

**On-line Appendix A** Studies of measures of maternal condition or dominance in ungulates in relation to sex ratio, from which data for meta-analysis were extracted.

Species	Test statistic in paper	Effect size (r)	N	Index of condition or dominance	Sampling time*	Status	Reference	Note
Fallow deer <i>Dama dama</i>	various	-0.017	61	Morphological	Pre	Captive	Birgersson 1998	1
Roe deer <i>Capreolus capreolus</i>	$c^2_1 = 5.40$	-0.095	600	Morphological	Post	Wild	Hewison and Gaillard 1996	2
	$c^2_1 = 9.98$	0.367	74	Body Mass	Post	Wild	Wauters et al. 1995	
	$c^2_1 = 0.92$	-0.134	51	Body Mass	Post	Wild	Hewison et al. 1999	
White-tailed deer <i>Odocoileus virginianus</i>	Calculated from paper	0.0965	468	Morphological	Post	Wild	Burke and Birch 1995	3
Red deer <i>Cervus elaphus</i>	$c^2_1 = 9.92$	0.134	555	Kidney fat index	Post	Wild	Kohlmann 1999	4
	$G_2 = 6.59$	0.262	98	Behavioral dominance	Pre	Wild	Clutton-Brock et al. 1984	5
	$P = 0.0251$	0.249	62	Kidney fat index	Post	Wild	Flint et al. 1997	
Reeve's Muntjac <i>Muntiacus reevesi</i>	Calculated from paper	0.096	135	Body mass	Post	Wild	Chapman et al. 1997	6
Moose <i>Alces alces</i>	$c^2_1 = 3.11$	-0.134	173	Dressed mass	Post	Wild	Nygen and Kojola 1997	7
	Calculated from paper	0.0531	39	Morphological	Unspecified	Captive	Schwartz and Hundertmark 1993	8
Reindeer <i>Rangifer tarandus</i>	$t = 2.47, df = 845$	0.085	847	Morphological	Post	Semi-wild	Kojola and Eloranta 1989	
	$F = +0.374, df = 1,233$	0.007	225	Body mass	Pre	Semi-wild	Kojola 1993	9

	Wilk's F = +0.181, df = 2,439	0.016	484	Weight and back fat	Post	Semi-wild	Kojola and Helle 1994	10
	Calculated from paper	-0.043	1525	Morphological	Post	Semi-wild	Reimers and Lenvik 1997	
	t = 1.36	0.0924	215	Morphological	Post	Wild	Reimers 1999	
	F-tests	0.0217	1658	Morphological	Post	Semi-wild	Weladji et al. (2003)	11
Cape mountain zebra <i>Equus zebra zebra</i>	$c^2_1 = 3.89$	-0.547	13	Behavioral dominance	Continuous	Wild	Lloyd and Rasa 1989	
Bighorn sheep <i>Ovis canadensis</i>	Calculated from paper	0.192	22	Behavioral dominance	Continuous	Wild	Hass 1991	12
Arrui <i>Ammotragus lervia</i>	$r^2 = 0.42, P = 0.04$	0.648	10	Behavioral dominance	Post	Captive	Cassinello 1996	
	$F_{4,28} = 3.1$	0.405	33	Behavioral dominance	Pre	Captive	Cassinello and Gomendio 1996	13
Bison <i>Bison bison</i>	$\chi^2 = 9.47$	0.340	82	Lactation status	Pre	Wild	Rutberg 1986	
	Calculated from paper	0.4105	20	Sex of previous calf	Pre	Wild	Wolff 1988	14
	Calculated from paper	0.1179	34	Behavioral dominance	Post	Wild	Wolff 1988	15
	$\chi^2 = 0.38$	0.0588	122	Lactation status	Pre	Wild	Shaw and Carter 1989	
	Calculated from paper	0.0131	140	Sex of previous calf	Pre	Wild	Wolff 1998	16
Cuvier's gazelle <i>Gazella cuvieri</i>	t = -0.34, t = -1.07	-0.159	21	Weight and body size	Unspecified	Captive	Alados and Escos 1994	17
	$F_{1,13} = 0.84$	0.200	15	Behavioral dominance	Unspecified	Captive	Alados and Escos 1994	18
Pronghorn <i>Antilocapra</i>	r = 0.90, P = 0.04	0.462	18	Behavioral dominance	Unspecified	Wild	Byers 1997	19

