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The History of Cytogenetic Investigations of Spiders in Turkey

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Abstract

Spiders are an ancient group of animals that probably originated in the Devonian period about 400 million years ago. Over time, they have adapted to major changes in climate and fauna and have become widespread on all continents, living in almost any terrestrial habitat. It is known that approximately 50000 spider species belonging to 120 families worldwide, today. and this number increases almost every day due to new records are being given from many countries. Despite the high diversity of species, the number of cytogenetic studies on spiders is very scarce. Upto now, 868 species belonging to the 74 families were investigated by cytogenetically. Although more than a thousand species of spiders in Turkey, the Cytogenetic studies are insufficient. Thus, spiders are the most richest group of arachnids among arthropods. In this study cytogenetic studies on spiders in Turkey were reviewed.

Keywords: Convergent Evolution; Rheumatoid Arthritis; Typhoid; HIV

Abbreviations: SCS: Sex Chromosome System.

Introduction

Basic Characteristics of Spiders

Spiders are one of the richest group in Chelicerata. The animals in this group do not have antennas [1]. The body structure of spiders consists of two main parts called cephalothorax (prosoma) and abdomen (opistosoma). These two parts are connected to each other by a narrow part called pedicel. The dorsal part of cephalothorax is covered with a structure called carapace, and its ventral part is covered with a plate called the sternum. The mouth, eyes and extremities are located ön the cephalothorax.

Generally, spiders have simple eyes and the number of eyes varies between 2-8. In determining family, characters related to the position, number and structure of the eyes are used. There are 6 pairs of extremities in the cephalothorax. Among them, the first extremity is called chelicer located on the front of the mouth with poison glands in their base [2]. The second pair of extremity is called pedipalpus. It is responsible for keeping food during feeding. In addition, pedipalpus, which has a bulging structure in male spiders, is an important structure in the transfer of sperm to the female. The remaning of the four extremity are walking legs. The opistosoma is the part of the body that contains the excretory system, reproductive organs and knitted glands. Male spiders have a pair of testes on either side of the abdomen. The sperm channels are long and curved, and the matured sperm are ejected from the middle of the epigastric slit through these channels. Sperm expelled from this opening is stored in the embolus at the ends of the pedipalps of male spiders, and from there, sperm is transferred to the female during mating [3,4].

All spiders are carnivores. Some of them live freely, while others live dependent on the net they built. Ecological and faunistic researches in forests, fields, gardens and grasslands has shown that spiders are the most common predators. A large number of spiders live in soil layers, stony, rocky and woodland, in the remains of organic matter and in terrestrial habitats such as plant tissues. A small number of spiders live on the water shores, on the surface of the freshwater and inside them. Since they are carnivorous, most of their nutrients are insects [5].

Cytogenetics of Spiders

The phase in which chromosome morphology is best observed during cell division is the metaphase. At this stage, chromosomes can be seen by regular condensation of chromatin threads. Karyotype refers to the ordering of chromosomes in a cell according to a certain order after matching, based on the chromosome morphology, number and size of an individual or species [6]. Karyotype features such as diploid number (2n), sex chromosome system (SCS) and chromosome morphology are important factors in understanding the cytogenetic structure of spiders.

Cytogenetic studies of spiders were firstly made by Carnoy [7], using gonads of male or females that imbedded in paraffin, sectioned, and stained with Heidenhain's iron haematoxylin. Visualisation and evaluation of chromosomes were not easy by the protocol used. Thus decades later Sharma, et al. [8] and Becak, et al. [9] were firstly obtained chromosomes using the squash methods of aceto-orcein and aceto-carmin [10]. After that colchicine solution was used for karyological preparations of spider gonads for both males and females by Pinter, et al. [11] to promote an increase in the number of cells in mitotic and/or meiotic metaphase. In the same decade Brum Zorrila, et al. [12] were used a fixative solution (3:1; methanol:acetic acid) and Giemsa solution as a stain. In 1977 Matsumoto, et al. [13] launched the use of observation of chromosomes in spider embryos which are valuable source of mitotic metaphase cells due to the high rate of cellular division that occurs during embryonic development. After that Wang, et al. [14] were described the number of tissues that can be used in spider cytogenetic studies, such as cerebral ganglion, cultured blood cells and gonads. Among them, the gonads were usablecomparing than the other tissues for cytogenetical analysis [10].

