THE FISHES OF THE BLUE RIVER IN OKLAHOMA WITH LESCRIPTIONS OF TWO NEW PERCID

HYBRID COMBINATIONS

By

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THESIS AND ABSTRACT APPROVED:

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TABLE OF CONTENTS

I.	Title Page	i
II.	Approval Sheet	ii
III.	Table of Contents	iii
IV.	List of Tables	iv
v.	List of Illustrations	v
VI.	Introduction and Acknowledgements	1
VII.	The Fishes of the Blue River in Oklahoma 1. Description of the river 2. List of collections 3. Annotated list of fishes	2224
VIII.	Description of the Hybrid Combinations 1. Methods 2. <u>Etheostoma (spectabile pulchellum X</u> <u>whipplei whipplei</u>) 3. <u>Etheostoma (radiosum subsp.x</u> <u>spectabile</u> subsp.)	12 12 14 23
IX.	Discussion	41
x.	Literature Cited	45

LIST OF TABLES

able		Page
1.	A brief color comparison of <u>Etheostoma spectabile</u> <u>pulchellum</u> , <u>Etheostoma whipplei</u> whipplei and the hybrid, <u>Etheostoma</u> (s. <u>pulchellum</u> x w. <u>whipplei</u>)	16
2.	Comparison of the <u>Etheostoma</u> (<u>spectabile</u> x <u>whipplei</u>) hybrid with the parental species	17
3.	A brief color comparison of <u>Etheostoma radiosum</u> subsp., <u>Etheostoma spectabile</u> subsp. and the hybrid, <u>Etheostoma (radiosum x spectabile)</u>	27
4.	Comparison of the male hybrid, <u>Etheostoma</u> (<u>radiosum</u> <u>x spectabile</u>), with male specimens of the parental species	28
5.	Comparison of the female hybrid, <u>Etheostoma</u> (<u>radiosum × spectabile</u>), with female specimens of the parental species	33
6.	Comparison of the male and female hybrids, <u>Etheostoma</u> (radiosum X spectabile), with male and female specimens of the parental species	36
7.	Comparison of the male and female hybrids, <u>Etheostoma</u> (<u>radiosum</u> <u>x</u> <u>spectabile</u>), with female specimens of <u>radiosum</u> and male specimens of <u>spectabile</u>	37
8.	Comparison of the male and female hybrids, <u>Etheostoma</u> (<u>radiosum</u> X <u>spectabile</u>), with male specimens of <u>radiosum</u> and female specimens of	
	spectabile	38

LIST OF ILLUSTRATIONS

Figure		Page
1.	Intermediacy in shape of genital papilla of hybrid, <u>Etheostoma</u> (<u>spectabile</u> <u>pulchellum</u> <u>x</u> <u>whipplei</u>)	21
2.	Etheostoma spectabile pulchellum, adult male	24
3.	Etheostoma (spectabile pulchellum X whipplei whipplei), adult male	24
4.	Etheostoma whipplei whipplei, adult male	24
5.	Etheostoma radiosum subsp., adult male	31
6.	Etheostoma (radiosum X spectabile), adult male	31
7.	Etheostoma spectabile subsp., adult male	31
8.	Etheostoma radiosum subsp., adult female	32
9.	Etheostoma (radiosum X spectabile), adult female	32
10.	Etheostoma spectabile subsp., adult female	32

THE FISHES OF THE BLUE RIVER IN OKLAHOMA WITH DESCRIPTIONS OF

TWO NEW PERCID HYBRID COMBINATIONS

INTRODUCTION AND ACKNOWLEDGMENTS

A review of the literature indicates that the fishes of the Blue River have received very little attention from ichthyologists. The early collectors apparently bypassed it completely. Paden (1948) reported <u>Microperca</u> (=<u>Etheostoma</u>, in part) <u>microperca</u> (Jordan and Gilbert) from Thomas Bricken Spring, a tributary of Blue River and Hubbs and Bonham (1951) reported <u>Notropis bleanius</u> (Girard) from the same locality. Moore and Rigney (paper in press) will describe a new subspecies of <u>Poecilichthys</u> (=<u>Etheostoma</u>, in part) <u>radiosus</u> Hubbs and Black and will include some notes concerning the percid associations in the river. Since there are so few literature references to the fish fauna of the Blue River, an annotated list seems pertinent.

Two new percid hybrid combinations are described. The combination <u>Etheostoma radiosum</u>, n. subsp., Moore and Rigney (MS) <u>X Etheostoma spectabile</u> (Agassiz) subsp. was taken from Blue River 24 miles south of Ada, Oklahoma. The hybrid, <u>Etheostoma</u> <u>spectabile pulchellum</u> (Girard) <u>X Etheostoma whipplei whipplei</u> (Girard), is included because of the close relationship of the parental species of it and those of the above mentioned hybrid. The latter specimen was taken from Sand Creek near Foreaker in Osage County, Oklahoma.

I am indebted to Dr. G. A. Moore for the assistance and suggestions offered by him in the preparation and writing of this paper and to his students who assisted in the collecting of the specimens used in this study. Criticisms of Doctors R. W. Jones, F. M. Baumgartner and I. E. Wallen in the preparation of this manuscript are also deeply appreciated.

THE FISHES OF THE BLUE RIVER IN OKLAHOMA

DESCRIPTION OF THE RIVER. The Blue River rises in Pontotoc County, Oklahoma, about six miles west of Fittstown. It is about 100 miles long and drains an area of approximately 660 square miles. After flowing in a southerly direction through Pontotoc and Johnston Counties to Milburn, it turns slightly to the east and flows in a southeasterly direction through Bryan County and joins the Red River south and east of Durant. The watershed is composed entirely of gently rolling hill country, about 48 per cent of which is timbered. Elevations at the headwaters are about 1250 feet above sea level, decreasing to approximately 500 feet above sea level near the mouth of the river. The average annual rainfall varies from 37 inches at the headwaters to 40 inches at the lower end of the basin. The overflow area is rather narrow and, in the lower 60 miles of the river, approximately 12,000 acres are subjected to overflow annually (Anon., 1936). It is a clear and moderately swift stream with an average gradient of about 7.5 feet per mile. The native vegetation of the entire watershed is a typical oak-woods association and is classified by Duck and Fletcher (1943) as a Post Oak Black jack game type habitat.

LIST <u>CF COLLECTIONS</u>. Collections were made with a minnow seine, a three-foot nylon net and a trotline. The collections, with dates and localities, are given in chronological order and are followed by a description of collection stations. The symbols (Mla, Mlb, M2, etc.) refer to collections by Moore and parties and are used in order to avoid long and frequent repetition in the annotated list.

Mla, 21 July, 1946. Thomas Bricken Spring in T1S, R6E, Johnston County, 24 miles south of Ada by the bridge on Highway 99. A small concrete dam was constructed below the spring which is now submerged by the impounded water which overflows to form a small creek about 100 feet in length and with a bottom of rock, gravel and some sand. The bottom of the creek immediately below the dam consists of gravel, sand and mud. Considerable water cress, algae and <u>Polygonum</u> were found below the dam but were not very abundant farther downstream. This station and the following are situated very close together but are separated because of great contrast in habitat and fish populations.

M1b, 21 July, 1946. Blue River in T1S, R6E, Johnston County, 24 miles south of Ada by the bridge on Highway 99. Here the river flows over an outcrop of limestone which produces a rocky and gravelly riffle between steep and heavily wooded banks. Very little aquatic vegetation was present. This is the type locality of <u>Etheostoma radiosum</u>, n. subsp., Moore and Rigney (MS).

M2, 4 April, 1947. Blue River near its source in Pontotoc County southwest of Ada. The river bed at this station is predominantly of fine sand and mud with some gravel and rocks. Aquatic vegetation was almost entirely lacking.

