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Karyotype Studies on Three Species of the Family Muridae (Mammalia; Rodentia) in Korea

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한국산 쥐과 3종의 핵형에 관한 연구

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적 요

등줄쥐(Striped field mouse, *Apodemus agrarius coreae* Thomas)의 염색체수는 2n=48이다. 핵형은 상염색체가 형태적으로 명백히 3군으로 나누어 지는데, 1쌍의 가장 큰 제 1 번차단부 염색체군, 4쌍의 작은 중부 내지 차중부 염색체군과 18쌍의 아크로 센트릭 염색체군이다. 제 1번 염색체군을 제외한 다른 염색체군들에서의 상동염색체 구별은 크기가 점차적인 차이를 보이기 때문에 쉽지 않다. X염색체는 제 3번 염색체와 같은 크기의 것이며 Y염색체는 작은 아크로센트릭 염색체와 차이를 나타내어서 새로운 형임이 밝혀졌다. 본 종의 집단내 또는 집단간 염색체 多形現象은 없었다.

갈밭쥐(Manchurian red vole, *Microtus fortis pelliceus* Thomas)의 염색체수는 2n=52이다. 핵형은 상염색체가 역시 3군으로 나누어 지는데, 5쌍의 중부내지 차중부 염색체군, 2쌍의 차단부 염색체군과 18쌍의 아크로센트릭 염색군이다. 아크로센트릭 염색체군에서의 상동염색체 구별은 점차적인 차이를 보이기 때문에 역시 어렵다. X염색체는 가장 큰 중부 염색체임으로 쉽게 구별이 되나 Y는 작은 아크로센트릭 염색체중 하나가 아닌가 생각된다. 또한 본 종은 아크로센트릭 염색체군중에 서로 다른 크기의 2차 응축현상을 보이는 상동 염색체들이 2쌍 있음이 밝혀졌다. 본 연구를 통해서 본 종의 핵형은 쏘련산 *M. fortis* 아종의 핵형과 같지 않음이 밝혀졌는데, 쏘련산 *M. fortis*의 핵형은 상염색체가 5쌍의 중부 염색체군, 1쌍의 차중부 염색체군과 19쌍의 아크로센트릭 염색체군으로 되어 있으며, X는 비교적 큰 아크로센트릭이고, Y는 보다 작은 아크로센트릭 염색체이다. 본 종의 한국내에서의 염색체 다형현상 및 성염색체의 대형화현상은 없었다.

비단털쥐(Korean giant hamster, *Cricetulus triton nestor* Thomas)의 염색체수는 2n=28이며, 염색체의 크기는 위의 2종 보다 커서 7.5μ–1.5μ이

다. 핵형은 상염색체가 아주 뚜렷한 2군으로 나뉘어 지는데, 11쌍의 큰 아크로센트릭 염색체군과 2쌍의 아주 작은 중부 염색체군이다. X염 색체는 비교적 큰 차단부 염색체로서 쉽게 구별이 된다. 본 실험에서는 숫컷을 재료로 사용하지 못했기 때문에 Y염색체는 판정할수가 없었다. 또한 본 종의 핵형은 쏘련산 *Tscherskia triton*의 핵형과 동일하다. 따라서 Cricetulus 속과 Tscherskia 속과의 분류에 있어서 동일함이 핵형으로도 증명된 셈이다. 본 종의 염색체수는 다른 햄스터류보다 많으나, 아주 작은 2쌍의 중부 염색체군이 있음이 특이하며, 한국산 햄스터로서의 세포유전학적 실험동물로서 이용가치가 있다고 사료된다.

INTRODUCTION

Korean Muridae (Mammalia; Rodentia) includes 12 species represented by three subfamilies (Won, 1967). In this family, several types of geographical chromosome polymorphisms have been documented (Matthey, 1973 a,b; Yosida and Kato, 1974). In view of the above fact, it is considered necessary to make a comparative study on the karyotypes of the Muridae species occurring in Korea.

It is a purpose of this paper to describe the somatic chromosomes of three Korean murine species with special regard to karyological characteristics.

MATERIALS AND METHODS

All specimens were collected by trapping, and were brought alive to our laboratory. The examined species, their localities, date of capture and numbers of specimens are shown in Table 1.

Karyotypes are based on direct bone marrow technique or cultured marrow cells according to the Hung (1968). Only well-spread metaphases were selected

Table 1. Specimens studied for the karyotype analyses.