<i>americana</i>								
Domestic Horse <i>Equus caballus</i>	$\eta^2 = 4.09$	0.3049	44	Sex of previous foal	Pre	Wild	Monard et al. 1997	20
	$\eta^2 = 7.89$	0.242	77	Body fat score	Pre	Wild	Cameron et al. 1999	21
Domestic Pig <i>Sus scrofa</i>	$t_{84} = 4.66$	0.453	85	Behavioral dominance	Pre	Captive	Meikle et al. 1996	22, 23
<i>domesticus</i>								
		-0.377	22	Behavioral dominance	Post	Captive	Mendl et al. 1995	24
Wild boar <i>Sus scrofa</i>	$r = 0.032$	0.032	49.4	Morphological	Post	Wild	Fernandez-Llario et al. 1999	25
Mountain goat	See note 6	0.211	91	Behavioral dominance	Pre	Wild	Cote and Festa-Bianchet 2001	26
Soay sheep <i>Ovis aries</i>	$\eta^2 = 0.06$	0.0122	406	Morphological	Pre	Wild	Lindström et al. 2002	27
Mouflon <i>Ovis musimon</i>	$\eta^2 = 0.06$	0.0258	90	Morphological	Pre†	Captive	Llandete-Castillejos et al. 2001	28

\*Time of sampling to obtain measure of condition, relative to conception.

† Female condition determined at about the time of conception.

Notes: 1. Effect size is weighted mean of four separate t-tests comparing females that had sons and daughters; weighted by the number of hinds contributing to the analysis.

2. Sample size (number of females) not stated in paper; N = 600 assumed from mean litter size of approximately two.

3. Calculated from data in Tables 1-3.

4. Fitted relationship between sex ratio and KFI suggests an asymptote at a sex ratio of approximately 0.55.

5. Clutton-Brock et al. (1986) treats the same data as in Clutton-Brock et al. (1984), but uses a cohort specific measure of dominance.

6. Combination of results from first year and older breeders, yields effect of body mass on sex ratio:  $\eta^2_1 = 1.25, P = 0.26$ .
7. Sufficient information to calculate effect size for monoparous females only.
8. Calculated from data in Table 3.
9. Comparison of mean body mass of individuals producing a male calf or a female calf (direction of difference is for son producers to be heavier).
10. Test statistic is from a MANOVA with maternal weight and back fat as independent variables, and foetal sex as a predictor, in addition to herd; calculated assuming that one-tailed P testing hypothesis = 0.37.
11. Effect size is the weighted mean of three estimates from different age-classes of female.
12. Population in Montana; effect size calculated from Table IV.
13. Linear relationship between sex ratio and dominance calculated using quoted F-ratio and rank ordering of means versus expected, following Rice and Gaines (1994).
14. Effect of sex of previous calf on next one produced (Table 3 in Wolff 1988).
15. Dominance status of mother in paired interactions with respect to sex of calf (Table 4 in Wolff 1988).
16. Calculated from part of Table 5 in Wolff (1998).
17. Trend is for more males born to small and light females; effect size is the mean of the two reported tests.
18. Trend is for more males born to high-ranking females.
19. Analysis is a regression across 5 dominance quintiles. P-value assumed = 0.05, with N assumed 18 from other analyses of reproductive success in relation to dominance.
20. Paper also reports a non-significant effect of maternal rank on sex ratio, but insufficient data for calculation of an effect size.
21. Statistics based on treating foals as independent (N = 135); weighted by number of mares contributing foals (N = 77).
22. Data in Meikle et al. (1993) are a subset of the data here.
23. Test statistic is comparison of mean sex ratio of high and low ranking sows (paper also reports correlation between percentile dominance ranks and sex ratio as  $r = 0.39, P < 0.03$ ).
24. Relevance of this study questioned by Meikle et al (1996) on the grounds that dominance ranks were not established until after conception.

25. Correlation coefficients and sample size means of five reported correlations between sex ratio and maternal condition.
26. Pers. comm. from S.D. Cote, August 2001.
27. Linear term for mother's weight.
28. Effect size taken from analysis of effect of body condition (scored on a five point scale); effect of body mass on sex ratio is positive:  $\eta^2 = 4.10$ ,  $P = 0.04$ .

