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Heritability in animal breeding pdf file pdf file free

[PMC free article] [PubMed] [Google Scholar]Rogers PL, Gaskins CT, Johnson KA, MacNeil MD. 1967;50:1283-1287. [Google Scholar]Gustafsson L. Heritability was estimated with a linear animal model using a multiple trait derivative free REML set of programs. Heritability of age of first birth in captive olive baboons. Ecological aspects of the heritability of body size in *Drosophila buzzatii*. The comparison of traits that do not contribute to fitness to those that do has been challenged on the basis that much of the variability in heritability estimates may be due to large discrepancies in the number of contributing loci [Merilä & Sheldon, 2000]. 1986;35:353-359. Swoope, Department of Experimental Statistics, Louisiana State University, Baton Rouge, LA for conversion of a numeric-alphabetic identification system to a numeric system and to the sorting and identification of dams of females in the data set. [Google Scholar]Lyons DM, Yang C, Sawyer-Glover AM, Moseley ME, Schatzberg AF. Menstrual cycle characteristics of seasonally breeding rhesus monkeys. *Mol Ecol*. [Google Scholar]Tanida H, Hohenboken HD, DeNise SK. In part, this is a reflection of the fact that data collection in wild populations is often difficult and that many captive species exist only in relatively small populations and have often very limited pedigree information. Intordscip Top Gerontol. 2004]. *J Evol Biol*. [Google Scholar]Falconer DS, McKay TFC. Selection response in traits with maternal inheritance. Death among females occurred on average 1.01 (± 1.16) years after giving birth to their last infant although this, too, revealed a significant range from 0.9-74 years. Adult males were removed from a social group when known or possible daughters reached breeding age and un related males were then introduced.Most females were experimentally naïve. [2002] found substantial heritability coefficients for HDL cholesterol in the same species. [PubMed] [Google Scholar]Wilson ME. 1974;21:61-80. Age social rank and lactational status influence ovulatory patterns in seasonally breeding rhesus monkeys. The estimate of heritability for number of infants born in the lifetime of a female was 0.221 ± 0.138 while the heritability of infant survival ranged from 0.021 ± 0.008 for birth status to 0.064 ± 0.011 for survival of infants at birth to 30 days when estimates were based on using binomial data. It is important to keep in mind that rhesus macaques are seasonal breeders and their reproductive behavior is therefore much more constrained. [Google Scholar]Mousseau TA, Roff DA. Age of female at birth of the first infant is most likely associated with age at puberty while the two subsequent birth intervals are determined by the timing of the return of postpartum menstrual cycles. [PubMed] [Google Scholar]Fisher RA. Because DNA-based techniques to assign paternity through the use of short tandem repeats (STR) or single-nucleotide polymorphisms (SNP) have only recently become available, they could not be used for a retroactive a study covering several decades. ARS-USDA, Washington, DC. 1995. New York: Plenum Press; 1992. [Google Scholar]Ha JC, Ha RR, Almasy A, Dyke B. Such traits are usually described as threshold traits [Lush et al., 1948; Robertson and Lerner, 1949] and were recorded as "1" for survival and "0" for failure to survive. Heritability has also been calculated for anatomical traits such as organ weights. Deceased females had from 1-18 infants with an average of 4.92 (± 3.46) births. Am Natralist. Mousseau & Roff [1997] reviewed heritability estimates from the literature covering a large number of animal populations and showed that fitness traits had significantly lower heritability traits than morphological or physiological traits which are less likely to be subjected to selection pressures. 1983;29:841-848. However, while fitness itself is often only vaguely defined, the interpretations of Fisher's theorem have been challenged as requiring assumptions that are unlikely to be found in natural populations [e.g. Charlesworth, 1987]. The MTDFREML program is an animal model procedure in which all sources of additive genetic relationships among animals (i.e. the females in this study) are used to estimate additive genetic variances. [PubMed] [Google Scholar]Charlesworth B. 1986;128:761-764. *Hum Biol*. 1989;123:803-813. This could contribute to differences among maternal half-sib families and daughter-dam pairs but less among other kinds of relatives. Amer J Primat. 1989;123:865-871. 1990;81:51-57. [2000] found that the decline in heritability in fitness among deer was accompanied by an increase in residual variance in longevity. *Genetica*. 