Scorpions:

Closely related to the spider, the scorpion is considered to be a "public enemy number one" out of the many venomous stinging insects and reptiles. Although scorpions favour hot desert regions, they are widely distributed throughout the world. More than 1,000 species are known of which only 86 have been reported in India (Caius and Mashkar, 1932). Indian scorpions belong to the Palamneus or Buthus genera. They are common in rural India and coastal areas. Urbanization and deforestation have greatly reduced the number of scorpions in India. In the South and in cities like Madras, species belonging to Buthus genus are commonly seen.

Scorpions are so well adapted to life that they have remained unchanged for more than 350 million years, as revealed by fossils. They are older than reptiles including the Dinosaurs and three times as old as mammals and perhaps 2,000 times as old as man, (Dickensen, 1977). They can go on without food or water for a year. Some can live under water and are immune even to atomic radiation.
Nature's greatest loner, little scorpion lives and hunts for as long as 25 years. The intense summer heat forces the scorpions out of their hiding place to seek for cooler parts. As nocturnal hunters, they have the diabolical talent of hiding out during daytime by clinging unseen and upside down to the underside of rafters, tiles, trees, etc. They also invade houses where they segregate themselves in every conceivable spot, inside shoes, under beds, behind drapes, stinging in panic and defence when startled by unwary humans. In rural areas, a favourite place for hiding is inside the earthenware pots used to keep cool drinking water. Although equipped with as many as twelve eyes, the scorpion "sees" only darkness and light. It is through microscopic sensory hairs on his pincers and with small comb like structures called pectines attached to his abdomen, that he knows about his environment. His diet consists principally of insects such as cockroaches and beetles, but the larger species have been known to conquer and devour
snakes and lizards up to 20 cm in length. He seizes the prey with his pincers, subduing it with his stinger when necessary. Then he mashes the body of his catch with two short pairs of shears called chelicerae which serve as teeth. Squeezing the prey's torn tissues with the base of his pedipalps he sucks away the body fluids to the last drop by the pumping action of pharynx.

Completely anti-social, the scorpion will eat anything that it can kill, including another scorpion. This cannibalism has given rise to the fable that after the mating act is concluded the female scorpion devours her lover. Eggs are hatched inside the mother; from 3 to 90 soft white young ones break out of the thin membranes. In 10 to 16 days the young ones after first molt, come down off mother's back and remain close to her for a day or two and then scatter.

Bernard Betts, who had studied scorpions for more than 10 years, observed that they are much maligned creatures. "They do a lot of good, they prey on
harmful insects, mice and even rats, if the scorpion is big enough like the Imperial variety. I think they are the most amazing creatures as they are."

Scorpions belong to phylum Arthropoda, class Arachnida order. Scorpionidia have seven families under group (1) Buthidae (2) Scorpionidae (3) Ischnuridae (4) Cheiridae (5) Chaetidae (6) Vejovidae; and (7) Bathrimumidae.

The most venomous species belongs to the Buthidae family. The two most abundant species of scorpion in India are the giant black scorpion of the Palamneus species and the red scorpion of the Buthus species. The latter is commonly seen in the City of Madras. Palamneus scorpions may measure up to 15-25 cm and the red Buthus varieties are half in size measuring approximately 2-3 cm rarely up to 19 cm and are the potent poison carriers. (Fig. 1, 2)

Some of the larger species (e.g. P. Swammerdam 1 of Southern India) emit rasp like sounds when alarmed. The noise is produced by a special stridulatory
Fig. 1.

HYTHRO TAMEUS
(Red Scorpion)

Fig. 2.

PALAMNUS GRAVINUS
(Black Scorpion)
apparatus consisting of a spinous scraper (Robert Barnes, 1977).

The world's largest scorpion, the Imperial scorpion, which can grow up to a foot long, lives in the dense tropical forest of Seirra Leone and this species is about to become extinct. The official name of this scorpion is Pandinus Imperator.

Exposure to ultraviolet light causes fluorescence and they shine at night or at dusk. This technique was discovered accidentally in USA a few years ago, and has the added advantage that the scorpions do not realise that they are visible. If a torch light is flashed on them, they would hide in their burrows thus avoiding capture.

