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THE SENSORY CANALS OF THE HEAD IN SOME CYPRINODONT FISHES, WITH PARTICULAR REFERENCE TO THE GENUS *FUNDULUS*

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INTRODUCTION

IN FLORIDA material of the genus *Fundulus* the distribution of the pores opening out from the sensory canals of the head was found to be useful in distinguishing species. This led to an examination of the sensory canal system as a taxonomic feature in *Fundulus* and in other cyprinodont genera represented in the Museum of Zoology collections.

During the course of this work I have have been aided by advice from Dr. W. K. Gregory concerning the nomenclature of one of the sensory canals and by suggestions from Dr. R. M. Bailey concerning cyprinodont systematics. Mr. William Bruden has prepared my rough pencil sketches for publication. I wish to express my appreciation to these persons. I have treated Mr. Bruden's excellent diagrams as an integral part of the text, and it is expected that the reader will make constant reference to them.

The use of the sensory canal system as a systematic character is not new. It has been employed in classification of the gobies by Iljin (1930) and in one group of the Percidae by Hubbs and

Cannon (1935). But so far as I can determine little use has been made of the character in cyprinodont fishes (Hubbs, Walker, and Johnson, 1943: Table II and Pl. III; Miller, 1948: 11, 81–82, 99, 111; and Tchernavin, 1946: 429–32). The object of the present paper is to point out how the system can be used in separating certain forms of the group and to call attention to some similarities and dissimilarities in sensory canals in cyprinodonts that may be of phylogenetic significance.

The subject with which this paper deals leads directly to a study of the comparative anatomy of canal systems and also to the classification of the order Cyprinodontes. Both of these are outside of the scope of the present paper. There is an extensive literature dealing with the morphology of the sensory system of the head in fishes, and the structure of the cheek canals has been recently dealt with, as Dr. Gregory has pointed out to me, by Stensiö (1947). Considerable research has been done on the classification of cyprinodonts in recent years, particularly by Hubbs, but most of this work has been on the viviparous forms. Many points concerning the relationships within the oviparous Cyprinodontidae remain obscure, and this is the family with which I am primarily concerned here. The most recent paper on the classification of this family as a whole is that of Myers (1931).

There are certain technical and zoological limitations to the use of the canal system as a taxonomic character. An air hose or some other apparatus for filling the sensory tubes with air is almost essential in tracing the canals and their pores. In specimens in which the heads have been dried, defaced, or compressed in preservation it is difficult or impossible to use the character.

Zoologically, some cyprinodonts have no closed canals or have them so greatly reduced as to be of little taxonomic value. In many of these forms, as *Rivulus holmiae,* the sensory canal system seems to have undergone simple reduction. In the Amblyopsoidea, although there appear to be no enclosed canals, an extensive network of tactile organs has been substituted.

In all species the system changes with growth. The enclosed canals, when present, are first apparent in the young as open grooves. Later, these become covered except for the pores. The presence of an open-groove system in the adults of many poeciliids is probably explainable as the retention of a juvenile character.

In addition, there are in cyprinodonts, as in other fishes, the so-called pit organs; these appear as small mounds in slightly depressed areas. The relationship between the pit organs and the canal system in cyprinodonts seems to be very close. Parts of the canals in some species are replaced by pit organs in others, and *vice versa*. In three species of *Fundulus* (see below), one of the pit organs on the snout seems to sink below the surface with growth, and an enclosed canal with two pores is formed over it. In certain other cyprinodonts the bones of the head come rather close to the surface in areas which the canals would normally pass over. (The canals in cyprinodonts are almost entirely enclosed in flesh, rather than in the dermal bones.) Where such is the case the canals are usually replaced by pit organs in these areas, but even the pit organs may be absent. This appears to provide one of the major sources of reduction in the canal system of cyprinodonts.

THE CANAL SYSTEMS OF CYPRINODONT GENERA

The simplest canal system developed in cyprinodonts is exemplified by *Cyprinodon*[1] (Pl. I, Figs. 1–2). In this genus the supraorbital canal is continuous on either side of the top of the head from a point behind the eye upward and forward over the eye to a point just behind the upper lip. It thus incorporates the posterior section of the infraorbital canal of other fishes. There are 7 pores (numbered 1–7, Pl. I, Fig. 1) opening out from this canal. The front of the usual infraorbital system is represented in *Cyprinodon* by a canal

[1] The specimens upon which observations were made are listed at the end of the paper.

running downward and forward from just below the posterior nostril (Pl. I, Fig. 2); for convenience this section of the infraorbital system will be called in this paper the preorbital canal. In cyprinodonts no closed tube connecting the anterior and posterior parts of the infraorbital canal has been observed, though there is usually a series of pit organs below the eye. The preopercular canal (also called opercular or hyomandibular canal by various authors) is represented in *Cyprinodon* by a tube with 6 or 7 pores (Pl. I, Fig. 2). The mandibular canal is either reduced to a canal with 2 pores or is absent.

