

Effect of a behaviour type of female Arctic fox (*Vulpes lagopus*) on the results of their reproductive performance

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The aim of the presented study was to determine the effect of behavior type observed in Arctic fox females on their reproductive performance, as determined using the empathic test and the feeding test. The study involved Arctic fox females kept in a commercial fur farm, located in the western part of the Wielkopolskie province, Poland. In the years 2002-2008 vixens in the foundation stock were evaluated based on their behavioural response (the empathic test and the feeding test). In order to assess the degree of balance and confidence of Arctic foxes for each animal participating in a given test the index test (IT) and the behavioural index (IB) were calculated. The coefficients of heritability and repeatability were estimated for trusting behaviour, as defined on the basis of IT and IB. The results of this study confirm the opinion that females with a docile-confident behaviour type, as determined using both the empathic test and the feeding test, were characterised by better reproduction performance indexes. The recorded values of the coefficients of heritability (in the empathic test – 0.10, in the feeding test – 0.23) and the coefficient of repeatability (the empathic test – 0.12, the feeding test – 0.26) were low.

KEY WORDS: Arctic fox / type of behaviour / reproduction

Arctic foxes are semi-wild animals, at present being in the course of the domestication process. In view of the short time period, over which foxes have been kept under unnatural conditions, considerable fearfulness and distrust among fur farm animals is a common phenomenon, while the level of their fear of humans may depend both on environmental and genetic factors [6, 8, 9, 10, 13]. Numerous studies [3, 4, 5, 8, 11, 14, 15, 18, 19, 20] have shown the existence of differences between the type of behaviour in females and results of their breeding performance. Insight into behavioural genetics has facilitated the

development of several tests, which may be applied to determine the behaviour type in animals [1, 4, 7, 14, 16].

The aim of this study was to determine the effect of the type of behaviour in Arctic fox females, as determined based on the empathic and feeding tests, on the reproduction performance results.

Material and Methods

The material for analyses comprised Arctic fox females kept in a commercial fur farm located in the western part of the Wielkopolskie province. In the years 2002-2008 the type of behaviour was evaluated for all the females in the foundation stock based on the type of their behavioural response (in the empathic and feeding tests). Animals, depending on the result of the behavioural test, were evaluated in the qualitative scale (type of behaviour) and in the quantitative scale (as a point score), which was developed and verified based on the results of endocrine testing.

In order to assess the degree of balance and confidence in Arctic foxes for each animal participating in a given test type the basic index test (IT) and the behavioural index (IB) were calculated in the form of a total score according to the following formulas:

$$IT = \frac{\sum b}{n_i \cdot (N_T - n_i + 1)}$$

where:

IT – index test,

b – the number of points given to a fox in the test,

N_T – the number of all replications of the test performed for a given age group of foxes,

n_i – the number of test replications, in which the fox participated;

$$IB = \frac{\sum IT_2}{n_2} + \frac{\sum IT_3}{n_3}$$

where:

IB – behavioural index,

IT_2 – index test expressed in a 2-point scale,

IT_3 – index test expressed in a 3-point scale,

n_2 – the number of test types expressed in a 2-point scale, in which the fox participated,

n_3 – the number of test types expressed in a 3-point scale, in which the fox participated.

Depending on the type of test the basic index test (IT) could assume values ranging from 0 points (animals, which in all the replications of the test were evaluated as fearful) up to the maximum score of 2-3 points (foxes, which in all the replications were classified as gentle or trustful). In the total score for the behavioural index (IB) animals could receive from 0 to 5 points.

Breeding records supplied data on reproductive performance of vixens (2002-2008), i.e. the number of mated and sterile females, those which produced young and which destroyed the litters, dates of mating and delivery, the number of kits born and weaned from the litter.

Statistical analyses were conducted using the SAS (ver. 9.1) software package, while genetic parameters were estimated using the DFREML programme (ver. 3.0) [17].

Results and Discussion

In the tested population we observed all the behaviour types indicated in the tests. Depending on the applied research method various numbers of animals were recorded in individual behaviour groups.

In the empathic test fearful vixens accounted for the greatest percentage of animals (Table 1), while the least numerous groups comprised aggressive and gentle animals (below 5% each), and those with an indifferent behaviour type (over 10%). The numbers of animals in individual groups differing in temperament remained comparable in the successive reproduction seasons. Results of the feeding test were more uniform, while still animals with an undesirable behaviour type predominated (Table 1). In 2003 and 2005 females with a trusting behaviour type constituted a majority in the foundation stock.

A similar percentage distribution for behaviour types based both on the empathic test and the feeding test was obtained in their studies by Przysiecki et al. [15]. Results of the empathic test conducted by Filistowicz et al. [5] showed no Arctic foxes with an aggressive behaviour type, with indifferent animals predominating (74.45%), followed by fearful animals (22.22%), while the least numerous group comprised animals of a gentle temperament (3.33%). In the analogous empathic test performed at ZZD Chorzew [7] foxes with a normal (positive) behaviour type predominated (72.38%), followed by a group of

Table 1

Percentage of females with different types of behavior as determined by empathic test and the feeding test in the subsequent breeding seasons

Type of behavior	Percentage of females with different types of behavior in the subsequent breeding seasons						
	2002	2003	2004	2005	2006	2007	2008
Empathic test							
Aggressive	4	2	2	2	2	3	3
Curious	5	3	4	4	3	1	2
Indifferent	17	13	14	13	15	10	14
Fearful	74	82	80	81	80	86	81
Feeding test							
Trustful	43	51	39	52	45	42	44
Fearful	57	49	61	48	55	58	56

aggressive animals (20.99%), while fearful animals accounted for the lowest percentage (6.63%) in that population.

