Morphological And Anatomical Studies Of Certain Systems In The False Horned Viper, *Pseudocerastes persicus fieldi* (Schmidt,1930), (Family Viperidae)

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DEDICATED
TO MY
DEAREST FAMILY
AND MY
BEST FRIENDS

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Abstract

Morphological And Anatomical Studies Of Certain Systems In The False-horned Viper, ***Pseudocerastes persicus fieldi*** (Schmidt, 1930) (Family Viperidae).

By

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The morphology, anatomy and histology of the false-horned viper, ***Pseudocerastes persicus fieldi*** (Schmidt, 1930), which is widely distributed in the eastern desert biotope of Jordan,is studied through this investigation. The morphological study of ***P.p.fieldi*** is based on seventeen preserved specimens. It is found that black tail tips are present only in fifty percent of male samples and absent in all females. The head measurements are higher in juvenile than adults when compared with snout – vent length. Also, no sexual dimorphism is present concerning the pholidosis and measurements of the false-horned viper from different localities in Jordan.

This study reveals that the skull architecture of the ***P.p.fieldi*** is in entire agreement with snakes belonging to the family Viperidae specially with the genus ***Vipera***. The dentition of the false-horned viper is characterized by higher teeth number on pterygoid, palatine, and dentary bones than other viprids but less than colubrid snakes. The head musculature of this species is characterized by well developed compressor glandulae muscle that acts in venom extrusion from the venom gland. Also, by the loss of the muscle levator anguli oris that was reported to be present in all solenoglyphous snakes. The vertebral column of ***P.p.fieldi*** exhibits

certain anatomical modifications which enable it to utilize all kinds of snake progressions. These characters are the triple articulation between successive vertebrae, presence of sizable neural spine and presence of hypapophyses through all of the vertebral column. The anatomy of the male reproductive system shows special features by having nonlobulated testes and the right testis is located anteriorly to the left. Also, the hemipenis has unique characteristics that can be used efficiently in taxonomy.

The anatomical and histological studies of the venom gland in the false-horned viper reveal that it attains similar features of other viprid snakes glands especially ***Vipera palaestinae***. The anatomy of seven samples and the histology as well as the histochemistry of two alive samples are studied. This study showed that the length of the esophagus in relation to other organs of the digestive tract is longer in juveniles than in adults, but the intestine ratio is more in the latter. In both, juveniles and adults, the esophagus forms the major length of the alimentary canal. Acidic mucopolysaccharides are abundant in the goblet cells of esophagus, small and large intestine. Neutral mucopolysaccharides are present mostly in the mucosa of the stomach. Moreover, muscularis externa is thicker in stomach than other regions. In general, the main components of the reptilian digestive tract are present in this species, with some modifications to attain for better adaptation to its feeding habits.

1-INTRODUCTION

The morphology of the false-horned viper was previously described by many authors (Schmidt, 1930; Mendelssohn, 1965; Marx and Rabb, 1965; Disi, 1983; Gasperetti, 1988; Disi, 1990). But each study dealt with a small nunber of specimens, and some variations in their results are observed.

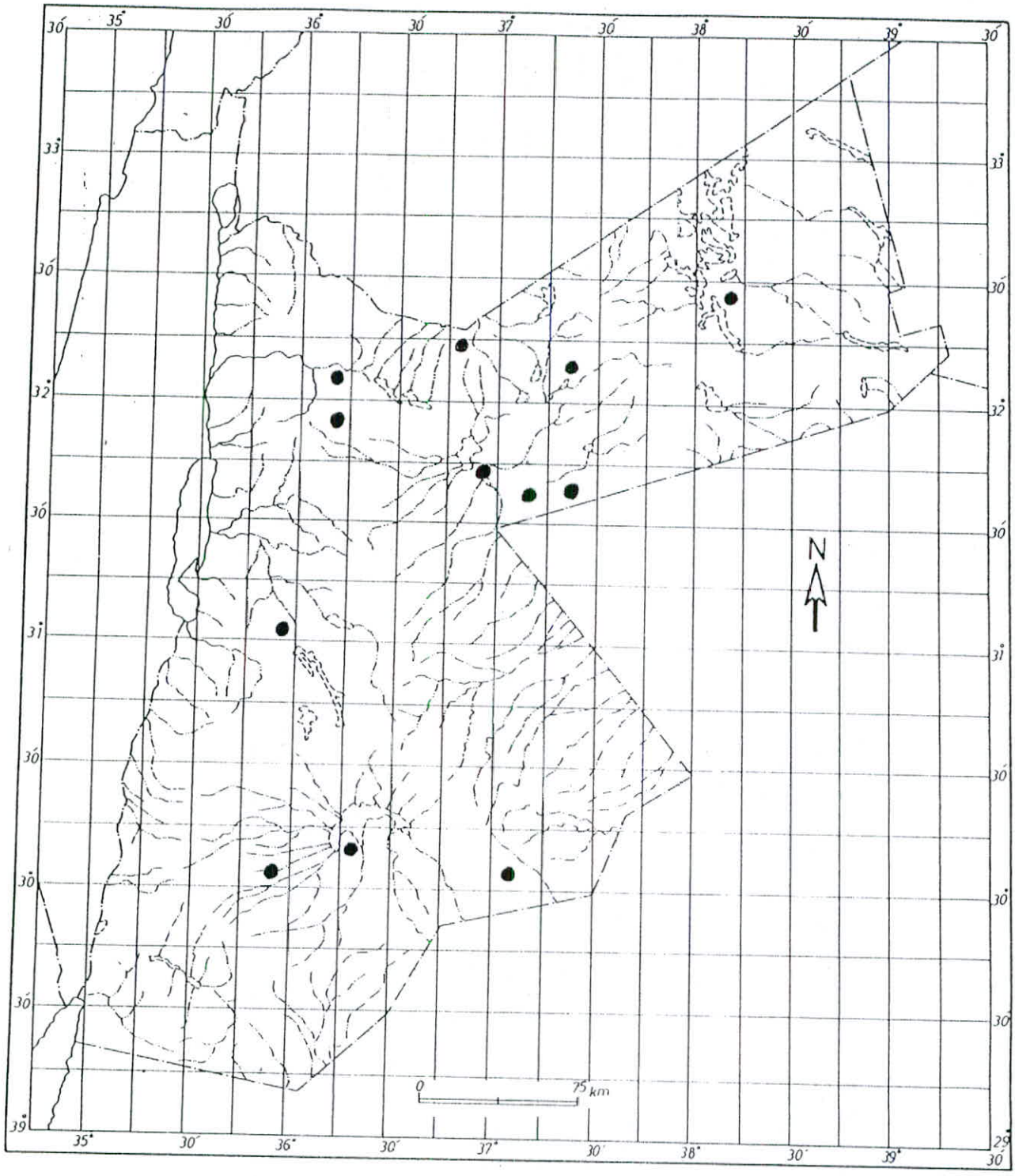
Snakes have evolved more than any other vertebrates in order to accommodate the harsh environment they live in. One of the challenges they face is capturing and also swallowing their prey for being a legless carnivorous animals. They had developed morphological adaptation that permits them to engulf prey considerably several times larger than their body diameter. These morphological adaptations are mostly obvious and clear in the unique characteristics of snakes skull, head muscles, venom gland and teeth, which act all together in prey capturing and swallowing mechanism. Also, the vertebral column of the snake which usually range from (120 - 400) vertebrae gave its body a great flexibility during different movement patterns (Engelmann and Obst,1981).

Many authors have studied snakes in term of their evolution, as a comparative study or as a detailed study dealt only with one species of snakes. This study focused on nominate subspecies ***Pseudocerastes***

persicus fieldi, because previous authors did not concentrate on the anatomical aspects of this species, in comparison with other viprids which were dealt with in detail. This may be due to its restricted distribution. It ranges from the Euphrates river (Northwestern Iraq) westwards, between the true desert in the south and the steppe in the north, in Sinai, Syria, Palestine to Jordan (map 1) and the extreme north of Saudi Arabia. (Gasperetti, 1988; Disi, 1990).

The histology of the venom gland of some vipers and some elapids snakes have been studied extensively (Kochva and Gans, 1965&1967; Shaham and Kochva, 1969; Ben-Shaul *et al.* 1971; Gopalakrishnakone and Kochva, 1990 & 1993). However, the venom gland of the viper ***Pseudocerastes persicus fieldi*** was not studied previously.

The alimentary canal of various reptiles has received more attention than snakes. Frenkel and Kochva (1970) described the visceral anatomy of ***Vipera palaestinae***. Also, Parsons and Cameron (1977) described the anatomy of the alimentary canal of some snakes. Unfortunately, ***Pseudocerastes persicus fieldi*** was not included. Survey of literature revealed that little has been published on the histology and histochemistry of the digestive tract of squamata. Some studies have dealt histologically with the alimentary canal of lizard (Bishai, 1959; Zaher *et al.*,1987). Other



Map 1 The Distribution of ***Pseudocerastes persicus fieldi*** in Jordan (●)

investigations have histochemically described the mucosal epithelium of the digestive tract of some lizards (Dehlawy and Zaher, 1985b; Dehlawy *et al.* 1988a&b). But few studies were performed on the histology and histochemistry of the digestive tract of snakes (Vialli, 1929; Reis and Iyons, 1943. Skoczylas, 1970; Ferri *et al.*, 1974; Luppa, 1977) and in Viperidae (Amer *et al.*, 1987), but none was done on the species ***Pseudocerastes persicus fieldi***.

The description of the male reproductive system was used in studying the taxonomical affinities between snakes of different genera (Fox, 1965 & 1977). But the male organs of the genus ***Pseudocerastes*** were not included in any previous descriptions of the family Viperidae. Inspite of the important role of the morphology of the hemipenis and its use as a taxonomical tool (Branch, 1981; Schatti, 1987 & 1988; Pinou and Dowling, 1994; Rasmussem, 1997; Shwayat, 1998), but few studies were performed for the hemipenes of the family Viperidae (Dowling and Savage, 1960; Murphy and Barker, 1980).

Aim of the study

The goal of this study is directed towards investigation of the following in the false-horned viper, ***Pseudocerastes persicus fieldi*** :

1- Reporting the synonymy and chresonymy.

2- Describing the external morphology, head and body measurements.

3- Descriptions of the skull, dentition, head muscles, venom gland and certain vertebrae of the column: atlas, axis, third vertebra, trunk and cloacal vertebrae

4- Studying the anatomy of the male reproductive system.

5- Studying the morphology and the gross anatomy of the digestive tract.

6- Studying the histology of the main venom gland and the digestive tract including the esophagus, the stomach, the small and large intestine and the cloaca.

7- Histochemical study of the esophagus, the stomach, the small and large intestine.

2- LITERATURE REVIEW

2.1 Morphology of *Pseudocerastes persicus fieldi*

Taxonomical Status of ***Pseudocerastes persicus fieldi*** (Romer, 1976)

Kingdom	Animalia
Phylum	Chordata
Subphylum	Vertebrata
Class	Reptilia
Subclass	Lepidosauria
Order	Squamata
Suborder	Ophidia
Superfamily	Colubroidae
Family	Viperidae
Subfamily	Viperinae
Genus	***Pseudocerastes***
Species	***Pseudocerastes persicus***
Subspecies	***Pseudocerastes persicus fieldi*** (Schmidt, 1930)
Common name	False-horned viper or field's horned viper

The description of ***Pseudocerastes persicus fieldi*** was first given by Schmidt (1930). He described three specimens, a male, a female and a juvenile. The male sample was first collected by Henry Field in May.9.1928 from eastern Transjordan and was studied by Schmidt. He called it ***Pseudocerastes fieldi.*** He explained the variations between ***P.fieldi***

and ***P.persica*** by having different scale count and color- pattern, as well as differences in their distribution.

Mendelssohn (1965) studied the morphology, distribution, feeding habits, reproduction and growth as well as the movement and behavior of the viper ***P.p.fieldi***. He described the color of the false-horned viper and mentioned that specimens of this species have little variations in color pattern. He found that in adults of either sex, the tip of the tail is black. Also, he considered ***P.p.fieldi*** a sidewinder when moving on sand, or on hard substrate although it can perform all other locomotion patterns of snakes.

The genus ***Pseudocerastes*** was synonymized with the genus ***Vipera*** on the basis of negligible differences (Marx and Rabb, 1965). They did a detailed morphological study of ***P.p.fieldi*** and ***P.p.persica***. In their study they considered the former as a subspecies of the latter although both types have considerable variations in their pholidosis and body measurements (table1). In contrast to the assumption of Marx and Rabb (1965), Groombridge (1980) suggested that the two genera, ***Pseudocerastes*** and ***Vipera***, form a strictly monophyletic group. In addition, the description of ***P.p. fieldi*** was given by Disi (1983) which was based on eleven specimens

Table 1 Geographic Variations of Certain Characters of ***Vipera Persica*** (Marx and Rabb, 1965)

Character	***V.p.persica***	***V.p.fieldi***
Midbody scale rows	23-24(23.3)14	21-23(21.8)5
Ventrals: ♂	144-158(151.0)9	134 1
Ventrals: ♀	145-155(149.0)5	134-138(136.7)8
Subcaudals: ♂	41-48(44.6)9	35 1
Subcaudals: ♀	38-43(40.8)5	36-38(37.0)3
Sales in ocular ring	13-23(18.3)32	14-18(15.8)12
Tail length relative to total length: ♂	0.116-0.155(0.128)7	0.116 1
Tail length relative to total length: ♀	0.121-0.132(0.126)5	0.105-0.118(0.111)3

* Numbers between brackets represent the mean of the studied samples, followed by the number of these samples.

gathered from different locations in Jordan. He reported the pholidosis, measurements as well as its distribution.

In his extensive study, Gasperetti (1988) had stated the morphological characteristics of ***P.p.fieldi***. He summarized the descriptions given by Schmidt (1930) and Marx and Rabb (1965) then he carried out a comparison between ***P.p.persica*** and ***P.p.fieldi*** based on their findings.

Disi (1990) discussed the venomous snakes in Jordan. In his study, he described the morphology of the false-horned viper presenting the pholidosis and other measurements. Also, he gave some color indications and stated that the tail of adult samples of ***P.p. fieldi*** have black tips.

2.2 Anatomical Studies

2.2.1 Head Skeleton

Snakes were thought previously to be a monophyletic group, so the origin of the solenoglypha has been neglected due to the assumption that colubrid snakes is the probable ancestor of all other snakes. Dullemeijer (1956&1958) was a major contributor in studying solenoglypha's skull anatomy in particular members of the family Viperidae. In his first article (1956) he studied the head structure of the common viper, ***Vipera berus***, in

relation to the function. In 1958, he performed a comparative study using different elements of head structure. He illustrated each bone by itself and showed the mismatches in the elements of the skull among the seven species of the venomous snakes he studied.

More recent studies concerning the description of snake skulls were done by Cundall (1981). He studied the cranial bones of five colubrine snake species, then he compared their skulls descriptions in order to connect them phenetically. Moreover, he (1983) described the skull of four genera of colubroid snakes to study the role of skull bones in prey capturing and swallowing mechanisms.

Pough and Groves (1983) studied the skulls of fifty species of snakes belonging to the families Viperidae, Colubridae and Elapidae. They compared the descriptions of the different skull elements to explain the characters that facilitate the swallowing process in viperid snakes.

A detailed description of the skull of four species of colubrid snake was performed by Cundall and Rossman (1984). Measurements were made for ninety seven different features of the studied skulls. Their goals of this analysis were to detect if the four taxa examined can be reliably differentiated on the basis of skull morphology. The obtained results

allowed them to determine which particular feature of the skull contributes most to separation of the taxa.

Mohammed (1991) described the skeletal elements of the boid snake ***Eryx jayakari*** in details. He illustrated the skull from different views and dealt with the morphology of each bone and its attachments with other bones.

Underwood and Kochva (1993) constructed a dendogram of the family Atractaspididae after analyzing eighty two variables of the fourteen genera they studied. They described the studied skulls and indicated the differences in each bone. Moreover, Underwood in (1998) dealt with the description of the palatine bone in order to correlate the affinity of the vipers with other groups.

2.2.2 Dentition

The studies concerning the biting apparatus of vipers are scant. Gans and Elliott (1968) studied the fangs of the viprids and stated that these were the largest and the most perfected poison injecting apparatus in nature. Kochva and Meier (1986) studied the structure of the fangs of the species ***Atrastaspis engaddensis***. They compared the biting apparatus between this

species and otherss (Colubridae and Elapidae) through describing the maxilla and the fangs which are carried on it.

Young and Kardong (1996) surveyed a broad sample of snake species across taxonomic groups to document and summarize the teeth variations present among them. Their survey included scoring of dentitional features of four dentiferous bones (dentary, pterygoid, palatine, maxilla). Also, they ranked the tooth type on each bone into four categories: basic, furrowed, grooved and hollow tooth.

2.2.3 Head Muscles

Previously, it was assumed that the solenoglypha to be a late offshoot of the colubrid snakes. This assumption was built on the basis of the skeletal structures and poisonous apparatus. Haas (1952) gave clear clues indicating that there is no phylogenetic connection between solenoglypha and proteroglyphous groups, nor between solenoglypha and opisthoglypha. He studied the head musculature anatomy of solenoglyphous snakes belonging to genera ***Causes, Bitis*** and ***Atractaspis***. Then he compared his observations with the aglyphous, proteroglyphous and opisthoglyphous head muscles descriptions in order to prove his theory. In addition, he indicated the importance of the head muscles in clarifying the phylogentic significance among different snake groups.

Dullemeijer (1956) described the head muscles and the pattern of their attachment for the common viper, ***Vipera berus***. In his further investigation (1958) he compared his previous findings of the common viper head muscles with other seven venomous snake species. In the same year, Kochva (1958) studied the head muscles of ***Vipera palaestinae***. He described the relation between the head muscles and the venom gland, also their role in fangs erection during biting mechanism and the action dependency between one muscle and another. Kochva (1962) stated that it is desirable to determine whether similar features of ***Vipera palaestinae*** head muscles were also found in other Viperidae. He illustrated the head muscles of the viprid snakes he studied, and explained the differences between them.

A detailed study of the puff adder, ***Bitis arientans,*** head anatomy was accomplished by Boltt and Ewer (1964). They studied the head muscles role in opening and closing of jaws, erection and retraction of the fangs, extrusion of the venom and finally drawing the prey into the mouth.

Cundall (1983) studied the activity of nine cranial muscles of four colubroid snakes. His study was done to gain needed measures of whether swallowing in advanced snakes is a conservative mechanism or not.

Gopalakrishnakone and Kochva (1990) studied the morphology of the head muscles associated with the venom glands of sea snakes. They compared their findings with those of several terrestrial elapids to find the shared characteristics between both snakes types. Also, they indicated the degree of the development in sea snakes venom apparatus. Underwood and Kochva (1993) performed a dendogram for the family Atractaspididae. They chose the superficial jaw muscles to be among the studied features of each genus.

2.2.4 Venom Gland

The study of snake venom has received special interest in the last four decades. Also, emphasis being placed on chemical and pharmacological aspects of the venom (Kochva and Gans, 1965). On the other hand, little attention was paid for the glands from which the venom is produced. Kochva (1958) studied the relation between head muscles and the venom gland for the ***Vipera palaestinae,*** but he didn't study the morphology of the venom gland. Several years later Kochva and Gans (1965) gave a topographical description of the venom gland in the ***Vipera palaestinae*** head. Also, they described the venom production and flow within the gland till it reaches the fang sheath. Kochva and Gans in their further study (1967), presented a description of the venom glands in the

Viperidae and compared it with venom glands of other species of poisonous snakes.

Gopalakrishnakone and Kochva (1990) analyzed some of the functional aspects of the sea snakes venom apparatus. They illustrated sagittal sections of the venom glands of these snakes and compared them with terrestrial elapid glands to get better understanding of the relationships between them. Also, in their further study (1993) they performed a histological study of the venom apparatus features for the sea snakes ***Lapemis curtus*** and presented gross anatomy of the venom glands.

2.2.5 Vertebral Column

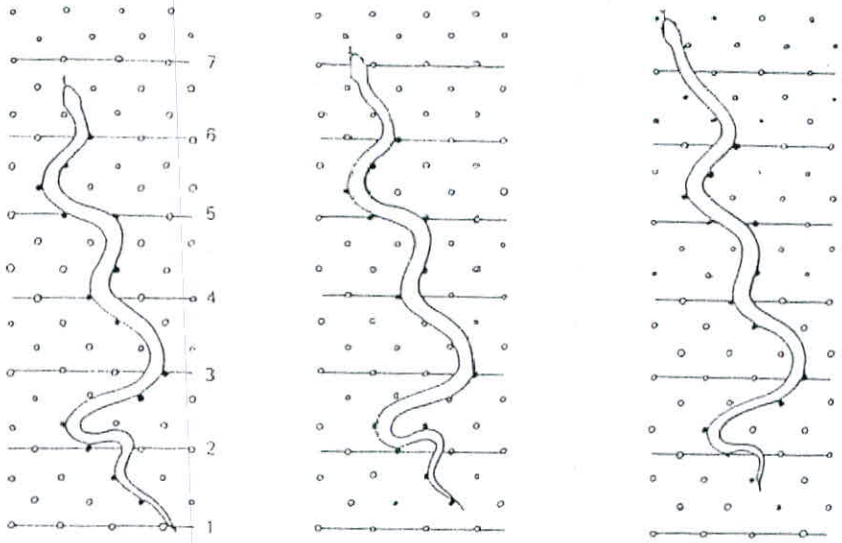
The vertebrae and ribs are characteristic features of vertebrates. They also are by far the most polyvalent part of the skeleton and are, therefore, the most difficult either to analyze or to systematize (Hoffstetter and Gasc, 1969). The vertebral column forms the longitudinal axis of the long supporting apparatus and secondarily a protective wall for the spinal cord. Furthermore, vertebral column has several additional characteristics (zygosphenes that provide the required rigidity to transmit forces from one part of the body to another) that enable snakes to have different movement patterns in relation to the habitats they live in (Engelmann and Obst, 1981).

Gans (1962) described the locomotion patterns of limbles vertebrates. He emphasized on the main four methods of terrestrial limbless locomotion (lateral undulatory, rectilinear, concertina and sidewinding). Also, he explained the anatomical modifications in the vertebral column that give the snakes their greatest average of complexity and flexibility within vertebral motion patterns.

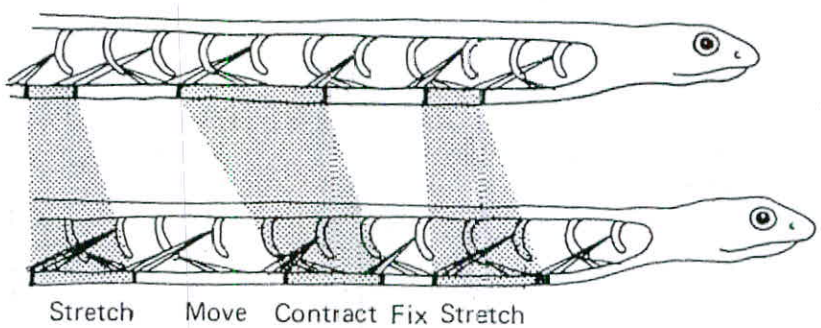
Snakes commonly employ four types of locomotion : (a) serpentine locomotion, in which the body is thrown into a series of curves (b) rectilinear locomotion, used primarily by heavy–bodied snakes (c) concertina locomotion, used in narrow places and (d) sidewinding which is used by snakes that live in deserts where windblown sand provides a substrate that slips sidewards during its locomotion (fig. 1) (McFarland *et al.*, 1979).

Mohammad (1991) discussed the skeletal elements of boid snake ***Eryx jaykari***. He illustrated the atlas-axis complex, 3rd vertebra, trunk and cloacal regions vertebrae. Underwood and Kochva (1993) considered the vertebrae of the mole viper, ***Atractaspis***, as an important element in the determination of this genus taxonomy. Furthermore, Underwood (1998) used the vertebrae as a tool to show the evolutionary relationship of viperines and crotaline snakes. He found that posterior hypapophyses have

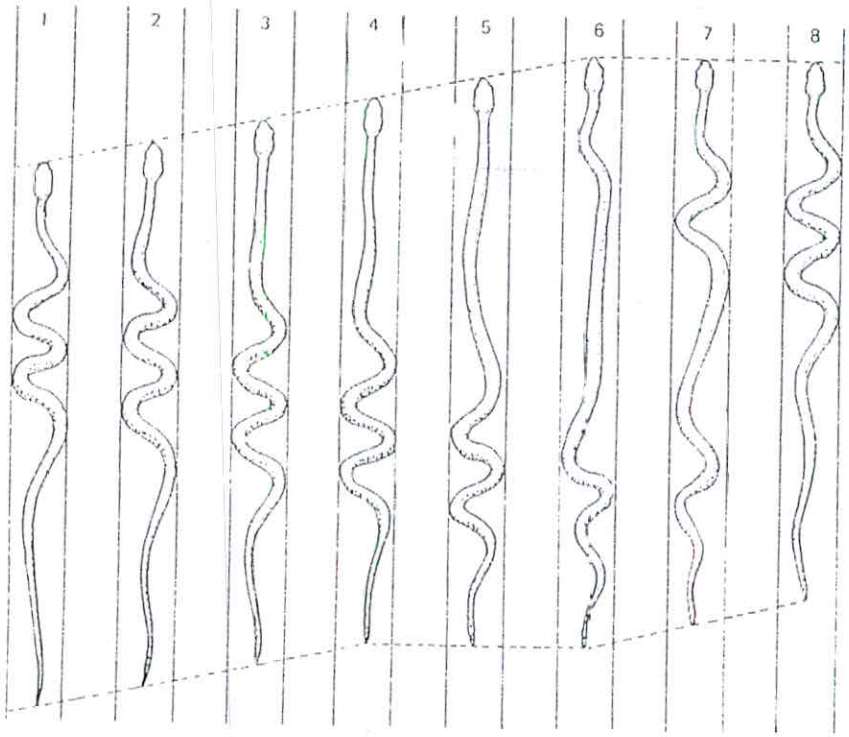
Fig. 1 Snakes: four types of locomotion (After McFarland *et al.*, 1979)



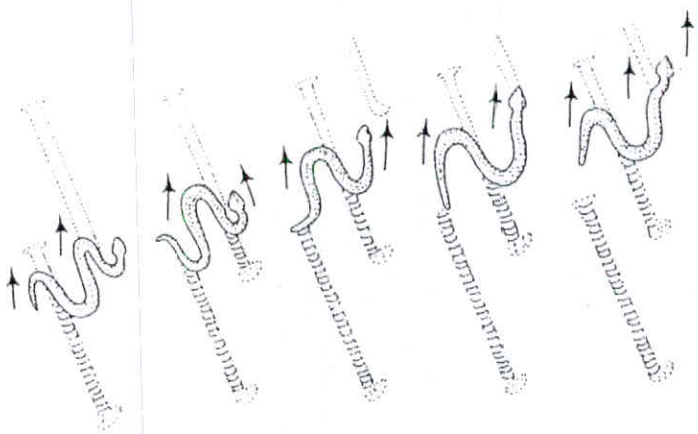
a. Serpentine Locomotion



b. Rectilinear Locomotion



c. Concertina Locomotion



D. Sidewinding locomotion

a taxonomical value, and both viperines and crotaline snakes have this element.

2.2.6 Male Reproductive System

Fox (1965) studied the male reproductive system of two blind snake families to show their taxonomical affinities. His study revealed so many similarities between the two studied families, Typhlopidae and Leptotyphlopidae. Accordingly, he suggested that the two families should not be isolated in their taxonomical arrangement from each other.

Fox (1977) described and measured the testes of ***Vipera berus,*** and compared between the testes of ***Vipera*** and ***Natrix***. He found that the testes of ***Vipera*** are twice as large as that of ***Natrix*** despite the larger body size of the latter because ***Vipera berus*** has a continous annual spermatogenetic cycle. In his study, he noticed a positive relationship between the size of snakes testes and their breeding seasons.

The morphology of hemipenes has been used extensively in snake taxonomy because it owns specific morphological modifications among different snake taxa. Dowling and Savage (1960) established a pattern of description for snake hemipenes and showed the importance of this character in combination with other characters in systematic studies.

Murphy and Barker (1980) studied the hemipenes of ***Vipera xanthina***. They described the hemipenis morphology and its relation to the function it performs. The basal spines were found to be important to anchor the organ into the female's cloaca during copulation.

Branch (1981) described the hemipenes of three Boinae snakes in details. He compared his findings with descriptions of other Boinae hemipenes, and he found that all of them have basically similar structure. However, each species has certain variations differentiating it from other members of the Boinae.

Schatti (1987) examined the phylogenetic significance of the hemipenes morphology between several species belonging to the genus ***Coluber***. He illustrated and described all the studied hemipenes and explained the variations presented among them. Moreover, Schatti (1988) studied other species of the genus ***Coluber*** by describing their hemipenes and comparing his findings with the previous reports. He explained the differences in the morphology of the hemipenes among all studied species. Also, he concluded that hemipenis could be used as a tool in construction of the phylogenetic relationships of Colubrinae snakes.

Pinou and Dowling (1994) studied the phylogenetic relationships of the snake ***Tretanorhinus***. The hemipenis morphology was considered as an important tool in their study among other characters they used. Rasmussem (1997) described the hemipenis of two African water snakes, ***Crotaphopeltis degeni*** and ***C. barotseensis***. He compared the two hemipenes types and explained the variations among these two species. Shwayat (1998) compared between the hemipenes of four ***Eirenis*** species from Jordan. She stated that a high similarity exists in the morphology of the hemipenes of the studied species.

2.2.7 Digestive Tract

The anatomy of the alimentary canal of various reptiles has been studied. Bishai (1959) studied the anatomy of the alimentary tract of the lizard, ***Varanus griseus***, as part of comparative studies aiming to relate it to the type of food that lizards ingest. Also, Chou (1977) investigated the anatomy of the digestive tract of the gecko, ***Gehyra mutilata***.

In comparison, less studies were performed on snakes concerning the anatomy of the digestive tract. Bergman (1965) measured the internal organs of the snake ***Calamaria multipunctata***. He reported that the anterior organs of the snake body are situated more cranially in females. Frenkel and Kochva (1970) studied the gross visceral anatomy of the snake

Vipera palaestinae. Their study was supported by few figures about the histology of the digestive tract. However, they gave only a brief description with no explanations of their findings.

The gross anatomy of snakes digestive tract was explained in details by Parsons and Cameron (1977). They performed a comparative study and described the folding patterns along the alimentary canal of snakes belonging to seven families. Their study included members of the family Viperidae but the false-horned viper was not part in their investigation. Also, Parsons and Cameron have grouped the esophageal folds into three types and suggested that almost all members of the family Viperidae have type-two relief in which folds are tall, rough-surfaced and branched.

2.3 Histological Studies

2.3.1 Venom Gland

The study of Kochva and Gans (1965) formed the initial step in understanding of the production of venom and its flow within the venom gland. They examined the venom gland of *Vipera palaestinae* histologically as well as histochemically. Also, they described the secretory cells, the tubules and the central lumen, that continues anteriorly to form the primary duct. The histochemical tests showed that the secretion of the

main gland contains a carbohydrate protein complex and the epithelium shows a positive reaction for RNA – protein. Moreover, Kochva and Gans (1967) performed another study including other viperid snakes. They found the same cell types, columnar and horizontal cells, are present in all viprids venom gland.

