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Karyotype for *Nebo hierichonticus* (Simon 1872) from the Palestinian Territories (Scorpiones: Scorpionidae)

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Summary In this paper we report the first karyotypic data on *Nebo hierichonticus* (Simon 1872) from the occupied Palestinian territories. The karyotype consists of 50 chromosomes which appear acrocentric except for pair 3, likely representing the XY. With additional data on scorpionidae coming through, we suggest that a model of chromosomal evolution might involve changes in chromosome numbers that relate to chromosomal stability in the nucleus and recombination affecting adaptability as previously suggested and supported by studies of salmonid fish chromosomes.

Key words Karyotype, *Nebo hierichonticus*, Palestinian territory, Scorpion.

The order Scorpiones is a fascinating order of arthropods with over 2000 species. Its taxonomy continues to undergo revision, and new species are described as new data accumulate, including data on morphology and DNA analysis (*e.g.* Prendini *et al.* 2003, Sousa *et al.* 2011). In the Eastern Mediterranean region, some morphological work on scorpions was done by Vachon (1966, 1974), Levy and Amitai (1980), Lourenço (1999, 2002), Amr and Al-Oran (1994), Kabakibi *et al.* (1999), and Stathi and Lourenço (2003).

A review showed that only about 80 of over 2000 known species of scorpions have been evaluated by chromosome studies (Moustafa *et al.* 2005, Schneider *et al.* 2009). We recently reported the karyotypes of three species from Palestine: *Leiurus quinquestriatus*, *Hottentotta judaicus*, and *Scorpio maurus fuscus* (Qumsiyeh *et al.* 2013). The only other study of chromosomes in the Middle East was done in Egypt of some members of the genus *Androctonus*, which had a fairly uniform 2*n*=24 (Moustafa *et al.* 2005).

Traditionally, *Nebo hierichonticus* was placed under the family Diplocentridae. However, Soleglad and Fet (2003) abolished this family and downgraded it to a subfamily rank in the family Scorpionidae. The karyotype of 15 species of this family was investigated, with 2*n* ranging from 52 in *Scorpio marus fuscus* (Qumsiyeh *et al.* 2013) to 175 in *Urodacus novaehollandiae* (Shanahan 1989b).

In this paper, we report the first chromosomal data for *Nebo hierichonticus*, and we comment on the variation seen in chromosome number and possible evolutionary origin of this variation.

Materials and methods

The collection of scorpions was done during the day by turning rocks or objects where they

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Table 1. Locality coordinates from which *Nebo hierichonticus* were collected.

Locality	N	E
Battir	31°43′	35°08′
Bil'in	31°93′	35°07′
EinFashkha	31°42′	35°27′
EinYabroud	31°56′	35°15′
Jebel KafrNe'mah	31°93′	35°10′
WadiAKouf	31°34′	35°02′
WadiFukeen	31°71′	35°10′

may hide, and during the night *via* walking and scanning the ground with ultraviolet flash lights. All specimens were retained in the nascent Palestine Natural History Museum (PMNH). Table 1 indicates the coordinates of localities from which materials were collected.

Karyotyping

Karyotyping was done from gonadal tissues dissected in saline solution by the method of Schneider *et al.* (2009). We found that the success rate is variable, and that it depends on the seasonality of reproduction in scorpions. Specimens collected in May to July gave us good results. For each specimen, at least five mitotic and/or meiotic cells were analyzed/counted.

Results

The karyotype for *N. hierichonticus* consists of 50 chromosomes. The chromosomes graded by size all appeared acrocentric with the exception of pair three, which in males appeared slightly heteromorphic, indicating it is likely the XY chromosome (Fig. 1). This is the first karyotypic data on *N. hierichonticus*.

Discussion

In Palestine, we reported the karyotypes of *Hottentotta judaicus* 2*n*=16, *Leiurus quinquestriatus* 2*n*=22, and *Scorpio maurus fuscus* 2*n*=52 (Qumsiyeh *et al.* 2013). The data above for *Nebo* adds an important element as it represents the first karyotype on the diplocentrid group within the Scorpionidae *sensu lato*.