1988;66:640-647. Cold restarts were made to insure a global maximum was reached. Laboratory estimates of heritabilities and genetic correlations in nature. Uncertain paternity in primate quantitative genetic studies. [PubMed] [Google Scholar]Proust T, Barker JSF. Heredity, and Tech; Harlow, UK: 1996. [PMC free article] [PubMed] [Google Scholar]Rogers J, Kochunov P, Lancaster J, Shelledy W, Glahn D, Blangero J, Fox P. Factors determining the onset of puberty. These estimates of heritability may be referred to as residual estimates because the phenotypic variance was reduced by variation due to significant fixed effects in the animal models. 1985;9:87-99. 1998;13:64-69. Atherosclerosis. [Google Scholar]Reale D, Festa-Bianchet M, Jorgenson JT. *Am J Primat*. Use of an average numerator relationship matrix for multiple-sire joining. [PubMed] [Google Scholar]Rawlings RG, Kessler MJ. *Proc Natl Acad Sci (USA)* 2000;97:698-703. [PMC free article] [PubMed] [Google Scholar]Lande R, Kirkpatrick M. Random samples of male and female progeny were routinely removed at 1.5-2 years of age for transfer to other research organizations or to be assigned to research within the TNPRC. [1993] showed modest but statistically significant heritability coefficients for the weights of heart, kidney and liver in the baboon. *Genetics*. Wiley; Chicester: 1987. Similarly, Gustafsson [1986] reported that heritability of a trait was inversely correlated with its association with fitness in the collared flycatcher (*Ficedula albicollis*) while Kruuk et al. Fixed sources of variation found to significantly influence the respective reproductive traits were: age at first reproduction: female birth year, Birth interval after first reproduction: infant birth year, infant birth month, and birth status (alive or dead).Age at second reproduction: female birth year, Birth interval after second reproduction: infant birth year, All birth intervals: infant birth year, infant birth month and birth order, Mean birth interval: female birth year, Time from last baby to death: number of infants born, Number of infants born: female birth year, Female age at death: female birth year, Female age at last infant: female birth year, Birth status (dead or alive): infant sex, infant birth year, infant birth month and female age, Survival birth to 30d: infant birth year, infant birth month and female age, Survival 30d to 1yr: infant sex, infant birth year, and infant birth month, General linear model procedures in SAS were used to determine model fit for each of the reproductive traits given above. Age as a determinant of reproductive success among captive female rhesus macaques (Macaca mulatta) *J Reprod Fertil*. 1991;45:853-861. Introduction to Quantitative Genetics. 1949;34:395-411. 4. All research protocols reported in this manuscript were reviewed and approved by the Tulane National Primate Research Center's (TNPRC) Institutional Animal Care and Use Committee. Average age at second parturition was 5.80 (± 1.09) years with a postpartum birth interval of 1.21 (± 0.53) years. Descriptive statistics for reproductive traits of female rhesus macaques. TraitNo. of records Means min value max value Early reproduction Female age at 1st infant1.8974.440.932.69.1081 after 1st infant 1.4291.380.640.596.16 Female age at 2nd infant1.4365.801.093.7012.0081 after 2nd infant1.0971.210.5304.426.09 Birth intervals All 815.9171.240.560.426.80 Mean B11.4321.300.460.4756.16 Interval from last infant to female death8631.011.160.008.74 Longevity; Production Female age at death86310.424.362.8027.80 Female age at last infant879.564.312.8023.90 No. of infants born at female's death8634.923.461.018.0 Infant survival birth status (alive/dead)7.6170.960.2001 Survival; birth to 30 d47.2870.950.2101 Survival; 30 d to 1 yr6.9950.810.3901 The average postpartum birth interval for all females was 1.30 (± 0.46) years, while for deceased females born before 1991, the average postpartum birth interval was 1.24 (± 0.56) years with a range of 0.42-6.80 years. For deceased females born before 1991, average age at death was 10.4 (± 4.36) years, ranging from 2.8-27.8 years. The heritability of fitness. 1988;66:1614-1621. 1992;27:145-156. A Manual for Use of MTDFREML. Hopefully the growing awareness that maintenance of social structures are important for captive rhesus macaques will lead to gathering of information on social hierarchies which in turn may facilitate genetic studies that can incorporate social rankings in their models. The authors are grateful for the assistance provided by Elizabeth A. Poultry Sci. [Google Scholar]Shaw RG. Evolutionary change is linked to the degree of additive genetic variance present in a population for various traits and natural selection pressures favoring certain phenotypes can result in changes in allele frequency. All research reported in this manuscript adhered to the American Society of Primatologists (ASP) Principles for the Ethical Treatment of Non-human Primates. Genetic analysis of herd life in Quebec Holsteins using Weibull models. Unfortunately, birth weights were not available for any of the infants, which would have facilitated estimates of its influence on survival to 30 days. II. Lifetime reproductive success and heritability: empirical support for