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FRANCIS RAMALEY
EDITOR

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UNIVERSITY OF COLORADO
BOULDER, COLO.

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CONTENTS OF VOLUME XI

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Fishes of Colorado

Max M. Ellis

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FISHES OF COLORADO[1]

BY MAX M. ELLIS

This review of the fish fauna of Colorado is based primarily on collections[2] made during the years 1912 and 1913 with the patronage of the Museum of the University of Colorado, as a part of the State Biological Survey. Through the generosity of the officials of the various museums in the state the writer has also had free use of the ichthyological material in their collections. In order to include data gathered by previous workers whose collections were not accessible,

[1] *Publication of the Colorado Biological Survey*, No. 15. The Amphibia and Reptilia of Colorado were treated in *Publication No. 14*, being Vol. X, No. 2, of these *Studies*.

[2] The fishes were killed in the field with 5 per cent formalin, pierced or injected, and preserved in 85 per cent grain alcohol.

an effort has been made to give a list of all published references to Colorado fishes which are based on specimen records.

Since fishes are difficult to collect and to transport, unless the party be especially prepared for such work, few specimens of fishes were taken by the early surveys as compared with reptiles and amphibians. The first collections of Colorado fishes reported upon were those made as part of the Wheeler Survey during the years 1872 to 1874. The specimens were studied by Cope and Yarrow. In 1889 Jordan and Evermann made collections in Colorado for the United States Fish Commission, publishing a report in 1891. The only local list of Colorado fishes was prepared by Juday in 1903 from specimens collected at Boulder and Longmont. In 1908 Cockerell compiled a list of the fishes of the Rocky Mountain region. Other records are cited under the particular species.

The writer wishes to express his thanks to the following persons who have materially aided this work: Professor Junius Henderson, curator of the Museum, Professor Francis Ramaley, Professor T. D. A. Cockerell, and Mr. Arthur G. Vestal, of the University of Colorado for their generous assistance both at the University and in the field; Colonel James A. Shinn, state commissioner of game and fish, for co-operation from his office; Messrs. Harold E. Robbins, Howell Ellis, Walter Reed, Stuart Way, and Russell Wells for assistance in collecting and seining; Professor A. E. Beardsley of the State Teachers' College, Professor E. Bethel of the East Denver High School, Messrs. J. C. Smiley and H. G. Smith of the Colorado State Historical and Natural History Museum, E. R. Warren and H. B. Baker of Colorado College, and F. A. Riedel of Canyon City, for specimens and records; Messrs. L. C. Paddock, state commissioner of immigration, A. D. Parker of the Colorado and Southern Lines, and E. L. Brown and Frank Wadleigh of the Denver and Rio Grande Railroad, whose interest in this survey made part of the field work possible.

Hydrography of Colorado

Since fishes are aquatic animals, a general survey of the hydrography of a given area is essential to the understanding of its fish fauna. For the study of the fishes found in them the waters of Colorado may be divided into two groups, the *river systems* and the *lakes*.

River Systems

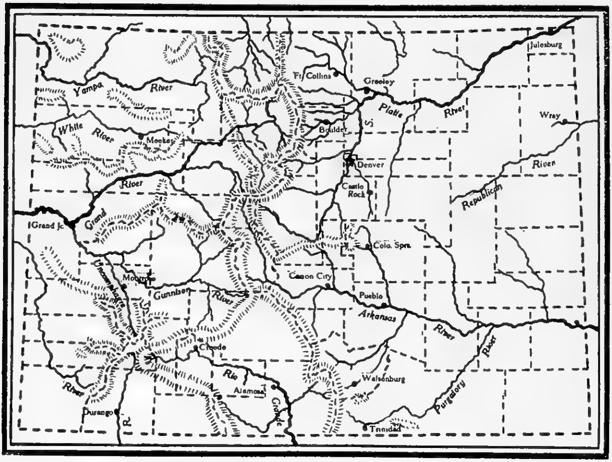
Two features of the river systems of the state, taken collectively, are particularly noteworthy: (*a*) three distinct drainages are represented, the Mississippi, the Rio Grande and the Colorado; (*b*) all of the large streams of the state have their headwaters in the mountains within the state. Both the diversity of drainage areas and the large number of headwater streams are the result of the presence of the Continental Divide in central Colorado, separating the lower, eastern and western portions. This division of the land areas by the mountains has a very important bearing on the fish fauna as a whole, since often many of the fishes of independent drainages are different, and the conditions to which fishes are subjected in the headwater streams are always more rigorous than in the lowland streams. The position of the mountains in Colorado is also responsible for the direction of the larger streams, these flowing east or west, while their tributaries enter from the north and south.

1. **The Mississippi System.**—This drainage in Colorado includes all of the streams east of the Continental Divide excepting the Rio Grande and its tributaries, and comprises the North Platte, the South Platte, the Republican and the Arkansas, with their tributaries.

The North Platte drains a high mountain park, North Park, inclosed by the Continental Divide on the south and west and the Medicine Bow Range on the east. The Colorado portion of this stream is entirely a mountain stream since it does not fall below the 8,000-foot contour and is fed from the snows on the surrounding mountains.

The South Platte and its tributaries drain roughly the northeastern quarter of the state, about 22,000 square miles in all, of which more than 12,000 square miles are below the 6,000-foot contour. The main stream, which is more than three hundred miles in length, rises in South Park at an altitude of about 11,000 feet, so that it is both a mountain and a plains stream in Colorado. Flowing out of

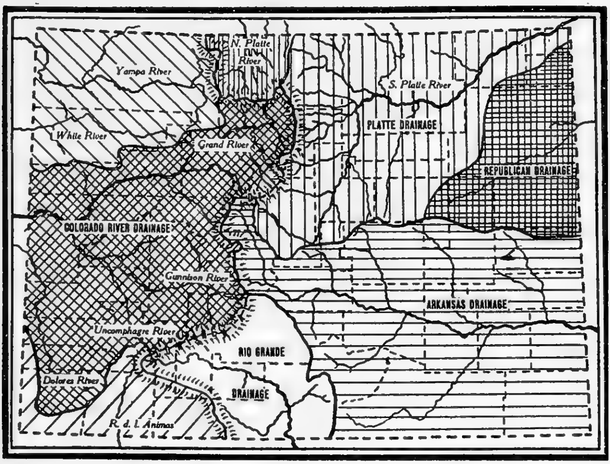
South Park it falls rapidly, descending 4,000 feet in the first hundred miles. The remaining two hundred miles of its course are in the plains, where the fall is more gradual. After leaving the foothills it is joined by Clear Creek, St. Vrain Creek and the Cache la Poudre River. These streams with their tributaries drain the east side of the Front Range and the foothill region north of Denver. Many other streams, which rise in the plains and are dry for a considerable



Map of Colorado showing principal places from which collections were examined.

portion of the year, join the South Platte from the north and south, west of 103° 30′. East of this meridian the Platte is without tributaries from the south since it flows quite close to the Platte-Republican divide.

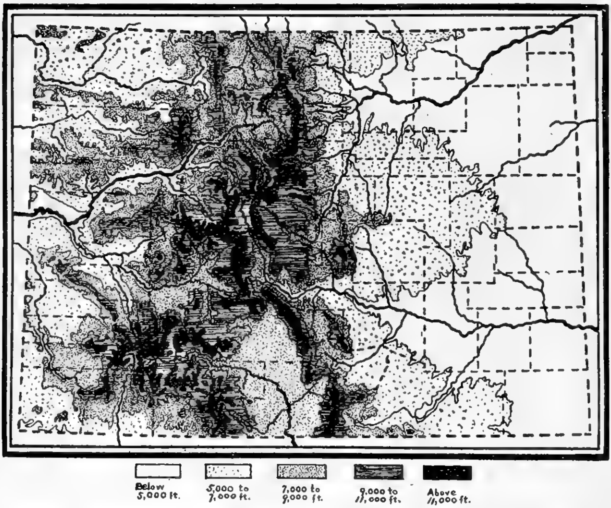
The Republican River is confined to the plains; it rises at an elevation of less than 6,000 feet. Five streams, the tributaries of which are for the most part wet-weather creeks, flow into the Republican River from Colorado. The North Fork of the Republican, which is the shortest of the five, leaves the state near the 40th parallel and unites with the Arikaree River a few miles beyond the Colorado line; the South Fork of the Republican parallels the Arikaree some twenty miles south of it. North of the North Fork of the Republican are two small streams, Red Willow Creek and Frenchman's Creek. The Smoky Hill River leaves the state near the Platte-Arkansas divide and comprises the extreme southeastern portion



Map of Colorado indicating the extent of the several drainage areas. (See table on p. 13.)

of the Republican drainage. It is here included in the Republican drainage, although it flows into the Kansas River, because the Kansas and Republican rivers unite before joining the Missouri.

The Arkansas and its tributaries drain the southeastern quarter, much as the South Platte drains the northeastern quarter of the state. The drainage area of the Arkansas is included for the most part between 102° and 103° 30′ West and 37° and 39° North. The Arkansas rises near the 11,000-foot contour in Lake County southeast of Homestake Peak. The headwaters and upper portion of the stream lie between the Continental Divide and the Mosquito Range, in a mountain valley which narrows at its southern end into a canyon. Leaving this canyon at Canyon City, where the stream has an elevation of but 6,500 feet, the Arkansas flows eastward across the state as a plains



Map of Colorado showing the mass elevations and their relations to the several river systems.

stream. It receives numerous tributaries from the foothill region, chief among which are Fountain Creek from the north and Greenhorn and Huerfano rivers from the south. The Arkansas is also joined in the plains by Horse Creek from the north and the Apishapa and Purgatory rivers from the south, the last two being typical plains streams although their headwaters are on the east slopes of the Sangre de Cristo and Culebra ranges. An area of a few hundred square miles just north of the New Mexico boundary is drained by the Cimarron River. This stream joins the Arkansas in Oklahoma. In the present paper it is considered a part of the Arkansas system.

2. **Rio Grande.**—The San Luis Valley is the only portion of Colorado east of the Continental Divide which is not a part of the Mississippi drainage, the Rio Grande emptying into the Gulf of Mexico. In Colorado this river does not fall below the 7,000-foot contour, yet flowing as it does through a fairly level mountain valley the lower half of the stream is for the most part sluggish and has a clay bottom. From its source on the east slope of the Continental Divide in San Juan County the Rio Grande descends 2,000 feet in the first twenty-five miles, and 1,200 feet in the next fifty, so that above Del Norte it is a mountain torrent flowing over large rocks and bowlders.

3. **The Colorado River System.**—West of the Continental Divide all of the streams in Colorado flow into the Colorado River, which empties into the Gulf of California. Western Colorado is divided into several rather isolated valleys. Five independent streams have their headwaters in this portion of the state. Starting with the most northern these streams are: the Yampa River, the White River, the Grand River, Rio Dolores and the San Juan River. Each of these joins the Colorado River shortly after leaving the state, most of them within a hundred miles of the Colorado line. The Grand River and its southern tributary, the Gunnison, together with the Rio Dolores, which flows into the Grand in eastern Utah, drain the central half of western Colorado. The Grand River proper rises in the extreme northern part of Middle Park. Flowing in a southwesterly direction, it leaves Middle Park through Gore Canyon and continues as a turbulent mountain stream to beyond Glenwood Springs. At Grand Junction, where it is still a vigorous stream, it is joined by the Gunnison River. Beyond this confluence the Grand becomes a wider, slower river, continuing to the state line as a typical plains stream. The Gunnison, although flowing through sage-brush plains for some distance before joining the Grand, is a rapidly moving river even at Grand Junction. The mountain streams that constitute the headwaters of the Gunnison, on the west slope of the Continental Divide

in Gunnison and Saguache counties, as also the main stream, flow through rather narrow valleys and canyons, over rough stream beds, making the Gunnison one of the most picturesque and turbulent rivers of the state. The South Fork of the Gunnison leaves the highland through the Grand Canyon of the Gunnison, meeting the North Fork near Delta. At Delta the Gunnison receives a large tributary from the south, the Uncompahgre River.

The summarized data concerning the river systems of the state are given in the following table (I). These data should be used in conjunction with the maps.

Lakes

Considered biologically the natural lakes of Colorado are of two types, the high mountain lakes and the plains lakes. Those of the first group are characterized by cold, clear water containing very little solid matter in solution, and almost none in suspension. These lakes are numerous throughout the mountains and usually have an altitude of more than 8,000 feet. Several of them are of considerable size although many are less than a mile across. Of the larger lakes the most prominent are Twin Lakes in Lake County, Grand Lake in Grand County, Marvine and Trapper's lakes in Rio Blanca County, John Lake in Jackson County and Santa Maria Lake in Mineral County.

The plains lakes usually contain an appreciable quantity of alkali in solution, are sometimes turbid with suspended material and vary much in temperature with the season. Many such lakes are found in the northeastern portion of the state and several in the upper part of the San Luis Valley. In this class must also be included, as regards the fishes contained, the various artificial reservoirs in the plains and foothill regions of the state.

Systematic Account of the Fishes of Colorado[1]

Class PISCES

Aquatic poikilothermous vertebrates with gills functional throughout life, usually with paired lateral fins, without digitate limbs, with a lower jaw.

[1] For definitions of the technical terms see glossary, p. 131.

TABLE I

General Drainage Data

Drainage	Stream	Length of Main Stream in Miles	Miles of Stream above 9,000 Ft.	Miles of Stream 7,000–9,000 Ft.	Miles of Stream 5,000–7,000 Ft.	Miles of Stream below 5,000 Ft.	Approximate Elevation at State Line in Feet
N. Platte 1,800 sq. mi.	N. Platte	55	5	50			8,000
S. Platte 22,000 sq. mi.	S. Platte	320	25	40	55	200	3,450
Republican 5,700 sq. mi.	South Fork Republican	75			10*	65	3,450
	Arikaree	100			15*	85	3,400
	North Fork Republican	30				30	3,400
Arkansas 29,000 sq. mi.	Arkansas	305	30	35	75	165	3,350
	Purgatory	145	5	15	55	70	
Rio Grande 7,500 sq. mi.	Rio Grande	175	25	150			7,500
Colorado River 39,000 sq. mi.	Yampa	165	10	20	135		5,500
	White	120	10	20	90		5,200
	Grand	185	5	15	115	50	4,350
	Gunnison	135	25	55	55		
	Uncompahgre	65	5	10	50		
	Dolores	160	10	35	115		5,100
	Rio d. l. Animas	65	10	20	35		6,000

* Wet-weather stream.

This group of animals, generally known as fishes, includes the sharks and chimeras, the ganoid fishes, the lung fishes and true fishes. It exceeds all other divisions of vertebrates in both numbers of species and numbers of individuals. All types of aquatic habitats from very shallow streams to the depths of the ocean are inhabited by fish. Because of the great diversity of forms represented it is necessary to divide the class Pisces into several large units and many smaller ones. All of the Colorado fishes are referable to a single series, the Bony Fishes.

Subclass TELEOSTOMI

The True Fishes

Series Teleostei

The Bony Fishes

Bones well ossified; body naked or covered with scales; spiral valve wanting.

Key to the Families of Fishes Found in Colorado[1]

A. Ventral fins inserted well back on the abdomen, their origins barely if at all reached by the tips of the pectoral fins; or ventral fins wanting.

B. Body without scales; adipose fin usually and barbels always present.
Family *SILURIDAE*, the Catfishes, p. 15

BB. Body more or less completely covered with scales (one species without an adipose fin, without scales).

C. Ventral fins present.

D. Head without scales.

E. No adipose fin.

F. Dorsal fin with 10 or more rays; fins without spines; mouth usually inferior; no barbels; body usually terete. Family *CATOSTOMIDAE*, the Suckers, p. 19

FF. Dorsal fin with 9 or fewer rays, without a serrate spine (native species); or dorsal fin with 17 to 21 rays and a serrate spine (introduced species); barbels present or absent; body often somewhat compressed.
Family *CYPRINIDAE*, the Minnows and Carp, p. 31

EE. Adipose fin present.

G. Dorsal fin long and high, with 19 to 24 rays.
Family *THYMALLIDAE*, the Graylings, p. 71

GG. Dorsal fin moderate, with 9 to 15 rays.
Family *SALMONIDAE*, the Trout and Whitefish, p. 73

DD. Sides of the head scaled, top of the head covered with leathery plates of skin; no adipose fin; lower jaw projecting; mouth somewhat superior.
Family *POECILIIDAE*, the Killifishes, p. 86

CC. No ventral fins; scales minute and imbedded in the skin; body long and snake-like.
Family *ANGUILLIDAE*, the True Eels, p. 91

[1] For the location of the various parts mentioned in this and the following keys, see Fig. 43 and the glossary. In using these keys read first "A" and "AA"; if the characters of the specimen under consideration are those of "A," "B" and "BB" are next to be read; if the characters are those of "AA," the two statements under "AA" of equal rank with "B" and "BB" (in the above key "H" and "HH") are to be read. Proceed in this manner, always considering the two alternatives of the same letter which are first in rank below the letter last chosen, until the name is reached.

AA. Ventral fins inserted well forward, their origins quite near the origins of the pectoral fins; anterior portion of the dorsal fin always with spines.

H. Body well covered with scales, which are regularly arranged; anal fin with spines.

I. Dorsal fin single, the spinous and soft portions always united.
Family *CENTRARCHIDAE*, the Sunfishes and Bass, p. 93

II. Dorsal fins two, the spinous and soft dorsals completely separated or just touching at the base . . . . . . Family *PERCIDAE*, the Perch and Darters, p. 102

HH. Body without scales, or at least not regularly and completely covered with scales; skin more or less covered with minute prickles; anal fin without spines.
Family *COTTIDAE*, the Sculpins, p. 113

Superorder *OSTARIOPHYSI*

The anterior vertebrae just back of the skull fused and modified, forming the Weberian apparatus which connects the air bladder with the internal ear. Most of the freshwater fishes are included in this group.

Order NEMATOGNATHI

The Catfishes and Related Forms

Family *SILURIDAE*

The Catfishes

Body scaleless, with or without bony plates, skin very tough, frequently silvery in color; barbels always present, often elongate; adipose fin generally present; dorsal and pectoral fins usually with heavy spines.