In the cyprinodonts examined, the mandibular and preopercular canals are connected only in the genus *Profundulus.* In the order, there is never any posterior extension of the supraorbital canal connecting it with the lateral line system of the body, nor is there a supratemporal canal running transversely across the back of the head.

The canal system described is found, with minor variations (Table I), in both *Cyprinodon v. variegatus* and *C. nevadensis mionectes.* It is almost exactly duplicated in *Floridichthys c. carpio* and *Garmanella pulchra.* In *Lucania parva* and *Chriopeops goodei* the system differs chiefly in that, as is more usual in cyprinodonts, the preorbital canal runs downward and backward rather than downward and forward.

Except for the genera just mentioned, the cyprinodonts examined show some fragmentation of the supraorbital canal at 1 (or both) of 2 places. In some species the prenarial section of the canal separates as a simple canal with a pore at either end; in some, the fore part of the supraorbital canal may remain continuous, but the postorbital part, presumably derived from the infraorbital canal, may be separated from the rest of the supraorbital canal; and in others, as in *Fundulus* (Pl. II, Fig. 1), the separation may occur at both places.

The simplest example that I found of only the posterior break in the supraorbital canal was in *Ilyodon* (Pl. I, Fig. 3) of the family Goodeidae, rather than in the Cyprinodontidae. *Ilyodon* is, however, rather atypical of the Goodeidae in canal system (see below). In this genus it seems fairly obvious that pore 4 (Pl. I, Fig. 3), instead of forming an outlet from a single continuous canal, as in *Cyprinodon,* has now been replaced by 2 pores (4*a* and 4*b*), the one a posterior terminus of the supraorbital canal and the other the upper outlet of the postorbital tube. Two other differences in *Ilyodon* are worth noting. Unlike *Cyprinodon,* there is in *Ilyodon* a well-developed canal with 4 pores on each side of the lower jaw, and the supraorbital canal between pores 1 and 2 does not form until the fish is about 3 inches long; in fact, pore 1 remains as a pit organ until approximately that length of fish is attained.

The supraorbital canal in specimens of *Jordanella floridae* is of the *Ilyodon* type, but is further reduced; the forward section of the tube stops at pore 3, and pore 4*a* is represented by a pit organ. Furthermore, *Jordanella* has no preorbital or mandibular canals.

In *Aphanius dispar* (Pl. I, Fig. 4), perhaps because of the small size or poor condition of available specimens, the supraorbital system appears to be reduced to canals between pores 2 and 4, and between 6 and 7. A preorbital canal is present, but there is no canal on the chin.

In the small specimens of *Cubanichthys cubensis* at hand the supraorbital system is represented by canals between pores 2 and 3 and between 6 and 7. In *Leptolucania ommata* and *Adinia xenica* only the canal between pores 6 and 7 remains.

It is possible to follow what appears to be another line of fragmentation of the supraorbital canal in cyprinodonts. In *Empetrichthys* (Pl. I, Fig. 5), pore 2 divides into 2 sections, the front half providing the terminus of a canal from pore 1, and the rear half the forward termination of the rest of the supraorbital system, which is continuous from pore 2*b* to pore 7. The entire canal system of *Crenichthys* is similar to that of *Empetrichthys.*

Fundulus (Pl. II, Figs. 1–6) has the canals about as in *Empetrichthys* and *Crenichthys* except that pore 4 has also divided into 2 parts, as in *Ilyodon. Profundulus* closely resembles *Fundulus,* except for the continuous preopercular-mandibular canal. *Plancterus* is also similar to *Fundulus,* but

TABLE I

SUMMARY OF CANAL AND PORE SYSTEMS OF CYPRINODONT GENERA EXAMINED, EXCLUSIVE OF GOODEIDS

In cyprinodont fishes all enclosed canals of the head contain two or more pores opening exteriorly. When the number of pores is listed as 0, there is no enclosed canal in that region, though grooves and pit organs may be present.

Family and Species	Supraorbital Canal Developed Between Pores Numbered	Number of Pores in Head Canals		
		Pre-opercular	Mandibular	Preorbital
Cyprinodontidae				
Floridichthys c. carpio	1–7	7	3	4
Cyprinodon v. variegatus	1–7	7	2	4
Cyprinodon nevadensis mionectes	1–7	6 or 7	0	2 or 3
Garmanella pulchra	1–7	7	0	2
Chriopeops goodei	1–7	7	0	4
Lucania parva	1–7	7	0	4
Aphanius dispar	2–4, 6–7	6 or 7	0	3
Jordanella floridae	1–3, 4–7	8 or 9	0	0
Cubanichthys cubensis	2–3, 6–7	7	0	0 to 3
Adinia xenica	6–7	7	0	2
Leptolucania ommata	6–7	4 or 5	0	0
Aplocheilus panchax	6–7	7	2	3
Oryzias javanicus	Not developed	5	0	3
Aphyosemion sp.	6–7	5	0	2
Rivulus holmiae	Not developed	0	0	0
Crenichthys b. baileyi	1–2*a*, 2*b*–7	7	3 or 4	4
Empetrichthys l. latos	1–2*a*, 2*b*–7	7	4	4
Profundulus oaxacae	1–2*a*, 2*b*–4*a*, 4*b*–7	7	5	4
Fundulus diaphanus	1–2*a*, 2*b*–4*a*, 4*b*–7	7	4	4
Plancterus kansae	1–2*a*, 2*b*–4, 6–7	7 or 8	4 or 5	3 or 4
Jenynsiidae				
Jenynsia lineata	1–2*a*, 2*b*–4, 6–7	7	5 or 6	4

