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Original Article

Intra- and inter-specific foraging in three scorpion species

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Abstract
Intra- and inter-specific feeding behaviour of three scorpion species: *Mesobuthus tumulus* (Fabricius, 1798), *Odontobuthus odonturus* (Pocock, 1897), and *Androctonus finitimus* (Pocock, 1897) inhabiting Punjab, Pakistan, was studied under laboratory and field conditions. Results of the study revealed that all three scorpion species were cannibalistic. *Mesobuthus tumulus* attacked and fed more upon juvenile and sub- adults (medium- sized), scorpions. They also consumed dead scorpions of their own species. *Odontobuthus odonturus* preferred to attack and consume healthy adults and did not feed on dead scorpions. *Androctonus finitimus* aggressively attacked and consumed all types of prey scorpions of its own species, except the dead ones. In inter-specific feeding experiment, *M. tumulus* consumed healthy adults, injured adults, pregnant females and dead adults of *O. odonturus*. However, *M. tumulus* did not consume any live *A. finitimus* but consumed its dead. *Androctonus finitimus* consumed all types of *O. odonturus* and *M. tumulus* but did not feed on the dead ones. Results of feeding behaviour of *A. finitimus* and *M. tumulus* recorded in the field were similar as observed in the laboratory. However, in the field, *O. odonturus* was observed to rarely feed upon on members of its own species.
Keyword: Cannibalism, feeding, field, scorpions, laboratory, prey

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INTRODUCTION

Scorpions are very primordial terrestrial arachnids (Ozkan *et al.,* 2007). They inhabit a wide range of allocations and are distributed in hot and dry environments throughout the world except Antarctica (Isbister *et al.,* 2003; Vatanpour, 2003). Along with highly venomous nature of scorpion venom (Ozkan *et al.,* 2006), their venom also contains a variety of peptides (especially of low molecular weight) having anti-inflammatory (Ahmadi *et al*., 2009), bio-pesticidal (Menez, 1998; Zlotkin *et al.,* 2000) and anti-tumoral potentials (Cheong *et al.,* 2010). Furthermore, scorpion toxins are useful in treatment required to prevent the rejection of organ transplants, pancreatitis, epilepsy (Wang *et al.,* 2001), anti-rheumatic activity (Nakajima *et al.,* 1991), cancer (Heinen and Da-Veiga, 2011), pain (Liu *et al.,* 2003), asthma and auto-immune disorders (Cheong *et al.,* 2010; Gao *et al.,* 2010). Although scorpion venom is imperative for medical and pesticidal research, their raring for venom extraction is a difficult task. Like some other arthropods, for example, spiders (Persons and Uetz 2005; Segoli *et al*., 2008) and praying mantis (Barry *et al*., 2008), scorpions are cannibalistic and may prey upon members of their own species. Thus far negligible work has been done on scorpion cannibalism and most of the reported studies concern feeding of the male scorpion by female during or after mating. This altruism strategy though helpful for males in terms of gene transfer to the next generation, significantly reduces the number of male scorpions in the habitat (Buskirk *et al*., 1984).

Polis and Farley (1979) observed under field conditions that female *Paruroctonus mesaensis* (Scorpiones: Vaejovidae) (Stahnke, 1957) become more aggressive than male in breeding season and cannibalize male before or after mating. A field study on scorpion foraging behaviour conducted by Lighton (2001) revealed that scorpions feed on small insects.

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Similarly, they also forage on juvenile scorpions of their own species. Most of the research work on scorpion cannibalism has been conducted under field conditions. Also, almost all the reported studies are on sexual cannibalism (Polis and Farley, 1979; Colombo, 2011; Fox, 1975). Thus far, to the knowledge of the authors, no systematic laboratory-observed work on scorpion cannibalism has been documented in the scientific literature. The present study was aimed to investigate the intra- and inter-specific foraging behavior in the laboratory as well as under field conditions of three scorpion species, *Mesobuthus tumulus, Odontobuthus odonturus, and Androctonus finitimus* that occur in Punjab, Pakistan.