Species	Locality	Date of capture	Number of specimens (sex)
Apodemus agrarius coreae	Cheongpyeong	24/VII, 74-05/IX, 75	7(♀2, ♂5)
	Incheon	23/IX, 74-19/IV, 75	2(♀1, ♂1)
	Pocheon	04/IX, 74	1(♀1, ♂0)
	Buyoe	24/X, 74	1(♀0, ♂1)
	Seoul	19/XII, 74	1(♀0, ♂1)
	Onyang	05/V, 75	1(♀0, ♂1)
Microtus fortis pelliceus	Dongducheon	22/XI, 74	2(♀1, ♂1)
	Pocheon	11/1, 75	4(♀1, ♂3)
Cricetulus triton nestor	Dongducheon	04/IX, 74	1(♀1, ♂0)

for analysis and were photographed by using phase contrast optics. More than 30 cells per individual of each species were examined.

RESULTS

The distribution of chromosome number from each of three species covering nine populations are shown in Table 2. The representative karyotypes of *Apodemus agrarius* are arranged in Fig. 1. and those of *Microtus fortis* in Fig. 2, and that of *Cricetulus triton* in Fig. 3.

Table 2. Distribution of chromosome number from bone marrow cells of each species.

Species	Localities (specimens)	Cells scored	2n	Chromosome count				
				46	47	48	49	50
A. agrarius coreae	Cheongpyeong(7)	726	48	13	29	665	12	4
	Incheon(2)	61	48		2	58	1	
	Pocheon(1)	37	48		1	35	1	
	Buyoe(1)	45	48		3	42		
	Seoul(1)	32	48	1	2	29		
	Onyang(1)	51	48	1	2	47		1
				50	51	52	53	54
M. fortis pelliceus	Dongducheon(2)	162	52			162		
	Pocheon(4)	221	52		3	216	2	
				26	27	28	29	30
C. triton nester	Dongducheon(1)	137	28			131	2	

1. *A. agrarius coreae*: Thirteen individuals trapped from six different localities have the same diploid number of 48. Their chromosome size ranges from 4.5 μ to 1.5 μ in length. On the basis of the position of centromere, 23 pairs of autosome are divided into three different groups; the largest No.1 subtelocentric group, 18 pairs of acro-telocentric group which gradually decrease in size and 4 pairs of meta-submetacentric group. X is the same size as the third larger acrocentric chromosome and Y is probably the one of smaller acrocentric chromosomes. Inter-and intrapopulational polymorphism are not found. The No. 1 pair of this species which has been found to be subtelocentric, however, differs in morphology from that of other subspecies, which were reported to be acro-telocentric (Soldatovic, 1969. Kral, 1970).

2. *M. fortis pelliceus*: Diploid number of all specimens is 52. Their chromosome size ranges from 5.0 μ to 1.5 μ. Three distinct groups of autosome are consisted of 10 meta-submetacentric, 4 subtelocentric and 36 acrocentric chromosome groups. Homologous pairing of the acrocentric group and the identification of

the Y are arbitrary, but the X is relatively easy to identify since it is the largest metacentric chromosome of the complement. Y is probably one of the smaller acrocentric chromosomes. The acrocentric group has 2 pairs of heteromorphic chromosomes with respect to the size of their secondary constrictions, *i.e.*, one of the homologous chromosomes always has more distinct secondary constriction than that of the corresponding homologous ones.

3. The karyotype of *C. triton nestor*: The chromosome complement has diploid chromosome number of 28 and their size ranges from 7.5μ to 1.5μ. The karyotype of its autosome has two different groups, one group is consisted of 2 very small metancentric pairs and the other group is composed of ill acrocentric pairs forming more or less continuous size gradation. X is the subtelocentric chromosome.