TABLE I-(*Cont.*)

Poeciliidae				
Mollienesia latipinna	2–3 or 2–4, 6–7	7	0	3 or 4
Girardinus metallicus	2–4, 6–7	7	0	4
Platypoecilus maculatus	6–7	7	0	3
Priapichthys annectens hesperis	6–7	7	4 or 5	3
Poeciliopsis sp.	6–7	7 or 8	0	3
Alfaro cultratus	Not developed	7	5 or 6	4
Belonesox b. belizanus	Not developed	0	0	0
Gambusia a. affinis	Not developed	0	0	0
Tomeurus gracilis	Not developed	0	0	0
Anablepidae				
Anableps anableps	1–2, 6–7	7	6 or 7	4

in *Plancterus* (as in a few species of *Fundulus*) pores 4*b* and 5 of the postorbital canal have been replaced by pit organs.

The presence of a separate canal between supraorbital pores 1 and 2*a* is found in *Jenynsia lineata* of the Jenynsiidae. This last species has a canal system which, pore for pore, repeats that of *Plancterus*.

I have tried to trace the canal system in various poeciliids. That of *Mollienesia latipinna* has the same canals and usually the same pores as *Aphanius dispar*. *Gambusia a. affinis* has the entire system represented by open grooves. *Alfaro, Girardinus, Poeciliopsis, Priapichthys,* and *Tomeurus* lie somewhere between *Mollienesia* and *Gambusia* in the development of head canals (Table I).

Anableps anableps of the Anablepidae has the supraorbital system reduced to canals between pores 1 and 2 and between 6 and 7.

In species of Rivulini and Aplocheilini of the Cyprinodontidae examined the canal system is so far reduced as to be of little taxonomic value. In *Aphyosemion* and in *Aplocheilus panchax* the supraorbital canal is present only between pores

6 and 7, whereas in *Rivulus holmiae* and *Oryzias javanicus* it is totally absent.

The data for the genera dealt with up to this point appear in Table I.

To summarize, the simplest type of well-developed canal system is that of *Cyprinodon, Floridichthys, Garmanella, Lucania,* and *Chriopeops.* These 5 genera have been placed in 2 different subfamilies of Cyprinodontidae. The similarity of the canal and pore systems, however, supports the opinion, held by others on different grounds, that the classification of these 2 subfamilies should be re-examined.

From the simple type of supraorbital canal in *Cyprinodon,* 2 lines of differentiation seem to have developed. One, in which there is a separate canal between pores 1 and 2*a,* contains *Crenichthys, Empetrichthys, Profundulus, Fundulus, Plancterus, Jenynsia,* and certain goodeids (see below). To the other group, in which the supraorbital canal is continuous between pores 1 and 4*a,* but broken between pores 4*a* and 4*b,* belong only *Jordanella, Ilyodon,* and *Balsadichthys* (see below) with certainty. In the remaining genera examined the supraorbital system is so reduced that it would be difficult to say to which line it belonged.

I wish to emphasize that the above types of variation in the canal system do not necessarily represent phylogenetic lines in the fishes concerned. There is no way of knowing that the "simplest" type of canal system may not be secondarily "simple" rather than primitive. And there is no reason why a relatively specialized fish might not retain a primitive sensory system. A phylogeny must be based on the sum of the characters, and the value of any 1 system as a taxonomic character will depend in part on how well it checks with other systematic characters.

THE CANAL SYSTEM OF THE GOODEIDAE

Fortunately, it is possible to check canal-system characters in the Goodeidae against an existing classification, for the interrelationships within this family have been thoroughly worked out (Hubbs and Turner, 1939; Turner, 1946). Without reference to these papers I have erected a classification of goodeid canal systems based on representatives of all the genera of the family in the Museum of Zoology collections. In canal structure these genera appear to fall into 3 major groups, although there is considerable variation within 2 of these. Group I, represented by *Ilyodon* (Pl. I, Fig. 3), has the supraorbital canal continuous between pores 1 and 4*a*. Group II has this section of the canal discontinuous between pores 2 and 2*a* as in

TABLE II

RELATIONSHIP BETWEEN TYPES OF CANAL SYSTEMS, TOOTH SHAPE, AND SUBFAMILY ALLOCATION OF THE GENERA OF GOODEIDAE AS PROPOSED BY HUBBS AND TURNER (1939) AND TURNER (1946)

See text for an explanation of the canal system groupings. A plus sign (+) indicates agreement, and a minus sign (−) disagreement with the statement at the head of the column.

