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Orijinal araştırma (Original article)

Karyotype analysis of *Zygoribatula cognata* (Oudemans) (Acari: Oribatida: Oribatulidae)

Zygoribatula cognata (Oudemans)'nın (Acari: Oribatida: Oribatulidae) karyotip analizi

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Summary

Karyotypic characters, mitotic metaphase chromosomes, monoploid ideogram and karyogram of *Zygoribatula cognata* (Oudemans) (Acari: Oribatida: Oribatulidae) were investigated for the first time. The chromosome number of *Zygoribatula cognata* was 2n = 30. The chromosomes were holocentric characterized with lack a localized centromere. No satellite was observed in the chromosomes. The sex chromosomes and sex determination of *Zygoribatula cognata* could not be determined.

Keywords: *Zygoribatula cognate*, oribatid mite, karyotype, holocentric chromosome

Özet

Bu çalışmada, *Zygoribatula cognata*'nın (Oudemans) (Acari: Oribatida: Oribatulidae) karyotipik karakterleri, mitotik metafaz kromozomları, monoploid idiyogramı ve karyogramı ilk kez araştırılmıştır. *Zygoribatula cognata*'nın kromozom sayısı 2n = 30'dur. Kromozomlarının lokalize bir sentromer eksikliği ile karakterize olan holosentrik yapıda olduğu saptanmıştır. Kromozomlarda satellit gözlenmemiştir. *Zygoribatula cognata*'nın cinsiyet kromozomları ve cinsiyet tayini belirlenememiştir.

Anahtar sözcükler: *Zygoribatula cognata*, oribatid akar, karyotip, holosentrik kromozom

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Introduction

Oribatid mites are placed in the order Oribatida Dugès in the subclass Acari Leach. The oribatid mites often called “moss mites” or “beetle mites”, are associated with organic matter in most terrestrial ecosystems. They found throughout the soil profile, in surface litter, on grasses, herbs and low-growing shrubs, the bark, twigs and leaves of trees, and in aquatic, semi-aquatic and coastal habitats (Behan-Pelletier, 1999). Orbatids comprise more than 10000 species representing 172 families (Gan, 2013).

The genus *Zygoribatula* Berlese placed in the family Oribatulidae Thor is distinguished from *Oribatula* Berlese with the presence of a strong translamella (Fritz, 1982). This genus has a cosmopolitan distribution and consists of at least 91 species and 6 subspecies are known (Subías, 2004; Bayartogtokh & Smelyansky, 2008).

The species *Zygoribatula cognata* (Oudemans) is distributed in the Palaearctic region (Subías, 2004). There are many studies on distribution, habitats and morphology of this species (Fritz, 1982; Ayyıldız, 1988; Behan-Pelletier, 1999; Subías, 2004; Bayartogtokh & Smelyansky, 2008; Gan, 2013).

Although there are many studies on *Z. cognata*, there is no information about the chromosome number and karyotype analysis in the literature. The aim of this study is to investigate the chromosome number, karyotype, ideogram and other detailed chromosomal measurements of *Z. cognata*.

Materials and Methods

The samples collected from natural habitats by Sedat Per. The collecting data is: Turkey: Kayseri, Erciyes Mountain, 38° 35.988' N, 35° 30.575' E, 1944 m, in moss under *Quercus pubescens* Willd. (Fagaceae), 11.XI.2001. 8 samples were used for chromosomal preparations.

Chromosomal preparations were obtained from the technique developed by Imai et al. (1988) and substantially modified by Gokhman & Quicke (1995). The samples were crushed in 1% hypotonic sodium citrate solution containing 0.005% colchicine (Sigma-Aldrich, Taufkirchen, Germany). Material was incubated with a fresh hypotonic solution for 20 min. Then the material was treated with solutions of fixative 1 (glacial acetic acid: absolute ethanol: distilled water 3:3:4), fixative 2 (glacial acetic acid: absolute ethanol 1:1), and fixative 3 (glacial acetic acid). After fixation process, the material was transferred onto pre-cleaned glass slides. The preparation was dried for 30 min, it was stained with Giemsa (Sigma-Aldrich, Taufkirchen, Germany).

10 metaphase plates were obtained. A qualified metaphase plate was selected and photographed with Olympus BX53 microscope (Figure 1). The chromosomes were measured in micrometers (µm) using the Bs200ProP image processing and analysis system. The karyogram and ideogram were drawn based on length of chromosome size (arranged large to small). In Figure 2 the karyogram derived from the metaphase plate in Figure 1. In Figure 1, the chromosomes were grown and separated with Adobe Photoshop CS5. The karyogram was formed. The sharpness was given to the karyogram.

