Phenotypic description of Egyptian endemic centipedes, genus Scolopendra Linnaeus, 1758 with a histological study of its venom glands.

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Research Article

Keywords: Centipedes, Scolopendra, Egypt, morphology, poisonous gland

Posted Date: April 26th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1534880/v1

Abstract

Background: Centipedes are widely distributed over all continents. They have important medicinal value and high toxicity, making it to be an interesting subject for evolutionary studies. Due to the lack of recent taxonomic revision in Egypt, this work and for the first study that is giving a fine report on the geographical distribution and morphometric description of Egyptian Scolopendra species.

Result: Two Egyptian Scolopendra species were re-described based on fresh material based on a surveillance study in Egypt. ***Scolopendra canidens*** Newport.1844 were found in only one location. ***Scolopendra moristans*** Linnaeus,1758 was more abundant. Both venomous glands were histochemically investigated. This study is the first comparative report on the histology, and histochemistry of the venom glands of the Egyptian centipede species the glands in both species are mostly made up of columnar secretory cells that are radially arranged side by side and open through pores in a central chitinous duct. Striated muscular fibers envelop each secretory cell. Except for the size of the glands, which is related to the body dimensions of each species, the secretion takes the shape of small PAS-positive granules, suggesting the presence of neutral polysaccharides.

Conclusion: According to this surveillance study the most abundant species was ***Scolopendra moristans*** Linnaeus,1758. ***Scolopendra canidens*** Newport.1844 were found only on the Northwest coast of Egypt. The findings show also that the analyzed species have a lot in common in terms of morphology and fundamental chemical makeup of their venom.

Background

Differential adaptations to various ecosystems are typically attributed for morphological variation. As a result, studying intraspecific morphological variation is a critical tool for understanding life's diversity and determining whether morphological variability is due to ecological and environmental causes or palaeogeographic history [1, 2]. Scolopendra has become a significant research material for historical biogeography because of its limited ability to travel [3]. Scolopendra is an important branch of terrestrial arthropods in the evolutionary process as an ancient biological community [3].

Comparatively less examined are other macro-invertebrates, like centipedes and scorpions. Centipedes are spread across all continents. They are an economically significant group of arthropods that play a key role in the management of the terrestrial ecosystem's toxic pests [4]. Because of their toxic nature and painful bite, they are often regarded as creatures of annoyance importance, particularly the Scolopendridae family members. They are elusive animals found in stones, potted plants, bushes, the bark of trees, gardens, rotting wood, damp soil, woodland, cultivated and semi-cultivated soil [5]. Taxonomic studies of scolopendrid centipedes have frequently documented diversity at the level of individuals and populations and have applied these data to species separation challenges [6]. The common and complex centipede genus is Scolopendra Linnaeus, 1758. In recent years, the systematics and taxonomy of Old World Scolopendra species have been investigated. Diagnosis, classification key, and an illustrated list of Old World species of Scolopendra were established by Lewis [7]. More previous findings have, moreover, focused on the systematics and distribution of several species of Scolopendra [8, 9, 10]. Simaiakis and Mylonas [11] have demonstrated that there are nine species widespread in the Mediterranean region, including the most widely distributed species, Scolopendra cingulate [12], which also exists in western Asia. Recent studies on the systematics and taxonomy of New World Scolopendra species are rare.

In the Old World, Scolopendra is typically comprised of 42 nominal species described by Lewis [7]. However, the precise detail of the distributional records is hampered by its dispersed distributional records. Some species' ranges are yet unknown, and they need to be updated. Because of their ecological preferences and, in some cases, economic value, certain Scolopendra species, such as S. morsitans Linnaeus, 1758, and S. subspinipes Leach, 1814, have been identified as widespread species and recognized as introduced by human transport [10]. Nine species [13–20] are reported in the Mediterranean region.

According to Guizze et al. [21], Species of the Scolopendra genus can reach up to 300 mm in length and some are responsible for most of the centipede accidents around the world that involve people. Because they are well adapted to urban environments, they frequently cause human accidents by injecting venom produced in glands inside their maxillipeds [22]. This gland secretion is used to kill or congeal prey by injection through horizontal movements of its maxillipeds [23].

The goal of this research is to provide the first comprehensive examination of the morphology, description, and distribution preferences of the Egyptian Scolopendromorpha centipede fauna. In addition, the histology and histochemistry of its venom glands were studied.