M3a, 5 April, 1947. Thomas Bricken Spring (see Mla). M3b, 5 April, 1947. Blue River (see Mlb). З

M4, 5 April, 1947. Little Blue River in Johnston County, NW¹₄, S36, T1N, R6E; the Howaró Smith Place, $1\frac{1}{2}$ miles due east of Connerville. The river bed consists of sand, gravel and rocks, mostly of small size. This area is surrounded by a level flood plain. Aquatic vegetation was absent.

M5, 6 April, 1947. Blue River in Johnston County, 10 miles west of Wapanuka on Highway 7 and 3 miles south at Hughes Crossing. The stream bed consists mainly of solid rock with, here and there, some sand and gravel. Water cress and <u>Spirogyra</u> were abundant in the small springs and creeks leading to the stream and a little <u>Vaucheria</u> was found on the rocks in the river. There is a flat flood plain with bluffs some distance from the stream.

M6a, 14 April, 1949. Thomas Bricken Spring (see Mla). M6b, 14 April, 1949. Blue River (see Mlb).

M7, 15 April, 1949. Cedar Creek in Bryan County, 7 miles east and 1 mile south of Durant on Old Highway 70. This fastflowing creek has many riffles and small falls with deep pools below the falls. The stream bed consists of rocks (covered with algae), gravel and sand. The surrounding area consisted of open woods and prairie.

M8, 15 April, 1949. JN Creek in Bryan County, 8 miles east and 1 mile south of Durant on Old Highway 70. The bottom of this small creek consists of sand and mud with a little gravel. There was no aquatic vegetation and the surrounding area contained typical oak-woods vegetation.

<u>ANNOTATED LIST</u>. Following the scientific and common names of each species, literature references, symbols referring to

collections and pertinent data, are given in that order. Species are being reported as first records for the Blue River and its tributaries unless followed by literature references.

Clupeidae

1. Dorosoma cepedianum (LeSueur). Gizzard shad.

Although no specimens were collected, Mr. A. B. Hughes of Hughes Crossing stated that he has caught this species with hook and line.

Catostomidae

2. <u>Moxostoma</u> <u>duquesnei</u> (LeSueur). Black redhorse.--M5. Only two specimens of this species were collected.

<u>Moxostoma erythrurum</u> (Rafinesque). Golden redhorse.- Mlb, M3b, M4, M5, M7.

The specimens collected from Little Blue River in April 1947 were in breeding color and a female specimen, one foot long, collected at the same time at Hughes Crossing contained large eggs about 2 mm. in diameter.

4. <u>Minytrema melanops</u> (Rafinesque). Spotted sucker.--M4. These specimens were also in breeding color.

Cyprinidae

<u>Hybopsis biguttata</u> (Kirkland). Hornyhead chub.--M3b,
 M5.

6. <u>Chrosomus</u> erythrogaster (Rafinesque). Southern redbelly dace.--Mla, M3a.

Collected only in the clear, cool water of Thomas Bricken Spring.

7. Notemigonus crysoleucas auratus (Rafinesque). Western

goldenshiner .-- M2, M3a, M3b, M4, M5.

These specimens are assigned to the subspecies <u>auratus</u> on the basis of an average of 12.2 anal rays.

8. <u>Notropis percobromus</u> (Cope). Plains shiner.--M3b, M6b. Collected only at the bridge on Highway 99.

9. Notropis rubellus (Agassiz). Rosyface shiner .-- M8.

Limited to JN Creek, a small tributary near the mouth of the river.

10. <u>Notropis fumeus fumeus</u> Evermann. Ribbon shiner.--M6b, M8.

This is believed to be the westernmost record for this shiner.

11. <u>Notropis umbratilis umbratilis</u> (Girard). Southern redfin shiner.--M3b, M7, M8.

12. <u>Notropis cornutus isolepis</u> Hubbs and Brown. Southern common shiner.--Mlb, M3a, M4, M5, M6b.

Very abundant wherever found.

 <u>Notropis blennius</u> (Girard). River shiner. Hubbs and Bonham (1951).--M3a.

A single specimen (probably an escapee from Mr. Bricken's holding pond) was collected below the dam at Thomas Bricken Spring.

14. <u>Notropis venustus venustus</u> (Girard). Blacktail shiner.--M4, M5, M6b, M7, M8.

This species was most abundant in JN Creek and Cedar Creek where 220 specimens were taken.

15. <u>Notropis lutrensis lutrensis</u> (Baird and Girard). Plains red shiner.--Mlb, M2, M6b, M7, M8. 16. <u>Notropis boops</u> Gilbert. Bigeye shiner.--Mlb, M2, M3a, M3b, M4, M5, M6b.

Quite abundant wherever collected.

17. <u>Notropis deliciosus deliciosus</u> (Girard). Eastern sand shiner.--Mlb, M2, M3b, M4, M7, M8.

The specimens collected from the Little Blue River in April 1947 were near the breeding stage.

<u>Notropis volucellus</u> (Cope). Mimic shiner.--M3a, M3b,
 M5, M6a.

19. <u>Phenacobius mirabilis</u> (Girard). Plains suckermouth minnow.--Mlb, M2, M3b.

The females collected from the Little Blue River in April 1947 were heavy with eggs in various stages of maturity.

20. Dionda nubila (Forbes). Ozark minnow .-- M8.

A single specimen, in breeding color, was collected from JN Creek in April 1949. The occurrence of <u>Dionda</u> in the river is interpreted as a case of bait-bucket introduction.

21. <u>Hybognathus placita</u> (Girard). Plains minnow.--M7, M8. Collected only in the tributaries near the mouth of the river.

22. <u>Pimephales vigilax</u> (Baird and Girard). Parrot minnow.--M7, M8.

Collected only in the small tributaries near the mouth of Blue River.

23. <u>Pimephales promelas confertus</u> (Girard). Southern fathead minnow.--M2, M7.

Collections from the Little Blue River in April 1947 consisted of males near breeding stage, gravid females, spent females and also young of the year.

24. <u>Pimphales notatus</u> (Rafinesque). Eluntnose minnow.--Mlb, M2, M3a, M4, M5.

Some of the females collected in April 1947 from the Little Blue River had spawned.

25. <u>Campostoma anomalum</u>: <u>plumbeum</u> (Girard) **X** <u>pullum</u> (Agassiz). Stoneroller.--Mla, Mlb, M2, M3a, M3b, M4, M5, M6a, M6b, M7.

Collected at all stations except from JN Creek near the mouth of the river. These specimens are regarded as intergrades by Moore and D. Homer Buck (MS) who, on the basis of 43 counts, obtained an average of 42.6, with limits of variation of 38 to 48, scales around the body.

Ameiuridae

26. Ictalurus furcatus (LeSueur). Blue catfish.

Although no specimens were collected, Mr. A. B. Hughes of Hughes Crossing maintains that he has caught them with hook and line. This species is known to be common in the Red River System.

27. <u>Ictalurus punctatus</u> (Rafinesque). Southern channel catfish.--M5.

This species was not collected but was observed on fishermen's strings at Hughes Crossing.

28. <u>Ameiurus melas catulus</u> (Girard). Southwestern black bullhead.--M2, M3a, M4, M7.

29. <u>Ameiurus natalis natalis</u> (LeSueur). Northern Yellow bullhead.--Nla.

Not very common in the Blue River. Collected only in 1946 at T. Bricken Spring. <u>Pilodictis</u> <u>olivaris</u> (Rafinesque). Flathead catfish.- M3b.

A head of this species was found at the bridge on Highway 99 in April 1947. Mr. A. B. Hughes said it has been taken at Hughes Crossing.

Cyprinodontidae

31. <u>Fundulus notatus</u> (Rafinesque). Blackstripe topminnow.--M4, M7, M8.

Poeciliidae

32. <u>Gambusia affinis affinis</u> (Baird and Girard). Western gambusia.--Mla, Mlb, M3a, M3b, M4, M5, M6a, M6b, M7.

Quite abundant and widely distributed throughout the Blue River System.

Percidae

<u>Percina caprodes</u> (Rafinesque). Logperch.--Mlb, M3b,
 M4, M5, M6b.

34. <u>Hadropterus scierus scierus</u> Swain. Common dusky darter. Moore and Rigney (MS).--M5, M7, M8.

