G-Banded Karyotypes of Four Egyptian Species of Order Carnivora (Mammalia: Carnivora)

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Summary The chromosomes of 4 carnivorous species were prepared and karyotyped from a bone marrow. 3 species from family Canidae including the Red Fox (*Vulpes vulpes*), the domestic dog (*Canis familiaris*) and a wild dog (*Lycaon pictus*) have a diploid chromosome numbers and fundamental numbers of, $2n=38$ and $FN=72$, $2n=78$ and $FN=80$, $2n=38$ and $FN=68$, respectively while the diploid number and fundamental number of Domestic cat (*Felis catus*) which belongs to the family Felidae are $2n=38$ and $FN=72$. Although the 3 species of *V. vulpes*, *L. pictus* and *F. catus* have the $2n=38$, they are clearly different in their chromosome morphology and G-banded karyotypes.

Recently, vertebrate systematics was based almost entirely on comparative morphological studies, recent advances in biochemistry and other areas have enabled systematists to utilize different kinds of data in determining phylogenetic and taxonomic relationships. Although the systematic value of comparing chromosomes of different species was known for several years, vertebrate cytogenetics was largely ignored until the technological breakthrough of Moorhead *et al.* (1960), Bickham and Baker (1976). However, many studies have indicated that G-banding patterns are conservative in related species of mammals (Pathak *et al.* 1973) and even between related genera (Evans *et al.* 1973, Hassan *et al.* 1994). The studies concerning the chromosome banding pattern of carnivores are not enough (Wurster-Hill and Centerwall 1982). On the other hand G- and R-banding has been investigated several times in the domestic cat but there is a total lack of sequential and counterstain-enhanced fluorescence studies in this species (Kalat *et al.* 1990).

Order carnivora was exposed for many cytogenetic studies to determine the karyological and phylogenetic relationships among its individuals such as Dutrillaux and Couturier (1983), Wayne *et al.* (1987), Laikre *et al.* (1992), Qumsiyeh (1994), Suzuki (1994) and Arnason (1996). The karyotypes of the family Canidae vary considerably in their chromosome number and morphology. The diversity of autosome morphology ranges from completely acrocentric in several species including domestic dog (*Canis familiaris*, $2n=78$) and the grey wolf (*Canis lupus*, $2n=78$), to entirely metacentric in red fox (*Vulpes vulpes*, $2n=38$) and wild dogs (Chiarelli 1965, Wurster-Hill and Centerwall 1982, Makinen 1985, Wayne *et al.* 1987). The uniformity of the karyotype pattern of family Felidae is recorded by Wurster and Benirschke (1968) and Wurster-Hill and Centerwall (1982) while, 30 species have studied, 25 of them are reported to have a diploid chromosome number of 38 and 5 to have 36, and the FN varies only from 70 to 76.

Materials and methods

Individuals of the 4 species, *Vulpes vulpes*, *Canis familiaris*, *Lycaon pictus* and *Catus felis* (two mals and two females from each species) were obtained from an animal dealer. They were collected from different localities around Qena city in Upper Egypt.

Air-dried bone marrow slides were prepared for the study of mitotic chromosomes according to Adegoke and Nadesan (1986) with some modifications made by Adegoke and Ejere (1991) and

(a)

(b)

Fig. 1. Male mitotic karyotypes of *Vulpes vulpes*, a) conventional Giemsa stain, b) G-banding, arrow indicates to sex chromosomes from a female.

Fig. 2. Idiogram of the chromosomes of male *Vulpes vulpes* which was constructed in respect to the relative length.

Salama *et al.* (1995) as follows: Animals were injected with 0.05% colchicine for 2–3 h before sacrifice, bone marrow was extracted with 0.56% KCl, cells from bone marrow were fixed three times with freshly prepared fixative of glacial acetic acid and methanol (1 : 3), respectively. Some slides were stained with conventional Giemsa while others were aged for G-banding. The G-banding technique of Seabright (1971) was used. This method involves aging fixed slides, flooding them with 0.025% buffered trypsin and finally stained with buffered 5% Geimsa stain, banding of long chromosomes are quite useful for identification of the daughter chromosomes. More than 15 spreads were counted to determine the diploid chromosome number and at least 10 mitotic metaphases were karyotyped from each species. Measurements and calculations were made and chromosome lengths were standardized as a percent of the total complement length. Centromeric position is described according to criteria established by Levan *et al.* (1964).

