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DEVELOPMENT OF THE DIGESTIVE SYSTEM OF THE FRESH WATER TELEOST, *GAMBUSIA AFFINIS* HOLBROOKII. VI. INTESTINAL CAECUM

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ABSTRACT

The development of the intestinal caecum of the viviparous teleost, ***Gambusia affinis*** *Holbrookii, was studied. Embryonic and adult stages were examined. The single intestinal caecum found in* ***Gambusia*** *started differentiation as evagination from the anterior intestine just behind the oesophagus. Mucosa, submucosa and muscularis were differentiated. The anterior portion of the caecum had tubular glands while the posterior protion was devoid of any glands. The caecum was elongated on the midline of the fish and was extended posteriorly. The functional significance of these structures was discussed.*

INTRODUCTION

Major subdivisions of the alimentary tract are bucal cavity, pharynx (buccopharyngeal cavity in some fishes), oesophagus, stomach and intestine. Associated with the tract are accessory organs such as tongue, taste buds, teeth, oral glands, liver, gall bladder and pancreas. In addition, blind evaginations, or caeca, may be found (Lagler *et al.* 1977; Bond, 1979; kent, 1987).

Intestinal caeca are present in some fishes (Suyehiro,1942 Rahimullah, 1945; Das and Moitra, 1956; Mohsin. 1962; Stroband and Dabrowski, 1982; Hussain and Dutta, 1988). The number of caeca ranges from one, as in polypterus (Bond, 1979), to 200 or more, as in mackerels (Bishop and Odense. 1966). Intestinal caeca may be histologically and morphologically similar to the proximal intestine (Islam,1951; Kapoor, 1958b; Jansson and Olsson 1960; Lal *et al.* 1964) or may be different from it (Al - Hussaini.1949; Strowband and Dabrowski, 1982; Hussain and Dutta, 1988). Intestinal caeca may be involved in digestion and absorption (barrington. 1957; Bond, 1979) or may act for harbouring bacteria (Rjomer, 1966, Lagler *et al.*, 1977; Bond 1979).

In the present work, the development of the intestinal caecum of *Gamusia affinis* was studied. The differentiation of different components of this structure was correlated with its possibile functions.

MATERIAL AND METHODA

Development of the intestinal caecum was studied by examining embryonic stages as well as the adult stage of Gambusia affinis Holbrookii Developmental stages were identified basically according to significant developmental changes in the intestinal caecum. Embryonic and adult tissues were fixed, embedded in paraffin, and serial sections were stained with different stains according to the methods of Soliman *et al.* 1992). Reconstruction of different developmental stages were made from serial transverse sections using a camera lucida.

RESULTS

ATAGE (1) (Figs 1.1-1.3)

The yolk sac seems to be completely absorbed. The total length of the embryo is about 8 mm.

A caecum - like structure was evaginated from the anterior intestine just behind the oesophagus (Figs. 1.1-1.3). This evagination extended to the middle of the embryo and represents the beginning of an intestinal caecum.

STAGE (2) (new born stage) (Figs 2.1 - 2.6)

The new born fish looks like the adult in that the head is dorsoventrally depressed and is occupied with large eyes and a superior terminal broad mouth. The total length is about 10.5 mm.

The caecal evagination from the anterior intestine extended posterioely on the middle line of the embryo forming an intestinal caecum (Figs 2.1-2.6). This intestinal caecum opens into the anterior intestine through a narrow valve - like opening (with a luminal diameter of about 25 um) (Fig. 2.2).

The wall of the intestinal caecum consists of mucosa, submucosa, muscularis and serosa. The mucosa is folded and consists of simple columnar cells which rest on a basement membrane rich in reticular fibres (Fig. 2.6). There are no mucous secreting cells in the mucosa. The submucosa contains tubular glands which are PAS negative. The muscular layer is thin and attaches the intestinal caecum with the anterior intestine. The posterior portion of the caecum is devoid of glands and has a less folded mucosa (Figs. 2.4-2.6). The lumen of the intestinal caecum contains food stuffs as the new born fish started its external feedig.