DISCUSSION

Table 3 contains the current information on the karyotypes of the genus *Apodemus, Microtus, and Critulus.*

From the information on the karyotype of genus *Apodemus*, it is shown that these species differ only in the number of meta-submetecentric chromosomes, that is, in the "Fundamental Number", and diploid number of most species is always 48. Thus, chromosomal evolution of this genus is thought to be resulted from by simple pericentric inversions. It was clear that pericentric inversions of smaller meta-submetacentric chromosomes play large roles, while bigger chromosomes have not been affected in the karyotype evolution of these species. In this study, however, new chromosome type has been found. This new type of No. I subtelocentric pair is probably due to pericentric inversion. Similar mechanism was reported in *Rattus rattus* (Yosida and Kato, 1971). In this connection, Yosida inferred that rats with No. 1 (S/S) pair were adapted to the hot climate. In the case of *A. agrarius*, we believe, striped field mouse with subtelocentric No. 1 pair adapted itself to circumstance of the temperate regions, and this pericentric inversion caused the distributional dominancy in that field. Pericentric inversion also plays significant roles in the evolution of *Peromyscus maniculatus* (Sparkes and Akaki, 1971).

The diploid number of genus Microtus varies from 17 (*M. oregoni*) to 60 (*M. chrotorrhinus*). So, the trend of karyotype evolution of this genus can be analyzed by complex mechanisms. Matthey (1973 b) divided this genus into five groups: The first group is represented by *M. aralis* and *M. orcadensis*. The second one is assigned to *M. ratticps, M. kikuchii*, and *M. montebelli*, which are characterized by a low diploid number. The third one consists of *M. guetheri, M. nivialis*, and *M. townsendi*, which have exclusively acrocentric chromosomes. The fourth

Table 3. Current information on the karyotypes of the genus *Apodemus*, *Microtus*, and *Cricetulus*.

Species	Locality	2n	Karyotype	References
A. agrarius	Yugo	48	8 m-sm, 38 ac, XY	Soldatović *et al.*, 1969
A. agrarius	Yugo	48	6 m-sm, 40 ac, XY	Soldatovič *et al.*, 1969
A. agrarius	Czecho	48	8 m-sm, 38 ac, XY	Král, 1970
A. a. manchuricus	USSR	48	8 m-sm, 38 ac, XY	Král, 1970
A. a. ognevi	USSR	48	8 m-sm, 38 ac, XY	Král, 1970
A. a. coreae	Korea	48	8 m-am, 2 st, 36 ac, XY	Present study
A. flavicolis	Czecho	48	46 ac, XY	Soldatović *et al.*, 1972
A. microps	Czecho	48	46 ac, XY	Soldatovič *et al.*, 1972
A. sylbaticus	Czecho	48	46 ac, XY	Král, 1971
A. speciosus	Japan	46	10 m-sm, 34 ac, XY	Shimba & Kobayashi, 1969
A. speciosus	Japan	48	8 m-sm, 38 ac, XY	Shimba & Kobayashi, 1969
A. speciosus	Korea	48	8 m-sm, 38 ac, XY	Kang & Kim, 1965
A. s. major	USSR	48-51	8-11 m-sm, 38 ac, XY	Král, 1971
A. s. preator	USSR	48	8-11 m-sm 38 ac, XY	Král, 1971
M. oregoni	USA	17♀, 18♂	16 m-sm, XO:XY	Hsu & Benirschke, 1969 b
M. montanus	USA	24	20 m-sm 2 st, XY	Schmid, 1967
M. montebelli	Japan	30	28 m-sm, XY	Hsu & Benirschke, 1970 b
M. arvalis	Germany	46	36 m-sm, 8 ac, XY	Hsu & Benirschke, 1970 a
M. towensendii	Canada	50	48 ac, XY	Hsu & Benirschke, 1971 a
M. hyperboreus	USSR	50	8 m-sm, 40 ac, XY	Hsu & Benisrchke, 1974 b
M. fortis	USSR	52	12 m-sm, 38 ac, XY	Meyer et al., 1967
M. f. pelliceus	Korea	52	10 m-sm, 4 st, 36 ac, XY	Present study
M. ochrogaster	USA	54	12 m-sm, 40 ac, XY	Hsu & Benirschke, 1971 b
M. longcaudus	USA	56	30 m-sm, 24 ac, XY	Hsu & Benirschhe, 1969 a
M. chrotorrhinus	Canada	60	4 m-sm, 54 ac, XY	Meylan, 1967
C. barabensis	USSR	20	16 m-sm, 2 st, XY	Radjabli & Kriukova, 1973
C. cricetus	Germany	22	18 m-sm, 2 ac, XY	Wolf, 1966
C. griceus	USA	22	14 m-sm, 6 st, XY	Hsu & Benirschke 1967
C. migratoris	USA	22	20 m-sm, XY	Yerganian & Papoyan 1965
Tscherskia triton	Korea	30		Makino, 1951
Tscherskia triton	USSR	28	22 ac, 4 sm, XY	Hsu & Benirschke, 1974 a
C. triton nestor	Korea	28	22 ac, 4 m XY	Present study

one is represented by *M. pennsylvanicus*. This is an isolated form, similar to *M. agrestic* but differ from the latter in that it has two pairs of metacentric autosomes and small X chromosomes. The fifth one consists of the species of *M. agrestis* characterized by acrocentric autosomes and giant X chromosome (Meyer *et al.*, 1967).

