Effects of goat social rank on kid gender

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ABSTRACT: Mechanisms of gender ratio in progeny are complex and the fine details are still largely unknown, even in mammals. Though the 50% ratio of males and females is expected, various factors have been shown to be effective in diverting the ratio from the expected. In this study, dominance index, effects of sire, age of dam, birth type and year of birth on the gender ratio of Turkish Saanen goat kids were investigated in a full model. The analysis indicated that dominance index (DI) of the dam had a significant influence on the gender ratio of kids (P = 0.036). Certain sires tended to father female descendants repeatedly and the dams with high dominance index gave birth to male kids. Effects of sire on kid gender approached significance (P = 0.094). Age of dam, year and birth type were insignificant.

Keywords: goat; gender ratio; sire effect; age; birth type

The progeny's gender ratio in mammals has many consequences. The genetic contribution of an animal to the succeeding generations is affected by the gender of its descendants (Clutton-Brock and Iason, 1986; West et al., 2000). In addition, the gender of progeny is of great importance in livestock production (Gray and Katanbaf, 1985). Dairy producers prefer female progeny while meat producers prefer male progeny.

Animals form a social hierarchy that keeps aggressive behaviour under check, which minimizes energy losses (Karaağaç et al., 2003). The structure of hierarchy is affected by several factors, such as the presence of horns, live weight and age of the goat (Barroso et al., 2000; Cote, 2000; Tölü and Savaş, 2003). The presence of horns encourages animals to fights and animals with horns belong to the top ranks of any herd (Cote, 2000; Tölü and Savaş, 2007). Animals at the top ranks of a herd tend to be more aggressive (Orgeur et al., 1990; Barroso et al., 2000; Cote, 2000; Tölü and Savaş, 2007), which causes the subordinate animals to be kept under constant pressure (Pusey et al., 1997). The social hierarchy of the herd may prevent the animals from accessing the food resources equally. Thus, the dominant animals benefit more from feed, water, shade and resting spaces compared to the subordinate animals, both in quality and quantity (Andersson et al., 1984; Mosley, 1999; Barroso et al., 2000; Phillips and Rind, 2002). Because the dominant animals can use the resources more efficiently, their condition increases and it has been shown that dams in better conditions tend to give birth to male descendants (Kojola, 1997; Cameron et al., 1999; Hewison et al., 1999). Cote and Festa-Bianchet (2001a) studied social hierarchy in mountain goats and reported that the top animals had higher reproductive performance. Alvarez et al. (2003) reported that goats higher in the social hierarchy had easier detection of heat and had higher pregnancy rates. Cote and Festa-Bianchet (2001b) stated that the probability of male progeny increased as the rank in social hierarchy increased in mountain goats. Górecki and Koscinski (2003) reported that goats with horns and high hierarchy rank had a higher probability of giving birth to male progeny.

Effects of the sire on gender ratio depend on age (Jacobsen et al., 1999), dominance rank and condi-

tion of the sire (Clutton-Brock et al., 1984; Graves et al., 1985), ejaculation interval (Chandler et al., 1998) and breed differences (Gorecki, 2003). Other factors effective on gender ratio include age of dam (Cote and Festa-Bianchet, 2001; Gorecki and Koscinski, 2003; Weladji et al., 2003), litter size (Gorecki, 2003), parity, season of mating (Sethi and Rao, 1981; Tomar and Tripathi, 1988), population size and the amount of precipitation (Kruuk et al., 1999a; Lindström et al., 2002).

The major purpose of this study was to investigate the effects of dominance index of the dam, sire, age of dam, birth type and year of birth on gender ratio in dairy goats.

MATERIAL AND METHODS

The data was collected from 225 Turkish Saanen goat kids, born in the Research Centre of the Çanakkale Onsekiz Mart University between the years 2002 and 2004. The Turkish Saanen breed was developed by crossing the Saanen breed with local goats during the last 25 years. These goats have an average of 240 days of lactation and they produce 600 kg milk yield per lactation on average.