Catfishes are found in most of the fresh waters of the world and some species are marine. They vary from forms like the little Stone Cat, *Schilbeodes nocturnus* (Jordan and Gilbert), which rarely exceeds three inches in length, to the Wels, *Silurus glanis* L., of the Danube River, which reaches the length of nine feet or more and a weight of four hundred pounds. Most species of Silurids have heavy erectile spines in the dorsal and pectoral fins by means of which they can inflict a painful wound. One species, *Malapterurus electricus* (Gmelin), found in the Nile River, can produce a powerful electrical discharge. Catfishes are particularly abundant in the tropical portions of Africa and South America. Eigenmann (1910) has listed three hundred species exclusive of related Nematognathi from South America, nearly one-sixth of the entire fish fauna of that continent. The total number of Catfishes has been estimated as about one thousand (Boulenger, 1904).

In the fresh waters of the United States about thirty species of Silurids are found, three of which are known to occur in Colorado. Catfishes are not native in the streams of the United States west of the Rocky Mountains, although they have been successfully introduced in several localities. Two genera of Silurids are represented in Colorado.

a. Tail entire or but slightly notched; size small to medium; adults generally less than sixteen inches in length . . . . *Ameiurus* Rafinesque
aa. Tail deeply forked; size medium to very large. . . . . . . *Ictalurus* Rafinesque

Subfamily Ictalurinae

Genus **AMEIURUS** Rafinesque

Bullheads; Horned Pout

Ameiurus Rafinesque, *Ichthyologia Ohiensis*, p. 65, 1820.

Adipose fin distinct, separate from the caudal fin; barbels eight; caudal fin generally entire or but slightly notched, although in some species distinctly forked; supraoccipital process pointed, separate from the interspinal buckler; small to medium sized fishes. Two species of this genus, one native and one introduced, are found in Colorado.

Ameiurus melas (Rafinesque)

Black Bullhead, Little Pout, Horner (Fig. 1)

Silurus melas Rafinesque, *Quart. Journ. Sci. Litt. Arts*, London, p. 51, 1820 (Ohio River).

Ameiurus melas (Rafinesque)—Jordan, *Bull. U.S. Fish Com.*, p. 16, 1889 (Pueblo).

Amiurus nebulosus (LeSueur)[1]—Cope and Yarrow, Wheeler Survey, Vol. V, p. 640, 1875 (Pueblo, Arkansas River).

Body stout and rather short, depth 3 to 4 (adult) or even 5 (young) in the length to the base of the caudal; head short, broad and flattened above, widest posteriorly, its greatest width about equal to the depth of the body; maxillary barbels extending to or slightly beyond the posterior margin of the head; mouth large and wide; dorsal fin higher than long; dorsal spine nearer to the tip of the snout than to the base of the caudal, usually short, slightly pointed and not curved; adipose fin prominent, distinctly elevated, its posterior margin free from the back; caudal fin very slightly, if at all, notched; pectoral fin with a spine, which is short and blunt, its length not more than 3 in the head, its posterior margin slightly curved and varying from almost smooth to serrate with 6 or more small teeth; tip of the pectoral fin reaching a point about midway between the origin of the ventral fin and the origin of the pectoral; anal fin rather short, with 18 or 19 well-developed rays and 2 or 3 rudimentary rays; lateral line prominent.

General color black, dark green or dark blue, sides with a brassy or greenish-yellow luster; ventral parts yellowish or greenish gray; fins dusky, the rays lighter; barbels black.

[1] This reference is placed under this species since the fin formula given by Cope and Yarrow is D.I,6; A.17; V.8.

Size small, length rarely more than 12 inches, average adults 9 or 10 inches. Spawning season, latter part of May and month of June.

Range, New York west into Colorado, south into Texas, very abundant in parts of Michigan and west of the Mississippi.

This little catfish is common in the ponds and lakes of eastern Colorado, occurring native in the Platte, Republican and Arkansas drainages. It has been introduced successfully into ponds both at Grand Junction and at Montrose. The species is of considerable economic importance, as it is marketed regularly.

Colorado specimens.—*University Museum:* Arkansas River (160 mm.), E. R. Warren, No. 307; Wray, Republican River, October 26, 1912 (19 specimens, 35–45 mm.), A. G. Vestal and M. M. Ellis, No. 308; *State Teachers' College Museum:* Ponds near Greeley, A. E. Beardsley; *Colorado State Historical and Natural History Museum:* Sloans Lake, Denver County, July 30 and August 1, 1900 (2 specimens, 90 and 200 mm.), W. C. Ferril; Cooper's Lake, Denver, August 5, 1900 (100 mm.), W. C. Ferril.

Ameiurus nebulosus (LeSueur)

Common Bullhead, Horned Pout (Fig. 4)

Pimelodus nebulosus LeSueur, *Mem. Mus.*, Vol. V, p. 149, 1819 (Lake Ontario).

Very much like the preceding one, *A. melas*, from which it differs in the number of anal rays, these being 22 or 23 with one or two additional rudimentary ones, and in the more elongate form of the body, the depth being contained 4 to 5 times in the length to the base of the caudal in the adult and more than 5 in the young. This species also grows to a larger size than *A. melas*, reaching the length of 20 inches.

Range, United States generally, east of the Rocky Mountains, introduced into the rivers of California.

Included in the Colorado fauna as an introduced fish. It is raised in several of the reservoirs in eastern Colorado. The specimens seen were from ponds in Denver County.

Genus **ICTALURUS** Rafinesque

The Channel Cats

Ictalurus Rafinesque, *Ichthyologia Ohiensis*, p. 61, 1820.

Adipose fin distinct, separate from the caudal fin; caudal fin deeply forked; barbels eight; supraoccipital process produced posteriorly, joining the second interspinal buckler, forming a continuous bony bridge from the skull to the base of the dorsal spine. The species of this genus, which are known only from North American streams, include some of the largest of the North American catfishes. Four species are known at present.

a. Anal fin of more than 30 rays, its outer margin straight or slightly concave; color bluish or silvery, white below . . . . *Ictalurus furcatus*[1] (LeSueur)

aa. Anal fin of less than 29 rays, its outer margin distinctly convex; color greenish, lighter below. *Ictalurus punctatus* (Rafinesque)

Ictalurus punctatus (Rafinesque)

White Cat, Channel Cat

Silurus punctatus Rafinesque, *Amer. Monthly Magazine*, p. 358, 1818.

Body stout but elongate, depth 4.5 to 5 in the length to the base of the caudal; head small and rather conical, widest posteriorly, its length about 4 in the length of the body; maxillary barbels long, usually reaching to beyond the gill openings; mouth large and wide; dorsal fin with a spine, which is long, about 1.8 in the head, its posterior margin without teeth; base of the dorsal spine nearer to the tip of snout than to the adipose fin; adipose fin prominent and elevated, its posterior margin free from the back; caudal fin deeply forked; pectoral fin with one strongly serrate spine; tip of the pectoral fin reaching less than half-way to the base of the ventral fin; anal fin short, its outer margin strongly convex, of 24 to 29 rays; lateral line prominent.

Color above dark green or bluish green, sides paler shading to silvery below, usually with several small dark spots; ventral parts grayish white with a yellowish cast forward; fins opaque, often dusky or greenish.

Size large, average adults weighing 4 to 10 pounds, very large individuals, 25 pounds or more.

Spawning season, latter part of May, June and early part of July.

Range, rapid waters of the large streams of the Mississippi System, south to the Gulf of Mexico, and the large rivers of northern Mexico.

In Colorado this large catfish is found in the Platte and Arkansas rivers, being fairly abundant in the latter during high water. With the decline of the high water individuals are often left in the pools. At Julesburg, in the South Platte River this fish is taken rarely during high water. In the Arkansas River it is fairly common as far west as Fowler during high water. The removal of water from the tributaries of the Arkansas for irrigation, as well as the introduction of refuse from various mining industries, has restricted the channel cat to the main stream in eastern Colorado. Several fishermen living along the Arkansas report the channel cat as at one time common in the Purgatory River, a stream now almost without fish.

Forbes finds the food of Illinois specimens of this species consists of vegetable and animal débris, garbage, other fishes and almost anything likely to be taken by a fish.

[1] A channel cat; probably this species was reported to the writer by several fishermen as occurring occasionally in the Rio Grande at Alamosa, Colorado, during high water. No specimens were seen, however and the species is here included only in the key.

Order Eventognathi

The Carps and Suckers

Family *CATOSTOMIDAE*

The Suckers and Buffalo Fishes

Body scaled; barbels wanting; no adipose fin; fins without spines; dorsal fin with ten or more rays.

The suckers are fresh-water fishes and, with the exception of a few species found in Asia, are restricted to North America. They are fishes of medium size, few species being small and few exceptionally large. Among fishermen, suckers are not in favor since they offer little sport and are so full of small bones. The flesh too is without a fine flavor, although that of the larger individuals is often sweet and palatable. Because of their good size and general abundance, however, several species of suckers are quite generally marketed as food fishes. Suckers also have a large economic importance in that their young form a considerable item in the food of many of the large game fishes, especially the trout.

Seven species of suckers have been taken in Colorado, the suckers of the Rio Grande, of the Colorado River and of the Mississippi drainages being distinct. Two of the three species recorded from the South Platte River and its tributaries are found in Colorado only in that system, while the third species, *Catostomus commersonii sucklii* (Girard), is common to both the South Platte and the Arkansas systems. As regards number of individuals, the suckers are second in this state only to the *Cyprinidae* or True Minnows, although these are represented in Colorado by nearly three times as many species.

The seven species of suckers known from Colorado are referable to four genera. These may be distinguished by the following key:

Key to Genera of Family Catostomidae in Colorado

a. Body short and deep, distinctly compressed; dorsal fin elongate, of more than twenty-four rays . . . . *Carpiodes* Rafinesque

aa. Body elongate, usually terete, slightly if at all compressed in the anterior half; dorsal fin of ten to thirteen rays.

b. Mid-dorsal region just back of the head not elevated into a hump.

c. Lower lip evenly joined to the upper, there being no indentations or at least very slight ones at the lateral junctions of the two lips; median indentation of the lower lip reaching the margin of the jaw or separated from it by not more than two rows of papillae; no well-developed cutting edge on either jaw . . . . . . *Catostomus* LeSueur

cc. A deep V-shaped indentation at the junction of the upper and lower lips on each side, the upper lip with a free portion which passes the junction with the lower; median indentation of the lower lip not reaching the margin of the lower jaw but separated from it by three or usually more rows of papillae; both jaws with broad, flattened, horny cutting edges . . . . *Pantosteus* Cope

bb. Mid-dorsal region just back of the head and in front of the dorsal fin elevated into a sharp-edged hump which is supported by the enlarged interneural bones; median indentation of the lower lip reaching the margin of the lower jaw, the two lobes of the lower lip being distinctly separated at their junction with the lower jaw by a median subtriangular space. *Xyrauchen* Eigenmann and Kirsch

Subfamily Ictiobinae

The Buffalo Fishes

Genus **CARPIODES** Rafinesque

The Carp Suckers

Carpiodes Rafinesque, *Ichthyologia Ohiensis*, p. 56, 1820.

Dorsal fin elongate, of more than 24 rays, the first of which is rudimentary, while the third and fourth are much longer than the others, the dorsal fin as a result being higher anteriorly than posteriorly; body distinctly compressed and quite deep; scales large, of rather uniform size and loosely imbricated; skull with a large fontanelle.

The species of the genus *Carpiodes*, because of their superficial resemblance to the German Carp, are popularly known as "Native Carp." They may, however, be easily distinguished by the absence of barbels and spines. The Carp Suckers feed largely upon mud and vegetable matter and have little value as food fishes since their flesh is so strongly flavored. One species of the genus *Carpiodes* is recorded from Colorado.

Carpiodes velifer (Rafinesque)

Quillback, Sailfish

Catostomus velifer Rafinesque, *Ichthyologia Ohiensis*, p. 56, 1820 (Ohio River).

Not *Carpiodes velifer* (Rafinesque)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (*vide* p. 000); Juday, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (*vide* p. 000).

Body stout and short but quite deep and compressed; dorsal profile strongly arched, ventral profile almost straight; depth of the body at the base of the first ray of the dorsal fin 3 or a little less in the length to the base of the caudal fin; head short and blunt, quite stout, its breadth being contained in its length twice; length of the head 3.5 to 4 in the length of the body; eye large, situated in the upper half of the head nearer to the tip of the snout than to the gill opening; diameter of the eye a little more than 1 in the snout; mouth ventral but slightly oblique, its anterior margin being the more dorsal; dorsal fin of 24 to 30 rays, the first and sometimes the second rudimentary, the third the longest, its length exceeding that of the head; pectorals shorter than the head, not reaching the ventrals; ventrals reaching the anal opening or beyond; anal large, of 7 or 8 rays; scales 6 or 7, 35–40, 5 or 6; length under 12 inches.

General color greenish yellow, darker dorsally, shading to dirty white below; sides with a metallic luster; fins pale, yellowish or greenish; mouth and lips flesh-color; top of head olive green to almost black, with tubercles in breeding males.

Carpiodes velifer, like the other species of the genus, feeds upon mud and vegetation. It spawns late in April and through the month of May. The Quill-back ranges throughout the Mississippi system and west into the Rio Grande. It is usually found in the quiet, weedy portions of the small streams, and since such habitats are not common in Colorado streams it is not abundant in this state. At present it is known only from the Cache la Poudre, although there is no very apparent reason why it should not occur in the Arkansas in eastern Colorado. A species, *Carpiodes tumidus* Baird and Girard,[1] now generally considered a synonym of *Carpiodes velifer* (Rafinesque)[2] was described in 1854 from the Rio Grande at Fort Brown, Texas. This form should be looked for in collections from the Rio Grande in Colorado near the New Mexico line, although it does not occur in collections made at Alamosa.

Colorado specimen.—*State Teachers' College Museum:* Cache la Poudre River near Greeley, A. E. Beardsley.

Subfamily CATOSTOMINAE

The True Suckers

Genus **CATOSTOMUS** LeSueur

The Fine-scaled Suckers

Catostomus LeSueur, *Journ. Acad. Nat. Sci. Phila.*, Vol. I, p. 89, 1817.

Dorsal fin short, often rather high, of ten to thirteen rays; body elongate, subterete anteriorly, compressed in the caudal region; ventral profile almost straight, dorsal profile sloping regularly; skull with large fontanelle.

This genus includes the several species of Common Suckers of North America. Three species of *Catostomus* are known to occur in Colorado.

a. Scales in the lateral line less than 85, those in the posterior half of the body quite large; species of the Mississippi drainage. . . . . *C. commersonii* (Lacépède)

aa. Scales in the lateral line 90 or more.

- **b.** Mouth rather broad; maximum length of the median free portion of the lower lip about 2 in the width of the lower lip; distance from the middle of the lower jaw to the angle of the mouth greater than the length of the free portion of the lower lip; species of the Platte drainage . . . . *C. griseus* (Girard)
- **bb.** Mouth narrower and longer than in the preceding species; maximum length of the median free portion of the lower lip 1.5 to 1.7 in the width of the lower lip; distance from the middle of the lower jaw to the angle of the mouth barely equal to or usually less than the length of the free portion of the lower lip; species of the Colorado River drainage. *C. latipinnis* Baird and Girard

[1] BAIRD AND GIRARD, *Proc. Acad. Nat. Sci. Phila.*, p. 28, 1854.

[2] JORDAN AND EVERMANN, *Bull. 47, U.S. Nat. Mus.*, p. 167, 1896.

Catostomus commersonii (Lacépède)

Common Sucker

Cyprinus commersonii Lacépède, *Hist. Nat. Poiss.*, Vol. V, p. 502, 1803 (locality unknown).
Cyprinus teres Mitchill, *Trans. Lit. Phil. Soc. N.Y.*, p. 458, 1815 (New York).

The Colorado specimens of this species are all referable to a well-defined subspecies, *C. commersonii sucklii* (Girard), which may be differentiated from the true *C. commersonii* of the eastern states by the number of rows of papillae on the upper lip. In *C. commersonii commersonii* the papillae on the upper lip are usually in 3 rows (2 to 4), while in *C. commersonii sucklii* they are usually in 5 or 6 rows (sometimes 7 or 8).

Catostomus commersonii sucklii (Girard)

Suckley's Sucker (Figs. 2, 3, 5, 8, 57 and 58)

Catostomus sucklii Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 175, 1856 (Milk River, Montana).

Catostomus commersonii sucklii (Girard)—Jordan and Evermann, *Bull. 47, U.S. Nat. Mus.*, p. 179, 1896 (eastern Colorado).

Catostomus teres sucklii (Girard)—Jordan, *Bull. U.S. Fish Com.*, p. 7, 1889 (Denver), p. 11 (Twin Lakes; Lake Creek near Granite), p. 16 (Arkansas at Canyon City and Pueblo).

Catostomus commersonii (Lacépède)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont and Boulder); Juday, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder; Longmont); *Bull. U.S. Fish Com.*, Vol. XXVI, p. 161, 1906 (Twin Lakes); Fowler, *Proc. Acad. Nat. Sci. Phila.*, Vol. LXV, p. 52, 1913 (Twin Lakes).

Catostomus alticolus Cope—Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 677, 1875 (Twin Lakes).

Moxostoma trisignatum Cope—Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 679, 1875 (Pueblo).

Body elongate, rather terete anteriorly, somewhat compressed posterior to the dorsal fin; depth 4.6 to 5.5 in the length to the base of the caudal; head broad, flattened above, and with rather vertical sides so that it is somewhat quadrate in cross-section; dorsal profile sloping to the truncate snout, ventral profile almost straight; length of the head 3.75 to 4.5 in the length of the body to the base of the caudal; snout broad, heavy, truncate, and over-passing the mouth by half the diameter of the eye or more; eye prominent, nearer the gill opening than the tip of the snout, situated near the dorso-lateral margin of the head; diameter of the eye 3 to 4 in the interorbital distance, about the same in the snout, and 5 or 6 in the head; nostrils large and prominent, a little less than the diameter of the eye in front of the eye; the mouth ventral; lips large and fleshy, no indentation at the lateral junction of the upper and lower lips; upper lip with 4 to 8, usually 6 rows of papillae; lower lip deeply cleft in the median line, the indentation being separated from the edge of the lower jaw by not more than two rows of papillae; cutting edges of the jaws wanting or but poorly developed; mouth as a whole protractile; dorsal fin short and rather high, the length of the longest ray equalling or slightly exceeding the length of the base of the fin; dorsal rays usually 11, sometimes 12, first ray of the dorsal distinctly nearer the tip of the snout than the base of the caudal; pectorals not reaching the ventrals by more than half of their length; ventrals not reaching the anal opening; anal long, reaching the caudal base or beyond, usually with 7 rays, the first being much heavier than the others, especially in breeding males; caudal large, its maximum width being almost equal to the depth of the body; scales 10 or 11, 58–75, 8 to 10, crowded anteriorly. All of the above measurements are taken from medium sized to adult specimens. Small individuals are longer and slimmer than the adults and with the body more uniformly terete.