Methods

Surveillance Studies:

Sites of collection:

Scolopendra was caught, maintained in captivity from different areas along most of the governorates of Egypt **(Fig. 1)** from July 2019 to August 2020 as 13 Sample from El- Giza (El-Mansouriya and Osim), 18 Sample from Baharia Oasis desert, 10 Sample from El-Faiyoum (Tamiya Center), 20 Sample from Ismailia (El-Qantra), Assiut: (3 Sample from Dairout, 5 Sample from Manfalut, 12 Sample from Menqebad), 22 Sample from North coast (El- Hammam), and 13 Sample from Alexandria (Borg El- Arab). Taking on 8–20 live animals from each researched location was used to measure the length and the morphological investigation.

Identification:

Scolopendra from each area was cursorily examined after anesthesia with 70% ethyl alcohol for the following characters; color, head (eyes, antenna, maxilliped), stigmata, legs, and anal cirri.

Histological studies:

The venom apparatus of 5 adult *Scolopendra canidens* and *Scolopendra morsitan* captured from different areas were utilized. The maxillipeds were removed from each and quickly immersed in 10%neutral buffered formalin fixative (pH 7.4) then were calcified by EDTA. The fixed samples were thoroughly washed in running water, dehydrated, cleaned, impregnated, and embedded in paraffin wax, sectioned at 4–5 μm thickness, and stained with hematoxylin-eosin for histological examination. For the identification of neutral and acidic mucosbstances, respectively, the sections were subjected to the periodic-acid Schiff (PAS) and Alcian blue, pH 2.5, techniques, as well as bromophenol blue for protein identification.

An Olympus (E330-ADU1.2X) microscope and a ZEISS stereomicroscope with a digital camera were used to take photomicrographs.

Results

The collected specimens were identified as shown in Table (1) According to Lewis [7] identification key of old-world Scolopendra species.

Table (1): The distribution and morphometric comparison of the two collected samples.

	Site	altitude	No. of samples	Color	Average length	Species
1-	**Northern Giza**: Aosem and Mansoura region **Southern Giza**: El Wahat El Bahariya	29.9870°N 31.2118°E 28°21'5.36"N 28°51'44.6"E	13 18	Olive green with reddish the ultimate legs	7.2 ± 0.68	*Scolopendra moristans*
2-	**El-Fayoum** (Tamya region)	29.308374°N 30.844105°E	10	Yellowish green with reddish the ultimate legs	6.9 ± 0.36	*Scolopendra moristans*
3-	**Dakahlia Governorate (Delta)** Belkas center	31°14'N 31°22'E	9	Yellowish green with reddish the ultimate legs	9.6 ± 0.32	*Scolopendra moristans*
4-	**Ismailia Governorate**) El Qantara city)	30.85°N 32.31°E	20	Yellowish-green with reddish the ultimate legs	5.9 ± 0.56	*Scolopendra moristans*
5-	**Asyut Governorate** Dairut - Manfalut - Manqabad	27°11'N 31°10'E	20	Deep green with reddish the ultimate legs	7.6 ± 1.1	*Scolopendra moristans*
6-	**Alexandria** Borg El- Arab region	30°50'56"N 29°36'42"E	13	Yellowish green with reddish the ultimate legs	4.7 ± 0.69	*Scolopendra moristans*
7-	**Marsa Matrouh** El Hammam city	30.841852°N 29.394043°E	12	Yellowish-brown	8.1 ± 1.3	*Scolopendra canidens*
			10	Deep green	5 ± 0.5	*Scolopendra moristans*

Scolopendra canidens Newport.1844

Figure (2)

S. canidens Newport 1844 Ann. Mag. nat. Hist. 13: 98

S. canidens cyrenaica Verhoeff 1908 Zool. Jahrb., Syst. 26: 274.

S. canidens canidens: Attems 1930 Das Tierreich 54: 36.

S. canidens: Würmli 1980 Sber. Österr. Akad. Wiss. 189: 339 & 346.

Distribution

Italy, Morocco, Algeria, Libya, Egypt, Palestine, Turkey, Syria, Israel, Jordan, Tunisia, Iraq, Iran, Uzbekistan, Saudi Arabia, Yemen, Tajikistan, Armenia, Azerbaijan, Turkmenistan, Afghanistan [7].

Distribution in Egypt

(Table 1) The distribution of this species is less common than S. moristans only found on the northwestern coast

Description

figure (1) Tergite without curved anterior transverse sulcus, Tarsus of the ultimate leg without spur, Coxopleural process long or of moderate length and with 6 or more spines and 1 or 2 side spines, Tergite with a median longitudinal suture, basal 5, 6 or more antennomeres glabrous. First pair of legs with 2 tarsal spurs, rarely with only 1, Each forcipular coxosternal tooth plate with 4 teeth, the lateral large and well separated, the medial 3 small and more or less fused. Forcipular trochanteroprefemoral process without teeth. Tergite 1 without longitudinal sutures, median suture of tergite 21 complete or almost so. Antennal segments with 18 antennomeres, with basal 10 to 12 antennomeres glabrous. Prefemoral process of ultimate legs mostly with 2 or 3 spines, the setae appearing gradually. Prefemoral process of ultimate leg mostly with more than 2 spines, Ultimate legs of male and female glabrous.