In the university herd, the goats are hand mated. Hornless bucks were not used in hornless goats so that hermaphrodism would not occur. The average litter size is 1.4. The births are done in closed barns while the adult goats are normally kept in semi-open barns. The bucks are kept separately from the herd. The herd grazes during the day with a shepherd on natural or grain pasture, or around bushes. Births take place once a year. The goats are machine-milked twice a day and they are fed concentrate during milking, including grains and concentrate pellets. They are fed lucerne, vetch, dry oat and corn silage as roughage.

The number of subordinate and dominant goats to the animal at hand was counted by direct observations of individual fights in the herd. For easy identification, ID numbers of the goats were dyed on their both sides. The herd was observed for two months and the interactions between the individual goats were recorded. If a goat hits, bites or threatens another goat, and the one being threatened backs off or runs away, the one running is labelled as the subordinate and the aggressor is labelled as the dominant goat (Tölü and Savaş, 2007).

The dominance index of Lamprecht (1986) was used to quantify the social hierarchy:

DI = number of animals subdominant/(number of animals dominant + number of animals subdominant) × 100

The dominance index (DI) of an animal is the ratio of the number of subordinates to the total number of animals in the herd. A high index value indicates a high rank within the herd.

Fisher's exact test (Agresti, 1992) was used in 618 goat-kids' gender data, collected between 1997 and 2004, to check whether the gender ratio significantly differed from the hypothesized value of 50%.

The statistical analysis was performed in SAS (1999) package program according to Generalized Estimating Equations (GEE) Logistic Regression method using the Genmod procedure.

The model used for analyses was:

$$y = \beta + A + B + C + D + E + F + \varepsilon$$

where:

y = gender of the kid (♀ = 0, ♂ = 1)
β = intercept
A = dominance index of the dam
B = sire effect (1,.., 6)
C = age of the dam (1,.., 7)
D = birth type (single, multi)
E = year of birth (2002, 2003, 2004)
F = repeated effect of goats (1,.., 72)
ε = error term

Table 1 indicates statistics that summarize the fit of the model. Deviance divided by the degrees of freedom is used to detect over-dispersion or under-dispersion. Values higher than one indicate overdispersion, i.e. the true variance is higher than the mean, values smaller than one indicate underdispersion, i.e. the true variance is smaller than the mean. Values closer to one indicate a better fit. The values in Table 1 indicate that the specified models fit the data reasonably well.

RESULTS

Between the years 1997 and 2004, 283 female and 335 male kids were born. During these eight years there were 52 more male kids, and on average 46% of the kids were female and 54% were male. Fisher's exact test indicated that there were no significant differences between the genders ($P = 0.23$).

Dominance index (DI) of the dam had a significant influence on the gender ratio of kids ($P = 0.036$; Table 2). The probability of having a male kid increased with the increasing dominance index of the

Table 1. Fitness of the full model

Distribution criterion	Degrees of freedom (DF)	Deviance	Deviance/DF
Binomial	196	271.22	1.38
Poisson	196	133.77	0.68
Negative binomial	196	133.77	0.68

Table 2. Number of kids (n), chi-square values (χ^2) and P-values

Variable	n	χ^2	P
Dominance index	211	4.27	0.036
Sire	211	9.81	0.094
Age of dam	427	2.28	0.892
Birth type	618	1.10	0.294
Year	618	7.21	0.408

dam (Table 3). The highest-ranking animals with a dominance index over 0.80 gave birth to 58% of male kids while the animals with a dominance index under 0.20 gave birth to only 47% of male kids. Different sires had different gender ratios in their progeny (P = 0.094). The estimations in Table 3 indicate that sire "9887" produced mainly female progeny. The probability of the remaining animals siring more male descendants was 3.3 to 7.4 times higher than in sire "9887". The variables year, birth type and age of dam had insignificant effects on the gender of kids (P = 0.294 – 0.892, Table 2).

DISCUSSION

Though there were no significant differences between the genders in this study, there were more male kids born than females. There are many reports with the number of males being higher than the number of females. In several studies (Hohenboken et al., 1987; Singh et al., 1991; Bansod and Jagtap, 1992; Kumar et al., 1992; Belsare et al., 1993; Demirci and Gür, 1993) the male progeny ratio ranged from 50.4% to 73.8%. Similar results were reported in humans who have a higher ratio of male newborns to female newborns (Parazzini et al., 1998; Jacobsen et al., 1999; Çelik et al., 2003; Grech et al., 2003). This is usually balanced by the higher death rate of male children and young men. Female humans tend to live longer than males, the balance shifts towards the females at old age.