A comparison of specimens from different drainages shows a tendency toward a greater number of scales in the lateral line in individuals from the plains streams as opposed to those from the foothill streams, regardless of the river system.

LATERAL LINE SCALES

South Platte:
- Plum Creek near Castle Rock—60, 60, 61, 62, 65, 65, 66, 66, 67.
- Boulder Creek, Boulder—60, 63, 64, 64, 65, 65, 66, 67.
- Julesburg—64, 65, 67, 68, 69, 70, 70.

Republican:
- Wray—60, 63, 65, 65, 66, 67, 69, 69, 70, 70, 71, 72, 73, 74, 75, 75.

Arkansas:
- Canyon City—58, 59, 60, 66, 67, 67.

General color of the dorsal half of the body and head dark greenish or bluish gray to olive-green; margin of the scales outlined with dusky, so that the body especially in the caudal region has a distinctly reticulated pattern; the dark dorsal color disappearing rather abruptly below the lateral line, leaving the lower third of the sides and the ventral parts cream-white; entire body with a metallic reflection; fins hyaline to milky white, the rays, especially those of the caudal, usually opaque white and outlined with dusky; upper surfaces of the pectorals and ventrals somewhat dusky; fins of breeding males, particularly the anal, more or less yellow or orange; under parts of the head yellowish white; lips often with a slightly pinkish cast; top of the head very dark green to almost black.

The young of this species are much lighter dorsally than the adults, the mid-dorsal region being distinctly mottled. In addition to the adult markings the young also have three rather distinct black or dusky spots along the lateral line, the largest and most prominent being quite near the base of the caudal fin, a second about midway between the base of the caudal and the posterior margin of the operculum, and the third a short distance behind the operculum. These spots are very prominent in individuals about 40 millimeters long, gradually disappearing as the fish grows larger. The caudal spot is the last to be lost, persisting in quite large and well-developed individuals. By means of these spots the young of *C. commersonii sucklii* may be recognized and distinguished from the young of *C. griseus.* It is interesting to note that similar lateral spots, four in number, occur on juvenile specimens of *Catostomus nigricans* LeSueur, the Hog-sucker of the Mississippi Valley, and often persist as rather distinct blotches on the adult.

Suckley's Sucker feeds upon algae and diatoms which taken together make up a large portion of the slime on submerged stones, and upon small mollusks, both bivalves and gastropods, insect larvae and small worms. In addition a few adult insects and quantities of débris are taken. When opportunity offers the freshly deposited eggs of other fishes are eaten. All of the food is such as may be found on the bottom or on stones. In the spring suckers are quite active and have been known to take the fly and other moving bait, and in this season they occasionally include some of the surface insects in their food. The food of individuals was found to vary considerably with the habitat and many kinds of small animals which had become water-logged and had sunk to the bottom were recovered from sucker stomachs. The data concerning the stomach contents of nine specimens follow:

West Plum Creek, near Castle Rock, June 8, 1912. From small streams with rocky bottom, the stones of which were covered with green slime.

200 mm., vegetable débris and algae, 99 per cent; one small bivalve, *Pisidium* sp.

190 mm., vegetable débris and algae, 100 per cent.

190 mm., vegetable débris and algae, 80 per cent; bivalves, *Pisidium* sp., 20 per cent.

Republican River, Wray, October 26, 1912. From small stream with weedy and muddy bottom, in lowland about one hundred yards from the main stream.

190 mm., algae, 100 per cent.

180 mm., midge larvae and pupae, 75 per cent. Stomach not full.

Grape Creek, Canyon City, November 8, 1913. Rapid mountain stream, rocks and bowlders filling stream bed, the submerged stones being heavily covered with a brown slime of diatoms, no shore vegetation.

150 mm., diatoms, 100 per cent.

250 mm., diatoms, 100 per cent.

Boulder Creek, near Boulder, July 25, 1912. Small stream, gravel bottom, shore vegetation and vegetation in the water near shore.

170 mm., small gastropods, *Physa* spp. and *Planorbis* spp., 50 per cent; vegetable débris, 50 per cent.

200 mm., vegetable débris, 50 per cent; small gastropods, *Physa* and *Planorbis,* 25 per cent; one Dytiscid beetle. Stomach not full.

This sucker reaches the length of 2 feet, although it is an inhabitant of the smaller streams as well as the rivers. Being a rapid swimmer it is often found in irrigation ditches at a considerable distance from the streams supplying the ditches. The shutting-off of the water in these leaves the suckers stranded in the fields, hence the name "Irrigation Sucker," by which they are popularly known.

The subspecies *C. commersonii sucklii* ranges through the western portions of the western tributaries of the Mississippi, east of the Continental Divide.

Colorado specimens.—*University Museum:* Boulder Creek near Boulder, October, 1903 (11 specimens, 40–185 mm.), C. Juday and J. Henderson, No. 4; West Plum Creek near Castle Rock, June 8, 1912 (170 specimens, 40–250 mm.), A. G. Vestal and M. M. Ellis, No. 309; South Platte, Julesburg, July 19, 1912 (18 specimens, 35–55 mm.), J. Henderson and M. M. Ellis, No. 310; Lodgepole Creek near Ovid, July 20, 1912 (25 specimens, 40–70 mm.), J. Henderson and M. M. Ellis, No. 311; Boulder Creek 6 miles east of Boulder, July 25, 1912 (49 specimens, 30–170 mm.), M. M. Ellis, No. 312; Boulder Creek near Boulder, August 10, 1912 (2 specimens, 250 and 300 mm.), No. 313; Republican River, Wray, October 25 and 26, 1912 (83 specimens, 40–300 mm.), A. G. Vestal and M. M. Ellis, No. 314; Grape Creek near Canyon City, November 8, 1913 (2 specimens, 150–250 mm.), A. G. Vestal and M. M. Ellis, No. 315; Outlet to Sells Lake, Canyon City, November 8, 1913 (3 specimens, 45–70 mm.), A. G. Vestal and M. M. Ellis, No. 316; *State Historical and Natural History Museum:* South Platte River, Denver, August 3, 1900 (130 mm.), W. C. Ferril; *State Teachers' College Museum:* South Platte and Arkansas, A. E. Beardsley.

Catostomus griseus (Girard)

GRAY SUCKER, PLATTE RIVER SUCKER, FINE-SCALED SUCKER (Fig. 6)

Acomus griseus Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 174, 1856 (Sweetwater Fork of the Platte River).

Catostomus griseus (Girard)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 7 (Denver, Boulder, Bear Creek above Morrison, Hartsel's Hot Springs, South Platte in South Park); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont and Boulder); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder; Longmont).

Body elongate and rather fusiform, somewhat compressed in the caudal half; depth 5 to 5.75 in the length to the base of the caudal fin; head elongate, flattened above, sides rounded, rather ovoid in cross-section, its length 4 to 4.25 in the length of the body; both dorsal and ventral profiles rather straight, the mid-dorsal region being but slightly arched; snout long, heavy and blunt, its tip being half or more of the diameter of the eye beyond the margin of the upper lip; eye small, nearer the gill opening than to the tip of the snout, its diameter 6 or more in the head; interorbital distance 2.25 to 2.75 in the head, about 1.25 in the snout; nostrils large and prominent; mouth ventral and rather broad, upper lip with 5 to 8 rows of papillae, median indentation of the lower lip reaching the margin of the lower jaw or separated from it by but one row of papillae, maximum length of the median free portion of the lower lip about 2 in the width of the lower lip; distance from the middle of the lower jaw to the angle of the mouth greater than the length of the free portion of the lower lip; mouth as a whole protractile; dorsal fin short and rather high, its longest ray equal to or exceeding the length of the base of the fin, of 10 or 11, sometimes 12 rays, the base of the first ray being nearer to the tip of the snout than to the base of the caudal, or rarely midway between them; pectorals not reaching the ventrals; ventrals barely if at all reaching the anal opening; anal long, reaching to or beyond the base of the caudal, of 7 or 8 rays, the fourth being the longest, sides of the rays tubercled in breeding males; scales small, crowded anteriorly, 14 to 16, 95–120, 13 or 14.

Color above the lateral line dark blue or green to almost black, sides lighter; below the lateral line the color fades rather abruptly into dirty white, ventral parts white to cream color; sides of the body with a yellowish or greenish cast; mouth and under parts of the head pinkish or yellowish white; ventral parts and the ventral and anal fins more or less orange-red in breeding males; fins hyaline to milky white, upper surfaces of the pectorals and ventrals dusky. Young individuals lighter and more uniformly colored than the adults, the mid-dorsal region distinctly mottled; sides without spots (see *C. commersonii sucklii*).

Size large, length up to 2 feet.

The Gray Sucker occurs in all of our foothill collections in company with Suckley's Sucker. The two species are probably competitors, since the stomach contents show the food to be the same. Two collections made in about the same type of habitat, one in West Plum Creek near Castle Rock and another from Boulder Creek near Boulder, also point to a condition of competition between these two species, since the relative frequency is reversed in the two localities, showing local rather than general dominance of either species. At both stations all of the fish taken were saved and in both cases the streams were shallow and less than twenty feet wide so that the collections are probably representative. From West Plum Creek 170 *Catostomus commersonii sucklii* and 26 *Catostomus griseus* were taken, a ratio of nearly 7 to 1, while from Boulder Creek 120 *C. griseus* were collected and but 49 *C. commersonii sucklii*, a ratio of a little less than 3 to 1 in favor of the Gray Sucker. One of the disturbing factors which probably entered into the West Plum Creek competition was the presence of large numbers of larval trematodes, nearly all of the Gray Suckers and but a few of the Suckley Suckers being infected, this unequal infection with a parasite giving a possible advantage to the Suckley Suckers. Both species are occasionally infected with this larval trematode in Boulder Creek.

Catostomus griseus is known only from the western portions of the Platte River and its tributaries.

Colorado specimens.—*University Museum:* Boulder Creek near Boulder, October, 1903 (102 specimens, 30–120 mm.), C. Juday and J. Henderson, No. 3; St. Vrain Creek, Longmont, October 17, 1903 (9 specimens, 120–180 mm.), C. Juday and D. W. Spangler, No. 5; West Plum Creek near Castle Rock, June 9, 1912 (26 specimens, 55–155 mm.), A. G. Vestal and M. M. Ellis, No. 317; Boulder Creek 6 miles east of Boulder, July 25, 1912 (125 specimens, 30–160 mm.), M. M. Ellis, No. 318; *Colorado State Historical and Natural History Museum:* South Platte, Denver, August 3, 1900 (205 mm.), W. C. Ferril; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley.

Catostomus latipinnis Baird and Girard

FLANNEL-MOUTHED SUCKER

Catostomus latipinnis Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 388, 1853 (Rio San Pedro, Gila basin); JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 26, 1889 (Grand River, Glenwood Springs; Gunnison and Uncompahgre Rivers at Delta).

Body elongate, terete in large specimens, slightly compressed in the caudal half; depth 5.5 to 5 in average specimens, about 4.6 in very large adults, in the length to the base of the caudal fin; head broad and flattened above, its length 4.5 to a little more than 5 in the length of the body; dorsal profile sloping in both directions from the suprapectoral region; ventral profile almost straight; snout broad, heavy and blunt, overhanging the mouth; eye rather small, situated in the posterior half of the head, near the latero-dorsal margin; diameter of the eye 6 to 8 in the head; interorbital distance equalling or exceeding the length of the snout; mouth large, ventral; maximum length of the median free portion of the lower lip 1.5 to 1.7 in the width of the lower lip; distance from the middle of the lower jaw to the angle of the mouth barely equal to or usually less than the length of the free portion of the lower lip; upper lip with 5 to 8 rows of papillae; dorsal fin high its longest ray equalling or exceeding in length the base of the fin, of 11 to 14 rays, usually 11 or 12, base of the first ray nearer the tip of the snout than the base of the caudal; pectorals not reaching the ventrals; ventrals not reaching the anal opening; anal large, of 7 or 8 rays, the fourth the longest, its length almost equalling that of the head; scales small, crowded anteriorly, 17 to 19, 100–120, 16 or 17. Size large, the species reaching a length of 30 inches.

General color above greenish or bluish gray, top of the head and region in front of the dorsal fin quite dark, scales outlined with dusky, so that the sides have a somewhat reticulated pattern; dorsal color extending well down the sides to the eighth or tenth row of scales below the lateral line where it fades abruptly; lower portion of the sides yellowish to orange-red, ventral parts lighter; under parts of the head pinkish; body as a whole with a silvery luster; dorsal and caudal fins dusky; anal and ventrals and to some extent the pectorals, yellowish to orange-red. Young much lighter than adults, sides quite silvery, mid-dorsal region indistinctly mottled. Mid-ventral region just back of the head sometimes dusky in either adult or young.

Jordan[1] states that the stomach of a specimen of this species was full of confervae and other vegetation, and Jordan and Evermann[2] list *C. latipinnis* as herbivorous. The stomach contents examined corroborate these statements. Seeds formed a considerable item in the stomach contents of several specimens, as may be seen below.

Grand River, Grand Junction, August 7, 1912.

425 mm., vegetable débris 100 per cent, including diatoms, algae, fragments of higher plants and mud.

435 mm., seeds, 100 per cent. 247 perfect seeds were counted and fragments of many others found. Most of the seeds were from sedges and grasses.

420 mm., algae, diatoms and débris, also a few seeds.

425 mm., seeds, 10 per cent; algae and slime, 90 per cent.

450 mm., vegetable débris, slime and algae, 100 per cent; seeds present.

[1] *Bull. U.S. Fish Com.*, Vol. IX, p. 26, 1889.

[2] *Bull. U.S. Nat. Mus.*, No 47, p. 175, 1896.

Uncompahgre River, Montrose, August 9, 1912.
400 mm., slime, 100 per cent.
150 mm., slime, 100 per cent.
100 mm., slime, 50 per cent; a few seeds. Not full.
170 mm., algae and slime, 100 per cent.

This species is the common large sucker of the Gila and Colorado rivers, being known only from those drainages. The large individuals of *C. latipinnis* are of considerable economic importance in supplying a cheap grade of fish for the market. They are taken in considerable numbers from the Grand River at Grand Junction for local use, the Fish Commission allowing the use of the seine by permit for the Flannel-mouth and other species of suckers below the trout streams. Two large females of this species taken at Grand Junction on August 7, 1912, contained well-developed egg-masses.

Colorado specimens.—*University Museum:* Gunnison River, Grand Junction, August 7, 1912 (13 specimens, 60–200 mm.), J. Henderson and M. M. Ellis, No. 319; Grand River, Grand Junction, August 7, 1912 (5 specimens, 370–450 mm.), J. Henderson and M. M. Ellis, No. 320; Uncompahgre River, Montrose, August 9, 1912 (74 specimens, 30–420 mm.), J. Henderson and M. M. Ellis, No. 321; *State Teachers' College Museum:* Delta, A. E. Beardsley.

Genus **PANTOSTEUS** Cope

The Mountain Suckers

Pantosteus Cope, *Wheeler Survey*, Vol. V, p. 673, 1876.

Much like *Catostomus;* fontanelle usually wanting or at least much reduced in the adult; lower lip not so deeply cleft as in *Catostomus;* both jaws with well-defined cutting edges.

The species of this genus are restricted to the streams of the Rocky Mountain region from the Columbia River south into Chihuahua. Two species are found in Colorado, one in the Colorado River drainage and one in the Rio Grande.

The two quite similar species of this genus found in Colorado may be separated by the number of scales in the lateral line. In most characters their differences are those of degree and are apparent only from a series of measurements.

a. Scales of the lateral line 80 to 92, usually about 85; species of the Rio Grande. *P. plebius* (Baird and Girard)

aa. Scales of the lateral line 95 to 115, usually about 100; species of the Colorado River drainage. *P. delphinus* (Cope)

Pantosteus plebius (Baird and Girard)

Rio Grande Sucker

Catostomus plebius Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 28, 1854 (Rio Mimbres, at tributary of Lake Guzman, Chihuahua).

Pantosteus plebius (Baird and Girard)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 19, 1889 (Del Norte; Alamosa; Rio Conejos 15 miles south of Alamosa); Fowler, *Proc. Acad. Nat. Sci. Phila.*, Vol. LXV, p. 48, 1913 (Watrita Creek).

Body elongate and terete, but slightly compressed in the caudal half; depth 4.75 to 5.25 in the length to the base of the caudal fin; head rather large, rounded above, its length 4.25 to 4.75 in the length of the body; dorsal profile sloping slightly, ventral profile almost straight; snout broad and rather long, overhanging the mouth by almost the diameter of the eye; eye small, 5 to 7 in the head, situated in the posterior half of the head; interorbital distance 2.5 to 2.75 in the head; mouth large, ventral; both jaws with well-developed cutting edges; upper lip large, forming a fleshy hood over the mouth opening, median indentation of the lower lip not reaching the margin of the lower jaw but separated from it by 4 or more rows of papillae; dorsal fin moderately high, its longest ray exceeding in length the base of the fin, of 10 or 11 rays, inserted nearer the tip of the snout than to the base of the caudal; pectorals not reaching the ventrals; ventrals not reaching the anal opening; anal rather small, of 7 or 8 rays; scales rather uniform in size, not much crowded anteriorly, scales in the lateral line 80 to 92, usually about 85.

General color dark greenish brown to blackish; mid-dorsal region and to some extent the sides, mottled with dusky; dorsal color extending well down on the sides of the body; lower portion of the sides yellowish to bright orange, orange-red in breeding males; under parts white to yellowish; a rather well-defined dark-red band along the lateral line; fins hyaline or yellowish, rays dusky; anal often reddish.