STAGE (9) (Adult stage) (Figs 3.1-2.6)

The maximum total length of the adult fish is about 6 cm. The head is dorso - ventrally depressed and is occupied with a superior terminally positioned mouth. The rest of the body, lie trunk and tail, are laterally compressed and are occupied with the different fins, pectoral, pelvic, dorsal, and caudal fins.

The intestinal caecum extended posteriorly on the middle of the embryo (Fig. 3.1). This narrow caecum is histologically similar to the rest of the intestine in being built up of the four ordinary layers, the mucosa, submucosa, muscularis and serosa. The differences which can be observed are that the submucosa contains tubular glandular structures near to the point of contact with the intestine (Figs 3.2, 3.3). Also, the mucosal cells have no striated border, like that of the intestine, but it has a subapical zone intensively stained with PAS stain (Figs 3.5, 3.6). There are dense collagenous (Fig. 3.3) elastic (Fig. 3.4) and reticular (Fig. 3.5) fibres in the mucosa of the caecum.

DISCUSSION

The alimentary tract of fishes has been the subject of many investigations, including morphological, histological and histochemical studies as well as studies dealing with absorptive mechanisms and the enzymatic equipment to determine the function of many specialized anatomical structures in relation to the different feeding adaptations (Jacobsen, 1939; kapoor *et al.*, 1975; Noaillac - Depeyre and Gas, 1976; Stroband and Debets, 1978; Ezeasor and stokoe, 1980 1981; Ferraris and Ahearn, 1984).

The intestine of *Gambusia* started as a narrow tube. Then, this tube incresed in length, coiled and was differentiated into its different regions (Agmy *et al.*, 1992).

Caeca are blind diverticulae from the gut that are common among fishes' especially in species lacking spiral valve (Kent, 1987). There is a controversy as to whether these tiny structures should be called pyloric caecae or intetinal caeca

(Dawes. 1929; Blak; 1930; Rahimullah, 1945; Mohsin. 1962; Groman. 1982; stroband and Dabrowski. 1982; Jossain and Dutta, 1988).

In *Gambusia*, one intestinal caecum was formed from the proximal part of the intestine just posterior to the end of the oesophagus prior to the new born stage. This caecum is connected to the intestine through a narrow, valve - like connection. This caecum has an extensive mucosal folding and has glandular structures in the submucosa of its anterior portion.

As *Gambusia* does not passess an obvious stomach (Bullock 1967; Agamy *et al.*, 1992); the caecum develops solely from the intestine; and hence is called intestinal caecum. From developmental studies, Hossain and Dutta (1988) reported that caeca of the stomach - bearing bluegill, *Lepomis macrochirus* develop from the intestinal tissue and therefore should not be referred to as pyloric cacae. Hossain and Dutta (1988) concluded that the number of caec is determined by the number of obstructed mucosal folds and the magnitude of the constriction at the gastro - intestinal junction. However, Lau and Shafland (1982) and Richard (1982) observed gut partitions by constriction in larvae of snooke and muskellunge, but no information was given on caeca. In addition' not all stomach - bearing fishes have caeca (Suyehiro, 1942; Rahimullah, 1945; Al - Hussaini. 1946; Mohsin, 1962; De Groot;1971; Tyler 1973; Groman, 1982). This establishes that constriction may occur between the stomach and intestine or through the intestine without caecum formation.

The single intestinal caecum observed in *Gambusia* has not been reported by Bulock (1967) who has done morphological and histological studies on the alimentary tract of *Gambusia affinis*. This may be due to its small size. There is variation in the number of intestinal caeca among different species of fishes as well as among individuals of a given species. For example, *Polypterus* has only one (Bond. 1979) and the yellow perch has three (Weisel, 1973), In others, such as mackerels (Bisop and Odense, 1966). salmons and sea nails (Bond, 1979), the number of these caeca may reach 200 or more. Variations in number of caeca among individuals of a given species were seen in family *Centrachidae* and *perca flavescense* (Reifel and travill, 1978). and in *Salvelinus namycush* (Martin and sandercok. 1967) and in *Gadusia shapra* Kapoor, 1958a).