On the basis of the data reported by Matthey (1973 a, b), *M. fortis pelliceus* investigated in the present study can be considered to be a particular group, since the diploid number of that species is 52 and X is the largest metacentric chromosome of the complement. It was reported that the autosomes of *M. fortis* in USSR consisted of 3 groups; 10 metacentric, 2 submetacentric and 38 acrocentric chromosomes (Meyer *et al.*, 1967). In the present work, however, that of *M. fortis pelliceus* is composed of 3 groups; 10 meta-submetacentric one, 4 subtelocentric one, and 36 acrocentric one. And X is the largest metacentric chromosome of the complement and Y is smaller acrocentric one. Thus, it is believed that the karyotype of *Microtus fortis* in Korea differs from that of the same species in USSR.

Indian muntjac chromosome complement has the same secondary constriction as that of *M. fortis* studied in the present experiment, showing two pairs of heteromorphic chromosomes (Kato *et al.*, 1974).

The karyotype of the genus *Cricetulus* show a characteristic, in which the diploid number is small. Ohno (1968) proposed that the first vertebrate had approximately 48 acrocentric chromosomes. And the mechanisms of pericentric inversions, translocations (especially centric fusion), deletions, and duplications (including polyploid) were responsible for an increase in chromosome number (dysploid increase). In this manner, the mechanisms could account for a decrease in chromosome number (dysploid decrease). We believe that all these well-known mechanisms occurred in producing the 20~28 chromosomes of the genus *Cricetulus* from a larger ancestral complement. The most spectacular example of dysploid decrease in another vertebrate is the Indian muntjac deer, *Muntiacus muntjac*, in which a diploid number of 7 for male and 6 for female apparently stammered from an ancestor with a diploid number of 46. One of the proposed mechanisms for this chromosome reduction was the rearrangement of acrocentric chromosome from an ancestor through centric fusions (Wurster and Benirschke, 1970).

The present result on the karyotype of *Cricetulus triton nestor* is similar to that of *Tscherskia triton* from USSR (Hsu and Benirschke, 1970). It is considered that this result proves the fact of karyological similarity between genus *Cricetulus* and genus *Tscherskia*.

In comparison with diploid number of other hamsters shown in Table 3, that of *C. triton nestor* is larger in number, but chromosome complement of Korean giant hamster is characterized by containing two pairs of smaller chromosomes as a marker chromosome. This minute chromosome was reported in the karyotype of *Akodon urichi venezuelensis* (Reig *et al.*, 1971).

Korean giant hamster for wide applications of cytogenetical study may have many advantages due to following reasons; chromosome complement is larger in size and smaller in numbers, the breeding of this hamster is easier than that of Chinese hamster considering body size of this hamster being not so big as that of the latter. Hence, breeding cost may not be so expensive.

So far, we have discussed the routine karyotype morphology of three murine rodents and the current information on these genera. Application of higher resolution technique such as banding patterns of chromosomes are to be encouraged to elucidate the problems on the karyotypes of Korean rodents.

SUMMARY

1. It has been found in the karyotype of *Apodemus agrarius coreae* that No. 1 chromosome pair is subtelocentric and this is the new chromosome type in comparison with acro-telocentric No. 1 pair of the other subspecies.
2. It was reported in the karyotype of *Microtus fortis* from USSR that the autosome consisted of 2 submetacentric, 10 metacentric and 38 acrocentric chromosomes, and that X is acrocentric and Y is small acrocentric one. In the present study, however, the autosome of *M. fortis pelliceus* in Korea is composed of three groups; 4 subtelocentric, 10 meta-submetacenric, and 36 acrocentric one. And X is the largest metacentric chromosome of the complement. Y is smaller acrocentric one. Thus, it has been found that the karyotype of *M. fortis* in Korea differs from that of the same species in USSR. In the karyotype of this red vole, two pairs of heteromorohic chromosome with respect to the size of their secondary constrictions have been shown in the acrocentric group.
3. The diploid number of *Cricetulus triton nestor* was found to be 28, and its chromosome size ranges from 7.5 μ to 1.5 μ. Autosomes contains 11 large acrocentric pairs and two pairs of very small metacentric ones. This feature is simillar to that of *Tscherskia triton* found USSR.