Scolopendra moristans Linnaeus,1758

Figure (3)

S. morsitans L. 1758 Systema Naturae 1: 637.

S. morsitans scopoliana C. L. Koch 1841 M. Wagner, Reis Alger. 3: 222.

S. morsitans: Attems 1930 Das Tierreich 54: 23.

S. m. scopoliana: Attems 1930 Das Tierreich 54: 23.

S. morsitans amazonica Bücherl 1946 Mem. Inst. Butatan 19:135.

S. amazonica: Jangi 1959 Ent. News 70: 253.

S. jodhpurensis Khanna 1977 Oriental Insects 11: 154.

Distribution

Mexico, Caribbean Central, and South America, Africa, Australia

Asia, islands of Atlantic, USA (Florida)Indian, and western and central Pacific Oceans.

Frequently introduced. European citations are dubious [7, 10]

Distribution in Egypt

(Table 1) The distribution of this species is more widespread all over Egypt.

Description: figure (2) Some tergites anterior to tergites 20 and 21 marginate, Prefemora of ultimate legs with spines not on elongated processes but sometimes on a swollen base Mostly with sternite paramedian sutures although these may be weak and incomplete, Prefemora of ultimate legs with 5 to many spines ventrally, Tergite 21 with a median longitudinal suture, Head plate without anterior diverging paramedian sutures and basal plates. Forcipular coxosternum without ramifying sutures. Head plate with incomplete posterior lateral sutures, Head plate lacking a median suture. Antennal segments with 19 antennomeres, basal 5–10 antennomeres glabrous. Leg 1 with a single tarsal spur. Coxopleuron with a side spine and coxopleural process with 3–5(7), mostly 4 apical spines. Pretarsus (claw) of ultimate leg shorter than the second tarsus and not serrate ventrally, Ultimate leg prefemur with 7–10 ventral spines, typically in 3 rows of 3, Ultimate leg prefemur with 4 to 6 dorsomedial spines in two rows, Porose area extending to the posterior edge of coxopleuron. Prefemur, tibia, and often tarsus of the ultimate leg of male dorsally flattened with swollen edges.

Histochemical

Figures 4 and 5 (D) showed the venom apparatus of both collected species which consists of a pair of maxillipeds of equal size found inside a chitinous covering and the venom glands situated anteriorly in the prosoma on either side of the first segment of the body. The glandular epithelium is folded and made up of secretory epithelium that is surrounded by a striated muscle sheath. The secretory epithelium is made up of abundant cytoplasmic venom granules and high columnar venom-producing cells. The glandular canal is bordered with a chitinous interior layer and simple cuboidal epithelium and lacks muscles. (Fig. 4,5 (A,B)).

The venom-producing cells are filled with granules with small nuclei situated at their bases. (Fig. 4,5 (A)).

The venom-producing cells reacted positively with the alcian-PAS reaction due to the presence of carbohydrate excretion (Fig. 4 (B),5 (C)). Also, reacted positively with bromophenol blue techniques due to the presence of protein inside the cells (Fig. 4(C),5(B)).

Discussion

All of the scolopendrid species studied here are common in the Middle East, although there haven't been enough investigations on them in Egypt. Scolopendra cingulata, Scolopendra Canidens, and Scolopendra moristans were all recorded for Egypt in ancient publications, but not all of them were detected in the newly gathered material. S. cingulata has been recorded in North Africa by Lewis [15] and Minelli [24], but we were unable to locate this species during our inquiry. On Egypt's northeastern shore, S. canidens has a limited distribution. It seems that S. morsitans and S. canidens occur all optically in the country, the latter being generally restricted to more humid parts, the former to the rest of the country.

As the two centipede species identified belong to the same Scolopendrinae subfamily, there are few comparative characters between them. In general, the histological and histochemical results did not show significant differences among both studied species. The venom glands of collected species are located inside each maxilliped of the first pair behind the head. Each one is covered with external striated muscles. Each gland ends with its duct at the venom subterminal pore which is located on the outer curvature of the claw. The glandular epithelium is a folded mass of secretory epithelium surrounded by a striated muscle sheath and chitinous membrane. Despite the study of Dugon and Arthur [25] that each secretory unit in the venom glands of all centipede species is made up of identical cells, the glands units of the two species have a nearly identical structure of these units. As a consequence, the glands of *S. canidens* and *S. morsitans* are made up of many small secretory units that extend almost perpendicularly from the calyx to the basal lamina. Between the calyx and the basal lamina, which is likewise enveloped in striated muscle, secretory units are alternated by striated muscle.