The important anatomical parts of the scorpion are, apart from the body, the hand and the fingers, a tail, a sting and a telson or venom gland. Two poison glands lie inside the ampulla of telson, one on each side of the midline (Fig. 3). Each gland is covered
Dorsal view of scorpion

Ventral view of scorpion.
by a sheet of muscle on the mesial and dorsal aspect, the compressor muscle. This muscle squeezes the poison out of the gland, along the duct and through the opening in the spine into the victim. The extent of the muscular contraction, and consequently the amount of venom injected are determined by the circumstance. Scorpions never sting unless disturbed and this too under grave provocation; as a rule, they simply whisk their tail as we do with our hand when disturbed by a troublesome fly. The sting of the scorpion is primarily a weapon for paralysing its prey. Scorpion seizes its prey with the pedipalp and sting them by inserting the tip of the telson well into the animal's body.

Scorpion sting:

Most scorpion stings occur during summer months and in the months following the monsoon. In the South, particularly in Madras City, the peak incidence of scorpion sting is around April to June. Many complications have been reported following scorpion sting in human beings. The seriousness of the complication differs from species
to species, and also depends on the age of the individual. Younger children are prone to serious complications. Scorpion sting almost always occurs under accidental circumstances more often at night. They occur in houses, in tents, in palmeries or in gardens.

The first symptom, immediately after the sting is a sharp pain. This is followed by numbness or drowsiness. Other symptoms include vomiting, excess sweating, etc.

Local effect manifests as intense pain and local inflammation. These may be attributed to the presence of histamine or 5-Hydroxy tryptamine like substances in the venom. The neurotoxic effects of the venom have been attributed either to the central action on the medulla or the spinal cord. Scorpion venom also affects neuromuscular transmission. Rarely convulsions may occur.

An important characteristic of scorpion sting is the sudden aggravation of the condition of the victim after the disappearance of the initial symptoms and apparent recovery. This is marked by sudden reappearance of grave respiratory trouble or cardiovascular signs like
tachycardia and shock. How the scorpion venom acts is not fully understood.

Characteristics of the venom:

Studies on venom obtained from scorpions of widely differing geographical regions indicate several common chemical properties. The venom is a mixture of several basic proteins and the enzyme content is usually low. Some species produce two or more neurotoxins with similar pharmacological properties. The venom according to Jackson (1910) and Kabota (1903) is a transparent liquid, which, when agitated, produces a froth and is acid in reaction; when evaporated it leaves scaly flakes of dark yellow colour, which is soluble in water, normal saline, glycerine and dilute alcohol. The venom loses its potency when heated to 100°C. The toxic principle in scorpion venom is of the nature of Toxalbumin or neurotoxin which acts on the medulla and motor end plates producing respiratory paralysis followed by stoppage of the heart. It also contains
cardiotoxin, lecithide (Keyes, 1903), agglutinins, ferments, cholestrin, etc.

Laboratory and clinical reports:

Maupartuis (1731) and Redi (1779) were the first to study the effects of scorpion venom on experimental animals but the detailed study was made by Paul Bert (1865). Jousset de Bellesme (1874) and Joyeaux Laffaie (1883) studied the effect of the venom of Buthus europens linn. Phisalix and deVarigny (1896) reported about the venom of Buthus australis Linn. Nicolle and Catovillerd (1905) observed the effect of the venom Buthus Quinquestriatus; Hemp and Ehrenb, Kubota (1918) observed the effects of Buthus Martensi Karshi and Centraurus exolincarda; Wood and Houssay (1919) studied the effects of the venom of Buthus Quinquestriatus also of Tityus Bahiensis and of Tityus Serrulatus (Lutz Mallo, Tityus Dorsomaculatus Lutz (1925). Mallo and Botryurus and Kopstein (1927) observed the effect of the venom of H. Cyaneus. Koch and Schulze (1927) observed
the effect of Palamneus longimanus Herbat. Caius and Mashkar (1932) extensively studied the effects of the venom obtained from Buthus and Palamneus species.