REFERENCES

Hsu, T.C. and K. Benirschke, 1967. An Atlas of Mammalian Chsomosomes, vol. 1. Springer-Verlag, New York. folio 13.

——and K. Benirschke, 1969 a. An Atlas of Mammalian Chromosomes, vol. 3. Sprinaer-Verlag, New York. folio 120.

——and K. Benirschke, 1969 b. An Atlas of Mammalian Chromosomes, vol. 3. Springer-Verlag, New York. folio 121.

——and K. Benirschke, 1970 a. An Atlas of Mammalian Chromosomes, vol. 4. Springer-Verlag, New York. folio 173.

——and K. Benirschke, 1970 b. An Atlas of Mammalian Chromosomes vol. 4. Springer-Verlag, New York. folio 174.

——and K. Benirschke, 1971 a. An Atlas of Mammalian Chromosomes, vol. 5. Springer-Verlag, New York. folio 223.

——and K. Benirschke, 1971 b. An Atlas of Mammalian Chromosomes, vol. 6. Springer-Verlag, New York. folio 272.

——and K. Benirschke, 1974 a. An Atlas of Mammalian Chromosomes, vol. 8. Springer-Verlag, New York. folio 365.

——and K. Benirschke, 1974 b. An Atlas of Mammalian Chromosomes, vol. 8. Springer-Verlag, New York. folio 372.

Hung, C.C., 1968. Karyologic and autoradiographic studies of the chromosomes of *Rattus natalensis*. *Cytogenetics* **7** : 97—107.

Kato, H., K. Tsuchiya and T.H. Yosida, 1974. Constitutive heterochromatin of Indian munjac chromosomes revealed by DNase treatment and a C-banding technique. *Can. J. Genet. Cytol.* **16** : 273—280.

Kang Y.S. and Y.J. Kim, 1965. Studies on chromosomes of Korean mammals. *Zoologica, Korea* **2** : 1—8.

Kral, B., 1970. Chromosome studies in two subgenus of the genus *Apodemus*. *Zool. Listy* **19** : 119—134.

Kral, B., 1971. Chromosome characteristics of certain murine rodents (Muridae) of the Asiatic part of the USSR. *Zool. Listy* **20** : 331—347.

Makino, S., 1951. Karyotype of *Tscherskia triton* (Muridae, Cricetinae). *La Kromosomo* **8** : 311—318.

Matthey, R., 1973 a. The chromosome formulae of eutherian mammals. *In;* Cytotaxonomy and Vertebrate Evolution (A.A. Chiarelli and E. Capanna, editors). Academic Press, New York pp. 531—613.

Matthey, R., 1973 b. The chromosome formulae of eutherian mammals. (supplement). *Mammalia* **37** : 394—421.

Meyer, M., M. Jordan, and J. Walknowska, 1967. A karyosystematic study of some *Microtus* species. *Fol. Biol.* **15** : 251—264.

Meylan, A., 1967. Karyotype and giant sex chromosomes of *Microtus chrotorrhinus* (Miller). *Can. J. Genet. Cytol.* **9** : 700—703.

Ohno, S., U. Wolf, and N.B. Atkin, 1968. Evolution from fish to mammals by gene duplication. *Hereditas* **59** : 169—185.

Radjabli, I.S. and E.P. Kriukova, 1973. Comparison of banding patterns in two hamster species. *Mammalian Chromosome Newsletter* **14** : 112.

Reig, O.A., N. Olivo, and P. Kiblisky, 1971. The idiogram of the *Venezuelensis* (Rodentia, Cricetidae). *Cytogenetics* **10** : 99—114.

Schmid, W., 1967. The karyotype of *Microtus montanus*. *Mammalian Chromosomes Newsletter* **8** : 15.