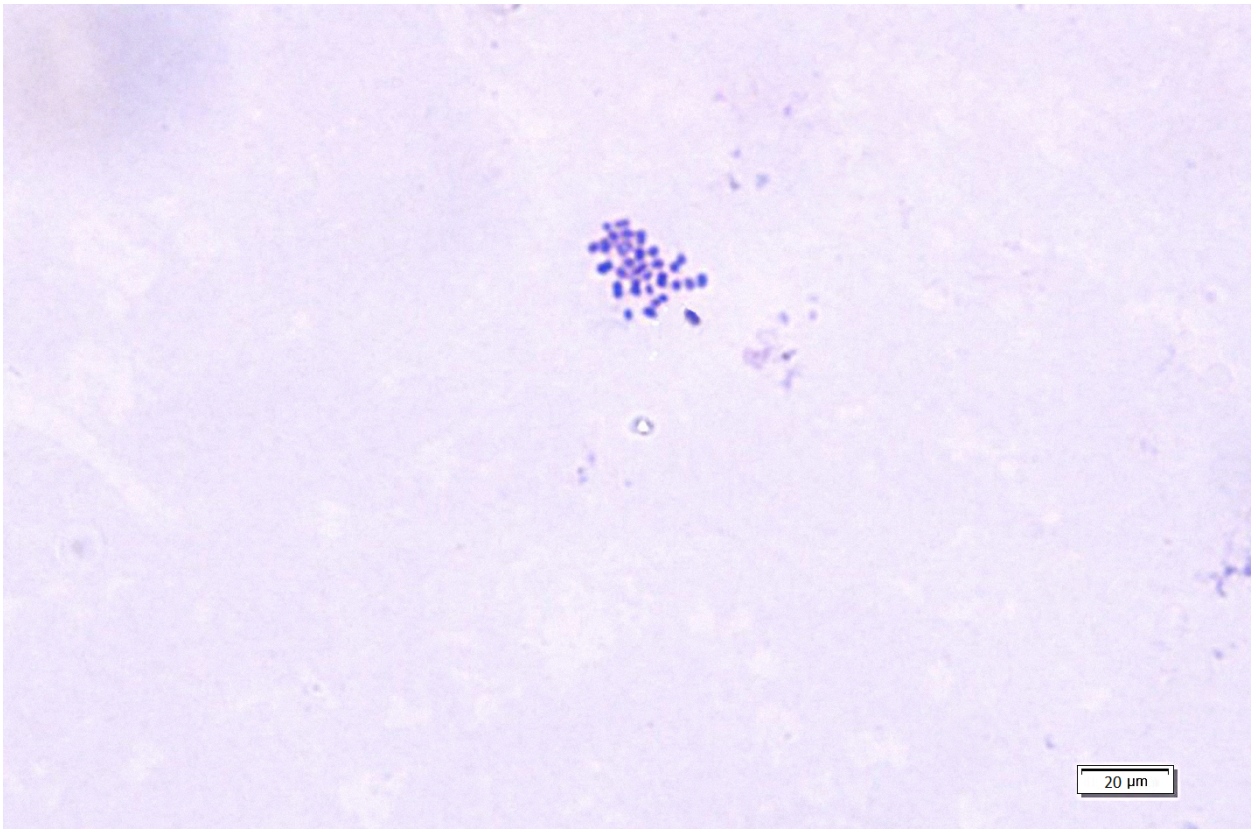

Figure 1. Somatic metaphase chromosomes of *Zygoribatula cognata*.