Results

Red fox (Vulpes vulpes)

V. vulpes has $2n=38$ and $FN=72$ arranging in 3 different groups of chromosomes. Group A consists of 13 pairs metacentric chromosomes with relative length ranges from 3.75% to 8.10%, group B has 3 subtelocentric pairs in which the relative length varying from 4.93% to 6.67%, group C has only 2 pairs of microchromosomes which appear to be acrocentrics in some spreads with relative length of 1.38% and 1.48%. X-chromosome is large metacentric which nearly has the size of no. 14, while Y-chromosome is very small nearly having the same size of no. 17 that appears in some spreads with high resolution to be biarmed (Figs. 1, 2, Table 1).

Domestic dog (Cains familiaris)

The domestic dog metaphase karyotype consists of 78 chromosomes and $FN=80$. All autosomes exhibit acrocentric configurations gradually diminish in size. These features make identification of homologous pairs by conventional staining be very difficult, so the using of Giemsa banding method facilitates this problem. The relative length of the autosomes ranges from 1.17% to

Table 1. Average of chromosomes measurements and classification obtained from observations on ten spreads *Vulpes vulpes*

Chromosome Pair No.	Chromosome lengths			Relative lengths %		Arm ratio Mean $\pm$ S.D	Centromeric index Mean $\pm$ S.D	Classification	
	Long arm Mean $\pm$ S.D	Short arm Mean $\pm$ S.D	Total Mean $\pm$ S.D	Long arm Mean $\pm$ S.D	Short arm Mean $\pm$ S.D				Total Mean $\pm$ S.D
1	0.51 $\pm$ 0.11	0.46 $\pm$ 0.06	0.97 $\pm$ 0.16	4.26 $\pm$ 0.32	3.84 $\pm$ 0.30	8.10 $\pm$ 0.47	1.11 $\pm$ 0.11	47.40 $\pm$ 2.43	M
2	0.54 $\pm$ 0.09	0.33 $\pm$ 0.03	0.87 $\pm$ 0.11	4.56 $\pm$ 0.35	2.78 $\pm$ 0.28	7.33 $\pm$ 0.47	1.66 $\pm$ 0.02	37.86 $\pm$ 2.78	M
3	0.44 $\pm$ 0.08	0.36 $\pm$ 0.06	0.81 $\pm$ 0.13	3.69 $\pm$ 0.22	3.05 $\pm$ 0.21	6.74 $\pm$ 0.23	1.22 $\pm$ 0.14	45.27 $\pm$ 2.81	M
4	0.44 $\pm$ 0.07	0.34 $\pm$ 0.06	0.77 $\pm$ 0.13	3.65 $\pm$ 0.16	2.81 $\pm$ 0.15	6.46 $\pm$ 0.18	1.30 $\pm$ 0.10	43.53 $\pm$ 1.91	M
5	0.40 $\pm$ 0.04	0.30 $\pm$ 0.06	0.70 $\pm$ 0.10	3.35 $\pm$ 0.18	2.49 $\pm$ 0.20	5.85 $\pm$ 0.24	1.36 $\pm$ 0.15	42.59 $\pm$ 2.71	M
6	0.34 $\pm$ 0.04	0.29 $\pm$ 0.05	0.63 $\pm$ 0.08	2.88 $\pm$ 0.15	2.46 $\pm$ 0.33	5.30 $\pm$ 0.37	1.20 $\pm$ 0.12	45.55 $\pm$ 2.53	M
7	0.36 $\pm$ 0.04	0.25 $\pm$ 0.05	0.62 $\pm$ 0.08	3.02 $\pm$ 0.26	2.12 $\pm$ 0.29	5.14 $\pm$ 0.35	1.45 $\pm$ 0.23	41.18 $\pm$ 4.07	M
8	0.36 $\pm$ 0.04	0.25 $\pm$ 0.05	0.61 $\pm$ 0.08	3.04 $\pm$ 0.24	2.07 $\pm$ 0.28	5.11 $\pm$ 0.30	1.50 $\pm$ 0.26	40.46 $\pm$ 4.12	M
9	0.34 $\pm$ 0.04	0.24 $\pm$ 0.04	0.58 $\pm$ 0.08	2.86 $\pm$ 0.17	2.01 $\pm$ 0.10	4.85 $\pm$ 0.06	1.43 $\pm$ 0.15	41.43 $\pm$ 2.54	M