Dominance index of the dams significantly affected the gender ratio of kids in this study. High dominance index increases the probability of dam having male progeny (Clutton et al., 1986; Gomendio et al., 1990; Boesch, 1997; Cameron et al., 1999; Cote and Festa-Bianchet, 2001b; Gorecki and Koscinski, 2003). The physiological cost for the dam is higher for male progeny than for female progeny, which sets the higher probability of male progeny for the animals higher in the hierarchy. The

Table 3. Estimation (b), standard error (SE) and confidence intervals (90%) for the sire effects and dominance index of the dams

Variable		b		SE	Confidence intervals 90%	
Dominance index		2.1		1.05	0.44	3.91
Sire	9887	0.0	a	0.00	0.00	0.00
	2042	1.3	b	0.52	0.45	2.15
	2101	1.2	b	0.71	0.05	2.38
	2216	1.8	b	0.94	0.28	3.38
	2251	2.0	b	0.98	0.42	3.66
	4188	1.3	ab	1.03	–0.37	3.01

The difference P = 0.10 is indicated by different letters

males are born heavier than females and raising the male progeny is more complex and requires more resources (Kruuk et al., 1999b). In addition, the probability of male progeny reproduction is smaller than in female progeny because of the high competition among males. However, if a dam produces several male progeny, then the chances that one of these male progeny will reproduce increase and thus, the dam will have success because its male progeny will have a great contribution, greater than any female progeny ever could (Andersson, 1994). The animals higher in the hierarchy can better use resources such as roughage, water, resting places etc. compared to the lower rank animals (Andersson et al., 1984; Mosley, 1999; Barroso et al., 2000; Phillips and Rind, 2002). If these resources improve the condition of high-ranking parents, they could produce more males than the low-ranking dams (Trivers and Willard, 1973).

Effects of sire on kid gender approached significance (P = 0.094) (Table 2). Even if a buck has a low probability of siring the male progeny, the age of the sire may change the progeny gender. The data record containing the progeny of sire "9887", which was always older than 3.5 years, in the years was used. The sires in the other groups were younger than 3.5 years. Jacobsen et al. (1999) reported that the effects of father's age and number of children per plural birth were significant in humans and the ratio of males decreased as father's age increased. They reported that the male ratio decreased with the paternal age from 51.6 in fathers <25 years to 51.0 in fathers aged ≥40 years. Gorecki (2003) reported that different sires with different testosterone levels could have different gender ratios in their progeny. In this study, older sires had more female progeny, which could be due to lower testosterone levels compared to younger sires (Harman et al., 1978).

In contrast to studies by Cote and Festa-Bianchet (2001b), Gorecki and Koscinski (2003) and Weladji et al. (2003), the analysis in this study indicated insignificant effects of dam's age on gender ratio. Cote and Festa-Bianchet (2001b) worked with mountain goats and reported that age significantly affected the rank of the animal. The same authors also reported that the female-progeny ratio of dams that were six years old or younger was 70%, while the female-progeny ratio of dams that were 10 years old or older was only 25%. As the animals age, they can benefit more from the resources and improve their weight and body condition, increasing in the ranks of the herd. The presence of horns, however, is an important factor in determining dominance and it sometimes suppresses the age effect (Tölü and Savaş, 2003).

CONCLUSION

In this study, the top animals of social hierarchy had horns; they were heavier and more aggressive compared to those in the lower ranks. These dominant animals tended to give birth to male descendants. Physiological and molecular genetic investigations may be needed to investigate the matter further and to clarify the working mechanisms.

REFERENCES

Agresti A. (1992): A survey of exact inference for contingency tables. Stat. Sci., 7, 131–177.

Alvarez L., Martin G.B., Galindo F., Zarco L.A. (2003): Social dominance of female goats affects their response to the male effect. Appl. Anim. Behav. Sci., 84, 119–126.

Andersson M. (1994): Sexual Selection. Monographs in behaviour and ecology. Princeton University Press.

Andersson M., Schaar J., Wiktorsson H. (1984): Effects of drinking water flow rates and social rank on performance and drinking behaviour of tied-up dairy cows. Livest. Prod. Sci., 11, 599–610.