**On-line Appendix B** Compilation of all studies located by literature search as being potentially relevant to tests of whether individual sex ratios are related to maternal condition.

Study	Species	Action	Reason for exclusion
Alados & Escos 1994	Cuvier's Gazelle	Included	
Barette & Vandal 1986	Caribou	Excluded	No relevant data
Berube et al. 1996	Bighorn sheep (Alberta)	Excluded	No relevant data
Birgersson 1998	Fallow Deer	Included	
Braza et al. 2000	Fallow Deer	Excluded	No relevant data
Burke & Birch 1995	White-tailed Deer	Included	
Byers 1997	American Pronghorn	Included	
Caley & Nudds 1987	Odocoileus spp.	Excluded	Contains no primary data (commentary on other work)
Cameron et al. 1999	Domestic Horse	Included	
Cassinello & Gomendio 1996	Ammotragus lervia	Included	
Cassinello 1996	Ammotragus lervia	Included	
Chapman et al. 1997	Reeve's muntjac	Included	
Clutton-Brock et al 1986	Red Deer	Excluded	Reports dominance corrected for age
Clutton-Brock et al. 1984	Red Deer	Included	
Cote & Festa-Bianchet 2001	Mountain goat	Included	
Degayner & Jordan 1987	White-tailed deer	Excluded	Have not been able to obtain
Fernandez-Llario et al. 1999	Wild Boar	Included	
Festa-Bianchet 1991	Bighorn sheep (Alberta)	Excluded	Reports dominance corrected for age
Festa-Bianchet 1996	-	Excluded	Contains no new primary data
Flint et al. 1997	Red Deer	Included	
Green & Rothstein 1991	Bison	Excluded	Not enough information to calculate effect sizes
Green & Berger 1990	Bison	Excluded	Contains no data relating to sex ratio
Hass 1991	Bighorn sheep	Included	
Hewison & Gaillard 1996	Roe Deer	Included	

Hewison et al. 1999	Roe Deer	Included	
Hoefs & Nowlan 1994	Six species	Excluded	No relevant data
Hogg et al 1992	Bighorn sheep	Excluded	No relevant data
Kent 1995	Domestic Sheep	Excluded	No relevant data
	Elk ( <i>C. elaphus</i> in Oregon)	Included	
Kohlmann 1999			
Kojola & Eloranta 1989	Reindeer	Included	
Kojola & Helle 1994	Reindeer	Included	
Kojola 1993	Reindeer	Excluded	No relevant data
Kojola 1997a	Reindeer	Excluded	No relevant data
Kojola 1997b	General	Excluded	No primary data – a review of other work
Kojola 1998	general	Excluded	No primary data – a review of other work
Kruuk et al. 1999	Red Deer	Excluded	Dominance effect significant only in interaction
Kucera 1991	Mule deer	Excluded	Analysis includes barren females with no sex ratio defined
Llandete-Castillejos et al. 2001		Included	
	Mouflon		
Lindström et al. 2002	Soay sheep	Included	
Lloyd & Rasa 1989	Cape mountain zebra	Included	
Mansell 1974	White-tailed Deer	Excluded	No relevant data
McCullogh 1979	White-tailed Deer	Could not obtain	
Meikle et al. 1993	Domestic swine	Excluded	Data are a subset of those in Meikle et al. (1996)
Meikle et al. 1996	Domestic swine	Included	
Mendl et al. 1995	Domestic swine	Included	
Mlikovsky 1988	Przewalski horse	Excluded	Contains no relevant data
Monard et al. 1997	Domestic horse	Included	
Novellie et al. 1996	Cape mountain zebra	Excluded	Only reports relationship between age and sex ratio
Nygen & Kojola 1997	Moose	Included	
Owen-Smith 1988	<i>Ceratotherium simum</i>	Excluded	Reports only relationship between age and sex ratio
Pederson & Harper 1984	White-tailed deer	Excluded	Comparison of different populations
Reimers & Lenvik 1997	Reindeer	Included	
Reimers 1999	Reindeer	Included	
Robinette et al. 1957	Mule deer	Excluded	Generally comparisons between populations
Robinette et al. 1973	Mule deer	Excluded	Comparison of herd on different diets
Rutberg 1986	American bison	Included	