Both collected Egyptian species had PAS-positive and diastase-resistant venom-producing cells, indicating that the venom of this centipede species contained neutral mucosubstances but no glycogen. Because neutral mucosubstances are a polymer of glucosamine, they may play a function in osmoregulation and the transport of the venom protein fragment into the victim's tissue These Scolopendra glands, on the other hand, were positive for Alcian blue, which is used to identify acid mucosubstances, whereas alcianophilia at pH 2.5 and 1.0 is used to identify sialomucins and sulfomucins, respectively [26]. Scolopendra venom contains sialidaselabile sialomucins and hyaluronidase-resistant sulfomucins, according to the results of the histochemical study. *Scolopendra moristans* and *Scolopendra canidens* venom contain acid mucosubstances that may aid in venom absorption following injection into the victim.

Conclusion

This study was able to conduct a survey of the endemic Egyptian Scolopendra, Two Egyptian Scolopendra species were re-described, Scolopendra canidens Newport.1844 were found in only one location. Scolopendra moristans Linnaeus,1758 was more abundant. Also, it is the first comparative report on the histology, and histochemistry of Egyptian centipedes' venom glands.

Abbreviations

PAS Periodic acid–Schiff

S. Scolopendra

pH potential of hydrogen

EDTA Ethylenediaminetetraacetic acid

SC Secretory cells

L lumen

M muscle sheath

C chitinous envelope

H&E hematoxylin and eosin.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Funding:

No funding

Author contributions:

Both authors gathered the data. analyzed the data, wrote and discussed the manuscript. All authors read and approved the final manuscript.