There are many different sex chromosome systems among spider species. Most of them have more than one X chromosome in their karyotypes. consists of two different X chromosomes, X_1 and X_2 for many species, and for male spiders, this system is considered to be ancestral. This sex chromosome system is generally seen in primitive spider groups namely Mesothelidae and Mygalomorphae. The other examples of sex chromosome systems of spiders are X_1X_20, X0, $X_1X_2X_30$, X_1X_2Y, $X_1X_2X_3X_4Y$, $X_1X_2X_3Y$ and $X_1X_2X_3X_4X_5Y$ and XnYn0. "0" in the sex chromosome systems indicates that there is no Y chromosome [15].

In Turkey, a total of 1117 spider species (with two subspecies) belonging to 52 families have been found. Among them, the richest families are Gnaphosidae (30 genera and 145 species), Salticidae (42 genera and 143 species), Linyphiidae (66 genera and 128 species), Thomisidae (14 genera and 90 species) and Lycosidae (15 genera and 87 species) [16]. Although some species are endemic, some are very widespread throughout the country. The first study of the spider cytogenetics in Turkey was carried out by Akan, et al. [17]. The authors were studied of three species belonging to the families Lycosidae and Theraphosidae. Adult and subadult individuals were used and as a result the diploid chromosome number of *Arctosa perita* (Latreille 1799), *Lycosa narborensis* (Walkenaer 1806) and *Chaetopelma anatolicum* (Schmidt, Smith 1995) was 2n=12, 2n=18 and 2n=16, respectively. There was no data about the sex chromosome system of the spiders studied.

In 2009, the karyotype of four species of the Gnaphosidae were raported by Kumbıcak, et al. [18]. The karyotype formula was 2n♂=22 (X_1X_20) for all species, *Callilepis cretica* (Roewer 1928), *Drassodes pubescens*, *Drassyllus pumilus* (C L Koch 1839) and *Zelotes strandi* (Nosek 1905).

The diploid chromosome number and the sex chromosome system of five species belonging to the families Gnaphosidae and Lycosidae were determined as 2n♂=22 (X_1X_20) and 2n♂=28 (X_1X_20), respectively and the studied species were *Nomisia conigera* (Spassky 1941), *Haplodrassus morosus* (O. Pickard-Cambridge 1872), *Haplodrassus dalmatensis* (L Koch 1866), *Pardosa bifasciata* (CL Koch 1834) and *Arctosa cinerea* [19]. Taşdemir, et al. [20] were reported the karyotype characteristics of three species belonging to the Gnaphosidae as *Zelotes petrensis* (CL Koch 1839) 2n=11, *Zelotes aeneus* (Simon 1878) 2n=9 and *Nomisia conigera* (Spassky 1941) 2n=10; two species of Theridiidae, *Theridion pictum* (Walckenaer 1802) 2n=14 and *Steotoda triangulosa* (Walckenaer 1802) 2n=12; one species for Lycosidae, *Trochosa ruricula* (De Geer 1778), 2n=9.