In a clinical analysis of 698 cases of scorpion sting, admitted in Trinidad hospital over a period of five years, from 1929 to 1933, Waterman (1928) found that the heart beat was generally slow but forceful and extrasystoles were frequent. ECG recordings of two cases of scorpion sting were published by Waterman (1950) where in the convulsions were attributed to ventricular tachycardia. Efrati (1949) observed in their study that scorpion sting produced hypertension, which they thought was due to a pressor substance released from the adrenals. Mundle gave a detailed report on 78 cases of scorpion sting observed over a period of 14 years in Manguan taluk, Bombay. 23 patients including 9 adults died either following bradycardia (26 per minute) fall of body temperature and profuse perspiration or tachycardia (140–160 per minute)
pulmonary edema, dyspnoea and frothy blood tinged expectoration. Poon King (1963) dealt extensively on the clinical picture and ECG study of patients stung by Tityus Trinitatis (Buthidae) of Trinidad. Death was ascribed to the toxic effect on the medullary centres and myocarditis was the commonest complication. There are further reports on cardiovascular manifestations following scorpion sting. Bose et al (1966) observed ECG changes in one out of 11 cases of peripheral circulatory failure following scorpion sting.

Isolation of toxic components from Brazilian scorpion - Tityus Serrulatus - venom was made using mainly electrophoretic techniques (1960) by Diniz and Goncalves. In 1966, Gomez and Carlos Diniz used a combination of extraction and chromatographic techniques with dextran gels and resin carboxy methyl cellulose.

The venom obtained by electrical stimulation contains insoluble substances that were separated by cold water extractions. The separation of
protein components from T. Serrulatus venom has been made by using electrophoresis technique and chromatographic technique with dextran gels and carboxy methyl cellulose resin, columns of 29 x 2.5 cm were packed with the fine grade suspension of Sephadex G.25 in distilled water. The water soluble extract was chromatographed on Sephadex G.25 columns using water and 0.1 TRIS buffer or 0.1 M ammonium acetate as eluents. Two main protein peaks, P₁ and T₁ (Fig. 4-a) appeared in the water elutes. Component T₁ contained approximately 30% of toxic activity.

After elution with TRIS buffer two additional components P₂ and T₂ were obtained, bulk of toxicity being in peak T₂. Elution with ammonium acetate following water elution (Fig. 4-b) showed a small inactive protein peak and a large peak of toxic activity. Electrophoresis on cellulose acetate paper showed peak T₂ either with TRIS or acetate buffer; it also contained several other components. Further purification with 0.01 M ammonium acetate at pH 7.7 revealed several inactive protein peaks and elution of toxic fraction was achieved with 0.15 M. ammonium acetate adjusted to pH 9.0 (Fig. 4-c).
Fig. 4

Isolation of Toxic components from Brazilian scorpion
*Tityus Serrulatus*
SEPERATION OF PROTEIN COMPONENTS FROM TITUS SERRULATUS VENOM

100 µg OF TOTAL VENOM
SEPHADEX G 25 - 29 x 24 cm
FLOW RATE 30 mL/h
STEPWISE ELUTION WITH WATER AND TRIS 0.1M

100 µg OF TOTAL VENOM
SEPHADEX G 25 - 37 x 25 cm
FLOW RATE 30 mL/h
STEPWISE ELUTION WITH WATER AND AMMONIUM ACETATE 0.1M

CM-CELLULOSE COLUMN 54 x 21 cm
5-10 µg % OBTAINED BY GEL FILTRATION
STEPWISE ELUTION
STARTING BUFFER AM ACET 0.04 M
FLOW RATE 15 mL/h
Severe myocardial damage and heart failure following scorpion sting were reported by Gueron and Cohen (1967) and these manifestations were related to the levels of circulating catecholamines released by the venom. Jain et al (1970) corroborated myocardial injury with elevated enzymes and ECG changes after scorpion sting, suggestive of myocardial damage. Sita Devi et al (1970) have postulated defibrination syndrome, with the venom of Buthus Tamulus species in Kurnool District of Andhra Pradesh. In the absence of specific antivenin, chlorpromazine was used in the treatment for scorpion sting by Masco (1970). Jadhav (1977) of Haffkine Institute mentioned general treatment like application of tourniquet, sucking out the poison and infusion of saline. Santhanakrishnan et al (1972) have reported that a combination of promethazine, pethidine and chlorpromazine in the form of a drip, was very useful in treating peripheral failure and cardiovascular complications following scorpion sting, in children.
Corticosteroids were also used as they will help in retaining sodium and eliminating excess of potassium. Purification of the toxin from North American S. Centruroides and Sculpturateus by E. Wing was reported in 1974. Freira Maia et al. (1974) using purified toxin of Tityus serrulatus on rats have reported cardiovascular effects, tachycardia and hypertension with low doses, and bradycardia with higher doses of the venom.