Species	Canal System Group	Subfamily	Teeth Bifid
Balsadichthys xantusi	I	Girardinichthyinae	+
Ilyodon furcidens	I	Girardinichthyinae	+
Characodon lateralis	II	Characodontinae	+
Alloophorus robustus	II	Goodeinae	−
Allotoca vivipara	II	Goodeinae	−
Chapalichthys encaustus	II	Goodeinae	+
Goodea luitpoldii	II	Goodeinae	+
Neoophorus diazi	II	Goodeinae	−
Xenoophorus exsul	II	Goodeinae	+
Xenotoca variata	II	Goodeinae	+
Zoogoneticus quitzeoensis	II	Goodeinae	−
Allodontichthys zonistius	II	Girardinichthyinae	−
Xenotaenia resolanae	II	Girardinichthyinae	+
Girardinichthys innominatus	III	Girardinichthyinae	−
Lermichthys multiradiatus	III	Girardinichthyinae	+
Ollentodon multipunctatus	III	Girardinichthyinae	+
Skiffia lermae	III	Girardinichthyinae	+

Fundulus. Group III, which may have been derived from either of the first groups, has the supraorbital canal entirely replaced by pit organs. Table II shows the relationship between these groupings and the classification of goodeids as proposed by Hubbs and Turner and supplemented by Turner. In the third column is listed the shape of the teeth, a character used earlier for classifying goodeids.

As may be seen from Table II, there is little agreement between tooth shape and canal structure. There is, for that matter, little correlation between tooth shape and Hubbs and Turner's classification. When the canal system groups are compared with this classification, Groups I and III are found to contain only genera of the Girardinichthyinae. Group II contains members of 3 subfamilies, 1 of which is the Girardinichthyinae. Of the 2 species in Group II belonging to this last subfamily, *Allodontichthys zonistius* has a somewhat degenerate canal system and was placed in Group II rather than in III with some hesitation; its canal system seems to be developing toward the condition present in Group III. Two

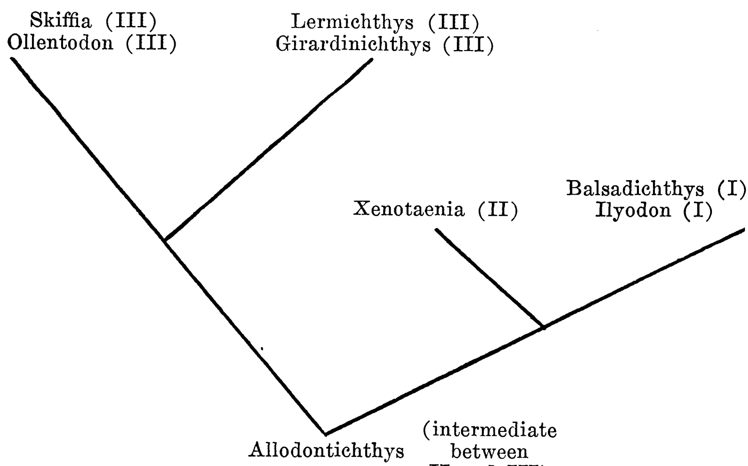


Fig. 1. Relationship between the phylogeny of the Girardinichthyinae as proposed by Turner (1946) and the type of canal system. For explanation of group numbers (in parentheses), see text.

paratypes of *Xenotaenia resolanae,* the other of the 2 species, however, definitely belong in Group II. I found no significant difference between the canal system of *Xenotaenia* of the Girardinichthyinae, *Characodon* of the Characodontinae, and certain genera of the Goodeinae. The fact that the Girardinichthyinae is represented in all 3 groups of canal types is disconcerting. When the groups are correlated with the phylogeny of this subfamily (Fig. 1) as proposed by

Turner (1946), considerable taxonomic sense can be made of the canal system even in the Girardinichthyinae.

The data presented for the Goodeidae lead to the conclusion that the canal system is useful in classification of the group, but like any other character, if used alone, it would lead to some erroneous deductions concerning relationships.

THE CANAL SYSTEM IN *Fundulus*

This paper is the outcome of an attempt to distinguish some Florida species of the genus *Fundulus*. All species of that genus represented in the Museum of Zoology collections have since been examined. In addition, data for 2 species of *Plancterus* and 3 of *Profundulus* are included in the following. In these 3 genera, although there is always the general pattern of canal structure already described, minor but apparently relatively stable differences occur. A comparison of *Fundulus similis* (Pl. II, Figs. 1–3) with *F. chrysotus* (Pl. II, Figs. 4–5) illustrates this. *F. similis* has the 3 sections of the supraorbital system relatively extended; the distance between pores *2a* and *2b* less than that between 3 and *4a*, with pore *2b* well in front of the middle of the posterior nostril; and the posterior pore of the chin (*W*) much closer to the front pore of the preopercular system (*V*) than to the nearest pore of its own system (*X*). In all of these characters *F. chrysotus* contrasts with *F. similis*.