MATERIALS AND METHODS

Test animals

Three common scorpion species, *i.e., M. tumulus* (Fabricius, 1798) (Kovarik, 2007), *O. odonturus* (Lourenco and Pezier 2002) and *A. finitimus* (Pocock, 1897) (Kovarik and Ahmed 2013) in Punjab, Pakistan, were selected for the study. The juveniles, sub- adults (medium-sized), and adult scorpions, ranging from 1cm to 10 cm in length, according to species, were used for the study. Scorpions were identified with the help of taxonomic keys and catalogues provided by Kovarik and Ahmed (2009) and Tikader and Bastawade (1983).

Scorpion collection

Experimental scorpions were field-collected from different areas of Punjab, Pakistan. *Mesobuthus tumulus*, were collected from old muddy houses located in rural areas of Sargodha (Chak # 34/SB 31.96º N, 72.86 º E; Bhagtanwala (Chak # 23A/SB) 32.04º N, 72.92º E; Chak # 76/SB 32.07º N, 72.85º E; Chak # 24/SB 32.05º N, 72.96º E) and Mianwali (32.55º N, 71.60º E. *Odontobuthus odonturus* were collected from Jhang (Jhang 31.22º N, 72.31º E; Malumor 31.13º N, 72.23º E; Mudduki 31.15º N, 72.31º E; Shorkot 30.87º N, 72.1ºE) and Sargodha (Dodha (31.98º N, 73.08º E) whereas *Androctonus finitimus* were captured from Shorkot (30.82º N 72.1º E) and Sargodha (Dodha 31.99º N, 73.04º E).

Portable battery-operated ultraviolet (UV) lamps (SOGO-JPN-139) were used to collect live scorpions of all three species at night. Sampling and the cannibalism experiments were conducted from May to September, 2013, 2014 and 2015.

Stocking the scorpions

Field-collected scorpions were stocked according to their size and gender. Round bottom flasks (1000 ml) were used for the stocking. The juvenile, sub- adults (medium-sized), adults, and injured adults (injured during handling), adult females (those containing eggs or baby bearing females) and dead scorpions were stocked in separate flasks. Small quantity of sand was provided in the flasks. All flasks were covered with mesh cloth and were maintained in the laboratory under 33-38˚C. 40-50% relative humidity, and 10:14 hours (L:D cycle).

Raring the scorpions

In the raring process in the laboratory, every field-collected (from bulk) pregnant female scorpion (containing eggs in their womb) was stocked separately in the 1000 ml round bottom flask. The females of all three scorpion species laid eggs and after 2-3 days juvenile scorpions emerged from the eggs and attached themselves to dorsal side of mother. After laying eggs, mother scorpions were found hungry and needed food so, female scorpions were fed at their station level with house crickets, *Acheta domestica* (Linnaeus, 1758), and houseflies *Musca domestica* (Linnaeus, 1758). After 8-10 days of birth, baby scorpions were separated from mother and stocked in different flasks.

Cannibalism experiments

In these experiments, cannibalistic activities of the study scorpions were observed both among the same species as well as among different species. Additionally, cannibalistic behaviour was also studied directly under field conditions.

Cannibalism study among the same species

For this experiment, juvenile (approximately 1 cm long), sub- adults (medium-sized), (3-4 cm in length), and adult scorpions (7.7-11 cm long) were selected as prey. Adult prey scorpions were further divided in to four categories i.e., healthy adults, pregnant females, injured adults, and dead adults. After this six 1000 ml round bottom flasks were taken and numbered from 1 to 6. One healthy adult scorpion, i.e., *M. tumulus* was placed in each experimental flask and was considered as the predator. Before initiating the experiment predator scorpions were fed to the satiation level and thereafter were starved for seven days to standardize their hunger level. Twenty juvenile (about10 days old) scorpions were added as a prey in 1st experimental flask. Similarly, ten medium sizes, five healthy adults, five pregnant, five injured adults and five dead adult scorpions were respectively added to the 2nd, 3rd, 4th, 5th and 6th experimental flasks. The number of prey consumed by the predator scorpions was recorded after every 12 hours for 144 hours. The experiment was repeated five times. Identical procedure was used for testing the other two scorpion species, *O. odonturus* and *A. finitimus*. Predator scorpions were marked with black ink for their identification. It was also ensured that the prey scorpions were not hungry before using them in the experiment. For this purpose, the prey scorpions were fed on house crickets and houseflies to their saturation level. In this experiment, the control flasks (n=6) contained only different prey types but no scorpion.