Fisher's fundamental theorem. Information on housing and management of the colony was described previously [Gagliardi et al., 2007]. Ninety-six percent of 7,617 births resulted in live infants of which 95% survived the subsequent 30 days and of those a further 81% survived to one year of age. The estimates of heritability for most traits were low (0.00-0.20) or moderate (0.21-0.40) in magnitude and are shown in Table 2. [PubMed] [Google Scholar]Pope NS, Gordon TP, Wilson ME. 1987;59:181-197. *Federal Register*. [PubMed] [Google Scholar]United States Department of Agriculture. SAS Institute Inc; Cary NC: 1996. They concluded that heritability estimates were generally similar to estimates calculated when the paternal parent was assigned. Reale et al. Intl J Primatol. Indeed, models have suggested that maternal genetic effects can significantly influence the rate of evolutionary change [Lande & Kirkpatrick, 1990], although very few studies have actually been reported in which the response of maternal effects to selection pressures has been demonstrated in wild populations [e.g. McAdam & Boutin, 2004]. Sinauer Associates, Inc.; Sunderland MA: 1996. *Trends Ecol Evol*. Quantitative genetics of relative organ weight variation in captive baboons. However, Weigensberg & Roff [1996] compared estimates of heritability measured in a large number of field studies to laboratory estimates on wild, outbred species and reported that most laboratory heritability estimates appear to provide reasonable estimates of the magnitude and significance of heritability in nature. A limitation to the analysis of reproductive traits that could contribute to an over estimation of the heritability coefficients in many non-human primates is their complex social hierarchy. We assume that paternal ties within and across female families within a corral is random, however, we have no way to document this. Animals were cared for and monitored daily by staff trained to provide food and water, observe for sickness or other abnormalities and to record reproductive and survival data. [2002] estimated a very strong genetic component for birth weights of pigtailed macaques, although they did not include its relevance to infant survival in their analysis. The fact that most heritability estimates for reproductive traits in captive rhesus macaque females appear low is consistent with predictions made by Fisher's theorem of natural selection which has been interpreted to mean that alleles in a population that are linked to traits conferring increased fitness should eventually become fixed resulting in low additive genetic variation [Fisher 1930]. Genetic groups in an animal model. [1995] were used to estimate heritability for reproductive traits. 1999;82:2503-2513. [Google Scholar]Williams-Blangero S, Blangero J. Genetic determinants of HDL variation and response to diet in baboons. If these effects cannot be partitioned from the additive genetic variance, they will be part of the estimate of additive genetic variance, and could bias heritability upward [Wilson et al., 2005]. Studies on small groups, where access to males is limited, have demonstrated that a dominant female can nearly monopolize a single male, even when in some cases the male's preference is for females of lower social rank. 2008;36:100-102. *Handbook of Behavioral Neurobiology: Sexual Differentiation*. For example, Kammerer et al. Over 95% of the females born before 1991 contributed to these records. Birth status of infants (alive or dead), survival of live infants at birth to 30 days of age and survival of live infants at 30 days to 1 year of age are generally considered to be maternal traits, although survival of infants from 30 days to 1 year may be due to factors not related to maternal care. Application of Linear Models in Animal Breeding. [PubMed] [Google Scholar]Zehr JL, Van Meter PE, Wallen K. The MIXED procedure of the Statistical Analysis System (SAS) set of programs [Littell et al., 1996] was used to obtain additive genetic and residual variance priors for MTDFREML and to identify the various fixed sources of variation significantly (P < 0.10) influencing each response trait. Average age at last infant was 9.56 (± 4.31) years ranging from 2.80-23.9 years. Evaluating longevity of composite beef females using survival analysis techniques. [2002] reported an analysis of a breeding population of over 600 baboons and calculated a heritability coefficient of 0.23 for age at death. A total of 592 foundation females were identified with an average of 3.2 female members per foundation family. Birth intervals following the first two parturitions, and over all intervals during a female's lifetime had heritability estimates ranging from 0.00 ± 0.072 for the first postpartum interval to 0.134 ± 0.148 for the interval from birth of the last baby to death of the female. Traits that were indicative of a female's life span, such as age at death or age at her last parturition had heritability estimates of 0.325 ± 0.143 and 0.247 ± 