Other species differ in various canal and pore characters. Such variations may best be considered by canals. The distance between the mandibular and preopercular canals is used as a starting point. In 3 species of *Profundulus*, the 2 canals are practically or completely confluent. The following species of *Fundulus* resemble *F. similis* in having the posterior pore of the mandible (*W*) nearer the anterior pore of the preopercular canal (*V*) than to the next pore in its own canal (*X*): *confluentus* and *majalis*. The following species have pore *W* about equidistant from pores *V* and *X*: *grandis*, *grandissimus*, and *parvipinnis*. The remaining species resemble *F. chrysotus* in that pore *W* is considerably nearer *X* than *V*: *cate-*

natus, cingulatus, diaphanus, dispar, heteroclitis, jenkinsi, notatus, olivaceus, rathbuni, sciadicus, seminolis, stellifer, and *waccamensis. Plancterus kansae* and *P. zebrinus* belong with this last group.

In the mandibular canal series 2 characters may be used to differentiate certain species. In *Profundulus, Plancterus kansae,*[2] *Fundulus grandis,* and *F. grandissimus* there are usually 5 pores on each side rather than the 4 usual in *Fundulus.* In *F. cingulatus,* there seem to be 3 pores as a modal number.

The distance between the 2 forward pores (*Z* and *Z′*) of the 2 mandibular canals is the other character. In *Fundulus chrysotus* (Pl. II, Fig. 5) the distance between *Z* and *Z′* is greater than the distance between *Y* and *Z;* in *F. confluentus* (Pl. II, Fig. 6) it is less. In *F. dispar lineolatus* and *F. sciadicus* the distance between *Z* and *Z′* is relatively great; in *F. notatus* it is relatively small; and in *F. olivaceus* it is intermediate.

In the preopercular series there are 7 pores in *Profundulus,* usually in *Plancterus zebrinus,* and in all but a few species of *Fundulus.* In *F. catenatus,* however, pore 11 (for the location of this pore see Pl. II, Fig. 2) has become considerably elongate. In *F. sciadicus, F. stellifer,* and often in *Plancterus kansae,* pore 11 has divided into 2 parts, and the preopercular canal is discontinuous between these parts. Thus, in the last 3 species there are 8 pores in the preopercular series, whereas *F. catenatus* seems to be in the process of developing an eighth pore.

In the postorbital section of the supraorbital canal system, pore 6 is often divided into 2 parts. In the species in which this has occurred, pores 4*b* and 5 may be rudimentary and the canal between the upper 3 pores of the postorbital section may not be present. The species in which the postorbital canal is well developed and contains 4 undivided pores are as follows: the 3 species of *Profundulus, Fundulus chrysotus, cingulatus,*

[2] The 2 species of *Plancterus* seem to be more variable in pore characters than are any other forms mentioned in this section.

confluentus, diaphanus, dispar, grandis, grandissimus, heteroclitus, majalis, seminolis, similis, and *waccamensis.* In the species in which pore 6 is modified, the pit organ, which usually lies at the surface somewhat behind it (not shown in figures), is often at the bottom of an open groove leading to pore 6. The species in which pore 6 is only partly divided and in which pores 4*b* and 5 usually are connected by a closed canal are as follows: *Fundulus catenatus, notatus, olivaceus, parvipinnis, rathbuni,* and *sciadicus.* The species in which pore 6 is divided and the canal between 4*b* and 5 absent are: *Fundulus jenkinsi* and *stellifer,* and both species of *Plancterus.*

In the preorbital canal there are 4 pores in all the species examined. The greatest variation is in *Plancterus zebrinus,* in which the pore number varies from 3 to 5. The configuration of the usual 4 pores changes considerably from species to species, but the differences are difficult to describe.

The last character of the canal system which I wish to discuss is one which is found only in relatively large specimens of a few species. In specimens over 45 mm. in standard length of *F. heteroclitus, grandis,* and *grandissimus* 2 of the pit organs which lie near the tip of the snout (labeled *P,* Pl. II, Figs. 1 and 4) apparently sink below the flesh, and a short transverse canal with 2 pores forms over each of them. No trace of such a canal is found in the largest available specimens of other species examined.

In the foregoing paragraphs I have tried to show how the canal system of the head and its parts can assist in differentiating various species of *Fundulus* and related genera. If a large number of specimens of any one species were examined, variations in the pore numbers could doubtless be found. Some species vary more than others; as noted, the species of *Plancterus* seem to be particularly inconstant, but on the whole, it is the uniformity rather than the diversity of the canal and pore system in the genus *Fundulus* which seems the more remarkable.

The summary of characters given in Table III indicates that it would be difficult to build a phylogeny of canal-system characters in the genus *Fundulus.* The species are arranged in the

TABLE III

SUMMARY OF SENSORY CANAL CHARACTERS IN SPECIES OF *Fundulus* AND RELATED GENERA

A plus sign (+) indicates agreement, and a minus sign (–) disagreement with the statement at the head of the column.