Shaham and Kochva (1969) studied the location of venom gland secretions of ***V. palaestinae*** using a fluorescent antibody technique. They represented the correlation between histological structure and fluorescence in venom glands. They stated that till six days after milking, the columnar epithelial cells are tall, the horizontal cells are conspicuous, the intratubular lumena are small and both cell types were fluorescing. From day 8 to 50 after milking, the columnar cells become lower, the intratubular lumena are larger and low fluorescence was shown indicating that all secretions were expelled and stored in the lumen. These findings were also confirmed by utilizing an ultrastructural study of venom gland cells of the Palestine viper (Ben- Shaul *et al.*, 1971) (fig 2).

Gopalakrishnakone and Kochva (1990) described the venom glands of some sea snakes of the family Elapidae. They stated that the main gland is of a serous type and secretes various toxins as well as toxic and non-toxic enzymes. The branching tubules converge obliquely on the anterior

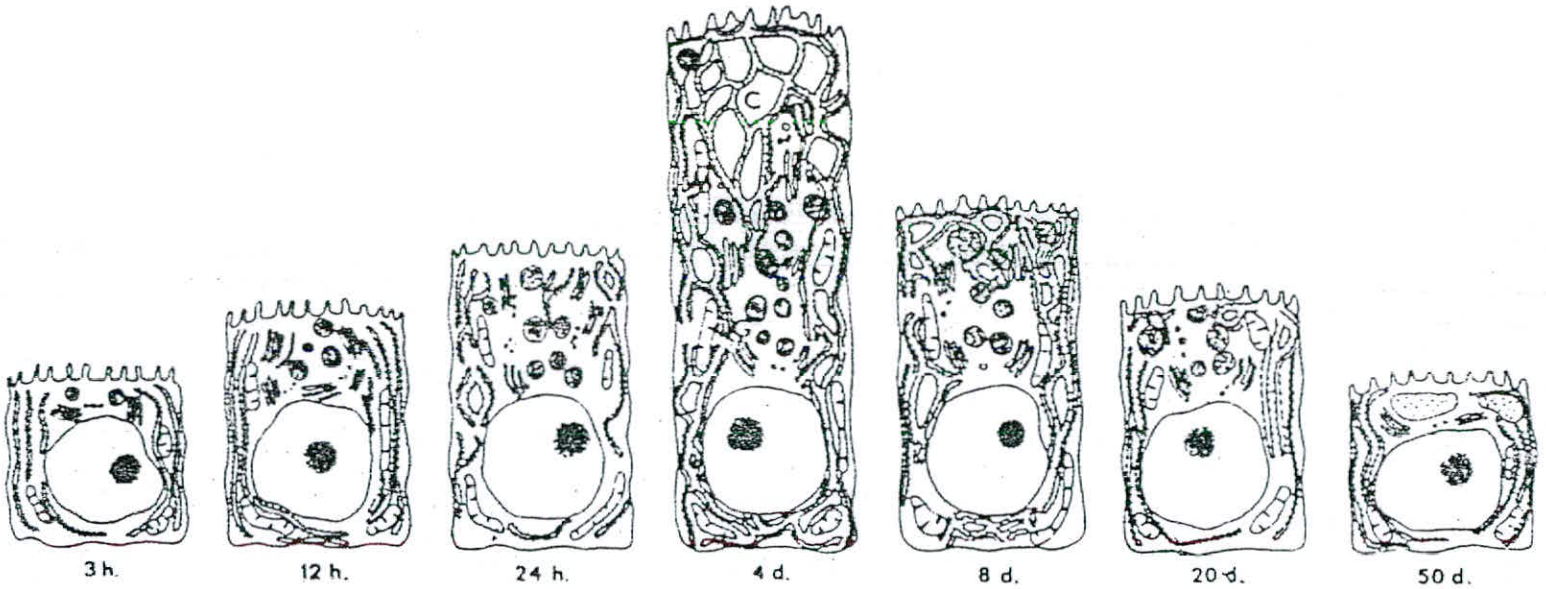


Fig. 2 Changes in the secretory cells at different intervals after milking in *Vipera palaestinae*. (After Ben-Shaul *et al.*, 1971)

center of the gland to form the lumen which continues as the gland duct. Another detailed study was performed by Gopalakrishnakone and Kochva (1993) concerning the venom gland of the sea snake ***Lapemis curtus***. They described the secretory epithelium of the main venom gland to be simple cuboidal.

2.3.2 Digestive Tract

A survey of literature revealed that among reptiles, lizards and geckos have received more attention than snakes concerning the histology and histochemisty of their digestive tract. Histological and histochemical studies of the alimentary canal of the gecko ***Gehyra mutilata*** were performed by Chou (1977).

Geckos mucosa was studied histochemically by Dehlawy and Zaher (1985a), Amer *et al.* (1987), Dehlawy *et al* (1987). They studied the distribution of acid and neutral mucopolysaccharides in the mucosal layer along the digestive canal. Also, lizards alimentary canal was studied histochemically for the mucosal layer by Bishai (1959), Dehlawy *et al.* (1988a) and Dehlawy *et al.* (1988b). The histology of lizards whole alimentary canal was studied by Dehlawy and Zaher (1985b) and Zaher *et al.* (1987). In geckos as well as in lizards the previous studies showed that goblet cells present in the esophagus and the intestine secrete acid

mucopolysaccharids. Chou (1977) explained the presence of large number of goblet cells in the gecko's esophagus to facilitate the passage of prey and in the large intestine to aid in the discharge of faeces after water reabsorption. The neutral mucopolysaccharides were the main component of mucosal cells in the stomach of lizards and geckos (Dehlawy *et al.*, 1987; Zaher *et al.*, 1987; Dehlawy *et al.*, 1988a ; Dehlawy *et al.*, 1988b).

Skoczylas (1970) examined the properties of the gastric juice in grass snakes ***Natrix natrix***. He noticed that changes in pH depend on the ambient temperature as the pH of the juice secreted at 35°C was higher than that at 25°C. The proteolytic activity of the juice was almost the same at both temperatures (25° and 35°C) but the secretion of pepsinogen was inhibited when the snakes were cooled to lower than 10°C. He included microphotographs of gastric glands for fed and fasted snakes. Frenkel and Kochva (1970) illustrated some histological figures of the alimentary canal of ***Vipera palaestinae***. But the study lacked any descriptions or explanations for their histological findings.

Ferri *et al.* (1974) studied the stomach of the snake ***Xenodon merremii*** histologically. They reported the absence of valve between the esophagus and the stomach; between the stomach and the duodenum a valve existed. They also described the mucosa of different parts of stomach

including cardiac, fundic, and pyloric regions. They explained the cellular types of the surface epithelium, fundic glands at pit, neck, and the body regions and the pyloric glands.

Luppa (1977) in a comparative study gave a description of the histology of the digestive tract among different types of reptiles including some snakes. He also studied each part histochemically and illustrated several sections from different regions of the alimentary canal of the examined samples. He compared his observations with results obtained by other authors: (Vialli, 1929; Skoczylas, 1970; Gabe and Saint Girons, 1972; Ferri *et al*., 1974). Vialli (1929) documented the absence of Paneth cells from the small intestine in all snake species he studied, excluding ***P.p.fieldi***. Gabe and Saint Girons (1972) described the gastric glands of most of the colubrid snakes and stated that the fundic glands are composed of neck cells and "dark" cells. Amer *et al*. (1987) studied the histochemistry of the alimentary canal mucosa of ***Echis carinatus*** which belong to the family Viperidae. They examined the different cell types in this layer and studied the distribution of mucopolysaccharides in these cells. Their results agree with those found in geckos and lizards. They showed that goblet cells contain acid mucopolysaccharides and stomach epithelial cells contain mainly neutral and some acid mucopolysaccharides.

3-MATERIALS AND METHODS

3.1 Morphological Study

A total of 17 preserved snake specimens belonging to ***Pseudocerastes persicus fieldi*** from different localities of Jordan were examined. The bulk of the materials examined were preserved specimens from Jordan University Museum (JUM) / Department of Biological Science / The University of Jordan / Amman; and two samples from Jordan Natural History Museum (JNHM) / Yarmouk University / Irbid. The description of head scales and other measurements were followed after Gasperetti (1988) (fig. 3).

a. Body Measurements (Followed after Gasperetti, 1988)

- Mid dorsal scale (MDS): Dorsal scales rows at midbody (fig. 4b).
- Ventral scale (VS): Number of scales from the first ventral to the scale that found before the anal scale.
- Subcaudal scales (SCS): Number of scales on the ventral side of the tail, posterior to the cloaca to the tip of the tail (fig. 4c).
- Total length (TO): Length from the tip of the snout to the tail tip (fig. 4a).
- Snout-vent length (SVL): The length from the tip of the snout to the tip of the vent (fig. 4a).
- Tail length (T): length from the vent to the tip of the tail (fig. 4a).

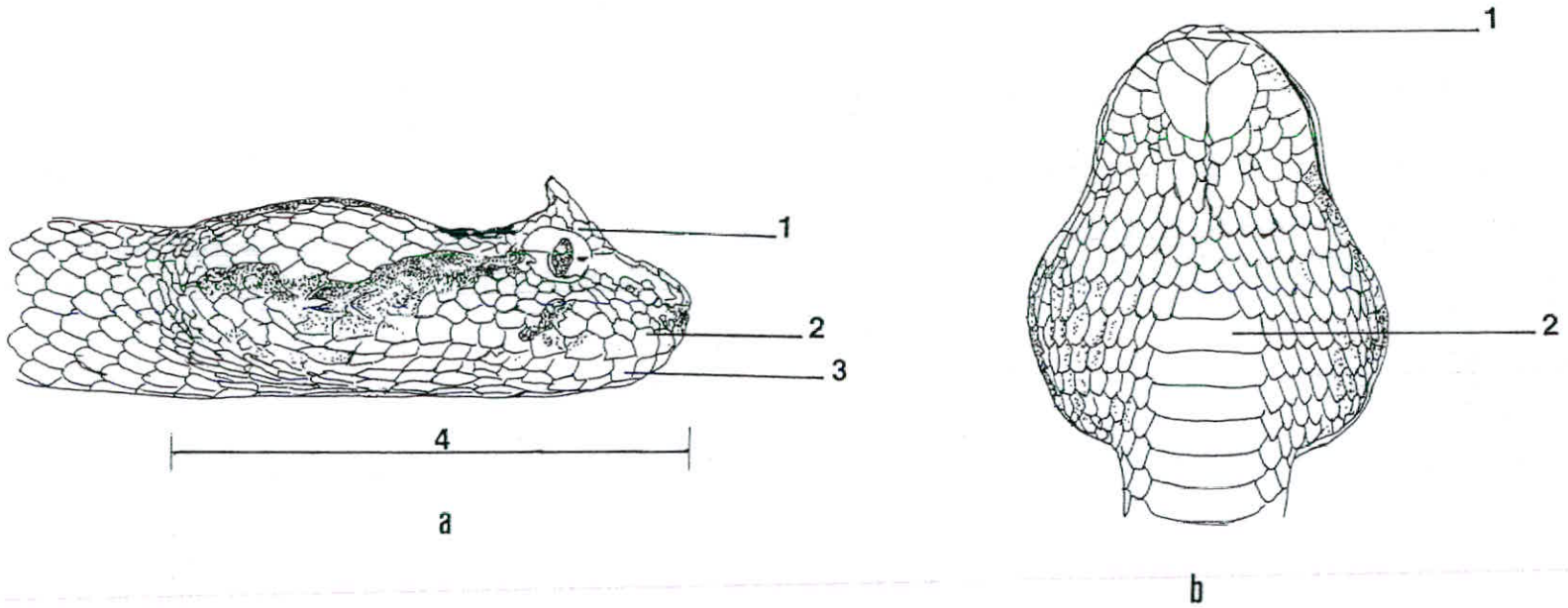
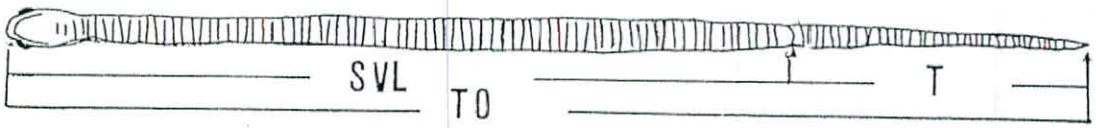


Fig.3 External Morphology of the Head of *Pseudocerastes persicus fieldi*

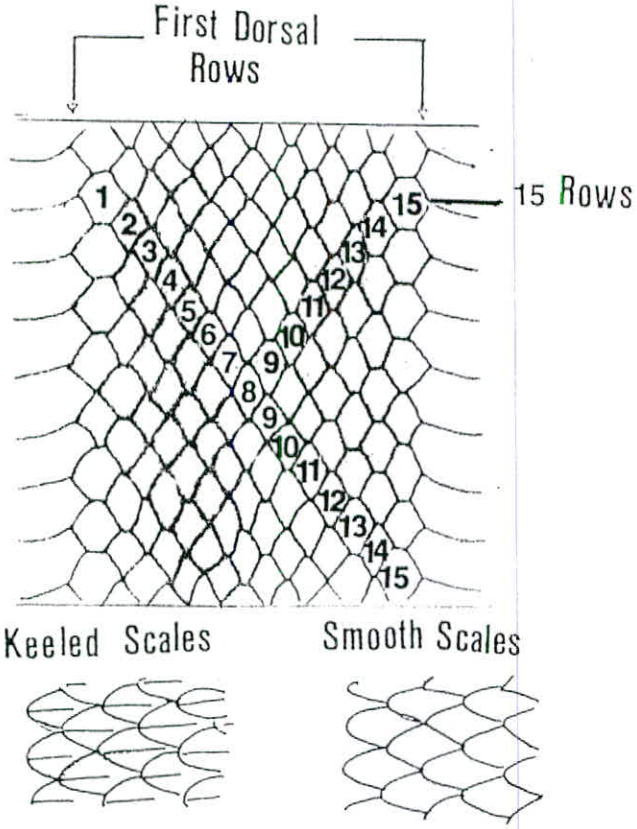
a. Lateral view. 1. Eye scales, 2. Upper labials, 3. Lower labials,4. Head length.
b. Ventral view. 1. Rostral, 2. The first ventral scale

Fig.4 External characteristics and methods of measuring snakes.

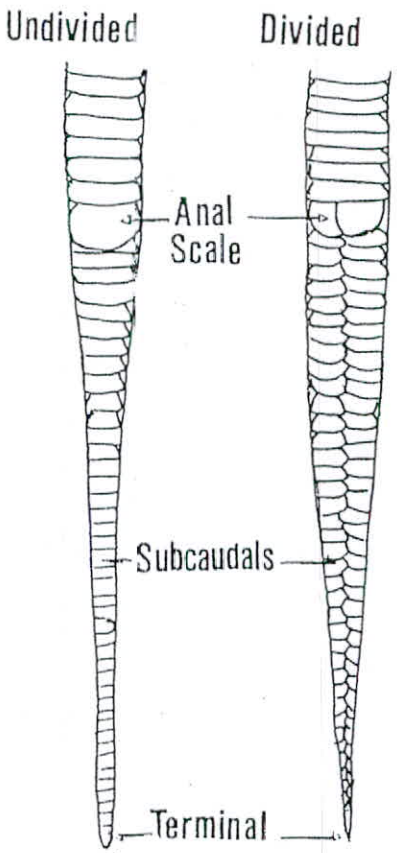
a. Snake Length Measurements



b. Counting Dorsal Scale Rows



c. Anal and Subcaudals



b. Head Measurements (Followed after Werner *et al.*, 1991)

- Head length (HL): Distance from tip of snout to line joining posterior tips of mandible.
- Head width (HW): Greatest width of head.
- Head height (HH): Depth of head, behind the eyes.

3.2 Anatomical Study

This study is based on seven samples which were preserved in 70% alcohol and kept at the Jordan University Museum / Department of Biological science. To perform the anatomical investigations, skulls and vertebrae were prepared by boiling them in borax solution for 1 hour (Abu-Laban, 1999) and then soaked in 1% hydrogen peroxide for 5-10 minutes to bleach the bones. For studying the skull, head muscles and vertebrae, adult male samples were used. The illustrations were drawn on tracing papers taking into consideration the dimensions of each bone. Also, for detailed study a dissecting microscope and a caliper ($\pm$ 0.1mm) have been used.

The terminology of Kochva (1962) is used in this study to nominate the head muscles of ***Pseudocerastes persicus fieldi***. The skull bones nomination have not changed as the head muscles, but ectopterygoid, supratemporal, collumella auris are used instead of transverse bone, squamosal, stapes respectively according to Engelmann and Obst (1981).

Hemipenis Preparation

The procedure for preparing the hemipenis of three preserved snakes was followed after Shwayat (1998) with modification in soaking time in potassium hydroxide solution. The hemipenis was removed from the tail region by using fine, sharp scalpel, through a careful superficial incision at the vent along the mid line section between the subcaudal scales of the tail. After that, the hemipenis was freed from the surrounding tissues and soaked in 2% potassium hydroxide solution for four weeks at room temperature. The hemipenis was removed and washed with distilled water where it remained for one day. Later on, the hemipenis was soaked in 0.1M HCL solution for one day. Next it was washed and soaked for one day in distilled water.

A syringe was filled with distilled water and its needle was introduced into the hemipenis through its base. The water was gently forced in while the organ was pressed between the fingers to facilitate the distension of the walls. For hemipenis eversion, a very fine forceps was used. During this procedure, the hemipenes was kept wet. Then, the everted hemipenis was kept in 75% ethyl alcohol in small glass vial. All the prepared hemipenes were examined by using dissecting microscope. At the end of preparation, photographs were taken for the hemipenis using colored

films (100ASA). Then a diagrammatic drawing for the hemipenis was made.

3.3 Histological and Histochemical Study

Seven adult preserved snake specimens (6 male and 1 female) were used to study the gross anatomy of their alimentary canal. Other two alive false-horned vipers were utilized to study the venom gland histologically and the whole alimentary canal was histolcgically and histochemically. Killing the snakes was achieved by exposing them to overdose of ether. The main venom gland was cut into pieces (5 x 5 x 5 mm) and fixed in 10% formalin solution for one day. Also, small pieces (5 x 5 x 5mm) of the anterior third, middle and posterior third parts of each organ of the digestive tract (esophagus, stomach, pylorus, small intestine and large intestine) as well as the cloaca were taken. The specimens were divided into two groups and immediately fixed using two different fixatives, the first group was fixed in 10% formalin, for 24 hours and the second group was fixed in Zenker fluid for 4 hours. Then tissues were processed using an automated processor following these steps:

a. Fixation

(First step for tissues fixed with 10% formalin)

10% Formalin I	1 Hour
10% Formalin II	1.5 Hour

b. Dehydration

(First step for tissues fixed in Zenker Solution after washing with running water for 8 hours)

70% Ethanol	1 Hour
95% Ethanol I	1 Hour
95% Ethanol II	1 Hour
100% Ethanol I	1 Hour
100% Ethanol II	1 Hour

c. Clearing

Xylene I	2 Hours
Xylene II	2 Hours

d. Infiltration

Paraffin Wax I	1.5 Hours
Paraffin Wax II	1.5 Hours

e. Embedding and Sectioning

The specimens were embedded in paraffin wax using metal blocks and thin sections of 5 µm were obtained using rotary microtome. Then, sections were mounted on albumenized glass slides.

f. Staining

(Table 2 summarizes the different histochemical staining techniques and their target tissue.)

Mayer's Hematoxylin and Eosin-Y (H&E)

1. Clearing	
Xylene I	10 Minutes
Xylene II	10 Minutes
2. Rehydration	
100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds
3. Staining	
Mayer Hematoxylin	10-20 Minutes
Tap Water	Washing
Eosin-Y	4 Minutes
4. Dehydration	
70% Ethanol	10 Dips
95% Ethanol	10 Dips
100% Ethanol	10 Dips

Table 2 Summary of Histochemical Tests

No.	*Technique*	*Fixation*	*Target*	*Color*	*Reference*
1.	H&E	Z/F	Acidic substances Basic substances	Blue Red	
2.	PAS	Z/F	General mucopolysaccharides	Red	LIllie And Fullmer, 1976*
3.	AB pH 1 or pH 2.5	F	Acid mucopolysaccharides	Blue	Taib and Jarrar, 1995
4.	AB / PAS	F	Acid mucopolysaccharides Neutral mucopolysaccharides	Blue Red	Mowry, 1956*
5.	FG	Z	Muscles Connective tissue	Green Violet	Lillie, 1965*
6.	VG	Z	Muscles Connective tissue	Yellow Pink	Mallory, 1938*
7.	MT	Z	Connective tissue fibers except elastin Myosin	Blue Dark Blue	Peacock and Bradbury, 1973

F. Formalin 10%; Z. Zenker.
PAS, Periodic Acid – Shiff method; AB, Alcian Blue; FG, Fast Green; VG, Van Gieson; MT, Mallory's Triple stain.
* These references were mentioned in Clark, 1981.

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Alcian Blue (pH = 1.0) (AB pH1)

1. Clearing

Xylene I	10 Minutes
Xylene II	10 Minutes

2. Rehydration

100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds

3. Staining

Alcian Blue (pH = 1.0) Solution	30 Minutes

4. Drying

Filter Paper was used to Dry the Slides

5. Dehydration

95% Ethanol	10 Dips
100% Ethanol	10 Dips

6. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Alcian Blue (pH = 2.5) (AB pH 2.5)

1. Clearing

Xylene I	10 Minutes
Xylene II	10 Minutes

2. Rehydration

100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds

3. Staining

Alcian Blue (pH = 2.5) Solution	20 Minutes
Tap Water	Washing for 5 Minutes
Eosin – Y	4 Minutes
Tap Water	Washing

4. Dehydration

70% Ethanol	10 Dips
95% Ethanol	10 Dips

100% Ethanol	10 Dips
5. Clearing	
Xylene I	15 Seconds
Xylene II	15 Seconds

Periodic Acid – Schiff's (PAS) Method

1. Clearing	
Xylene I	5 Minutes
Xylene II	5 Minutes
2. Rehydration	
100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
50% Ethanol	20 Dips
30% Ethanol	20 Dips
Distilled Water	15 Seconds
3. Staining	
Periodic Acid 1%	10 Minutes
Tap Water	Washing For 5 Minutes
Distilled Water	10 Dips
Schiff's Reagent	20-30 Minutes

Sodium Meta – Bisulfate (0.5%)	3 Dips
Tap Water	Washing
Harris Hematoxylin	10 Minutes
Tap Water	Washing For 5 Minutes

4. Dehydration

50% Ethanol	10 Dips
70% Ethanol	10 Dips
80% Ethanol	10 Dips
95% Ethanol	10 Dips
100% Ethanol	10 Dips

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Alcian Blue - Periodic Acid Schiff (AB - PAS)

1. Clearing

Xylene I	10 Minutes
Xylene II	10 Minutes

2. Rehydration

100% Ethanol	20 Dips
95% Ethanol	20 Dips

70% Ethanol	20 Dips
Distilled Water	15 Seconds

3. Staining

Alcian Blue (pH = 1.0 or pH = 2.5)	30 Minutes
Tap Water (For Alcian Blue pH = 2.5)	Washing for 5 Minutes
Dry Using Filter Paper	
(for Alcian blue pH = 1.0)	
Periodic Acid 1%	10 Minutes
Tap Water	Washing for 5 Minutes
Schiff's Reagent	20 Minutes
Sodium Meta – Bisulfate I	2 Minutes
Sodium Meta – Bisulfate II	2 Minutes
Tap Water	Washing for 10 Minutes

4. Dehydration

90% Ethanol	10 Dips
100% Ethanol	10 Dips

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Fast Green (FG)

1. Clearing	
Xylene I	10 Minutes
Xylene II	10 Minutes
2. Rehydration	
100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds
3. Staining	
Iron Hematoxylin	10 Minutes
Tap Water	Washing
Fast Green Solution	4 Minutes
Acetic Acid 1%	Washing
Acid Fuchsin Solution	10 – 15 Minutes
Acetic Acid 1%	Washing for 2 Minutes
4. Dehydration	
70% Ethanol	10 Dips
95% Ethanol	10 Dips
100% Ethanol	10 Dips

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Van Gieson (VG)

1. Clearing

Xylene I	10 Minutes
Xylene II	10 Minutes

2. Rehydration

100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds

3. Staining

Iron Hematoxylin	10 Minutes
Tap Water	Washing
Van Gieson's Solution	3-5 Minutes
Tap Water	Washing

4. Dehydration

70% Ethanol	10 Dips
95% Ethanol	10 Dips

100% Ethanol	10 Dips

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

Mallory's Triple Stain (MT)

1. Clearing

Xylene I	10 Minutes
Xylene II	10 Minutes

2. Rehydration

100% Ethanol	20 Dips
95% Ethanol	20 Dips
70% Ethanol	20 Dips
Distilled Water	15 Seconds

3. Staining

Iron Hematoxylin	10 Minutes
Tap Water	Washing
Acid Fuchsin Solution	3-20 Minutes (Till Red)
Distilled Water	Washing
Phosphomolybdic Acid (1% Aq.)	1 Minute
Distilled Water	Washing

Aniline Blue Solution	5-20 Minutes (Till Blue)
Distilled Water	Washing

4. Dehydration

95% Ethanol	10 Dips
100% Ethanol	10 Dips

5. Clearing

Xylene I	15 Seconds
Xylene II	15 Seconds

(The preparation of solutions used in fixation and staining methods is explained in appendix A).

g. Mounting :

The stained sections were covered by cover slips, mounted on D.P.X. and were kept to dry at room temperature for one day. Finally, all slides were examined under the light microscope for histological and histochemical investigations. Micrographs were taken using Olympus Vanox- T AH2 microscope and colored film (Agfa) of ASA 100.

4- RESULTS

4.1 Synonymy and Chresonymy of *Pseudocerastes persicus fieldi*

1930 ***Pseudocerastes fieldi*** Schmidt, Field Museum of Natural History , Chicago, Zool. Ser., P. 227-229.

1933 ***Pseudocerastes fieldi*** Flower, Proc. Zool. Soc., P.830.

1939 ***Pseudocerastes fieldi*** Schmidt, Field Museum of Natural History , Chicago, Zool. Ser., P. 87-88.

1951 ***Pseudocerastes fieldi*** Haas, Bull. Res. Coun. Isreal, p. 91-92.

1957 ***Pseudocerastes fieldi*** Haas, proceedings of the California Academy of Sciences, P. 82.

1962 ***Pseudocerastes fieldi*** Kochva, J. Morph., P. 240.

1965 ***Pseudocerastes fieldi*** Corkill and Cochrane, J.Bombay Nat. Hist. Soc., P. 503.

1965 ***Vipera persicus fieldi*** Marx and Rabb, Fieldiana Zool., P. 170, 174.

1965 ***Pseudocerastes fieldi*** Mendelssohn, Israel J. Zool., P. 203-210.

1966 ***Pseudocerastes persicus fieldi*** Minton, Bull.Am.Mus. Nat. Hist., p. 158.

1968 ***Vipera persica fieldi*** Marx, Checklist of the reptiles and amphibians of Egypt. Special Publication U.S. Naval. Med. Res. Unit Number 3, Cairo,P. 42.

1969 ***Pseudocerastes fieldi*** Mahdi and Georg, Iraq Nat. Hist. Mus. Publ., P. 33.

1971 ***Pseudocerastes fieldi*** Werner, Bull. Br. Mus. Nat. Hist. (Zool.), P. 155.

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1980 ***Pseudocerastes persicus fieldi*** Groombridge, Ph.D. Thesis, P.50.

1980 ***Pseudocerastes persicus fieldi*** Moore, Poisonous Snakes of the world, P. 111.

1982 ***Pseudocerastes fieldi*** Werner, In: Herpetological communities: A symp. Soc. Stud. Amph. Rept. Herpetologists league. Wildlife Research Report 13., P. 155-158.

1983 ***Pseudocerastes persicus fieldi*** Disi, Dirasat, P. 174-176.

1983 ***Pseudocerastes persicus fieldi*** Amr and Amr, The Snake, P. 81.

1984 ***Pseudocerastes persicus fieldi*** Joger, the Venomous Snakes of the Near and Middle East, Dr. Ludwig Reichert Velag Wisbaden, P. 50.

1987 ***Pseudocerastes persicus fieldi*** Arnold, Pro. Symp. Fauna and Zoo. Geog. Middle. East, Mainz, Beihefte Zum TAVO, Wisbaden, P. 249.

1987 ***Pseudocerastes persicus fieldi*** Disi, Pro. Symp. Fauna and Zoo Geog. Middle. East, Mainz, Beihefte Zum TAVO, Weisbaden, P. 301.

1987 ***Pseudocerastes persicus fieldi*** Werner, Pro. Symp. Fauna and Zoo.Middle. East, Mainz, Beihefte Zum TAVO, Weisbaden, P. 284.

1988 ***Pseudocerastes persicus fieldi*** Disi *et al.*, The snake, P. 49.

1988 ***Pseudocerastes persicus fieldi*** Disi *et al.*, The snake, P. 146.

1988 ***Pseudocerastes persicus fieldi*** Gasperetti, Fauna of Saudi Arabia, P. 352.

1990 ***Pseudocerastes fieldi*** Kochva, Venomous snakes of Israel , P. 315.

1990 ***Pseudocerastes persicus fieldi*** Disi, Venomous snakes in Jordan , P. 366.

1992 ***Pseudocerastes persicus fieldi*** Leviton *et al.*, Society for the Study of Amphibian and Reptiles, U.S.A, P. 115.

1993 ***Pseudocerastes persicus fieldi*** Golaly *et al.*, Herpetological Data center. Switzerland. P. 277.

1994 ***Pseudocerastes persicus fieldi*** Amr *et al.*, The Snake, P.47.

1994 ***Pseudocerastes persicus fieldi*** El-Oran *et al*., Boll. Zool., P. 364.

1994 ***Pseudocerastes persicus fieldi*** Moravec and Modry, Zool. Middle East,P. 53-55

1995 ***Pseudocerastes persicus fieldi*** Amr and Al-Oran, The Snake of Jordan. Publication of Deanship of Academic Research . Mutah University, Karak. P. 63, (in Arabic).

1995 ***Pseudocerastes persicus fieldi*** Ashafee , The Snakes of Jordan. Publication of El - Yarmouk University , Irbid , P. 25-26, (in Arabic).

1996 ***Pseudocerastes persicus fieldi*** Disi, Herpetozoa, P. 79.

1996 ***Pseudocerastes persicus fieldi*** Disi and Bohme, Herpetozoa, P. 68.

1998 ***Pseudocerastes fieldi*** Kochva , Public Health Rev., P.210.

4.2 Morphological Study

4.2.1 Color Pattern

The dorsal surface of the false-horned viper is yellowish- gray with two rows of light brown rectangular blotches, each row contains twenty eight to thirty five blotches along the whole body. Opposite blotches anteriorly and precaudally fuse to form brown crossbands. Also, on each side of the body is a row of smaller and more blotches, of the same color as

the dorsal blotches and arranged alternating to them. The ventral surface of the body is white or straw in color with fine dark dotes in some places. In adults, almost half of the studied male samples have a black tail tip, and sharply distinct from the rest of the body. The three female samples as well as the juvenile samples lack this black pigment. (table 3), (figs 5,6&7). In general, the studied specimens have almost similar color except when tail tip is considered.

4.2.2 Description of Type

The head is very broad with more width than height in all studied samples. Actually the head length, width and height are more in juveniles than in adults in comparison to snout vent length (table 4).The upper head scales are small, imbricate and keeled. Above each eye a horn like structure is present, which is composed of a number of imbricated scales, found in all samples, adult males and females as well as in juveniles. Around the eyes 15-17 scales, two series of scales between the eye and the upper labials, 12 or 13 upper labials, and 14-16 lower labials are present in all studied specimens.