This species does not reach the large size attained by some of the species of *Catostomus*, average adults being from 9 to 12 inches in length.

The Rio Grande Sucker is a species of the Rio Grande drainage ranging from the San Luis Valley in Colorado south into Chihuahua. It is quite abundant throughout its range.

The stomachs and intestines of twenty specimens of this species from Alamosa, July 27, 1912, were packed with slime, algae and mud. So much of the green algae was present that the alcohol in which the Alamosa collections were placed was colored green by the extracted chlorophyll.

Colorado specimens.—*University Museum:* Rio Grande, Alamosa, July 27, 1912 (309 specimens, 60–200 mm.), M. M. Ellis, No. 322.

Pantosteus delphinus (Cope)

Blue-headed Sucker, Western Chisel-mouthed Sucker (Fig. 9)

Minomus delphinus Cope, *Hayden's Survey of Wyoming for 1870*, p. 435, 1872 (probably Henry Fork of Green River, Wyoming).

Pantosteus delphinus (Cope)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 27, 1889 (Eagle River; Gunnison at Delta; Uncompahgre; Rio las Animas Perdidas; Rio Florida).

Pantosteus virescens Cope—Cope and Yarrow, *Wheeler's Survey*, Vol. V, p. 675, 1875 (wrongly ascribed to Arkansas at Pueblo, corrected by Jordan and Evermann, *Bull. 47, U.S. Nat. Mus.*, p. 171, 1896).

Body elongate, somewhat compressed in the caudal half; depth 5 to 5.5 in the length to the base of the caudal; head rather large, its length about 4.5 in the length of the body; dorsal profile sloping, ventral profile almost straight; snout broad and heavy; eye small, its diameter 6 to 9 in the head; interorbital distance about 2.5 in the head; mouth large, ventral; both jaws with broad horny cutting edges; upper lip large, forming a fleshy hood over the mouth opening; median indentation of the lower lip separated from the margin of the lower jaw by 4 to 7 rows of papillae; dorsal fin high, of 10 or 11 rays, base of the first ray nearer tip of snout than to the base or the caudal or rarely midway between them; pectorals and ventrals as in *P. plebius;* anal fin large, reaching to the caudal base; scales small in the anterior half of the body increasing in size toward the caudal, 95 to 115 in the lateral line.

General color grayish blue, darker dorsally; scales outlined with dusky, giving a reticulated pattern; dorsal color extending down the sides of the body to the level of the origin of the pectoral; sides of the body below the lateral line, especially in the anal region, pink to orange-red; pectoral and ventral fins yellowish; a more or less interrupted band of red along the lateral line.

This species ranges throughout the Colorado River drainage in the headwater streams, being very abundant near the mountains and less so in the lower portions of the system. The stomachs of several specimens from both Montrose and Durango were examined and were found to contain masses of algae and slime.

Colorado specimens.—*University Museum:* Uncompahgre, Montrose, August 9, 1912 (283 specimens, 50–270 mm.), J. Henderson and M. M. Ellis, No. 323; Rio Florida near Durango, August 11, 1912 (90 specimens, 150–250 mm.), J. Henderson and M. M. Ellis, No. 324; *State Teachers' College Museum:* Delta, A. E. Beardsley.

Genus **XYRAUCHEN** Eigenmann and Kirsch

The Humpbacked Sucker

Xyrauchen Eigenmann and Kirsch, *Proc. U.S. Nat. Mus.*, p. 556, 1888.

Interneural bones in front of the dorsal fin elevated, supporting a sharp-edged hump; mouth much as in *Catostomus.*

The single species of this remarkable genus is found only in the Colorado River and its tributaries.

Xyrauchen texanus (Abbott)

Humpbacked Sucker, Razorbacked Sucker (Figs. 7 and 59)

Catostomus texanus Abbott, *Proc. Acad. Nat. Sci. Phila.*, p. 473, 1860 (Colorado and New rivers).

Catostomus cypho Lockington, *Proc. Acad. Nat. Sci. Phila.*, p. 237, 1880 (Colorado River at the mouth of the Gila).

Xyrauchen cypho (Lockington)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 26, 1889 (Delta, in Gunnison and Uncompahgre rivers).

Xyrauchen uncompahgre Jordan and Evermann, *Bull. U.S. Fish Com.*, Vol. IX, p. 26, 1889 (Delta).

Xyrauchen texanus (Abbott)—Fowler, *Proc. Acad. Nat. Sci. Phila.*, Vol. LXV, p. 54, 1913.

Body somewhat compressed, greatest depth 4 to 5 in the length to the base of the caudal; back abruptly elevated just in front of the dorsal fin into a sharp-edged hump which is borne by the enlarged interneural bones; head rather broad, somewhat depressed, dorsal surface quite flat; length of the head 4 or a little less in the length of the body; snout broad and blunt, overhanging the mouth; length of the snout 2.5 to 3 in the head; nostrils large, prominent and double, the dividing septum elevated; eye prominent, situated in the upper half of the head, a little nearer to the tip of the snout than to the posterior margin of the operculum; diameter of the eye 8 or 9 in the head; mouth large and ventral; median indentation of the lower lip reaching the margin of the lower jaw, the two lobes of the lower lip being distinctly separated at their junction with the lower jaw by a median subtriangular space; upper lip with about 4 rows of papillae; margins of the jaws rounded; dorsal fin high, its base about equal in length to the head, of 12 to 15 rays, base of the first ray nearer to the tip of the snout than to the base of the caudal; pectorals about 1.2 in the head, separated from the ventrals by almost the length of the latter; ventrals nearly 2 in the head, inserted below the eighth or ninth ray of the dorsal, not reaching the anal opening; anal long, equalling or slightly exceeding the length of the pectorals, its base short, being about one-half the length of the longest ray, of 7 rays; caudal large, broad and rather deeply forked, its width equalling the greatest depth of the body; scales 13 to 15, 70–86, 13 or 14.

General color bluish gray to olivaceous; top of the head and anterior portion of the hump quite dark; dorsal color extending well down on the sides, fading gradually to silvery white below. Size large, length often over 20 inches.

This species is distributed quite generally throughout the Colorado River drainage in the large streams below the foothill region. Because of their large size the adult Humpbacked Suckers are often marketed with the Flannel-mouthed Suckers. Professor Junius Henderson has told the writer that *X. texanus* is taken in numbers by the Mohave Indians from the Colorado River near Fort Mohave.

Colorado specimens.—*University Museum:* Grand River, Grand Junction, August 7, 1912 (3 specimens, 290–400 mm.), J. Henderson and M. M. Ellis, No. 325.

Family *CYPRINIDAE*

The Minnows and Carp

Mouth without teeth, teeth on the pharyngeal bones generally well developed; head naked, body usually scaled; barbel present or absent; air bladder with a *ductus pneumaticus;* fresh-water species.

The species of this family are very numerous, considerably over 1,000 being known at present. They are found in the fresh waters throughout the world with the exception of those of South America and Australia. The family is divided into several large groups all of which intergrade more or less; by some authors the suckers, *Catostomidae*, are included in the *Cyprinidae* as one of these groups. Considering the extremes, two types of Cyprinids may be recognized as regards the alimentary canal and the food taken. These are the herbivorous forms with long, much-coiled alimentary canal, the more primitive forms on the whole, and the carnivorous forms with a relatively short alimentary canal. Between these are other intermediate forms, and both herbivorous and carnivorous types are usually represented in each large group of species.

The economic importance of the *Cyprinidae* does not come from their value to man directly, for few species are extensively marketed or sought as game fishes, but from their value as food for other game and food fishes. A few species, as the Goldfish and the Tench, are raised as aquarium fish and for small ponds and lakes in parks.

The large number of species, their general similarity and small size conspire to make the identification of Cyprinids difficult. The introduced species may be recognized by the long dorsal and the serrate anal and dorsal spines, but the native species are more confusing. In using the keys for this family one of the most elusive structures to be looked for is the barbel. In some species, as the German Carp, the barbel is quite prominent, but in most of the native species it is quite small. The barbel when present is on the ventral surface of the head at the junction of the upper and lower jaws, usually in a small depression or, in *Semotilus* and *Couesius*, just above the junction of the jaws on the outside margin of the upper. In most of the Cyprinids found in Colorado having a barbel, the barbel is less than one-sixteenth of an inch in length although in large specimens of *Semotilus atromaculatus* it may be almost a quarter of an inch long. The characters based on internal anatomy given in the keys are not necessary for the determinations but may be used to confirm them.[1]

Key to Genera of Family Cyprinidae in Colorado

a. Dorsal fin elongate, of more than 20 rays; both dorsal and anal fins preceded by a serrate spine. Introduced species natives of Asia.

  b. Barbels 4; body completely scaled, partly scaled or naked
Cyprinus (Artedi) Linnaeus, p. 34

  bb. Barbels wanting; body completely scaled; color often orange-red. *Carassius* Nilsson, p. 36

aa. Dorsal fin short, of 10 or fewer rays; fins without a serrate spine. Native species.

  c. Body scaled; dorsal fin without a spine.

    d. Intestine long, wound around the air bladder; mouth ventral and sucker-like; premaxillaries protractile; no maxillary barbel; color dusky, irregularly mottled, sides with a more or less brassy luster. . . . . . . *Campostoma* Agassiz, p. 36

    dd. Intestine not wound around the air bladder.

      e. No maxillary barbel; premaxillaries usually protractile.

        f. Two very distinct dark lateral bands; scales small, usually about 80 in the lateral line, imbedded in the skin; species small, length under 70 mm.; intestine about twice the length of the body. . . . *Chrosomus* Rafinesque, p. 38

[1] The common tench, *Tinca tinca*, was introduced into Colorado in 1894 (see *Rept. U.S. Fish Com.* for 1894–95, p. 53), but there are no reports of this species from Colorado waters. This fish may be recognized by the long dorsal fin of 10 rays and by the small scales, more than 60 in lateral line.

ff. Sides plain or with a single lateral dusky band.

g. Basal fulcra of the caudal fin not greatly enlarged; caudal peduncle not narrow and elongate.

h. First (rudimentary) ray of the dorsal fin heavy, blunt and spine-like, broadly joined to the second (i.e., to the first long ray); intestine more than twice the length of the body; mouth terminal; scales large, usually about 45 in the lateral line . . . *Pimephales* Rafinesque, p. 40

hh. First (rudimentary) ray of the dorsal fin not heavy and blunt, usually adnate to the second (i.e., the first long ray).

i. Inside of the lower jaw with a small hard lump near the tip; scales large, about 35 in the lateral line; intestine more than 3 times as long as the body; peritoneum black; mouth terminal; dorsal fin with its first ray distinctly in front of the origin of the ventrals.
Hybognathus Agassiz, p. 42

ii. Inside of the lower jaw without a hard protuberance; alimentary canal short.

j. Mouth ventral and sucker-like, the upper lip recurved around the lower at their junction; dorsal fin with first ray distinctly in front of the ventrals; scales rather large, 40–50 in the lateral line.
Phenacobius Cope, p. 45

jj. Mouth not sucker-like, although sometimes rather ventrally placed; base of the first dorsal ray on a level with or posterior to the ventrals.

k. Scales in the lateral line less than 80, usually less than 60.

l. Colorado species, scales in the lateral line 45–80; if less than 60, anal rays 8. . . . . . . *Richardsonius* Girard, p. 46

ll. Colorado species, scales in the lateral line less than 45; if 45–50, anal rays 9 or 10 . . . . *Notropis* Rafinesque, p. 48

kk. Scales in the lateral line more than 80 (Colorado species).
Ptychocheilus Agassiz, p. 54

gg. Basal fulcra of the caudal fin much enlarged (see Fig. 36); caudal peduncle slender; scales small, 80 or more in the lateral line, often wanting from the mid-dorsal and mid-ventral regions . . *Gila* Baird and Girard, p. 55

ee. Maxillary barbel present.

m. Barbel lateral, on the anterior, outer surface of the upper jaw, a little in front of the depression at junction of the two jaws.

n. Colorado species with a black spot at the base of the first few rays of the dorsal fin; head 3.2 to a little less than 4, usually 3.5 in the length.
Semotilus Rafinesque, p. 57

nn. Colorado species with no black spot at the base of the dorsal fin; head 4.25 to 4.5 in the length.
Couesius Jordan, p. 59

mm. Barbel in the axil at the junction of the upper and lower jaws.

o. Scales in the lateral line less than 70; scales with apical radii only; body somewhat compressed; maxillary barbel prominent.

p. Scales in the lateral line 35–45; dorsal, pectoral and anal fins rounded; Colorado species with the first ray of the dorsal on the level with or slightly behind the ventrals. . *Hybopsis* Agassiz, p. 60

pp. Scales in the lateral line 50–60; dorsal, pectoral and anal fins emmarginate or falcate; Colorado species with the first ray of the dorsal in front of the level of the ventrals. . *Platygobio* Gill, p. 62

oo. Scales in the lateral line 65–90; scales with both apical and basal radii; body subterate; mouth ventral and sucker-like.

q. Premaxillaries not protractile, upper lip continuous with the skin of the top of the head, frenum broad. . *Rhinichthys* Agassiz, p. 63

qq. Premaxillaries protractile, upper lip not continuous with the skin of the top of the head, frenum rarely present. . *Agosia* Girard, p. 68

cc. Scales entirely wanting; dorsal fin with a double spine; anal fin without a spine, premaxillaries protractile; maxillary barbel present. . . . *Plagopterus* Cope, p. 70

Subfamily Cyprininae

Genus **CYPRINUS** (Artedi) Linnaeus

The Carp

Cyprinus (Artedi) Linnaeus, *Systema Naturae*, ed. X, p. 320, 1758.

Body compressed; barbels long and prominent; scales large when present; dorsal fin elongate; dorsal and anal fins each with a serrate spine. Large species, natives of Central Asia. Represented in Colorado by the introduced German Carp.

Cyprinus carpio Linnaeus

"German" Carp (Figs. 10 and 11)

Cyprinus carpio Linnaeus, *Systema Naturae*, ed. X, p. 320, 1758.

Body compressed, deep and robust; dorsal profile elevated, ventral profile sloping or almost straight; head large, subconic; depth of the body 2.75 to 3.25, head 3 to 4 in the length to the base of the caudal; snout heavy, somewhat pointed, 2.75 to 3.25 in the head; eye small, 5.5 to 6.5 in the head; dorsal fin with a strong spine, the posterior edge of which is strongly serrate, and 17 to 21 rays, anterior fourth of the dorsal fin higher than the remaining posterior portion; base of the dorsal spine in front of the level of the ventrals; pectorals almost reaching the ventrals; ventrals not reaching the anal opening; anal fin short, with a serrate spine and 5 or 6 rays; scales large when present, resembling those of the suckers, with both basal and apical radii; scales in completely scaled individuals 5 or 6, 35–38, 5 or 6, lateral line complete. In some individuals only a few large scales along the lateral line and in the dorsal and ventral regions remain; these fish are known as "Mirror Carp"; still others are completely scaleless, the "Leather Carp." These forms are merely varieties or races of the normally scaled type.

Color olivaceous to bluish or dark green above, shading to yellowish below, sides of young specimens often bright golden yellow, of adults usually a dirty greenish yellow. Size large, reaching a length of over 30 inches and a weight of 50 pounds, average adults 5 to 8 pounds, those raised in ponds usually heavier.

"German" Carp is a native of Central Asia but was introduced into Europe centuries ago, probably before 1300. It was first brought to the United States in 1872 and to Colorado in 1882. In the *Report of the United States Fish Commission for 1884* are numerous signed statements from citizens of Colorado concerning the care given this fish and its success in this state. These accounts are quite interesting in view of the general disfavor into which the Carp has fallen. This fish is now found in each of the principal river systems of the state and is quite abundant in many ponds and lakes. Not only is it well established in Colorado but also throughout the United States. The artificial propagation of this species has been discontinued and by many its introduction is regarded as a serious mistake. The Carp question has been discussed at length by Cole,[1] who concluded that the damage done by the carp is about offset by its value. The carp eat the spawn of other fishes and uproot the aquatic vegetation near shore which forms a refuge for young fishes and contributes to the food of the aquatic game birds. The young carp, on the other hand, are eaten by the bass, crappies and sunfish, as well as by snakes and aquatic birds.

Cyprinus carpio is a herbivorous or omnivorous feeder, preferring warm sluggish water. Under fair or favorable conditions it grows very rapidly and despite the general prejudice against this fish its flesh is marketable. Forbes[2] states that several million pounds having a value of several hundred thousands of dollars are taken annually in Illinois.

The German Carp spawns in the latter part of May and through June, the eggs being deposited near shore where they adhere to weed stems and débris. The remarkable rapidity with which this species has become established in the United States is the result of its general hardiness and the enormous number of eggs produced—a single female spawning about 500,000 eggs—and the rapid rate of growth. The carp eggs hatch in about two weeks and by the end of the first summer the young are five inches or more in length. A year-old carp weighs on an average three-quarters of a pound, and under favorable conditions even more. In ponds where conditions have been optimum this fish has been known to reach a weight of four pounds in two years.

Colorado specimens.—*University Museum:* Rio Grande, Alamosa, July 27, 1912 (mirror, 20 specimens, 70–130 mm., No. 272; scaled, 50 specimens, 35–130 mm., No. 271), M. M. Ellis; Grand River, Grand Junction, August 7, 1912 (137 specimens, 30–70 mm. scaled; mirror, 1 specimen, 60 mm.), J. Henderson and M. M. Ellis, No. 326; Boulder Lake, Boulder, October 16, 1913 (3 specimens, 60–140 mm.), M. M. Ellis, No. 327; *Colorado State Historical and Natural History Museum:* Denver, August 18, 1900 (160 mm.), W. C. Ferril; Denver, April 19, 1902, A. H. Felger; Barr Lake, Adams County, March 16, 1906 (180 mm., from the stomach of American Merganser, *Merganser americanus* [Cass.]); *State Teachers' Museum:* Lakes near Greeley (large specimens), A. E. Beardsley.

[1] *Rept. U.S. Fish Com. for 1904*, pp. 525–641, 1905.

[2] Forbes and Richardson, *Ichthyology of Illinois*, pp. 108–109, 1909.