0.141, respectively. p. Franke2 Division of Veterinary Medicine, Tulane National Primate Research Center, Covington LA 70433 USA Find articles by H. [Google Scholar]Kammerer CM, Cox LA, Mahaney MC, Rogers J, Shade RE. Eight of the 13 estimates of heritability for reproductive traits in this study were different from zero [P < 0.05]. Theory and analysis of threshold traits. Sexual selection: testing the alternatives. [PubMed] [Google Scholar]Small MF. 1993;65:991-1003. Heritability of body measurements in a natural population of toque macaques (Macaca sinica) Amer J Primat. [PubMed] [Google Scholar]Van Vleck LD. 2000;155:301-310. I Division of Gene Therapy, Tulane National Primate Research Center, Covington LA 70433 USA Find articles by Christine Gagliardi2 Division of Veterinary Medicine, Tulane National Primate Research Center, Covington LA 70433 USA Find articles by Kathrine P. 2004;271:75-79. 1985;2:225-232. 2005;14:2839-2850. Heritability of Brain Size and Surface Features in Rhesus Macaques (Macaca mulatta) *J Hered*. [PubMed] [Google Scholar]Wilson ME, Gordon TP, Bernstein JS. However, the estimate of heritability of age at first birth in the present study was much smaller than that reported for baboons by Williams-Blangero & Blangero [1995], but numerically higher than the estimate obtained by Blomquist [2009] for free ranging rhesus macaques. The estimates of heritability for birth intervals, even when different approaches were used to calculate them, showed only a negligible genetic component. They concluded that when the rate of mis-assignment of sires exceeded 20% or when levels of heritability were increased, heritability was underestimated by up to 17%. *Genetics and Analysis of Quantitative Traits*. 1982;54:1079-1096. The number of female members in foundation families ranged from 2-20. The average number of generations of female relatives per foundation female was 2.7 and ranged from 2.0-4.4. Kinships consisted of maternal half-sib, dam-daughter, dam-granddaughter, dam great-granddaughter, aunt-niece, cousin and other less related females. Significant sources of variation found with proc MIXED were included in the animal model procedure to account for those sources of influence for a particular trait. For other traits, records exceeding a trait mean ± 3 standard deviations (representing 99% of a normal distribution) were removed as were records with an infant sex code of 'unknown'. The reproductive records analyzed were divided into early reproductive traits, birth interval traits, female longevity and productive traits and infant survival. For example, onset of puberty, which is presumably the key factor in determining age at first birth, has been shown to be influenced by social status, with ovulation generally occurring earlier in juveniles from dominant matriline. 1989;83:526-532. This would have been of interest because Ha et al. Estimates of similar lifetime traits in other species have been shown to range from 0.05-0.25 [Durr et al., 1999; Miller et al., 1967; Rogers et al., 2004; Tanida et al., 1988]. Average age at first parturition was 4.44 (± 0.93) years with a subsequent first postpartum birth interval of 1.38 (± 0.64) years. On the low heritability of life-history traits. Hypertension. Heritability of fitness in a wild mammal population. [PubMed] [Google Scholar]Lynch M, Walsh B. Indeed, Martin et al. [PubMed] [Google Scholar]Westell RA, Quass R, Van Vleck LD. This was most evident where heritability estimates for longevity and productivity were moderate and generally significant from zero whereas estimates for birth intervals were generally very low and not different from zero. Sodium-lithium countertransport activity is linked to chromosome 5 in baboons. Thus, the pedigree structure of rhesus females in this study involves a relatively large number of families with a limited number of females per family. Body fat, rank, and nutritional status in a captive group of rhesus macaques. Estimation of heritability of threshold characters. Social and growth correlates of the onset of puberty in female rhesus monkeys. He noted that one limitation of the use of an all female pedigree file is that maternal additive genetic variance could not be obtained in order to calculate an estimate of maternal heritability. The estimates of heritability for the various reproductive traits in this study were variable. It is noteworthy that previous reports have shown that female rhesus macaques can live a substantial amount of time between the birth of their last infant and their own death suggesting the occurrence of menopause in this species [Gagliardi et al., 2007; Borries & Koenig, 2008]. Low estimates of heritability were found for live birth and survival of infants when estimated on the binomial scale; although they were slightly higher when transformed to an underlying normal distribution. Available information on age at puberty and gestation length in rhesus macaque females was used to determine outliers, i.e. for the analysis of female age at first birth