Dorsal scales are keeled with 21 or 22 mid dorsal rows. Ventral scales range from 131 – 135, they are smooth, with no sharp angulation or

Table 3 Tail and body brown blotches measurements of

Pseudocerastes persicus fieldi

Specimen no.	Collection time	Locality	Sex	BT cm	T cm	BB
JUM 975	31.8.1982	Karak	J	A	3.34	—
JUM 324	198?	Eastern desert	J	A	3.01	—
JUM 350	198?	Eastern desert	J	A	4.43	—
JUM 543	1980	Jafer	J	A	4.94	—
JUM 1986	1991	Ennab, Jafer	♂	1.7	6.6	28
JUM 2089	1982-83	Shaumari	♂	1.0	7.31	29
JUM 1993	3.10.1991	Al-Hazeam	♂	1.5	9.6	35
JUM 436	1980	Shumari,Azraq	♂	1.8	6.57	N.A
JNHM 1171	18.6.1998	Azraq	♂	2.8	9.2	28
JUM 1706	10.1986	Qasr El-Halabat	♂	A	6.0	33
JUM 2093	1982-83	Shaumari	♂	A	8.37	28
JUM 2283	1997	Eastern desert	♂	A	7.63	30
JNHM 814	7.6.1988	Azraq	♂	A	7.5	31
JUM 928	1.7.1982	Jawa	♂	A	9.0	32
JUM 2514	11.1997	Jawa	♀	A	5.5	32
JUM 2230	6.1998	Shaumari	♀	A	7.0	33
JUM 689	9.7.1978	Shaumari	♀	A	6.5	31

J, Juvenile; BT, Black Tip; T,Tail length; BB,Brown blotches number

A, Absent; N.A, not available.

A.

B.

Fig. 5 ***Pseudocerastes persicus fieldi***

A. Dorsal view, B. Ventral view

A.

B.

Fig. 6. Head of *Pseudocerastes persicus fieldi*

A. Dorsal view, B. Ventral view

Fig. 7. Tail Tip of *Pseudocerastes persicus fieldi*

From right to left: male without black tip, male with black tip and female without black tip.

Table 4 Head Measurements of *Pseudocerastes persicus fieldi*

No.	Sex	SVL(mm)	HL(mm)	HL/SVL (%)	HW(mm)	HW/SVL (%)	HH(mm)	HH/SVL (%)
JUM 975	J	235	19.6	8.34	12.4	5.28	7.8	3.32
JUM 324	J	205	16.2	7.90	11.8	5.76	6.2	3.02
JUM 350	J	282	20.0	7.09	13.0	4.61	7.0	3.52
JUM 543	J	300	19.8	6.60	13.8	4.60	9.0	3.00
JUM 1986	♂	465	30.5	6.56	20.7	4.45	12.3	2.64
JUM 928	♂	660	32.6	4.94	26.0	3.94	16.6	2.51
JUM 1993	♂	780	43.6	5.59	34.1	4.37	18.9	2.42
JUM 436	♂	505	29.6	5.86	22.5	4.45	12.2	2.42
JUM 2093	♂	610	34.1	5.59	27.2	4.46	16.0	2.62
JUM 1706	♂	520	30.0	5.77	23.8	4.58	13.5	2.60
JUM 2089	♂	510	32.3	6.33	22.2	4.35	14.6	2.86
JUM 2283	♂	550	36.6	6.65	24.2	4.40	15.7	2.85
JUM 2514	♀	445	27.5	6.18	20.4	4.58	10.8	2.43
JUM 2230	♀	565	32.4	5.73	24.2	4.28	12.6	2.23
JUM 689	♀	490	29.8	6.08	18.4	3.75	9.5	1.94

HH, Head Height; HL, Head Length; HW, Head Width; J, Juvenile; SVL, Snout – Vent Length.

keeled. Anal scale is entire, subcaudals range from 33 – 38 and are divided (table 5).

4.2.3 Measurements

Total lengths of juvenile and adult samples as well as tail lengths are summarized in table 5. But the maximum length of juvenile samples was 349.4mm and of adults were 876mm. The mean ratio of tail length to total length was 0.13 for juveniles and 0.11 for adults with no marked difference between males and females (table 5).

4.3 Anatomical Study

4.3.1 Head Skeleton

4.3.1.1 The Cranial Skull and the Upper Jaw Elements

The cranium of ***Pseudocerastes persicus fieldi*** is an oblong box. On the upper side, it is flat, nearly rectangular and broadened rostrally. The lateroventral surface of the cranium is formed of four parts: The orbit from inside, semicircular canals from outside, a crest on the ventromedian and the rest is formed of the cerebral capsule bony wall.

The lateral part of the roof of the skull near the eye is concaved ventrally and also forms the dorsal ridge of the orbit. Close to the orbit and in front of it, there is a small process of the frontal bone with which the

Table 5 Pholidosis and measurements for ***Pseudocerastes persicus fieldi***

Specimen number	Collecting date	Locality	Sex	MDS	VS	SCS	UL	L	ES	SVL (mm)	T (mm)	TO (mm)	T/TO
JUM 975	31.8.82	Karak	J	21	132	36	12/12	14/14	16/17	235	33.4	268.4	.12
JUM 324	198?	Eastern desert	J	22	134	33	12/12	14/15	16/16	205	30.1	235.1	.13
JUM 350	198?	Eastern desert	J	22	133	37	12/12	15/16	16/16	282	44.3	326.3	.14
JUM 543	1980	Jafar	J	22	132	37	12/12	15/15	15/15	300	49.4	349.4	.14
JUM 1986	1991	Ennab, Jafer	♂	21	131	37	12/12	15/15	16/16	465	66.0	531.0	.12
JUM 928	1.7.1982	Jawa	♂	21	134	35	12/12	15/15	15/16	660	90.0	750.0	.12
JUM 1993	3.10.91	Al-Hazeam	♂	22	132	34	12/12	16/16	15/16	780	96.0	876.0	.11
JUM 436	1980	Shaumari, Azraq	♂	21	134	38	13/13	16/16	16/16	505	65.7	570.7	.11
JUM 1706	10.1986	Qasr El-Halabat	♂	21	132	34	12/12	14/15	16/16	520	60.0	580.0	.10
JUM 2089	1982-83	Shaumari	♂	21	133	37	12/12	15/15	16/16	510	73.1	583.1	.12
JUM 2283	1997	Eastern desert	♂	21	135	36	12/13	16/16	16/17	550	76.3	626.3	.12
JUM 2514	11.1997	Jawa	♀	22	131	33	12/12	15/15	16/17	445	55.0	500.0	.11
JUM 2230	6.1998	Shaumari	♀	22	132	34	12/12	15/15	16/16	565	70.0	635.0	.11
JUM 689	9.7.78	Shaumari	♀	21	133	33	13/13	16/16	15/15	490	65.0	555.0	.12

MDS,Mid dorsal scale; VS,Ventral scale; SCS,Subcaudal scales; UL,Upper labials; LL,Lower labials; ES, Eye scales; SVL, Snout-vent length; T,Tail length; TO,Total length

prefrontal bone is articulated. The caudal border of the orbit is formed by the postfrontal and frontal bones which both form together the postorbitalis. The prefrontals are flat, nearly square pair of bones, they are dorsally triangular bones that form the rostral border of the orbit. The reduced descending two prefrontal bones articulate with the vomer. The paired frontals appear rectangular, articulate dorsocaudally with the parietal bone, rostrally with the prefrontals and laterally with the postfrontals. The parietal is an unpaired rectangular bone, its dorsal plate articulates with the supraoccipital caudally, the frontal rostrally and the postfrontal rostrolaterally.

The caudal part of the roof is as wide as the part in the orbital region, although the most caudal part of the skull narrows strongly in the dorsal plane. The supratemporal bone articulates with the rostrolateral portion of the quadrate bone. It is a rectangular bone partially incorporated into the wall of the brain case and projects beyond the occipital bones. The quadrate bone is a relatively long, broadened and slightly curved bone at its rostral part. It articulates caudally with the compound bone (lower jaw).

The medial wall of the ethmoidal capsule consists of a bony septum from which the pointed-shaped premaxillary bone extends, caudally it articulates with the vomer and the septomaxilla bones. No articulation is

present between the premaxilla and the maxilla bones. The nasals bones are broad and elongated. Caudally, they suture with the frontal bones, ventrolaterally with the septomaxilla and caudolaterally they suture with the prefrontal bones. Rostrally, the nasals are reduced in size and approach the lateral premaxillary process giving the snout enough structural rigidity. The septomaxilla is a triangular shaped bone, together with the vomer they form the ventral bottom of the ethmoidal capsule, it is sutured caudolaterally with the maxilla and rostrally with the premaxilla.

The vomer bone articulates rostrally with the tips of the premaxilla and laterally it is sutured with the palatine bone while medially there is a narrow slit in its caudal part articulating with the parasphenoid bone. The maxilla laterally attains triangular form, at its rostral end it sutures with the prefrontal bone, the caudal part of the maxilla articulates with the rostral end of the ectopterygoid. Laterorostrally, the maxilla sutures with the septomaxilla, caudally with the vomer, and caudolaterally with the prefrontal bone.

Ectopterygoid is an oblong flat bone and broadened rostrally more than caudally. The rostral part of it is formed by an extension which is nearly triangular that fits the medial knob of the oblong articular surface of

the maxilla. The caudal end of the ectopterygoid bone bends inward and articulates with the pterygoid bone.

The pterygoid bones articulate rostrolaterally with the basisphenoid bone and rostrally with the palatine bone. The pterygoid consists of two parts, the first is a flat rod part which bears the teeth on its narrow ventral side, this part articulates with the ectopterygoid. The second caudal part is a thin winged rod devoided from teeth to which muscles are attached, it has a pointed free end that does not articulate with the quadrate bone.

The palatine bone is short, flat and slender, it is sutured rostrally to the vomer and extends caudally to articulate with the pterygoid bone. Also, the palatine sutures caudolaterally with the ectopterygoid, but no articulation occurs with the prefrontal nor with the basisphenoid bone. Palatine carries teeth on its narrow ventral surface.

The last elements of the cranium are the brain case elements. The single supraoccipital bone sutures with the caudomedial margin of the parietal bone, rostroventrally, it sutures at its both sides with each prootic bone. The caudoventral limits of the supraoccipital articulates with the exoccipital bone. Laterally, the supraoccipital does not articulate with the supratemporal bone. The exoccipital bones are fused together dorsally, they

suture the supraoccipital bone rostrodorsally, and the basioccipital bone ventrolaterally. The basioccipital has a smooth surface carrying one occipital condyle from the ventral side. The rostral margin of the basioccipital is sutured to the basisphenoid bone and the lateral margins are sutured to the exoccipital.

The prootic bone suture with the parietal bone rostrodorsomedially, with the supraoccipital bone caudodorsomedially, and with the opisthotic bone caudally. The opisthotic sutures with the prootic rostrally, with the quadrate bone caudomedially and with the supratemporal bone lateromedially. Moreover, the collumella auris is a very slender, delicate, elongate bone extending caudolaterally from the prootic, and underlying most of the length of the quadrate bone. The basisphenoid bone articulates with the pterygoid bone rostrolaterally, the basioccipital bone caudally, and the prootic dorsolaterally. It is also partly fused with the parasphenoid rostroventromedially forming together a broad floor of the brain case (figs. 8&9).

4.3.1.2 The Lower Jaw Elements

The lower jaw is formed by the articulation of the three distinguishable bones: The compound bone, this is the largest and the most caudal one, it is formed by complete fusion of four bones, the surangular,

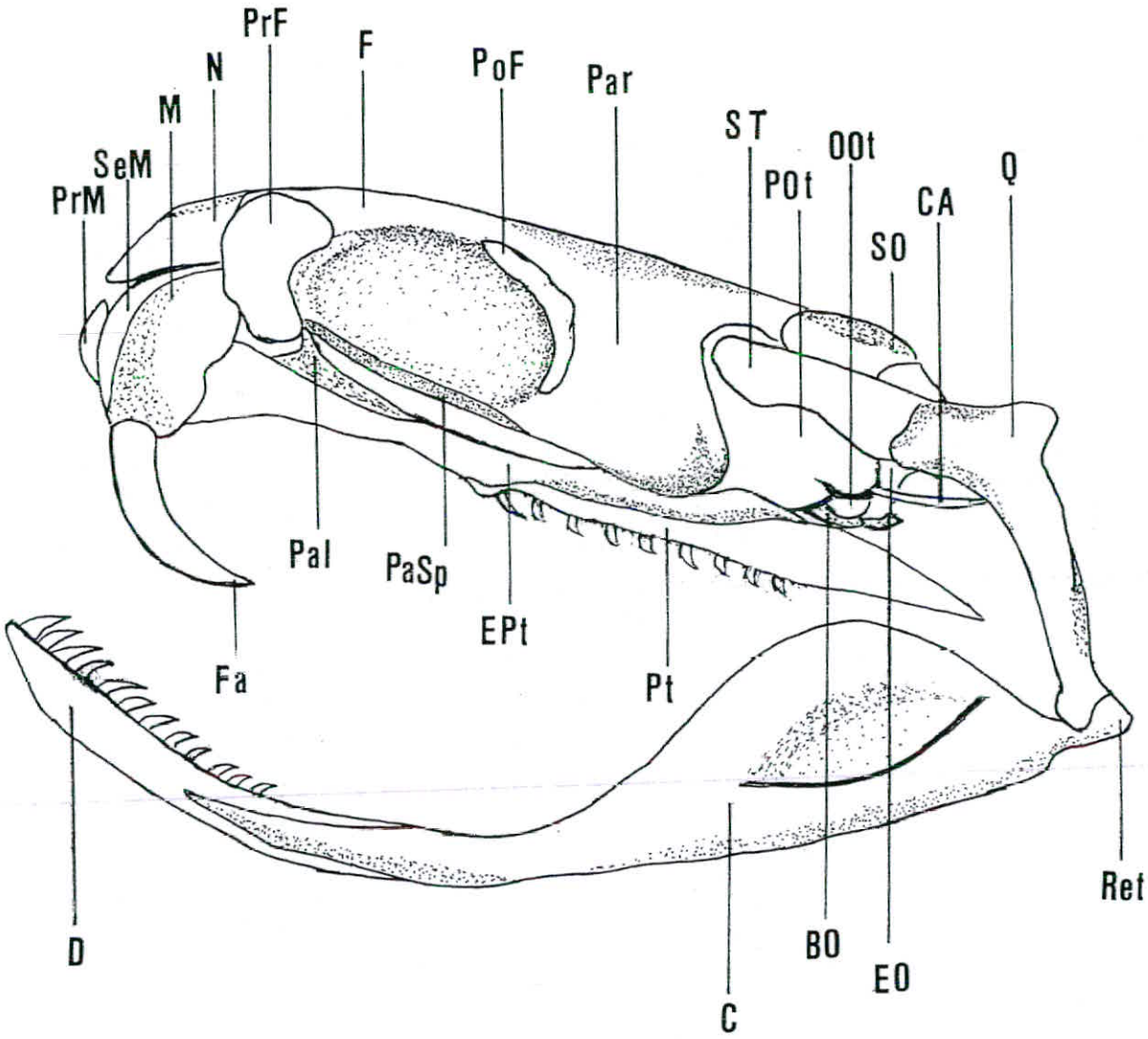


Fig. 8 Lateral view of the skull of *Pseudocerastes persicus fieldi* (x6)

BO, Basioccipital; C, Compound Bone; CA, Columella Auris; D, Dentary; EO, Exoccipital; EPt, Ectopterygoid; F, Frontal; Fa, Fang; M, Maxilla; N, Nasal; OOt, Opisthotic; Pot, Prootic; PaSp; Parasphenoid; Pal, Palatine; Par, Parietal; PoF, Postfrontal; PrF, Prefrontal; PrM, Premaxilla; Pt, Pterygoid; Q, Quadrate; Ret, Retroarticular Process; SeM, Septomaxilla; SO, Supraoccipital; ST, Supratemporal.

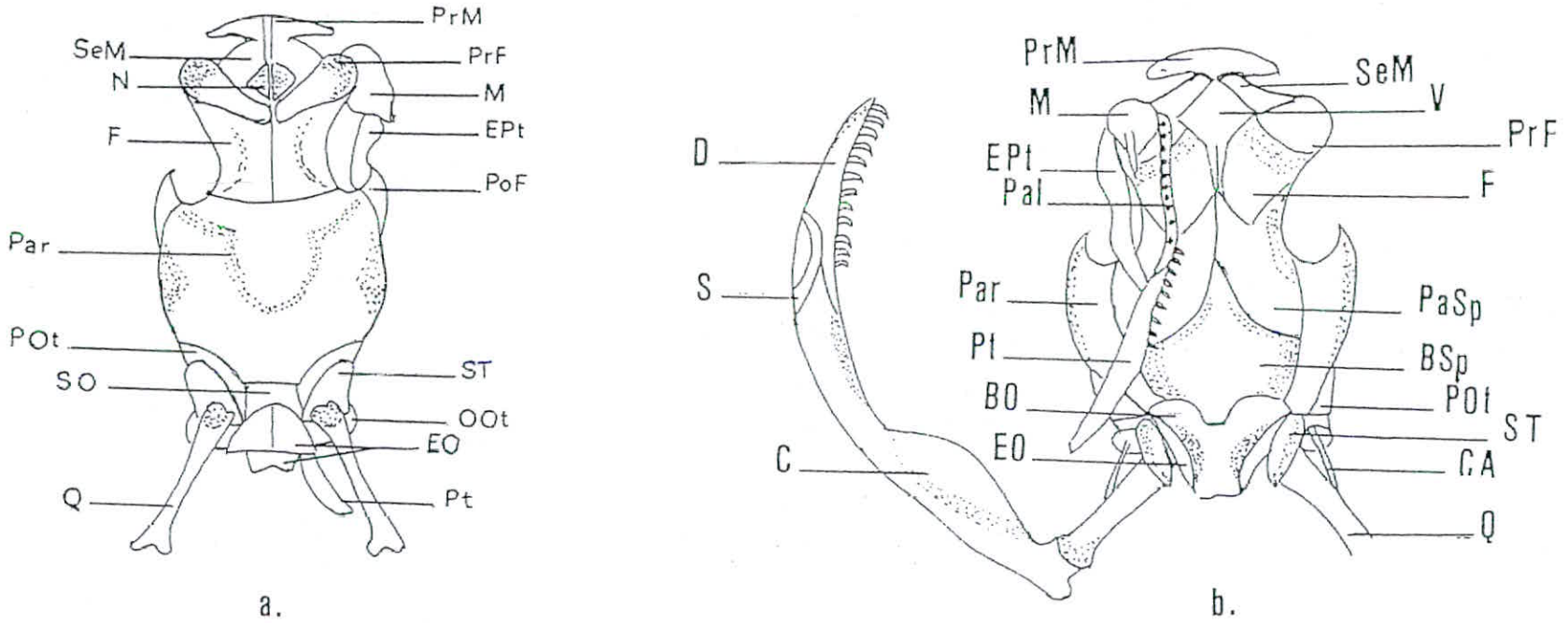


Fig. 9 a. Dorsal and b. Ventral views of the skull of *Pseudocerastes persicus fieldi* (x2.3)

BO, Basioccipital; BSp, Basiophenoid; C, Compound bone; CA, Columella Auris; D, Dentary; EO, Exoccipital; Ept, Ectopterygoid; F, Frontal; Fa, Fang; M, Maxilla; N, Nasal; OOt, Opisthotic; Pot, Prootic; PaSp, Parasphenoid; Pal, Palatine; Par, Parietal; PoF, Postfrontal; PrF, Prefrontal; PrM, Premaxilla; Pt, Pterygoid; Q, Quadrate; Ret, Retroarticular Process; SeM, Septomaxilla; SO, Supraoccipital; ST, Supratemporal; V, Vomer

the prearticular, the articular, and the angular, and appear as one bone. The dorsolateral part of the compound bone is curved, at its caudal part an oval foramen, the fossa mandibularis, is seen. This bone tends to get thinner at its rostral part where it is articulated in V-shaped end to the second bone of the lower jaw, the dentary.

The dentary bone is a rectangular bone, slightly curved upwards, it bears teeth at its dorsal part, while its ventral part is smooth. The third bone is the splenial bone. It is a small bone which extends along the lower margin of the jaw, between the compound bone and the dentary (fig 9b).

4.3.2 Dentition

The dentition of ***P.p.fieldi*** consists of a marginal row of teeth implanted on the palatine, pterygoid and dentary bones, and of a single modified tooth (fang) implanted on the maxilla. The largest-sized teeth row is found on the dentary bone, which is characterized by having (12-14) simple, elongated, recurved, sharp and pointed teeth that gradually become smaller posteriorly. These teeth have a joint of pleurodont type of implantation (fig. 10) which is achieved by the loss of the lingual wall, so that the teeth are ankylosed to the inner side of the high labial wall. The ventral surface of the palatine bears 9-11 teeth, while 8-10 teeth are implanted on the ventral surface of the pterygoid. Although, teeth on the

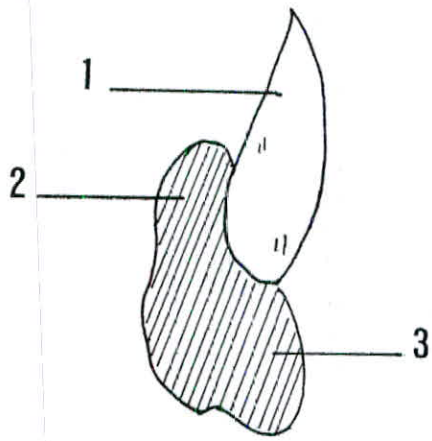


Fig.10 Pleurodont attachment method

1. Tooth, 2. Labial walls, 3. Lingual wall

palatine and pterygoid are smaller than those on the dentary but they are similar in being simple, recurved, sharp and pointed, also, by having a similar pleurodont attachment type. The teeth size of the pterygoid attain to become smaller in size posteriorly and its third caudal part is free of teeth.

The maxillary fangs are of two types: One main fang and one or two spares on each maxilla. Spare fangs are smaller than the main ones and ready to replace their loss. Both fang types are tubular, forming an enclosed channel within most of the middle of the tooth. This internal channel is open at both ends, but in between, the tooth surface folded over this channel enclosing it and forming a secondary surface folded furrow where the contributing edges of the tooth folds meet and fuse.

4.3.3 Head Muscles

4.3.3.1 The Superficial Layer of Head Musculature

(They are exposed immediately after removal of the skin) (Fig.11).

a. Compressor Glandulae (Com.)

This muscle was previously called adductor externus superficialis 1b, it is one of the largest head muscles. It originates dorsally from the upper and lateral surface of the venom gland, then curves around the dorsal third

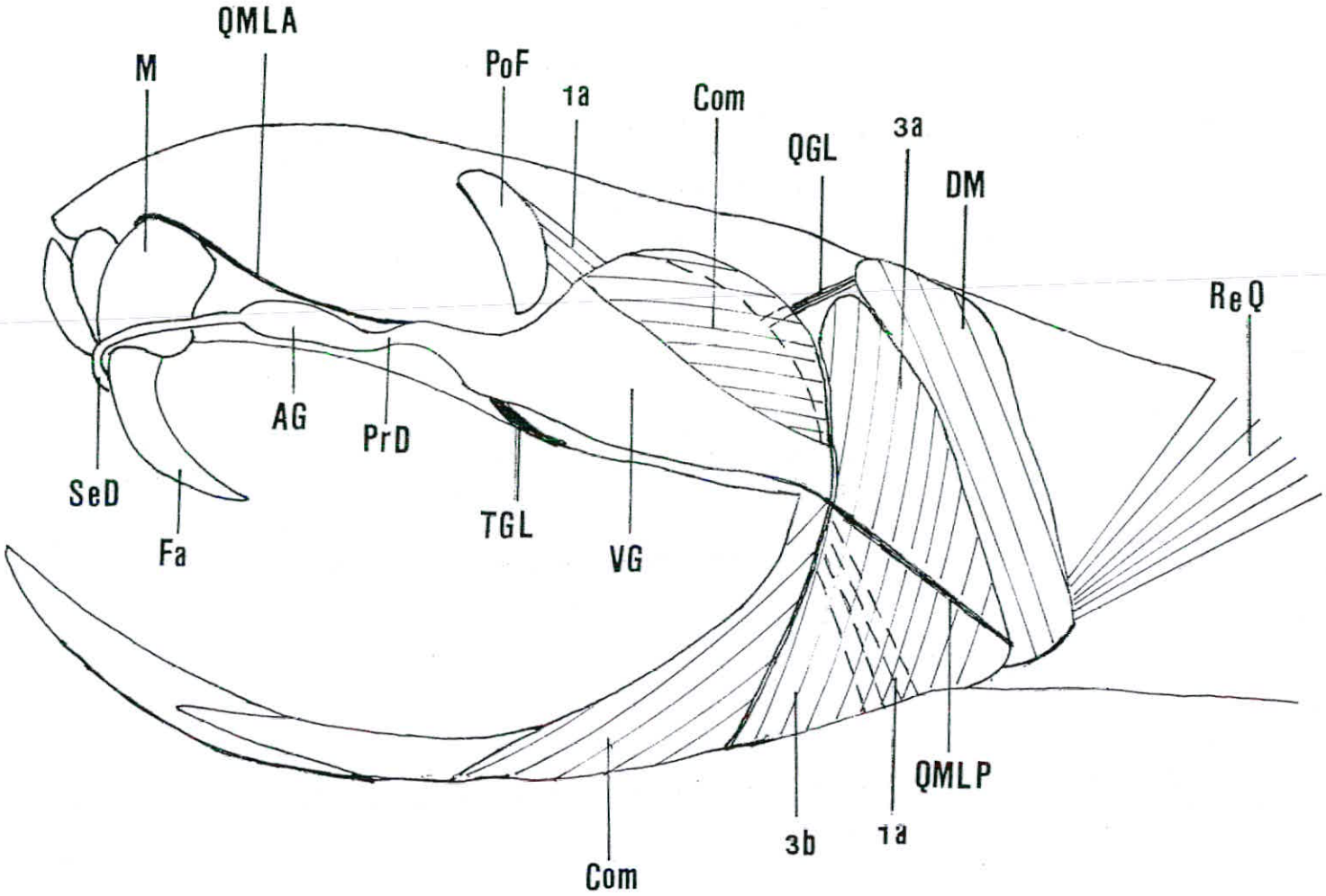


Fig. 11 Lateral view of the head muscles of *Pseudocerastes persicus fieldi* (x6).

1a, Adductor Externus superficialis; 3a, Adductor Externus Profundus Portion 3a; AG, Accessory Gland; Com, Compressor Glandulae; 3b, Adductor Externus Profundus Portion 3b; DM, Depressor Mandibulae; Fa, Fang; M, Maxilla; PrD, Primary Duct; QGL, Quadrate-Glandular Ligament; QMLA, Quadrate-Maxillar Ligament (Anterior part); QMLP, Quadrate-Maxillar Ligament (Posterior part); ReQ, Retractor Quadrati ; SeD, Secondary Duct; TGL,Transverso-Glandular Ligament; VG, Venom Gland.

and caudal surface of this gland inserted on the lateroventral side of the compound bone of the mandible.

b. Depressor Mandibulae (DM)

This muscle is closely attached to the posterior face of the quadrate bone and inserts on the retroarticular process of the mandible.

c. Adducctor Externus Profundus (3a&3b).

It lies behind the muscle compressor glandulae, adheres to and is linked with it by connective tissue. This muscle originates dorsally from the quadrato-supratemporal articulation. It descends alongside the quadrate bone and inserts in front of it on the mandible lateroventrally behind the compressor glandulae. The posterior fibers of the profundus, that originate from the quadrato-supratemporal articulation and descend straightly alongside the quadrate bone are compressed by a transverse band of connective tissue which extends from the glandular capsule towards the quadrato-mandibular articulation. This ligament divides the anterolateral face of the profundus into two parts. The upper part which is the adductor externus profundus 3a portion that originates along the whole length of the quadrate and inserts on the lateral face of the quadrato-mandibular articulation. Some of the external layer fibers of portion 3a, insert at the posterior angle of the venom gland capsule. Adductor externus profundus

portion 3b, which is the lower part of the profundus muscle that originates on the medial face of the quadrate and inserts on the medial surface of the quadrato-mandibular articulation (fig.11).

4.3.3.2 The Intermediate Layer of Head Musculature.

a. Adductor Externus Superficialis (1a).

The anterior third of this muscle originates from the dorsal side of the postfrontal bone and from the parietal bone. Its posterior part begins directly from the ridge of the parietal, then it descends obliquely downward and inward, passes through the loop of the compressor glandulae, beneath the gland and appears again on the ventrolateral side of the lower jaw (fig. 11).

b. Adductor Externus Medialis. (AM)

It originates behind the muscle adductor externus superficialis, from the parietal and from the supratemporal bones. It descends medially to the muscle adductor externus superficialis, crossing it then inserts in the mandible. Throughout its entire length, the muscle is separated from the pseudotempralis muscle which lies under it (fig.12).

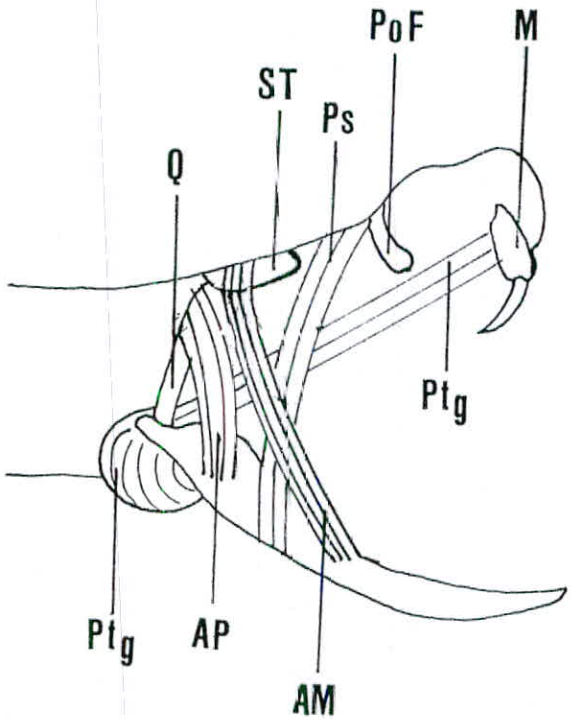


Fig.12 Lateral view of the head muscles after removal of the external layer of muscles of *Pseudocerastes persicus fieldi* (x2.3).

AM, Adductor Externus Medialis; AP, Adductor Posterior; M,Maxilla; PoF, Postfrontal; Ps, Pseudotemporalis; Ptg, Pterygoideus; Q,Quadrate; ST, Supratemporal.

c. Pseudotemporalis. (Ps)

This muscle runs nearly parallel with the muscle adductor externus superficialis but more deeper. It crosses the adductor medialis and the pterygoideus muscle . Ventrally this muscle inserts on the mandible behind the muscle adductor externus medialis while it originates from the base of the postorbitalis on the parietal and postfrontal bones posterior to the muscle compressor glandulae (fig.12).

d. Pterygoideus (Ptg)

This is considered to be one of the deep layers of head musculature, in spite of the fact, that its insertion is seen at the base of the mandible beneath the skin. It is a strong bipartite muscle originates by two slips, the deep fibers arising from the dorsal surface of the ectopterygoid and the other part originates externally from the posteroventral extremity of the maxilla after passing over the ectopterygo-maxillary articulation (fig.12). The muscle inserts by means of aponeurosis on the ventral side of the angle of the mandible, the retroarticular process, and partly on the pterygoid. The muscle turns downward and internally then disappears from the surface, passing along the upper lip, beneath the venom gland, inserted into the maxilla. Also, pterygoideus has two aponeuroses, one of them is connected with the capsule of the venom gland on its ventral side, while the other aponeurosis is linked to the sheath of the fang (fig.13).