Karyotypes of roughly 5% of the species of scorpions in the world are now available and show significant inter-genus and inter-specific variation (Schneider *et al.* 2009). However, our data on *Nebo hierichonticus* and a review of available data shows an interesting pattern —the karyotype of the Buthidae *sensu lato* ranges from 2*n*=6 to 2*n*=48, while that of the Scorpionidae *sensu lata* range from 2*n*=29 to 2*n*=175 (Shanahan, 1989a, 1989b, Mattos *et al.* 2013). Schneider *et al.* (2009) stated that the low diploid numbers were restricted to the most cytogenetically investigated family (Buthidae) and in Opiliones, but not in the Scorpiones groups. There are complications to studying chromosomes of scorpions. Parthenogenesis was noted in some species including a number of species of *Tityus* (Lourenço 2002). Other species (*e.g. Urodacus novaehollandiae*) were noted to have high chromosome numbers, perhaps suggesting polyploidy (Shanahan 1989a). Even if we exclude those two phenomena, we still have to explain why there is such a high variation in chromosome numbers.

Schneider *et al.* (2009) does not explain the possible evolutionary advantage of chromosome number in scorpions. Qumsiyeh (1994, 1995) proposed a model in which increases and decreases in chromosome number in mammals are selected based on their effect on recombination and stability

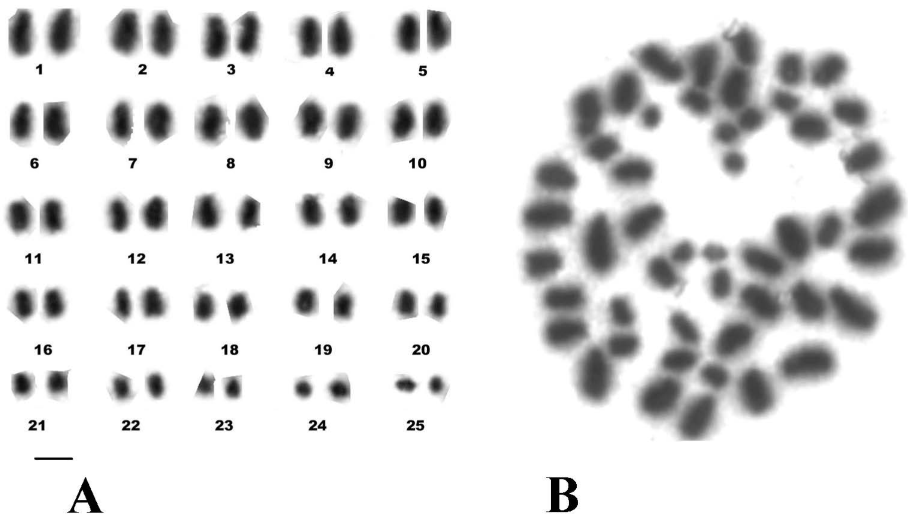

Fig. 1. A. Karyotype and B. metaphase of a male *N. hierichonticus* from Battir. Pair 3 is likely the XY. Bar=2μm.

of chromosomes in interphase nuclei. The model seemed useful to explain chromosomal variation in salmonid fish (Phillips and Ráb 2001), and it would be interesting to study its applicability in scorpions, especially as more ecological and reproductive data are collected.

Most of the reported species of Buthidae *sensu lata* are apoikogenic, while most of the reported species of Scorpionidae *sensu lata* are katoikogenic in the sense that was developed by Laurie (1896). The phylogenetic difference remains if we take the modification of this classification of apoikogenic and katoikogenic by Lourenço *et al.* (1986), Lourenço (2002) and Warburg (2010). Lourenço *et al.* (1986) suggested that the Buthidae have the most complex gradient of embryonic development, while Scorpionidae species have less complexity. Variables like adaptability to different habitats and reproduction strategies should be correlated to karyotypic data in species of scorpions to understand evolutionary strategies. Better understanding of these strategies will come as more data accumulate including better phylogenetic trees based on molecular data.

References

Amr, Z. S. and Al-Oran, R. 1994. Systematics and distribution of scorpions (Arachnida, Scorpionida) in Jordan. Boll. Zool. **61**: 185–190.

Kabakibi, M. M., Khalil, N., and Amr, Z. 1999. Scorpions of Southern Syria. Zool. Middle East **17**: 79–89.

Laurie, M. 1896. Notes on the anatomy of some scorpions, and its bearing on the classification of the order. Ann. Mag. Natr. Hist. Ser. 6 **17**: 185–194.

Levy, G. and Amitai, P. 1980. Fauna Palaestina. Arachnida I: Scorpiones. The Israel Academy of Science and Humanities, Jerusalem.