Saltz & Rubenstein 1995	Wild ass	Excluded	No data on individual condition and sex ratio
Saltz 2001	Asiatic wild ass	Excluded	Only data on age and sex ratio
	Persian fallow deer <i>Dama dama mesopotamica</i>	Excluded	Only data on age and sex ratio
Saltz 2001			
San Jose et al. 1999	Fallow Deer	Excluded	No relevant data
Schwartz & Hundertmark 1993	Moose	Included	
Shaw & Carter 1989	American bison	Included	
Skogland 1986	Reindeer	Excluded	Comparison between populations
Smith et al. 1996	Red deer	Excluded	Comparison between populations
Thomas et al. 1989	Reindeer	Excluded	Insufficient detail presented for meta-analysis
Verme 1965	White-tailed Deer	Excluded	Comparison of groups on different diets
Verme 1969	White-tailed Deer	Excluded	Comparison of groups on different diets
Verme 1983	<i>Odocoileus</i> spp (3)	Excluded	Review of other work
Verme 1985	White-tailed Deer	Excluded	Comparison of groups on different diets
Verme 1989	White-tailed deer	Excluded	Comparison of groups on different diets
Wauters et al. 1995	Roe Deer	Included	
Weladji et al. 2003	Reindeer	Included	
Wolff 1988	American bison	Included	
Wolff 1998	American bison	Included	
Woolf & Harder 1979	deer sp	Excluded	No relevant data
Yang et al. 1989	Pig	Excluded	No relevant data

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### On-line Appendix C Life-history data for ungulates used in meta-analysis

Species	Litter Size	Gestation	Ad m mass	Ad f mass	Mating system	Social Organization	Sources
Fallow Deer <i>Dama dama</i>	1	235.5	68	44.6	lek	Herd	1
White-tailed Deer <i>Odocoileus virginianus</i>	1.8	203.5	110	55	single female defence	solitary	1
Red Deer <i>Cervus elaphus</i>	1	235	185.1	140.2	rut	Herd	1
Roe Deer <i>Capreolus capreolus</i>	2.14	294	24.2	23.4	single female defence	solitary	1, 7
Reeve's Muntjac <i>Muntiacus reevesi</i>	1	210	14.7	11.8	male dom poly	solitary	1
Moose <i>Alces alces</i>	1.4	245	510.2	358.8	Rut	solitary	
Reindeer <i>Rangifer tarandus</i>	1	225	145	85.8	harem poly	Herd	1
Cape Mountain Zebra <i>Equus zebra zebra</i>	1	365	255	234.3	harem poly	Herd	8
Arrui <i>Ammotragus lervia</i>	1.18	160	111.8	51.6	harem poly	Herd	1
Bison <i>Bison bison</i>	1	285	795.3	452.8	rut	Herd	1
Cuvier's Gazelle <i>Gazella cuvieri</i>	1.4	170	29.4	20.4	harem poly	Herd	5
Pronghorn <i>Antilocapra americana</i>	2	250	56.2	49.8	Rut	Herd	1,2
Horse <i>Equus caballus</i>	1	337	265	235	Harem poly	Herd	
Pig <i>Sus scrofa</i>	6	115	200	130	male dom poly	Herd	1
Mountain Goat <i>Oreamnos americanus</i>	1	180	95.9	61	unknown	Herd	1,6
Bighorn Sheep <i>Ovis canadensis</i>	1.5	175	83.4	58.7	male dom poly	Herd	1
Soay Sheep <i>Ovis aries</i>	1.15	165	32.6	22	rut	Herd	10
Mouflon <i>Ovis musimon</i>	1.33	170	42.5	27.5	male dom poly	Herd	9

Sources: 1. McDonald (2001). 2. Byers (1997). 3. Nowak (1999). 4. Perez-Barberia and Gordon (2000). 5. Olmedo et al. (1985). 6. Cote and Festa-Bianchet (2001). 7. Andersen and Linnell (1997) Variation in maternal investment in a small cervid: the effects of cohort, sex, litter size and time of birth in roe deer (*Capreolus capreolus*). 8. Skinner and Smithes (1990). 9. Llandete-Castillejos et al. (2001). 10. Lindström et al. 2002. 11. Pelabon et al. (1995). Note: Took the midpoint of quoted ranges, if no mean was indicated.

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