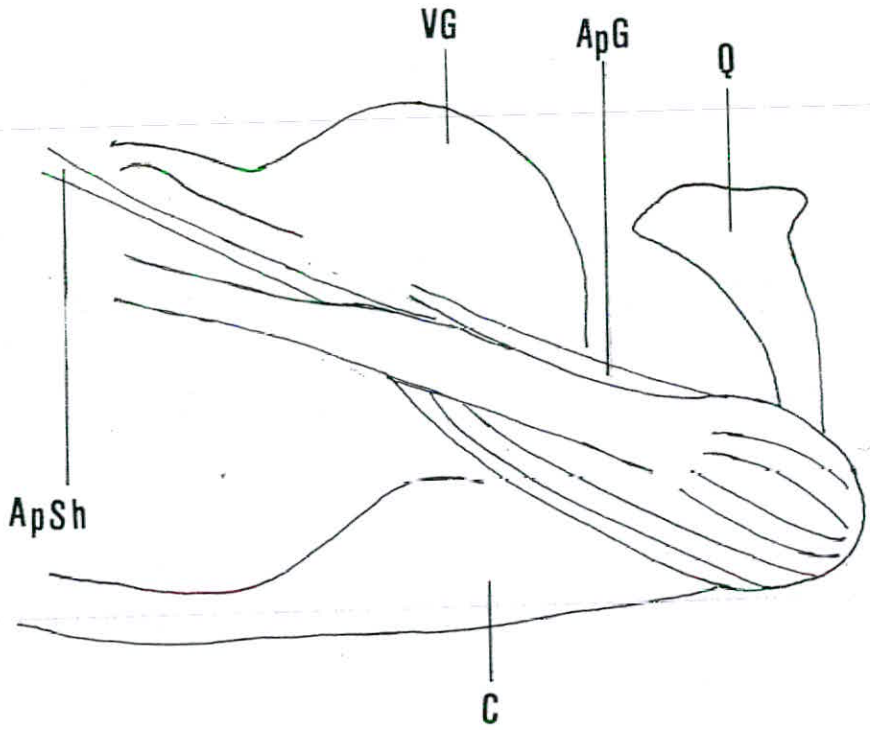


Fig. 13 Muscle Pterygoideus of *Pseudocerastes persicus fieldi* (ventral view)(x6).

ApG, Aponeurosis to the Venom Gland; ApSh, Aponeurosis to the Sheeth of the Fang; Q, Quadrate; VG, Venom Gland.

e. Adductor Posterior. (AP)

It forms the deepest part of the intermediate layer of head muscles. It lies beneath the adductor externus profundus muscle, originates dorsally from the quadrate bone and inserts in the fossa mandibularis (fig.12).

4.3.3.3 The Deep Layer of Head Musculature

Five deep muscles are distinguished after the removal of the outer and the intermediate muscle layers (fig.14). These muscles are:

a. Levator Pterygoidei. (Lev.)

This muscle originates postorbitally from the parasphenoid bone, and inserts on the anterior part of the dorsal surface of the pterygoid bone.

b. Protractor Pterygoidei. (PrP)

This muscle arises from the ventral part of the basicranium between the paraspheniod and basisphenoid bones and inserts on the dorsal surface of pterygoid bone.

c. Retractor Pterygoidei. (ReP)

This muscle originates on the ventral surface of the parietal bone. Its anterior part inserts on the anterior quarter of the pterygoid and the palatine bones.

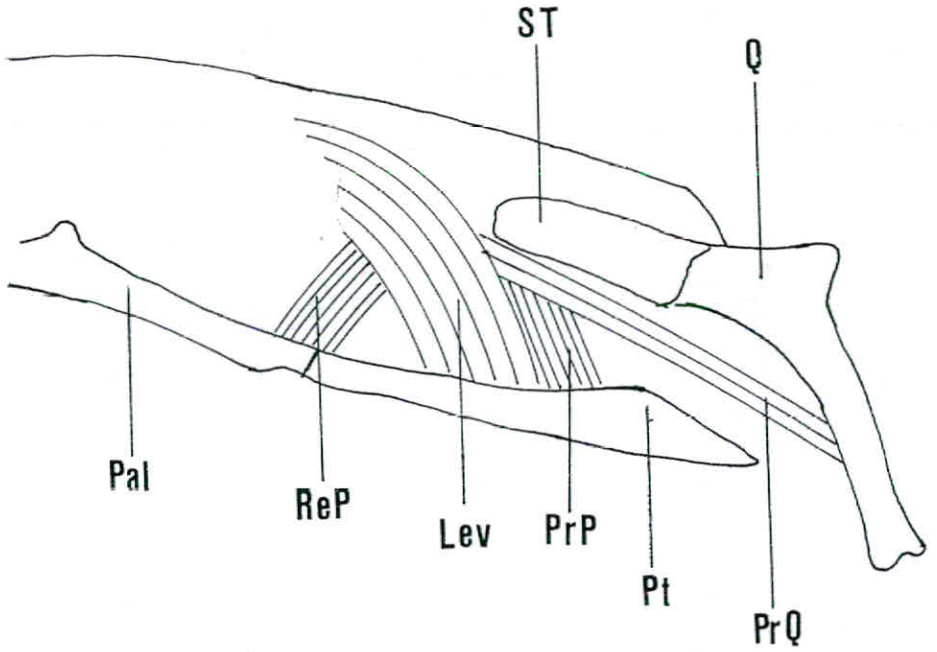


Fig. 14 The internal layer of head muscles of *Pseudocerastes persicus fieldi* (Lateral view)(x6)

Lev, Levator Pterygoidei; Pal Palatine; PrP, Protractor Pterygoidei; PrQ, Protractor Quadrati; Pt, Pterygoid; ReP, Retractor Pterygoidei; ST, Supratemporal.

d. Retractor Vomeris (ReV)

It originates from the vomer bone ventrolaterally. It insertes on the most caudal part of the orbital crest,which resembles the lateral edge of the parasphenoid bone.

e. Protractor Quadrati. (PrQ)

This muscle arises anteriorly from the sphenoid bone, it runs backward to its insertion on the ventral surface of the quadrate bone.

4.3.3.4 Other Muscles Associated with the Jaws

a. Retractor Quadrati. (ReV)

It is a distinct muscle which appears immediately after the removal of the head skin. This muscle originates as a fan-shaped structure from the neck region at the level of the 5^{th} – 6^{th} vertebrae. It narrows near its insertion on the quadrato-mandibular articulation crossing the muscle depressor mandibulae (fig.11).

b. Neuro-Costo-Mandibularis. (NCM)

This muscle is characterized by being subdivided into a widely separated lateral pair of muscles and a medial pair of muscles. The lateral portion of the muscle originates from the ventral side of the vertebral column. At its anterior part it runs along the ventral end of the dentary

bone. The medial pair of the muscle neuro-costo-mandibularis originate from the ribs, run anteriorly along the hyoid and insert rostrally on the dentary bone (fig.15).

c. Constrictor Ventralis. (IMA & IMP)

This muscle is divided into two parts, intermandibularis anterior and posterior. Although both originate from the ventral end of the dentary bone between the two parts of the muscle neuro-costo-mandibularis, their insertion points differ. The posterior portion is inserted at the ventromedial part of the muscle pterygoideus, but the anterior portion inserts on the medial part near the trachea at the same level of the caudal end of the pterygoideus muscle (fig.15).

d. Intermaxillaris. (I Max)

It is an anteroventromedial muscle, it is very small compared to the other intermandibular muscles previously described. The pair of this muscle overlap at the medial part, they are surrounded by the posterior pair of the muscle intermandibularis (fig.15).

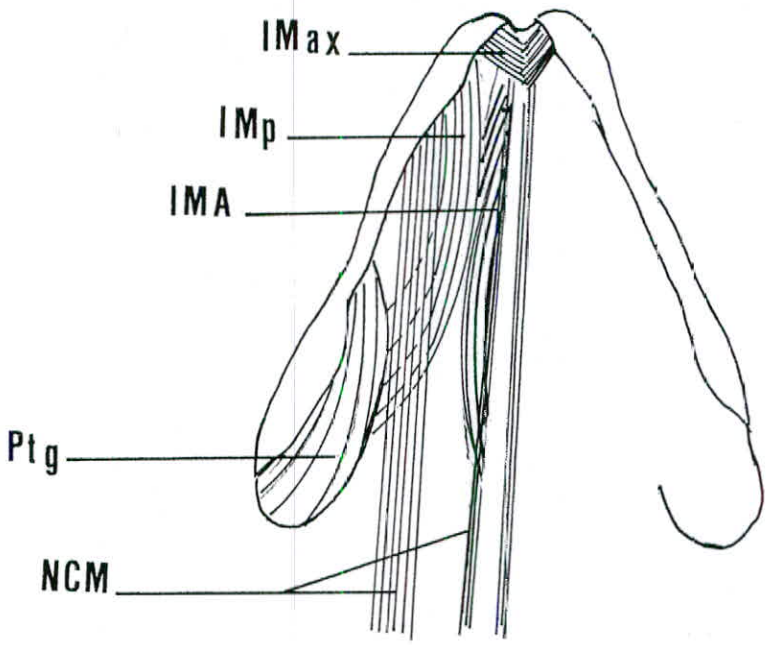


Fig.15 Ventral view of the intermandibular muscles (x2.3).

IMA, Intermandibularis Anterior; IMP, Intermandibularis Posterior; IMax, Intermaxillaris; NCM, Neuro- Costo- Mandibularis; Ptg, Pterygoideus;

4.3.4 Venom Gland

The venom gland has almost a triangular shape and attains a length of 1-1.2 cm. It occupies most of the lateral side of the head and extends posteriorly towards the corner of the mouth. A thick capsule of a connective tissue covers the gland to which ligaments and muscles are attached (fig.11).

Three muscles are associated with the venom gland, two of them have direct attachment, while the third is indirectly associated with it. Its posterior third is covered by the muscle compressor glandulae which originates from the glands capsule. The anterior superficial fibers of the muscle adductor externus profundus are interrupted by the posterior angle of the gland. One aponeurosis of the complex muscle pterygoideus attaches to the gland capsule in the region of the primary duct.

Three ligaments are associated with the venom gland. The quadrato-maxillar ligament which have two parts, the posterior one connects the posteroventral portion of the venom gland, and extends from its capsule to the quadrto-mandibular articulation. This part separates the muscle adductor externus profundus into its two portions, 3a and 3b. The anterior portion of the quadrato-maxillar ligament originates from the connective tissue on the lateral surface of a region between postfrontal and

prefrontal bones. Then, it passes anteroventrally to the eye and dorsolaterally to the maxilla, connecting finally to the anterolateral surface of this bone. The second ligament is the quadrato-glandular ligament which connects the posteriomedial surface of the venom gland capsule to the quadrato-supratemporal articulation. The transverso-glandular ligament connects the ventral aspect of the gland to the ectopterygoid.

The venom gland is subdivided into four parts. The major part of the gland is the main venom gland which occupies the posterior region. It is formed of tubules that open into the second part which is the primary duct that proceeds anteriorly forming a loop in the suborbital area and enters the third, oval-shaped part, that is the accessory gland. Finally, the anteroventral part of the accessory gland and the primary duct reach the secondary duct which passes ventrally and posteriorly and opens into the sheath of the fang opposite the proximal opening of the fang canal. The fang sheath where the secondary duct opens forms a V-shaped duct when the fangs are folded into resting position. The branches of the V-shaped sheath pass towards both the functional and the replacement fang (fig.11).

4.3.5 Vertebral Column

4.3.5.1 Atlas – Axis Complex

It is impossible to recognize a cervical region in a strict sense. Only the first two vertebrae, owing to the role they play in the occipito-vertebral articulation may be distinguished from the rest of the precloacal part of the vertebral column.

The atlas consists of three pieces, the two halves of a neural arches, which are connected together medially by a transverse ligament and inferiorly by a ventral ligament, and the intercentrum (fig.16). There are no prezygapophysis nor postzygapophysial facets for articulation with the neural arch of axis.

The axis is a composite vertebra consisting of the second neural arch, the first centrum, the second centrum bearing a posterior condyle, and a single hypapophysis. The first centrum is separated from the centrum of the atlas and fused to the second vertebra, the axis, forming what is known as the odontoid process. The hypapophysis is formed from the third intercentrum which is fused under the posterior part of the proper centrum of the axis. Although the axis lack prezygapophyses but it contains postzygapophyses which articulate with the prezygapophyses of the third

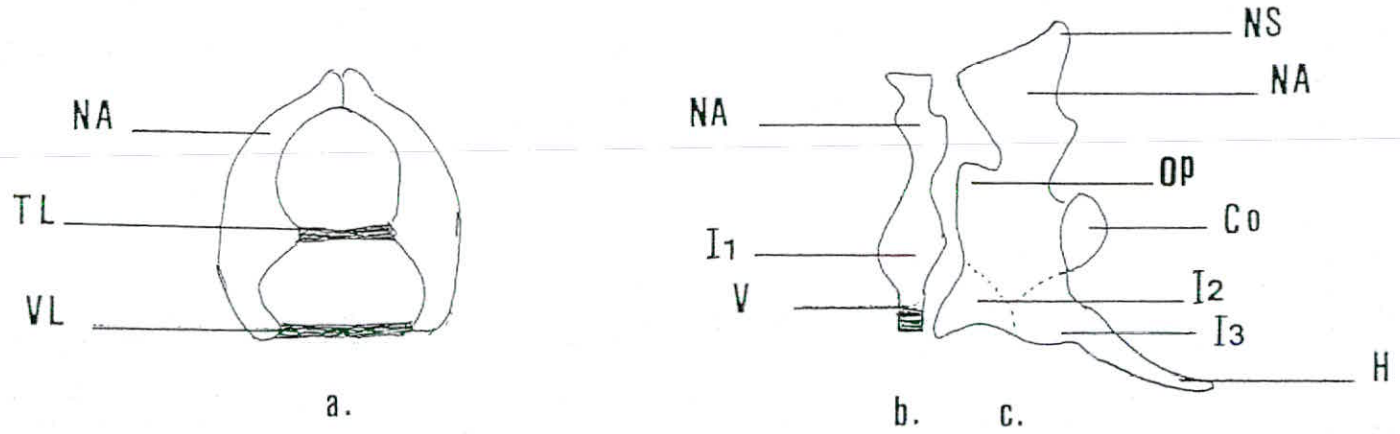


Fig. 16 a. Anterior view of atlas, b. lateral view of atlas and c. lateral view of axis of *Pseudocerastes persicus fieldi*(x10)

Co, Condyle; H, Hypapophysis; I (1,2,3), Intercentrum, NA, Neural Arch; NS, Neural spine; OP, Odontoid process; TL, Transverse Ligament; VL, Ventral Ligament

vertebra. (fig.16b). The third vertebra has the same structure of trunk vertebrae but only its size is smaller even from the cloacal ones (fig 17).

4.3.5.2 Trunk and Cloacal Regions

Vertebral morphology does not vary along the trunk. The neural arch and the centrum are intimately fused, and the centrum is procoelous. The centrum, inscribed in a conical frustrum, it bears a large anterior cotyle (fig.18b). The cotyle has a depression to receive the convex surface of the posterior condyle (fig.18a) of the successive vertebra forming together a ball-and-socket type of articular joint. This type of articulation is established between successive centra along the whole vertebral column.

The ventral surface of the centrum is limited on both sides by a clear crest, the margo ventralis. The hypapophysis rises from the posterior part of the centra at the midventral line (fig.18c). The neural arch consists of tectum (roof) and descending parts (walls). The margo lateralis crest joins the zygopophysial wings (postzygapophysis and prezygapophysis) forming the boundary of the neural arch parts (fig.18c) at the end of each prezygapophysis there is a pronounced process called the prezygapophysial process.

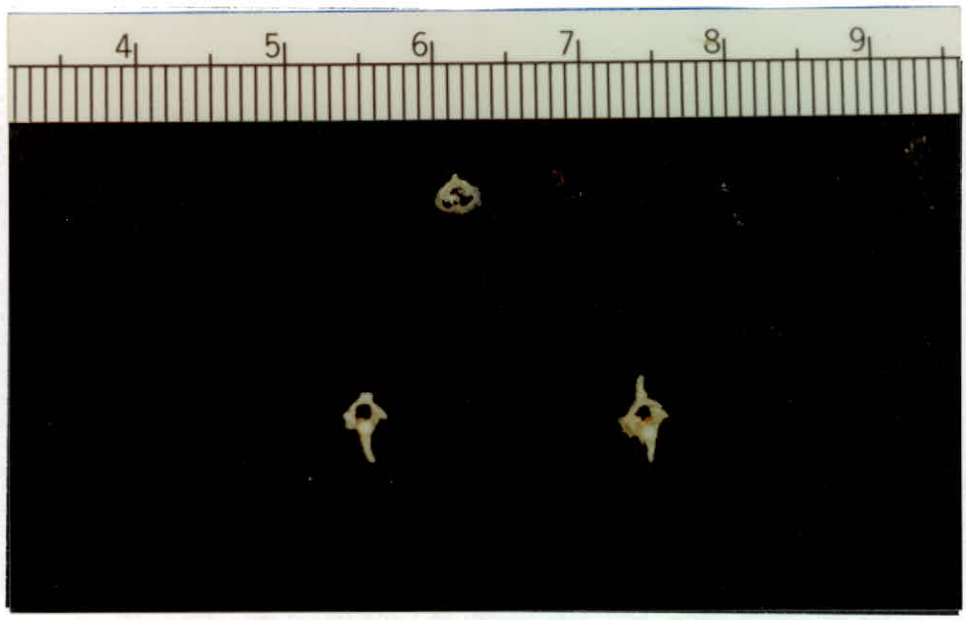


Fig.17 Atlas – axis complex

Posterior view of the (upper), Atlas, (lower left), Axis and (lower right) third vertebra

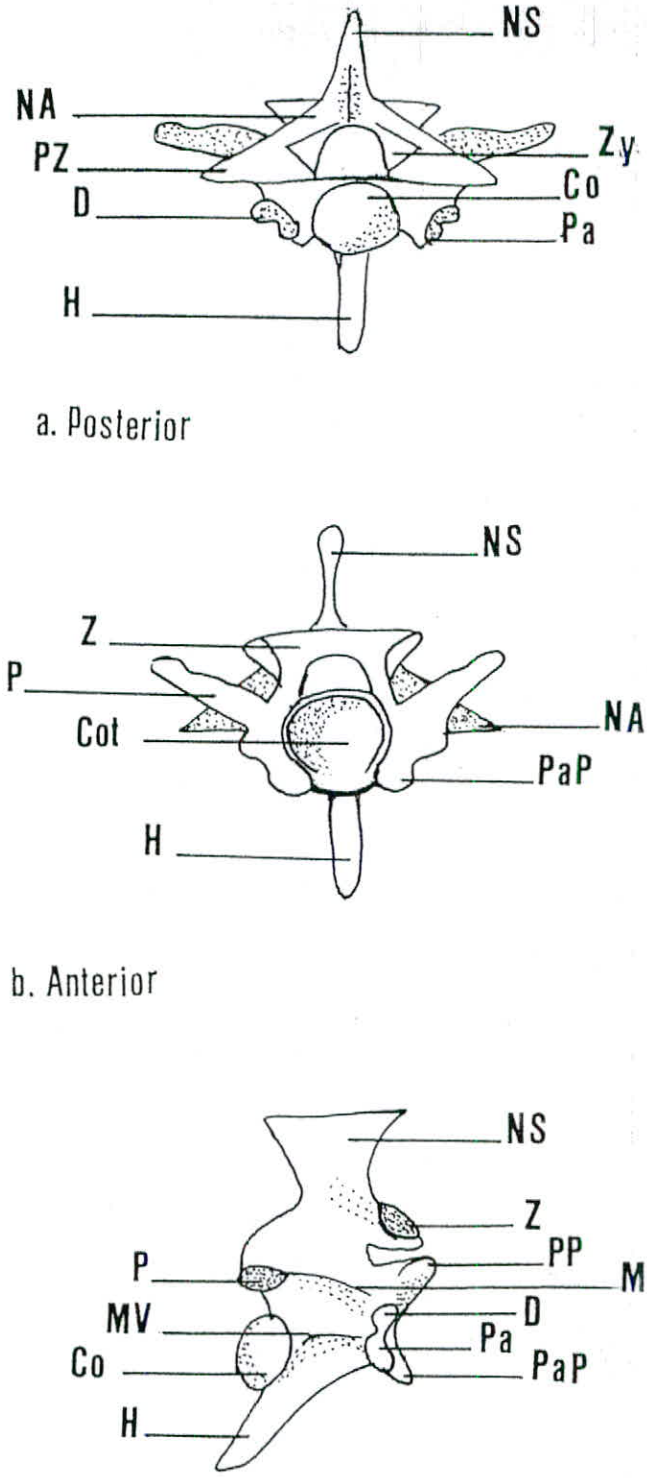


Fig. 18 Morphological features of a trunk vertebra in *Pseudocerastes persicus fieldi* (x5)

Co, Condyle; Cot, Cotyle; D. Diapophysis; H, Hypapophysis; ML, Margo Lateralis; MV, Margo Ventralis; NA, Neural Arch; NS, Neural Spine; P, Prezygapophysis; Pa, Parapophysis; PaP, Parapophysial Process PP, Prezygapophysial Process; PZ, Postzygapophysis; Z, Zygosphene; Zy, Zygantrum.

The zygosphene is located at the anterior end of the neural arch, while the zygantrum is at the posterior end. Both together, zygosphene and zygantrum, articulate along the whole trunk and cloacal vertebrae.

The unifacet rib articulates ventral to the prezygapophysis on a facet clearly divided into a posterodorsally convex area, the diapophysis, and an anteroventral surface which is slightly concave, the parapophysis (fig.18b). The atlas, axis and the third vertebra do not bear ribs, ribs only start to articulate with the fourth vertebra of the vertebral column and continued on the whole trunk and cloacal vertebrae.

The variation between trunk and cloacal vertebrae is limited. It is represented only by the difference in size by which the cloacal vertebrae are smaller than the trunk ones (fig 19).

4.3.6 Male Reproductive System

The position of the gonads shows a certain asymmetry. The paired testes lie in the posterior part of the abdominal cavity in front of the kidneys. The right testis lies at the level where the small intestine straightens out after its convolutions, and it lies anterior to the left one. They are an elongated creamy and non lobulated organs, the right testis is longer in length and less in width than the left testis in the examined

Fig. 19 The Vertebrae of *Pseudocerastes persicus fieldi*

From right to left: Atlas (Top), axis (Lower Left) and third vertebrae(Lower Right); In the middle are the cloacal vertebrae anterior view (Top Left), posterior view (Top right), Lateral view (Low); trunk vertebrae anterior view (Top left), posterior view (Top right), Lateral view.

specimens (table 6). At the dorsomedial surface of the testes lie a narrow, yellow, band-shaped epididymes. The epididymis leads into the proximally long, slender, convoluted tube which is the vas deferens. The two ducts extend at the lateral sides of the right and left kidneys and straight posteriorly. Caudally, it accompanies with the ureter to form the common channel which opens in the urodaeum in the cloaca (fig. 20).

The hemipenes are present in the tail region that start directly posterior to the cloaca, located at the upper third of the tail. Each hemipenis has bifurcate sulcus on the bilobed organ, the two forks of sulcus meet at the base of the hemipenis. It has four rows of large spines forming the macroornamentations. Also, the hemipenis is covered with small spines that become smaller at the tip of the hemipenis, these spines are called microornamentations (fig. 21).

Table 6 Testes Measurements of the *Pseudocerastes persicus fieldi*

Specimen no.	SVL(mm)	Left Testis (mm)			Right Testis (mm)		
		L	W	D	L	W	D
JUM 928	660	34	8.2	480	56	5.1	450
JUM 2093	610	22	6.1	450	30	4.6	425
JUM 2089	510	20	6.8	410	30	4.8	350
JUM 2283	550	25	4.9	406	39	3.5	380
JUM 814	490	18	5.3	395	27	4.1	360

L: Length of testis

W: Greatest width of testis

D: The distance from the snout to the anterior tip of the testis

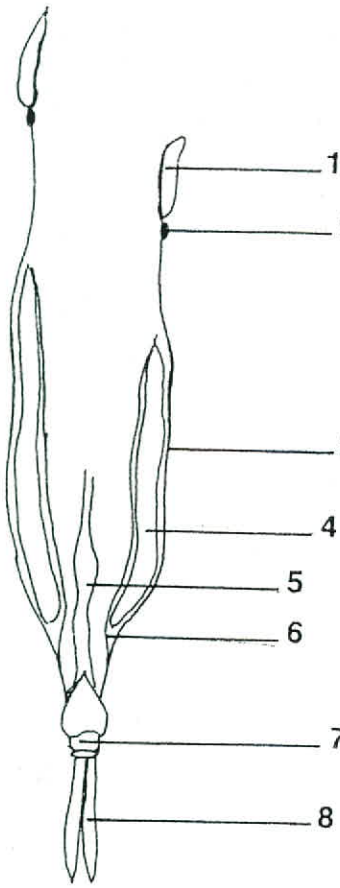


Fig. 20 The male reproductive system of *Pseudocerastes persicus fieldi* .

1. Testis, 2. Adrenal gland, 3. Vas deferens, 4. Kidney,

5. Rectum, 6.Ureter, 7. Cloaca, 8. Hemipenis.

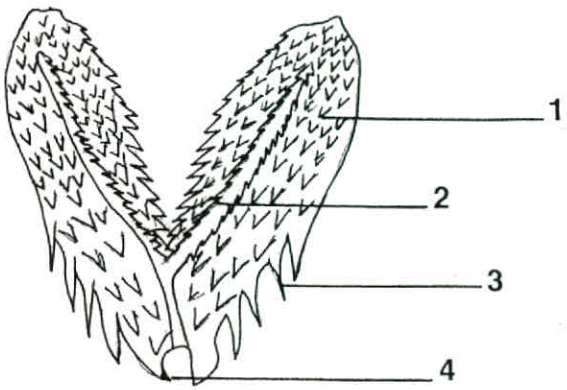


Fig. 21 Everted right hemipenis of *Pseudocerastes persicus fieldi* .

1. Microornamentation, 2. Sulcus, 3. Macroornamentation,

4. Base

4.3.7 Digestive Tract

4.3.7.1 Esophagus

This part is long cylindrical tube has ratio ranges from (0.449-0.478) in adults and (0.514-0.538) in juveniles forming more than 45% of the whole alimentary tract length (Table 7). It is longer in juveniles samples than adults when compared to the actual length of the alimentary canal. The esophagus is divided anatomically into two sections of different lengths; the more extensive anterior section is differentiated from the shorter, posterior esophageal section which enters the visceral cavity dorsal to the heart.

The esophageal wall has longitudinal folds along its whole length. The anterior part is characterized by unbranched folds of almost the same diameter. They are straight and long, the wall between the folds is thin and smooth. The posterior part of the esophagus can be differentiated by having thicker wall which is not smooth but has longitudinal, fine striations between the straight and deep folds.

4.3.7.2 Stomach

The stomach of ***Pseudocerates persicus fieldi*** forms less than 20% of the digestive canal length, its ratio ranges from (0.165-0.186) in adults and (0.172-0.191) in juveniles (Table 7). The stomach shows no marked

Table 7 Digestive Tract measurements for *Pseudocerastes persicus fieldi*

No.	Sex	SVL (mm)	Head Length (mm)	Actual Length (mm)	Esophagus (mm)	Esophagus / Actual Length	Stomach (mm)	Stomach / Actual Length	Intestine (mm)	Intestine / Actual length
JUM 975	J	235	19.6	215.4	111.4	0.517	37.0	0.172	67.0	0.311
JUM 324	J	205	16.2	188.8	97.0	0.514	36.0	0.191	55.8	0.296
JUM 350	J	282	20.0	262.0	141.0	0.538	48.0	0.183	73.0	0.279
JUM 1986	♂	465	30.5	434.5	202.5	0.466	72.0	0.166	160.0	0.368
JUM 928	♂	660	32.6	627.4	300.0	0.478	115.0	0.183	212.4	0.338
JUM 436	♂	505	29.6	475.4	226.0	0.475	78.4	0.165	171.0	0.360
JUM 2093	♂	610	34.1	575.9	270.0	0.469	99.8	0.173	206.1	0.358
JUM 1706	♂	520	30.0	490	220.0	0.449	89.8	0.183	180.2	0.368
JUM 2089	♂	510	32.3	477.7	215.5	0.451	89.0	0.186	173.2	0.363
JUM 689	♀	490	29.8	460.2	211.1	0.459	79.1	0.172	170.0	0.369

J, Juvenile; SVL, Snout-Vent length.

Actual length is the snout-vent length minus the head length.

difference between juveniles and adults in relation to the actual length of the digestive tract. It contains two clearly identified parts; the corpus, the pyloric regions and a cardiac region which can not be distinguished from the external morphology. The corpus is also called fundic region. Morphologically, the stomach is elongated corresponding to the body shape of the snake. The border between the esophagus and the stomach is indicated mostly by the nature of the mucous membrane. However, the stomach can be differentiated from the esophagus by the widening in the former diameter and thicker wall. No sphincter was found between the esophagus and the stomach. The transition zone between the gastric and intestinal epithelium ordinary shows a ring-fold or funnel-shaped pyloric valve.

The stomach has the thickest wall among other organs of the alimentary tract, it has a rough spongy appearance between folds. In the corpus region , the longitudinal folds are so close together that a little space can be seen between them. The folds of the stomach are straight, regular and unbranched, but they are broader, more distinct and deeper than those of the esophagus. In pyloric region, which is characterized by a marked bending and forms S-shaped curve, the folds remain deep but clefts are more broad and parallel to each other.

4.3.7.3 Intestine and Cloaca

The intestine in ***P.p.fieldi*** is short relative to body length forming less than 40% of the digestive canal length including both the small and the large intestine, its ratio ranges from (0.338-0.369) in adults and from(0.279-0.311) in juveniles (Table 7). A marked variation is noticed in the length of this part between juveniles and adults in relation to the actual length of the digestive tract which is found to be less in the former. The small intestine extends from the pylorus as a narrow tube. The anterior portion which is the duodenum is short and not coiled. Immediately following the duodenum is the coiled long part of the small intestine including both jejunum and ileum, but they can not be differentiated by their external morphology.

The liver, which is the largest gland in the body, consists of one elongated lobe. The gall bladder, is an elongated, thin walled, pear – shaped saccular structure, its narrow neck is connected with a cystic duct. The hepatic duct drains the liver and joins the cystic duct to form the common bile duct, which opens into the duodenum. The pancreas is a small pyramidal organ consists of one lobe. It lies in the loop between stomach and duodenum. Two pancreatic ducts persist, one of them open independently into the duodenum, while the other joins the bile duct shortly before the common duct end in the duodenum (fig.22).