The beneficial effects of adrenergic blocking agents, upon the survival rate in shock in experimental animals as well as in clinical trials have been reported (Nickerson, 1962). It is not clear whether this effect is due to the adrenergic blocking action alone. Reserpine was used in dogs under oligemic shock (Ernest Scifen et al 1964). In 1971, dogs pretreated with guanethidine were studied to assess the detrimental role of the sympathetic nervous system in hypovolemia. The increase in heart rate, blood sugar and fluid mobilisation, observed in oligemic shock was effectively blocked after pretreatment with guanethidine (Subbu, 1971).
Since chlorpromazine is a central adrenergic blocking agent it was used in the present experimental work to assess the detrimental role of the sympathetic nervous system in cases of scorpion sting.

The published work so far indicates that different species of animals exhibit different degrees of resistance. Cold blooded frogs are more resistant than mammals; dogs, rabbits and guinea pigs are more sensitive than mice or birds. The venom of scorpions consists of the following active principles:

1. Neurotoxins: These act on the respiratory and vasomotor centres, and motor end plates and plain muscle; in some of the observations, in the earlier experimental animal studies on nervous system, there was initial stimulation leading to convulsions followed by paresis (curare mimetic action). The venom acts on the spinal cord as evidenced by the painful general spasm.

2. Cardiotoxic effects: The venom stimulates the heart and raises the blood pressure.

3. Effect on the vascular system: On smooth musculature the venom acts through nervous plexuses and produces spasmodic contractions.
Death is often due to paralysis of the respiratory centre.

Treatment:

Treatment is mainly confined to the administration of specific scorpion antiserum if available.

Specific treatment:

Anti-scorpion serum was first produced in Cairo in 1909. Scorpion venom is a poor antigen. Immunization of horses for serum preparation therefore requires at least 8 months and involves the use of 400-500 telsons (or scorpions). Yet, immunization is never complete and certain physiological reactions are never suppressed even in horses immunized over a period of several years. Anti-scorpion serum was made in India on an experimental basis in 1961, but was given up later; the serum is expensive and is not very effective unless given early after the sting within a period of 20 minutes. The amount of antivenin to be injected is very large, approximately 60 to 80 ml intramuscularly even in infants.
None of the plant remedies seem to have any therapeutic value. The following general treatment has been quoted by Jadhav of Haffkine Institute:

A tourniquet is applied above the sting and a light incision made to suck the venom out; ice applied at the site of the wound reduces the absorption of venom and its diffusion; cauterisation in the vicinity of the sting is not beneficial. Glucose solution is avoided because of hyperglycemia but in combination with ergotamine is recommended and it helps to reduce excessive intestinal secretion and pulmonary edema. Injection of emetine is also suggested. Use of corticosteroids are well documented.

Freire Maia et al (1974) have studied the mechanism of the cardiovascular effects produced by the scorpion venom in anesthetised rats. They used the purified toxin fraction of the scorpion Tityus Serrulatus in doses of 5-20 microgram (µg) per 100 gm and also in doses of 40 and 80 µg per 100 gm. In low doses, the authors observed that the toxins produced sinus tachycardia whereas in high doses it evoked sinus
bradycardia, sino atrial, atrioventricular block, ventricular ectopic beats and idioventricular rhythm. Bilateral vagotomy did not prevent the arrhythmias. In vagotomised animals, physostigmine enhanced, hexamethonium decreased and atropine abolished the bradycardia.

Propranolol prevented or abolished the sinus tachycardia and changed the ventricular rhythm into sinus rhythm. The pressor effects of the toxin was not abolished by hexamethonium but was significantly decreased by reserpine and guanethidine. The authors concluded that, (1) the cardiac arrhythmias were caused by the release of acetyl choline and catecholamines, (2) hypertension by the release of catecholamines from adrenal glands and postganglionic nerve endings, (3) sinus tachycardia, ventricular ectopic beats and idioventricular rhythm by activation of beta adrenergic receptors in the heart and the bradycardia was due to the release of acetylcholine by the action of toxin on vagal ganglia and postganglionic nerve endings in the
heart. The hypotensive effects are due at least in part to sinus bradycardia, sino-atrial and atrio-ventricular blocking.

In the present study, dogs, cats, rabbits, rats, guinea pigs and frogs were used. The venom was dissolved in normal saline and administered in these animals and the effects recorded.