10	0.32 $\pm$ 0.06	0.23 $\pm$ 0.02	0.55 $\pm$ 0.08	2.67 $\pm$ 0.13	1.91 $\pm$ 0.13	4.57 $\pm$ 0.16	1.41 $\pm$ 0.13	41.29 $\pm$ 1.88	M
11	0.28 $\pm$ 0.06	0.24 $\pm$ 0.04	0.52 $\pm$ 0.09	2.35 $\pm$ 0.29	2.00 $\pm$ 0.23	4.35 $\pm$ 0.29	1.20 $\pm$ 0.24	46.06 $\pm$ 4.85	M
12	0.29 $\pm$ 0.04	0.21 $\pm$ 0.04	0.50 $\pm$ 0.07	2.41 $\pm$ 0.25	1.78 $\pm$ 0.23	4.18 $\pm$ 0.32	1.38 $\pm$ 0.23	42.45 $\pm$ 4.34	M
13	0.24 $\pm$ 0.07	0.21 $\pm$ 0.04	0.45 $\pm$ 0.10	1.95 $\pm$ 0.36	1.79 $\pm$ 0.23	3.75 $\pm$ 0.57	1.09 $\pm$ 0.11	48.08 $\pm$ 2.50	M
14	0.61 $\pm$ 0.06	0.18 $\pm$ 0.03	0.79 $\pm$ 0.08	5.15 $\pm$ 0.42	1.51 $\pm$ 0.18	6.67 $\pm$ 0.43	3.45 $\pm$ 0.51	22.76 $\pm$ 2.60	S.T
15	0.51 $\pm$ 0.10	0.16 $\pm$ 0.03	0.70 $\pm$ 0.12	4.32 $\pm$ 0.69	1.36 $\pm$ 0.16	5.25 $\pm$ 0.57	3.19 $\pm$ 0.45	23.34 $\pm$ 1.54	S.T
16	0.46 $\pm$ 0.09	0.14 $\pm$ 0.03	0.59 $\pm$ 0.12	3.80 $\pm$ 0.26	1.13 $\pm$ 0.13	4.93 $\pm$ 0.40	3.38 $\pm$ 0.17	22.85 $\pm$ 0.87	S.T
17	0.18 $\pm$ 0.05	0.0	0.18 $\pm$ 0.05	1.48 $\pm$ 0.19	0.0	1.48 $\pm$ 0.19	∞	0.0	Acro.
18	0.17 $\pm$ 0.04	0.0	0.17 $\pm$ 0.04	1.38 $\pm$ 0.13	0.0	1.38 $\pm$ 0.13	∞	0.0	Acro.
X	0.42 $\pm$ 0.05	0.33 $\pm$ 0.09	0.75 $\pm$ 0.12	3.54 $\pm$ 0.29	2.80 $\pm$ 0.48	6.34 $\pm$ 0.72	1.30 $\pm$ 0.19	43.80 $\pm$ 3.49	M
Y	0.20 $\pm$ 0.05	0.0	0.20 $\pm$ 0.05	1.62 $\pm$ 0.22	0.0	1.62 $\pm$ 0.22	∞	0.0	Acro.
Sum			11.93 $\pm$ 1.69

(a)

(b)

Fig. 3. Male mitotic karyotypes of *Canis familiaris*, a) conventional Giemsa stain, b) G-banding, arrow indicates to sex chromosomes from a female.

Fig. 4. Idiogram of the chromosomes of male *Canis familiaris* which was constructed in respect to the relative length.

4.78%. The metacentric X-chromosome represents the largest one of the karyotype with relative length of 5.46% while Y-chromosome is medium-sized submetacentric with relative length of 3.5% (Figs. 3, 4, Table 2).

Wild dog (Lycaon pictus)

This species has $2n=38$ and $FN=68$, the chromosomes are arranged in the karyotype in 4 groups as follows: Group A is composed of 6 metacentric pairs with relative length varies from 3.63% to 6.57%, group B has 3 pairs of submetacentric chromosomes with relative length ranges from 4.46% to 8.35%, group C has 5 subtelocentric pairs with relative length ranges from 4.9% to 7.54%, group D is composed of 4 acrocentric pairs in which the relative length ranges from 2.44% to 3.97%. Regarding sex chromosomes, X-chromosome is metacentric with relative length of 7.4% which nearly equals no. 10 in size, while Y-chromosome is microchromosome which appears to be acrocentric with relative length of 1.25% (Figs. 5, 6, Table 3).