Shimba, H. and T. Kobayashi, 1969. A Robertsonian type polymorphism of the chromosomes in the field mouse, *Apodemus speciosus*. *Jap. J. Genet.* **44** : 117—122.

Soldatovic, B., B. Djulic, I. Savic and D. Rimsa, 1969. Chromosomes of two species of the genus *Apodemus* from Yugoslavia. *Arch. Biol. Sci.* **21** : 27—32.

Soldatovic, B., I. Savic, B. Dulic, M. Milosevic and M. Mikes, 1972. Prilog poznavanju kariotipa roda *Apodemus kaup*, 1829. *Arch. Sci. Biol.* **24** : 125—130.

Sparkes, R.S. and K.T. Akaki, 1971. Chromosome polymorphism in interbred subspecies of *Peromycus maniculatus* (deer mouse). *Can. J. Genet. Cytol.* **13** : 277—282.

Wolf, U., 1966. Sex chromatin in hamster. *Chromosoma* **31** : 16—67.

Won, P.H., 1967. Illustrated Encyclopedia of Fauna and Flora of Korea Mammals. Samhwa, Seoul. **7** : 185—258.

Wurster, D.H., and K. Benirschkke, 1970. Indian muntjac, *Muntiacus muntjak*: A deer with a low diploid chromosome number. *Science* **168** : 1366.

Yerganian, G., and S. Papoyan, 1965. Isomorphic sex chromosomes, autosomal heteromorphism, and telomeric associations in the grey hamster of Armenia, *Cricetulus migratorius*. *Hereditas* **52** : 307—319.

Yosida, T.H. and H. Kato, 1974. Cytogenetical survey of black rats *Rattus rattus*, in Southwest and Central Asia, with special regard to the evolutional relationship between three geographical types. *Chromosoma* **45** : 99—109.

Fig. 1. Karyotypes of striped field mouse, *Apodemus agrarius;* a female, b male.