Acknowledgments

No Acknowledgement

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Figures

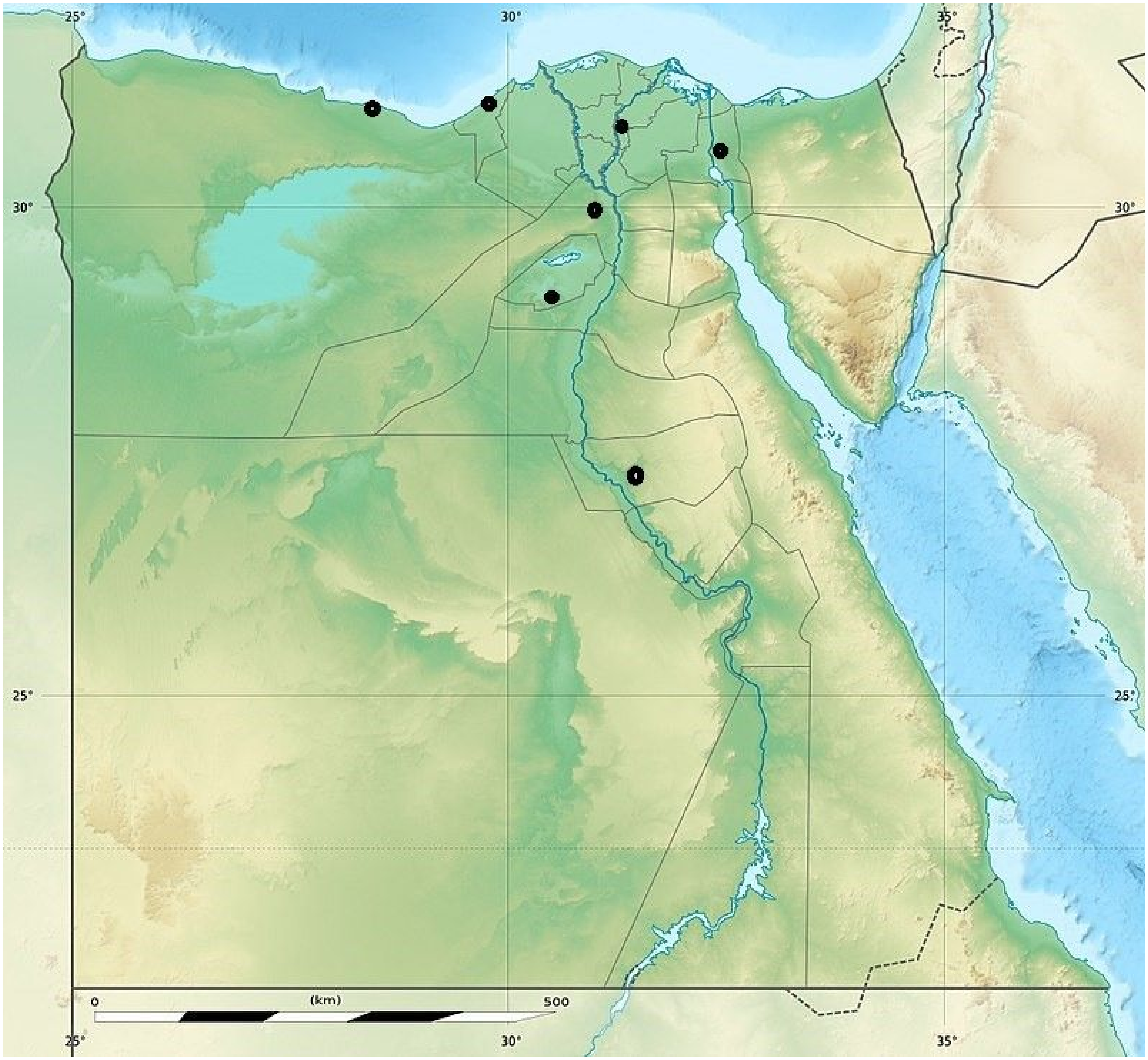

Figure 1

Egypt map showing the samples collection sites. https://upload.wikimedia.org/wikipedia/commons/thumb/9/9e/Egypt_relief_location_map.jpg/650px-Egypt_relief_location_map.jpg?20170818140153