Genus **CARASSIUS** Nilsson

The Crucian Carp

Carassius Nilsson, *Prodromus Ichthy. Scand.*, 1832.

Body deep and compressed; barbels wanting; dorsal fin long; dorsal and anal fins each with a serrate spine; scales large, lateral line complete. Natives of central Asia.

Carassius auratus (Linnaeus)

GOLDFISH (Fig. 62)

Cyprinus auratus Linnaeus, *Systema Naturae*, ed. X, p. 323, 1758.

Carpiodes velifer (Rafinesque)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont).

Body deep and compressed; head 3 to 3.25, depth 2.5 to 3 in the length to the base of the caudal fin; dorsal fin and anal fin much like the dorsal and anal of *Cyprinus carpio*, each with a serrate spine; scales large, 4–6, 28–30, 5–6; size medium, reaching the length of 12 inches or more.

Color of specimens in captivity usually orange-red, silvery or yellowish, often somewhat marked with black; wild specimens olivaceous to greenish blue, darker dorsally; orange varieties reverting to greenish form when liberated into streams.

The Goldfish is valued because of the orange-colored varieties so extensively raised for aquaria and small ponds. By selective breeding many curious forms of this fish have been established, the color, shape and size of the fins and even the position of the eyes being variable. One very remarkable type of Goldfish, known as the Telescope Fish, has the portions of the head bearing the eyes enlarged so that the eyes are borne on conical projections. The Goldfish has escaped from ponds in Colorado and the green wild form is now found in the Grand and South Platte rivers. This fish is sometimes confused with the Quillback, *Carpiodes velifer* (Rafinesque), from which it is easily separated by the presence of a serrate spine in both the dorsal and anal fins.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (6 specimens, 80–90 mm.), C. Juday and D. W. Spangler, No. 13; small pool near Grand River, Grand Junction, August 8, 1912 (10 specimens, 70–80 mm.), J. Henderson and M. M. Ellis, No. 328; *State Teachers' College Museum:* Ponds near Greeley, A. E. Beardsley.

Subfamily CAMPOSTOMINAE

Genus **CAMPOSTOMA** Agassiz

The Stone-rollers

Campostoma Agassiz, *Amer. Journ. Sci. Arts*, p. 218, 1855.

Herbivorous Cyprinids; alimentary canal very long, its length 6 or more times that of the body, wound around the air bladder which is thus suspended in the abdominal cavity; premaxillaries protractile; mouth more or less ventral and sucker-like; peritoneum black. *Campostoma* is unique among fishes in the position of the air bladder. Its species are known only from central and southwestern

North America. A single species, quite abundant in the plains streams of the eastern part of the state, is known from Colorado.

Campostoma anomalum (Rafinesque)

STONE-ROLLER, GREASED CHUB (Figs. 13, 14 and 16)

Rutilus anomalus Rafinesque, *Ichthyologia Ohiensis*, p. 52, 1820 (Licking River, Kentucky).

Campostoma anomalum (Rafinesque)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 16, 1889 (Arkansas River, Canyon City); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont and Boulder); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder; Longmont).

Campostoma aikenii Cope—COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 672, 1875 (Pueblo).

Body rather elongate, fusiform, but slightly compressed; depth 4 (old males) to 5 (young and medium individuals) in the length to the base of the caudal; head moderately large and pointed, somewhat conical as a whole, its length 3.75 to almost 4.5 (young) in the length; snout rather long, blunt, slightly overhanging the mouth; eye fairly small, larger in the young, its diameter 4.7 (young) to 6.5 (old males) in the length of the head, 2 to 2.25 in the interorbital distance; 1.5 to 2.7 in the snout; nostrils prominent, situated about the diameter of the eye in front of the eye and dorsal to the center of the eye; mouth ventral and slightly oblique, sucker-like; lips thick, especially the upper, a fleshy lobe at the angle of the mouth on each side, formed by the fusion of the two lips; angle of the mouth reaching the level of the nostrils; premaxillaries protractile; dorsal fin rather short, its length slightly less than that of its longest ray, inserted near the middle of the body, on a level with or just in front of the ventrals, base of the first ray of the dorsal nearer to the tip of the snout than to the base of the caudal in adults, in small individuals nearer the base of the caudal; dorsal rays 8; pectorals short, not reaching the ventrals; ventrals not reaching the anal opening; anal smaller than the dorsal; anal rays 7; scales rather large, 7 to 9, 46–58, 7 or 8; lateral line complete, quite decurved before the dorsal.

Dark above, almost black in the mid-dorsal region, with a metallic luster; sides brassy yellow to silvery, mottled irregularly with dusky; below the lateral line silvery white, ventral parts immaculate; top of the head dark green; sides of the head brassy to yellowish; a faint dusky caudal spot; fins hyaline or yellowish, dorsal usually somewhat dusky; length 6 to 10 inches.

Breeding and old males with the body just back of the head and in front of the dorsal distinctly elevated; body above the lateral line with pearl organs (some below the lateral line in the caudal region); top of the head with conical horny tubercles. General color of breeding males much the same as that of other individuals, all markings and colors, however, more prominent; dorsal fin with a series of heavy black Λ-shaped marks, one on each ray with the point toward the margin of the fin, the entire series forming a deeply serrate band crossing the middle of the dorsal, area below this black band yellowish or often bright orange-red; anal fin often marked much like the dorsal; other fins more or less yellowish.

The Stone-roller feeds upon the brown and green slime found on stones and débris in the stream, in this way taking diatoms, algae, small insect larvae and small snails. Several specimens from Wray were found to have the alimentary tract filled with sandy mud in which almost nothing of food value could be found. The larger specimens of this fish were taken in the deeper parts of small streams, and the young from the more shallow weedy portions near shore. Several individuals were collected in the quiet water back of a beaver dam on West Plum Creek. As a food fish the Stone-roller has little value, although the larger individuals are often eaten. The young make very good live bait for bass and both old and young live very well in large aquaria and small artificial ponds.

Campostoma anomalum ranges throughout the Mississippi Valley west to the Rocky Mountains. It spawns in the early spring.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (7 specimens, 75–125 mm.), C. Juday and J. Henderson, No. 6; Boulder Creek east of Boulder, May, 1909 (12 specimens, 95–125 mm.), David Rusk and Donald Kloke, No. 31; West Plum Creek near Castle Rock, June 8, 1912 (12 specimens, 40–150 mm.), A. G. Vestal and M. M. Ellis, No. 329; South Platte River, Julesburg, July 19, 1912 (72 specimens, 50–120 mm.), J. Henderson and M. M. Ellis, No. 330; Lodgepole Creek near Ovid, July 20, 1912 (4 specimens, 75–120 mm.), J. Henderson and M. M. Ellis, No. 331; Boulder Creek 6 miles east of Boulder, July 25, 1912 (4 specimens, 50–85 mm.), M. M. Ellis, No. 332; Republican River, Wray, October 26, 1912 (63 specimens, 45–105 mm.), A. G. Vestal and M. M. Ellis, No. 333. *Reported* by A. E. Beardsley as common at Greeley until killed out by the refuse from the sugar factories.

Subfamily Chrosominae

Genus **CHROSOMUS** Rafinesque

The Red-bellied Dace

Chrosomus Rafinesque, *Ichthyologia Ohiensis*, p. 47, 1820.

Small herbivorous Cyprinids; alimentary canal about twice as long as the body; peritoneum black; no maxillary barbel; mouth terminal; lateral line short and interrupted or wanting; scales small, with apical, lateral and basal radii, 65–90 in the lateral line series. Species of the United States and lower Canada east of the Rocky Mountains. One species known from Colorado.

Chrosomus erythrogaster Rafinesque

Red-bellied Dace

Chrosomus erythrogaster Rafinesque, *Ichthyologia Ohiensis*, p. 47, 1820 (Ohio River).

Represented in Colorado by the western subspecies.

Chrosomus erythrogaster dakotensis (Evermann and Cox)

Western Red-bellied Dace (Fig. 12)

Chrosomus dakotensis Evermann and Cox, *Rept. U.S. Com. Fisheries for 1894*, pp. 395–396, 1896 (Crow Creek, Chamberlain, South Dakota).

Chrosomus erythrogaster Rafinesque—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder and Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder; Longmont).

Body moderately compressed, depth 4.2 to 4.7 in the length to the base of the caudal; head 3.8 to 4.25 in the length of the body; snout short and rather blunt; eye prominent, its diameter about equal to the length of the snout, 1.25 to 1.5 in the interorbital space, 3.5 to 4 in the head; dorsal margin of the eye almost on a level with the top of the head; mouth small and oblique; lower jaw very slightly longer than the upper; angle of the mouth barely reaching the level of the nostril; premaxillaries protractile; dorsal fin short but high, inserted behind the ventrals, base of the first ray of the dorsal nearer the base of the caudal than the tip of the snout; dorsal rays 7–9, usually 8; pectorals small, not reaching the ventrals; ventrals barely if at all reaching the anal fin; anal short and rather small; anal rays usually 8; caudal large, its width greater than the greatest depth of the body; scales very small, circular, with apical, lateral and basal radii, 15 to 17, 78–88, 9 to 12; lateral line incomplete.

General color above olive to brownish; a broad mid-dorsal stripe of dark green to black; sides with two blackish stripes, one beginning at the tip of the snout and crossing the head through the eye as a more or less imperfect bar, continuing from the posterior margin of the opercle along the region of the lateral line as a heavy stripe and ending in a rather well-defined black caudal spot; the second stripe lying about midway between the stripe along the lateral line and the mid-dorsal one, narrower and less distinct, usually breaking up in the caudal region; a row of small black dots, often entirely wanting, between the second stripe and the mid-dorsal stripe; area between the first and second lateral stripes silvery, with a yellowish cast; region below the lower lateral stripe pink or yellowish, overlaid with silvery; fins, especially the ventrals and pectorals, yellowish, the rays outlined with black; length 2.5 inches or less.

Males in the breeding season with the entire region below the first lateral stripe and the under parts of the head a bright vermilion red; ventral and pectoral fins bright yellow; dorsal fin yellow with a broad red spot at the base.

Since the species *Chrosomus dakotensis* Evermann and Cox has been taken at Valentine in western Nebraska,[1] it was first thought that the Colorado specimens might be referable to that species. On examination it was found that the 12 specimens at hand did not warrant the recognition of such a species. *C. dakotensis* differs from *C. erythrogaster* in having 8 instead of 7 dorsal rays and in lacking the distinct caudal spot (*vide* Jordan and Evermann[2]). The tabulated comparison of data from the Colorado specimens and those from Maine and Nebraska shows no correlation of these characters (see Table II).

It may be added that Forbes and Richardson[3] give the dorsal fin rays of *C. erythrogaster* as 7, rarely 6. The difference in the number of fin rays between the Colorado specimens and the true *C. erythrogaster* from the eastern states seems

[1] Evermann and Cox, *Rept. U.S. Com. Fisheries for 1894*, p. 395, 1896.

[2] *Bull. 47, U.S. Nat. Mus.*, pp. 209–210, 1896.

[3] *Ichthyology of Illinois*, p. 113, 1909.

constant enough to retain the name of Evermann and Cox for the western subspecies.

This little fish spawns in May and June and at this season the male is one of the most brilliantly colored of North American fishes. Smith[1] who has studied the spawning habits of *C. erythrogaster* in Michigan finds that two males with a female held between them by the pearl organs on their scales form a spawning unit. The eggs are laid on the gravel bottoms of shallow rapid streams.

TABLE II

Locality	Dorsal Rays 7	Dorsal Rays 8	Dorsal Rays 9	No Caudal Spot	Caudal Spot
Boulder Creek ...	....	×	....	....	×
	....	×	....	....	×
	....	×	....	×	....
	....	×	....	....	×
	×	....	....	....	×
West Plum Creek.	....	×	....	....	×
	....	×	....	....	×
	....	×	....	....	×
	....	....	×	×	....
	....	×	....	....	×
Total........	1	8	1	2	8
Cross Lake, Me...	....	×	....	×	....
Valentine, Neb...	....	×	....	×	....

The food of this species, as shown by the contents of the alimentary canals examined, consists of the brown and green diatomaceous and algal slime and such other material as may be taken with this. So much green algal material was contained by the specimens from West Plum Creek that the alcohol in which they were preserved became bright green within a few days. Two specimens in this same collection were badly infected with larval trematodes.

Chrosomus erythrogaster and its varieties range throughout the northern portion of the Mississippi Valley, east into Maine and west into Colorado.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (65 mm.), C. Juday and D. W. Spangler, No. 18; Boulder Creek, Boulder, October, 1903 (5 specimens, 60–65 mm.), C. Juday and J. Henderson, No. 27; West Plum Creek near Castle Rock, June 8, 1912 (6 specimens, 50–65 mm.), A. G. Vestal and M. M. Ellis, No. 334; Boulder Creek 6 miles east of Boulder, July 25, 1912 (5 specimens, 40–60 mm.), M. M. Ellis, No. 335; *State Teachers' College Museum:* Greeley, A. E. Beardsley.

Subfamily PIMEPHALINAE

Genus PIMEPHALES Rafinesque

The Fat-headed Minnows

Pimephales Rafinesque, *Ichthyologia Ohiensis*, p. 52, 1820.

Small herbivorous Cyprinids; alimentary canal more than twice the length of the body; peritoneum black; premaxillaries protractile; mouth terminal; head

[1] "The Spawning Habits of *Chrosomus erythrogaster* Rafinesque," *Biol. Bull.*, Vol XIV, pp. 9–18, 1908.

short and broad, its top usually somewhat flattened; no maxillary barbel; first (rudimentary) ray of the dorsal fin separated from the second, short, thick and blunt, especially so in the males; lateral line more or less incomplete. Species of the Mississippi Valley, represented in Colorado by the Black-headed Minnow.

Pimephales promelas Rafinesque

BLACK-HEADED MINNOW, FAT-HEAD (Figs. 15, 17, 18 and 19)

Pimephales promelas Rafinesque, *Ichthyologia Ohiensis*, p. 53, 1820 (pond near Lexington, Kentucky); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Longmont).

Pimephales promelas confertus (Girard)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 16, 1889 (Arkansas at Canyon City; Pueblo; pond near Canyon City; Fountain Creek near Pueblo).

Pimephales maculosus Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 180, 1856 (sluices of the Arkansas River, Ft. Makee, Arkansas).

Hyborhynchus nigellus Cope, *Wheeler Survey*, Vol. V, p. 671, 1875 (Arkansas River, Pueblo).

Body short, deep and stout, slightly compressed; head short and rather globose, its length about equal to the depth of the body; depth 3.25 to 4 in the length to the base of the caudal; eye 4 to 4.5 in the head, equal to or a little less than the snout, 2 to 3 in the interorbital distance; mouth terminal and small; angle of the mouth not reaching the level of the anterior margin of the eye by about the diameter of the eye; nostril large, prominent, septum high; dorsal fin short, length of its base equal to or less than the length of the longest ray; first ray of the dorsal, especially in breeding males, short, thick and blunt, separated from the second; base of the first dorsal ray on a level with or slightly in front of the ventrals; dorsal rays, not counting the first short thick one, 7 or 8; pectorals short, not reaching the ventrals by the diameter of the eye; ventrals reaching to the anal opening or beyond; anal fin short; anal rays, not counting the first short thick one, 7; caudal peduncle broad, its least depth less than 2 in the head; caudal fin deeply forked; scales 8 or 9, 45–55, 5 or 6; lateral line more or less incomplete, rather straight; length 4 inches or less, average specimens about 3 inches in length.

Color of young and females olivaceous above, shading to yellowish below, with a rather distinct mid-dorsal dusky stripe; young with a dusky lateral stripe 2 to 4 rows of scales wide, extending from behind the gill opening to the base of the caudal fin; this stripe usually wanting or incompletely developed in adult males and often very much reduced in adult females; sides of the body with a brassy luster; scales more or less outlined with dusky; fin rays often dusky. Breeding males with the entire head excepting the posterior margin of the operculum dusky to jet black; outer third of the dorsal fin dusky, its first 2 or 3 rays, including the first blunt ray and the basal two-thirds of each of the remaining rays, dusky to jet black; membranous portion of the fins hyaline; the pre-dorsal region more or less swollen; anterior portion of the head with conical, white or yellow tubercles arranged in three rows between the nostrils and the margin of the upper lip, and in two rows below the lower lip; three or more smaller tubercles just in front of the eye; males at other than the breeding season much like adult females, but more brassy in color and with a more or less dusky head.

This species spawns in late spring, laying its eggs in sheltered places under stones and débris in shallow excavations. Males in breeding colors and with tubercles, and females with the abdomen much distended with eggs were taken from West Plum Creek at an altitude of 6,500 feet June 8, 1912, and from Glacier Lake, Boulder County, at an altitude of 9,500 feet on July 30, 1912. The smallest breeding male found was 55 mm. in length and the smallest female distended with eggs was 30 mm. long. Many of the Plum Creek specimens were badly infected with larval trematodes. Like the other small herbivorous Cyprinids with long intestines, the Black-headed Minnow feeds upon slime and ooze and the contained substances. The alimentary canals of the many specimens opened were packed with dark masses of this material.

The *Pimephales maculosus* Girard described from the Arkansas River and based on specimens with a rather complete lateral line is here considered synonymous with *P. promelas* since individuals in a single collection from the Republican River at Wray were found with quite complete and very incomplete lateral lines.

Pimephales promelas ranges throughout the western and upper portions of the Mississippi Valley and Great Lakes region. It is a species of the quieter, more weedy parts of small streams.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (70 mm.), C. Juday and D. W. Spangler, No. 26; West Plum Creek near Castle Rock, June 8, 1912 (15 specimens, 45–80 mm.), A. G. Vestal and M. M. Ellis, No. 336; Lodgepole Creek near Ovid, July 20, 1912 (75 mm.), J. Henderson and M. M. Ellis, No. 337; Glacier Lake, Boulder County, July 30, 1912 (240 specimens, 45–55 mm.), Howell Ellis, No. 338; Boulder Creek 6 miles east of Boulder, July 25, 1912 (60 mm.), M. M. Ellis, No. 339; Republican River, Wray, October 26, 1912 (504 specimens, 30–80 mm.), A. G. Vestal and M. M. Ellis, No. 340; Sells Lake, Canyon City, September, 1912 (2 specimens, 40–45 mm.), F. A. Reidel, No. 341; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley.