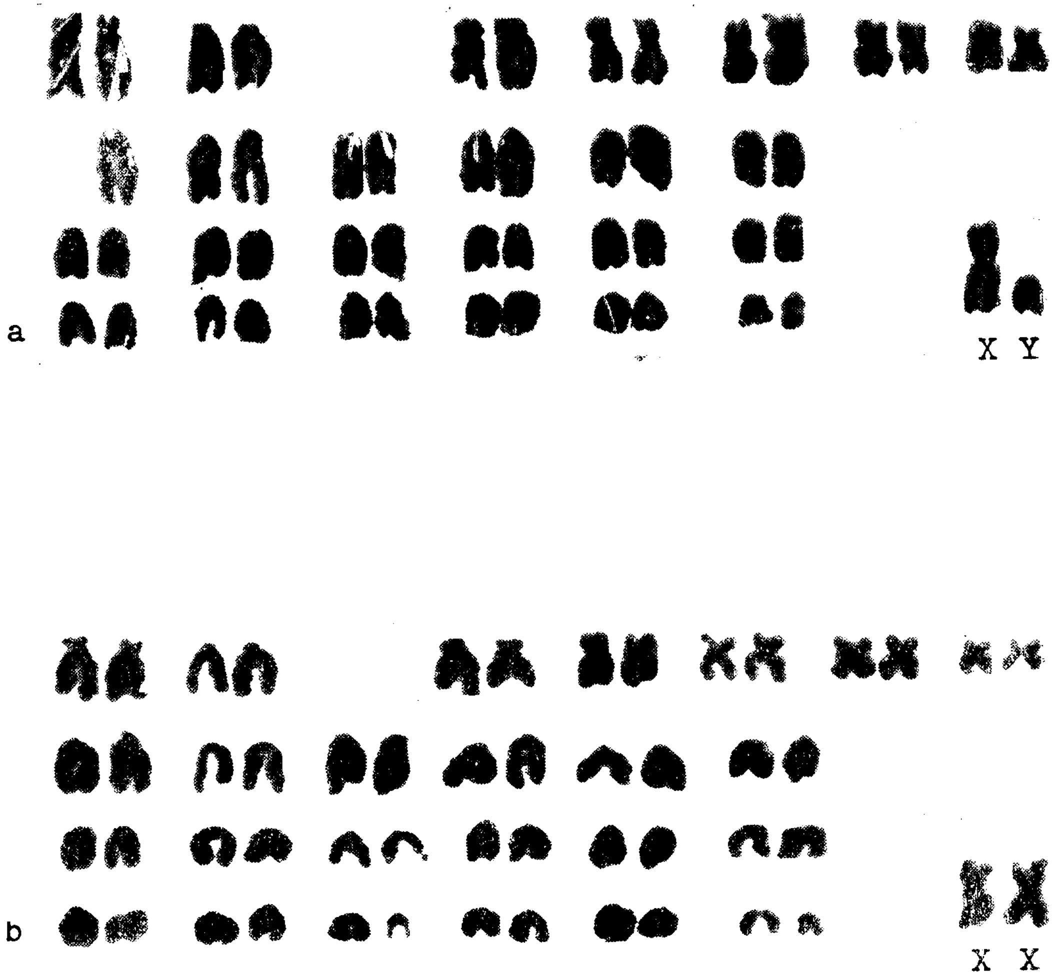

Fig. 2. Karyotypes of Manchurian red vole, *Microtus fortis;* a female, b male.

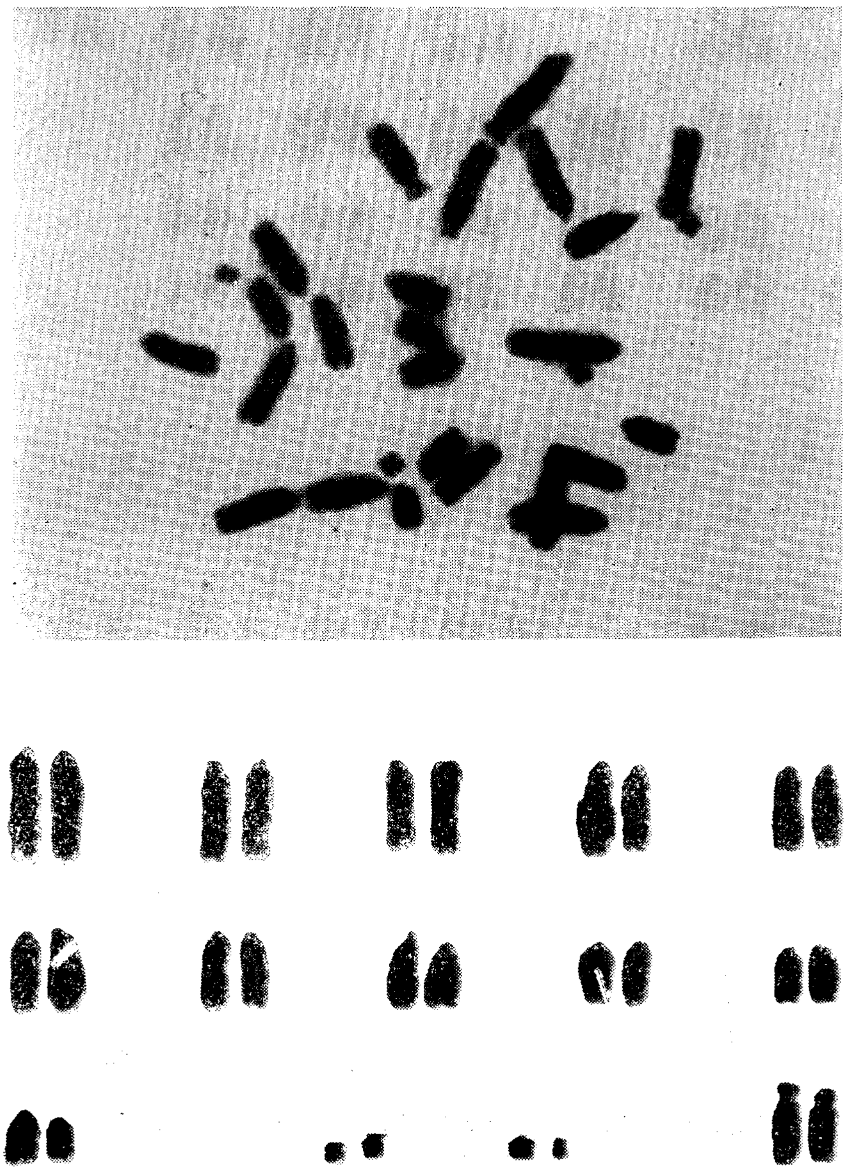

Fig. 3. Metaphase and karyotype of female Korean giant-hamster, *Cricetulus triton nester*.