Cannibalism study on different scorpion species

This experiment was divided into three sets. In the first set, *M. tumulus* was considered as predator and the other two species, *O. odonturus* and *A. finitimus* as prey. Eight round bottom flasks (each1000 ml capacity) were divided into two groups (I &II), with each group containing four flasks. Flasks were numbered I to IV. One healthy adult predator (*M. tumulus*) was added into each flask of both groups. Healthy adult scorpions (n=5) pregnant females (n=5), injured adults (n=5), and dead adult scorpions (n=5) of *O. odonturus* were added into flasks I, II, III and IV, respectively in flasks in group 1. Similarly, healthy adult scorpions (n=5) pregnant females (n=5), injured adult (n=5), and dead adult scorpions (n=5) of *M. tumulus* were introduced respectively into flasks I, II, III and IV in group 2. In second set of experiments, *O. odonturus* was used as predator and *M. tumulus* and *A. finitimus* as the prey scorpions. In the third set of the experiment, *A. finitimus* was used as predator and *M. tumulus* and *O. odonturus* as prey scorpion species. Other experimental protocol was the same as described above for *M. tumulus*. All experiments were replicated thrice.

Field observations for scorpion cannibalism

Cannibalistic activities of the three experimental scorpion species, *M. tumulus, O. odonturus,* and *A. finitimus* were also observed directly in the field. For this purpose, scorpion-rich field habitats were selected (Sargodha i.e., Dodha 31.99º N, 73.04º E; Midh Ranjha 32.05º N 73.13º E; Chak # 34/SB 31.96º N, 72.86 º E; Bhagtanwala (Chowki Bhagat) 32.04º N, 72.92º E; Chak # 76/SB 32.07º N, 72.85º E and Jhang 31.22º N, 72.31º; Shorkot (30.82º N, 72.1º E). A team of three persons perform this activity. Portable UV lamps were used for locating the scorpions at night. Preying and cannibalistic behaviour was observed by using LED flash light (SOGO-JPN-75). The study was conducted between 8 to 11 PM during May to September 2013, 2014, 2015.

RESULTS

Cannibalism behavior among the same scorpion species

Results of this experiment showed the presence of cannibalism in all three studies scorpion species. *Mesobuthus tumulus* attacked and fed more on juvenile and sub- adults (medium-sized) scorpions compared to healthy adults, injured adults or pregnant females (Fig. 1); this species consumed lesser number of dead scorpions compared to the two other scorpion species. *Odontobuthus odonturus* was observed to prefer attacking and consuming healthy adults. (Fig. 2) and did not feed upon dead scorpions. *Androctonus finitimus* was found to be highly aggressive with significantly higher cannibalism compared to the other two scorpion species. *Androctonus finitimus* was observed to attack and consume all types of prey scorpions except for their dead ones (Fig. 3).

Foraging on different scorpion species

It is depicted in Table 1 that *M. tumulus* consumed healthy adults, injured adults, pregnant females and dead adults of *O. odonturus*. However, *M. tumulus* did not consume any live *A. finitimus* but consumed the dead ones of this species (8%). *Androctonus finitimus* consumed all types of *O. odonturus* and *M. tumulus*. These scorpions did not feed on dead ones.

Field observations

Higher cannibalism was noted in *A. finitimus* during field study. It was observed that

Juvenile and sub- adults (medium- sized), scorpions were easier prey for adult *A. finitimus*. However, in case of two adult *A. finitimus* encountering each other, one scorpion won the battle after nearly 2-3 hours of severe engagement and the looser was eventually consumed by the winner. Normally, *Odontobuthus odonturus* did not leave their burrows, thus minimizing the probability of countering each other.