Not very common, a total of eight specimens were collected.

35. <u>Hadropterus copelandi</u> (Jordan). River darter. Moore and Rigney (MS).--Mlb, M3b, M5.

36. Etheostoma chlorosomum Hay. Bluntnose darter .-- M8.

A single gravid female was collected from a slough on JN Creek.

37. <u>Etheostoma spectabile</u> (Agassiz). Orangethroat darter. Moore and Rigney (MS).--M3a, M3b, M6b.

This species is listed in the binomial because there is

evidence that it is possibly an undescribed subspecies. It is not <u>E. s. pulchellum</u> of northern Oklahoma. Collected only at the bridge on Highway 99 and Thomas Bricken Spring.

10

38. <u>Etheostoma radiosum</u>, n. subsp., Moore and Rigney (MS). Western orangebelly darter. Moore and Rigney (MS).--Mla, Mlb, M2, M3a, M3b, M4, M5, M6a, M6b, M7, M8.

This form was collected at all stations. April 1949 collections from Cedar Creek contain gravid females. Most abundant species in the Blue River System.

39. <u>Etheostoma gracile</u> (Girard). Western swamp darter.--M8. Four specimens were collected from a slough on JN Creek.

40. <u>Etheostoma microperca</u> Jordan and Gilbert. Least darter. Paden, J. M. (1948), Moore and Rigney (MS).--Mla, M3a, M6a. This species was collected only from Thomas Bricken Spring.

Centrarchidae

41. <u>Micropterus punctulatus punctulatus</u> (Rafinesque). Northern spotted bass.--Mlb, M3a, M4, M5, M6a, M6b.

This was by far the most abundant game fish in the river.

42. <u>Micropterus</u> <u>salmoides</u> (Lacépède). Largemouth bass.--

Only two specimens were collected.

43. <u>Chaenobryttus coronarius</u> (Bartram). Warmouth.--M6b.
A single specimen was collected at the bridge on Highway 99.
44. <u>Lepomis cyanellus</u> Rafinesque. Green sunfish.--Mlb,
M2, M3a, M3b, M5, M6a, M8.

Quite abundant and well distributed in Blue River.

45. Lepomis megalotis previceps (Baird and Girard). Southern longear sunfish.--Nlb, M2, M3b, M4, M5, M6b, M7, M8.

This species was present at all localities except the spring fed creek of Thomas Bricken Spring.

46. Lepomis humilis (Girard). Orangespotted sunfish.--M2, M3a, M6b, M7, M8.

47. <u>Lepomis macrochirus</u> Rafinesque. Bluegill.--M4, M7, M8.

Not abundant in the swifter headwaters but limited more to the lower part of the stream where the river is deeper, more sluggish and where sloughs and backwaters are more numerous.

48. Pomoxis sp. Rafinesque. Crappie.

No specimens were taken, but Mr. A. B. Hughes of Hughes Crossing maintains that he has caught them with hook and line.

Sciaenidae

49. <u>Aplodinotus grunniens</u> Rafinesque. Freshwater drum.--

A single 1-pound female with small gonads was caught on a trotline. Mr. A. B. Hughes stated that it is frequently caught with hook and line.

Hybrid Combinations

<u>Etheostoma</u> (radiosum, n. subsp. X <u>spectabile</u> subsp.).- M3a, M3b.

Two specimens of this combination were collected and are described in this paper (page 23).

DESCRIPTION OF THE HYBRID COMBINATIONS

METHODS. All specimens used in this study were collected in Oklahoma and are deposited in the Museum of Zoology of the Oklahoma Agricultural and Mechanical College (OAM). Only the largest available specimens were used for the counts and measurements and only specimens collected from the same localities as the hybrids were utilized. Ten specimens of each parental species of each hybrid were used and the diagnoses are based on specimens of the same sex as the hybrids.

All counts and measurements were taken by Linder and later checked by Moore. When significant differences were obtained the counts and measurements were repeated, according to the methods of Hubbs and Lagler (1947), until accordance was obtained. Some counts and measurements taken deviate from or are not mentioned by the above writers and are explained below.

Since the scales at the origin of the spinous dorsal are embedded and difficult to see the count of the scales above the lateral line was made below the origin of the soft dorsal.

The measurement of the distance from the origin of the dorsal fin to the occiput was made from the structural base of the first spine of the dorsal fin to the occiput.

Body width is the greatest width of the body exclusive of the pectoral fins.

The width of the premaxillary frenum is the distance between the anterior ends of the premaxillary grooves.

The distance from the union of the gill membranes to the mandible was measured from the apex of the angle formed by the

union of the gill membranes to the tip of the mandible.

The distance from the union of the gill membranes to the pelvics was measured from the apex of the angle formed by the union of the gill membranes to the insertion of the pelvic fin.

All scale counts were made on the left side of the fish and all measurements were taken from the right side. All measurements were recorded to the nearest tenth of a millimeter and computed by machine into thousandths of standard length, head length, soft dorsal fin length, body depth and caudal peduncle length.

Some characters studied exhibited such small differences between the parental species that they were considered to be of little value, and therefore, only those counts and proportions which show more than four per cent difference between the parental species were used. Other characters exhibited values which were beyond the range of either parent. Hubbs and Kuronuma (1942) ascribed certain extreme characters in hybrid flounders to heterosis. They also indicated that if there is a genetic tendency in both parental species toward the reduction of a certain character, hybridization will cause an additive effect and produce an extremely reduced character in the hybrid.

Several characters exhibited by the hybrids were identical with those of one or the other parental species indicating a possible dominant influence of one parent or the other. An aggregate of hybrid index values in each instance gave an average value of near exact intermediacy, but the individual character values tend to range from 0 to 100.

Although the range of some of the characters of the parental

species overlap, it was believed that if a random sample of the parental species was taken the average value would be of more significance than the range. This overlapping of characters was found to be common among the species of this large genus (Moore and Rigney, MS), (Hubbs, 1943).

The hybrid index used in this study is the same as that used by Hubbs and Kuronuma (1942) and explained by Hubbs, Hubbs and Johnson (1943), in which the formula, $\frac{V_{H}-M_{1}}{M_{2}-M_{1}} = P$, is used to determine the position of the hybrid. V_{H} is the count or measurement for the hybrid, M_{1} for one parent and M_{2} for the other parent. The value obtained multiplied by 100 gives the hybrid index. In all comparisons each average index is expressed as a figure on the scale of 100, in which the average value of one parental type is set at 0 and that for the other parental type at 100. A hybrid index value of 50 would indicate exact intermediacy between the two parental types while a value of 25 would indicate a tendency toward the parental type assigned the value of 0 and a value of 75 would indicate a tendency toward the parental type assigned the value of 100.

ETHEOSTOMA (S. PULCHELLUM X W. WHIPPLEI). The hybrid, OAM 4225, is an adult male 61.5 mm. in standard length collected by Moore et al. on March 25, 1950 from Sand Creek, 3 miles east of Foreaker, Oklahoma. The specimens of the presumed parental species used, Etheostoma spectabile pulchellum (Girard) (OAM 4226) and Etheostoma whipplei whipplei (Girard) (OAM 4227), were collected at the same time and from the same locality as the hybrid. The value of O (M_1) has been assigned to spectabile and 100 (M_2) to whipplei.

All specimens used are adult males. The range of standard length in <u>spectabile</u> is 32.9 to 44.3 mm. and the range of standard length in <u>whipplei</u> is 43.0 to 69.0 mm. The hybrid had been preserved in a weak formalin solution and refrigerated in the dark for two months when the color description was taken. The color description for <u>spectabile</u> was taken from unpublished notes of Moore and that for <u>whipplei</u> from Hubbs and Black (1941) and Moore and Rigney (MS) (Table 1).

Since but one specimen of the hybrid was available it was decided that an average of counts and measurements taken from ten specimens of each parent would be sufficient material upon which to base this study.