Bansod R.S., Jagtap D.Z. (1992): Gender ratio of crossbred calves field and organised farm. Indian Vet. J., 69, 655–656.

Barroso F.G., Alados C.L., Boza J. (2000): Social hierarchy in the domestic goat: effect on food habits and production. Appl. Anim. Behav. Sci., 69, 35–53.

Belsare V.P., Singh V.P., Chourasia S.K., Singh N.P. (1993): Factors affecting secondary gender ratio in Friesian × Sahiwal crossbreds. Indian J. Anim. Reprod., 14, 124.

Boesch C. (1997): Evidence for dominant wild female chimpanzees more in sons. Anim. Behav., 54, 811–815.

Cameron E.Z., Linklater W.L., Stafford K.J., Veltman C. J. (1999): Birth gender ratios relate to mare condition at conception in Kaimanawa horses. Behav. Ecol., 10, 472–475.

Çelik K., Serbest S., Vurur S., Pala A., Dağlioğlu K. (2003): Experiments to investigate the factors that affect the rate of gender constitution. Pak. J. Nutr., 2, 238–241.

Chandler J.E., Steýnholt-Chenevert H.C., Adkýnson R.W., Moser E.B. (1998): Sex ratio variation between ejaculates within sire evaluated by polymerase chain reaction, calving, and farrowing records. J. Dairy Sci., 81, 1855–1867.

Clutton-Brock T.H., Iason G.R. (1986): Gender ratio variation in mammals. Q. Rev. Biol., 61, 339–374.

Clutton-Brock T.H., Albon S.D., Guinness F.E. (1984): Maternal dominance, breeding success and birth sex ratios in red deer. Nature, 308, 358–360.

Clutton-Brock T.H., Albon S.D., Guinness F.E. (1986): Maternal dominance, breeding success and birth gender ratio in Red deer. Nature, 308, 460–471.

Cote S.D. (2000): Dominance hierarchies in female goats: stability, aggressiveness and determinants of rank. Behaviour, 137, 1541–1566.

Cote S.D., Festa-Bianchet M. (2001a): Reproductive success in female goats: the influence of age and social rank. Behaviour, 62, 173–181.

Cote S.D., Festa-Bianchet M. (2001b): Offspring sex ratio in relation to maternal age and social rank in mountain goats (*Oreamnos americanus*). Behav. Ecol. Sociobiol., 49, 260–265.

Demirci E., Gür S. (1993): Effect of age, breeding year and gender of foetus on pregnancy length in Brown Swiss cows. Med. Sci. Mag., 7, 124–129.

Gomendio M., Clutton-Brock T.H., Albon S.D., Guinness F.E., Simpson M.J. (1990): Mammalian gender ratios and variation in costs of rearing sons and daughters. Nature, 343, 261–263.

Górecki M.T. (2003): Sex ratio in litters of domestic pigs. Biol. Lett., 40, 111–118.

Górecki M.T., Koscinski K. (2003): Offspring sex ratio in domestic goat (*Capra hircus*). Arch. Tierz., 46, 277–284.

Graves H.B., Hable C.P., Jenkins T.H. (1985): Effects of morphology and dominance on female spatial behaviour. Behav. Proc., 11, 189–197.

Gray E., Katanbaf M.N. (1985): Gender ratio and distribution of genders in swine. J. Hered., 76, 36–38.

Grech V., Vassallo-Agius P., Savona-Ventura C. (2003): Secular trends in gender ratios at birth in North America and Europe over the second half of the 20th century. J. Epidemiol. Community Health, 57, 612–615.

Harman S.M., Danner R.L., Roth G.S. (1978): Testosterone secretion in the rat in response to chorionic gonadotrophin: alterations with age. Endocrinology, 102, 540–544.

Hewison A.J.M., Andersen R., Gaillard J.M., Linnell J. D.C., Delorme D. (1999): Contradictory findings in studies of sex ratio variation in roe deer (*Capreolus capreolus*). Behav. Ecol. Sociobiol., 45, 339–348.

Hohenboken W.D., Seifert G.W., Aspden W.J. (1987): Genetic and environmental influences on offspring gender ratio and neonatal survival in Bos Induces × Bos Taurus cattle. J. Anim. Brit. Genet., 104, 309-316.