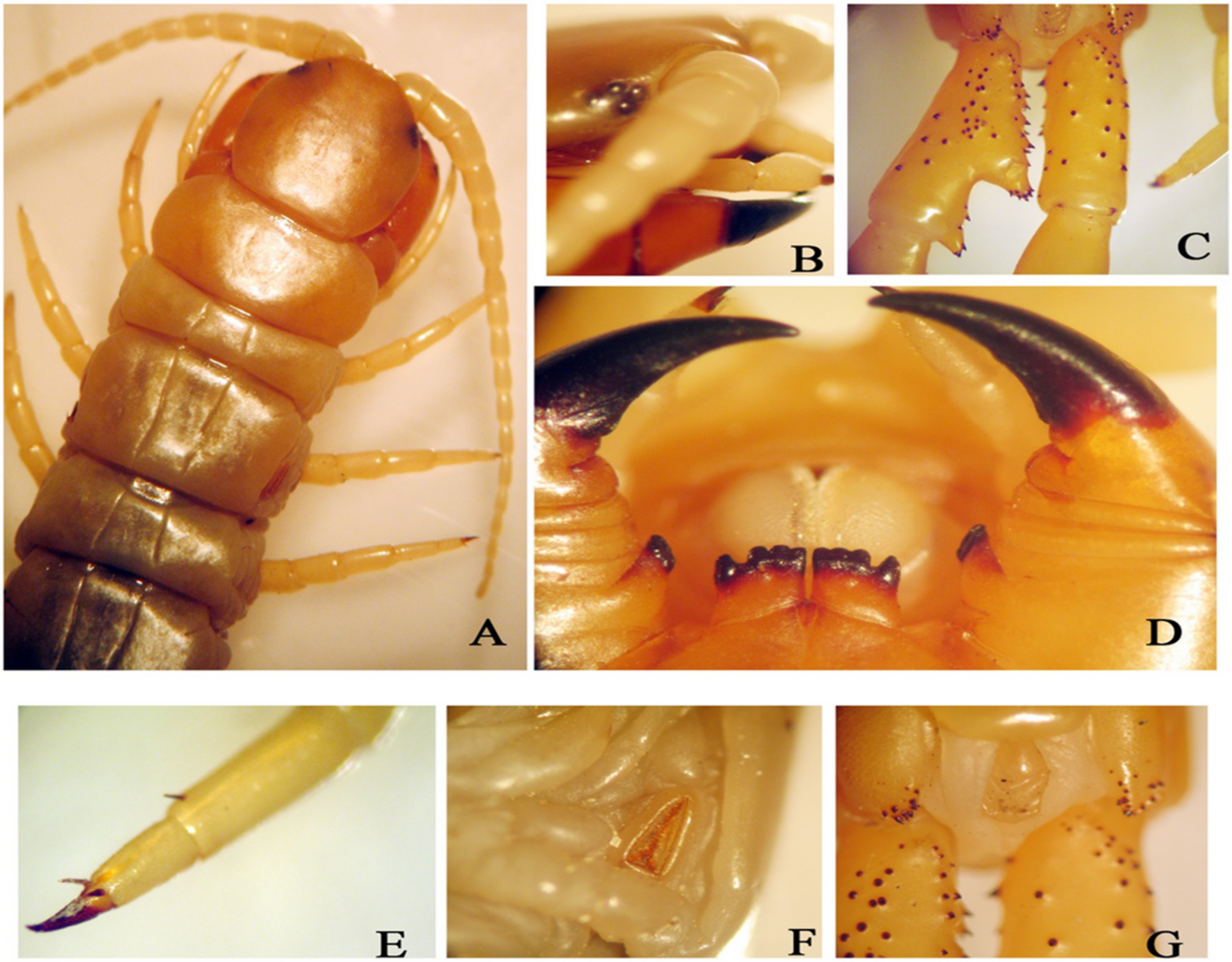

Figure 2

Scolopendra canidens A- Head plate with antenna and trunk segments, B- 4 eyes in lateral sides, C- Prefemure of the terminal leg, D- forcipular coxosternal teeth plate, trochant-prefemoral process, and 2 poisonous claw in the ventral side, E- leg with 3 lateral spines, F- spiracle, G- prefemure of the ultimate leg with coxsoternal process with spines in ventral view.

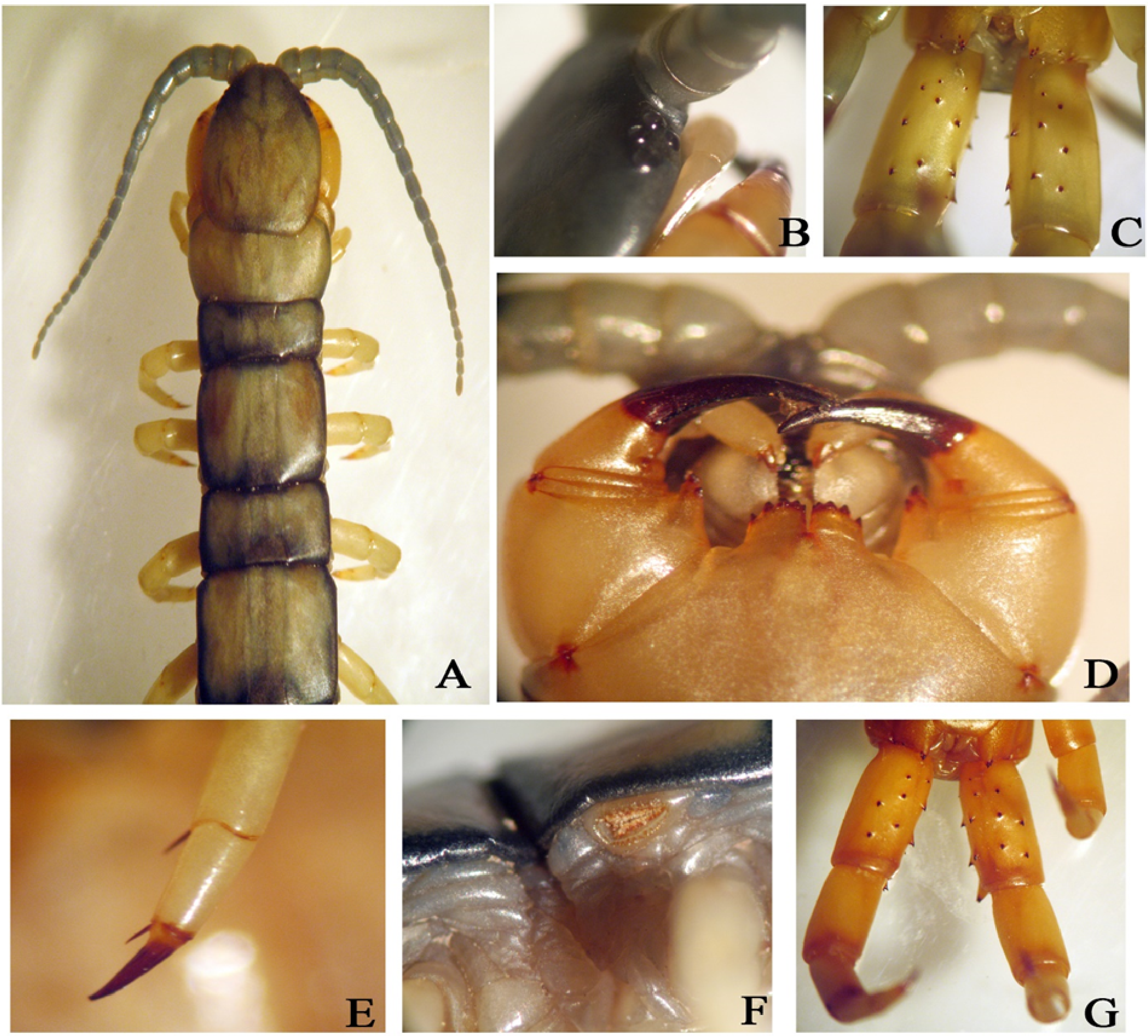

Figure 3

Scolopendra moristans Scolopendra moristans; A- Head plate with antenna and trunk tergites, B- 4 eyes in lateral sides, C- Prefemure of the terminal leg, D- forcipular coxosternal teethplate, trochantero-prefemoral process, and 2 poisonous claw in ventral side, E- leg with 2 lateral spines, F- spiracle, G- prefemure of the ultimate leg with coxsoternal process with spines in ventral view.