A review of recent work on hybrids shows an emphasis on the more or less exact intermediacy of the hybrid (Hubbs, Hubbs and Johnson, 1943; Hubbs, Walker and Johnson, 1943; Trautman, 1948). These workers also indicated that all hybrid index values should give an average of nearly exact intermediacy. The present hybrid met this condition in that the twenty-five characters shown in Table 2 give an average hybrid index value of 51.7. It is also of interest that fourteen of these characters have tendencies toward one parent and eleven lean toward the other parent. Trautman (1948) obtained an average hybrid index value of 52.43 for an ameiurid combination and Hubbs, Walker and Johnson (1943) reported average hybrid index values of 42-66 for some cyprinodont hybrid combinations.

The hybrid shows its most direct intermediacy in the number of lateral-line scales; number of scales below the lateral line;

A brief color comparison of <u>Etheostoma</u> <u>spectabile</u> <u>pulchellum</u>, <u>Etheostoma</u> <u>whipplei</u> <u>whipplei</u> and the hybrid, <u>Etheostoma</u> (s. <u>pulchellum</u> x w. <u>whipplei</u>)

	spectabile	Hybrid	whipplei
Head	slate, orange on cheeks and gill membranes	light slate	no bright colors with pale green on cheeks
Sides of trunk	black spots forming bars	bars of bluish green	small red spots
Side s of c audal peduncle	reddish orange and black bars	bars of bluish green	reticulated with red and black
Belly	gray	yellow-green	light orange on sides, milky- white mid-line
Fins (colors in order distad			
Spinous dorsal	red, white, blue-green	reddish brown, orange-red, greenish to emerald-green	gray (with red spots), red, white, blue- green
Soft dorsal	grayish red, brown, white, blue-green	olive-brown, reddish, green	brown, brick- red, white, blue-green
Caudal	bluish gray, reticulated with black	black and red, greenish yel- low, red, white, olive- green	gray (with red spots), red, white, blue- green
Anal	green	red spots, green	reddish, white, blue-green
Pectorals	yellowish, black rays, clear membranes	yellowish-olive	yellowish, clear membranes
Pelvics	blue-black, white	deep blue-green	green

Comparison of the E. (spectabile \mathbf{X} whipplei) hybrid with the parental species

yn yn dellan an yn derann y dellan Charles yn haf man yn ar friffie an had yn a'r arleidyd yn ar har man de hand yn yn yn ar friffie arlein yn yn yn yn ar friffie ar friffie yn yn yn	spectabile	Hybrid		whipplei
		Counts;		
Character	Range	propor-	Hybrid	Range
	(Average)	tions	Index	<u>(Average)</u>
Counts				
Spinous dorsal	÷		· /	
rays	9-11(10)	11	71.4	9-12(11.4)
Anal rays	8-9(8.7)	10	72.2	10-11(10.5)
Pored lateral-		10		
line scales	30-39(35.0)	48	65.9	50-62(54.7)
Total lateral-				de paras as
line scales	50-60(53.2)	59	43.3	65-72(00.6)
Scales above			00.0	
lateral line	5-7(6.2)		20.0	8-10(9.2)
Scales Delow		10	00 0	10 10/10 11
lateral line	7-10(8.2)	10	30.7	12-10(13.1)
Scales around	10 00 (00 5)	672	60 0	
caudal pecuncie	TA-53(50.9)	20	50.9	29-33(31.3)
Proportions				
Standaro Length	20 0 44 2(26 1)	61 5		12 0 60 0(52 7)
Thougondthe of	36.9-44.3(30.1)	01.0		43.0-09.0(32.7)
ctendend longth				
Spout length	67-80(71)	70		55-70(61)
Caudal naduncia	07-00(71)		10.0	
langth	248-274(258)	237	77.1	218-241 (231)
Pectoral length	249-295(272)	244	58.1	212-237(224)
Pelvic length	206-240 (230)	226	20.0	202-220 (210)
Head denth	175 - 206(189)	180	31.0	151-168(160)
Distance from				
UGN*to mandible	125-167(147)	151	20.0	156-176(167)
Distance from				
UGM*to pelvics	151-180(173)	146	77.1	126 - 143(138)
Head length in mm.	10.0-13.8(11.1)	18.5		12.9-20.5(15.4)
Thousandths of head				
length				
Distance from				
UGM*to mandible	409-529(475)	503	28.5	536-612(573)
Distance from				
UGM*to pelvics	474-590(540)	486	86.1	420-500(475)
Head depth	573-652(615)	600	23.0	536-579(550)
~				

*UGM--Union of gill membranes

Table 2 (concluded)

	spectaoile	Hyor	id	whipplei
Character	Range (Average)	Counts; Propor- tions	Hybrid Index	Range (Average)
Soft dorsal length in mm. Thousandths of soft	9.4-14.1(10.6)	20.0	••••	12.7-22.0(16.1)
Pectoral length Pelvic length Snout length Head depth Body depth Body width Body depth in mm.	$\begin{array}{c} 863-1020(926)\\ 714-842(781)\\ 216-266(242)\\ 615-691(642)\\ 670-766(726)\\ 412-504(462)\\ 6.5-10.5(7.7) \end{array}$	750 695 215 555 660 435 13.2	90.7 92.4 61.3 76.3 48.4 58.7	682-787(732) 629-725(688) 182-236(198) 490-563(528) 530-630(602) 371-455(416) 7.7-13.0(9.7)
Thousandths of body depth Caudal peduncle depth Body width AVERAGE HYBRID INDEX	463-523(492) 600-686(641)	553 659	51.0 14.7 51.7	552-625(602) 640-770(690)

number of scales around the caudal peduncle; pectoral length expressed in thousandths of standard length; body depth, body width and snout length expressed in thousandths of soft dorsal length and caudal peduncle depth expressed in thousandths of body depth. These eight characters yielded hybrid index values between 35 and 65 and are considered to be significant values (Table 2).

The distance from the union of the gill membrane to the insertion of the pelvics expressed in thousandths of the head length and head length, pectoral length and pelvic length expressed in thousandths of soft dorsal length gave hybrid index values over 80. The snout length expressed in thousandths of standard length and body width expressed in thousandths of body depth gave hybrid index values below 20.

Although these high and low values are poor to show intermediacy, they are regarded as important in that they show tendencies in the hybrid toward one or the other parent. The presence in the hybrid of marked influences of both parents is believed to be strong evidence that the parental species have been correctly ascertained. These high and low values are therefore included in Table 2 for the purpose of calculating the average hybrid index.

The shape of the genital papilla is another character in which the hybrid expresses intermediacy. The genital papilla of <u>whipplei</u> is typically a squarish flap with slight emarginations on the posterior edge. In <u>spectabile</u> the genital papilla is typically triangular with a pronounced pointed tip. The genital papilla of the hybrid is tapered distally but without the

prominent tip of <u>spectabile</u> and more blunt as in <u>whipplet</u> (Figure 1).

The color description of the hybrid shows the direct influence of one or the other parent in most instances. The following color description was kindly taken by Doctors Milton and Mary Trautman.

Eye with blue-black pupil and dusky iris. The postorbital dorsal head surface darkest portion of head, a deep olive lightening toward the spout. The cheeks and opercles slate-colored, the former light and the latter darker. Ventral surface of head light slate-color and without spots. A definite preorbital bar, about two-thirds diameter of pupil in width, extends from tip of snout, through the nostril, to the eve. A pronounced tear drop of the same width extends vertically downward to angle of mouth. A short triangulate intensely dusky postocular spot located slightly below center of eye. Background body color, olive, darkest dorsally and grading progressively lighter over sides to belly. Eleven dark bluish-green bars cross the sides; the first, immediately behind the head, extends obliquely downward to include the dark humeral spot and continues as an oblong greenish blotch at the pectoral base. The second bar, as wide as the length of the eye, and the most pronounced of any on body, begins on back immediately before spinous dorsal and extends slightly obliquely backward and downward to the lower belly, but not quite across the midline. Three short saddle-like blotches beneath spinous dorsal; the posterior and anterior brokenly connected with continuing bars on sides. The middle saddle connected by

Figure 1. Intermediacy in shape of genital papilla of hybrid, <u>Etheostoma (spectabile pulchellum X whipplei whipplei</u>). <u>E. s. pulchellum</u>, left; <u>E. w. whipplei</u>, right; and the hybrid, center. broken bars around body. Three saddle-like bars beneath the soft dorsal continue almost unbroken around the body. Two vertical green bars alternate with two intense orange-red blotches, as in <u>Etheostoma variatum</u>, one above and one below the lateral line on the caudal peduncle.