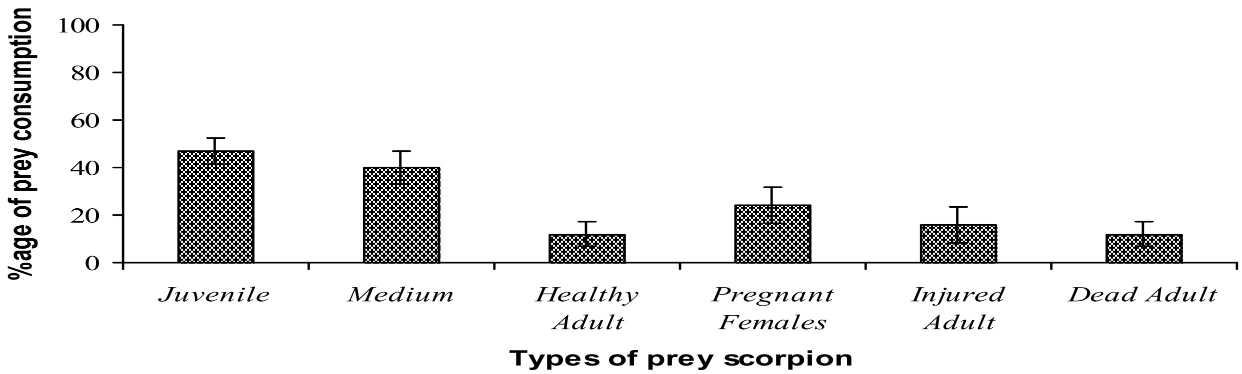

Figure 1. Feeding of *Mesobuthus tumulus* on different prey types of same species. Bars and error bars in the figure are representing mean percentage and strand error, respectively.

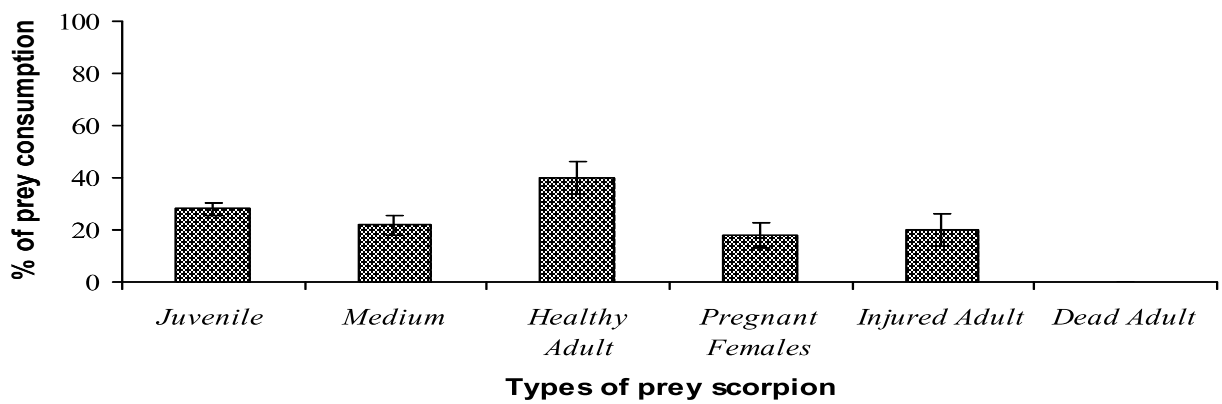

Figure 2. Feeding of *Odontobuthus odonturus* on different prey types of same species. Bars and error bars in the figure are representing mean percentage and strand error, respectively.