a record was omitted if the value was less than 2.6 years and postpartum birth intervals were deleted if they were less than 0.45 years (164 days), regardless of the survival of the previous infant. Reproductive and behavioral characteristics of aging in female Asian colobines. Michael Kubisch Author information Copyright and License information DisclaimerRecords from a colony of captive Indian rhesus macaques (Macaca mulatta) were used to estimate heritability for a number of reproductive traits. To avoid this, females born after 1990 were not included in the analysis for age at death, number of infants born at death or age at the birth of the last infant. The heritability of resistance to death in the fowl. Both traits provide information about the early reproductive success of the female. In contrast postpartum birth intervals between all progeny and mean postpartum birth interval of individual females are measures of reproductive success throughout a lifetime and may suggest a measure of adaptability in a particular environment. Because more recently born deceased females will have younger death ages than their live older contemporaries, they would introduce bias into records relating to age at death. Proc R Soc Lond B. Generally, heritability estimates reported here for reproductive traits of captive rhesus macaque females are similar to those reported in the literature for free ranging rhesus macaque females and for similar reproductive traits of other species. We are not aware of any published heritability estimates for reproductive traits in captive populations of rhesus macaque. Reproductive records from a colony of Indian rhesus macaques maintained at the Tulane National Primate Research Center (TNPRC) in Covington, LA were available from the years 1979 to 2007. *J Anim Sci*. [PubMed] [Google Scholar]McAdam AG, Boutin S. [1999] used an animal model and pedigree file based totally on female relatives for estimation of heritability of body mass in wild bighorn sheep. Primate population studies at Polonnaruwa. *Genet Res*. Genetic aspects of longevity in Angus and Hereford cows. *Biol Reprod* 2004. These effects can be represented in matrix notation as where known matrices X and Z relate the unknown fixed contemporary group (b), the random direct genetic effects (u), and random environmental effects (e), respectively, to observations in y. [PubMed] [Google Scholar]Boldman KG, Kriese LA, Van Vleck LD, Van Tassel CP, Kachman SD. Folia Primatol. The distribution of infant birth dates in this study is similar to that reported by Rawlings & Kessler [1985] for births of rhesus monkeys in a free ranging colony near La Parguera, Puerto Rico, but the peak birth dates in our colony occur slightly later in the year. A reproductive record included identification of the female and the infant, their birthdates, age of female at the time of birth of the infant, subsequent birth intervals, birth order of each infant, infant sex, number of infants produced by the female up to that time in her life, survival of the infant, age of the female at her death or transfer and whether the female was alive, deceased or had been transferred out of the colony. Female age at first, second and last infant and age at death were recorded in years as real numbers with one decimal, while birth interval was recorded in years as a real number with two decimals. Heritability estimates calculated from the animal model were tested for significance from zero by using likelihood ratio tests comparing the likelihood of the full animal model to the likelihood of a model without animal as a source of variation [Lynch & Walsh, 1996; Shaw, 1987]. Simple statistics for the various reproductive traits are given in Table 1. Animal Welfare Standards, Final Rule. 2007;133:819-826. [2001] reported a genetic component on hypertension among baboons, while Rainwater et al. Merilä & Sheldon [2000] concluded that low heritability was the result of an increase in residual variance while Price & Schluter [1991] have proposed that such higher residual variance might be the consequence of the fact that most fitness traits manifest themselves over long periods of time, which makes them more subject to environmental variation. The assumption that heritability estimates calculated in captive populations are reliable indicators of heritability in wild populations has been challenged because those indicators tend to be larger due to a smaller phenotypic variance [Riska et al., 1989; Prout and Barker, 1989]. 