Species	Preopercular and Mandibular Canals Little Separated	Five (or Six) Pores in Mandibular Series	Seven Pores in Preopercular Series	Postorbital Series Not Interrupted	Pit Organ on Snout Not Forming a Canal in Adult
Profundulus					
labialis	+	+	+	+	+
oaxacae	+	+	+	+	+
punctatus	+	+	+	+	+
Fundulus					
confluentus	+	–	+	+	+
majalis	+	–	+	+	+
similis	+	–	+	+	+
grandis	–	+	+	+	–
grandissimus	–	+	+	+	–
heteroclitus	–	–	+	+	–
chrysotus	–	–	+	+	+
diaphanus	–	–	+	+	+
dispar	–	–	+	+	+
seminolis	–	–	+	+	+
waccamensis	–	–	+	+	+
cingulatus	–	–*	+	+	+
jenkinsi	–	–	+	–	+
notatus	–	–	+	–	+
olivaceus	–	–	+	–	+
parvipinnis	–	–	+	–	+
rathbuni	–	–	+	–	+
catenatus	–	–	–	–	+
sciadicus	–	–	–	–	+
stellifer	–	–	–	–	+
Plancterus					
kansae	–	+	–	–	+
zebrinus	–	–	+	–	+

* *Fundulus cingulatus* appears to have 3 as a modal number of chin pores on each side, whereas all the other species listed in the table have 4, 5, or 6.

table with those most resembling *Profundulus* in canal system at the top and those most unlike *Profundulus* at the bottom. No species of *Fundulus* resembles *Profundulus* in all 5 characters listed. But within *Fundulus* each of the following groups of species have all of the 5 similar: (1) *confluentus*, *majalis*, and *similis*; (2) *grandis* and *grandissimus*; (3) *heteroclitus*; (4) *chrysotus, diaphanus, dispar, seminolis*, and *waccamensis*; (5) *cingulatus*; (6) *jenkinsi, notatus, olivaceus, parvipinnis*, and *rathbuni*; (7) *catenatus, sciadicus*, and *stellifer*. These groupings may or may not represent relationship. Probably some do, whereas others may be merely the result of parallel or convergent evolution.

LITERATURE CITED

HUBBS, CARL L., BOYD W. WALKER, and RAYMOND E. JOHNSON
1943 Hybridization in Nature between Species of American Cyprinodont Fishes. Contrib. Lab. Vert. Biol. Univ. Mich., 23: 1–21, Pls. I–IV.

HUBBS, CARL L., and MOTT D. CANNON
1935 The Darters of the Genera *Hololepis* and *Villora*. Misc. Publ. Mus. Zool. Univ. Mich., 30: 1–93, Pls. I–III.

HUBBS, CARL L., and C. L. TURNER
1939 Studies of the Fishes of the Order Cyprinodontes. XVI. A Revision of the Goodeidae. Misc. Publ. Mus. Zool. Univ. Mich., 42: 1–80, Pls. I–V.

ILJIN, B. S.
1930 Le Système des Gobiidés. Instituto español de oceanografía, Trabajos, 2: 1–63, Figs. 1–48.

MILLER, ROBERT R.
1948 The Cyprinodont Fishes of the Death Valley System of Eastern California and Southwestern Nevada. Misc. Publ. Mus. Zool. Univ. Mich., 68: 1–155, Figs. 1–5, Pls. I–XV, Maps 1–3.

MYERS, GEORGE S.
1931 The Primary Groups of Oviparous Cyprinodont Fishes. Stanford Univ. Publ., 6: 1–14.

STENSIÖ, ERIK A.
1947 The Sensory Lines and Dermal Bones of the Cheek in Fishes and Amphibians. Kungl. Svenska Vetenskapsakademiens Handlinger, (3) 24: 1–195, Figs. 1–38.

TCHERNAVIN, V. V.
1946 On the Lateral Line System of Some Cyprinodonts (Order Microcyprini). Ann. Mag. Nat. Hist., ser. 11, 13: 429–32.

TURNER, C. L.
1946 A Contribution to the Taxonomy and Zoogeography of the Goodeid Fishes. Occ. Papers Mus. Zool. Univ. Mich., 495: 1–13, Pl. I.