Ventral surface of body with a distinct yellow-green cast.

Spinous dorsal with bars of reddish brown spotting on the inter-radial membrane, the most anterior being smallest and becoming progressively larger posteriad. Above this basal bar is a deep orange-red band, about the width of eye, composed of triangular inter-radial blotches with the longest leg of the triangie parallel to the anterior spine and the opposite angle slightly above and touching the next spine. Above this red bar is a very light greenish bar abruptly merging into a distal bar of emerald.

Basal one-fourth of soft dorsal brownish olive; above this a broad reddish band, confined to inter-radial membranes, and covering at least one-half width of fin; the rays remain olive in the band. Above this broad red band is one of pale greenish yellow contiguous with the narrow, deep green border.

Caudal base mesially marked with an indistinct dark triangular spot anteriad to which are two bright red spots, about size of pupil, one above and one below the lateral line. Above these spots a greenish triangle and below them a greenish suffusion.

Anterior third of caudal fin greenish yellow followed posteriad by a vertical reddish bar about width of the eye, then a whitish bar and an olive-green border.

Anal distally bright emerald green with the spines and soft

rays more intense than the webbing, and basally, on one-third its width, a deep orange on all inter-radial membranes except that between the fourth and fifth rays.

Pelvics a deep blue-green with rays more intense than membranes. Pectorals rather uniform, centrally yellowish olive and peripherally slate-colored.

From the above color description the parental influences can be summarized as follows. The influence of <u>whipplei</u> is seen in the general coloration of the soft dorsal and caudal fins, the presence of a preorbital bar and the basal red of the anal fin. The influence of <u>spectabile</u> is expressed in that the red bar of the soft dorsal diminishes in intensity proximad, the green color of the rudimentary caudal rays, a faint suggestion of streaking on the sides and the faintly orange throat (Figures 2, 3 and 4 and Table 1).

Further influence of <u>spectabile</u> is evident in the naked cheeks, opercles and breast. The presence of embedded scales on the nape of the hybrid may be interpreted as a <u>whipplei</u> influence, although <u>spectabile</u> sometimes has a scaley nape. The complete infraorbital canal (8 pores) in the hybrid indicates a definite influence of <u>whipplei</u> which averages 8.1 pores in the complete canals on each side.

On the basis of the foregoing evidence it was concluded that the specimen in question is a hybrid, <u>Etheostoma</u> (<u>spectabile</u> <u>pulchellum X whipplei</u> whipplei).

ETHEOSTOMA (RADIOSUM SUBSP. X SPECTABILE SUBSP.). Two specimens of this hybrid combination, a male (61.0 mm. standard length)



Figure 2. <u>Etheostoma spectabile pulchellum</u>. Adult male (44.3 mm. standard length) from Sand Creek 3 miles east of Foreaker, Oklahoma.



Figure 3. <u>Etheostoma</u> (<u>s. pulchellum</u> **x** <u>w. whipplei</u>). Adult male (61.5 mm. standard length) from Sand Creek 3 miles east of Foreaker, Oklahoma.



Figure 4. <u>Etheostoma whipplei whipplei</u>. Adult male (55.0 mm. standard length) from Sand Creek 3 miles east of Foreaker, Oklahoma (from Moore and Rigney, MS). and a famale (54.5 mm. standard length); (OAM 2923), were collected by Moore et al. from the Blue River in south-central Oklahoma on April 14, 1949. The female specimen, when dissected, revealed the presence of eggs of various sizes, some apparently mature. The date of collection and the presence of large ova suggest the possibility that the individual had begun spawning.

The specimens of the presumed parental species used, <u>Etheostoma</u> <u>radiosum</u> subsp., (OAM 2913), and <u>Etheostoma</u> <u>spectabile</u> subsp., (OAM 2915, 2099, 1604), were collected from the same locality on the same and different dates. Since the two specimens are of opposite sex and express sexual dimorphism in certain characters, it was considered advisable to analyze these individuals separately. Therefore, the male specimen has been compared with males of the parental species and the female specimen with females of the parental species. Also, comparison of both hybrids with males of one species and females of the other species and the reciprocal cross of this combination was made. In all instances the value of 0 (M_1) has been assigned to <u>spectabile</u> and 100 (M_2) to <u>radiosum</u>.

All specimens used were adults with the range of standard length in <u>radiosum</u> males, 52.5-66.4 mm., in females, 51.5-59.8 mm.; and in <u>spectabile</u> males, 38.4-54.5 mm., and females, 42.3-53.6 mm.

The color description of the male hybrid was taken in the field at the time of collection. The female was not recognized as a hybrid until later and therefore, no color description was available. The color description for <u>radiosum</u> was obtained from Moore and Rigney (MS) and that for <u>spectabile</u> from unpublished

::5

notes of Moore taken from a specimen collected with the hybrid (Table 3).

In this combination, as in the previous one, an average of counts and measurements taken from ten specimens of each parental species (males and females considered separately) was deemed sufficient material upon which to base the study of the hybrids.

The male hybrid is treated first in the following discussion. When compared with males of the parental species, this hybrid shows its most direct intermediacy in the number of pored lateralline scales; number of unpored lateral-line scales; number of scales below the lateral line; number of scales around caudal peduncle; distance from the occiput to dorsal origin, distance from the union of the gill membranes to the tip of mandible and caudal peduncle length expressed in thousandths of head length; and head length expressed in thousandths of soft dorsal length. These eight characters give hybrid index values between 35 and 65 and are, therefore, considered to be significant index values (Table 4).

The soft dorsal length expressed in thousandths of standard length and caudal peduncle length expressed in thousandths of head length give hybrid index values over 80. The pectoral length and caudal peduncle length expressed in thousandths of soft dorsal length give hybrid index values below 20.

This marked influence in the hybrid of both parents is believed to be strong evidence that the parental species have been correctly ascertained. Although these high and low values are poor to show intermediacy, they are regarded as important

A brief color comparison of <u>E. radiosum</u>, <u>E. spectabile</u> and the hybrid, <u>E. (radiosum x spectabile</u>)

	radiosum	Hybrid	spectabile
Head	gill membranes and cheeks or- ange, dorsally blue-green slate	opercles and cheeks orange, gill membranes red	gill membranes orange, cheeks greenish, red- dish brown dor- sally
Side of trunk	buffy olive suffused with orange below lateral line	black bars ven- trally suffused with orange	black blotches forming bars
Sides of caudal peduncle	indistinct bars	greenish black and red bars	greenish black and red bars
Belly	orange	orange	red spots
Fins (colors in order distad from base) Spinous dorsal	brown and buffy olive, orange, white, green	red, white, dark green	red, white, green
Soft dorsal	brown and buffy olive, orange, white, green	red, white, light green	reddish brown, white, green
Caudal	brown and buffy olive, orange, white, green	red spots, brown, red, brown, green	red spots, re- ticulated with black
Anal	orange, blue- green	red, green	red, green
Pectorals	blue-green, orange tips	red and orange	yellow
Pelvics	orange, pale	green	green, yellow