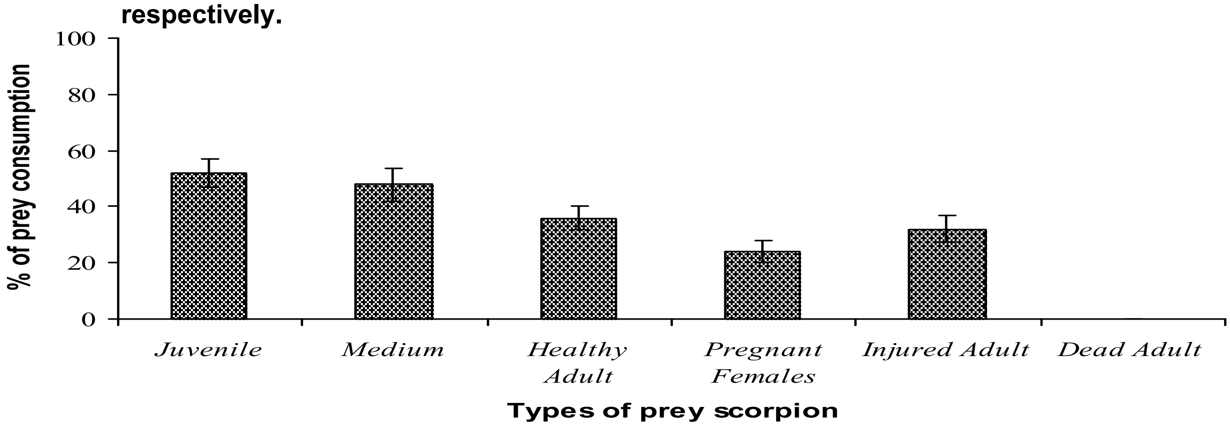

Figure 3. Feeding of *Androctonus finitimus* on different prey types of same species. Bars and error bars in the figure are representing mean percentage and strand error, respectively.

As a result cannibalism in *A. finitimus* is rare in their natural habitat. *Mesobuthus tumulus* habitats were diverse, they occurred solitary in grassy fields; they were also found in old muddy and brick houses in a sub-social state. Normally, they did not attack each other when their prey were abundant in the field/under bricks; however, they only consumed member of their own species when their prey were scarce.

Table I: Feeding study among different scorpion species

Predators	**Prey types**			
	Healthy Adults	**Injured Adults**	**Pregnant Females**	**Dead Adults**
Set 1	**Prey (** *Odontobuthus odonturus* **)**			
Mesobuthus tumulus	8% (2/25)	8% (2/25)	20% (5/25)	4% (1/25)
Androctonus finitimus	56% (14/25)	24% (6/25)	44% (11/25)	0% (0/25)
Set 2	**Prey (***Mesobuthus tumulus***)**			
Androctonus finitimus	36% (9/25)	16% (4/25)	44% (11/25)	0% (0/25)
Odontobuthus odonturus	12% (3/25)	8% (2/25)	12% (3/25)	0% (0/25)
Set 3	**Prey (***Androctonus finitimus***)**			
Mesobuthus tumulus	0% (0/25)	0% (0/25)	0% (0/25)	8% (2/25)
Odontobuthus odonturus	0% (0/25)	0% (0/25)	0% (0/25)	0% (0/25)

DISCUSSION

In the present study, intra- and inter-specific foraging behaviour of three most common species of scorpions, *A. finitimus, O. odonturus and M. tumulus* occurring in Punjab, Pakistan, was observed. Members of all three scorpion species consumed members of their own species; and also fed upon scorpions of other species.

Colombo (2011) studied the ecology of *Buthus occitanus* (Amoreux, 1789) and discovered that the members of this scorpion species feed on juvenile and adults when counter each other. Fox (1975) reported cannibalism in different species of scorpions and other arachnids. Our results showed that all the three scorpion species attacked and consumed more juvenile and sub- adults (medium- sized), scorpions of their own species or other species. This is not surprising as capturing, handling and consumption of small-sized prey would be easier. Also, it could be a strategy of the predatory scorpion to save energy content that could be consumed in fighting with adult scorpions requiring more energy. Similar results were reported by Polis and Farley (1979) who showed that under field conditions scorpions preferred to prey on small-sized scorpions, other arachnids or insects.