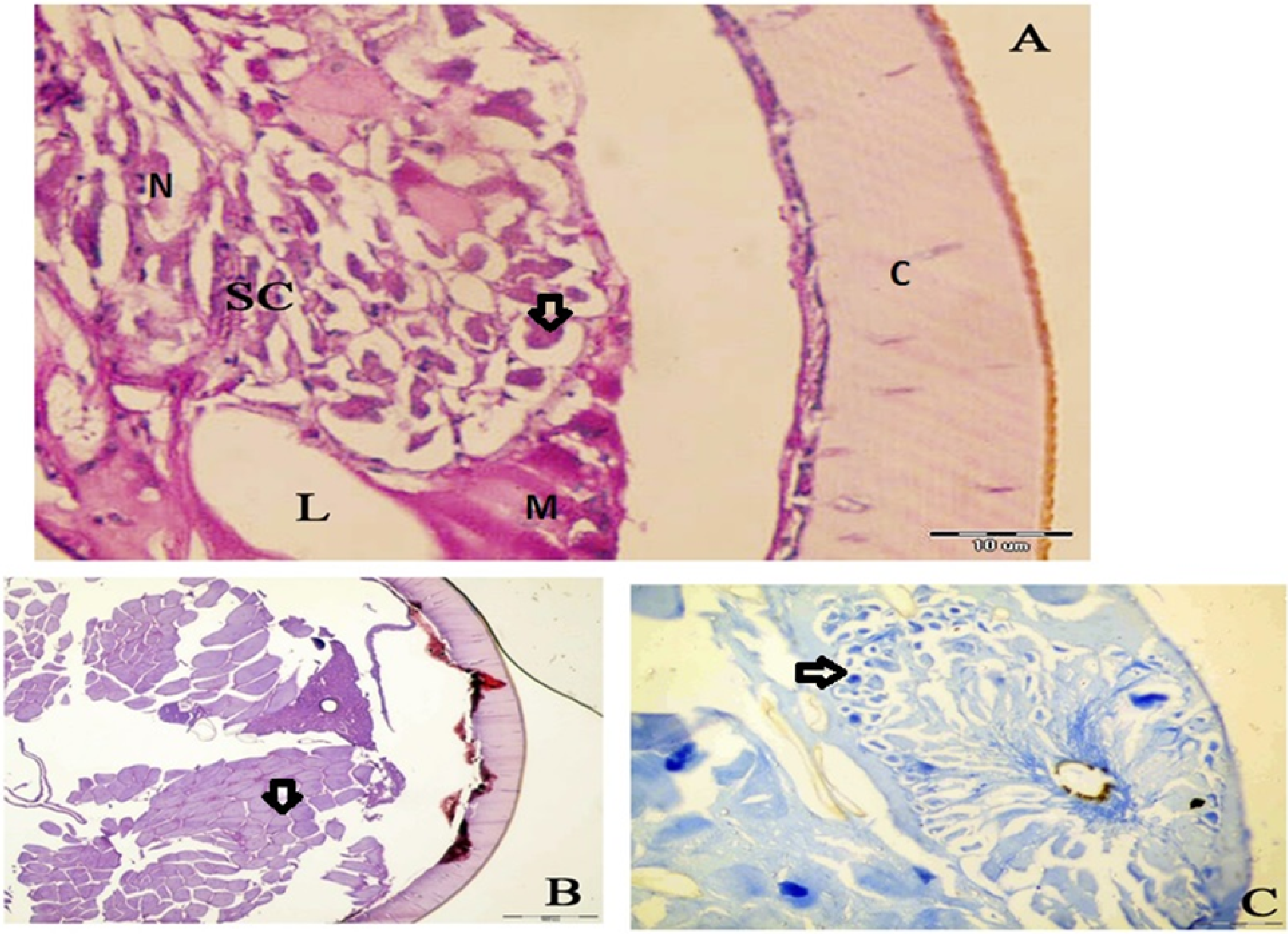

Figure 4

A- Photomicrograph showing a section of *S. canidens* through the venom glands. The secretory cells(SC) with basal nuclei; lateral lumen (L) and glandular muscle sheath (M); surrounded by ca chitinous envelope (C).H&E. B- Photomicrograph an f section through *S. canidens* stained with alcian- PAS. for carbohydrates (arrow). C- Photomicrograph of a section of *S. canidens* through the venom glands stained with bromophenol blue for proteins (arrow).