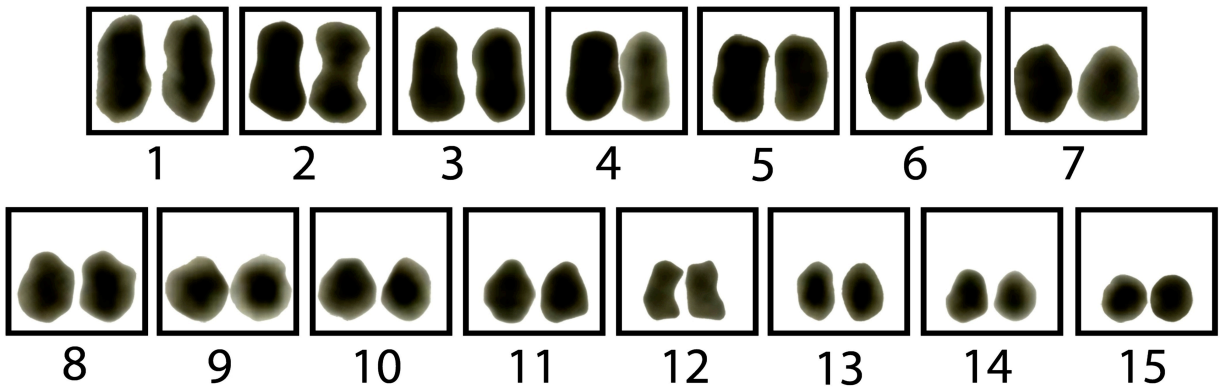

Figure 2. The karyogram of *Zygoribatula cognata*.

Results

Mitotic metaphase chromosomes, karyotype and monoploid ideogram of *Z. cognata* shown in Figures 1-3, respectively. Analysis of somatic metaphases shown that the chromosome number of the species was 2n = 30. Karyotype formula could not be given because the chromosomes were holocentric. No satellite was observed in the chromosomes.

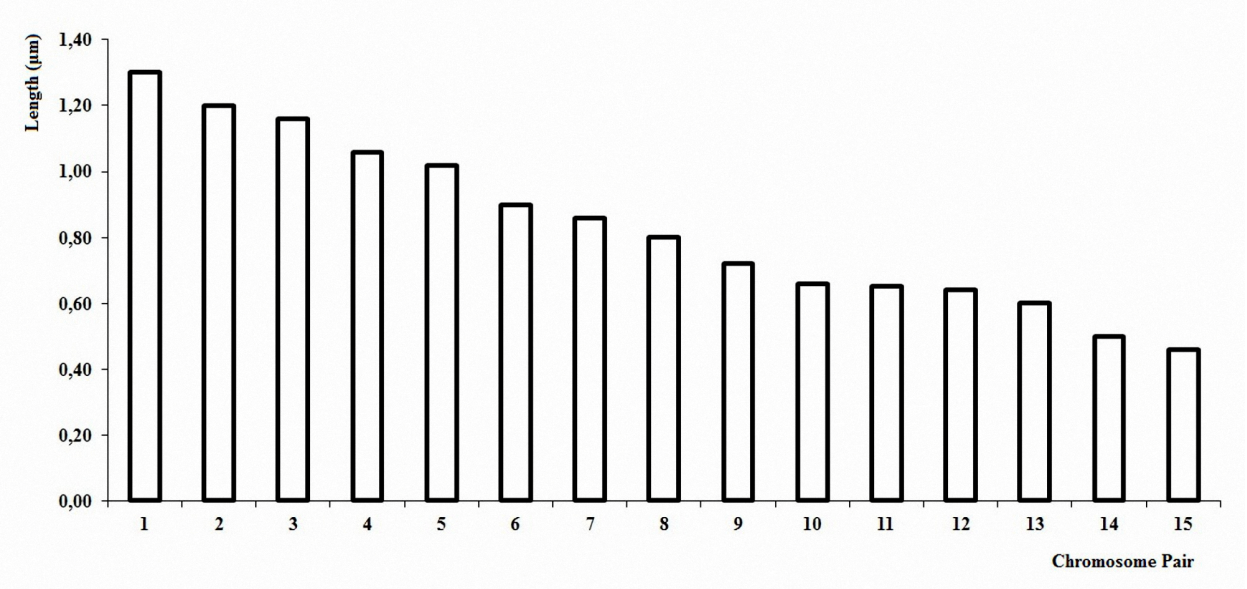

Figure 3. The ideogram of *Zygoribatula cognata*.

The measurement data of the chromosomes were given (Table 1). The length of chromosomes varied from 0.46 to 1.30 µm, and the average length of chromosomes was 0.84 ± 0.26 µm. The total haploid length was 12.53 µm.