Jacobsen R., Moller H., Mouritsen A. (1999): Natural variation in the human gender ratio. Hum. Reprod., 14, 3120–3125.

Karaaḡaç F., Özcan M., Savaṭ T. (2003): Verlauf von aggressivem Picken and einigen Verhaltensmerkmalen in rangordnungsinstabilen Käfiggruppen bei Legehennen. Arch. Tierz., 46, 391–396.

Kojola I. (1997): Social status and physical condition of mother and sex ratio of offspring in cervids. Appl. Anim. Behav. Sci., 51, 267–274.

Kruuk L.E.B., Clutton-Brock T.H., Albon S.D., Pemberton J.M., Guinness F.E. (1999a): Population density affects gender ratio variation in Red deer. Nature, 399, 459–461.

Kruuk L.E.B., Clutton-Brock T.H., Rose K.E., Guinness F.E. (1999b): Early determinants of lifetime reproductive success differ between the sexes in Red deer. Proc. R. Soc. Lond., B, 266, 1655–1661.

Kumar A., Lavania G.S., Lathwal S.S. (1992): Gender ratio in crossbred cattle. Indian J. Anim. Res., 26, 25–28.

Lamprecht J. (1986): Structure and causation of the dominance hierarchy in a flock of bar-headed geese (*Anserindicus*). Behaviour, 96, 28-48.

Lindström J., Coulson T., Kruuk L., Forchhammer M.C., Coltman D.W., Clutton-Brock T. (2002): Sex ratio variation in Soay sheep. Behav. Ecol. Sociobiol., 53, 25-30.

Mosley C.J. (1999): Influence of social dominance on habitat selection by free-ranging ungulates. In: Launchbaugh K., Sanders K., Mosley J. (eds.): Proc. Grazing Behaviour of Livestock and Wildlife. Idaho Forest, Wildlife and Range Experiment Stn. Bull #70, Univ. ID. 23-24 March, 109–118.

Orgeur P., Mimouni P., Sinoret J.P. (1990): The influence of rearing conditions on the social relationships of young male goats (*Capra hircus*). Appl. Anim. Behav. Sci., 27, 105–113.

Parazzini F., Carlo L.V., Levi F., Fransceschi S. (1998): Trends in male: female ratio among newborn infants in 29 countries from five continents. Hum. Reprod., 13, 1394–1396.

Phillips C.J.C., Rind M.I. (2002): The Effects of social dominance on the production and behavior of grazing dairy cows offered forage supplements. J. Dairy Sci., 85, 51–59.

Pusey A., Williams J., Goodali J. (1997): The influence of dominance rank on the reproductive success of female chimpanzees. Science, 277, 828–831.

SAS (1999): SAS OnlineDoc®, Version 8, Cary, NC., USA.

Sethi R.K., Rao M.K. (1981): Variation in gender ratio in dairy cattle. Indian J. Dairy Sci., 34, 454–456.

Singh A., Kirmani M.A., Choudhary R.P. (1991): Factors affecting gender ratio in crossbred cattle. Indian Vet. J., *68*, 282–285.

Tölü C., Savaş T. (2003): Factors affecting rank-order development in goats. In: 2nd Joint Meeting of Departments of Animal Science of the Balkan Countries Associated with the 32nd Annual Session of Scientific Communications of the Bucharest Faculty of Animal Science, 15–17 October, Romania.

Tölü C., Savaş T. (2007): A brief report on intra-species aggressive biting in a goat herd. Appl. Anim. Behav. Sci., 102, 124–129.

Tomar S.S., Tripathi V.N. (1988): Inheritance of gender ration in murrah buffaloes. Indian Vet. J., 65, 687–692.

Trivers R.L., Willard D.E. (1973): Natural selection of parental ability to vary the sex ratio of offspring. Science, 179, 90–92.

Weladji R.B., Holand R., Yoccoz N.G., Lenvik D. (2003): Maternal age offspring sex ratio variation in reindeer (*Rangifer tarandus*). Ann. Zool. Fenn., 40, 357–363.

West S.A., Herre E.A., Sheldon B.C. (2000): The benefits of allocating gender. Science, 290, 288–290.

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