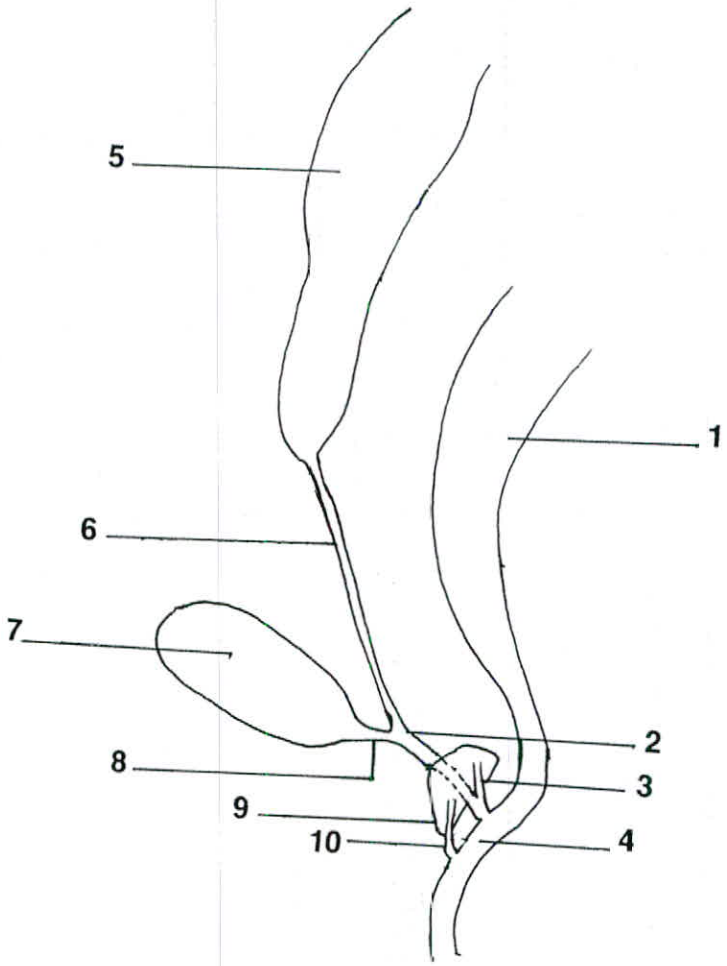


Fig.22 Arrangement of gall bladder, bile duct, and pancreatic ducts in relation to duodenum in *Pseudocerastes persicus fieldi* .

1. Stomach, 2. Common bile duct, 3. Pancreatic duct,

4. Duodenum, 5.Liver, 6. Hepatic duct, 7. Gall bladder, 8. Cystic duct, 9. Pancreas, 10.Pancreatic duct.

The wall of the small intestine is thinner than the stomach with predominant, wavy, villiform folds. Anteriorly, the longitudinal folds are very wavy, convoluted in ribbon like pattern of zigzag form having constant diameter with no obvious branches. The clefts between the folds are irregular and narrow. Posteriorly, the folds become straighter and widely separated but still wavy and irregular. Near the colon, folds become low and unbranched, with smooth wide spaces between the folds. A valve can be observed separating the small intestine from the large intestine called the ilio-colic valve.

An increase in diameter marks the beginning of the short large intestine. It appears as a straight short enlarged tube that can be demarcated into anterior colic and posterior rectal parts by slightly thicker walls for the later region. Following the large intestine is the cloaca in which the rectum empties. The male cloaca also receives the ductus deferens and ureters. It is subdivided by folds in its walls into a coprodaeum into which the large intestine opens, the urodaeum into which the urinogenital ducts open, and the posterior proctodaeum into which both urodaeum and coprodaeum empty. Posterior to the anal opening (at the base of the cloaca) two other openings through which the hemipenes are everted (fig.23). The female cloaca is not studied because the female samples were not sufficient.

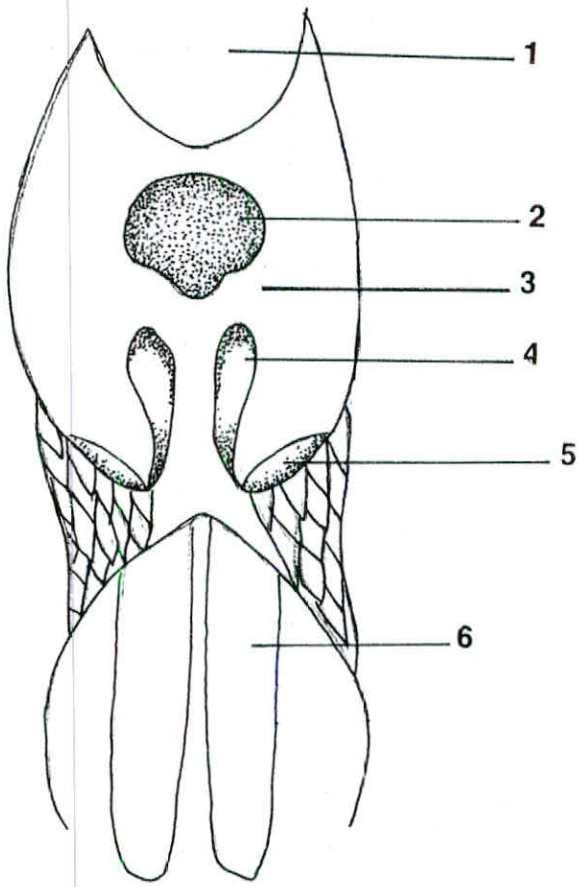


Fig. 23 Male cloaca of *Pseudocerastes persicus fieldi* (x3).

1.Coprodaeum, 2. Papilla, 3. Proctodaeum, 4. Urodaeum,

5. Hemipenial opening, 6. Hemipenis.

Anteriorly, the wall of the large intestine is thinner than posteriorly with few permanent folds. These folds are very low but long, and the wall between them is smooth. Posteriorly, high transverse folds with clear deep transverse clefts are found (fig.24).

4.4 Histological Study of the Main Venom Gland

The main venom gland of ***Pseudocerastes persicus fieldi*** was covered with a tough fibrous capsule of connective tissue (fig.25a). This gland is subdivided into many lobules by ingrowing sheets of the connective tissue capsule. The septation provides an inward path for blood vessels and nerves that form the intertubular septa. The intratubular lumina were extended and filled with secretions.

The tubules are lined with a simple columnar epithelium, these cells generally have an ovoid basal nucleus. Most of the epithelium is simple, formed of single layer, except that at occasional sites it contains relatively wide and flat "horizontal" cells. The nuclei of the horizontal cells are smaller than those of the simple columnar epithelial cells (fig. 25b).

The cytoplasm of the simple columnar epithelial cells sometimes appear as a network with granules of various sizes at different levels of concentrations. The granules are concentrated near the free surface in some

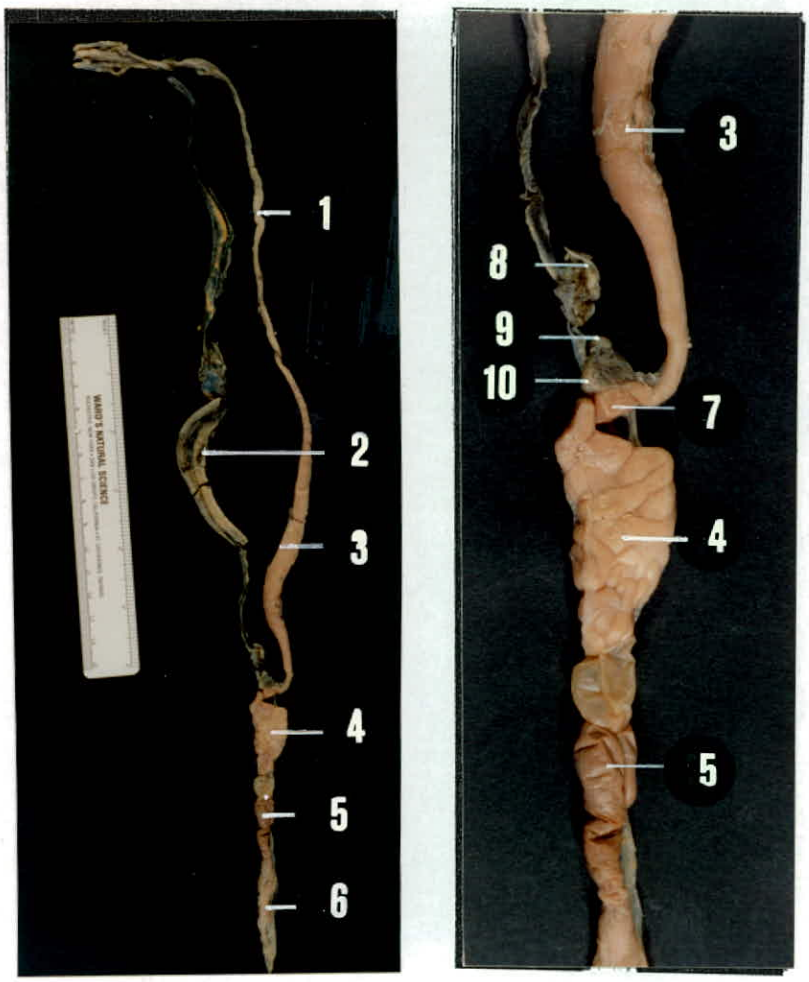
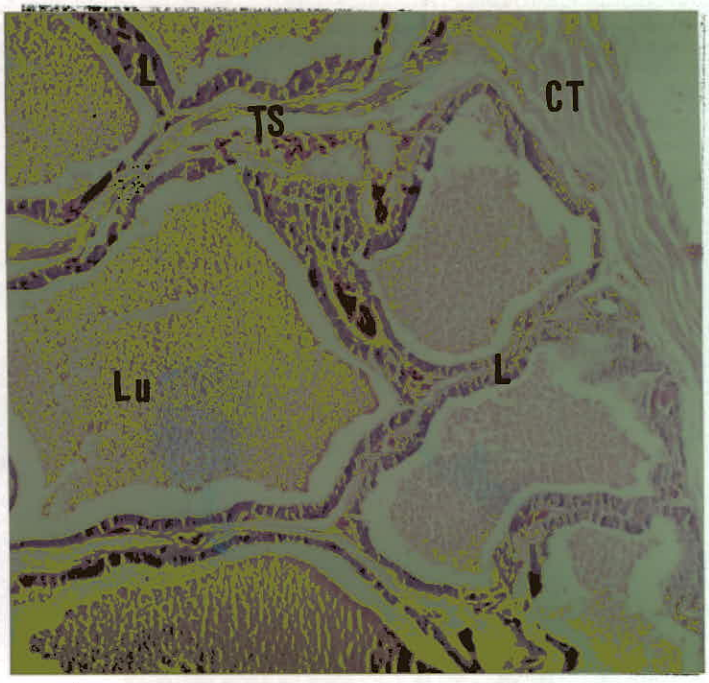


Fig. 24 The Digestive system of *Pseudocerastes persicus fieldi* .

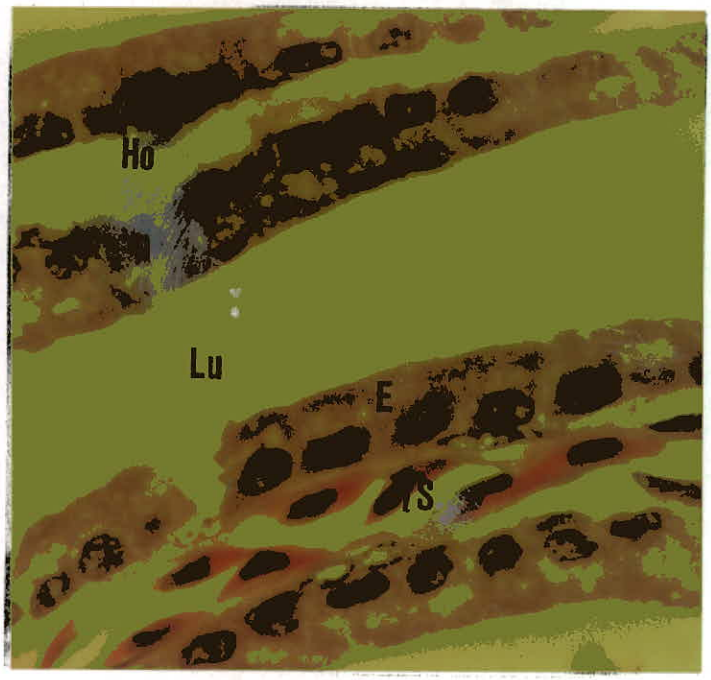
1.Esophagus, 2. Liver, 3. Stomach, 4. Small Intestine,

5.Colon, 6. Rectum, 7. Duodenum, 8. Gall bladder, 9. Spleen,

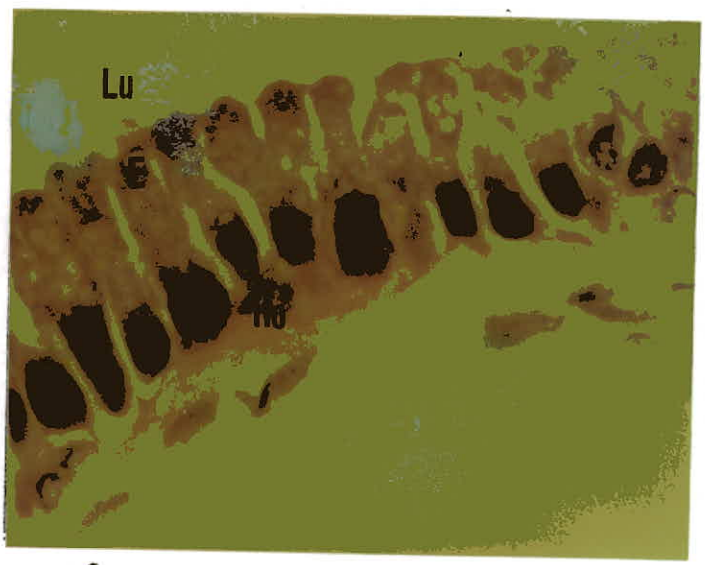
10. Pancreas.



a.



b.



c.

Fig. 25 T.S. of the main venom gland of *Pseudocerastes persicus fieldi*. a. H&E X87.5, b. H&E X875, c. H&E X875.

CT, Connective Tissue; E, Epithelium; Ho, Horizontal cell; L, Lobule; TS, Intertubular Septum; Lu, Intratubular Lumen; Nu, Nucleus.

cells, while in others the granules are found at the middle region between the nucleus and the free surface of the cell (fig. 25c). The columnar cells of the main venom gland have different heights. In some places they are tall (fig. 25c), in other regions they are more reduced in height almost to the level of the nucleus (25b).

4.5 Histological and Histochemical Study

4.5.1 Esophagus

The esophagus is a muscular tube which conveys food from the mouth to the stomach. The initiation of swallowing is a voluntary act involving the skeletal musculature of the anterior part of the esophagus, (fig. 26).

The lumen of esophagus is lined by two types of cells forming a single layered-epithelium. These cells are goblet cells and oval shaped simple columnar ciliated cells (fig.27). They are both PAS-positive (fig.28) because they both have considerable amount of neutral mucopolysaccharides in their cytoplasm. But they can be differentiated better by using the AB-PAS method which revealed acid mucopolysaccharides in the goblet cells (blue color) and neutral

Fig. 26 T.S. of the anterior region of the esophagus (VG X140).

ME, Muscularis Externa;

MU, Mucosa;

SM,Submucosa..

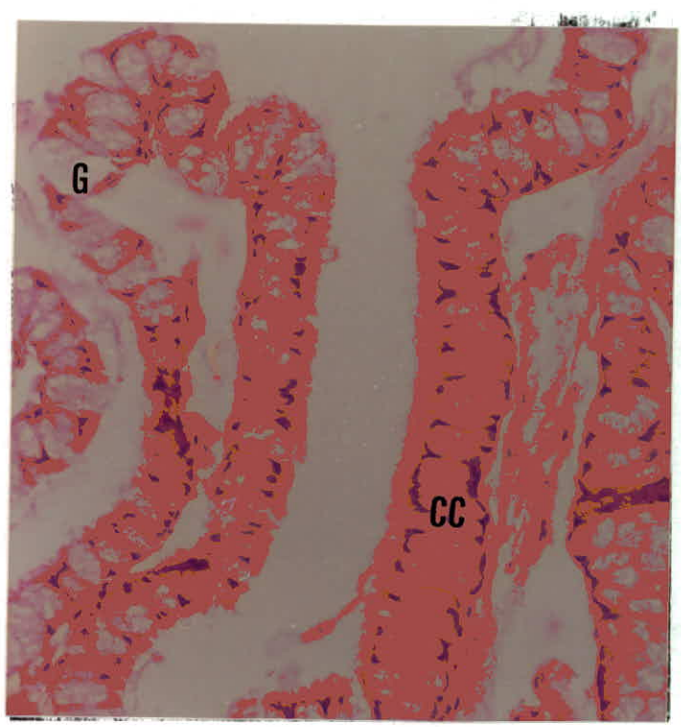


Fig. 27 T.S. of the middle region of the esophagus (H&E X231).

CC, Simple Columnar Ciliated Epithelial Cells;

G, Goblet Cell.

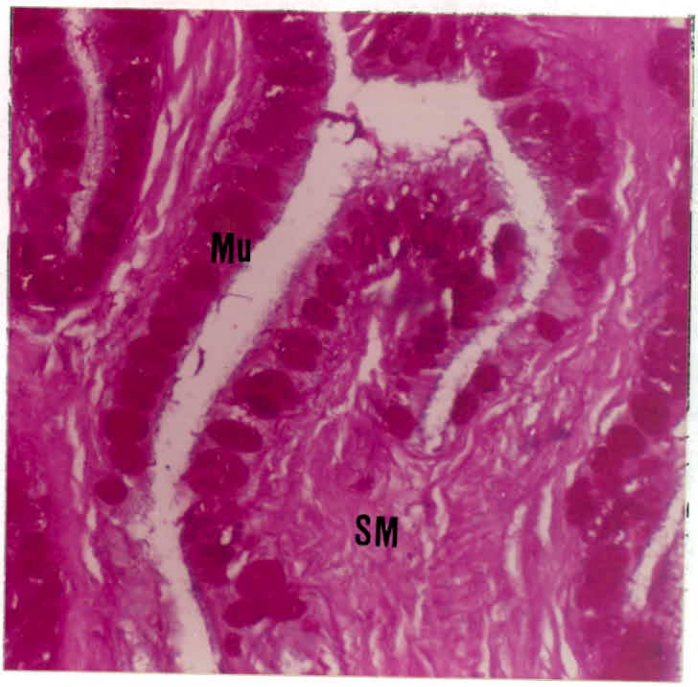


Fig. 28 T.S. of the middle region of the esophagus(PAS X175).

MU, Mucosa;

SM, Submucosa..

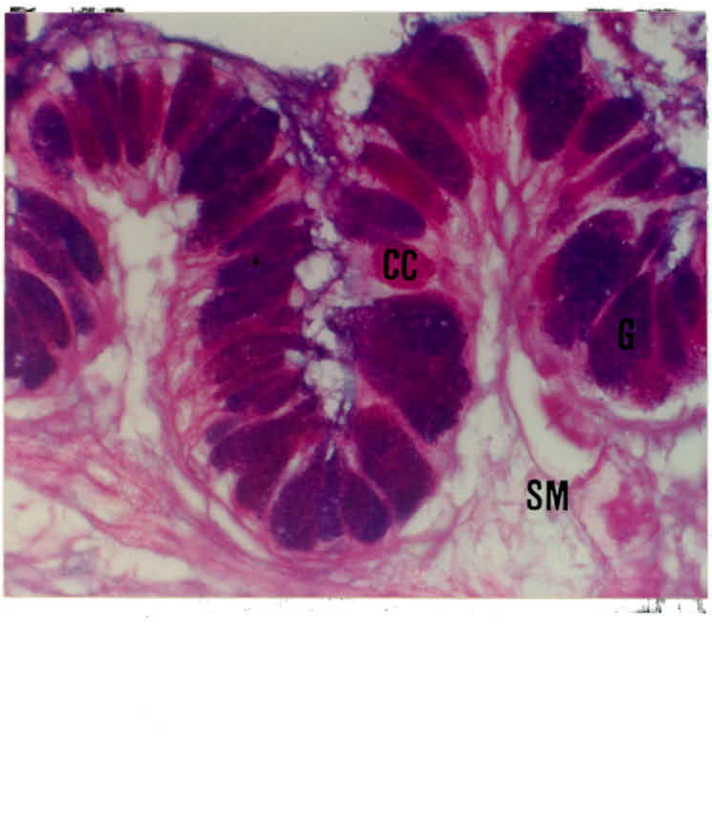


Fig. 29T.S. of the anterior region of the esophagus (AB-PAS X350).

CC, Simple Columnar Ciliated Epithelial Cells;

G, Goblet Cell;

SM, Submucosa.

mucopolysaccharides in the columnar epithelial cells (red color) (fig.29). The cytoplasm of the basal parts of the goblet cells contain fine red granules which indicate the presence of little amounts of neutral mucopolysaccharides (fig.29), but no acid mucoid can be detected in the cytoplasm of the columnar cells. From the previous figures it is clear that the abundant cell type in the mucosa is the goblet cell and not the ciliated columnar cell. Also, the goblet cells are more abundant in the anterior part of esophagus (fig. 29) than the posterior part (fig.31). The nuclei of the mucosal cell types are found in the lateral region of the cells. The structure and types of the mucosal cells is almost the same along the anterior and posterior part of the esophagus. However, in the posterior part columnar cells become less oval shaped and more regular (fig.30) than that in the anterior and middle part (fig.27).

The lamina propria is formed of loose connective tissue, and the presence of some blood vessels was noticed in the middle and posterior part of the esophagus where this layer was more differentiated than the other parts (fig 32 a&b). In the anterior part of esophagus, the lamina propria was not clear. But in both parts of esophagus no lymphatic aggregations were found in the lamina propria.

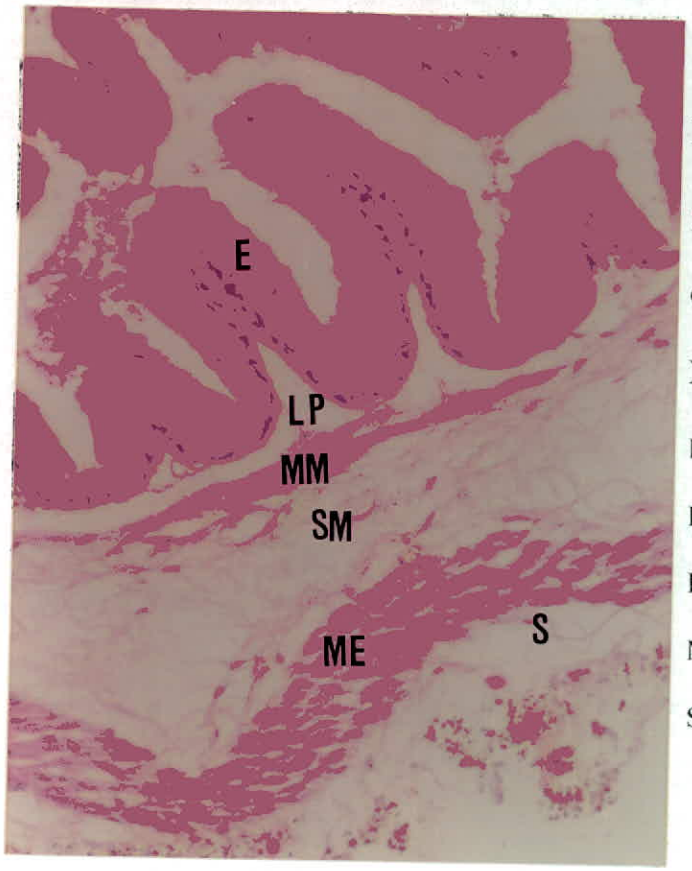


Fig. 30 T.S. of the posterior region of the esophagus (H&E X231).

E, Epithelium; LP, Lamina Propria; ME, Muscularis Externa; MM, Muscularis Mucosa; Mu, mucosa; S, Serosa; SM, Submucosa.

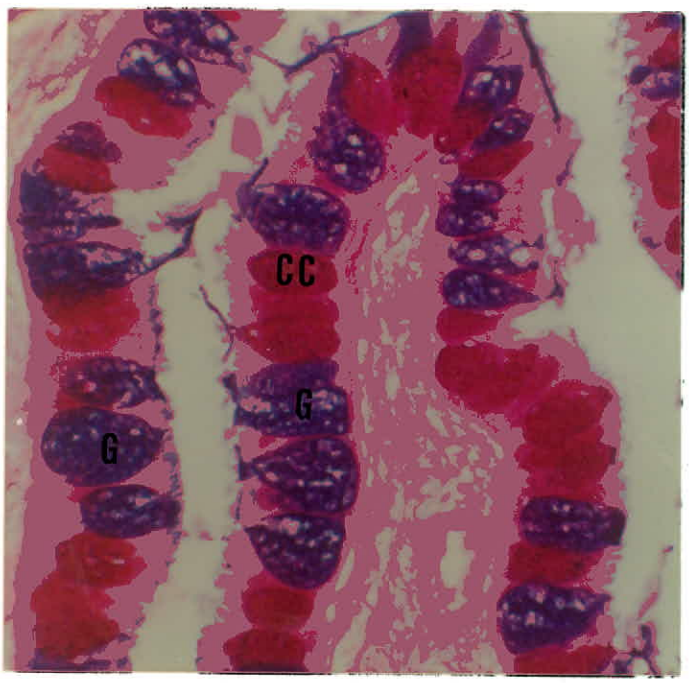
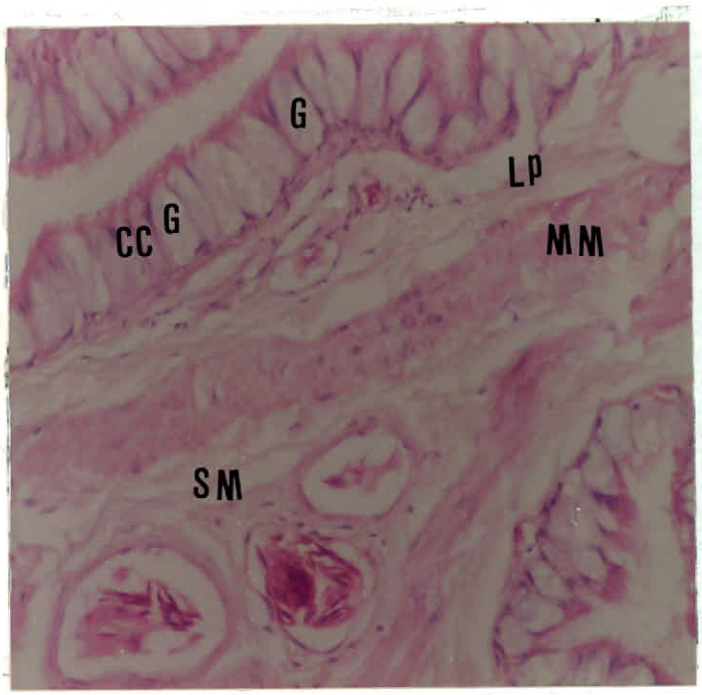
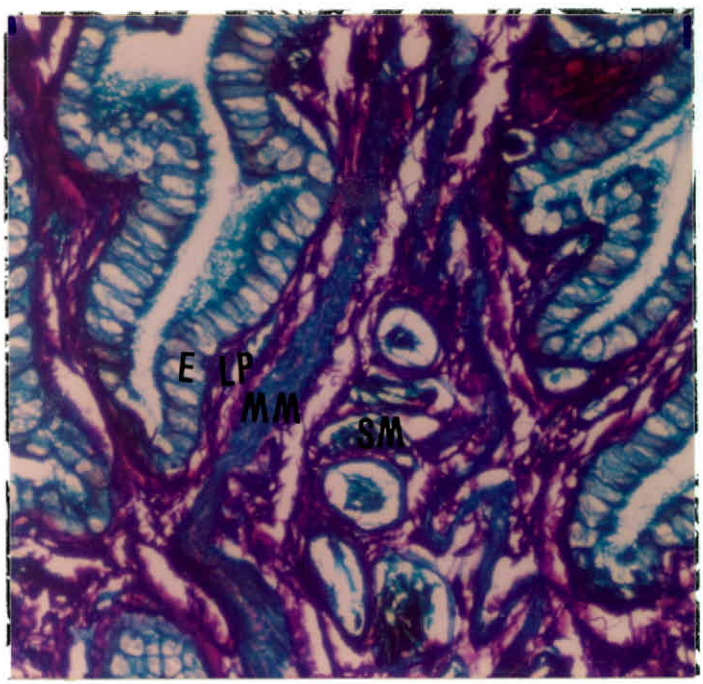


Fig. 31 T.S. of the middle region of the esophagus (AB-PAS X350).

CC, Simple Columnar Ciliated Epithelial Cells; G, Goblet Cell; SM, Submucosa.



a.



b.

Fig. 32 T.S. of the middle region of the esophagus a. H&E X231, b. FG X140.

CC, Simple Columnar Ciliated Epithelial; G, Goblet Cell; LP, Lamina Propria; MM, Muscularis Mucosa Cells; SM, Submucosa.

The muscularis mucosa is a thin smooth muscular layer and barely visible anteriorly (fig. 26). The muscularis mucosa becomes more distinct posteriorly (fig. 32b) but still it is formed of one layer only.

The submucosa is highly vascularized and relatively loose allowing for considerable distension during passage of food (fig. 32 a&b). It is formed of connective tissue with no esophageal glands being found.

Muscularis externa is the third layer of the esophagus. In the anterior region, it is composed of only one layer of circular skeletal muscles having orange color by applying Van Gieson stain (fig. 26). In the middle and posterior region, it is composed of one layer of smooth muscles (fig 33).

The outer layer of the anterior part of the esophagus is the fibrous layer containing connective tissue and few blood vessels. This layer is less clear in the middle than the first anterior part of esophagus. The serosa layer which is lined with a single layer of simple squamous epithelial cells (mesothelium) is absent in the anterior and middle parts of the esophagus, it starts to appear only posteriorly near the stomach.

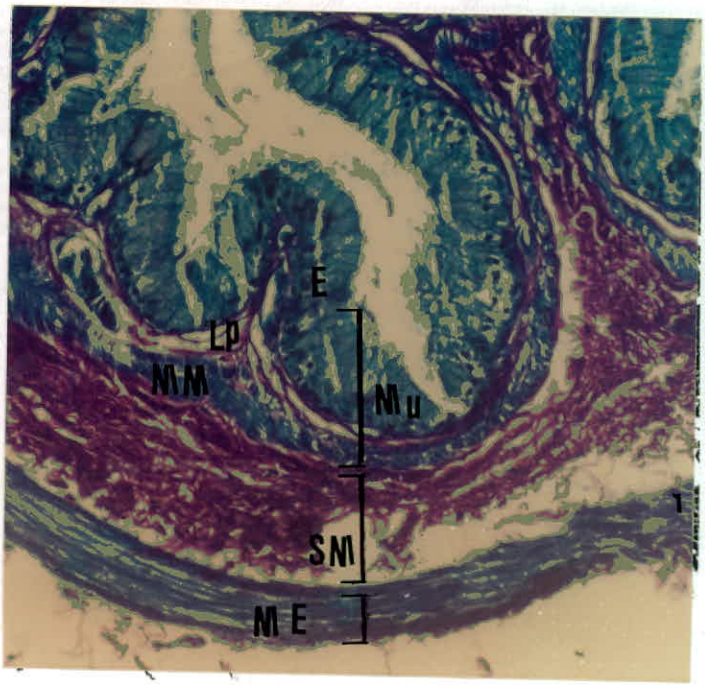


Fig. 33 T.S. of the posterior region of the esophagus (FG X175).

E, Epithelium; LP, Lamina Propria; ME, Muscularis Externa; MM, Muscularis Mucosa; MU, Mucosa; SM, Submucosa.