Mesobuthus tumulus preyed upon juvenile and sub- adults (medium- sized), scorpions as well as pregnant females and injured adult scorpions. This species predominantly inhabits old muddy/brick houses and were found almost in every village in the study area. They live in sub-social conditions and do not attack members of their own species under normal circumstances but attack crickets (Casper, 1985) and other insects (Mc-Cormick and Polis, 1990) which become common prey of *M. tumulus* as they are attracted to domestic lights and then disperse in the muddy houses becoming easy prey of *M. tumulus*. However, under circumstances of scarcity of their prey animals, they may attack and consume members of their own species.

According to previous reports, scorpions consume only live scorpions (Brownell, 2001), but the present study has revealed that *M. tumulus* also consumed dead scorpions and other insects as well for their survival when striving and having no other prey options, It was also noted during the present study that female

M. tumulus after laying eggs become more aggressive and feed on pregnant females, weak adults or dead ones, perhaps for revival of their energy level; however, *O. odonturus and A. finitimus* did not show this type of foraging behavior.

Relatively low level of cannibalism was observed in the juvenile (up to 2nd instar) scorpions of all three species. Female scorpions did not consume their baby scorpions attached on their back. Furthermore, it was difficult for other scorpions to attack the juveniles because of the defensive behaviour of their mother. Similar observations were reported by Benton (1991) and Shaffer and Formanowicz (1996) in scorpions, and Yip and Rayor (2014) in spiders. Female consumed the male scorpions during the sexual activity (Benton, 1993; Polis and Farley, 1979); the present study revealed that males of *M. tumulus* consumed females that contained eggs in their belly because the egg bearing *M. tumulus* become almost inactive which reduces their defensive ability, making them vulnerable to the hungry males.

Scorpions use substrate vibrations to capture their prey (Brownell, 2001; Marina and Kleber, 2006). Members of *Odontobuthus odonturus* are active predators and produce more vibrations during running and digging burrows in sandy soils so, these substrate vibrations could be a solid stimulus for other adult scorpions for predation of vibration producing scorpions. The present study is in agreement with that of Brownell (2001) and Marina and Kleber (2006). To confirm that substrate vibrations are important for prey detection by *O. odonturus*, dead prey were offered in the present study but they were not consumed by *O. odonturus* and this could have been due to lack of vibratory cues.

Androctonus finitimus was the largest scorpion among three studied scorpion species. Our laboratory and field study suggested that this species attacked very aggressively on members of their own species and on different scorpion species. The reason could be that the members of *A. finitimus* were always found solitary in their habitat; not found sub-social conditions like that of *M. tumulus*. Similarly, their habitat was not restricted to small specific patch of sand dunes area like that of *O. odonturus* (personal observations). So they spend their maximum energy to search the prey. It was also observed that the habitat, where *A. finitimus* found, the prey populations were low as compare to habitat of other two scorpion species, *O. odonturus* and *M. tumulus*. So, they try to capture everything equal or less than their body size that produces vibrations to minimize the uses of their energy.

When male adult *A. finitimus* contacted female scorpion for mating purpose, the female cannibalize the male after mating. This finding is in agreement with the observations of Buskirk *et al*. (1984) and Peretti *et al*. (1999). The reason could be altruism himself by male scorpion for continuation of his genes to next generation. After mating, female scorpion requires more protein for developing eggs. If the male would not sacrifice himself then it would be necessary for the female to search for other protein source for devolving eggs and in this endeavor she could become vulnerable as prey of other adult scorpions. Therefore, to avoid the risk of predation of the female, the male sacrifices himself for cannibalism.

CONCLUSION

It is concluded that all three scorpion species not only feed on other scorpion species but also consume on the members of their own species. So, in rearing process it is very necessary to keep each scorpion in separate jar to avoid cannibalism.