1948;27:375-388. In total, 8 of the 13 heritability estimates presented in this study proved to be significantly different from zero (P < 0.05). This study was carried out to determine estimates of heritability for a number of reproductive traits among captive rhesus macaque females maintained in an outdoors facility. Factors regulating the timing of puberty onset in female rhesus monkeys (Macaca mulatta): role of prenatal androgens, social rank, and adolescent body weight. [PubMed] [Google Scholar]Price T, Schluter D. Natural selection and the heritability of fitness components. [Google Scholar]Henderson CR. Maximum likelihood approaches applied to quantitative genetics of natural populations. [1988] have discussed methods to account for unknown paternal parents in multi-sire mating of livestock for quantitative genetic studies. Up to six generations of female kinship were identified in the female pedigrees. The failure to conceive or an embryonic or fetal loss, particularly during the end of the breeding season, can extend the interval between births by a much larger period than would be the case in animals cycling throughout the year. Estimates of heritability for longevity and productivity overall were slightly higher, particularly when defined as the age of a dam's death, age at her last parturition or the overall number of infants she had produced. 30. Although some infants were born in all months of the year, about 80% of the births occurred in April, May and June, with the largest number occurring in May. Female progeny not transferred remained with their natal groups throughout their lives, although some females were moved among corrals to balance numbers. The transformation is: h2n = h2b [P(1 - P)](z2), where h2n is an estimate of heritability on the underlying normal scale, h2b is the estimate of heritability from the linear model using binomial observations, P is the proportion of infants with survival observations of 1, and Z is the height of the ordinate at the truncation point for an area of P under the normal curve. Phenotypic variance unadjusted for fixed effects in each trait is presented. When binomial estimates of heritability were transformed to a normally distributed underlying scale, the estimates increased to 0.108 ± 0.050, 0.290 ± 0.050 and 0.061 ± 0.018 for birth status, survival to 30 days and survival to 1 year, respectively. [PubMed] [Google Scholar] University of Guelph Press; Guelph, Canada: 1984. 1996;50:2149-2157. Lifetime reproductive success and heritability in nature. *Nutr Behav*. Briefly, rhesus females were housed in large outside half-acre corrals that offered activity and housing components with accessibility to food and water. [Google Scholar]Charmanier A, Reale D. Hum Brain Mapp. Maternal genetic effects set the potential for evolution in a free-living vertebrate population. Timing of births and reproductive success in rhesus monkey social groups. Early stress and inherited variation in monkey hippocampus volumes. Similarly, Charmanier & Reale [2005] reported that social and genetic pedigrees in the blue tit bird (*Parus caeruleus*) gave similar heritability estimates when heritability is low and there is a low percentage (5-10%) of mis-assigned sires. 2004;72:1087-1094. Falkenstein3 School of Animal Sciences, Louisiana State University AgCenter, Baton Rouge, LA 70803 Find articles by Donald E. Early reproductive traits included age of female at the birth of the first and second infant and the birth interval after the first and second births. The pedigree file used to calculate the additive genetic covariance (A) matrix included female identification, a '0' for sire of female since sires were unknown and dam of the female. A threshold point P on this underlying normal distribution separates those that survive from those that failed to survive [Gianola 1982; Falconer & McKay 1996; Lynch & Walsh 1996]. The multiple trait derivative free REML (MTDFREML) programs of Boldman et al. The assumption for survival or threshold traits is that there are many loci and environmental effects that create a normal underlying distribution. [PMC free article] [PubMed] [Google Scholar]Robertson A, Lerner IM. Moreover, when fitness traits are considered separately the trend is not always consistent; for example Kruuk et al. Longman Sci. Nevertheless, the low heritability estimates for most reproductive traits in this study confirm observation from other non-domesticated species. Similarly, females that had no parental identification or had no daughters that produced progeny in the colony were omitted from the analysis. 1991;56:32. [PubMed] [Google Scholar]Riska B, Prout T, Turelli M. 01375. Heritability of brain volume, surface area and shape: an MRI study in an extended pedigree of baboons. Animal model procedures using restricted maximum likelihood rely on maximum use of genetic relationships among relatives in the pedigree and allow unbalanced sets of related individuals. Estimates of heritability from the analysis of threshold traits with the linear animal model were transformed to an underlying normal scale using the formula proposed by Robertson & Lerner [1949] and discussed by Van Vleck [1972] and others. These findings are consistent with results from other non-human primate species. [2000] made similar observations in red deer (*Cervus elaphus*). 2009;135:209-219. Natural heritabilities: Can they be reliably estimated in the laboratory? 