five potential mating males are not determined.

[b] p value considered significant before comparison with adjusted α-level

Group-Season	Np	Nb	InfS	InfnS	% α-pat	*B* index	P (*B* index) *α'=0.0083*	equal*B*	monopol*B*	lCI	uCI	rho	P (rho) *α'=0.0083*
PT-13	13 (10)	3	8	0	0.0	0.181	**0.004**	-0.111	0.766	0.035	0.497	0.291	0.415
PT-14	7 (6)	6	11	0	27.3	-0.008	0.476	-0.075	1.082	-0.075	0.910	0.883	0.020[b]
PT-15	4 (4)	2	2	0	50.0	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
PT-16	10 (10)	1	1	1	0.0	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
RBM-13	23 (19)	5	9	1	22.2	0.091	0.023 [b]	-0.105	0.873	0.012	0.272	0.474	0.040[b]
RBM-14	21 (20)	6	12	1	33.3	0.087	0.011 [b]	-0.079	0.860	0.015	0.234	0.727	**<0.001**
RBM-15	16 (12)	6	10	1	33.3	0.040	0.173	-0.099	0.999	-0.099	0.321	0.313	0.322
RBM-16	8 (6)	2	3	6	66.7	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
RST-13	19 (14)	6	12	0	10.0	0.088	0.014 [b]	-0.093	0.837	0.012	0.254	0.183	0.531
RST-14	15 (13)	7	10	1	20.0	0.018	0.247	-0.092	0.981	-0.092	0.931	0.733	**0.004**
RST-15	17 (17)	7	10	2	10.0	0.012	0.308	-0.092	0.825	-0.092	0.128	-0.183	0.483
RST-16	17 (17)	8	9	1	11.1	-0.051	0.947	-0.101	0.935	-0.101	0.188	0.299	0.244
Mean	14.17	4.92			23.7	0.051							
SD	5.88	2.31			20.0	0.069							

[a] For groups and seasons with less than five infants sampled there is not enough power to calculate the *B* index. Spearman rank test for groups and seasons with less than five potential sires or with less than five infants sampled are not determined.

[b] p value considered significant before comparison with adjusted α-level