Domestic cat (Felis catus)

The diploid chromosome number and fundamental number of this species are $2n=38$ and $FN=72$ with 4 groups of chromosomes. Group A is composed of 4 submetacentric pairs with relative length ranges from 5.28% to 8.55% while group B has 6 metacentric pairs with relative length varies from 2.92% to 7.82%, group C consists of 6 pairs of subtelocentrics in which the relative length ranges from 3.5% to 6.90% and the last group D has only 2 acrocentric pairs with relative length of 2.89% and 2.2% for the large and smaller ones. X-chromosome is metacentric nearly equals no. 17 in size, while Y is also metacentric equals no. 16 in size (Figs. 7, 8, Table 4).

Discussion

The number of species in family Canidae is 35 (Van Gelder 1978). Fundamental and diploid numbers have been published for only about half (19) of the species in which the diploid numbers vary from 34 to 78 and the FN for over 90% of the reported species range from 66 to 80 (Ward *et al.* 1987). Several karyological studies were carried out on the red fox. Wodsedalek (1931) described the diploid chromosome number of 42 for this species while Andres (1938) and Mayr *et al.* (1986) reported the diploid number of 34 and Bishop (1942) a diploid number of 32. The exact diploid number of this species was reported by Renzoni and Omodeo (1972) and Wayne *et al.* (1987) to be $2n=38$.

Our karyotypic data of *V. vulpes* (Figs. 1, 2) of $2n=38$ and $FN=72$ are in complete agreement

Table 2. Average of chromosomes measurements and classification obtained from observations on ten spreads *Canis familiaris*