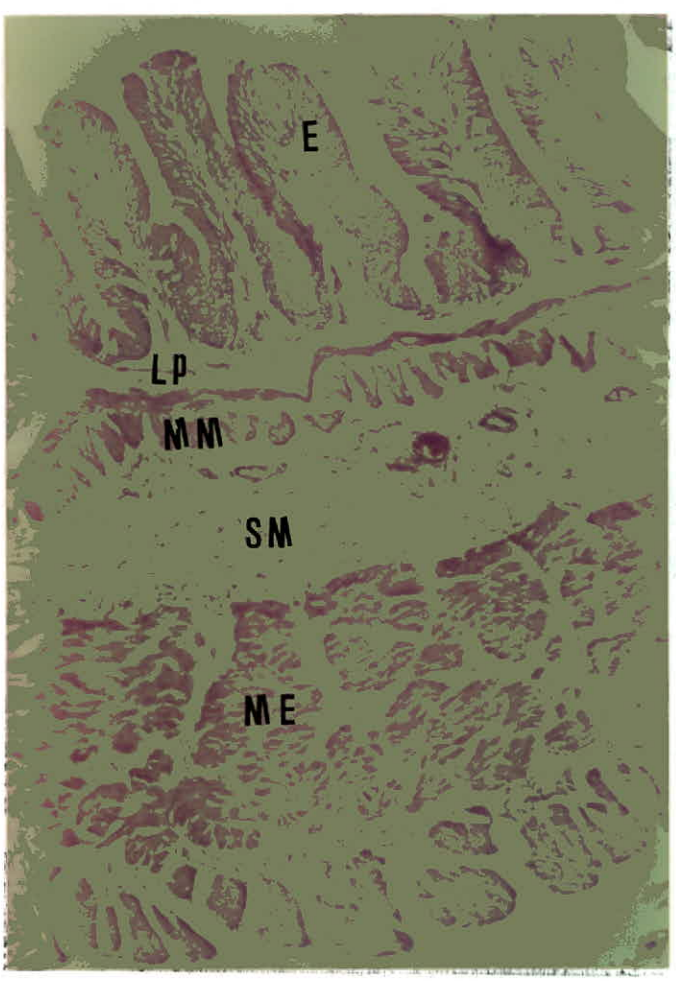


Fig. 34T.S. of the cardiac region of the stomach (H&E X87.5).

E, Epithelium; LP, Lamina Propria; ME, Muscularis Externa; MM, Muscularis Mucosa; MU, Mucosa.

4.5.2 Stomach

Histologically, the stomach can be divided mainly into two glandular regions according to the type of glands present, and one aglandular region. The first part of stomach is the aglandular cardiac region which is characterized by having thicker muscular layer than the esophagus and being differentiated into inner circular and outer longitudinal. The epithelial cells are less oval, smaller in size and shorter than the epithelial cells of the esophagus. The muscularis mucosa is distinguishable by having inner circular and outer longitudinal layers of smooth muscles. This part is too short relatively to the other parts of the stomach and can be differentiated from the corpus by lacking of the mucosal glands (fig. 34).

The first glandular part and the longest among the two other parts of the stomach is the corpus region which can be differentiated from the region by having the fundic glands in the mucosa. The glandular portion of the corpus is formed by thickly packed, straight, tubular and ramified glands called fundic glands and they secrete their contents through the gastric pits. Each fundic gland is divided into a pit region, a glandular neck, and a glandular body (figs.35&36) (table 8). The tubular glands are combined into groups separated by connective tissue (fig. 37) clearly shown by using Mallory's triple stain in which the connective tissue has a blue color and the muscles dark gray color. Clear mucoid neck cells are

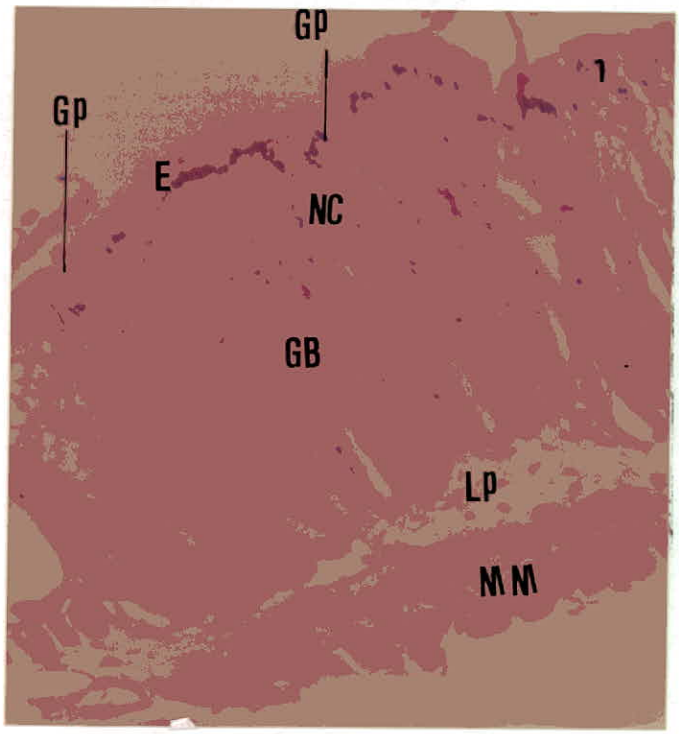


Fig. 35 T.S. of the corpus region of the stomach (H&E X175).

E, Epithelium;

GB, Glandular Body;

GP, Gastric Pit;

LP, Lamina Propria

MM, Muscularis Mucosa;

NC, Neck Mucous Cells.

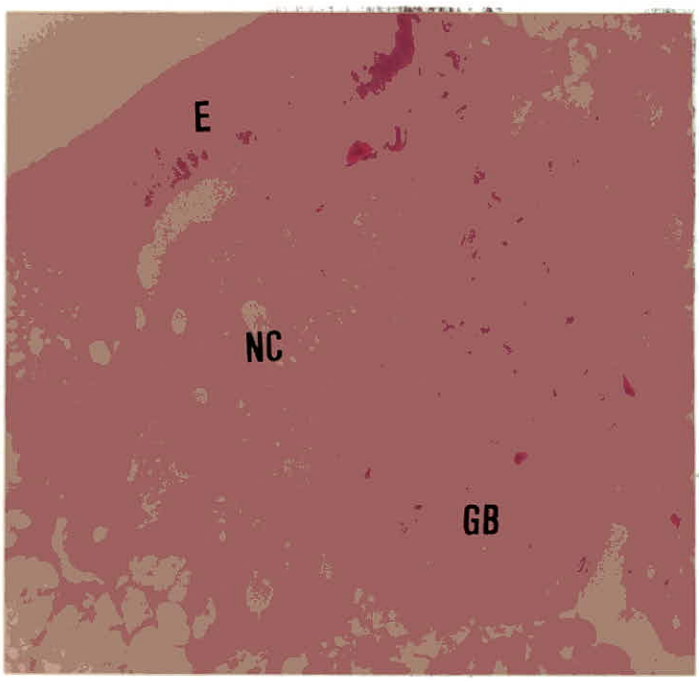


Fig. 36 L.S. of the corpus region of the stomach (H&E X350).

E, Epithelium;

GB, Glandular body;

NC, Neck Mucous Cells.

Table 8 Results of histochemical tests on the secrction zone of the cell types in the fundic gastric glands of ***Pseudocerastes persicus fieldi***

Stain	Superficial & pit cells	Neck cells (mucous secreting cells)	Main glandular cells (serous secrting cells)
PAS	+ +	+	-
AB pH 1	+	-	-
AB pH 2.5	+	-	-

- negative; + slightly positive; + + positive.

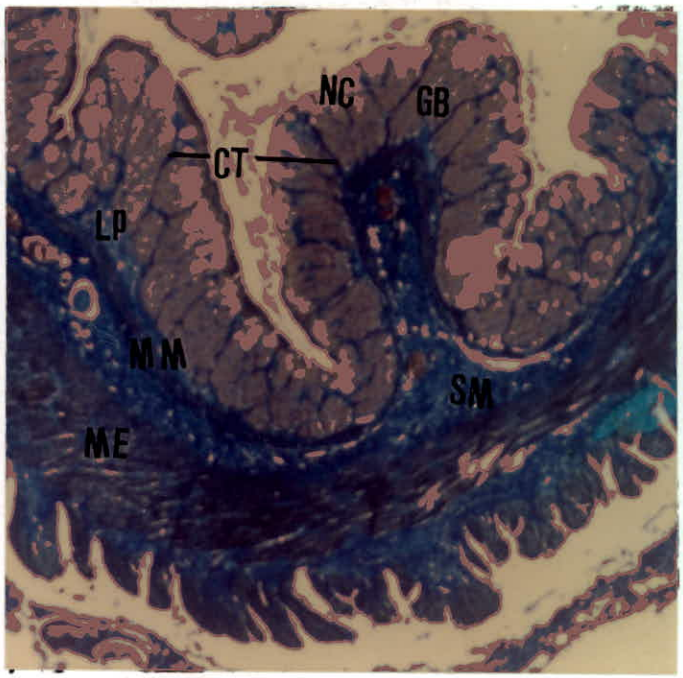


Fig. 37 T.S. of the corpus region of the stomach (MT X35).

CT, Connective Tissue;
GB, Glandular Body;
LP, Lamina Propria;
ME, Muscularis Externa;
MM, Muscularis Mucous;
SM, Submcosa.

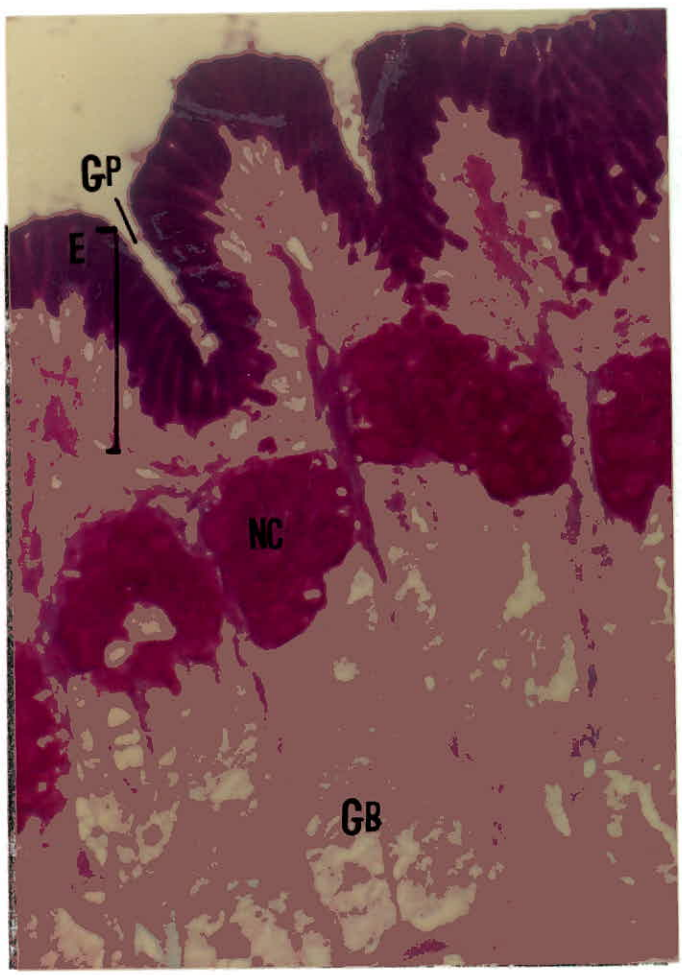


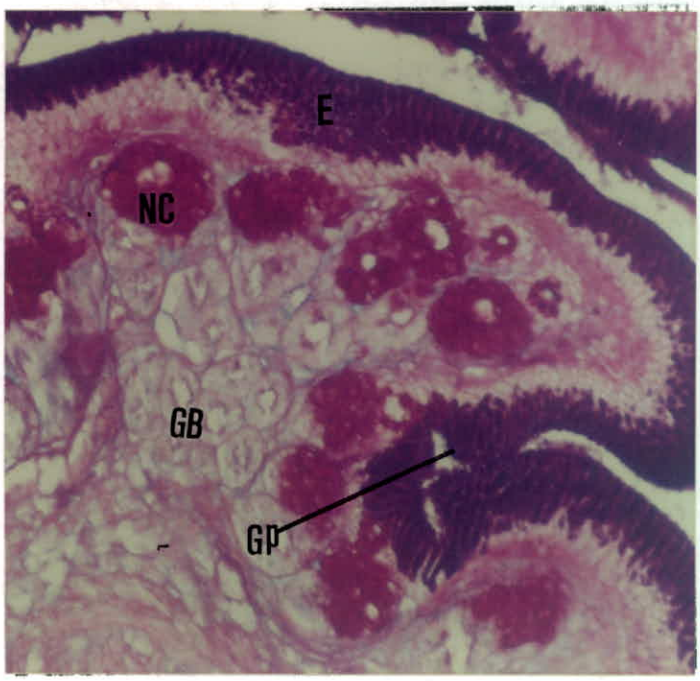
Fig. 38 T.S. of the corpus region of the stomach (AB- PAS X462).

E, Epithelium;
GB, Glandular body;
GP, Gastric Pit; NC, Neck Mucous Cells.

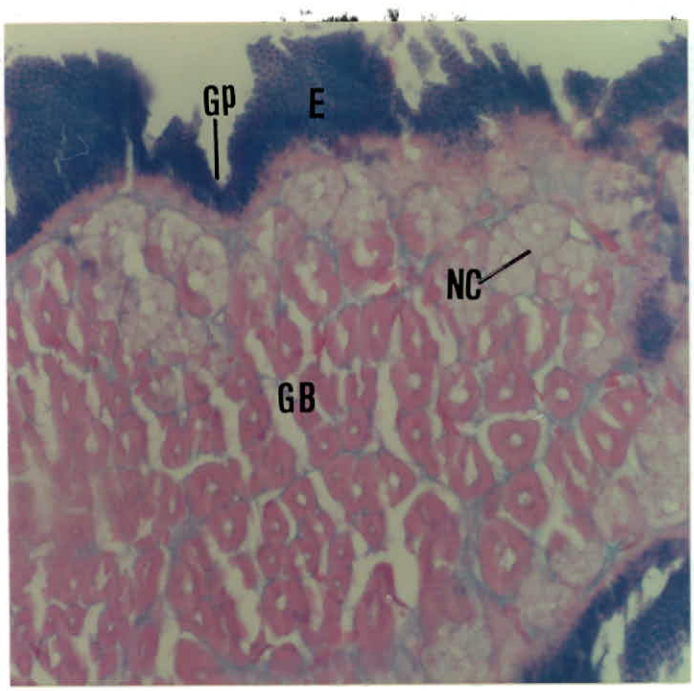
especially common in the tubular glands lying at the upper region of the glandular portion (fig 38). These cells are colorless using H & E stain, but they got the red color when PAS/AB pH 2.5 stain is used indicating the presence of neutral mucopolysaccharids (fig. 39a). The mucous cells do not contain acid mucopolysaccharides because no purple color appears when PAS/AB pH 2.5 was used nor blue color when AB pH2.5 stain alone was used (fig. 39b). These cells have small flattened or oval nuclei which are compressed at the base of the cells.

Towards the lumen, the cells are simple high columnar epithelium in which the longitudinally oval nuclei lay close to the base of the cells (fig. 40). This epithelium is fundamentally the same in different regions of the stomach. The superficial cells are provided with mucous plug at their upper portion, which contains a substance related to mucin as they are stained with mucin dyes. In addition, these cells as well as the pit cells secrete mainly neutral and some acid mucopolysaccharides as indicated by the strong PAS-positive reaction (fig. 41) and by having some blue color with alcian blue stain (fig. 42).

The third type of glands present in the mucosa of the corpus region is the main gland cells and sometimes called the fundic cells. These cells are characterized by fine acidophilic granules when stained with H&E and



a.



b.

Fig. 39 L.S. of the corpus region of the stomach a. AB-PAS X231, b. AB X175.

E, Epithelium;

GB, Glandular Body;

GP, Gastric Pit; NC, Neck Mucous Cells.

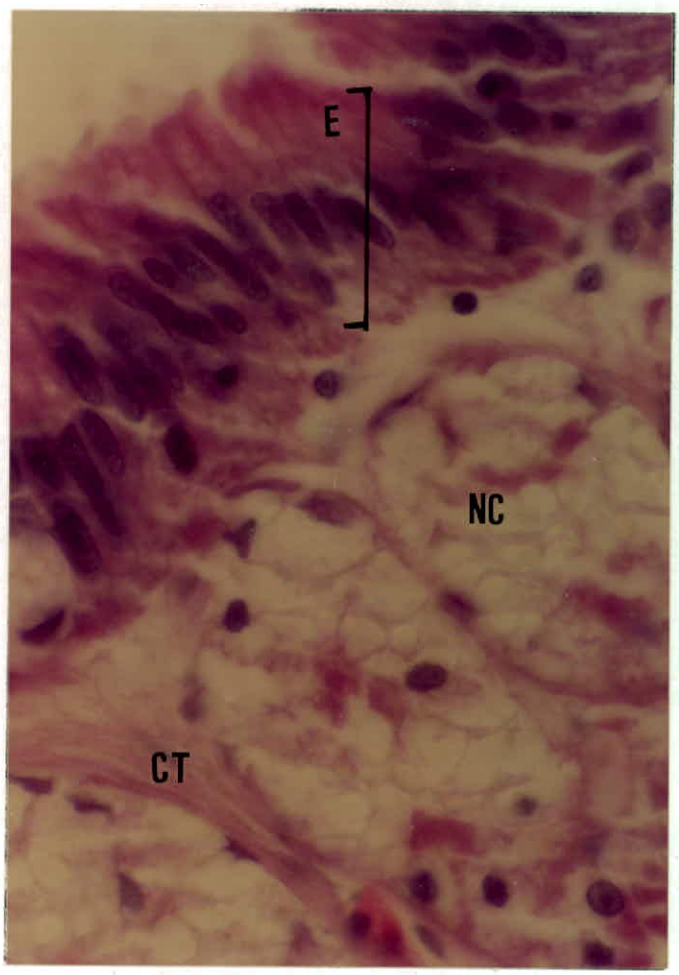


Fig. 40 L.S. of the corpus region of the stomach (H&E X875).

E, Epithelium;

CT, Connective Tissue;

NC, Neck Mucosa Cells.

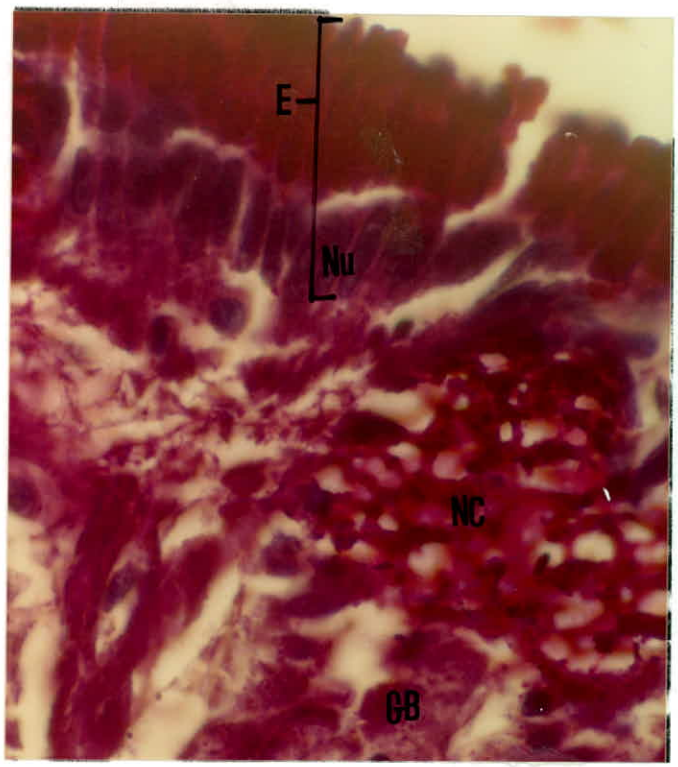


Fig. 41 T.S. of the corpus region of the stomach (PAS X875).

E, Epithelium;

GB, Glandular body;

NC, Neck Mucous Cells;

Nu, Nucleus.

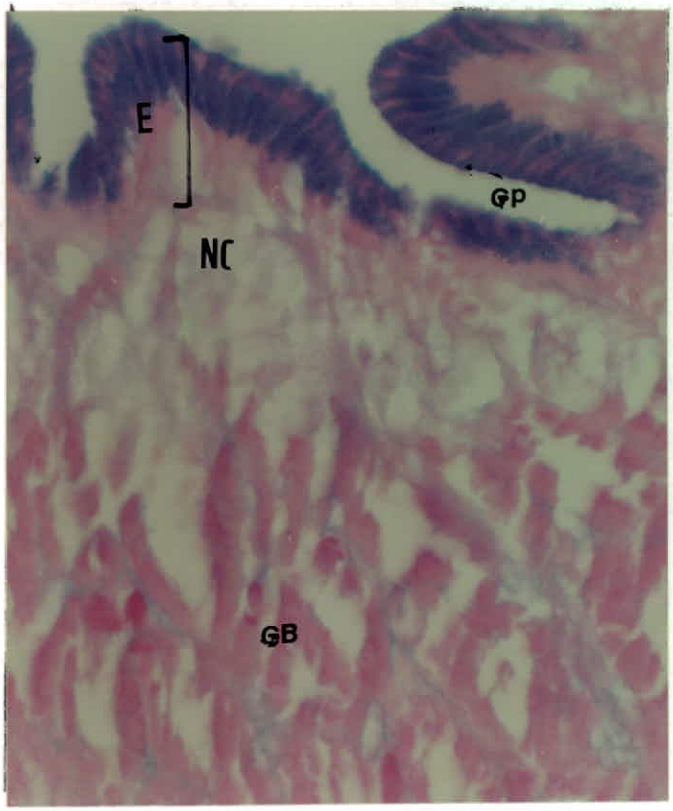


Fig. 42 T.S. of the corpus region of the stomach (AB X462).

E, Epithelium;
GB, Glandular Body;
GP, Gastric Pit; NC, Neck Mucous Cells.

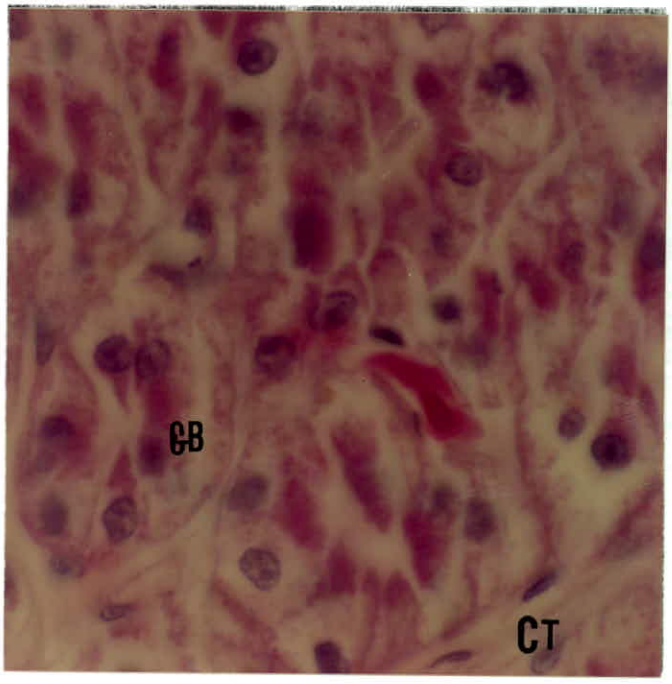


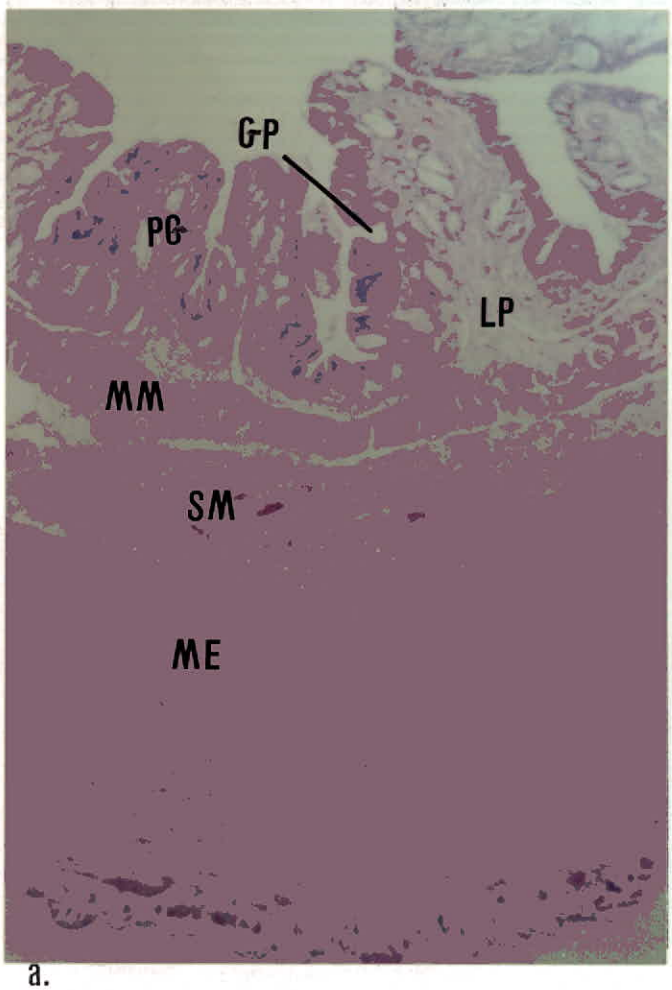
Fig. 43 L.S. of the corpus region of the stomach (H&E X875).

CT, Connective Tissue;
GB, Glandular body.

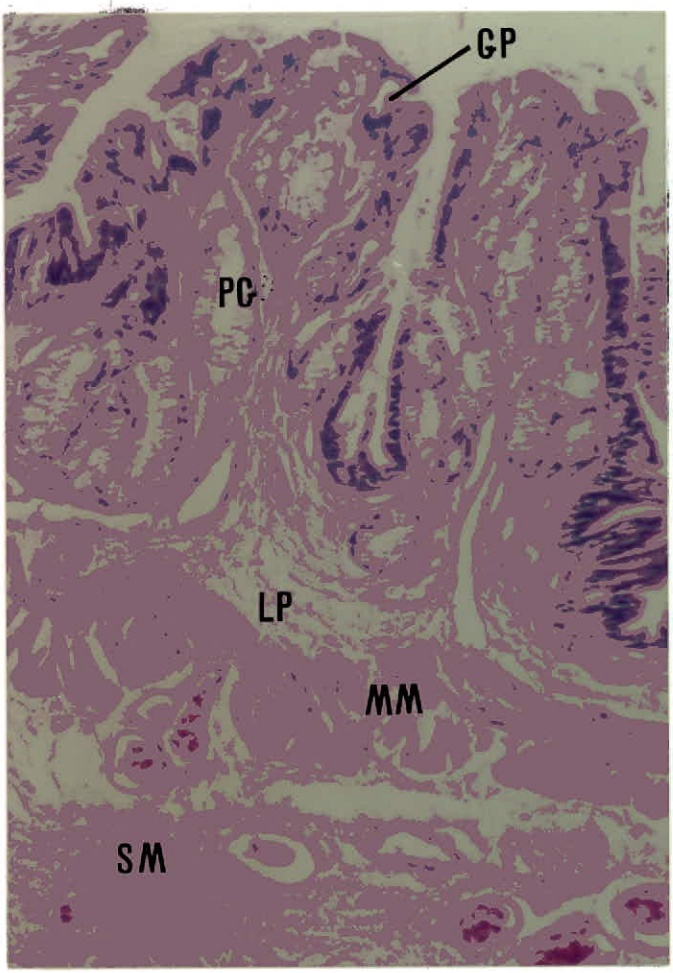
large rounded central basophilic nucleus provided with darkly stained nucleoli (fig. 43).

The posterior part of stomach is the pyloric region. The tubular glands are generally shorter, less branched than those of the corpus (fig. 44a) and are formed of pit region and gladular body containing only mucous cells which are PAS-positive. The epithelial cells lining the pyloric region and the pit cells of the pyloric glands are histologically and histochemically similar to those of the corpus region of stomach. The body of the gland consists of morphologically similar, clear, columnar cells, with basally positioned, rounded, loosely formed nuclei in the cytoplasm (fig. 44b). The histochemical peculiarities of these cells are closely similar to those of the neck cells of the corpus glands.

The other layers shared by the three regions of stomach (cardiac, corpus, and pyloric) are lamina propria, muscularis mucosa, submucosa, muscularis externa and serosa. The lamina propria is formed in the three regions of stomach of vascularized loose connective tissue. The muscularis mucosa is well developed and subdivided into internal, primarily circular layers of smooth muscles, and an external longitudinal one along the three regions of stomach.



a.



b.

Fig. 44 T.S. of the pyloric region of the stomach. a. H&E X56, b. H&E X140.

GP, Gastric Pit;

LP, Lamina Propria;

ME, Muscularis Externa;

MM, Muscularis Mucosa;

PG, Pyloric Gland;

SM, Submucosa.

The second layer under the mucosa is the submucosa. It is a narrow layer relative to the other main layers of stomach. Also, it consists of loose connective tissue, penetrated by large blood vessels (figs. 34,44a&45).

The muscularis externa is always formed of smooth muscles and consists of two layers, the inner circular and the outer longitudinal connected together by fibers of connective tissue. The circular layer, which represents a direct continuation of the circular layer of the esophagus, is more developed than the longitudinal layer especially in the cardiac and pyloric regions. However, in the corpus of the stomach, both layers are well developed (fig. 45). In the pyloric region the muscularis externa is a thick layer of one type, the circular, and only few scattered patches of longitudinal muscle are present (fig. 44a). The serosa is the outer layer, which is lined by the mesothelium, covers the three regions of the stomach (fig. 46).

4.5.3 Small Intestine

The mucous membrane of the small intestine, is in the form of numerous finger-like cylindrical villi. Between the villi no intestinal crypts, Paneth cells or glands are found. The columnar epithelium lies on a basal membrane and contains two types of cells: enterocytes and goblet cells.

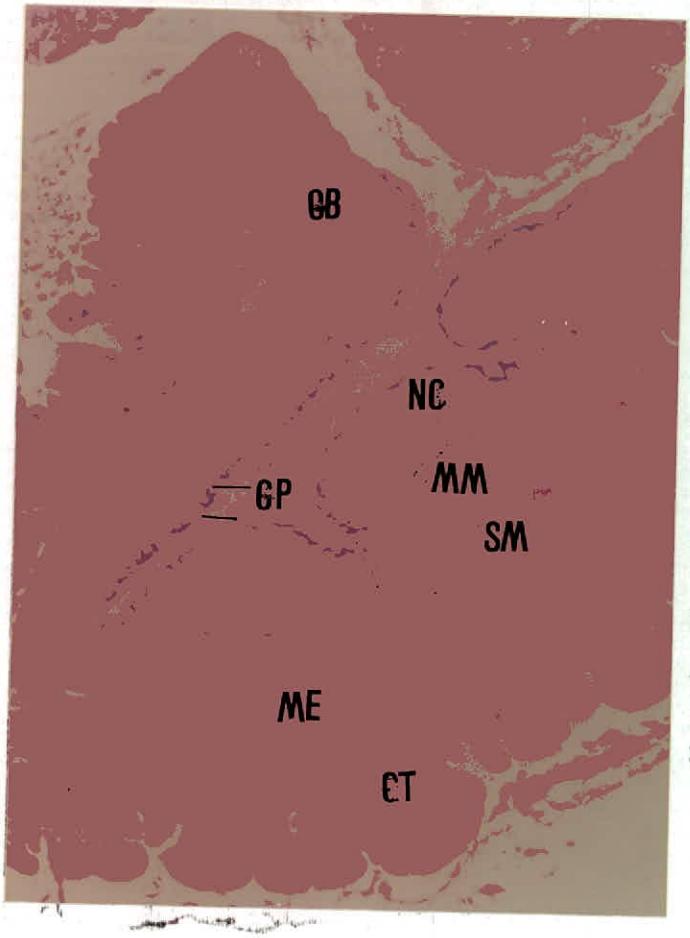


Fig. 45 T.S. of the corpus region of the stomach (H&E X35).

