Secondly, because they are easily captured and because they have rather small home ranges, a high percentage of the population can be marked thus reducing the chance of error in calculation of the minimum number known to be alive. Therefore, although *S. elegans* provides an ideal opportunity to test these censusing procedures, application of the results to other species is limited. Nevertheless verification of censusing techniques is an important aspect of ecological research that should not be neglected.

Acknowledgements: Sigma Xi and the Kathy Lichty Memorial Fund of the University of Colorado provided financial aid. Dr. Olwen Williams gave many useful suggestions and guidance. Dr. Steven Telleen assisted with some of the field works. Dr. Guy Steuek performed the statistical analysis. James Ha and Drs. D. McCracken and G. Steuek made helpful suggestions when reviewing the manuscript.

REFERENCES

Bergerud A. T., 1968: Numbers and densities. Pp 21—42, [In: »A practical guide to the study of the productivity of large herbivores«, F. B. Golley and H. K. Buechner, eds.]. IBP Hdb. No. 7, Blackwell Sci. Publ.: 1—308, Oxford. — Hadow H. H., 1972: Freeze-branding: a permanent marking technique for pigmented mammals. J. Wildl. Manage., *36:* 645—649. — Jolly G. M., 1963: Estimates of population parameters from multiple recapture data with both death and dilution — deterministic model. Biometrika, *50:* 113—128. — Krebs C. J., 1972: Computer programs for analysis of demographic data from small mammal populations. 17 pp. mimeo. — Zegers D. A. 1977: Energy dynamics and role of Richardson's ground squirrel (*Sphermophilus richardsonii elegans*) in a montane meadow ecosystem. Ph. D. thesis, Univ. Colorado, Boulder 177 pp. — Zegers D. A. & Williams, O., 1979: Energy flow through a population of Richardson's ground squirrels. Acta theriol., *24:* 221—235.

Accepted, October 3, 1980.

Secondary Sex Ratio in Siberian Tigers, Przewalski Horses and European Bisons

STOSUNEK PŁCI U TYGRYSA SYBERYJSKIEGO, KONIA PRZEWALSKIEGO I ŻUBRA

Luděk BARTOŠ

Bartoš L., 1981: Secondary sex ratio in Siberian tigers, Przewalski horses and European bisons. Acta theriol., 26, 7: 125—128.

[Res. Inst. Anim. Prod., 251 61 Praha 10 — Uhříněves, Czechoslovakia].

There are many publications on the sex ratio of various mammalian species, mainly laboratory animals. The aim of this paper was to analyse three species kept in zoos, for various factors in connection with the sex ratio of their progeny. These were the Siberian tiger *Panthera tigris altaica* (Temminck, 1844), the Przewalski horse *Equus przewalskii,* Poliakov, 1881, and the European bison *Bison bonasus* (Linnaeus, 1758). All the data used were obtained from the pedigree books of individual species, and cover progeny registered in zoological gardens all over the world, during the period 1940 — 1976 in Siberian tigers (Seifert &

Müller, 1976—1978), 1905—1976 in Przewalski horses (Volf, 1960—1977) and 1926—1972 in European bisons (Żabiński, 1947, 1949, 1952, 1957—1959, 1962, 1964, 1966a, 1966b, 1972—1974). Unfortunately the more recent data on European bison were not available. The secondary sex ratio of all three species was analysed according to the following factors: parental age, parental individuals, post-natal mortality (until the age of 1 year), sibs or litter order (and size in tigers), seasonal and annual influence. Chi-square method was used for statistical analysis.

Total sex ratio. Total sex ratio (♂♂ : ♀♀) was 0.991 (n=1131) in Siberian tigers; 0.909 (n=590) in Przewalski horses and 1.064 (n=2000) in European bison.

Parental age. No significant relationship was found between paternal age and the sex ratio of progeny in tigers and bisons. On the other hand, in the Przewalski horse a significant shift in sex ratio towards ♂♂ was recognised in the progeny of the paternal age group of 20 years ($P < 0.05$). Maternal age plays no role in the sex ratio of tigers' progeny. In European bison old cows (group of 17 and more years of age) it was found that they produced a lower sex ratio of the progeny (0.866; $P<0.05$). A similar tendency was also noticed in Przewalski horses. Mares of the age of 5 years produced offspring of a higher sex ratio (1.619; $P<0.05$), while older mares (16 years) produced a low sex ratio (0.389; $P < 0.05$).

Maternal age at first parturition. There were no age classes at first parturition which showed any shift of sex ratio in horses and bison. Tiger ♀♀ being 4 years old at first parturition had significantly higher ♂♂ proportion in progeny (1.284; $P<0.05$).

Parental individuals. Three ♂♂ tigers, 1 Przewalski horse stallion and four European bison bulls were recognised to have progeny of significantly different sex ratio than other fathers of the species (Table 1). While two ♂♂ produced a high sex ratio and 1 ♂ a low one in tigers, all four bison bulls produced a low sex ratio. Mothers producing significant shift of sex ratio in their progeny were found in tigers and bisons only (Table 1). Half the mothers of both species produced a higher sex ratio and *vice versa*.

Postnatal mortality until the age of 1 year did not show any significant shift of sex ratio in tigers and bison. A significant preponderance of ♂♂ was found in horses (1.475; $P<0.05$).