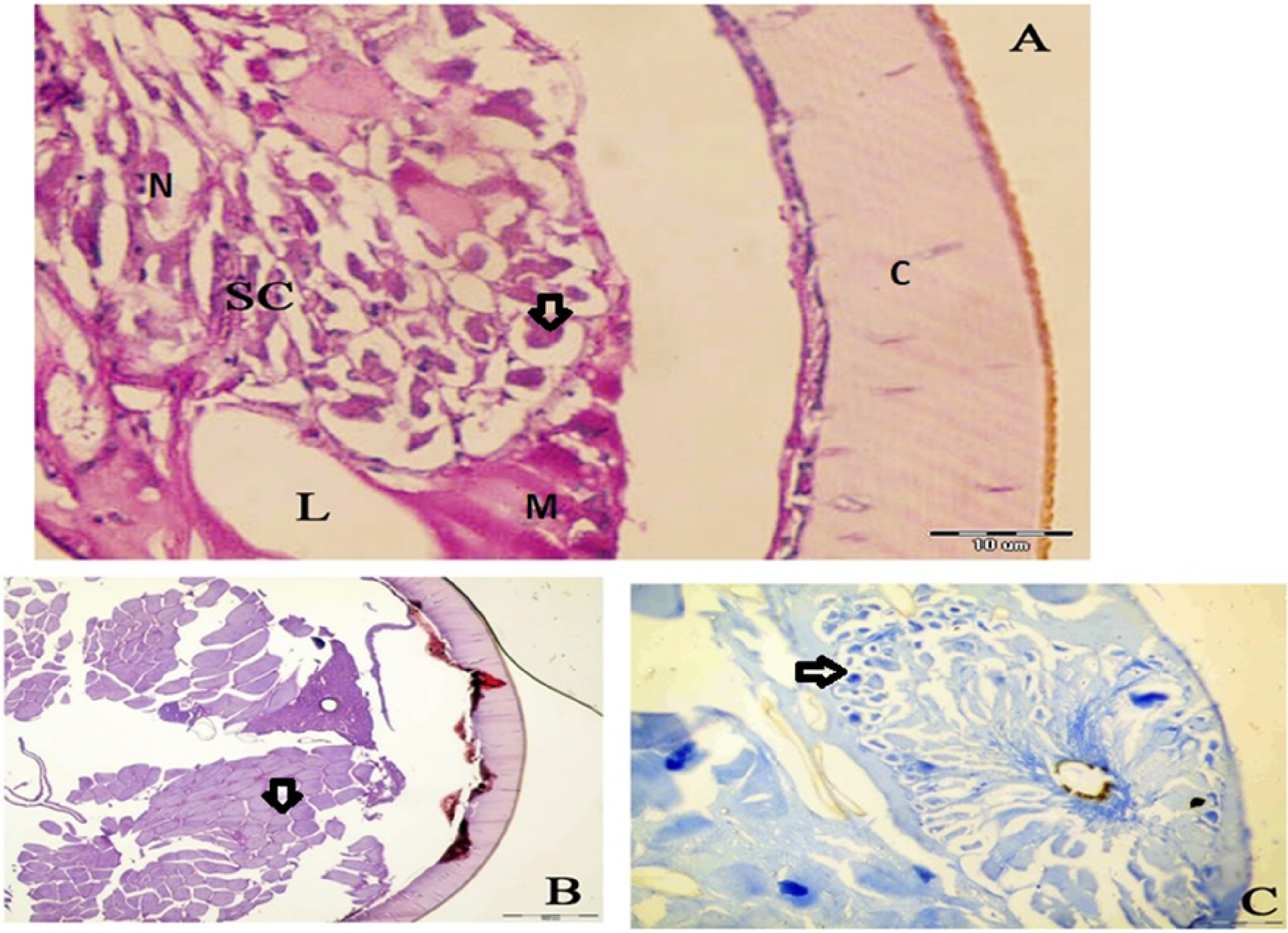

Figure 5

A- Photomicrograph showing a section of *S. morsitans* through the ven glands. The secretory cells(SC) with basal nuclei; lateral lumen (L) and glandular muscle sheath (M); surrounded by a chitinous envelope (C).H&E. B- Photomicrograph of a section through *S. morsitans* stained with alcian- PAS. for carbohydrates (arrow). C- Photomicrograph of a section of *S. morsitans* through the venom glands stained with bromophenol blue for proteins (arrow).