Table 4

Comparison of the male hybrid, <u>E.</u> (<u>radiosum</u> \times <u>spectabile</u>), with male specimens of the parental species

and konstruction of a first state and and a databased of the state state and a state of the state of the state	radiosum	Hybr	id	spectabile
		Counts;		
Character	Range	Propor-	Hybrid	Range
	(Average)	<u>tions</u>	Index	(Average)
Counts				
Pored lateral-				
line scales	40-51(47.1)	43	53.4	35-41(38.3)
Unpored lateral-			0	and the state of the
line scales	4-13(7.9)	11	51.6	12-16(14.3)
Scales below	** -0./	10	~~ 0	
lateral line	11-13(11.7)	10	55.3	6-9(7.9)
Scales around		0.5	<u> </u>	
caudal peduncie	26-29(27.2)	25	62.7	19-23(21.3)
Proportions				
Standard Length		27 0		
in mn.	52.5-66.4(60.5)	61.0	••••	38.4-54.5(43.2)
Thousandins of		4		
standard Length				
Caudal peduncie	010 040(000)	000	ore	
Length	212-248(228)	238	00.0	247 - 271(207)
50IU dorsai lengu	300-304(333)	320	87.9	275-321(299)
Distance from	7/0 101(166)	150	75 0	100 165/141)
Util 0J Mill	148-181(100)	10 G	10.0	123-100(141)
Head tength th mm.	14.9-19.((1(.)	TQ*0		11.0-10.0(14.0)
housanduns of	к.			
Tietenco from	· ,		<u>, </u>	
UDBUBHCE LIUM	100,600(564)	504	50 0	199 550 (121)
Cangel Dequire	406-006(00-1)	JGH	00.0	466-000(404)
lanoth	791-872(781)	784	07.0	826-965(881)
Soft dorsal length		102	01.0	
in mm.	17.5 - 23.0(20.2)	20.0		11.0-17.5(12.9)
Thousandths of soft	T1:0-00:0(00:0)		****	
doreal length				
Distance from				
accipit to				
dorsal origin	400-469(434)	465	60.2	440-591 (512)
Pectoral length	632-811(674)	840	14.4	780-982(868)
Shout length	195-232(205)	215	50.0	198-255(225)
Orbit length	175-211(195)	210	60.5	211-256 (233)
Caudal peduncle				· · · · · ·
length	636-811(684)	725	19.9	808-982(860)
Head length	829-930 (878)	925	52.0	874-1091 (976)
AVERAGE HYBRID INDEX			57.5	

in that they show tendencies toward one parent or the other and are included in Table 4 for the purpose of calculating the average hybrid index.

The color pattern of the male hybrid exhibits, for the most part, the direct influence of one or the other parent. The color description of the male is as follows. Entire dorsum very dark with bars, alternating with olive-brown, extending diagonally downward and backward. Seven dark bars extend around the body from the vent to the end of the caudal peduncle. The last three bars a greenish black with bright red interspaces.

Breast washed with green, opercles red and cheeks orange. A green bar extends downward from the eye and spreads out on the chin. Sides of belly washed with orange.

Spinous dorsal basally bright red and distally a bright green, the two colors being separated by a narrow white line. Soft dorsal basally red with distal green bar, narrower than that of the spinous dorsal and separated from the red by a thin white line.

Caudal fin with two bright red basal spots, one above the other and behind which vertical bars of the following colors occur in order distally: brown, red (widest bar), light brown and green at the border.

Anal fin brilliant red with green border; pelvics green, with red and white in the swollen anterior fin-ray tips; and pectorals washed with orange and red.

The influence of <u>radiosum</u> is expressed by the dark head dorsum, bright orange cheeks, bright caudal bars and basally

red anal fin. On the other hand, the green breast, basal red on the dorsals and two basicaudal red spots reflect the influence of <u>spectabile</u> (Figures 5, 6 and 7 and Table 3).

When compared with females of the parental species, the female hybrid (Figures 8, 9 and 10) shows its most direct intermediacy in the number of scales around the caudal peduncle; premaxillary frenum width expressed in thousandths of standard length; distance from the union of the gill membranes to insertion of pelvics expressed in thousandths of soft dorsal length; and caudal peduncle depth and body width expressed in thousandths of caudal peduncle length. These five characters give significant hybrid index values between 35 and 65 (Table 5).

The pelvic length expressed in thousandths of soft dorsal length and upper jaw length expressed in thousandths of caudal peduncle length give hybrid index values over 80. The number of pored lateral-line scales and the number of scales below the lateral line give hybrid index values below 20.

Although these high and low values are poor to show intermediacy, they are regarded as important in that they show tendencies in the hybrid toward one or the other parent. They are included in Table 5 for the purpose of calculating the average hybrid index. The presence in the hybrid of marked influences of both parents is believed to be strong evidence that the parental species have been correctly ascertained.

The results of the present investigation compare favorably with those of other workers. Hubbs, Walker and Johnson (1943)



Figure 5. <u>Etheostoma</u> <u>radiosum</u> subsp. Adult male (68.0 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma (from Moore and Rigney, MS).



Figure 6. <u>Etheostoma</u> (<u>radiosum</u> subsp. X <u>spectabile</u> subsp.). Adult male (61.0 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma.



Figure 7. Etheostoma spectabile subsp. Adult male (54.5 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma.



Figure 8. <u>Etheostoma</u> radiosum subsp. Adult female (55.0 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma (from Moore and Rigney, MS).



Figure 9. <u>Etheostoma</u> (<u>radiosum</u> subsp. X <u>spectabile</u> subsp.). Adult female (54.5 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma.



Figure 10. <u>Etheostoma spectabile</u> subsp. Adult female (53.6 mm. standard length) from Blue River 24 miles south of Ada, Oklahoma.

Comparison of the female hybrid, <u>E.</u> $(radiosum \times spectabile)$, with female specimens of the parental species

an a	radiosum	Hybrid		spectabile
-		Counts;		
Character	Range	Propor-	Hybrid	Range
ى ئىلىغان بىرى بىلىك كالىستانىر. ئۇدىزە يولىلىغانىن ئىلىستىرىنى ئولىرىنىڭ قىيىد ئىلىسىرىمىتىرىنىڭ بىلىلىسى بىلى	(Average)	tions	<u>Index</u>	<u>(Average)</u>
Counts				
Pored lateral-				
line scales	46-53(49.3)	38	10.3	31-40(36.7)
Unpored lateral-				
line scales	4-10(7.1)	14	23.3	12-21(16.1)
Scales below				
lateral line	10-13(11.2)	8	5.8	7-9(7.8)
Scales around				
caudal peduncle	24-28(25.6)	23	35.0	19-24(21.6)
Proportions				
Standard Length		FAF		AD D EV CLAG EN
in mm.	51.5-59.8(54.0)	54.5	••••	42.3-33.0(40.0)
Thousandths or				
standard length		70	05 0	69 75(71)
Snout Length		206	20.0	
Pelvic length	108-519(198)	200-	34.0	194-209(210)
Premaxillary	04 91 (90)	9/3	50 0	15 96 (94)
irenum width	24-31(20)	20	00.0	$\pm 0^{-20}(2\pm)$
Soft dorsal length	14 0 17 7(16 6)	16 5		17 1-11 8(14 5)
in mm.	14.0-17.7(10.0)	10.0	* * * *	II. I I I I I I I I I I I I I I I I I I
Thousanduns of Solu				
Delvie longth	501-712(658)	678	R1 R	712-860(813)
Pervic rengun	051-712(000)	070	01.0	111-000 (010)
Distance irom	AA7-564(516)	582	35 2	568-661 (618)
Caudel modunalo		002	00.2	
longth in mm	11 6-13 7(19 4)	199		10.8 - 13.5(11.9)
Thousandthe of call-	TT*0-TO*1(TT*T)	10.0	••••	10.0 10.0(11.0)
dal nadurale langth				
Unner jaw length	354-416 (379)	377	95.3	311-376(336)
Body depth	850-1034(952)	926	72.6	763-914 (857)
Caudal peduncle				
denth	467-555(500)	467	53.5	391-469(429)
Body width	575-717(645)	623	61.4	526-683 (588)
AVERAGE HYBRID INDEX			45.2	

*UGM--Union of gill membranes

working with cyprinodonts obtained average hybrid index values ranging from 42-66 and a grand average hybrid index value of 55. Hubbs, Hubbs and Johnson (1943) recorded a grand average value of 49 for catostomid hybrids. The hybrid index values of the male and female hybrids, herein studied, are 57.5 and 45.2 respectively with a grand average value of 51.4.