Genus **HYBOGNATHUS** Agassiz

The Silvery Minnows

Hybognathus Agassiz, *Amer. Journ. Sci. Arts*, p. 223, 1855.

Small herbivorous Cyprinids; alimentary canal 3 to 8 times the length of the body; peritoneum black; inner surface of the lower jaw with a small, hard protuberance near the tip; premaxillaries usually protractile; no maxillary barbel; first (rudimentary) ray of the dorsal fin adnate to the second; base of the first dorsal ray in front of the level of the ventrals. Species of central and southern United States and northern Mexico.

Hybognathus nuchalis Agassiz

SILVERY MINNOW

Hybognathus nuchalis Agassiz, *Amer. Journ. Sci. Arts*, p. 224, 1855 (Quincy, Illinois); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder; Longmont); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont).

Hybognathus nuchalis placita (Girard)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, pp. 8 and 17, 1889 (Denver; Pueblo).

Body elongate and compressed; head subconic, rather long, its length equalling or exceeding the greatest depth of the body; depth 4 to 4.5, or 5 (young), head 3.8 to 4.75 in the length to the base of the caudal; eye medium, 3.8 to almost 5 in the head (Table III); snout rather prominent, tip of the snout rounded, projecting slightly beyond the upper jaw; mouth small, terminal, slightly ventral, lips thin, angle of the mouth not reaching the level of the anterior margin of the eye by half the diameter of the eye or more; inside of the median portion of the lower jaw enlarged at the tip, into a hard, more or less conical protuberance, so that the jaw when seen from in front is Λ-shaped; lower jaw shorter than the upper and obtuse at the tip; dorsal fin short and high, the length of its base almost 2 in the length of its longest ray; base of the first ray of the dorsal distinctly in front of the level of the ventrals; dorsal of 8, sometimes 7 rays; pectorals short, about 1.25 in the head, not reaching the ventrals by almost the length of the latter; ventrals just reaching the anal opening; anal fin short, of 8, rarely 7 rays; caudal peduncle tapering, its least depth about 2 in the head, caudal fin moderately broad and distinctly forked; scales moderately large and well imbricated, 5 or 6, 36–40, 4; lateral line complete and prominent, straight, little if at all decurved in the pectoral region, pores large; size rather small, length up to 6 inches, average adults 3 or 4 inches in length.

Color above the lateral line pale olivaceous to brownish green, with a distinct dusky mid-dorsal stripe, sides and body below the lateral line silvery with a steel-blue iridescence; ventral parts cream color to silvery; scales in the region just above the lateral line with numerous fine blue-black chromatophores overlying an indistinct dusky stripe (this stripe is quite distinct or even prominent in preserved specimens, but usually obscured in living specimens by the silvery color of the sides); fins hyaline, rays outlined with dusky.

A western subspecies of this Minnow, known as *Hybognathus nuchalis placita* (Girard), has been recognized by some writers on the basis of the smaller eye, its diameter in this variety being 5 in the head. Such specimens were found in the collections examined but, associated as they were with specimens having larger eyes and not being confined to a particular drainage area, the subspecies is not separated from the species proper in this report. Table III gives the number of times the eye was contained in the head for several series of specimens.

Since the specimens with the small eyes occur in the collections from the Arkansas River drainage with one exception and the specimens from the Platte and Republican drainages are quite similar in having larger eyes it may be shown by the examination of large series from the upper Arkansas that this subspecies is valid for that drainage. *Hybognathus nuchalis placita* (Girard) was described from the Arkansas River at Ft. Makee, in 1856, under the name of *Hybognathus placitus* Girard.[1]

TABLE III

DIAMETER OF THE EYE IN THE LENGTH OF THE HEAD

Locality	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
Lodgepole Creek..	1	2	6	2	4	1	1	2	1	1	...	...	...
St. Vrain Creek..	...	...	...	...	...	...	...	1	...	...	...	...	...
Republican River..	1	1	3	...	1	1	...	1	...	...	...	1	...
Canyon City......	...	...	...	...	...	...	...	1	...	...	...	...	1
Cripple Creek.....	...	...	...	...	...	...	...	...	...	...	...	...	1
Total........	2	3	9	2	5	2	1	5	1	1	0	1	2

The Silvery Minnow is quite abundant in the plains streams of eastern Colorado where it is taken in company with *Pimephales promelas*, *Notropis scylla* and *Catostomus commersonii sucklii*. Like that of the other herbivorous Cyprinids, its food consists of the slime and water-logged material at the bottom of the stream. This species is occasionally used as live bait but is not so valuable for that purpose as some of the other more hardy Cyprinids. Large individuals are often eaten.

Hybognathus nuchalis ranges from the east coast through southern United States west to the Rocky Mountains and north through the Mississippi Valley to the Red River of the North.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, September and October, 1903 (3 specimens, 45–55 mm.), C. Juday and J. Henderson, No. 24; St. Vrain Creek, Longmont, October 17, 1903 (85 mm.), C. Juday and D. W. Spangler, No. 17; South Platte River, Julesburg, July 19, 1912 (12 specimens, 70–100 mm.), J. Henderson and M. M. Ellis, No. 342; Lodgepole Creek near Ovid, July 20, 1912 (57 specimens, 65–95 mm.), J. Henderson and M. M. Ellis, No. 343; Boulder Creek 6 miles east of Boulder, July 25, 1912 (38 specimens, 50–75 mm.), M. M. Ellis, No. 344; Republican River, Wray, October 26, 1912 (161 specimens, 35–80 mm.), A. G. Vestal and M. M. Ellis, No. 345; 4 miles west of Cripple Creek, July, 1913 (80 mm.), F. A. Hassenpflug, No. 346; Sells Lake, Canyon City, September, 1913 (2 specimens, 50–60 mm.), F. A. Reidel, No. 347; *Colorado State Historical and Natural History Museum:* Clear Creek near Denver, August 7, 1900 (150 mm.), W. C. Ferril; *State Teachers' College Museum:* Greeley, A. E. Beardsley.

Subfamily LEUCISCINAE

To this subfamily belong all of the species of carnivorous Cyprinids found in Colorado. Most of them are small forms represented by large numbers of individuals in the small plains streams of eastern Colorado. One species is found in the Rio Grande drainage and three west of the Continental Divide in Colorado. One of these western slope species is the enormous "White Salmon."

[1] *Proc. Acad. Nat. Sci. Phila.*, p. 182, 1856.

Genus **PHENACOBIUS** Cope

The Sucker-mouthed Minnows

Phenacobius Cope, *Proc. Acad. Nat. Sci. Phila.*, p. 96, 1867.

Rather small, elongate, carnivorous Cyprinids; alimentary canal short; peritoneum white; mouth ventral and sucker-like; premaxillaries protractile; no maxillary barbel; scales rather large, lateral line complete; first ray of the dorsal adnate to the second; base of the first ray of the dorsal in front of the level of the ventral fins. Species of the western and southern portions of the Mississippi Valley. A single species is found in eastern Colorado.

Phenacobius mirabilis (Girard)

SUCKER-MOUTHED MINNOW (Figs. 20, 21, 22, 23 and 24)

Exoglossum mirabile Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 191, 1856 (Arkansas River, Ft. Smith).

Sarcidium scopiferum Cope, *Hayden Geol. Survey of Wyoming for 1870*, p. 440, 1871 (Missouri River near St. Joseph, Missouri).

Phenacobius scopifer (Cope)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); COCKERELL, *Science*, N.S., Vol. XXXIV, p. 615, 1911 (Julesburg).

Body rather elongate, fusiform, and somewhat compressed behind the dorsal, depth 4.25 to 5 in the length to the base of the caudal; head broad and flattened above, rather short and blunt, in some males covered with fine tubercles, its length 3.9 to 4.5 in the length of the body to the base of the caudal; dorsal and ventral profiles both sloping toward the tip of the snout; snout broad and blunt, overhanging the mouth; eye prominent, medium, situated about midway between the tip of the snout and the posterior margin of the opercle, in the upper half of the side of the head, its upper margin almost on a level with the flat portion of the top of the head, its diameter about 1.5 in the interorbital space, 1.75 to 2 in the snout, and 3.75 to 4.75 in the head; nostrils large and prominent, directed dorsally; mouth ventral and sucker-like; lips large and fleshy, the upper recurved around the angles of the mouth; premaxillaries protractile; dorsal fin rather short, inserted in front of the ventrals and in the anterior half of the body, the base of the first ray of the dorsal being nearer the tip of the snout than the base of the caudal by the length of the snout or more; dorsal rays usually 8, rarely 7 or 9; pectorals not reaching the ventrals; ventrals barely if at all reaching the anal opening; anal shorter than the dorsal; anal rays 7, rarely 8; caudal large, its width equal to or greater than the greatest depth of the body; scales 6 or 7, 44–52, 5 or 6, rather circular, with 12 to 29 apical radii and rarely one or two basal radii.

Body above the lateral line dusky olive to brownish, mid-dorsal region with a very narrow but distinct dark stripe which is more prominent in front of the dorsal than behind it; a rather broad stripe of bluish, greenish or dark-blue color, along the lateral line, ending in a distinct black caudal spot; a double series of small black hyphen-shaped marks, one on each side of the pore in each scale of the lateral line, forming the middle of the lateral stripe; below the lateral stripe immaculate, white to cream color, often tinged with pink; sides as a whole silvery; top and sides of the head to the level of the lower margin of the eyes dark; rays of the dorsal, of the caudal excepting the most ventral ones, and those of the other fins to some extent, outlined with black; scales above the lateral line outlined with dusky; length 4 inches or less.

The Sucker-mouthed Minnow is a species of the shallow rapid streams of the western portion of the Mississippi Valley, ranging east of the Rocky Mountains to Illinois and from South Dakota south into southern Texas. Each of the Colorado collections of this species was made in clear shallow water with a sand or gravel bottom. This minnow feeds on the small insect larvae and snails found on the stream bed.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (3 specimens, 95–100 mm.), C. Juday and D. W. Spangler; Lodgepole creek near Ovid, July 20, 1912 (16 specimens, 75–95 mm.), J. Henderson and M. M. Ellis, No. 348; Boulder Creek 6 miles east of Boulder, July 25, 1912 (8 specimens, 60–70 mm.), M. M. Ellis, No. 349.

Genus **RICHARDSONIUS** Girard

The Dace

Richardsonius Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 201, 1856.

Moderately large to small carnivorous Cyprinids; alimentary canal short; mouth rather large, terminal and slightly oblique; no maxillary barbel; lateral line decurved, usually complete; pharyngeal teeth[1] in two rows, 2–5–5–2, 1–5–4–1 or rarely 1–4–4–1, usually hooked and without grinding surfaces. Most species of this genus are found west of the Rocky Mountains, although the genus is represented in the Mississippi Valley and eastern United States. The species are variable and concerning many little is known. In general the species of *Richardsonius* have finer scales and are larger and more elongate than the species of *Notropis* which, in many respects, they resemble. Two species[2] of *Richardsonius* are known from Colorado.

[1] The formulae refer to the number of teeth in the two rows on each side of the head. By 2–5–4–1 is understood 5 large teeth in one row with 2 smaller ones in front of them on one side of the head, and 4 large teeth with 1 small one in front of them on the opposite side of the head, i.e., the fish need not be bilaterally symmetrical as regards pharyngeal teeth. To examine these teeth, raise the operculum, insert a small pair of forceps or a hook behind the last gill, seize the pharyngeal bone which lies just behind and below the last gill, and remove the bone. Wash the adhering material from the bone and the teeth may be readily counted with a low-power lens. Care must be used not to break off the teeth while removing the bone from the fish.

[2] Professor A. E. Beardsley reports to the writer the species *Richardsonius intermedius* (Girard) from Durango, Colorado. Since no specimens of this species have been examined in the present study, it is not listed. If found it may be separated by the smaller scales (the formula being 15, 73–78, 9) from *R. pulchellus*, which it closely resembles. *R. intermedius* is a species of the Gila River.

a. Scales quite small, 60 to 70 in the lateral line; size rather large, length up to 12 inches; color bluish silvery, no lateral stripe; species of the Rio Grande. *R. pulchellus* (Baird and Girard)

aa. Scales larger, 45 to 47 in the lateral line; size small, length 3.5 inches; with a dusky lateral stripe; species of the South Platte . . . . *R. evermanni* (Juday)

Richardsonius pulchellus (Baird and Girard)

"Pescadito," Rio Grande Chub

Gila pulchella Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 29, 1854 (Rio Mimbres, Lake Guzman, Chihuahua).

Tigoma nigrescens Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 207, 1856 (Boca Grande and Janos River, Chihuahua).

Leuciscus pulcher (Girard)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 20, 1889 (Rio Conejos 15 miles south of Alamosa; Del Norte).

Leuciscus nigrescens (Girard)—Jordan and Evermann, *Bull. 47, U.S. Nat. Mus.*, p. 235, 1896 (Rio Grande, Alamosa); Cockerell and Allison, *Proc. Biol. Soc. Wash.*, Vol. XXII, p. 159, 1909 (Alamosa).

Clinostomus pandora Cope, *Hayden Survey of Montana for 1871*, p. 475, 1872 (tributaries of the Rio Grande, Sangre de Cristo Pass).

Body elongate, subterete, not strongly compressed; head conical; depth 4 to 4.5, head 3.8 to 4.2 in the length to the base of the caudal; eye large, 4 (young) to 5.5 in the head, about 1.25 in the snout and 1.25 to almost 2 in the interorbital distance; mouth large, slightly if at all oblique; angle of the mouth barely if at all reaching the anterior margin of the eye; dorsal fin short and rather high, of 8 rays, length of its base less than that of its longest ray, base of the first dorsal ray just behind the level of the ventrals; pectorals long, almost reaching the ventrals; ventrals just reaching the anal opening; anal fin short, of 7 or usually 8 rays; caudal peduncle rather narrow, its least depth a little more than 2 in the head; caudal fin rather narrow and deeply forked; scales small, closely imbricated, 15 to 17, 60–70, 10 or 11; lateral line complete and strongly decurved in the pectoral region; size moderately large, length 12 inches or less.

Color above the lateral line dark, iridescent steel blue, mid-dorsal region with a faint dusky stripe; sides of the body and head densely sprinkled with purplish-blue chromatophores; below the lateral line lighter, shading to silvery white ventrally; dorsal, caudal, and to some extent the anal, fins, sprinkled with dusky; top of the head dark; axil of the pectorals and ventrals, and body at the base of the anal yellowish to orange-red.

This species is known only from the Rio Grande drainage, ranging from Colorado south into Mexico. It is very abundant and very variable and as a result several species now considered as synonyms of this one have been proposed.

Colorado specimens.—*University Museum:* Rio Grande, Alamosa, August, 1889 (110 mm.), D. S. Jordan, No. 350; San Luis Lake, Costilla County, June 5, 1909 (3 specimens, 170–190 mm.), E. R. Warren, No. 351; Rio Grande, Alamosa, July 27, 1912 (251 specimens, 50–200 mm.), M. M. Ellis, No. 352. *State Teachers' College Museum:* Antonito, Conejos County, A. E. Beardsley; *Colorado College Museum:* San Luis Lake, Costilla County, June 5, 1909, E. R. Warren.

Richardsonius evermanni (Juday)

Evermann's Dace

Leuciscus evermanni Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder Creek, Boulder); *Idem, Bull. U.S. Fish Com. for 1904*, p. 226, 1905 (Boulder Creek, Boulder).

Body elongate, somewhat compressed; head about 3.75, depth about 4.5 in the length to the base of the caudal; eye about 4.5 in the head, a little more than 1 in the snout, and 1.5 in the interorbital distance; mouth large, angle of the mouth almost reaching the level of the anterior margin of the eye; base of the first ray of the dorsal fin on a level with the base of the ventrals, dorsal rays 8; pectorals short, not reaching the ventrals by the diameter of the eye; ventrals passing the anal opening but scarcely reaching the anal fin; anal fin of 8 rays; caudal peduncle rather broad, about 2.5 in the head; scales 8 or 9, 45–47, 5, 25 in the predorsal series; lateral line interrupted, decurved in the pectoral region. Dusky above, lighter below; a dark mid-dorsal stripe and a dusky lateral band; scales outlined with dusky, giving the body above the lateral line somewhat reticulated pattern.

This species is known at present from three specimens collected by Juday in 1903 in Boulder Creek near Boulder. The above description was made from Cotype No. 1, University of Colorado Museum, No. 14.

Genus NOTROPIS Rafinesque

The Shiners

Notropis Rafinesque, *Amer. Monthly Magazine*, Vol. II, p. 204, 1818.

Small compressed or elongate, carnivorous Cyprinids, the larger species rather deep; alimentary canal short; mouth terminal, usually not very large; no maxillary barbel; pharyngeal teeth (see *Richardsonius*) in one or two rows, 0–4–4–0, 1–4–4–1 or 2–4–4–2; species very numerous and variable, distributed throughout the United States and lower Canada east of the Rocky Mountains. The following key will serve to separate the Colorado species of this genus.

Key to Colorado Species of Notropis

a. With dusky lateral band or stripe, or at least dusky lateral clouds; sides more or less silvery.
- **b.** Lateral stripe prominent, extending across the side of the head through the eye to the tip of the snout . . . . *N. cayuga* Meek
- **bb.** Lateral stripe not extending across the head to the tip of the head, often rather indistinct and much interrupted.
  - **c.** Anal rays 7 or 8; body elongate and not deep.
    - **d.** Entire predorsal region usually scaleless, or scales if present in this region small, crowded and wanting near the head. . . . . . . *N. piptolepis* (Cope)
    - **dd.** Predorsal region regularly and evenly scaled; 14 to 16 scales of rather uniform size, in front of the dorsal fin . . . . *N. scylla* (Cope)
  - **cc.** Anal rays 9 or 10.
    - **e.** 5 to 7 scales between the base of the first ray of the dorsal fin and the lateral line.

f. Body elongate; depth 5.2 in the length. . . . . *N. horatii* Cockerell

ff. Body compressed, quite deep in adults; depth 4.4 (young) to 3.25 (adults) in the length; scales on the sides much deeper than long. *N. cornutus* (Mitchill)

ee. 9 scales between the base of the first ray of the dorsal fin and the lateral line. *N. universitatis* Evermann and Cockerell

aa. Without dusky lateral bands or clouds; body much compressed and deep; color bluish, sides dull silvery, a dusky violet humeral bar; fins of the males often bright red. *N. lutrensis* (Baird and Girard)

Notropis cayuga Meek

Cayuga Shiner

Notropis cayuga Meek, *Ann. Acad. Nat. Hist. N.Y.*, p. 305, 1888 (Cayuga Lake, New York); Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Longmont).