2002;56:207-213. In: Gerall AA, Moltz H, Ward JL, editors. Higher estimates of heritability were found for female longevity (0.325 ± 0.143) and for productivity of deceased females born before 1991 (0.221 ± 0.138). 1992;27:133-143. Fitness-related patterns of genetic variation in rhesus macaques. 1995;37:233-239. In most instances, higher ranked females appear to initiate sexual activity to a significantly higher degree. The dominant social structure in macaques reported by many authors suggest daughters of dominant females and of subordinate females tend to be more like their mother than like unrelated females. *Genetics and caging type affect birth weight in captive pigtailed macaques (Macaca nemestrina)* *Am J Primatol*. 2000;55:189-197. 2005;18:405-414. All research reported in this manuscript complied with the protocol approved by the TNPRC Institutional Animal Care and Use Committee. This study was funded by NIH grant RR000164. Blomquist GE. Because no male parents were identified, the numerator relationship matrix contained female kinships established over six generations. Records were based on a total of 7,816 births by 1,901 females from 1979 to 2007. [Google Scholar]Cheverud JN, Vannier M, Konigsberg L, Helmkamp RC, Hildebolt C. A few females were exposed to research projects at various times in their lives, but these were removed from our study because of the possibility that experimental treatments may have influenced their subsequent reproductive potential. In: Bradbury JW, Andersson MB, editors. Analyses were initially performed at a convergence of 1 × 10-6 and then rerun to a convergence of the simplex of 1 × 10-9. [PubMed] [Google Scholar]Gianola D. 2002;123:1461-1467. The heritability of all or none traits: viability of poultry. [PubMed] [Google Scholar]Schwartz SM, Wilson ME, Walker ML, Collins DC. These estimates are slightly larger than adjusted or residual phenotypic variance used to estimate heritability in this study. How do misassigned paternities affect the estimation of heritability in the wild? All models had R-square values between 73% and 79% except the models for infant survival traits and the model for all birth intervals, which ranged from 25% to 30%. The assumption underlying a quantitative genetic model is that a response of an individual can be partitioned into fixed contemporary group effects, random (animal) additive genetic effects and random residual effects [Henderson, 1984; Lynch & Walsh, 1996]. Nevertheless, an understanding of inheritance of fitness traits such as fecundity is essential for a better understanding of forces that drive evolution. The objective of this study was to estimate direct additive genetic and phenotypic variance associated with various female reproductive responses in a captive breeding colony of rhesus macaque monkeys and to calculate estimates of heritability using data collected over several decades. 2007;28:576-583. [Google Scholar]Walker ML, Gordon TP, Wilson ME. All animals were housed in conditions approved by the TNPRC Institutional Animal Care and Use Committee and adhered to the requirements described in the Animal Welfare Act [USDA, 1991]. Females included in the data set had given birth to at least one infant. Estimates of heritability for early reproduction ranged from 0.000 ± 0.072 for birth interval following the first reproduction to 0.171 ± 0.062 for age of female at the first infant. Male progeny were removed from their natal groups at puberty (~3.0-3.5 yrs), kept in peer groups for at least two years, and then were introduced to unrelated females. [Google Scholar]Wolf JB, Brodie ED, III, Cheverud JM, Moore AJ, Wade MJ. Blomquist [2009] also reported a low heritability of 0.07 ± 0.19 for average inter-birth interval in rhesus macaques. Cheverud & Dittus [1992] and Konigsbert & Cheverud [1992] used offspring-dam regression as well as maximum likelihood methods to estimate heritability of body measurements in non-human primates when sire of female was unknown. Heritabilities of 0.21 ± 0.17 and 0.08 ± 0.17 were reported for lifespan and for number of offspring produced in a lifetime, respectively, by Blomquist [2009] in rhesus macaques. 2004;82:860-866. Expectations for the random vectors are E(u) = E(e) = 0, which leads to E(y) = Xb. Residual effects are assumed independent from the direct additive genetic effects. A total of 2,557 females contributed information to the A-matrix in the animal model program. Heritability estimates using total and unadjusted phenotypic variance in this study would be only slightly smaller than when using residual phenotypic variance. Summary of heritability estimates for reproductive traits of captive female rhesus macaques (Macaca mulatta) estimated with an animal model. TraitVRAVTPVAPH2 (se)=ProbEarly reproductionAge at 1st infant0.6810.1410.8650.8220.171 (0.062)0.00181 after 1st infant0.3820.0000.4100.3820.000 (0.072)106Age at 2nd infant0.3660.1471.1881.1140.132 (0.077)0.08481 after 2nd infant0.2470.0260.2810.2730.095 (0.098)0.33681 Birth intervalsAll B10.2910.0110.3140.3020.036 (0.010)

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