Chromosome Pair No.	Chromosome lengths			Relative lengths %			Arm ratio Mean±S.D	Centromeric index Mean±S.D	Classification
	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D			
1	0.57±0.06	0.0	0.57±0.06	4.78±0.05	0.0	4.78±0.50	∞	0.0	Acro.
2	0.48±0.05	0.0	0.48±0.05	3.95±0.21	0.0	3.95±0.21	∞	0.0	Acro.
3	0.44±0.07	0.0	0.44±0.07	3.67±0.29	0.0	3.67±0.29	∞	0.0	Acro.
4	0.41±0.06	0.0	0.41±0.06	3.41±0.40	0.0	3.41±0.40	∞	0.0	Acro.
5	0.39±0.05	0.0	0.39±0.05	3.24±0.08	0.0	3.24±0.08	∞	0.0	Acro.
6	0.39±0.05	0.0	0.39±0.05	3.24±0.08	0.0	3.24±0.08	∞	0.0	Acro.
7	0.38±0.04	0.0	0.38±0.04	3.17±0.10	0.0	3.17±0.10	∞	0.0	Acro.
8	0.37±0.06	0.0	0.37±0.06	3.08±0.13	0.0	3.08±0.13	∞	0.0	Acro.
9	0.37±0.06	0.0	0.37±0.06	3.07±0.13	0.0	3.07±0.13	∞	0.0	Acro.
10	0.37±0.05	0.0	0.37±0.05	3.03±0.14	0.0	3.03±0.14	∞	0.0	Acro.
11	0.37±0.05	0.0	0.37±0.05	3.03±0.14	0.0	3.03±0.14	∞	0.0	Acro.
12	0.34±0.07	0.0	0.34±0.07	2.80±0.18	0.0	2.80±0.18	∞	0.0	Acro.
13	0.34±0.07	0.0	0.34±0.07	2.80±0.18	0.0	2.80±0.18	∞	0.0	Acro.
14	0.34±0.07	0.0	0.34±0.07	2.80±0.17	0.0	2.80±0.17	∞	0.0	Acro.
15	0.33±0.05	0.0	0.33±0.05	2.70±0.14	0.0	2.70±0.14	∞	0.0	Acro.
16	0.31±0.07	0.0	0.31±0.07	2.53±0.22	0.0	2.53±0.22	∞	0.0	Acro.
17	0.29±0.05	0.0	0.29±0.05	2.39±0.15	0.0	2.39±0.15	∞	0.0	Acro.
18	0.29±0.05	0.0	0.29±0.05	2.39±0.15	0.0	2.39±0.15	∞	0.0	Acro.
19	0.28±0.05	0.0	0.28±0.05	2.34±0.08	0.0	2.34±0.08	∞	0.0	Acro.
20	0.28±0.05	0.0	0.28±0.05	2.27±0.16	0.0	2.27±0.16	∞	0.0	Acro.
21	0.28±0.05	0.0	0.28±0.05	2.27±0.16	0.0	2.27±0.16	∞	0.0	Acro.
22	0.28±0.05	0.0	0.28±0.05	2.37±0.16	0.0	2.27±0.16	∞	0.0	Acro.
23	0.26±0.06	0.0	0.26±0.06	2.15±0.21	0.0	2.15±0.21	∞	0.0	Acro.
24	0.26±0.06	0.0	0.26±0.06	2.15±0.21	0.0	2.15±0.21	∞	0.0	Acro.
25	0.23±0.05	0.0	0.23±0.05	1.88±0.17	0.0	1.88±0.17	∞	0.0	Acro.
26	0.23±0.05	0.0	0.23±0.05	1.88±0.17	0.0	1.88±0.17	∞	0.0	Acro.
27	0.23±0.05	0.0	0.23±0.05	1.88±0.17	0.0	1.88±0.17	∞	0.0	Acro.
28	0.21±0.02	0.0	0.21±0.02	1.75±0.10	0.0	1.75±0.10	∞	0.0	Acro.
29	0.20±0.04	0.0	0.20±0.04	1.69±0.10	0.0	1.69±0.10	∞	0.0	Acro.
30	0.19±0.03	0.0	0.19±0.03	1.60±0.08	0.0	1.60±0.08	∞	0.0	Acro.
31	0.19±0.03	0.0	0.19±0.03	1.60±0.08	0.0	1.60±0.08	∞	0.0	Acro.
32	0.19±0.03	0.0	0.19±0.03	1.53±0.10	0.0	1.53±0.10	∞	0.0	Acro.
33	0.18±0.02	0.0	0.18±0.02	1.46±0.12	0.0	1.46±0.12	∞	0.0	Acro.
34	0.17±0.03	0.0	0.17±0.03	1.42±0.14	0.0	1.42±0.14	∞	0.0	Acro.
35	0.16±0.03	0.0	0.16±0.03	1.30±0.09	0.0	1.30±0.09	∞	0.0	Acro.
36	0.15±0.02	0.0	0.15±0.02	1.23±0.09	0.0	1.23±0.09	∞	0.0	Acro.
37	0.14±0.02	0.0	0.14±0.02	1.17±0.12	0.0	1.17±0.12	∞	0.0	Acro.
38	0.14±0.02	0.0	0.14±0.02	1.17±0.12	0.0	1.17±0.12	∞	0.0	Acro.
X	0.40±0.05	0.26±0.04	0.66±0.09	3.32±0.34	2.15±0.31	5.46±0.63	1.56±0.10	39.18±1.50	M
Y	0.28±0.04	0.14±0.02	0.41±0.05	2.30±0.33	1.20±0.26	3.50±0.57	1.96±0.26	34.07±2.71	S,M
Sum			12.1±1.71

(a)

(b)

Fig. 5. Female mitotic karyotypes of *Lycaon pictus*, a) conventional Giemsa stain, b) G-banding, arrow indicates to sex chromosomes from a male.

Fig. 6. Idiogram of the chromosomes of male *Lycaon pictus* which was constructed in respect to the relative length.

with Renzoni and Omodeo (1972) and Wayne *et al.* (1987). On the other hand, the canine diploid number was established as 78 (Gustavsson and Sundt 1964, Ford 1966, Chiarelli 1965, Mayr *et al.* 1986, Schmid and Guttenbach 1988). They also reported 76 acrocentric autosomes and two biarmed sex chromosomes. The karyotype of domestic dog (Fig. 3) confirm the previous reports. *C. familiaris* and *C. lupus* represent the highest autosomal complement of acrocentric chromosomes, while *V. vulpes* represents the highest autosomal complement of biarmed chromosomes of Canidae (Wurster-Hill and Centerwall 1982, Makinen 1985, Wayne *et al.* 1987).