Body elongate, not strongly compressed, head rather long; depth 4.5 to 5.25, head 3.75 to 4 in the length to the base of the caudal; eye large, 3 to 3.5 in the head and about 1 in the snout; mouth small terminal and somewhat oblique, angle of the mouth not reaching the level of the anterior margin of the eye; dorsal short and high, base of its first ray posterior to the level of the ventrals; dorsal rays 8; pectorals short, not reaching the ventrals; ventrals reaching the anal opening; anal fin of 8 or sometimes 7 rays; scales 5, 34–38, 3 or 4, lateral line rather straight, somewhat interrupted; 12 to 16 rows of scales in front of the dorsal fin; size small, length 2.5 inches or less.

Color olivaceous dorsally, shading to lighter below; sides more or less silvery; a very faint dusky mid-dorsal stripe; a distinct black lateral stripe extending from a faint spot at the base of the caudal fin along the lateral line, across the side of the head, through the eye to the tip of the snout; scales above the lateral line outlined with dusky.

This little shiner ranges through northern United States and lower Canada east of the Rocky Mountains and south into Arkansas. It spawns in late spring and early summer.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (6 specimens, 45-60 mm.), C. Juday and J. Henderson, No. 25.

Notropis piptolepis (Cope)

Platte River Shiner

Photogenis piptolepis Cope, *Hayden Geol. Survey of Wyoming for 1870*, p. 438, 1871 (Red Cloud Creek, tributary of the North Platte River).

Notropis piptolepis (Cope)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder).

Notropis gilberti Jordan and Meek—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 Denver. (Listed as possibly *Photogenis piptolepis* Cope.)

Body elongate, subterete, but slightly compressed; head rather long; depth 4 to 4.5, head 3.75 to 4 in the length to the base of the caudal; eye rather large, 3 to 3.5 in the head, about 1 in the snout; mouth small and rather ventrally placed, angle of the mouth not reaching the level of the anterior margin of the eye; pharyngeal teeth usually 1–4–4–1; dorsal fin short and high, length of its base about 1.5 in the length of the longest ray, base of the first dorsal ray on a level with or very slightly behind the base of the ventrals; dorsal rays 7 or 8; pectorals short, not reaching the ventrals; ventrals barely reaching the anal opening; anal fin short, of 7 or 8 rays; scales 5 or 6, 38–42, 4; lateral line complete and somewhat decurved in the pectoral region; predorsal region without scales, or scales if present small and much crowded just in front of the dorsal and wanting near the head; size small, length 3 inches or less.

Color above the lateral line yellowish or light olivaceous, overlaid with dusky or greenish; sides silvery, lighter ventrally; a distinct dusky mid-dorsal stripe; a dusky bluish lateral stripe along the lateral line, this stripe often much interrupted and obscured by the silvery color of the sides; a series of small, black hyphen-shaped marks on each side of the pores of the lateral line; fins hyaline, rays more or less outlined with dusky.

This shiner is much like the following species, *Notropis scylla*, from which it may be recognized most easily by the absence of scales in the predorsal region.

Notropis piptolepis is known only from the western portion of the Platte River drainage, being a species of the small shallow streams of the plains and foothills. Most of the females of this species collected at Boulder, July 25, 1912, were distended with well-developed eggs, so it is probable that the spawning season is July and early August.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (127 specimens, 55–70 mm.), C. Juday and J. Henderson, No. 9; West Plum Creek near Castle Rock, June 8, 1912 (59 specimens, 35–75 mm.), A. G. Vestal amd M. M. Ellis, No. 353; South Platte, Julesburg, July 19, 1912 (5 specimens, 60–70 mm.), J. Henderson and M. M. Ellis, No. 354; Lodgepole Creek near Ovid, July 20, 1912 (15 specimens, 50–70 mm.), J. Henderson and M. M. Ellis, No. 355; Boulder Creek 6 miles east of Boulder, July 25, 1912 (11 specimens, 40–65 mm.), M. M. Ellis, No. 356.

Notropis scylla (Cope)

Western Shiner (Fig. 28)

Hybopsis scylla Cope, *Hayden Geol. Survey of Wyoming for 1870*, p. 438, 1871 (Red Cloud Creek, tributary of Platte River); Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 566, 1875 (Fountain Creek).

Notropis scylla (Cope)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Denver; Pueblo); Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder; Longmont).

Body elongate, slightly compressed, head rather long; depth 3.9 to 4.5, (3.6 in gravid females), head 3.75 to 4 in the length to the base of the caudal; eye rather large, 3 to 3.5 in the head, about 1 in the snout and 1 to 1.5 usually about 1.25 in the interorbital distance; snout short, abrupt and rounded anteriorly, slightly overhanging the closed mouth; mouth rather small, oblique to ventral; angle of the mouth not reaching the anterior margin of the eye, but on a level with the nostril; pharyngeal teeth usually 0–4–4–0, distinctly hooked; dorsal fin short and rather high, length of its base about 1.5 in the length of its longest ray; base of the first ray of the dorsal on a level with the base of the ventrals, dorsal rays 7, sometimes 8; pectorals short, not reaching the ventrals by almost the length of the latter (females) or by about one-half the length of the ventrals (males); ventrals barely if at all reaching the anal opening; anal fin short, of usually 7 rays; scales large, 5 or 6, 33–39, 4; lateral line complete, slightly decurved in the pectoral region; predorsal region regularly scaled, 14 to 16 scales in front of the dorsal; size small, length 3 inches or less.

Color above the lateral line yellowish overlaid with dusky and greenish; sides silvery, ventral parts cream color to white; mid-dorsal region with a narrow but distinct dusky stripe (indistinct in but 3 out of 147 specimens examined for this character); sides just above the lateral line with a dusky bluish stripe, usually rather distinct in the caudal half of the body, where in the young it ends in a small caudal spot, this spot often indistinct in adults; a row of hyphen-shaped black marks on each side of the lateral line pores; scales above the lateral line outlined with dusky giving the upper half of the body, especially in the predorsal region, a distinctly reticulated pattern; fins hyaline, rays often outlined with dusky; head dark above.

Notropis scylla is a species of the plains streams of the western part of the Mississippi Valley near the Rocky Mountains. Females taken at Julesburg and Ovid, July 19 and 20, 1912, were distended with well-developed eggs.

Colorado specimens.—*University Museum*: Boulder Creek, Boulder, October, 1903 (3 specimens, 60–75 mm.), C. Juday and J. Henderson, No. 28; St. Vrain Creek, Longmont, October 17, 1903 (3 specimens, 60–70 mm.), C. Juday and D. W. Spangler, No. 20; South Platte, Julesburg, July 19, 1912 (174 specimens, 40–70 mm.), J. Henderson and M. M. Ellis, No. 357; Lodgepole Creek near Ovid July 20, 1912 (18 specimens, 50–75 mm.), J. Henderson and M. M. Ellis, No. 358; Republican River, Wray, October 26, 1912 (51 specimens, 30–70 mm.), A. G. Vestal and M. M. Ellis, No. 359; *State Teachers' College Museum*: Cache la Poudre near Greeley, A. E. Beardsley.

Notropis horatii Cockerell

Notropis horatii Cockerell, *Science*, N.S., Vol. XXXIV, p. 614, 1911 (South Platte, Julesburg).

A very doubtful species, based at present on a single specimen. Although extensive collections have since been made at the exact station from which this unique specimen was taken, no other individuals referable to this species have been found. The following data are compiled from the original description:

Head 5.2 in the length to the base of the caudal; dorsal rays 8; anal rays 9; scales 5 or 6, 38–40, 4; eye a little more than 1 in the snout; mid-dorsal stripe present; length 47 mm.

Notropis cornutus (Mitchill)

Common Shiner (Figs. 27 and 60)

Cyprinus cornutus Mitchill, *Amer. Monthly Magazine*, Vol. I, p. 289, 1817 (Wallkill River, New York).

Notropis cornutus (Mitchill)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder; Longmont).

Notropis megalops (Rafinesque)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Denver).

Body moderately elongate (young) and quite compressed (adults), and in adults moderately deep; depth 4.25 (young) to 3.2 (adult), head 4.25 to 3.7 in the length to the base of the caudal; head short and rather chubby; eye large, 4 to 5 in the head, about 1.5 in the snout and 2 in the interorbital distance; mouth large, slightly oblique, angle of the mouth not reaching the anterior margin of the eye; nostril large and prominent, situated on the dorsal surface of the head about one-half of the diameter of the eye in front of the eye; dorsal fin short, of 8 rays, base of the first ray nearer to the tip of the snout than to the base of the caudal, about on a level with the ventrals; pectorals short, not reaching the ventrals; ventrals barely if at all reaching the anal opening; anal fin of about the same length as the dorsal, of 9, sometimes 10 rays; caudal peduncle moderately deep, its least depth about 2.5 (young) to 2 (adult) in the head; caudal fin broad and deeply forked; scales large, those on the sides with the exposed portion much deeper than long, 6 or 7, 37–45, 3 or 4, 16 or more in front of the dorsal; lateral line complete, strongly decurved in the pectoral region; length 9 inches or less, average adults about 4 inches in length.

Color olivaceous dorsally, shading to almost white below, sides silvery, with a bluish iridescence; mid-dorsal region especially in the young with a narrow rather well-defined, dusky stripe; lateral line region with a broad dusky lateral stripe, sometimes quite prominent, but in adults usually much interrupted and poorly defined; top of the head dark bluish green; dorsal and caudal fins dusky. Sides of breeding males much blotched with salmon pink and dusky emerald green; dorsal, caudal and anal fins broadly margined with rose pink; pectorals and ventrals cream color with suffuse pink along the rays; anterior margin of the pectorals dusky blue; top of the head with numerous horny tubercles; throat and under parts of the head pearly white; sides with a steel-blue iridescence.

The common shiner ranges over the whole of the United States east of the Rocky Mountains excepting the southern portion of the Mississippi Valley, and through lower Canada. It is often the most abundant fish in the small clear streams of the central states. From an economic standpoint the shiner is of little importance except as its young are eaten by other more valuable fishes. Large specimens are, however, often eaten, as this species readily takes any sort of still bait. By some it is recommended as live bait for bass.

Notropis cornutus spawns in late spring. Like that of most of the other species of this genus, its food consists of surface insects, aquatic insects and some plant material, other types of food being utilized occasionally.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (5 specimens, 90–140 mm.), C. Juday and J. Henderson, No. 2; St. Vrain Creek, Longmont, October 17, 1903 (120 mm.), C. Juday and D. W. Spangler, No. 41; Boulder Creek, Boulder, April 23, 1904 (2 specimens, 150 mm.), J. Henderson, No. 23; West Plum Creek near Castle Rock, June 8, 1912 (148 specimens, 35–135 mm.), A. G. Vestal and M. M. Ellis, No. 360; Boulder Creek 6 miles east of Boulder, July 25, 1912 (92 specimens, 50–130 mm.), M. M. Ellis, No. 361; South Platte, Julesburg, July 19, 1912 (66 specimens, 70–100 mm.), J. Henderson and M. M. Ellis, No. 362; Lodgepole Creek near Ovid, July 20, 1912 (59 specimens, 75–125 mm.), J. Henderson and M. M. Ellis, No. 363; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley; *Colorado College Museum:* Cache la Poudre River near Greeley, I. C. Hall.

Notropis universitatis Evermann and Cockerell

Notropis universitatis Evermann and Cockerell, *Proc. Biol. Soc. Washington*, Vol. XXII, p. 187, 1909 (Boulder Creek, Boulder).

This species is based at present on one specimen collected in Boulder Creek at a time when all of the fishes were killed by the introduction of mine waste in the canyon above Boulder. No other specimens have been found in the several subsequent collections made at Boulder. The original description is quoted below:

Close to *N. zonatus*, but with smaller scales and different coloration. There are 45 scales in the lateral line and 9 between the origin of the dorsal and the lateral line, as against 42 and 6 in *N. zonatus*. A pale-orange dorsal band on a bright straw-yellow ground, the scales minutely black-dotted, but not appearing dusky margined; sides strongly silvery; lateral line complete; a grayish lateral stripe; dorsal and caudal fins yellowish; dorsal and chin black-speckled.

Notropis lutrensis (Baird and Girard)

REDFIN (Fig. 29)

Leuciscus lutrensis Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 391, 1853 (Otter Creek, tributary of the north fork of Red River, Arkansas).

Notropis lutrensis (Baird and Girard)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, pp. 8 and 16, 1889 (Denver; Pueblo; Fountain Creek, Pueblo); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Longmont).

Hypsilepis jugalis (Cope)—COPE AND YARROW, Wheeler Survey, Vol. V, p. 654, 1875 (Pueblo).

Body strongly compressed, rather deep in adults; head short and conic; depth 3.25 to almost 4, head 3.75 to 4.25 in the length to the base of the caudal; young and females more slender than adult males, their depth often as low as 5 in the length; eye 3 (very small specimens) to 4 (adult males) in the head, about 2.25 in the interorbital distance and 1 to 1.5 in the snout; mouth small, terminal and oblique, angle of the mouth not reaching the anterior margin of the eye; nostril prominent, on the dorsal surface of the head, septum large; dorsal fin short and high, of usually 8 rays, length of its base less than that of its longest ray base of the first ray of the dorsal slightly behind the level of the ventrals; pectorals short, 1 or a little more in the head, not reaching the ventrals; ventrals reaching the anal opening or the base of the anal fin; anal fin short, of 8 or 9 rays, length of its base less than that of its longest ray; caudal peduncle rather narrow, its least depth 2 or a little more in the head; caudal fin rather broad and deeply forked; scales large, closely imbricate, those on the sides broader than long, 6, 35–40, 3; lateral line complete, strongly decurved in the pectoral region; size small, length under 4 inches, average adults 2.5 to 3 inches.

Young and females pale olivaceous dorsally, with a bluish or lead-gray cast, shading through dull silvery to almost white below; adult males dusky dorsally, the region above the lateral line a bright steel blue, with a purplish or pinkish iridescence; dull silvery below the lateral line; top of the head bluish; scales in both sexes, especially above the lateral line, rather regularly outlined with dusky or bluish, giving the sides a somewhat reticulated pattern; adults with a long narrow triangular dusky violet humeral spot, margined behind with paler; fins in all excepting breeding males rather hyaline, the dorsal and caudal somewhat dusky, and the anal and ventrals whitish; in breeding males, dorsal reddish, pectorals, ventrals and anal yellowish to cherry-red; the head and predorsal region with small tubercles; operculum and sides of the body posterior to the violet humeral spot with more or less red.

The Redfin is one of the more abundant fishes of the western portion of the Mississippi Valley, ranging from the Rio Grande River north through western United States east of the Rocky Mountains into South Dakota, and east into Illinois.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (6 specimens, 50–70 mm.), C. Juday and D. W. Spangler, No. 12; Lodgepole Creek near Ovid, July 20, 1912 (32 specimens, 40–75 mm.), J. Henderson and M. M. Ellis, No. 364; Republican River, Wray, October 26, 1912 (13 specimens, 30–85 mm.), A. G. Vestal and M. M. Ellis, No. 365; 4 miles west of Cripple Creek, July, 1913 (2 specimens, 165–170 mm.), F. A. Hassenpflug, No. 366; *Colorado State Historical and Natural History Museum:* South Platte River near Denver, August 3, 1900 (65 mm.), W. C. Ferril; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley.

Genus **PTYCHOCHEILUS** Agassiz

The Squawfish and "White Salmon"

Ptychocheilus Agassiz, *Amer. Journ. Sci. Arts*, p. 229, 1855.

Very large carnivorous Cyprinids, the largest known North American Cyprinid being a member of this genus; body rather elongate; head long and pike-like; alimentary canal short; caudal peduncle not abruptly narrowed just in front of the caudal fin; basal fulcra of the caudal fin not strongly developed. All of the species of this genus are found west of the Continental Divide. *Ptychocheilus* is represented in Colorado by the "White Salmon."

Ptychocheilus lucius Girard

"White Salmon" of the Colorado

Ptychocheilus lucius Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 209, 1856 (Rio Colorado); Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 28, 1889 (Gunnison and Uncompahgre rivers at Delta).

Body elongate, subterete and but slightly compressed, head long; depth 5 to 5.5, head 3.25 to almost 4, usually about 3.5, in the length to the base of the caudal; eye small, 6 to 8 in the head, about 2.25 in the snout; mouth terminal and large, angle of the mouth reaching the level of the anterior margin of the eye or beyond; dorsal fin high, length of its base less than that of its longest ray, base of the first ray of the dorsal posterior to the level of the ventrals, dorsal rays 9; pectorals short, not reaching the ventrals; ventrals barely if at all reaching the anal opening; anal fin short, of 9 rays; caudal peduncle rather deep, not abruptly narrowed just in front of the base of the caudal, least depth of the caudal peduncle about 3 in the head; basal fulcra of the caudal fin not strongly developed; caudal fin broad and deeply forked; scales small and loosely imbricate, lateral line decurved, of 80 to 90 scales; size very large, reaching a length of 5 feet and a weight of almost 100 pounds.

Color dusky greenish dorsally, sides somewhat silvery, ventral parts dirty yellow; fins hyaline, reddish or yellowish in the spring; young, with a distinct caudal spot and a dusky lateral stripe often margined below with lighter.

This remarkable fish, the largest of the North American Cyprinids, occurs in Colorado only in the Grand, White and Yampa rivers and their tributaries. Because of the large size of this species, even though it be but a minnow, it is a valuable food fish.

Ptychocheilus lucius is a species of the Colorado River drainage.

Colorado specimens.—*University Museum:* Uncompahgre River, August, 1889 (115 mm.), No. 367; *State Teachers' College Museum:* Delta, A. E. Beardsley.