REFERENCES

AHMADI, M., ZARE-MIRAKABADI, A., HASHEMLOU, M. AND HEJAZI, M., 2009. Study on anti-inflammatory effect of scorpion (*Mesobuthus eupeus*) venom in adjuvant-induced arthritis in rats *Arch. Razi Inst.,* **64**: 51-56.

BARRY, K.L, HOLWELL, G.I. AND HERBERSTEIN, M.E., 2008. Female praying mantis use sexual cannibalism as a foraging strategy to increase fecundity. *Behav Ecol.,* **19**: 710-715.

BENTON, T.G., 1991. Reproduction and parental care in the scorpion, *Euscorpius flavicaudis*. *Behaviour,* **117**: 20-28.

BENTON, T.G., 1993. The courtship behaviour of the scorpion, *Euscorpius flavicausis*. *Bull. Br. Arachnol. Soc.,* **9**: 137-141.

BROWNELL, P.H., 2001. Sensory ecology and orientational behaviors. In: *Scorpion Biology and Research* (eds. Brownell, P.H. and Polis, G.A.). pp. 159-183.

BUSKIRK, R.E., FROHLICH, C. AND ROSS, K. G., 1984. The natural selection of sexual cannibalism. *Am. Nat.,* **123**: 612-625.

CASPER, G.S., 1985. Prey capture and stinging behavior in the Emperor scorpion, *Pandinus imperator* (Koch) (Scorpiones, Scorpionidae). *J. Arachnol*., **13**: 277-283.

CHEONG, A., LI, J., SUKUMAR, P., KUMAR, B., ZENG, F., RICHES, K., MUNSCH, C. AND WOOD, I.C., 2010. Potent suppression of vascular smooth muscle cell migration and human neointimal hyperplasia by KV1.3 channel blockers. *Cardiovasc. Res*., **89**: 282-289.

COLOMBO, M., 2011. On Fabre's traces: an important contributor to the knowledge of *Buthus occitanus* (Amoreux, 1789). *Euscorpius,* **117**: 1-10.

FOX, L.R., 1975. Cannibalism in natural populations. *Annu. Rev. Ecol. Syst.,* **6**: 87-106.

GAO, B., PEIGNEUR, S., TYTGAT, J. AND ZHU, S., 2010. A potent potassium channel blocker from *Mesobuthus eupeus* scorpion venom. *Biocheme,* **92**: 1847-1853.

HEINEN, T.E. AND DA-VEIGA A.B., 2011. Arthropod venoms and cancer. *Toxicon*, **57**: 497- 511.

ISBISTER, G.K., VOLSCHENK, E.S., BALIT, C.R. AND HARVEY, M.S., 2003. Australian scorpion stings: a prospective study of definite stings. *Toxicon,* **41**: 877-883.

KOVARIK, F., 2007. A revision of the genus *Hottentotta* (Birula, 1908) with descriptions of four new species. *Euscorpius,* **58**: 1-105.

KOVARIK, F. AND AHMED, Z., 2009. Three new species of *Scorpiops* Peters, 1861 (Scorpiones:Euscorpiidae:Scorpiopinae) from Pakistan. *Euscorpius,* **88**: 1-11.

KOVARIK, F. AND AHMED, Z., 2013. A review of *Androctonus finitimus* (Pocock, 1897), with description of two new species from Pakistan and India (Scorpiones, Buthidae) *Euscorpius,* **168**: 1-10.

LIGHTON, J.R.B., BROWNELL, P.H., JOOS, B. AND TURNER, R.J., 2001. Low metabolic rate in scorpions: implications for population biomass and cannibalism. *J. Exp. Biol.,* **204**: 607-613.

LIU, Y.F., MA, R.L., WANG, S.L., DUAN, Z.Y., ZHANG, J.H., WU, L.J. AND WU, C.F., 2003. Expression of an antitumor-analgesic peptide from the venom of Chinese scorpion Buthus martensi Karsch in Escherichia coli. *Protein Express. Purif*., **27**: 253-258

LOURENCO, W.R. AND PEZIER, A., 2002. Taxonomic consideration of the genus *Odontobuthus* Vachon (Scorpiones, Buthidae), with description of a new species. *Rev. Suisse Zool.,* **109**: 115-125.