LIST OF SPECIMENS FROM MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, UPON WHICH DATA WERE BASED

Species	Catalogue Number	Locality
Adinia xenica	153454	Florida, Pinellas Co.
Alfaro cultratus	72579	Panama
Allodontichthys zonistius	97316	Mexico, Colima
Alloophorus robustus	154339	Mexico, Jalisco
Allotoca vivipara	143303	Mexico, Michoacán
Anableps anableps	108901	British Guiana
Aphanius dispar	146556	Egypt, Red Sea Coast
Aphyosemion sp.	146262	French West Africa, Dakar
Aplocheilus panchax	146561	Java
Balsadichthys xantusi	145309	Mexico, Colima
Belonesox belizanus belizanus	143521	Guatemala, Petén
Chapalichthys encaustus	108650	Mexico, Ocatlán
Characodon lateralis	65228	Mexico, Durango
Chriopeops goodei	113243	Florida, Dade Co.
Crenichthys baileyi baileyi	125006	Nevada, Lincoln Co.
Cubanichthys cubensis	146977	Aquarium Material
Cyprinodon nevadensis mionectes	132902	Nevada, Nye Co.
Cyprinodon v. variegatus	135901	Florida, Santa Rosa Co.
Empetrichthys latos latos	140489	Nevada, Nye Co.
Floridichthys carpio carpio	153447	Florida, Pinellas Co.
Fundulus catenatus	105271	Tennessee, Dickinson Co.
Fundulus chrysotus	153465	Florida, Pinellas Co.
Fundulus cingulatus	136600	Florida, Santa Rosa Co.
Fundulus confluentus confluentus	139228	Florida, Hillsborough Co.
Fundulus diaphanus diaphanus	145553	Maine, Penobscot Co.
Fundulus dispar lineolatus	110633	Florida, Marion Co.
Fundulus grandis	153546	Florida, Pinellas Co.
Fundulus grandissimus	143095	Mexico, Yucatan
Fundulus heteroclitus heteroclitus	123285	North Carolina, New Hanover Co.
Fundulus heteroclitus macrolepidotus	89232	Massachusetts, Barnstable Co.
Fundulus jenkinsi	146252	Texas, Liberty Co.
Fundulus majalis	109847	New Jersey, Ocean Co.
Fundulus notatus	145079	Michigan, Barry Co.
Fundulus olivaceus	152117	Missouri, Ozark Co.
Fundulus parvipinnis	133068	California, Ventura Co.
Fundulus rathbuni	147631	North Carolina, Randolph Co.
Fundulus sciadicus	152773	Missouri, Miller Co.
Fundulus seminolis	136591	Florida, Alachua Co.

LIST OF SPECIMENS (*Cont.*)

Species	Catalogue Number	Locality
Fundulus similis	153579	Florida, Pinellas Co.
Fundulus stellifer	88286	Georgia, Cobb Co.
Fundulus waccamensis	138474	North Carolina, Columbia Co.
Gambusia affinis affinis	129784	Texas, Brazos Co.
Garmanella pulchra	....	Mexico, Yucatan
Girardinichthys innominatus	97509	Mexico, Dist. Fed.
Girardinus metallicus	103333	Cuba
Goodea luitpoldii	108644	Mexico, Ocatlán
Ilyodon furcidens	145304	Mexico, Colima
Jenynsia lineata	106429	Argentina, Buenos Aires
Jordanella floridae	111769	Florida, Manatee Co.
Leptolucania ommata	135866	Georgia, Ware Co.
Lermichthys multiradiatus	108630	Mexico, Mexico
Lucania parva	139223	Florida, Hillsborough Co.
Mollienesia latipinna	139221	Florida, Hillsborough Co.
Neoophorus diazi	154344	Mexico, Michoacán
Ollentodon multipunctatus	154336	Mexico, Jalisco
Oryzias javanicus	146556	Java, Batavia
Plancterus kansae	94937	Colorado, Prowers Co.
Plancterus zebrinus	89489	Texas, Pecos Co.
Plancterus zebrinus	112975	New Mexico, Chaves Co.
Plancterus zebrinus	137103	Texas, Reeves Co.
Platypoecilus maculatus	143789	Guatemala
Poeciliopsis sp.	141220	Arizona, Cochise Co.
Priapichthys annectens hesperis	146998	Costa Rica
Profundulus labialis	131145	Guatemala
Profundulus oaxacae	108595	Mexico, Guerrero
Profundulus punctatus	144654	Guatemala
Rivulus holmiae	141930	Venezuela, Río Porlamar
Skiffia lermae	154342	Mexico, Jalisco
Tomeurus gracilis	108897	British Guiana
Xenoophorus exsul	118121	Mexico, San Luis Potosí
Xenotaenia resolanae	143025	Mexico, Jalisco
Xenotoca variata	108554	Mexico, San Luis Potosí
Zoogoneticus quitzeoensis	108651	Mexico, Ocatlán

PLATE I

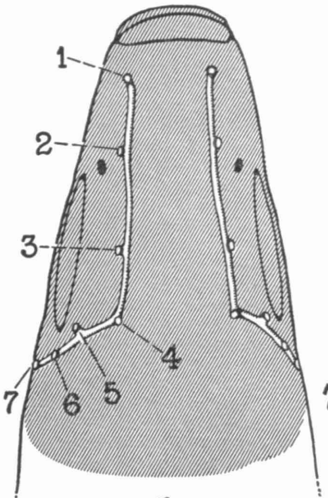
FIGS. 1 and 2. Sensory canals and pores of the head in *Cyprinodon v. variegatus*. Diagrammatic view of the head from above and from the side. The posterior nostril is indicated in black just above and before the eye. The 2 mandibular pores and their canal are not shown.