Lourenço, W. R. 1999. On the phylogenetic position of the genus *Birulatus* Vachon, 1973 (Scorpiones, Buthidae) and redescription of *Birulatus haasi*. Zool. Middle East **18**: 109–113.

Lourenço, W. R. 2002a. Further morphological considerations on the genus *Birulatus* Vachon (Scorpiones, Buthidae), with the description of a new species from Israel. Revista Iberica de Aracnologia **6**: 141–145.

Lourenço, W. R. 2002b. Reproduction in scorpions, with special reference to parthenogenesis. In: Toft, S. and Scharff, N. (eds.). Proceedings of the 19th European Colloquium of Arachnology, European Arachnology 2000. Aarhus University Press, Aarhus. pp. 71–85.

Lourenço, W. R., Kovoor, J., and Muñoz-Cuevas, A. 1986. Morphogenèse des premiers stadesembryonnaires chez des Scorpions. Boll. Zool. **53**: 105.

Mattos, V. F., Cella, D. M., Carvalho, L .S., Candido, D. M., and Schneider, M. C. 2013. High chromosome variability and

the presence of multivalent associations in buthid scorpions. Chromosome Res. **21**: 121–136.
Moustafa, M. A., Alaa, A. M., Sarhan, M. H., and Yaseen, A. E. 2005. Chromosomal studies on four Egyptian scorpion species of genus *Androctonus* (Family: Buthidae). Cytologia **70**: 161–165.
Phillips, R. and Ráb, P. 2001. Chromosome evolution in the Salmonidae (Pisces): An update. Biol. Rev. Camb, Philos. Soc. **76**: 1–25.
Prendini, L., Crowe, T. M., and Wheeler, W. C. 2003. Systematics and biogeography of the family Scorpionidae Latreille, with a discussion of phylogenetic methods. Invertebr. Syst. **17**: 185–259.
Qumsiyeh, M. B. 1994. Evolution of number and morphology of mammalian chromosomes. J. Hered. **85**: 455–465.
Qumsiyeh, M. B. 1995. Impact of rearrangements on function and position of chromosomes in the interphase nucleus and on human genetic disorders. Chromosome Res. **3**: 455–465.
Qumsiyeh, M. B., Salman, I. N.A., Salsaa', M., and Amr, Z. S. 2013. Records of scorpions from the Palestinian Territories, with the first chromosomal data (Arachnida: Scorpiones). Zool. Middle East **59**: 70–76.
Schneider, M. C., Zacaro, A. A., Pinto-Da-Rocha, R., Candido, D. M., and Cella, D. M. 2009. A comparative cytogenetic analysis of 2 Bothriuridae species and overview of the chromosome data of scorpiones. J. Hered. **100**: 545–555.
Shanahan, C. M. 1989a. Cytogenetics of Australian scorpions. I. Interchange polymorphism in the family Buthidae. Genome **32**: 882–889.
Shanahan, C. M. 1989b. Cytogenetics of Australian scorpions. II. Chromosome polymorphism in species of *Urodacus* (family Scorpionidae). Genome **32**: 890–900.
Soleglad, M. E. and Fet, V. 2003. High-level systematics and phylogeny of the extant scorpions (Scorpiones: Orthosterni). Euscorpius **11**: 1–175.
Sousa, P., Froufe, E., Harris, D. J., Alves, P. C., and Van Der Meijden A. 2011. Genetic diversity of Maghrebian *Hottentotta* (Scorpiones: Buthidae) scorpions based on CO1: New insights on the genus phylogeny and distribution. Afr. Invertebr. **52**: 135–143.
Stathi, I. and Lourenço, W. 2003. Description of a new scorpion species of the genus *Birulatus* Vachon, 1974 (Scorpiones, Buthidae) from Syria. Zool. Middle East **30**: 105–110.
Vachon, M. 1966. Liste des scorpions connus en Egypte, Arabie, Israel, Liban, Syrie, Jordanie, Turquie, Irak, Iran. Toxicon **4**: 209–218.
Vachon, M. 1974. Etude des caracteres utilises pour classer les familles et les genres de Scorpions (Arachnides). Bull. Musé. Nat. Hist Natur, Paris **3**: 857–895.
Warburg, M. R. 2010. Reproductive system of female scorpion: a partial review. Anat. Rec. **293**: 1738–1754.