Although morphological, histologicl (Islam, 1951; Kapoor. 1958b; Lal *et al.*, 1964) and ultrastructural (Jansson and Olsson, 1960) similarities have reported between these caeca and the proximal intestine. Some differences have been observed between the same structures in *Gambusia*. The itestinal caecum of *Gambusia* lacks mucous secreting cells, is partitioned by the mucosal folds, and has glandular structures in its submucosa. In addition, the supranuclear region of its mucosal cells is strongly PAS - positive, indicating its active secretory function. Tubular glands were demonstrated in the submucosa of the intestinal caecum. Also, there were dense fibres in the caecal submucosa.

There is a controversy on the function of these caeca Two major opinions could be concluded from the literature:

1) The function of caeca probably involves both digestion and absorption. This opinion depends on the isolation of digestive enzymes from the caeca of many species (Barrington, 1957; Bond, 1979).

2) These caeca function for harbouring intestinal bacteria. This opinion

depends on the similarity between fish caecae and caeca of insects (Andrew, 1959) and man (Romer, 1966) which have similar functions.

In the present work. three observations of the intestinal caecum of *Gambusia* are in favor of the first opinion which suggests a digestion and absorptive function of the caecum. These observations are :

1) The presence of exogenous food in the caecal lumen.

2) The presence of glandular structures in the caecal subumucosa. and

3) The presence of strongly PAS - positive material in the supranuclear spaces of mucosal cells which may represent secretory or absorbed materials.

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LIST OF ABBREVIARION

Col	Collagen
EF	Elastic fibres
H. E	Haematoxylin and eosin
I	Intestine
Live	Liver
M	Mucosa
MC	Mucous secreting cells
M. T. C.	Masson stricrome stain
MU	Muscularis
Oes	Oesophagus
RF	Reticular fibres
SB	Swim bladder
Se	Serosa
SM	Submucosa

EXPLANATION OF FIGURES

Fig. (1.1) : Reconstruction of the digestive tract of stage (1) showing evagination from the anterior intesting (I) just behind the oesophagus (Oes). This evaginated part of the intestine represents the primordium of the intestinal caecum (IC). X 49.

Figs (1.2 -1.3) : Transverse sections at level (A) of Fig. (1.1) showing the intestinal caecum. X 117.

Fig. (1.2) : Shows evagination from proximal part of the anterior intestine (I). This evagination is the primordium of intestinal caecum (IC). H. E. stain.

Fig. (1.3) : Shows the mucous secreting cells (MC) of the intestinal mucosa (I) and intestinal caecum (IC). P. A. S. Stain.

Fig. (2.1) : Reconstruction of the digestive tract of stage (2) showing that the intestinal caecum (IC) has extended posteriorly. X49.

Fig. (2.2) : T. S. at level (A) of Fig. (2. 1) showing the narrow connection between the anterior intestion (I) and the intestinal caecum (IC) . H. E. stain. X 117.

Fig. (2.3) : T. S. at level (B) of Fig. (2. 1) showing that the wall of the of the anterior portion of the intesinal caecum consists of mucosa (M), submucosa (SM) and muscularis (MU). Tubular glands (TG) are found in the submucosa of the intestinal caecum. Smooth muscles (SmM) attach the intestinal caecum with the anterior intestine. H.E. stain. X24.

Figs. (2.4 - 2.6) : Transverse sections at level (C) of Fig. (2.1) Showing the posterior portion of the intestinal caecum.

Fig. (2.4) : Shows the less folded mucosa (M) and the well developed muscularis (Mu). H. E. Stain. X 234.

Fig. (2.5) : Shows dense collagenous fibres (Col) in the submucosa. M. T. C. Stain. X 234.

Fig. (2.6) : Shows dense reticular fibres (RF) in the submucosa and PAS positive material (arrows) in the mucosal Cells. P.A.S. Stain. X 468.

Fig. (3.1) : Camera lucida drawing of the digestive tract of the adult fish showig the narrow elongated intestinal caecum (IC). X10.

Figs. (3.2-3.6) : Transverse sections at level (A) showing the intestinal caceum.