The squamation of the male and female hybrids suggest influences of different parental species. The squamation of the female hybrid differs from that of the male hybrid in that the cheeks and opercles are naked as they are in <u>spectabile</u>. The cheeks and opercles of the male hybrid have embedded scales as in <u>radiosum</u>. Embedded scales are found on the nape in both hybrids and also in both parental species. The breast of <u>spectabile</u>, but not usually <u>radiosum</u>, is naked as are those of both hybrids.

The parental species also exhibit a striking difference in the infraorbital canal. In <u>spectabile</u> it is incomplete and has an average of 7.2 pores on each side of the head while in <u>radiosum</u> it is complete with an average of 8 pores on each side. The infraorbital canals of the hybrids are incomplete thus indicating the influence of <u>spectabile</u>, but intermediate in that the two sexes average 7.5 pores on each side of the head.

Most of the characters which show intermediacy in Table 4 do not indicate intermediacy in Table 5 and vice versa. This is probably due to the prominent sexual dimorphism expressed by the parental species in some of these characters. Therefore, an average of counts and measurements, taken from twenty specimens (ten males and ten females) of each parental species and the two hybrids (one male and one female) so as to compute an average of each character and thereby obtain a value intermediate to the two sexes, were compared (Table 6). In this comparison there are sixteen characters which give values between 0 and 100, eight of which show tendencies toward one parent and eight toward the other with an average hybrid index value of 46.7.

Since there is prominent sexual dimorphism expressed by the presumed parental species it was thought that possibly a comparison of <u>spectabile</u> males and <u>radiosum</u> females with the two hybrids; and also the reciprocal cross, male <u>radiosum</u> and female <u>spectabile</u>, might produce some interesting comparisons.

Table 7 shows a comparison of ten female <u>radiosum</u> and ten male <u>spectabile</u> with the two hybrids (one male and one female). Ten characters, five of them scale counts, yielded index values between 0 and 100 with an average hybrid index value of 40.7.

Table 8 demonstrates the reciprocal cross using ten male <u>radiosum</u> and ten female <u>spectabile</u>. In these data 26 characters yielded values between 0 and 100 with an average hybrid index value of 61.6.

Since the latter comparison yielded 16 more characters than the former, with values between 0 and 100, it might be concluded that the parents of the hybrids were a male <u>radiosum</u> and a female <u>spectabile</u> if, as Hubbs (1940) implied, systematic characters in fish hybrids tend to be intermediate between the two parental species.

Although the tables are not included, comparisons were made

Comparison	of th	ne male	anđ	female	hybr	ids, <u>E</u>	<u>theostoma</u>	(<u>radiosum</u>	X
	spect	tabile),	wit	h male	and	female	specimens		
		of	the?	parent	tal s	pecies			

	radiosum	Hybrids		<u>spectabile</u>
		Counts:		
Character	Range	Propor-	Hybrid	Range
	(Average)	tions	Index	(Average)
Counts				and the second
Pored lateral-				
	40 59(40 0)	40 E	96 5	21 41 (27 5)
	40=00(40.2)		20.0	$01 - 41(01 \cdot 0)$
onpored lateral-		105	C	
Line scales	4-13(7.5)	15.2	57.4	12-21(15.2)
Scales above				
lateral line	7-9(8.0)	7.0	23.1	6-8(6.9)
Scales below				
lateral line	10-13(11.5)	9.0	30.6	6-9(7.9)
Scales around				
caudal peduncle	24-29(26.4)	24.0	51.0	19-24(21.5)
Proportions				
Standard length				· · · ·
in mm.	51.5-66.4(57.3)	57.8		38.4 - 54.5(44.9)
Thousandthe of				
standard langth				
Coudel reduced				
l caudat peduncie	010 040(000)	021	00.0	690 070 (957)
		231	32.0	
Pectoral length	197-254(227)	250	11.0	234-211(203)
Premaxillary		0.0	05.0	
frenum width	24-36(29)	20	25.0	19-31(25)
Distance from				
UGM*to pelvics	132-167(151)	162	21.4	155-178(165)
Head length in mm.	14.1-19.7(16.6)	16.9	••••	11.5-15.8(13.2)
Thousandths of				
head length				
Distance from				
UGM*to pelvics	467-572(525)	573	11.1	508-629(579)
Soft dorsal length				
in m.	14.0-23.0(17.9)	18.3		11.0-17.5(12.7)
Thousandths of soft	,			
dorsal length				
Distance from				
Discance from				
dengel enicin	400 569(475)	197	94 6	440-618(553)
Distanal length		700	671	
Pectoral Length			42.0	200-202 (202) 200-202 (202)
Pervic Length	522-(12(629)	14	43.3	
Snout length	190-252(214)	223	72.1	
Body width	387-557(474)	488	72.5	430-588(525)
Distance from				100 000 (000)
UGM*to pelvics	432-564(486)	531	55.9	483-001(588)
1				,
AVERAGE HYBRID INDEX	•••••		46.7	

*UGM--Union of gill membranes

Comparison of the male and female hybrids, <u>Etheostoma</u> (<u>radiosum</u> X <u>spectabile</u>), with female specimens of <u>radiosum</u> and male specimens of <u>spectabile</u>

	radiosum	Hybrids		spectabile
		Counts;		
Character	Range	Propor-	Hybrid	Range
	(Average)	tions	Index	(Average)
Counts				
Pored lateral-				
line scales	46-53(49.3)	40.5	20.0	35-41(38.3)
Unpored lateral-				
line scales	4-10(7.1)	12.5	25.0	12-16(14.3)
Scales above	·			
lateral line	7-9(8.0)	7.0	16.6	6-7(6.8)
Scales below				
lateral line	10-13(11.2)	9.0	33.3	6-9(7.9)
Scales around				
caudal peduncle	24-28(25.6)	24.0	62.8	19-23(21.3)
Proportions				-
Standard length			t.	
in mm.	51.5-59.8(54.0)	57.8		38.4-54.5(43.2)
Thousandths of				~ .
standard length				
Caudal peduncle				
length	217-243(230)	231	96.3	247-271(257)
Pectoral length	197-254(228)	250	29.0	234-271(259)
Distance from				
UGM*to pelvics	132-159(147)	162	25.0	157-175(167)
Soft dorsal length	• •		l	
in mm.	14.0-17.7(15.5)	18.3		11.0-17.5(12.9)
Thousandths of soft			}	
dorsal length				
Pelvic length	591-712(658)	714	34.9	662-868(744)
Distance from				
UGM*to pelvics	447-564(516)	531	64.3	483-636(558)
AVERAGE HYBRID INDEX			40.7	

*UGM--Union of gill membranes

Comparison of the male and female hybrids, <u>Etheostoma</u> (<u>radiosum</u> X <u>spectabile</u>), with male specimens of <u>radiosum</u> and female specimens of <u>spectabile</u>