CT, Connective Tissue;
GB, Glandular Body;
GP, Gastric Pit;
ME, Muscularis Externa;
MM, Muscularis Mucosa;
NC, Neck Mucous Cells;
SM, Submucosa.

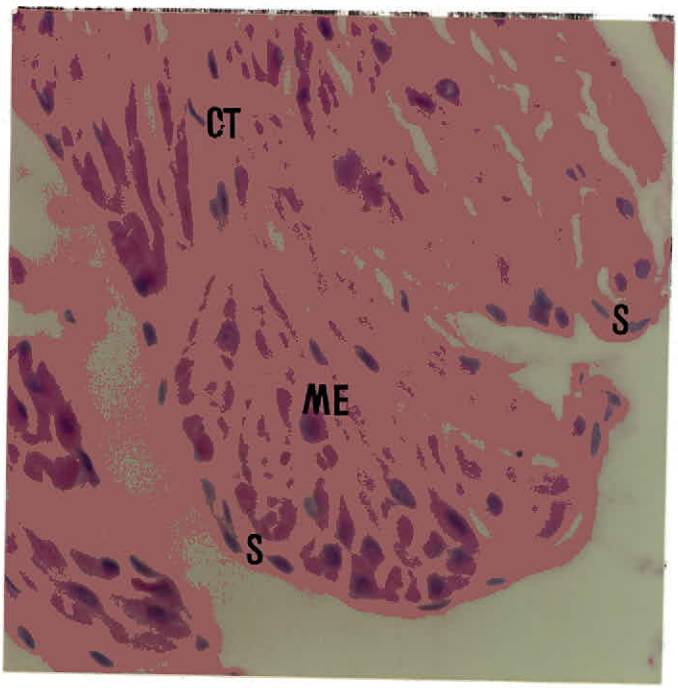


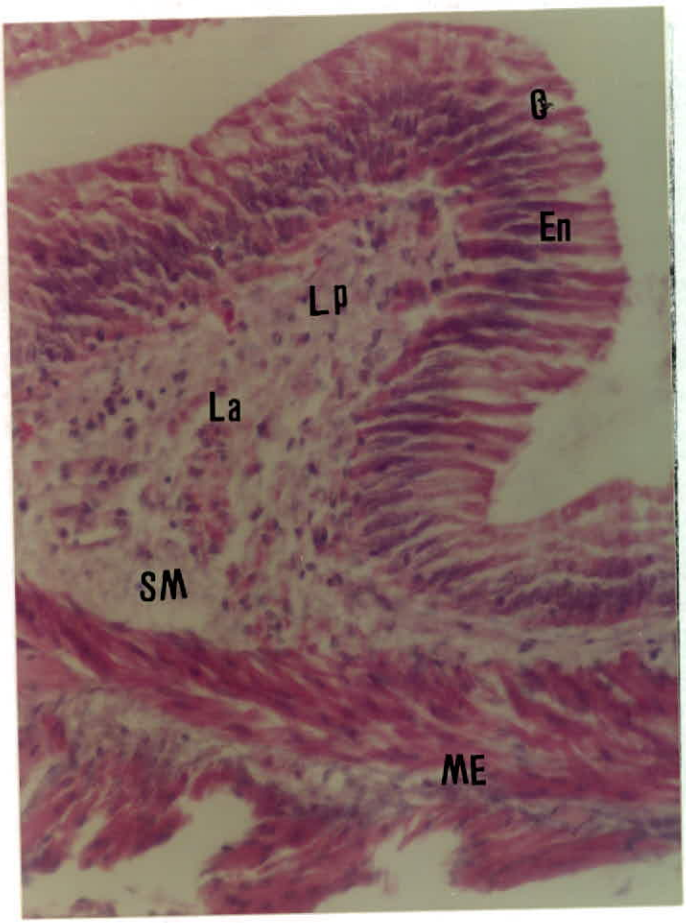
Fig. 46T.S. of the corpus region of the stomach (H&E X462).

CT, Connective Tissue;
ME, Muscularis Externa;
S, Serosa.

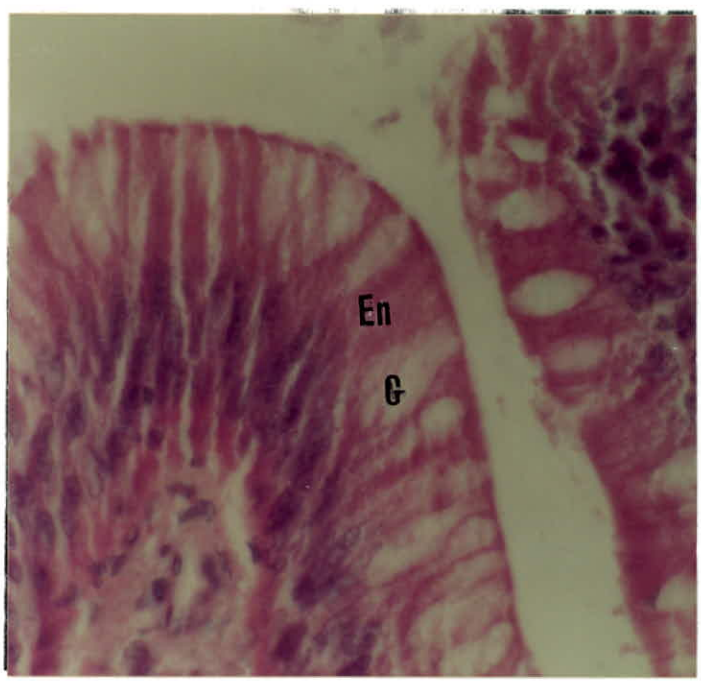
The enterocytes are also called marginal cells or absorptive cells according to their location and function respectively. These cells are tall columnar cells with basally located oval nuclei; they react negatively with PAS and AB (fig. 47a). The second type has the same morphological and histological characteristics of the esophageal goblet cells but slightly smaller, they are irregularly placed between the enterocytes (fig. 47b). The secretion of these cells is acid mucopolysaccharides which is clear using PAS stain in which goblet cells attain a red color (fig. 48) and purple color when stained with AB-PAS (fig. 49). The lamina propria occupies the center of the core of each villus which contains large lymphatic vessels, the lacteals, that transport fatty acids into the lymphatic system (fig. 48).

The muscularis mucosa is not clear in the anterior, middle and posterior parts of small intestine. The submucosa is narrow and formed of connective tissue in the anterior part and posterior part of the small intestine (figs. 49&50).

Muscularis externa is a well developed layer, it is composed along the whole length of the small intestine from both inner circular and outer longitudinal smooth muscles (fig. 50). This layer is followed by the serosa which is composed of mesothelium and present along the whole small intestine.



a.



b.

Fig. 47 T.S. of the posterior region of the small intestine. a. H&E X280, b. H&E X560.

En, Enterocytes; G, Goblet Cell; La, Lacteal; LP, Lamina Propria; ME, Muscularis Externa; SM, Submucosa.

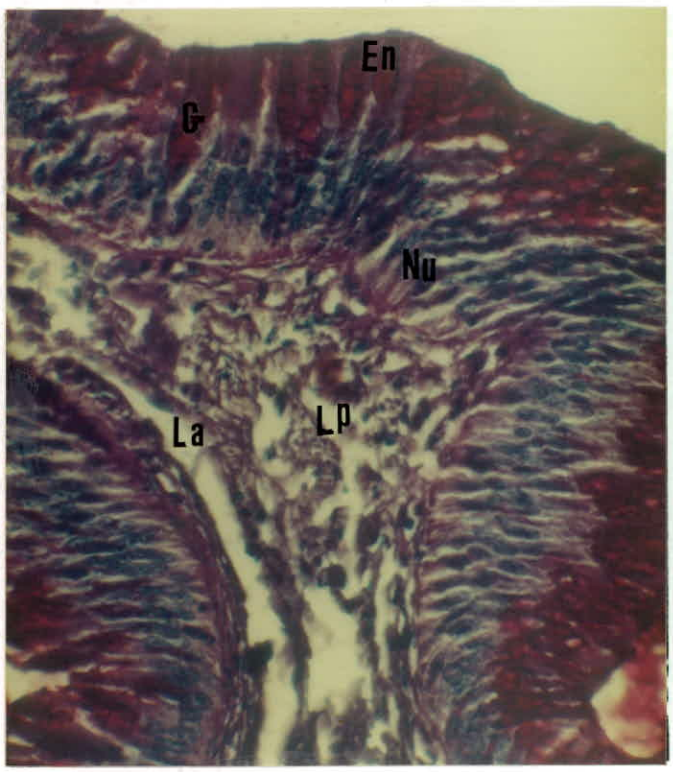


Fig. 48 T.S. of the posterior region of the small intestine (PAS X350).

En, Enterocytes; G, Goblet Cell; La, Lacteal; LP, Lamina Propria; Nu, Nucleus.

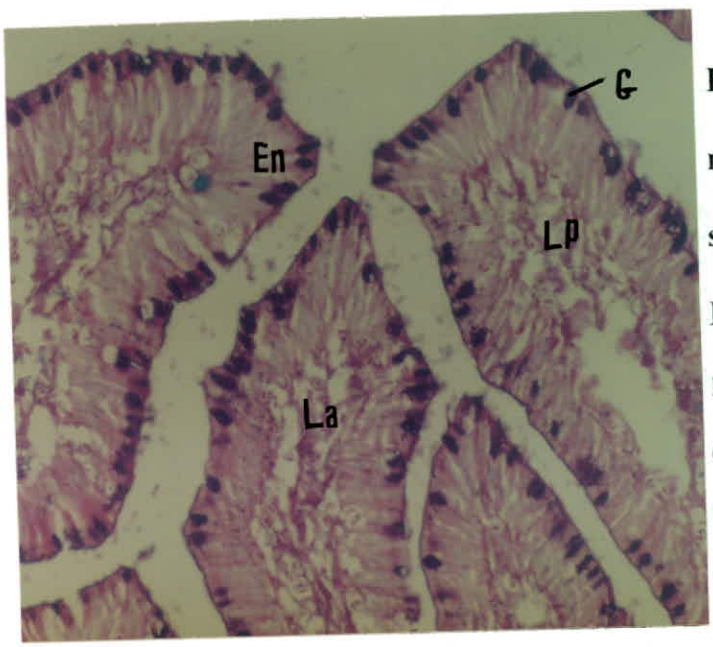


Fig. 49 T.S. of the middle region of the small intestine (AB-PAS X175)

En, Enterocytes; G, Goblet Cell; La, Lacteal; LP, Lamina Propria.

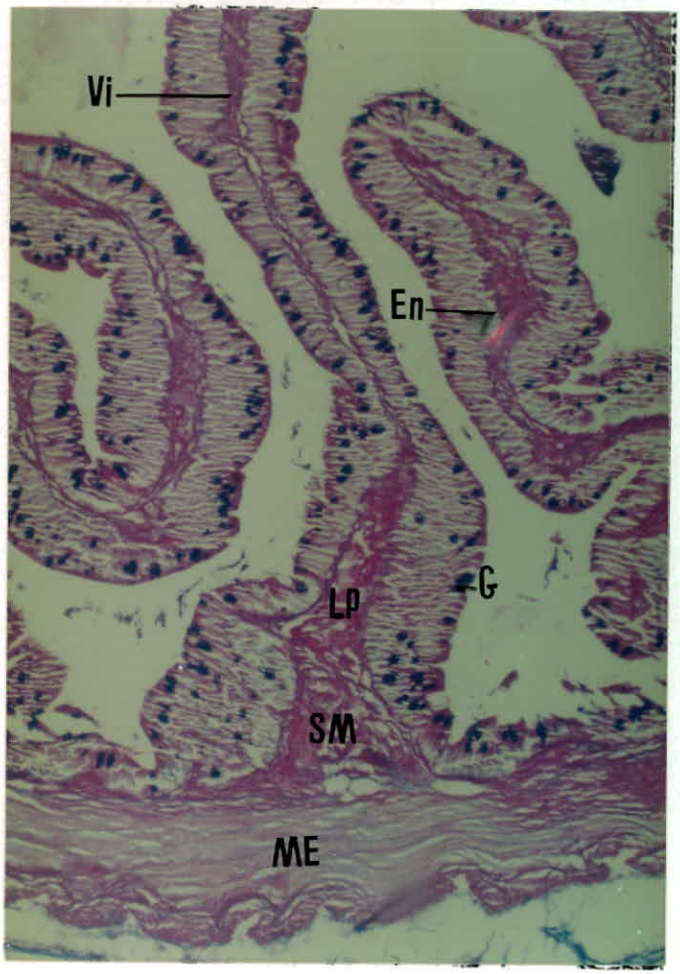


Fig. 50 T.S. of the anterior region of the small intestine (AB-PAS X87.5).

En, Enterocytes; G, Goblet Cell; LP, Lamina Propria; ME, Muscularis Externa; SM, Submucosa; Vi, Villus.

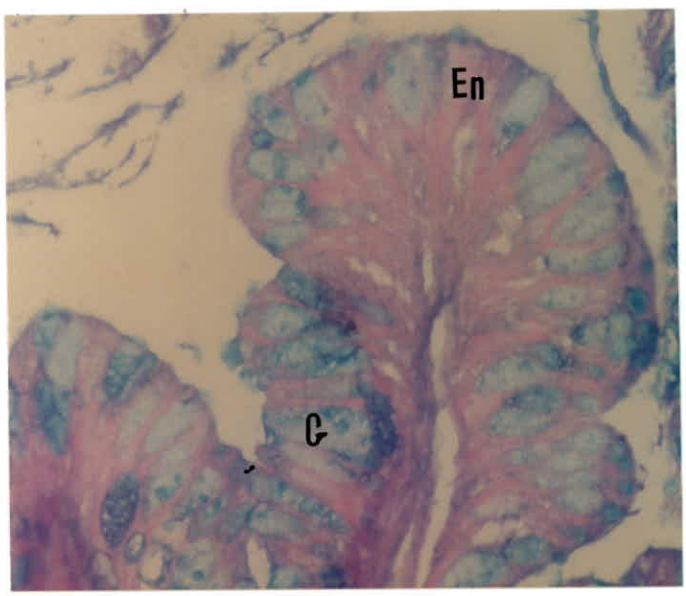


Fig. 51 T.S. of the colonic region of the large intestine (AB X231).

En, Enterocytes; G, Goblet Cell.

4.5.4 Large Intestine

The mucosa of the large intestine is similar to that of the small intestine by having the same type epithelium. The lining of the mucosa is composed of simple columnar epithilium which contains throughout many goblet cells but more in number and larger in size than those of small intestine (fig. 51). Goblet cells contain acid mucopolysaccharides that are PAS-positive (fig. 52) as well as having positive reaction when stained with alcian blue (fig. 51).

The colon differs from the small intestine in having separated lamina propria by a clear muscularis mucosa which is thin and of one layer of the smooth muscles. However, the submucosa here is made of a thin layer of connective tissue (fig. 53).

The muscularis externa is thick in comparison to the mucosa. As in the small intestine, it consists of two layers, inner circular and outer longitudinal of smooth muscles (fig. 53).

The rectum is short, dilated and forms the terminal portion of the large intestine. Histologically, this part can be differentiated from the colon by having more numerous goblet cells (fig. 54a) and for containing large number of lymphoid aggregations in the mucosa (fig. 54 b&c).

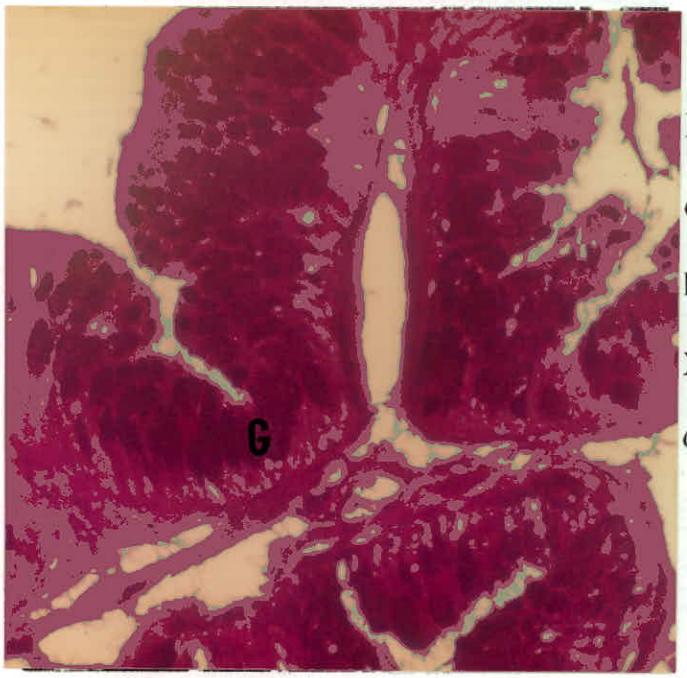


Fig. 52 T.S. of the colonic region of the large intestine (PAS X175).

G, Goblet Cell.

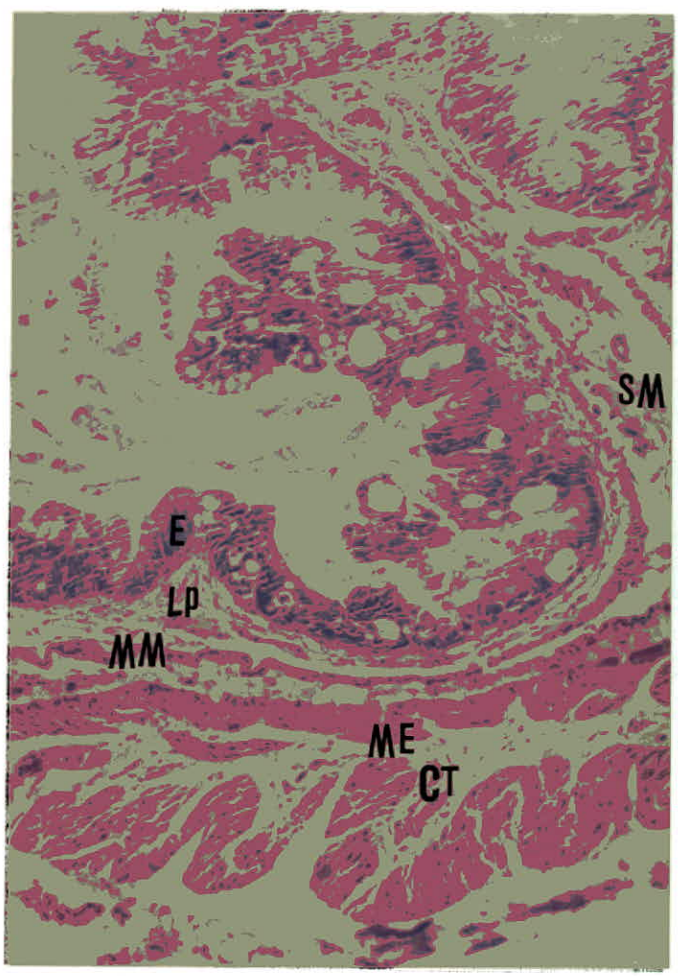


Fig. 53 T.S. of the colonic region of the large intestine (H&E X87.5).

E, Epithelium;

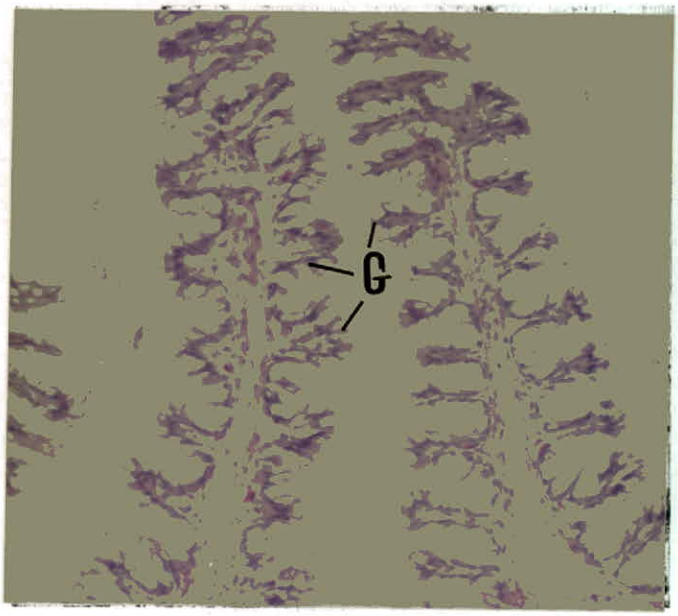
CT, Connective Tissue;

LP, Lamina Propria;

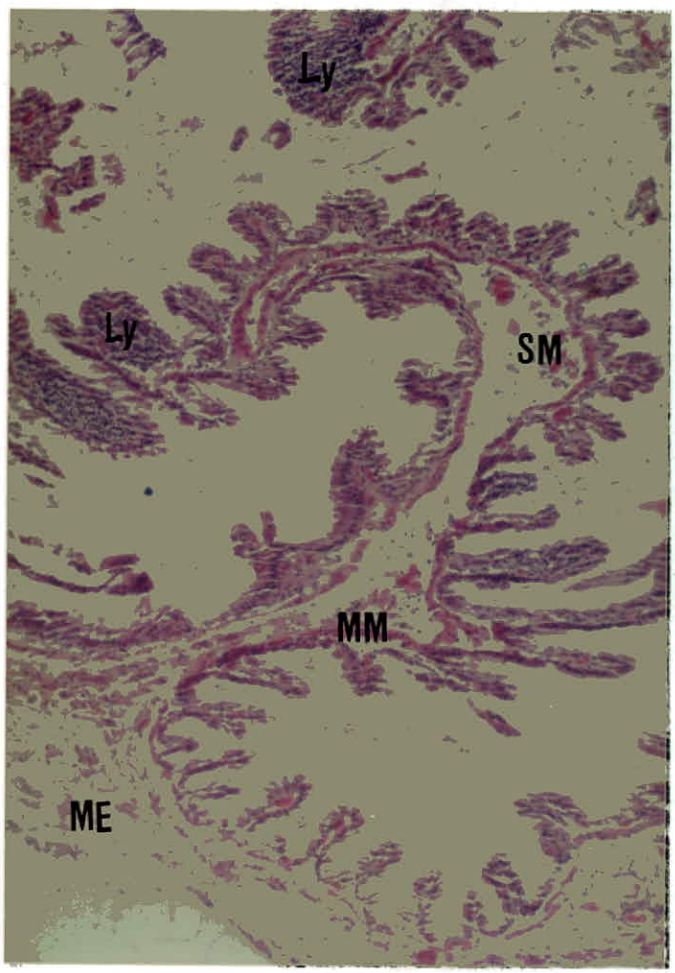
ME, Muscularis Externa;

MM, Muscularis Mucosa;

SM, Submcosa.



a.



b.

Fig. 54 T.S. of the rectal region of the large intestine. a. H&E X115.5, b. H&E x87.5, c. H&E X115.5.

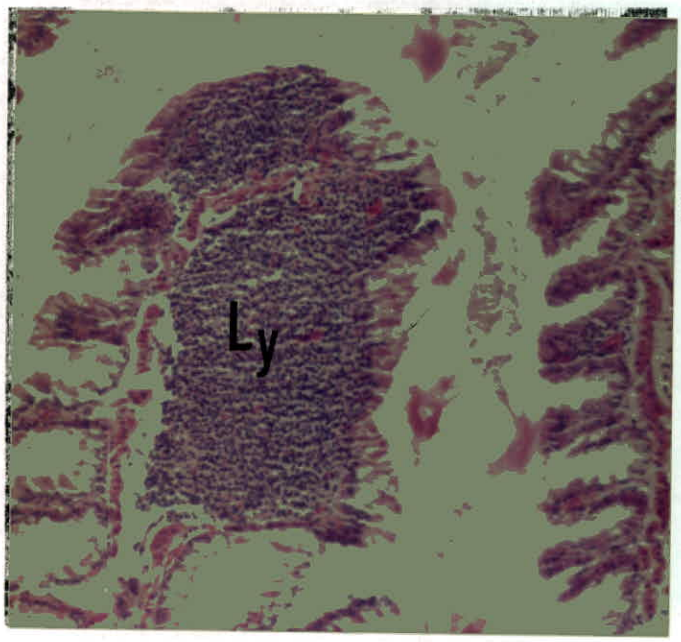
G, Goblet Cell;

Ly, Lymphoid ggregation,

ME, Muscularis Externa;

MM, Muscularis Mucosa;

SM, Submcosa.



c.

Fig. 54 (cont.)

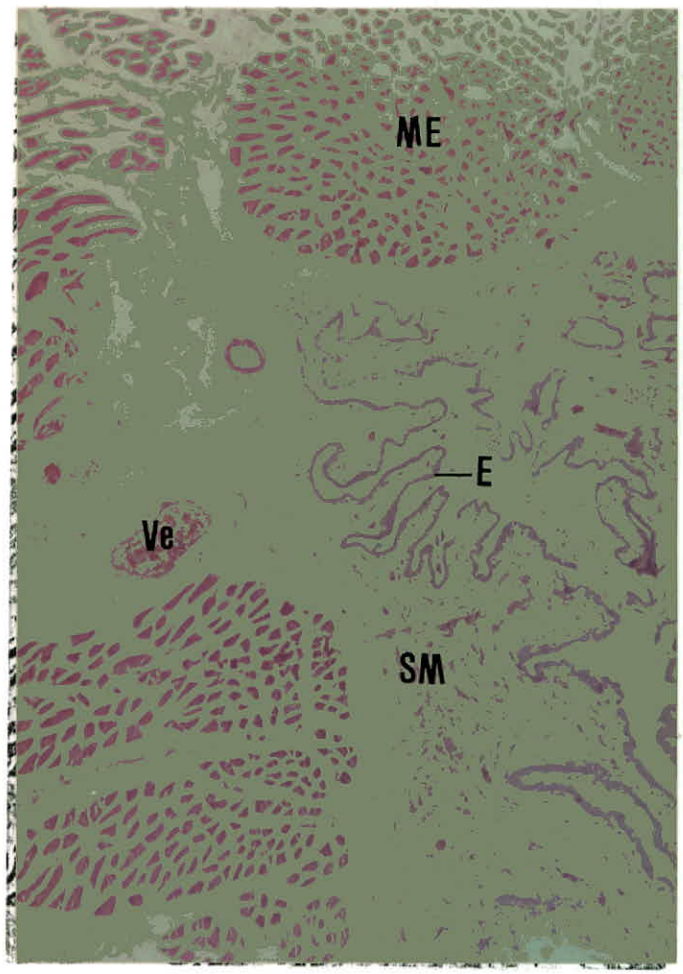


Fig. 55T.S. of the cloaca. (H&E X35).

E, Epithelium;

ME, Muscularis Externa;

SM, Submucosa; Ve, Vein.

Muscularis mucosa doesn't differ along the large intestine, it is also composed of thin circular layer of smooth muscles in the rectum (fig. 54 b). The submucosa of the rectum is almost of the same histological composition as the colon except that in the rectum it is more vascularized in some places (fig. 54b). The muscularis externa of the rectum is less developed than the colon because it is composed mainly of only one circular layer of smooth muscles (fig. 54 b). The serosa layer forms the outer layer for the colon and the rectum.

4.6 Histological Study of the Cloaca

The mucosa is greatly folded, lined with stratified squamous epithelium (fig. 55). The muscularis mucosa is not clear but the submucosa is a thick layer of connective tissue characterized by having a large number of different sized veins and arteries. The cloaca lacks any mucosal or submucosal glands. The muscular coat is much thicker than that of the large intestine and consists mainly of longitudinal skeletal muscles forming the outer muscle layer (fig. 55).

5- DISCUSSION AND CONCLUSION

5.1 Morphological Findings

The color pattern of the dorsal and ventral surfaces of the false-horned viper coincide with the descriptions given by Schmidt (1930) and Mendelssohn (1965). The only difference was in the color of the tail tip of ***P.p.fieldi***. Schmidt (1930), Mendelssohn (1965) and Disi (1990) stated that all adult male and female samples, have black tip. In this study only half of the male samples have a black tip and this character was not present in any of the three studied females. Underwood (personal communication, 1999) offered the author his observations of ***P.p.fieldi*** samples in the British Natural History Museum, London. He found that five of six male samples have a black tail tip and only one out of four female samples has a black tail tip. The results of this study and the informations obtained from Underwood indicate that not all adults of ***P.p.fieldi*** have the black tail tip. Also, this character is more dominent in males than females. This result exclude the role of female black tip in breeding as suggested by Mendelssohn (1965) who reported that waving of the female black tip may possibly act as sign stimulus. Further investigations are needed which can be performed by noticing the snakes along a whole year to be sure that whether the black tail tip feature is permanent or temporarly present according to breeding season.

Scale counts of the studied specimens are within the range of the reported studies (Schmidt, 1930; Marx and Rabb, 1965; Disi, 1983). Also, the results of the tail to total length ratio obtained in this study agree with ratios stated by the same authors (table 9).

Studying both pholidosis and measurements of the false-horned viper from different localities in Jordan do not show signs of sexual dimorphisms (table 5). The only exception was the black tail tip. But some differences were present between juvenile samples and adults, the head measurements were higher in juvenile in comparison with the total length with adults (fig.56). The tail to total length ratio also was higher in juveniles than adults. The comparison between juveniles and adults was not performed by previous studies. The only comparison was done by Schmidt (1930) and Mendelssohn (1965) who stated that juveniles lack the black tail tip as obtained in this study (table 3).

5.2 Anatomical Findings

The skull of ***Pseudocerastes persicus fieldi*** was found to have the snakes unique characteristics which allow to accomodate its feeding needs. Snakes, in general, face many challenges in capturing and swallowing their preys for being limbless carnivorous animals. So their skulls have evolved morphological adaptations that permit them to engulf a prey which is

Table 9 A comparison of *Pseudocerastes persicus fieldi* morphological descriptions by different authors with the present results.

Character	Schmidt (1930)	Marx&Rabb(1965)	Disi(1983)	This Study Observation
Mid dorsal scales	21&22(2)	21-23(5)	21-22(11)	21-22(14)
Ventral scales	134(1♂) 138(1♀)	134(1♂) 134-138(3♀)	127-142(11)	132-134 (4 juv.) 131-135 (7♂) 131-133 (3♀)
Subcaudal scales	35(1♂) 38(1♀)	35(1♂) 36-38(3♀)	34-46(11)	33-37 (4 juv.) 34-38 (7♂) 33-34 (3♀)
T/TO For adults	0.11(1♂) 0.12(1♀)	0.116(1♂) 0.105-0.118(3♀)	0.11-0.12(6)	0.10-0.12(10)
Upper labials Lower labials Scales around the eye	13&14(2) 14&16(2) 15,17&18(2)	.... 14-18(5)	12-14(11) 14-16(11) 14-18(11)	12-13(14) 14-16(14) 15-17(14)
Black tail tip	Present (1♂) Present (1♀)	....	....	Present (5♂),Absent(5♂) Absent (3♀) Absent (4juv.)

Numbers in parenthesis indicate number of specimens. Juv, juvenile.