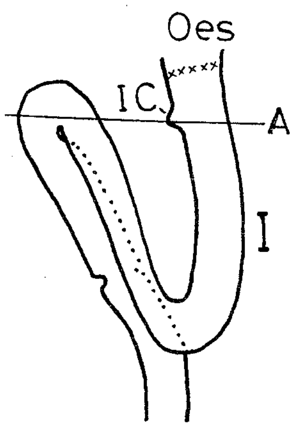
Fig. (3.2) : Shows the mucosa (M), submucosa (SM) and muscularis (Mu) of the intestinial caecum. The mucosa is folded forming septa inside the caecal lumen. H. E. stain. X 117.

Fig. (3.3) : Shows the collagenous fibrs (Col) and tubular glands (TG) present in the submucosa. M. T. C. stain. X 234.

Fig. (3.4) : Shows the elastic fibres (EF) of the submucosa. Orcein stain. X 234.

Fig. (3.5) : Shows the reticular fibres (RF) of the submucosa and the subapical PAS positive region of the mucosal cells (arrows). P.A.S. Stain. X 234.

Fig. (3.6) : Higher maginfication showing that the subapical PAS Positive Zone of the mucosal cells (arrows) is located inside the cell membranes. Note the extensive reticular fibres (RF) of the submucosa. P.A.S. stain. X 468.



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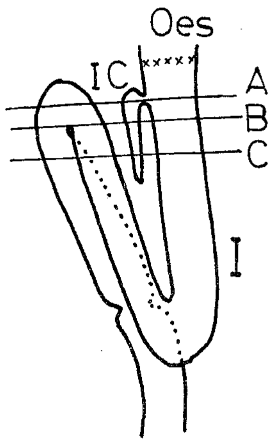

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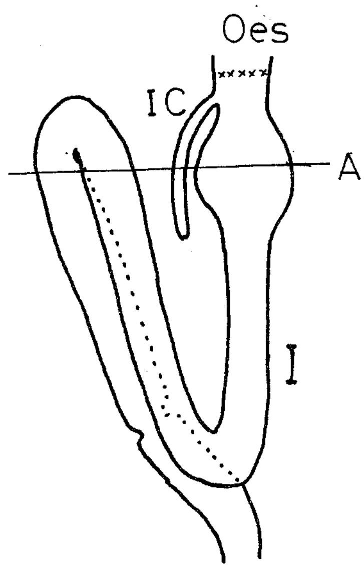