MARINA, F.M. AND KLEBER, D.C., 2006. Mechano-receptive function of pectines in the Brazilian yellow scorpion *Tityus serrulatus*:perception of substrate-borne vibrations and prey detection. *Acta. Ethol*., **9**: 79-85.

MC-CORMICK, S.J. AND POLIS, G.A., 1990. Prey, Predators, and Parasites. In: *The Biology of Scorpions*. (Eds. Polis, G.A). pp. 294-320.

MENEZ, A., 1998. Functional architectures of animal toxins: a clue to drug design? *Toxicon,* **36**: 1557-1572.

NAKAJIMA, H., TAKAMORI, H., HIYAMA, Y. AND TSUKADA, W., 1991. The effect of treatment with recombinant γ-interferon on adjuvant-induced arthritis in rats. *Agents and Actions*, **34**:1-2.

OZKAN, O., ADIGUZEL, S., YAKISTIRAN, S., CESARETLI, Y., ORMAN, M. ANDKARAER, K.Z., 2006. *Androctonus crassicauda* (Olivier 1807) scorpionism in the Sanliurfa provinces of Turkey. *Turkiye. Parazitol. Derg*., **30**: 239-245.

OZKAN, O., ADIGUZEL, S., YAKISTIRAN, S., KAR, S., CESARETLI, Y. AND KARAER, K.Z., 2007. Determination of potency and paraspecific effects of *Androctonus crassicauda* (Olivier, 1807) antivenom against *Mesobuthus gibbosus* (Brulle, 1832) venom (Scorpiones: Buthidae). *J. Venom. Anim. Toxins. Incl. Trop. Dis*., **13**: 500-508.

PERETTI, A.V., ACOSTA, L.E. AND BENTON, T., 1999. Sexual cannibalism in scorpions: fact or fiction? *Biol. J. Linnean. Soc.,* **68**: 485-496.

PERSONS, M.H., AND UETZ, G.W., 2005. Sexual cannibalism and mate choice decisions in wolf spiders: influence of male size and secondary sexual characters. *Anim. Behav.,* **69**: 83-94.

POLIS, G.A. AND FARLEY, R.D., 1979. Behavior and ecology of mating in the cannibalistic scorpion , *Paruroctonus mesaensis* Stahnke (Seorpionida : Vaejovidae) . *J . Arachnol.,* **7** :33-46 .

SEGOLI, M., ARIELI, R., SIERWALD, P., HARARI, A.R. AND LUBIN, Y., 2008. Sexual cannibalism in the brown widow spider(*Latrodectusgeometricus*). *Ethol.,* **114**: 279-286.

SHAFFER, L.R. AND FORMANOWICZ, D.R. J.R., 1996. A cost of viviparity and parental care in scorpions: reduced sprint speed and behavioural compensation. *Anim. Behav.,***51**: 1017-1024.

TIKADER, B.K. AND BASTAWADE, D.B., 1983. *Fauna of India: Scorpions: Scorpionida: Arachnida*. Zoological Survey of India, Calcutta, pp 671.

VATANPOUR, H., 2003. Effects of black scorpion *Androctonus crassicauda* venom on striated muscle preparation in vitro. *Iranian J. Pharm. Res.,* **2:** 17-22.

WANG, C.G., HE, X.L., SHAO, F., LIU, W. LING, M.H., WANG, D.C. AND CHI, C.W., 2001. Molecular characterization of an anti-epilepsy peptide from the scorpion *Buthus martensi* Karsch. *Eur. J. Biochem.*, **268**: 2480-2485.

YIP, E.C. AND RAYOR, L.S., 2014. Maternal care and subsocial behaviour in spiders. *Biol. Rev.* **89**: 427-449.

ZLOTKIN, E., FISHMAN, Y. AND ELAZAR, M., 2000. AaIT: from neurotoxin to insecticide. *Biochimie,* **82**: 869-881.