The diploid number of *L. pictus* and its FN are located in-between the range of $2n$ and FN of Canidae as recorded by Ward *et al.* (1987). *L. pictus* which represents one of the wild canid species has a large number of biarmed autosomes (Figs. 5, 6) supporting the results of Chiarelli (1965) who found that the autosomes of wild dogs exhibit a great amount of large biarmed chromosomes suggesting fusion, while those of domestic dog is characterized by a totality of acrocentrics thus indicating fission. These results indicate the important role of Robertsonian changes in the karyotype evolution of Canids.

The karyotype and idiogram of *Felis catus* (Figs. 7, 8) with $2n=38$ and $FN=72$ are in complete agreement with those reported for the most majority of individuals of Felidae which exhibit uniformity of the karyotype pattern (Wurster and Benirschke 1968, Ford *et al.* 1980, Wurster-Hill and Centerwall 1982), where 30 species have studies, 25 of them are reported to have a diploid chromosome number of 38 and 5 to have 36, and the FN varies only from 70 to 76.

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Table 3. Average of chromosomes measurements and classification obtained from observations on ten spreads *Lycodon pictus*

Chromosome Pair No.	Chromosome lengths			Relative lengths %			Arm ratio Mean±S.D	Centromeric index Mean±S.D	Classification
	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D			
1	0.45±0.10	0.38±0.06	0.83±0.14	3.56±0.38	3.01±0.37	6.57±0.33	1.21±0.26	45.88±5.09	M
2	0.44±0.05	0.32±0.05	0.76±0.10	3.51±0.27	2.54±0.20	6.06±0.35	1.39±0.14	42.01±2.46	M
3	0.40±0.08	0.30±0.06	0.70±0.13	3.16±0.31	2.38±0.23	5.54±0.25	1.35±0.23	42.99±4.28	M
4	0.34±0.07	0.24±0.07	0.58±0.14	2.63±0.11	1.89±0.31	4.52±0.39	1.42±0.20	41.60±3.33	M
5	0.29±0.10	0.23±0.05	0.52±0.14	2.26±0.47	1.80±0.10	4.06±0.56	1.25±0.21	44.81±4.32	M
6	0.23±0.06	0.23±0.06	0.47±0.12	1.82±0.18	1.82±0.18	3.63±0.37	1.00±0.00	50.00±0.00	M
7	0.69±0.10	0.37±0.08	1.06±0.17	5.48±0.48	2.87±0.45	8.35±0.69	1.96±0.37	34.28±3.79	S.M
8	0.48±0.17	0.25±0.06	0.73±0.23	3.66±0.72	1.94±0.15	5.60±0.87	1.87±0.24	35.15±3.07	S.M
9	0.38±0.07	0.18±0.03	0.57±0.10	3.01±0.17	1.45±0.08	4.46±0.21	2.08±0.13	32.53±1.39	S.M
10	0.76±0.09	0.19±0.03	0.95±0.11	6.02±0.69	1.52±0.12	7.54±0.76	3.97±0.38	20.26±1.59	S.T
11	0.61±0.13	0.17±0.04	0.78±0.16	4.79±0.24	1.36±0.21	6.15±0.42	3.59±0.44	21.98±2.17	S.T
12	0.58±0.12	0.17±0.05	0.74±0.17	4.53±0.30	1.29±0.19	5.81±0.38	3.59±0.57	22.10±2.63	S.T
13	0.56±0.13	0.16±0.04	0.72±0.16	4.40±0.25	1.22±0.19	5.62±0.37	3.57±0.60	21.47±2.52	S.T
14	0.48±0.11	0.13±0.01	0.63±0.14	3.76±0.27	1.13±0.06	4.90±0.30	3.34±0.23	23.13±1.23	S.T
15	0.52±0.17	0.0	0.52±0.17	3.97±0.61	0.0	3.97±0.61	∞	0.0	Acro.
16	0.42±0.04	0.0	0.42±0.04	3.33±0.34	0.0	3.33±0.34	∞	0.0	Acro.
17	0.35±0.05	0.0	0.35±0.05	2.80±0.45	0.0	2.80±0.45	∞	0.0	Acro.
18	0.31±0.06	0.0	0.31±0.06	2.44±0.38	0.0	2.44±0.38	∞	0.0	Acro.
X	0.52±0.07	0.40±0.03	0.92±0.07	4.12±0.31	3.28±0.67	7.40±0.88	1.30±0.23	43.93±4.41	M
Y	0.15±0.01	0.0	0.15±0.01	1.25±0.26	0.0	1.25±0.26	∞	0.0	Acro.
Sum			12.72±2.21						