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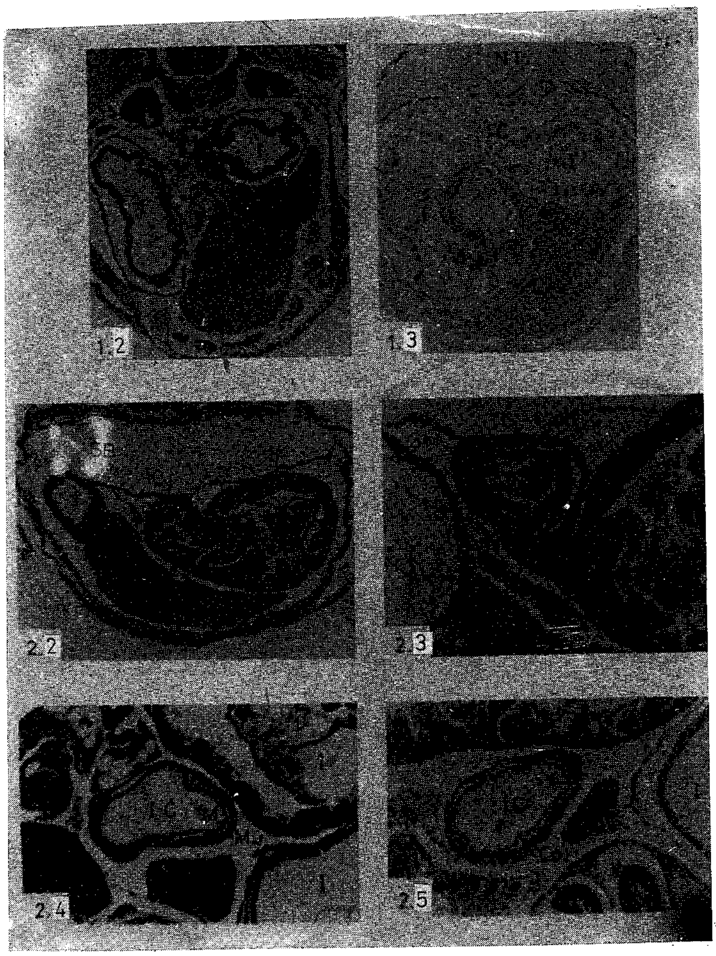
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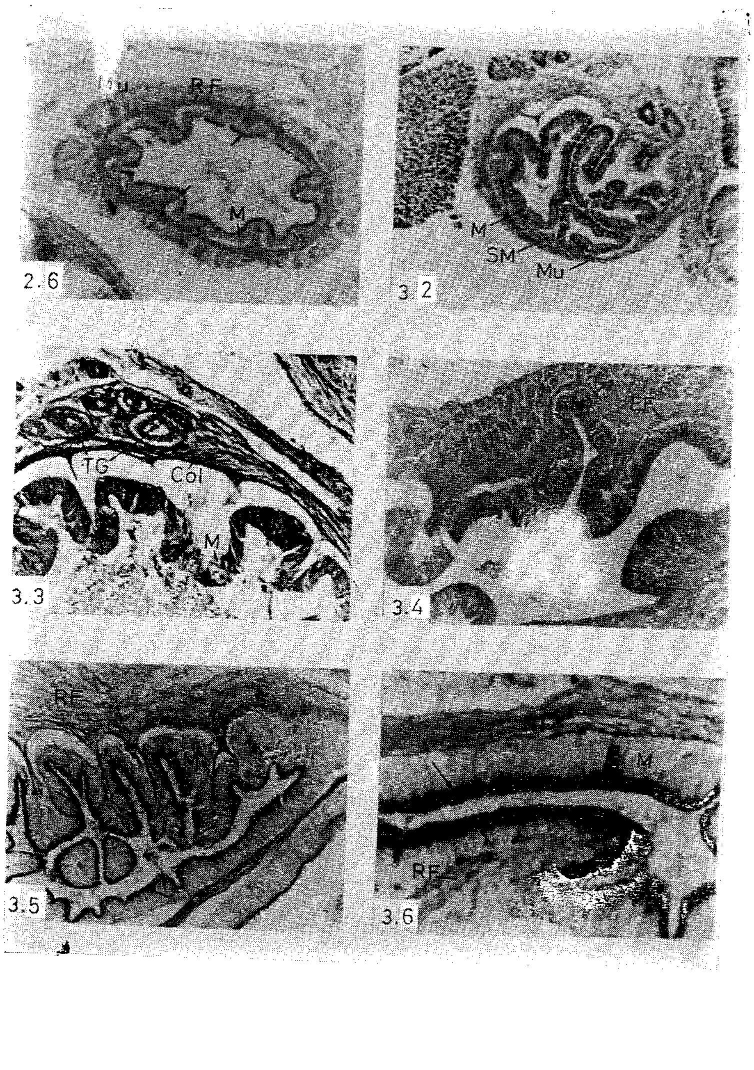
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التكوين الجنينى للردب المعوى فى السمكه العظمية جامبوزيا افينس هولبروكى

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تم دراسة التكوين الجنينى للردب المعوى فى السمكة العظمية، جامبوزيا أفنيس هولبروكى. وتم فحص أطوار جنينية بالأضافة الى السمكه اليافعة ، وقد وجد ردب معوى واحد فى سمكة الجامبوزيا. بدأ هذا الردب تميزه كبروز من المنطقه الأماميه للامعاء خلف المرىءمباشرة . ثم تميزت الطبقات المخاطية والعضلية. ولقد وجدت غدد أنبوبيه فى الجزء الأمامى للردب المعوى بينما خلا الجزء الخلفى من أية غدد. ثم أستطال الردب المعوى وظهرت مواد مصبوغة بشده بصبغة الشيف وذلك فى خلايا الطبقة المخاطيه . وقد تم مناقشة وظائف هذه التراكيب.