Sibs or litter order and size. No significant difference was found between the litter order (1 to 8 and more) and size (1 to 5 young per litter) in tigers. The second sibs' sex ratio was higher (1.298; $P<0.05$) in horses. However, this tendency was not indicated in either the first or other sibs. European bison born as first progeny of their mothers had a high sex ratio (1.476; $P<0.01$) compared to other sibs.

Season. There were no seasons showing shifts of the sex ratio in horses. In tigers the offspring from January, July and October showed a significant shift of the sex ratio ($0.273-P<0.05$; $1.727-P<0.01$; $2.333-P<0.01$). In European bisons, however, the sex ratio of progeny born in May and June was very different, showing opposite trends ($0.668-P<0.01$; $1.233-P<0.01$).

Table 1

Parental individuals significantly influencing the shift of their progeny's sex ratio. [1] Dead.

Species	Parent Register number	Name	Progeny Sex ratio	n	$P <$	Site
FATHERS						
Siberian tiger	84	Ulan	3.000	20	0.05	Praha
	187	Alexis II.	0.444	26	0.05	Baton Rouge
	336	—	6.000	21	0.01	Paris
Przewalski horse	285	Askania	0.480	37	0.05	Praha
European bison	789	Plamiec	0.273	14	0.05	Smardzewice
	1211	Plutamir	0.300	13	0.05	Niepołomice
	1450	Poleszuk	0.300	13	0.05	Białowieża
	1641	Herward	0.250	10	0.05	Basel
MOTHERS						
Siberian tiger	2	Sachsa	0.268	18	0.05	Hamburg[1]
	69	Pjassina	3.000	20	0.05	Toronto
	107	Cilla	0.333	20	0.05	Rotterdam
	150	—	3.000	20	0.05	Paris
Przewalski horse	—	—	—	—	—	—
European bison	157	Borghild	5.500	13	0.05	Warszawa
	242	Puma	0.250	10	0.05	Niepołomice
	760	Puzorka	4.500	11	0.05	Niepołomice
	871	Murzilka	0.111	10	0.001	Sierpuchov

Annual sex ratio. A low sex ratio was seen in 1967 in tigers (0.480; $P<0.05$). A high sex ratio was produced in 1970 (2.222; $P < 0.05$) in horses. In bisons two calendar years showed a raised sex ratio: in 1959 (1.679; $P<0.05$) and in 1965 (1.550; $P < 0.05$) respectively.

DISCUSSION

The results of the analysed sex ratios of the three species are rather different, showing no general tendency except the incidence of parental individual' influence on the sex ratio of their descendants. Parental individual' influence sex ratio were recorded, for example, in domestic bulls (McWhirter, 1956), in pigs (Nishida *et al.*, 1972), in men (Bernstein, 1975; Renkonen *et al.*, 1962; Shettles, 1970) etc.

Studies of large collections of statistics on farm or laboratory animals showed that there is no general relationship between litter order and size, season, etc., and sex ratio for instance in pigs (Nishida *et al.*,

1969; Nishida *et al.*, 1972), rats (Nishida & Nakama, 1971) and mice Nishida *et al.*, 1974). However, many previous authors, having studied much smaller collections of data, belived that they found some regularities regarding the sex ratio of progeny. In this respect it may be suggested that most of statistically significant findings in the three zoo species might be accidental, although in general, species-specific differences might exist.

Acknowledgements: I am indepted to Miss. H. Hykšovà and Miss. L. Poláková for excelent technical assistance in the preparation of the data for statistical analysis. I also thank to Mrs. R. Kenworthy who kindly reviewed the English text.

REFERENCES

Bernstein M. E., 1975: Factors affecting sex ratio. New England J. Med., *292:* 650. — McWhirter K. G., 1956: Control of sex ratio in mammals. Nature, Lond., *178:* 870—871. — Nishida S., Ino T. & Kondo M., 1974: Secondary sex ratio in ten inbred strains of mice. Nat. Inst. Anim. Hlth. Quart., *14:* 145—152. — Nishida S., Mamba K., Seta S., Otsuka J., Shudo S. & Tokoro K., 1969: Sex ratio of offspring in domestic animals. Pigs. Jpn. J. Zootech. Sci., *40:* 449—462. — Nishida S. & Nakama K., 1971: The sex ration in rat. Jpn. J. Anim. Reprod., *17:* 74—78. — Nishida S., Otsuka J., Ohashi T., Sugawara K. & Yamagishi T., 1972: sex ratio of offspring in domestic animals: Swine III. Jpn. J. Zootechn. Sci., *43:* 187—192. — Renkonen K. O., Mäkelä O. & Lehtovaara R., 1962: Factors affecting the human sex ratio. Nature, Lond., *194:* 308—309. — Seifert S., Müller P., 1976—1978: International tiger studbook. Zool. Garden, Leipzig. — Shettles L. B., 1970: Factors influencing sex ratios. Int. J. Gynec. Obstet. *8:* 643—647. — Volf J., 1960—1977: Pedigree book of the Przewalski horse. Zool. Garden, Prague. — Żabiński J., 1947, 1949, 1952, 1957—1959, 1962, 1964, 1966a, 1966b, 1972—1974: European bison pedigree book. Polish Scient. Publish., Warsaw.

Accepted, December 20, 1979.