Table 4. Average of chromosomes measurements and classification obtained from observations on ten spreads *Felis catus*

Chromosome Pair No.	Chromosome lengths			Relative lengths %			Arm ratio Mean±S.D	Centromeric index Mean±S.D	Classification
	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D	Long arm Mean±S.D	Short arm Mean±S.D	Total Mean±S.D			
1	0.69±0.10	0.35±0.06	1.04±0.15	5.70±0.48	2.85±0.25	8.55±0.45	2.02±0.30	33.39±3.18	S.M
2	0.48±0.02	0.25±0.03	0.73±0.04	4.00±0.47	2.07±0.19	6.07±0.56	1.95±0.23	34.17±2.81	S.M
3	0.41±0.04	0.23±0.02	0.64±0.06	3.38±0.44	1.95±0.27	5.33±0.70	1.73±0.10	35.97±1.85	S.M
4	0.40±0.14	0.26±0.16	0.65±0.30	3.24±0.85	2.04±1.03	5.28±1.86	1.73±0.30	36.43±4.90	S.M
5	0.51±0.07	0.44±0.05	0.95±0.11	4.17±0.41	3.66±0.51	7.82±0.81	1.15±0.13	46.62±2.90	M
6	0.40±0.04	0.31±0.05	0.72±0.09	3.35±0.34	2.59±0.32	5.93±0.60	1.30±0.13	43.54±2.45	M
7	0.31±0.04	0.23±0.03	0.55±0.02	2.57±0.21	1.96±0.36	4.53±0.32	1.37±0.32	43.04±5.93	M
8	0.24±0.02	0.22±0.03	0.46±0.03	2.03±0.30	1.78±0.21	3.82±0.33	1.16±0.25	46.89±4.73	M
9	0.24±0.02	0.20±0.04	0.44±0.04	2.01±0.22	1.66±0.26	3.67±0.23	1.26±0.33	45.15±5.91	M
10	0.19±0.04	0.16±0.03	0.35±0.04	1.56±0.32	1.36±0.19	2.92±0.33	1.18±0.37	46.84±6.32	M
11	0.66±0.11	0.18±0.02	0.84±0.12	5.45±0.47	1.45±0.12	6.90±0.39	4.13±1.11	21.21±2.77	S.T
12	0.59±0.05	0.15±0.03	0.74±0.05	4.91±0.25	1.21±0.23	6.13±0.32	4.21±0.89	19.75±3.35	S.T
13	0.54±0.07	0.15±0.01	0.69±0.08	4.41±0.14	1.24±0.09	5.65±0.19	3.57±0.23	21.95±1.12	S.T
14	0.51±0.09	0.15±0.03	0.65±0.11	4.16±0.39	1.19±0.12	5.36±0.41	3.43±0.48	22.30±2.19	S.T
15	0.42±0.11	0.12±0.01	0.53±0.11	3.39±0.56	0.98±0.12	4.36±0.56	3.52±0.83	22.72±3.28	S.T
16	0.32±0.04	0.10±0.01	0.42±0.04	2.66±0.16	0.85±0.09	3.50±0.19	3.17±0.43	24.17±2.21	S.T
17	0.35±0.06	0.0	0.35±0.06	2.89±0.29	0.0	2.89±0.29	∞	0.0	Acro.
18	0.31±0.05	0.0	0.31±0.05	2.52±0.34	0.0	2.52±0.34	∞	0.0	Acro.
X	0.34±0.10	0.30±0.06	0.65±0.16	2.81±0.61	2.48±0.35	5.28±0.93	1.13±0.12	47.18±2.70	M
Y	0.23±0.08	0.17±0.07	0.41±0.15	1.92±0.55	1.40±0.49	3.32±1.03	1.40±0.15	41.86±2.52	M
Sum			12.14±1.32

(a)

(b)

Fig. 7. Male mitotic karyotypes of *Felis catus*, a) conventional Giemsa stain, b) G-banding, arrow indicates to sex chromosomes from a female.

Fig. 8. Idiogram of the chromosomes of male *Felis catus* which was constructed in respect to the relative length.

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