Karyotype features of *Drassyllus praeficus* (L. Koch 1866) (Gnaphosidae) and *Thanatus imbecillus* (Philodromidae) (L. Koch 1878) were obtained using chromosomes from gonads. The diploid chromosome number and the sex chromosome system of *D. praeficus* and *T. imbecillus* was 2n♂= 22 (X_1X_20) and 2n♂= 28 (X_1X_20), respectively [21]. In the year 2014, a total of 23 species were investigated by cytogenetically as follows: *Berinda hakani* Chatzaki & Seyyar 2010 2n♂ =22 (X_1X_20), *Berinda ensigera* (O. Pickard-Cambridge 1874) 2n ♂=22 (X_1X_20), *Trachyzelotes lyonneti* (Audouin, 1826) 2n ♂=22 (X_1X_20), *Trachyzelotes malkini* Platnick & Murphy 1984 2n♂ =22 (X_1X_20), *Zelotes caucasius* (L. Koch 1866) 2n♂ =22 (X_1X_20) (Gnaphosidae); *Thanatus pictus* L. Koch 1881 2n♂=28 (X_1X_20), *Tibellus macellus* Simon 1875 2n ♂=24 (X_1X_20) (Philodromidae); *Neon reticulatus* (Blackwall 1853) 2n ♂=21 (X0) (Salticidae); *Peucetia virescens* (O. Pickard-Cambridge 1872) 2n♂ =28 (X_1X_20) (Oxyopidae) and *Loxosceles rufescens* (Dufour 1820) 2n♂ = 21 (X_1X_2Y)

(Sicariidae) [22]; *Pterotricha kochi* (O. Pickard-Cambridge 1872) and *Pterotricha lesserti* Dalmas 1921 2n♂ =22 (X_1X_20) (Gnaphosidae) [23]; *Drassyllus sur* Tuneva & Esyunin 2003, 2n♂=22 (X_1X_20), *Nomisia exornata* (C. L. Koch, 1839) 2n♂=22 (X_1X_20), and *Nomisia orientalis* Dalmas 1921 2n♂=22 (X_1X_20), *Sitticus caricis* (Westring 1861) 2n♂=28 (X_1X_20); *Xysticus gallicus* Simon 1875 2n♂=23, X0 and in *Pax islamita* (Simon 1873) 2n♂=42, (X_1X_20) [24]; *Drassodes lutescens*: 2n♂=21 (X0), *Micaria albovittata* 2n♂=22 (X_1X_20), *Cheiracanthium mildei* 2n♂=26 (X_1X_20), *Cheiracanthium pennyi*: 2n♂=26 (X_1X_20) and *Philodromus lividus*: 2n♂=28 (X_1X_20) [25].

In 2018, the karyotype formula of *Tegenaria elysii* Brignoli, 1978 were found as 2n♂=42 (X_1X_20) [26,27], and *Hersiliola bayrami* Danisman, et al. as 2n♂=35 ($X_1X_2X_30$). The next year, karyotype features based on diploid number and sex chromosome system of *Steatoda grossa* (C.L. Koch 1838) was reported as 2n♂=22 (X_1X_20) for Turkish populations [28], for *Eratigena agrestris* (Walckenaer 1802) the diploid chromosome number and sex chromosome system was 2n♂=42 (X_1X_20) [29], and for *Gnaphosa lugubris* (CL Koch, 1839) the karyotype formula was 2n♂=22 (X_1X_20) [30]. The last study on spider cytogenetics was made by Kumbıçak, et al. [31] on *Drassodes bifidus* (Kovblyuk and Seyyar 2009) and *Drassodes serratichelis* (Roewer 1928), according to the results the karyotype characteristics of them was 2n♂=22 (X_1X_20) for both *D. bifidus* and *D. serratichelis*.

Conclusion

There are 1117 spider species known in Turkey, among them almost 60 species (5.37%) were investigated by cytogenetically. belonging to the families Agelenidae, Gnaphosidae, Hersiliidae, Lycosidae, Oxyopidae, Philodromidae, Salticidae, Sicariidae, Theraphosidae, Theridiidae, and Thomisidae. Of these families, Gnaphosidae is the most studied group due to its widespread. The studies have provided information about the diploid chromosome number and sex chromosome systems of the species, but chromosome banding studies have not been included. According to these studies, cytogenetic features were generally conservative at the family.

The reproduction period of spiders takes place in a short period of time, which reduces the rate of obtaining chromosomes from them. Thus, spider cytogenetic studies are progressing slowly. As a result, since there are many families that have not been studied yet, samples of these families should also be investigated. Therefore, more field studies should be organized and more samples should be collected and applied. Moreover, chromosome banding techniques such as C-banding and NOR staining should be included in the studies to obtain detailed data.

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