FIG. 3. *Ilyodon furcidens*.

FIG. 4. *Aphanius dispar*.

FIG. 5. *Empetrichthys l. latos*. FIGS. 3–5. Diagrammatic views of head from above showing the sensory canals and pores. The posterior nostril is indicated in black just above and before the eye.

PLATE I



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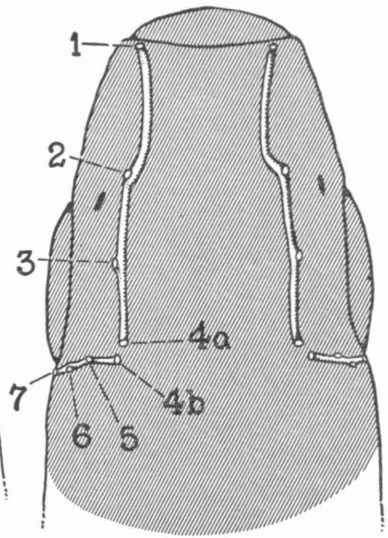

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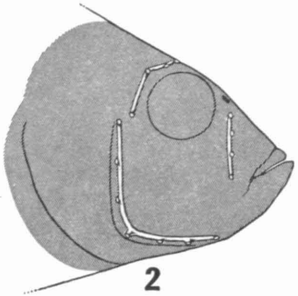

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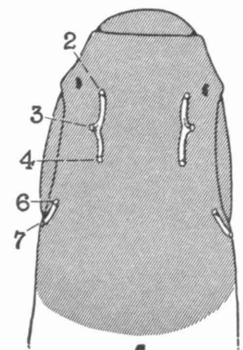

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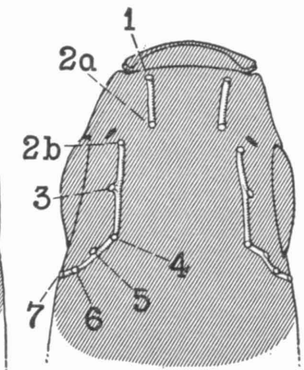

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PLATE II

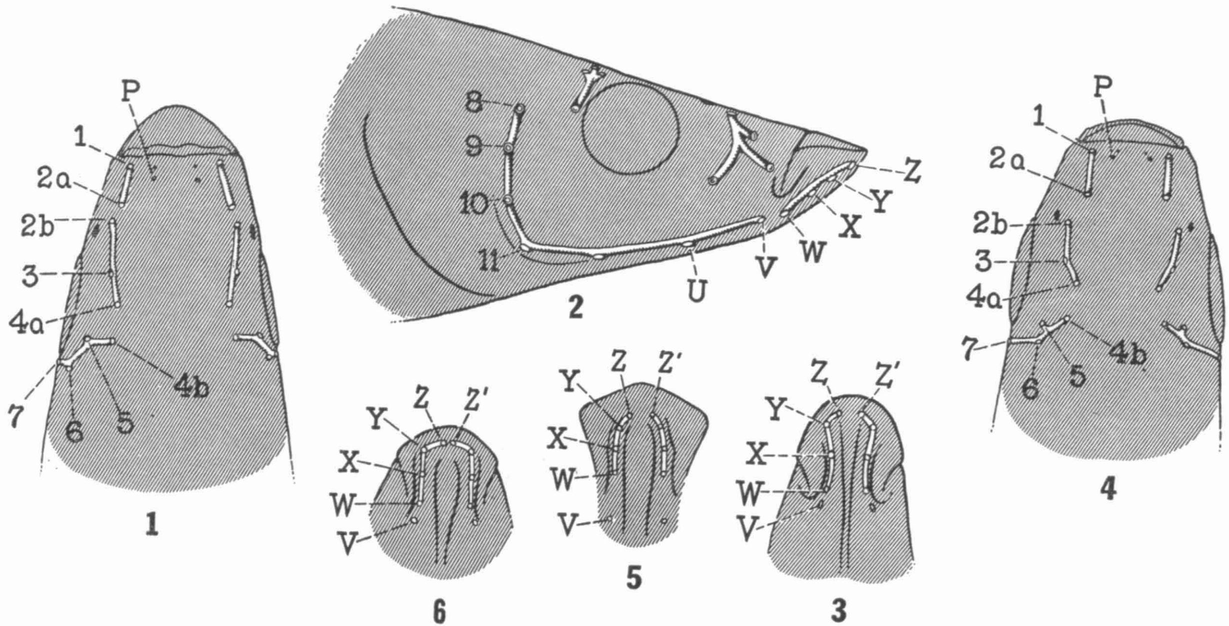
FIGS. 1, 2, and 3. Sensory canals and pores of head of *Fundulus similis* seen from above, from the side, and those on the chin from below.

FIGS. 4 and 5. Sensory canals and pores of the top of head and on the chin of *Fundulus chrysotus.*

FIG. 6. Mandibular canals and pores of *Fundulus c. confluentus.*

All figures diagrammatic.

PLATE II



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