Table 1. The measurement data of the chromosomes of *Zygoribatula cognata*

Chromosome Pair	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length (µm)	1.30	1.20	1.16	1.06	1.02	0.90	0.86	0.80	0.72	0.66	0.65	0.64	0.60	0.50	0.46

Discussion

The chromosome number of *Z. cognata* is 2n = 30. The situation is uncommon. Although the chromosome numbers in mites and ticks vary from 2 to 36 (Oliver Jr., 1977), the oribatid karyotypes usually have much smaller chromosome numbers in the range of 14-18 (Norton et al., 1993; Heethoff et al., 2006). A comparable situation was reported from two sibling species of muntjak which are Indian muntjac (*Muntiacus muntjak*, Zimmermann) and Chinese muntjac (*Muntiacus reevesi*, Ogilby) (Yang et al., 1995). Chromosome numbers of *Muntiacus* are extremely variable, ranging from 6 in Indian muntjac to the relatively high number of 46 in Chinese muntjac (Wang & Lan, 2000).

The chromosomes are holocentric or holokinetic chromosomes. The holocentric chromosomes are characterized with lack a localized centromere. In contrast, monocentric chromosomes are characterized with a single localized centromere in many organisms (Schvarzstein et al., 2010). Chromosome break is a diagnostic feature of holocentric chromosomes. In addition, if a holocentric chromosome is fragmented, each fragment retains centromere activity. The holocentric chromosomes, owning to their diffuse kinetochor activity, do at least theoretically pose no restriction to the multiplication of chromosomes via multiple breakages, as the recovery of all fragments after chromosome break (Melters et al., 2012). The holocentric chromosomes have been described in arthropods such as Acari, Odonata, Hemiptera and Lepidoptera (White, 1973; Heethoff et al., 2006). The small holocentric chromosomes are approximately

0.5–2 µm length (Wrensch et al., 1994). Mitotic figures of metaphase plates of *Z. cognata* have small holocentric chromosomes between 0.46–1.30 µm. Wrensch et al. (1994) reported that there are holocentric chromosomes in the oribatid mites and superorder Acariformes. Many mites such as *Platynothrus* (Berlese) (Camisiidae) (Taberly, 1987; Palmer & Norton, 1992), *Trhypochthonius tectorum* (Berlese) (Trhypochthoniidae) (Taberly, 1987; Palmer & Norton, 1992) *Tetranychus urticae* (Koch) (Tetranychidae) (Wrensch et al., 1994), *Hemisarcoptes coccophagus* (Meyer) (Hemisarcoptidae) (Izraylevich et al., 1995) and *Archegozetes longisetosus* (Aoki) (Trhypochthoniidae) (Heethoff et al., 2006) have holocentric chromosomes.

The sex chromosomes of *Z. cognata* could not be determined. In addition, the sex determination of *Z. cognata* is quite difficult according to morphological features. Gender of the samples could not be determined because their genital opening are covered with plates and very small. There are diplodiploidy in the Acari and their ancestors (Norton et al., 1993; Wrensch et al., 1994). In diplodiploidy, sex determination is often performed with sex chromosomes and sex ratio is 1:1, approximately (Fisher, 1930). Despite diplodiploidy, the sex determination is unknown in order Oribatida with the lack of sex chromosomes (Sokolov, 1954; Norton et al., 1993; Wrensch et al., 1994; Heethoff et al., 2006). Therefore, the males and females of oribatid mites have similar karyotypes with the equal number and type of chromosomes (Sokolov, 1954). However, the sex rate is close to unity in sexual oribatid mites. Beside that males are rare and sterile in parthenogenetic species (Taberly, 1987).

The chromosome number, chromosome type and chromosome symmetry/asymmetry are important cytotaxonomic characters. The karyotype symmetry/asymmetry index formula was reported for calculation of karyotype asymmetry in animal organisms (Eroğlu, 2015). The formula includes monocentric chromosomal type and centromeric position. It is not possible to calculate the karyotype symmetry/asymmetry in animal organisms have holocentric chromosomes. Therefore, the karyotype asymmetry of *Z. cognata* can not be determined.

In this study, the chromosome number, karyotype and ideogram of *Z. cognata* were determined. The chromosome number was firstly reported.

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References

Ayyıldız, N., 1988. Türkiye faunası için yeni *Zygoribatula* Berlese (Acari, Oribatulidae) türleri. Doğa Türk Zooloji Dergisi, 12 (3): 204-209.

Bayartogtokh, B. & I. E. Smelyansky, 2008. Contribution to the knowledge of soil mite genera *Zygoribatula* and *Peloribates* (Acari: Oribatida: Oripodoidea) in Central Asia. Soil Organisms, 80 (1): 19-44.

Behan-Pelletier, V. M., 1999. Oribatid mite biodiversity in agroecosystems: role for bioindication. Agriculture, Ecosystems & Environment, 74 (1-3): 411-423.