Animals with similar behaviour types, regardless of the applied test, were characterised by comparable levels of investigated reproduction performance traits (Tables 2 and 3).

Table 2

Effect of type of behavior in female Arctic foxes, defined on the basis of a feeding test, on the level of reproductive traits

Type of behavior	Date of mating		Date of birth		Length of pregnancy		Number of kits born		Number of kits weaned	
	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd
Trustful n=572	81.36 ^a	10.80	133.21 ^a	10.69	51.85	1.57	10.48	3.09	7.73	2.64
Fearful n=620	80.00 ^b	10.94	131.90 ^b	10.81	51.90	2.03	10.36	3.26	7.44	2.99

aA – in the columns, the means indicated by different letters differ significantly: lower case letters – $P \leq 0.05$, capital letters – $P \leq 0.01$

Table 3

Effect of type of behavior in female Arctic foxes, defined on the basis of an empathic test, on the level of reproductive traits

Type of behavior	Date of mating		Date of birth		Length of pregnancy		Number of kits born		Number of kits weaned	
	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd	\bar{x}	Sd
Aggressive n=23	76.46 ^{Aa}	10.30	128.04 ^{Aa}	10.48	51.58	1.38	10.63	2.79	6.65 ^a	3.09
Curious n=29	82.14 ^B	9.34	134.00 ^B	9.43	51.86	1.43	11.18	3.40	8.02 ^b	3.19
Indifferent n=163	80.05	11.60	131.75	11.58	51.70	2.65	10.80	3.03	7.82	3.39
Fearful n=977	80.83 ^b	10.81	132.75 ^b	10.65	51.92	1.66	10.32	3.20	7.50	3.04

aA – in the columns, the means indicated by different letters differ significantly: lower case letters – $P \leq 0.05$, capital letters – $P \leq 0.01$

Females classified as trustful in the feeding test (Table 2) were characterised by a delayed onset of the copulation season as well as a later date of delivery when compared to fearful vixens. Trustful animals produced a slightly greater number of kits and were more caring mothers. Also females classified as gentle in the empathic test (Table 3) produced and reared the largest number of kits, particularly in comparison to fearful and aggressive animals. Moreover, among animals manifesting aggressive behaviour forms the greatest losses were recorded in the number of reared kits (3.98 head). Among the four behaviour types aggressive females entered the reproduction season on average 5 days earlier when compared with gentle and fearful vixens, with the difference in the date of delivery between aggressive and gentle females amounting to almost 6 days and being statistically highly significant (Table 3).

Results of this study are consistent with the findings reported by other authors, who showed that calm females of Arctic foxes had better reproduction performance results than fearful and aggressive females and stated a dependence between behaviour types of females and their breeding performance traits [6, 8, 13, 15, 19]. It was confirmed that females with a calm temperament are better at rearing the young than aggressive or fearful females [3, 10, 13, 15, 16, 18, 20]. According to Filistowicz et al. [5], the number of sterile females was much lower in skulls composed of trustful animals, while gentle females showing no fear of humans reared larger litters.

The recorded values of Pearson's correlation coefficients (Table 4) between the level of trust in Arctic fox females and their reproduction performance traits showed significant dependencies between the behaviour types and the number of kits born and reared from the litter. In contrast, no relationship was observed between the level of trust and the date of oestrus, the date of delivery or length of pregnancy.

In his study Belyaev [2] showed a correlation between aggressive behaviour of females and the date of oestrus. It was found that females with a gentle temperament started their reproduction season earlier.

Table 4

Simple Pearson correlation coefficients between the level of confidence determined by its indices ($IT_{empathic}$, $IT_{feeding}$, IB) and reproductive traits

Trait	$IT_{empathic}$	$IT_{feeding}$	IB
Date of mating	0.27	-0.03	0.14
Date of birth	0.28	-0.01	0.16
Length of pregnancy	-0.05	0.14	0.06
Number of kits born	0.51***	0.58***	0.68***
Number of kits weaned	0.51***	0.50***	0.63***

***Correlation values significant at $P \leq 0.001$

Table 5

The coefficients of heritability (h^2) and repeatability (t) of trustful behavior, determined on the ground of particular index test (IT) and the behavioral index (IB)

Indicator of trustful behavior	$h^2 \pm SE$	t
IT _{empathic test}	0.10 \pm 0.04	0.12
IT _{feeding test}	0.23 \pm 0.07	0.26
IB	0.09 \pm 0.05	0.13

Recorded values of the coefficients of heritability and repeatability (Table 5) were low, while higher values were obtained only for the feeding test index. Low heritability of trusting behaviour in the empathic test and in the total behavioural index probably resulted from the predominance of foxes with the fearful behaviour type and limited phenotypic and genetic variability in the group of analysed animals.

Values of estimated parameters are consistent with the results reported by Kenttämies et al. [12]. Studies conducted in Finland and Norway showed low heritability of trusting behaviour in the feeding test. The mean value of this parameter was 0.12 in the Norwegian population and 0.20 in the Finnish population, respectively. Estimated coefficients of repeatability amounted to 0.24 in Finland and 0.32 in Norway. In turn, Belyaev [2] in the study on selection of red foxes for trust in humans obtained a very high repeatability of the behaviour ($t=0.85$).

Summing up the obtained results it needs to be stated that:

- trustful females (the feeding test) produced a slightly larger number of kits and were more caring mothers;
- reproduction performance of gentle females (the empathic test) was characterised by much better index values when compared to aggressive and fearful females;
- results of this study confirm the opinion that females with a gentle–trusting behaviour type, identified both in the empathic and feeding test, are characterised by better values of reproduction performance traits.

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