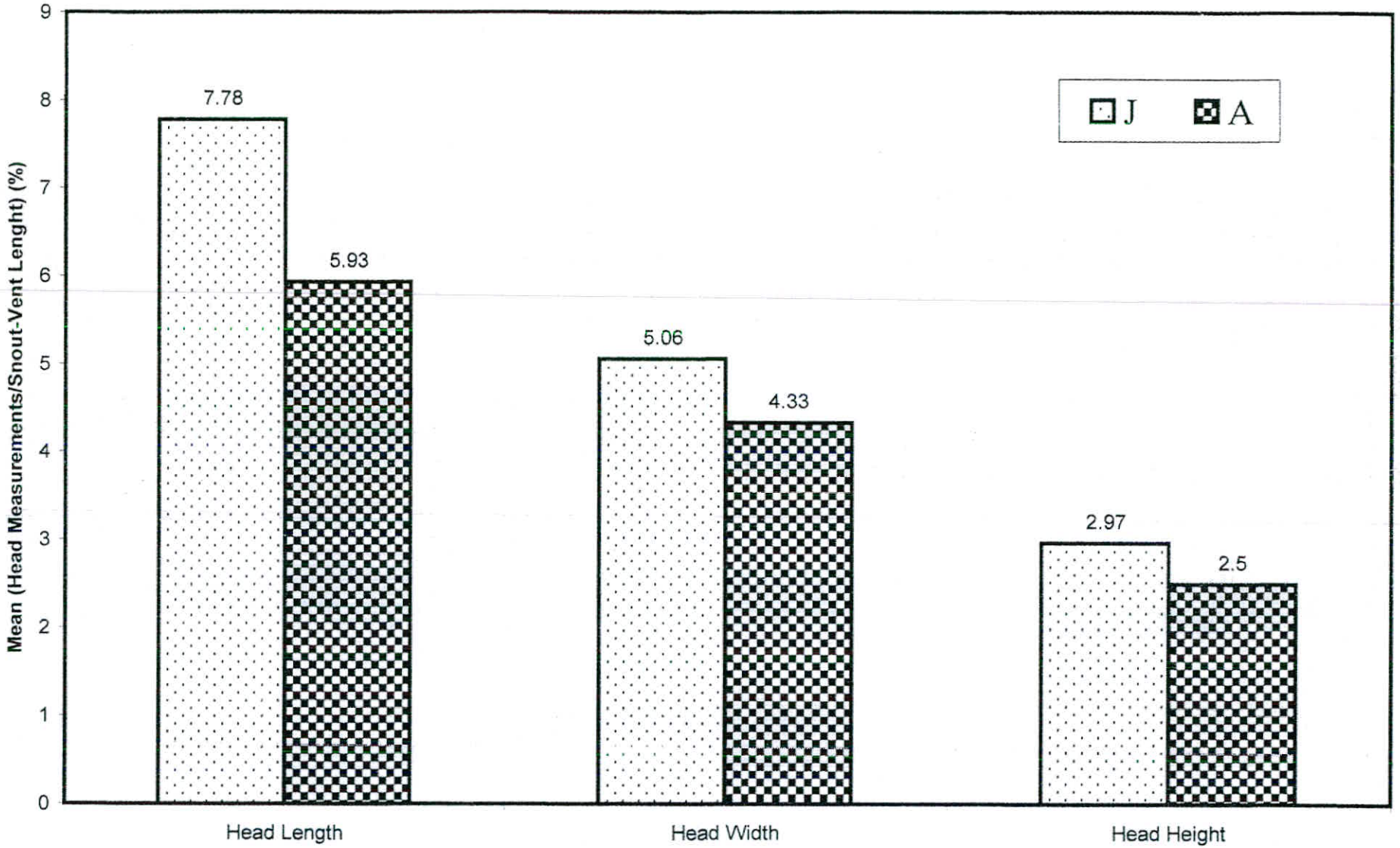


Fig. 56 Comparison of head measurements percentages between adult (A) and juvenile (J) samples of ***Pseudocerastes persicus fieldi***

considerably larger even several times than their heads and bodies diameter (Romer, 1976).

The evolution of the snakes skull is characterized by the dissociation of the upper jaw from the skull base. This is accompanied by a general loosening of the articulations between various bones of the plato-maxillary apparatus (consisting of the maxilla, palatine, pterygoid and ectopterygoid).

This investigation reveals that the jugal bones which link the upper jaw to the cranium have been lost. Also, the temporo-mandibular joint represented by the supratemporal bone and the quadrate has been liberated from the cranium and extended beyond the back of the head or occipital region. Moreover, the supratemporal which is only loosely set against the roof of the skull articulates with the quadrate bone by means of ligament. These bones, articulating at the back with the lower jaw make the temporo-mandibular joint, which explains the mechanism that yields great extension of the jaw providing a large opening that snake mouth is capable to perform. Similar findings were reported in taxa of the family Viperidae (Engelmann and Obst, 1981).

Another anatomical and functional modification includes the liberation of the mandibular tips from a firm attachment. This means that

the interquadrate distance is no longer the sole determinant of the maximum size of prey that can be swallowed. Also, in order to produce great freedom of the movement of the lower jaw two halves, a joint-like articulation is present between the two front lower bones (dentary and splenial bone), and the compound bone. These findings coincide with findings reported by Romer, (1976) and Engelmann and Obst, (1981) for colubrid and viprid snakes. All previously mentioned skull features supply the snake with the recommended flexibility during prey capturing, mouth opening and closing, pulling the prey inside the mouth (by hand over hand manner) which leads to swallowing it.

In comparing the skull descriptions of the examined ***Pseudocerastes persicus fieldi*** with previous findings, it can be stated that in outline the patterns of the constructions are in entire agreement with snakes belonging to the family Viperidae (Dullemeijer, 1956 & 1958) and more with the genus ***Vipera*** than ***Bitis***. Moreover, ***P.persicus fieldi*** cerebral skull and the head is narrower than ***Bitis*** (Boltt and Ewer, 1964), this may be because ***Bitis*** swallows relatively bigger prey than any other Viperidae (Dullemeijer,1958).

In spite of skull minute differences between ***Pseudocerastes*** and other members of the family Viperidae, but still the main skull architecture

is the same. They all depend on their venom to envenomate their prey and kill it. Prey capturing mechanism is initiated by the erection of venom fangs, this step involves the movement of a series of bones: pterygoid, palatine, ectopterygoid, prefrontal and maxilla as explained also for ***Bitis*** (Boltt and Ewer, 1964). To form an efficient striking mechanism, the maxilla is able to rotate foreward so that the fang moves from its almost horizontal, backwardly directed resting position to one in which its tip is directed vertically downwards. From observing the ***Pseudocerastes persicus fieldi*** striking mechanism by the author, it is found that changes in the position of fang, enable the viper to strike its prey and injects venom deep into it, then the snake leaves the prey to die before it engulfs and swallows it without any struggling.

The skull of ***P.p.fieldi*** differs from the Colubridae snakes skull which were examined by Cundall (1981&1983) and Cundall and Rossman (1984). With the trend for the reduction of maxillary dentition to paired fangs as in vipers, the maxilla becomes greatly shortened and more freely movable. On the contrary colubrid maxilla is more posteriorly extended bearing a large number of teeth. So predotary behavior of snakes may be closely associated with modification in anatomical and morphological features. The colubrid snakes swallow their prey with more jaw movements

and smaller in size than vipers (Pough and Groves, 1983) because they can not poison their prey and kill it before the engulfing process.

Another difference between ***P.p.fieldi*** and other viper and colubrid snakes was the teeth number on each teeth bearing bone. All Viperidae including the false-horned viper contain only one main fang on the maxillary bone. This study showed that the pterygoid, palatine, dentary bones of ***P.p.fieldi*** bear 8-10, 9-11, 12-14, teeth respectively which is more than other vipers that bear 5-8, 1-2, 3-6 teeth respectively (Dullemeijer, 1958). Also, by comparison of teeth number between the false-horned viper and colubrid snakes, it is clear that the latter have more teeth on each bone, maxilla (16-18), pterygoid (17-19), palatine (14-15), and dentary (21-24) (Dullemeijer, 1958; Mohammed, 1991; Rasmussem, 1996; Awwad, 1999) than the former.

The shape of the teeth is not very aberrant in the various Viperidae, all of them are conical and more or less curved (Dullemeijer, 1958). But in general, the tooth morphology is complex, because the surface features of the teeth differ not only between different genera but also according to dentition bearing bones of single species skull (Young and Kardong, 1996). In comparing the dentitional results of ***Pseudocerastes persicus fieldi*** with the descriptions of each category scored by Young and Kardong (1996), it

becomes clear that the dentary, pterygoid and palatine bones carry a type 1 teeth which lack any surface depressions and called the basic type. The maxillary fangs were a 4-type teeth or the hallow teeth as referred by them. The ***Pseudocerastes persicus fieldi*** teeth scoring results matches the results of the majority of species belonging to family Viperidae. This indicates that not only the number of teeth on each bone, but also the surface features of the teeth may have taxonomical importance among genera, subfamilies and families.

The head musculature of ***Pseudocerastes persicus fieldi*** are almost similar to members of the genus ***Vipera,*** these muscles are similar to the descriptions of the head muscles of ***Vipera palaestinae*** (Kochva, 1958). The main similarities between ***P.persicus fieldi*** and ***Vipera palaestinae*** are: The connection of the anterior fibers of the muscle adductor extrenus profundus to the venom gland to cooperate in the venom gland fixation in its position. Also, both snakes have thick, well developed compressor glandulae which functions mainly for ejaculating the venom from the gland. In ***Bitis,*** Dullemeijer (1958) suggested that venom release is to be performed by the adductor externus superficialis muscle which is more developed in ***Bitis*** than other vipers. The venom gland in the latter taxon hangs tightly on the joint between supratemporal and the quadrate bones. However, in ***Pseudocerastes persicus fieldi*** this hanging does not occur,

and the venom gland is fixed more anteriorly at the temporal region of the head.

This investigation shows that ***P.p.fieldi*** lacks the muscle levator anguli oris. Although, Haas (1973) reported that solenoglyphous snakes possess a distinct muscle levator anguli oris, but he marked two exceptions, ***Atractaspis*** and ***Vipera russelii***. So the existence of the muscle levator anguli oris can be of taxonomical value of the members belonging to the family Viperidae. The function of this muscle and its relation with the two compressors of glands, (compressor glandulae or adductor externus superficialis), have not been explained yet (Haas, 1973).

The structure of the investigated venom gland in the ***P.p. fieldi*** is equally shaped as viprid snakes. The venom gland position (temporal region of the head) and the several parts forming it (main venom gland, primary duct, accessory gland and secondary duct) were the same as in ***Vipera palaestinae*** (Kochva and Gans, 1965& 1967). However, the function of the accessory gland and its secretion are not completely understood (Gans and Kochva, 1965; Gopalakrishnakone and Kochva, 1993).

This study shows that there is no clear difference in the anatomy of trunk and cloacal vertebrae except that the latter have smaller sized vertebrae than the former (fig. 19). The vertebral column anatomical characteristics of the false-horned viper exhibits certain anatomical adaptations involving triple articulation of condyles, zygapophyses, and zygosphene – zygantrum; presence of sizable neural spine; presence of hypapophysis through all of the vertebral column; overlapping of neural arches, which permits special ligamentous connections. Similar observations were reported for vipers and some colubrids by Gans (1962). These adaptations allow the false-horned viper to achieve the greatest average complexity of movement. As it is able to utilize almost all kinds of progression which were recorded for this taxon beside being a sidewinder (Mendelssohn, 1965). The last type of movement is applied by ***P.p.fieldi*** because it lives mostly in the deserts as recorded by Marx (1965) and this was also confirmed according to the observations of its motility in captivity by the author.

The trunk vertebrae of the ***P.p.fieldi*** are characterized by the presence of clear hypapophysis. Same results were obtained for some viprid snakes (Hoffsterrer and Gasc, 1969), for ***Atractaspis*** (Underwood and Kochva, 1993) and for viperine and crotaline snakes (Underwood, 1998).

From studying the vertebrae of the false-horned viper no major differences between the trunk and the cloacal vertebrae were noticed. In the contrary in other species of snakes like some colubrids, the cloacal vertebrae are characterized by having haemapophyses instead of the hypapophyses (Mohammed, 1991; Awwad, 1999).

The structure and position of the testes, epididymes and ductus deference of ***Pseudocerastes persicus fieldi*** were basically as described for ***Vipera berus*** (Fox, 1977). The right testis is positioned anteriorly to the left, also, it is longer and thinner than the left one. These features are present in snakes in general in order to adapt to the elongated body form (Engelmann and Obst, 1981). The testes of the false-horned viper are non lobulated as described of ***Vipera berus*** (Fox, 1977), but differ from the primitive group of snakes,Leptotyphlopidae and Typhlopidae, where testes are lobulated (Fox, 1965). Accordingly, the structure of the testes can be used as a taxonomical tool among different snake families. Also, testes morphology is important in studying snake evolution because in primitive snakes the testes are multipartite (Werner and Drook, 1967).

In contrast to a true penis, the hemipenis does not possess a seminal duct, but simply a sulcus which form a groove along which the semen are conducted (Engelmann & Obst, 1981). The hemipenis of the false-horned

viper was bilobed containing bifurcate sulcus as present in ***Vipera xanthina*** (Murphy & Barker, 1980). However, clear variations exist between them concerning the number of rows of macroornamentation that are less in ***Vipera xanthina*** than ***P.p.fieldi*** .

The results summarized in table 4 show that the esophageal length is more in juveniles than in adults when compared with the actual length of the digestive tract. However, in both cases the esophagus is the longest part among other regions of the alimentary canal. Furthermore, no differences in the lengths of stomach is obvious. Also, clear variation is present for the intestine length which is longer in adults than juveniles in comparison to the length of the alimentary canal (fig.56). These observations may explain the change in length of certain organs of the digestive tract at different stages of age in relation to the feeding habits. Newly hatched snakes start by feeding on small organisms such as worms and lizards. As they become older, snakes engulf larger prey, birds and mammals, even if their diameter is more than the diameter of the snakes body. In both ages, the prey is large and rough, but in juveniles the esophageal tube is not as wide as for adults or number of goblet cells may be less in the esophagus of juveniles. Accordingly, the esophagus is longer in juveniles for producing more mucoid substances from the mucous cells to allow for easy passage of prey. But further investigations are needed to confirm this assumption. Chou

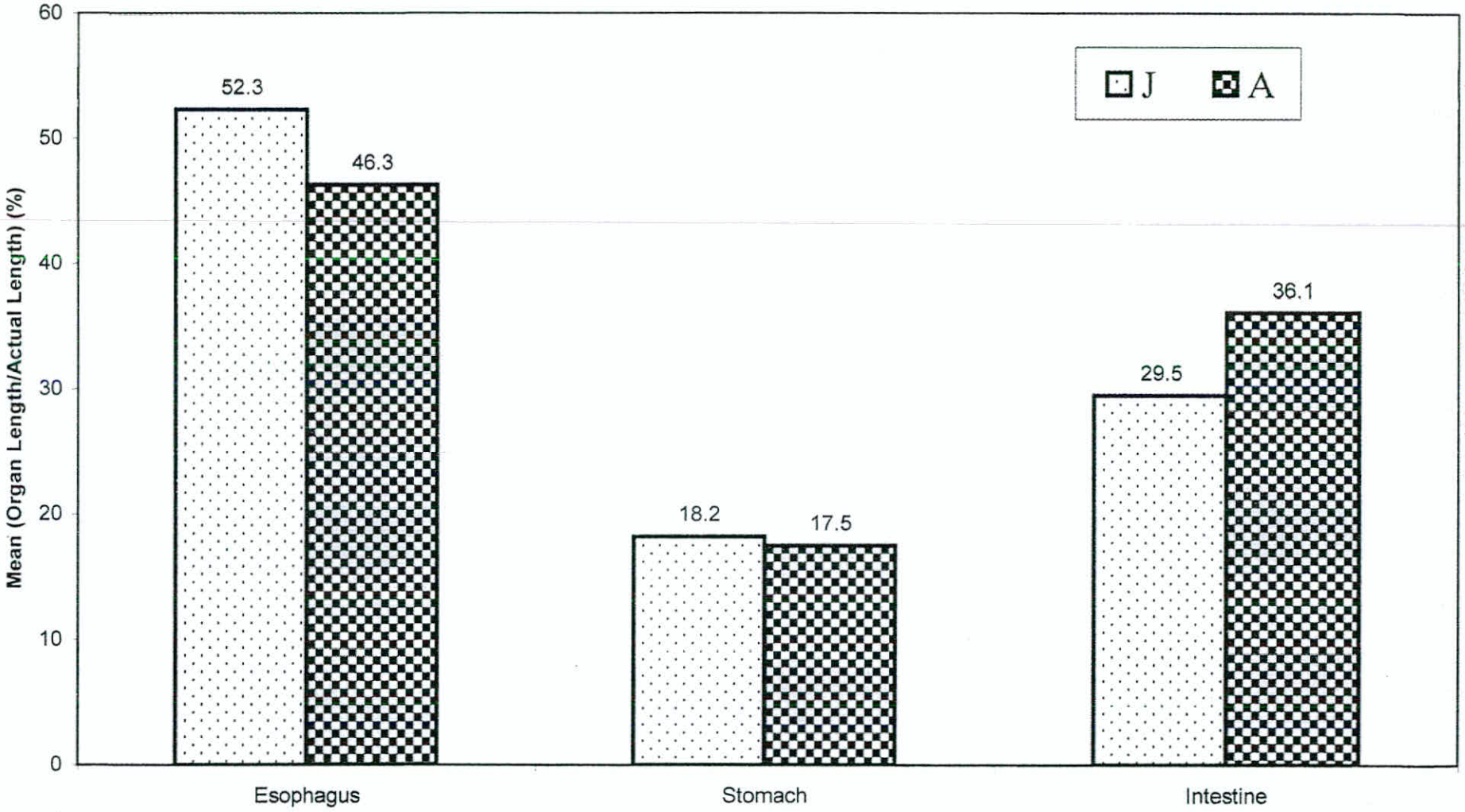


Fig. 57 Comparison between percentages of the digestive tract organs lengths of ***Pseudocerastes persicus fieldi*** in adults (A) and juveniles(J)

(1977) indicated that esophagus and stomach are provided with great number of mucous cells which act as lubricant, to facilitate the passage of rough-edged prey that is usually swallowed whole since there is no chewing occurs in the buccal cavity. The longer intestine for adults may be explained by more surface area needed for better absorption of the larger prey ingested than juveniles. Also, for the larger size of the discharged material which needs more amount of enterocytes and goblet cells in adults intestine.

The results of this investigation of the false-horned viper indicate that the esophageal foldings differ from other viprids discussed by Parsons and Cameron (1977). This difference was due to the presence of type-three relief and not type-two as they have reported in the family Viperidae. In the stomach of the studied taxon, the rugae are longitudinal and broad, running throughout the length of the stomach and the wall between folds has spongy appearance. In the small intestine, the folds are similar to the general viprid pattern. The folds become low and straight posteriorly till the beginning of the colon. ***P.p.fieldi*** has no distinctive pattern of colonic relief, only simple and few permanent folds are present. However, the rectum has slightly thicker wall with higher and more clear transverse folds. The above descriptions of the stomach, small and large intestine folding patterns coincide with Parsons and Cameron (1977).

5.3 Histological Findings

This study indicates that the light microscopic features of the main venom gland agree with the descriptions of the viprid snakes venom glands (Kochva and Gans 1965 & 1967). The epithelial cells of the main venom gland are of two types, secretory columnar and horizontal cells. Similar findings were reported by Shaham and Kochva (1969) and Ben-Shaul *et al.* (1971). These findings differ from the description of elapid snakes venom glands (Gopalakrishnakone and Kochva, 1993). In elapids one cell type, cuboidal epithelial cells were present. This variation may have taxonomical value between different families of venomous glands.

The cytoplasmic granules that are present in the epithelial cells of the main venom gland were found at different levels within the cells. This distribution of granules within different cells heights may indicate that the secretion of venom is an apocrine process. The different heights of the columnar epithelial cells seen in this study (fig. 22b&c) may be due to different stages of secretion. This finding agrees with the theories presented by Shaham and Kochva (1969) and Ben-Shaul *et al.* (1971) for the venom gland of ***Vipera palaestinae***.

The mucosa of the whole alimentary canal is lined with simple columnar epithelial cells, which appear ciliated in the esophagus, since the

general trend in vertebrate esophageal lining in stratified squamous epithelial cells and non ciliated. So further investigations are needed to verify the present finding. This is best accomplished by and ultrastructural study. The goblet cells are abundant in the esophagus, present in the small intestine, enormous in the large intestine and absent in the mucosa of the stomach (table 9). The obtained results of this study indicate that the mucosa of the alimentary canal in ***P.p.fieldi*** is greatly similar to the basic reptilian pattern. Acid mucopolysaccharides are highly concentrated in the goblet cells, which in turn are abundantly found in the esophagus, small and large intestine. Moreover, the columnar epithelial cells of the esophagus and stomach, as well as the pit and neck cells are stained positively for neutral mucopolysaccharides. These findings were similar to those of other reptiles especially lizards (Chou, 1977; Dehlawy and Zaher, 1985b; Zaher *et al.*, 1987; Dehlawy *et al.*, 1988), geckos (Dehlawy and Zaher, 1985a; Dehlawy *et al.*, 1987; Amer *et al.* 1987), the viper ***Echis carinatus*** alimentary tract mucosa (Amer *et al.*, 1987).

The abundance of acid mucopolysaccharides in the esophagus is very likely to facilitate swallowing (Amer *et al.*, 1987). In the small and large intestine, acid mucopolysaccharides have protective role and in large intestine they aid in the discharge of the undigested material (Taib, 1984;

Table 10 Summary of the mucosal cells and types of their secretions of the alimentary canal of *Pseudocerastes persicus fieldi*

Organ	Acid Mucopolysaccharides (AB)	Neutral Mucopolysaccharides (PAS)
-Esophagus		
Ciliated columnar epithelial cells	-	+
Goblet cells	+	Few
-Stomach		
Columnar epithelial cells	Few	+
Pit cells	Few	+
Neck mucous cells	-	+
Main glandular cells	-	-
Pyloric glands	-	+
-Intestine		
Enterocytes	-	-
Goblet cells	+	Few
-Cloaca		
Stratified squamous Epithelial cells	-	-

+ Present , - Absent

Amer *et al.* 1987). In the esophagus, the multicellular esophageal glands are absent. Similar feature was also observed in other reptiles (Dehlawy and Zaher, 1985a&b; Zaher *et al.*, 1987).

The bodies of the glands in the corpus region of ***P.p.fieldi*** stomach are formed of granulated main gland cells. These cells were termed as "dark" cells by Gabe and Saint Girons (1972) in many reptiles including some colubrid and boid snakes. Luppa (1977) investigated the ultrastructure of these cells and strongly suggested that the so-called "dark" cells of the glands of the corpus region function in production of both pepsinogen and hydrochloric acid. Also, he suggested the substitution of "dark" cells by the term "main gastric glandular cells". The function of the main gland cells which is the production of both pepsinogen and hydrochloric acid was also suggested by Bellairs (1970) in lizards and by Chou (1977) for the gecko ***Gehyra mutilata***. This investigation also reveals that the fundus gastric glands contain only one type of cell after excluding pit and neck mucous cells (table 8).

The stomach of the false-horned viper is characterized by having the thickest muscularis externa. This arrangement of the muscle coat allow for a great dilation in diameter for being served as a storage bag for the prey till it is digested. The small and large intestines are comparatively short

(less than 40% of the digestive canal length) and therefore, typical of carnivorous nature of ***P.p.fieldi***. In herbivorous reptiles, such as tortoises, the small and large intestine are of great lengths since food of plant origin are more resistant to digestion than animal food (Bellairs, 1970).

Small intestine of the false-horned viper lacks crypts and Paneth cells. The absence of intestinal crypts in four vipers and colubrid snakes was also reported by Vialli (1929) and in the common green snake studied by Reis and Lyons (1943). Also, loss of Paneth cells was stated by Vialli (1929) in certain snakes including members of the families Colubridae and Viperidae. The small intestine of ***P.p.fieldi*** is characterized by having poorly developed muscularis mucosa. Similar results were reported for the common green snake ***Thamnophis sirtalis*** (Reis and Lyons, 1943).

The boundary between esophagus and stomach in the false-horned viper lack any sphincter. However, two valves are present between the stomach and the small intestine and between small intestine and large intestine of ***P.p.fieldi.*** Similar technique findings were reported by Ferri *et al.* (1974) for ***Xenodon merremii*** and Luppa (1977) for some colubrid and boid snakes.

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7- Appendix A

Preparation of Fixatives

Formalin Fixative (10%) (Taib and Jarrar, 1990)

Formalin 40%	100ml
Sodium Monophosphate	4g
Sodium Diphosphate	6.5g
Distilled Water	900ml

Zenker's Fixative (Taib and Jarrar, 1990)

Mercuric Chloride	50g
Potassium Dicromate	25g
Sodium Sulfate	10g
Glacial Acetic Acid	50ml
Distilled Water	950ml

Preparation of solutions

Acid Fuchsin Solution

Acid Fuchsin	0.2g
Saturated Aqueous Picric Acid (about 1.22%)	100ml

Alcian Blue (pH=1.0)

Alcian Blue	1g
Hydrochloric Acid 0.1m	100ml

Alcian Blue (pH=2.5)

Alcian Blue	1g
Glacial Acetic Acid (3%)	100ml

Aniline Blue Solution

Aniline Blue	0.5g
Orange G	2g
Oxalic Acid	2g
Distilled Water	100ml

Eosin-Y

Eosin	1g
Phloxin B	10ml
95% Ethanol	780ml
Glacial Acetic Acid	4ml
Distilled Water	100ml

Fast Green Solution

Fast Green	0.1g
Acetic Acid 1%	100ml

Harris Hematoxylin

Hematoxylin 10%in Absolute Ethanol	10ml
Mercuric Oxide	0.5g
Potash Alum (10%)	200ml
Glacial Acetic acid	4ml

Iron Hematoxylin

Solution A

Hematoxylin 10% in Absolute Ethanol	100ml

Solution B

Ferric Chloride 30%	4ml
Hydrochloric Acid (1m)	1ml
Distilled Water	95ml

Just before use, mix A and B solutions.

Mayer Hematoxylin

Hematoxylin	1g
Aluminium Pastassium Sulfate	50g
Chloral Hydrate	50g
Sodium Iodate	0.2g

Citric Acid	1g
Distilled Water	1L

Schiff Reagent

Basic Fuchsin	1g
Sodium Meta-Bisulfate	1.9g
Hydrochloric Acid (1m)	15ml
Distilled Water	85ml

Van Gieson Solution

Acid Fuchsin	0.1g
Saturated Aqueous Picric Acid	100ml
(about 1.22%)	

8-ABSTRACT

(IN ARABIC)

الملخص

دراسة مظهرية وتشريحية لبعض الأجهزة في الأفعى ذات القرون الكاذبة

Pseudocerastes persicus fieldi (Schmidt, 1930)،

والتي تتبع عائلة الافاعي السامة ، Viperidae.

إعداد

زليخـــة سعيـــد أبو النيـــل

المشـــرف

أ. د. أحمـــد الديســـي

اجري هذا البحث لغرض التعرف على الصفات التشريحية والنســـيجية والوصفيـــة لبعـــض الأجهزة الحيوية في الأفعى ذات القرون الكاذبـــة ، ***Pseudocerastes persicus fieldi*** (Schmidt, 1930) ، من عائلة الأفاعي السامة التي تنتشر انتشـــارا واســـعا فـــي الصحـــراء الشرقية من الأردن. لقد بنيت الدراسة الوصفية للأفعى ذات القرون الكاذبة على وصف ســـبعة عشر عينة محفوظة . ومن الملاحظات التي لم تذكر في دراسات سابقة ، وجود نهاية سوداء فـي ذيول نصف عدد عينات الذكور وخلو ذيول الإناث من هذه الصفة . كذلك كانت قياسات الـــرأس بالنسبة للطول ، من مقدمة الرأس إلى فتحة الشرج ، عند العينات الغير بالغة اكـــبر منـــه عنـــد العينات البالغة . وكذلك لوحظ عقد دراسة أعداد الحراشف والقياسات العامـــة للأفـــاعي انـــه لا توجد فروق واضحة بين الجنسين .

لقد بينت هذه الدراسة تشابه كبير في بناء الجمجمة بين الأفعـــى ذات القـــرون الكاذبـــة والأفاعي التي تنتمي إلى عائلة الأفاعي السامة ، Viperidae، وخاصة الى الجنـــس ***Vipera***، وقد وجد أن عدد الأسنان المحمولة على العظمات الجناحية ، الحنكية والسنية عند هذه الأفعـــى اكبر من عدد الأسنان التي تمت دراستها عند أفراد آخرين من عائلة الأفاعي السامة ، لكن اقـــل من أفراد عائلة الثعابين الأصيلة . بالنسبة لعضلات الرأس فقد تميزت بوجود واضـــح للعضلـــة الضاغطة الغدية ، Compressor glandulae ، المهمة في قذف السم من الغدة السمية إلـــى

الناب . وكذلك غياب العضلة الرافعة الزاوية ، Levator anguli oris ، التي سجل وجودها في جميع الحيات ذات الناب الامامي المتحرك . وقد لوحظ من خلال تناول العمود الفقري وجود بعض الصفات الخاصة التي تمكن هذه الأفعى من ممارسة جميع أنواع الحركة المعروفة للحيات . وتتمثل هذه الصفات بوجود ثلاث أنواع من الروابط بين كل فقرتين متتابعتين ، كذلك وجود شوكة عصبية واضحة ونتوء سفلي ، Hypapophysis ، على طول العمود الفقري . وقد تمت دراسة الجهاز التناسلي الذكري تشريحيا حيث تميز بتكون الخصيتان من جزء واحد وان الخصية اليمنى تقع اقرب للرأس من اليسرى. وكذلك بوصف خاص لشبه القضيب الهام جدا في عملية تصنيف الحيات .

اشتملت هذه الدراسة على وصف تشريحي ونسيجي للغدة السمية في الأفعى ذات القرون الكاذبة وقد وجد أنها تشبه في تركيبها الغدد السمية للأفاعي السامة وخاصة الأفعى السامة الفلسطينية ، ***Vipera palaestinae***. وقد تم استخدام سبع عينات محفوظة للدراسة التشريحية وعينتان حيتان للدراسة النسيجية . لوحظ أن طول المريء بالنسبة لبقية الأجزاء المكونة للقناة الهضمية هو الأكثر عند العينات البالغة والصبية . وكذلك أن طول المريء عند العينات الغير بالغة بالنسبة لطول بقية أجزاء القناة الهضمية اقل منه عند الأفاعي البالغة بعكس طول الأمعاء التي تبين أنها أطول عند الأفاعي البالغة . تبين من خلال الدراسة النسيجية وجود كمية كبيرة من السكاكر المخاطية الحامضية في الخلايا الكأسية المنتشرة في الطبقة المخاطية للمريء، الأمعاء الدقيقة والأمعاء الغليظة . أما السكاكر المخاطية المتعادلة فقد وجدت بكثرة في الطبقة المخاطية للمعدة وان الطبقة العضلية الخارجية كانت اكثر كثافة في المعدة. وبشكل عام فقد كانت المكونات الرئيسية للطبقات المكونة للقناة الهضمية في الزواحف موجودة في النوع المدروس مع وجود بعض التغيرات التي من شأنها أن تساعد الأفعى على التكيف مع عاداتها الغذائية .