Eroğlu, H.E., 2015. Which chromosomes are subtelocentric or acrocentric? A new karyotype symmetry/asymmetry index. Caryologia, 68 (3): 239-245.

Fisher, R. A. 1930. The Genetical Theory of Natural Selection. Clarendon Press, Oxford, 272 pp.

Fritz, G., 1982. *Zygoribatula floridana* n. sp. (Acari: Oribatulidae), with a list of species in the genus. Florida Entomologist, 65 (4): 483-492.

Gan, H., 2013. Oribatid Mite Communities in Soil: Structure, Function and Response to Global Environmental Change. (Unpublished PhD thesis) University of Michigan, Michigan, 164pp.

Gokhman, V. E. & D. L. J. Quicke, 1995. The last twenty years of parasitic Hymenoptera karyology: an update and

phylogenetic implications. Journal of Hymenoptera Research, 4: 41-63.

Heethoff, M., P. Bergmann & R. A. Norton, 2006. Karyology and sex determination of oribatid mites. Acarologia 46 (1-2): 127-131.

Imai, H., R. W. Taylor, M. W. Crosland & R. Crozier, 1988. Modes of spontaneous chromosomal mutation and karyotype evolution in ants with reference to the minimum interaction hypothesis. The Japanese Journal of Genetics, 63 (2)**:** 159-185.

Izraylevich, S., U. Gerson & M. Wysoki, 1995. Karyotype and the sex determining mechanism of the mite *Hemisarcoptes coccophagus* Meyer (Acariformes: Astigmata: Hemisarcoptidae). International Journal of Acarology, 21 (4): 229-232.

Melters, D. P., L. V. Paliulis, I. F. Korf & S. W. Chan, 2012. Holocentric chromosomes: convergent evolution, meiotic adaptations, and genomic analysis. Chromosome Research, 20 (5): 579-593.

Norton, R. A., J. B. Kethley, D. E. Johnston & B. M. OConnor, 1993. "Phylogenetic Perspectives on Genetic Systems and Reproductive Modes of Mites, 8-99". In: (Eds. D. Wrensch & M. A. Ebbert) Evolution and Diversity of Sex Ratio in Insects and Mites. Chapman & Hall, New York, 634 pp.

Oliver Jr, J. H. 1977. Cytogenetics of mites and ticks. Annual Review of Entomology, 22: 407-429.

Palmer, S. C. & R. A. Norton, 1992. Genetic diversity in thelytokous oribatid mites (Acari; Acariformes; Desmonomata). Biochemical Systematics and Ecology, 20 (3): 219-231.

Schvarzstein, M., S. M. Wignall & A. M. Villeneuve, 2010. Coordinating cohesion, co-orientation, and congression during meiosis: lessons from holocentric chromosomes. Genes & Development, 24 (3): 219-228.

Sokolov, I. I. 1954. The chromosome complex of mites and its importance for systematics and phylogeny. Trudy Leningrad Obshchest Estestvoispyt, 72: 124-159.

Subías, L. S. 2004. Listado sistemático sinonímico y biogeográfico de los Ăcaros Oribátidos (Acariformes, Oribatida) del mundo (1758–2002). Graellsia, 60 (1): 3-305.

Taberly, G. 1987. Recherches sur la parthéogenèse thélytoque de deux espèces d'acariens oribatides: *Trypochthonius tectorum* (Berlese) et *Platynothrus peltifer* (Koch). III. Etude anatomique, histologique et cytologique des femelles parthénogenétiques. Acarologia, 28: 389-403.

Wang, W. & H. Lan, 2000. Rapid and parallel chromosomal number reduction in muntjac deer inferred from mitochondrial DNA phylogeny. Molecular Biology and Evolution, 17(9): 1326-1333.

White, M. J. D. 1973. "Animal Cytology and Evolution". Cambridge University Press, London, 468 pp.

Wrensch, D. L., J. B. Kethley & R. A. Norton, 1994. "Cytogenetics of Holokinetic Chromosomes and Inverted Meiosis: Keys to the Evolutionary Success of Mites, with Generalization on Eukaryotes, 282-343". In: Mites: Ecological and Evolutionary Analyses of Life-History Patterns (Eds. M. A. Houck). Chapman & Hall, New York, 357 pp.

Yang, F., N. P. Carter, L. Shi & M. A. Ferguson-Smith, 1995. A comparative study of karyotypes of muntjacs by chromosome painting. Chromosoma, 103 (9): 642-652.