	radiosum	Hybrids		spectabile
		Counts;		
Character	Range	Propor-	Hybrid	Range
naala maamininii 12,780 milii ooladoo ka qogo "mahuu ahuma u taadoodi sijadoo Macalii walau uu oonaa maa somay	(Average)	tions	Index	(Average)
Counts				
Pored lateral-				
line scales	40-51(47.1)	40.5	36.5	31-40(36.7)
Unpored lateral-				
line scales	4-13(7.9)	12.5	43.9	12-21(16.1)
Scales below				
lateral line	11-13(11.7)	9.0	30.8	7-9(7.8)
Scales around				
caudal peduncle	26-29(27.2)	24.0	42.9	19-24(21.6)
Proportions		- 94 		
Standard length				
in mm.	52.5-66.4(60.5)	57.8	••••	42.3-53.6(46.5)
Thousandths of				
standard Length	02 00 (05)			
Orbit Length	6 T- 68(63)	67	50.0	67-75(71)
Caudal peduncie		003	00.11	
length	212-248(228)	231	89.3	239-278(256)
Solt dorsal length	300-354(333)	310	13.4	203-293(209)
Premaxillary	05 75 (20)	00	04 0	15 06 (04)
			JJ.J	
Head rength in ma.	1 14 •9-19•((1(•()	10.9	* • • •	12.4-10.0(13.7)
hood longth				
Orbit langth	201-235(222)	222	68 4	228-252(241)
Contra rengon		200	00.4	
length	721-872(781)	791	88.6	810-964(869)
Head denth	631-722(672)	638	34.6	591-664(620)
Soft dorgal length		000	01.0	
in mm.	17.5 - 23.0(20.2)	18.3		11.4 - 14.8(12.5)
Thousandths of soft	21.0.00.0(20.0)			
dorsal length				
Distance from				
occiput to				
dorsal origin	400-469(434)	487	66.7	520-618(593)
Pectoral length	632-743(674)	790	55.6	797-974(935)
Pelvic length	522-649(599)	714	46.1	712-860 (813)
Snout length	195-232(205)	223	57.1	236-273(268)
Upper jaw length	269-308(278)	295	63,8	284-342(325)
Caudal peduncle				ч.
length	636-811(684)	732	83.0	878-1022(967)
Orbit length	175-211(195)	211	77.9	243-274(268)
			1	

Table 8 (concluded)

	radiosum	Hybr	ids	spectabile
		Counts;		
Character	Range	Propor-	Hybrid	Range
	(Average)	tions	Index	(Average)
Thousandths of soft				
dorsal length(con't)				
Body depth	632-755(693)	720	80.1	703-843(829)
Body width	387-486(431)	488	58.7	526-588(569)
Distance from				
UGM*to pelvics	432-498(455)	531	53.4	568-661(618)
Body depth in mm.	14.9 - 19.7(17.4)	13.2		9.2 - 11.7(10.2)
Thousandths of				
body depth				
Body width	574-674(619)	678	11.9	632-817(686)
Caudal peduncle				
length in mm.	11.9-15.4(13.8)	13.4		10.8 - 13.5(11.9)
Thousandths of cau-				
dal peduncle length				
Upper jaw length	377-429(406)	402	94.3	311-376(336)
Anal length	953-1326(1174)	1128	84.7	770-1031 (874)
Body depth	867-1101(1014)	988	83.4	763-914(857)
Caudal peduncle				
depth	487-601(558)	537	83.7	391-469(429)
*				
AVERAGE HYBRID INDEX			61.6	

*UGM--Union of gill membranes

as in Tables 7 and 8 except that the hybrid sexes were treated separately. These comparisons yielded very much the same results as those obtained in Tables 7 and 8.

Without experimental data it is apparently impossible to predict the appearance of the hybrids between the two possible reciprocal crosses, but if darter characters behave in the same manner as those of their relatives the centrarchids or as those of poeciliids (Hubbs, 1940), the data obtained in Tables 7 and 8 should be closely similar. This is not true, since, as stated above, 16 more characters yielded values between 0 and 100 when male <u>radiosum</u> and female <u>spectabile</u> were compared with the hybrids.

When we consider individual characters, there is sometimes a lack of expression in one sex suggesting the possibility that the character is of the sex-linked or sex-influenced type. For example, the so-called humeral scale is well-developed in <u>radiosum</u> but poorly-developed in <u>spectabile</u>. The male hybrid resembles <u>radiosum</u> in this character while the female does not. It seems possible, therefore, that in the cross between the two species the emphasis of this character goes only to the male, whereas in ordinary matings it is either well-expressed or not.

Squamation of the head is similarly in expression. The <u>radiosum</u> head is quite regularly scaled and the <u>spectabile</u> head is naked. The hybrid male has scaley cheeks and opercles whereas the female has these areas naked.

It is evident that these percids present a somewhat different problem than that of the centrarchids and poeciliids. Experimental work will be necessary to demonstrate the inheritance

of some characters in E. radiosum and E. spectabile.

On the basis of the preceding evidence it is concluded that the specimens under discussion represent the hybrid combination, <u>Etheostoma</u> (radiosum subsp. χ spectabile subsp.).

DISCUSSION

The Blue River System has a relatively rich fish fauna consisting of 49 known species which represent nine families and 32 genera. Future collections will probably produce the following additional families: Polyodontidae, Lepisosteidae, Hiodontidae and Anguillidae as well as additional genera and species of the families already taken.

The collections from Hughes Crossing provided the greatest variety of species with a total of 21 taken and records for three others obtained from Mr. Hughes. It is also of interest that although a relatively large number of species was collected, only 34 specimens, the smallest number from any locality, were taken there. The scarcity of specimens is explained by the difficulty encountered in seining operations over the very irregular bottom, often strewn with large boulders.

The JN Creek collection produced the largest number of individuals. Two hundred and forty-seven specimens representing 18 species, of which <u>Notropis venustus venustus</u> made up 172, were collected there.

Etheostoma radiosum, represented by 432 specimens, the largest number of individuals of any species taken, was the most widely distributed form in the Blue River System. This abundance in the collections is in part due to concerted effort to obtain large series. <u>Notropis venustus venustus</u> and <u>Notropis cornutus</u> <u>isolepis</u> were next in order of abundance. <u>Campostoma anomalum</u> was collected at ten different stations.

The hybrid combinations described in this paper probably originated by accident since there has been such a small number collected. The fact that there is interfertility between the parental species is indicative of their close relationship. Although the geographical ranges of the parents of each combination are superimposed, the species have maintained themselves as distinct species, indicating that interbreeding is not widespread. There has possibly been a breakdown of the complex isolating mechanisms which prohibit mass interbreeding by such distinct species within a common range (Blair, 1951).

The scarcity of recognized interspecific hybrids such as these has been discussed by Blair (1951), who suggested that isolating mechanisms are so effective that hybrids are rare. Blair also indicated that we do not appreciate the extent of hybridization in nature and may seldom recognize the hybrids which are produced, since so little work has been done.

Some of these barriers may have been broken down by the unbalanced sex ratio found in the parental species collected at Foreaker. Of the 144 specimens of <u>spectabile</u>, collected at the same time and place as the hybrid, 88 (61.1%) are females and 56 (38.9%) are males; or the 31 specimens of <u>whipplei</u>, collected at the same time and place, 19 (61.3%) are females and 12 (38.7%) are males. Coupled with this unbalanced sex ratio at Foreaker is a predominance of one parent. In a total of 175 specimens

collected, 31 (17.7%) are whipplei and 144 (82.3%) are spectabile.

The sex ratio of the parental species collected from the Blue River are approximately 1-1, but there is a predominance of one parental species. In a total of 347 specimens collected from the same localities as the hybrids, 217 (62.5%) are <u>radiosum</u> and 130 (37.5%) are <u>spectabile</u> indicating a predominance of <u>radiosum</u>, unless some selectivity in collecting method existed. It must be added that the collectors were striving to obtain as many examples of <u>radiosum</u> as possible. A predominance of one species, accompanied by an unbalanced sex ratio, is an explanation proposed by Hubbs, Hubbs and Johnson (1943) for some catostomid hybrid combinations and also by Hubbs, Walker and Johnson (1943) for cyprinedents.

A breakdown of ecological barriers may have altered the spawning habits of the species concerned. If one species spawns in the riffles and fast-moving water of the stream and the other in the pools directly below the riffles, it is quite possible that milt from the male riffle-spawner may float into the spawning beds of the other species in the pools and fertilize the eggs. This possible explanation is supported by field experience which indicates that <u>spectabile</u>, in Oklahoma, is more abundantly collected in the quieter water than in the faster riffle habitat. <u>E. radiosum</u>, on the other hand, is taken, in breeding color, most often from riffles. This was proposed as a possible explanation for a cyprinid combination by Moore and Paden (1950).

Intensive studies of the breeding habits of the parental

species and the ecological conditions in the habitats will be necessary before definite conclusions can be drawn as to what combination of factors brought about hypridization.

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TYPIST PAGE

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