Genus **GILA** Baird and Girard

The Bony Tails

Gila Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 368, 1853.

Moderately large carnivorous Cyprinids; alimentary canal short; peritoneum dusky; no maxillary barbel; mouth oblique and large; base of the first ray of the dorsal posterior to the level of the ventrals; basal fulcra of the caudal fin large and prominent; caudal peduncle narrowed just before the caudal fin; scales small, loosely imbricated, mid-dorsal and mid-ventral regions often incompletely scaled or naked. The species of this genus are known only from the Colorado River drainage and are quite different from the ordinary Cyprinids. A single species is found in Colorado.

Gila robusta Baird and Girard

ROUND TAIL, BONY TAIL, "GILA TROUT" (Figs. 34, 35 and 36)

Gila robusta Baird and Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 368, 1853 (Zuni River); JORDAN AND EVERMANN, *Bull. 47, U.S. Nat. Mus.*, p. 227, 1896 (Uncompahgre River at Delta).

Gila elegans Baird and Girard—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 27, 1889 (Gunnison at Delta).

Gila pandora Cope—COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 661, 1875 (Pagosa).

Gila egregia Cope—COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 662, 1875 (Loma, Grand River, wrongly ascribed to the Rio Grande).

Body elongate, somewhat compressed, depth 4.6 (young) to almost 6, usually about 5 in the length to the base of the caudal fin; dorsal and ventral profiles sloping regularly in small specimens, dorsal profile just back of the head rising abruptly, so that the body in this region bears a more or less distinct hump; head rather large, somewhat flattened dorsally, especially in old individuals, 3.5 (young) to 4.7 in the length; eye large, situated nearer to the tip of the snout than to the posterior margin of the operculum, its diameter 5 or 6 in the head, about 2 in the interorbital distance, 2 or a little less in the snout; nostril large, septum very prominent and much elevated, its length about 2 in the eye; mouth terminal, broad, and slightly oblique, angle of the mouth reaching the level of the anterior margin of the eye; premaxillaries protractile; dorsal fin short, length of its base less than that of the first ray, base of the first ray almost equidistant from the tip of the snout and the base of the caudal, rays usually 10, sometimes 9; tip of pectorals not reaching the ventrals; ventrals reaching or passing the anal opening; anal fin with 9 or 10 rays; caudal peduncle elongate and quite narrow, its least depth 1.25 to 1.5 in the maxillary, equalling or slightly exceeding the diameter of the eye; basal fulcra of the caudal fin much developed; caudal fin long and broad, deeply forked, its width equalling or exceeding the greatest depth of the body; scales small, irregularly placed, ventral parts and mid-dorsal region often incompletely scaled or naked; lateral line very prominent, strongly decurved and rather irregular, pores beginning at the base of the occipital region and extending well out onto the base of the caudal fin; scales about 30 in vertical series between the base of the first ray of the dorsal and the base of the ventrals, 85 to 95 in the lateral line.

General color silvery, dusky dorsally; axils of the pectorals and ventrals and the base of the anal fin yellowish to orange; males with more or less red on the sides of the head. Size small to moderately large, average specimens about 9 inches in length, very large individuals 12 to 15 inches.

The Round Tail has very little economic importance since its body is so bony as to make its value as a food fish slight. The flesh of large specimens is occasionally eaten and is said to have a very good flavor. While collecting at Grand Junction the writer found this species confused with the young and small specimens of *Ptychocheilus lucius* Girard by the local fishermen, both species being known as "Squawfish."

Gila robusta is found only in the Colorado River and its tributaries. *Gila elegans* Baird and Girard is here considered as synonymous with this species, since intermediate forms and those agreeing with the descriptions of both species were taken from the same station in the Grand River at Grand Junction. In addition, specimens were collected with both the ventral and dorsal portions of the body free from scales, the character given as diagnostic for *Gila seminuda* Cope and Yarrow. This character seemed fairly constant, although individuals with the ventral region partly scaled were found. Since those individuals naked ventrally and dorsally agreed in other points with *Gila robusta*, *Gila seminuda* has been retained as a subspecies of *Gila robusta*. The specimens examined are listed here under the species proper since intermediate forms were present and this subspecies may not be separable.

Colorado specimens.—*University Museum:* Bear River, Lily, Moffatt County, June 30, 1907 (230 mm.), E. R. Warren and J. W. Frey, No. 368; Grand River, Grand Junction, August 8, 1912 (33 specimens, 40–180 mm.), J. Henderson and M. M. Ellis, No. 369; *State Teachers' College Museum:* Delta, A. E. Beardsley; *Colorado College Museum:* Bear River, Lily, Moffatt County, E. R. Warren (labeled *G. seminuda*).

Gila robusta seminuda (Cope and Yarrow)

Gila seminuda Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 666, 1875 (Rio Virgen, Utah).

Specimens of this subspecies differ from the typical *G. robusta* in having no scales on the mid-ventral portion of the body as far posterior as the base of the ventrals and no scales on the mid-dorsal region as far back as the middle or last ray of the dorsal fin.

Genus **SEMOTILUS** Rafinesque

The Fall-fishes

Semotilus Rafinesque, *Ichthyologia Ohiensis*, p. 49, 1820.

Moderately large carnivorous Cyprinids; alimentary canal short; mouth large and terminal, very slightly oblique; maxillary barbel present, attached to the upper outer surface of the upper jaw just above the junction of the two jaws, the free portion of the barbel dropping downward and backward into the groove at the junction of the two jaws; lateral line complete and strongly decurved in the pectoral region; length under 20 inches. Species of upper United States and Lower Canada east of the Rocky Mountains; represented in Colorado by the Horned Dace.

Semotilus atromaculatus (Mitchill)

HORNED DACE, CREEK CHUB, THE "CHUB" (Figs. 25, 26 and 61)

Cyprinus atromaculatus Mitchill, *Amer. Monthly Magazine*, Vol. II, p. 324, 1818 (Wallkill River).

Semotilus atromaculatus (Mitchill)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Denver); JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont).

Semotilus atromaculatus macrocephalus (Girard)—COCKERELL, *Science*, N.S., Vol. XXXIV, p. 615, 1911 (Julesburg).

Body elongate, subterete, not strongly compressed; head large, rather conical, its length exceeding the greatest depth of the body; depth 4.7 (young) to 4, head 3.2 to 3.9 in the length to the base of the caudal; eye rather large, 2 in the snout, 5 to 7 in the head and 2.5 to 3 in the interorbital distance; mouth large, terminal and somewhat oblique; angle of the mouth barely reaching the level of the anterior margin of the eye; maxillary barbel present, quite small, often very obscure in the young, placed on the upper, outer surface of the upper jaw just above the junction of the two jaws, the free portion of the barbel dropping backward and downward into the groove at the junction of the two jaws; nostril large and prominent, septum much elevated; dorsal fin short and high, of 8, rarely 9 rays, base of the first ray distinctly posterior to the level of the ventrals; pectorals short, not reaching the ventrals by about half the length of the latter; ventrals not reaching the anal opening; anal fin short, of 8 rays; least depth of the caudal peduncle 3 or a little less in the head, caudal broad and moderately forked; scales 10 or 11, 55–70, 5 to 7; lateral line complete, strongly decurved in the pectoral region; size moderately large, average adults about 8 inches, large specimens reaching the length of 12 inches.

Color above dusky to quite dark with a bluish or greenish cast dorsally; below the lateral line almost white with a yellowish or pinkish cast shading to pearly white on the ventral surface between the pectorals; a rather indistinct dusky stripe from the tip of the snout crossing the side of the head and the operculum at the level of the eye and continuing along the side of the body as a dusky or blackish lateral stripe, extending to the base of the caudal where it terminates in a distinct caudal spot; this stripe and spot quite prominent in the young, but often rather indistinct in the adults, the stripe breaking up into a suffuse lateral band or entirely wanting; a rather distinct dusky or black spot covers the bases of the first three or four rays of the dorsal fin, fins otherwise hyaline, the rays somewhat outlined with dusky; sides of the body and axils of the pectoral and ventral fins in breeding males with more or less rose-red.

The larger individuals of *Semotilus atromaculatus* are used for food, although the Chub is not greatly esteemed as a food fish. Because of the hardiness of this species it is generally considered one of the best live baits for bass and wall-eyed pike. The common Chub ranges over most of the United States east of the Rocky Mountains, in Colorado being quite abundant in the plains streams of the eastern part of the state. The chub is an active, vigorous fish and will often provide considerable sport when hooked, fighting much like some of the game fishes. The larger individuals congregate in the deeper pools of the small streams while the small specimens are found in the more shallow and weedy portions with the small species of minnows. The adult chub is a voracious fish feeding upon surface insects, aquatic insects, small fishes and even the spawn of other fishes. Not infrequently this species feeds upon vegetable matter. The Chub spawns in late spring, the eggs being deposited in a shallow excavation made in the sand or gravel by the male.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (2 specimens, 90 and 180 mm.), C. Juday and D. W. Spangler, No. 7; Boulder Creek, Boulder, October, 1903 (59 specimens, 35–190 mm.), C. Juday and J. Henderson, No. 8; Boulder Creek east of Boulder, May, 1909 (3 specimens, 95–120 mm.), David Rusk and Donald Kloke, No. 30; Sterling, June 10, 1910 (115 mm.), H. G. Smith, No. 370; West Plum Creek near Castle Rock, June 8, 1912 (90 specimens, 50–135 mm.), A. G. Vestal and M. M. Ellis, No. 371; South Platte, Julesburg, July 19, 1912 (395 specimens, 30–140 mm.), J. Henderson and M. M. Ellis, No. 372; Lodgepole Creek near Ovid, July 20, 1912 (37 specimens, 35–140 mm.), J. Henderson and M. M. Ellis, No. 373; Boulder Creek 6 miles east of Boulder, July 25, 1912 (84 specimens, 30–110 mm.), M. M. Ellis, No. 374; Republican River, Wray, October 25, 1912 (125 specimens, 45–190 mm.), A. G. Vestal and M. M. Ellis, No. 375; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley.

Genus **COUESIUS** Jordan

The Mountain Dace

Couesius Jordan, *Bull. Hayden Geol. Survey Terr.*, Vol. IV, p. 785, 1878.

General characters the same as *Semotilus* to which this genus is very closely related and from which it differs in the number of pharyngeal teeth. These are 2–4–4–2 in *Couesius* and 2–5–4–2 in *Semotilus.* The species of the genus *Couesius* have not been studied in detail so that at present this genus is rather uncertain.

A single species, *Couesius dissimilis,* is known from Colorado.

Couesius dissimilis (Girard)

Mountain Dace

Leucosomus dissimilis Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 189, 1856 (Milk River and Little Muddy River, Montana).

Couesius dissimilis (Girard)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder).

Body elongate, somewhat fusiform; head conical, moderately short, its length a little more or a little less than the greatest depth of the body; in adult specimens depth 4 to 4.75, head 4.25 to 4.5 rarely 4, in the length to the base of the caudal; eye rather large, 4 to 5 in the head, about 1.5 in the snout, 2 or a little less in the interorbital distance; mouth large, terminal and oblique, angle of the mouth not reaching the level of the anterior margin of the eye, barbel prominent, attached on the upper, outer surface of the upper jaw, just above the junction of the upper and lower jaws, but its free portion dropping downward and back into the groove at the junction of the two jaws; dorsal fin short and rather high, of 8 rays, length of its base less than the length of its longest ray; pectorals short, about 1.25 to 1.5 in the head, not reaching the ventrals by almost the length of the latter; ventrals barely reaching the anal opening; anal fin short, of 8 rays; least depth of the caudal peduncle about 2 or 2.5 in the head; caudal fin moderately forked; scales rather small, 12 or 13, 65–75, 7 or 8; lateral line complete, and rather straight, but slightly decurved in the pectoral region; length under 6 inches.

Color above the lateral line lead gray to rather dark, with a distinct bluish cast; somewhat darker along the mid-dorsal line; abruptly lighter below the lateral line, yellowish shading to almost white ventrally; sides somewhat silvery with a more or less bluish iridescence; fins hyaline, the rays more or less outlined with dusky; scales above the lateral line, and below the lateral line in the pectoral region more or less distinctly outlined with dusky.

This species, although quite distinct from *Semotilus atromaculatus* in detail, resembles it in general appearance. The Mountain Dace is a species of the upper Missouri and Platte drainages.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (110 mm.), C. Juday and D. W. Spangler, No. 44; Boulder Creek, Boulder, September and October, 1903 (34 specimens, 55–115 mm.), C. Juday and J. Henderson, No. 1.

Genus **HYBOPSIS** Agassiz

The Horny-heads

Hybopsis Agassiz, *Amer. Journ. Sci. Arts*, p. 358, 1854.

Moderately large to small carnivorous Cyprinids; body somewhat elongate and compressed; alimentary canal short; peritoneum pale, dusky or black; mouth large and terminal; a conspicuous maxillary barbel present on each side at the junction of the upper and lower jaws (one species has two barbels on each side); premaxillaries protractile; lateral line complete; species small to medium, length up to 12 inches. A genus of about 20 species distributed over the United States east of the Rocky Mountains; two species have been taken in Colorado.

a. Maxillary barbels 4; dorsal fin inserted directly above the ventrals . *H. tetranemus* Gilbert
aa. Maxillary barbels 2; dorsal fin inserted behind the ventrals . *H. kentuckiensis* (Rafinesque)

Hybopsis tetranemus Gilbert

Four-barbeled Chub

Hybopsis tetranemus Gilbert, *Bull. Washburn College Lab.*, p. 208, 1886 (Elm and Spring Creeks, Medicine Lodge, Kansas); Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 17, 1889 (Pueblo).

A single specimen of this remarkable fish was collected at Pueblo by Jordan in 1889. It has not been recorded from Colorado in any subsequent collection. As it does not occur in any of the collections examined its description is copied below:

Head 4; depth 5.3; snout 2.5 in the head, one-third of it projecting beyond the mouth; eye small, 5 in the head. D.8; A.8; lateral line 36 to 38; teeth 4–4. Closely resembling *H. aestivalis* but with two long barbels at each angle of the mouth, the one pair taking the place of the fleshy prominence seen in *gelidus* and *aestivalis;* longest barbel as long as the eye. Head very slender, slenderer than in *aestivalis*. Dorsal over ventrals, a little nearer tip of snout than caudal. Fins large. Color as in *aestivalis*, translucent silvery, with irregular, scattered black dots above; median rays of each caudal lobe dusky at base. Length 2 inches. Tributaries of Arkansas River in Kansas and Arkansas; not rare; a most remarkable little fish, the only American Minnow with more than two barbels.—JORDAN AND EVERMANN, *Bull. 47, U.S. Nat. Mus.*, pp. 315–16, 1896.

Hybopsis kentuckiensis (Rafinesque)

HORNY-HEAD, INDIAN CHUB, JERKER

Luxilus kentuckiensis Rafinesque, *Ichthyologia Ohiensis*, p. 48, 1820 (Ohio River).

Hybopsis kentuckiensis (Rafinesque)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder; Longmont).

Body elongate, somewhat compressed; head rather long, equalling or usually exceeding the depth of the body; depth 4 to 4.75, head 3.75 to 4.1 in the length to the base of the caudal; eye medium, 4 to 4.25, or even 5.6 in large specimens, in the head, 1.5 to 2 in the snout, and 2 or a little more in the interorbital distance; mouth rather large, terminal, slightly oblique; angle of the mouth not reaching the anterior margin of the eye but reaching the level of the posterior margin of the nostril; maxillary barbel prominent, its length a little more than 2 in the diameter of the eye, situated in the depression at the junction of the upper and lower jaws; dorsal fin short, base of the first dorsal ray on a level with or usually distinctly posterior to the ventral; dorsal rays 8; pectorals short, 1.5 to 1.75 in the head, not reaching the ventrals by half or more of the length of the latter; ventrals short, barely reaching the anal opening; anal fin with 7 or 8 rays; caudal peduncle rather broad, least depth about 2 in the head; caudal fin moderately forked; scales 6 or 7, 40–45, 5; lateral line almost straight, scarcely decurved in the pectoral region; size rather large, reaching the length of 10 inches, average adults 6 or 7 inches in length.

Color above dark green shading to yellowish gray below; sides dull gray with greenish or brassy iridescence, but not silvery; a more or less indistinct lateral dusky band ending in faint caudal spot (this stripe and spot quite prominent in young specimens); sides of the head yellowish green with a pale red spot just back of the eye; a dusky bar just back of the operculum; dorsal and caudal fins yellowish to orange yellow, margined with bluish gray; pectoral and ventral fins light; anal fin yellow or orange; breeding males with the colors much brighter; top of the head elevated and with numerous tubercles.

The Horny-head ranges through the northern portion of the United States east of the Rocky Mountains and south through the Mississippi Valley into Alabama. It is a species of small streams and lakes, preferring rather rapid water. This species is an omnivorous feeder, taking both animal and vegetable matter. The larger individuals have many of the qualities of true game fish and would doubtless be prized as such were it not for the fact that the bass and other more interesting game fishes are usually found in the same locality with the Horny-head. It will take any kind of bait and on light tackle will give an interesting fight. The flesh of this species is of fair flavor and is often eaten. The young

Horny-heads are very hardy and make excellent bait for the large game fishes, being recommended by many as the best live bait. This Chub spawns in the late spring.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (2 specimens, 85 and 115 mm.), C. Juday and D. W. Spangler, No. 16; Boulder Creek, Boulder, April 23, 1904 (90 mm.), J. Henderson, No. 36; *Colorado State Historical and Natural History Museum:* Clear Creek, August 15, 1900 (2 specimens, 105 mm.), W. C. Ferril; *State Teachers' College Museum:* Cache la Poudre near Greeley, A. E. Beardsley.

Genus **PLATYGOBIO** Gill

The Flat-headed Chubs

Platygobio Gill, *Trans. Amer. Phil. Soc. Phila.*, Vol. V, p. 178, 1863.

Moderately large carnivorous Cyprinids; body rather elongate and compressed; head short; alimentary canal short; mouth large, terminal or slightly oblique; maxillary barbel present and prominent, inserted at the junction of the upper and lower jaws; dorsal fin inserted on a level with or usually in front of the ventrals; scales large; lateral line complete and quite straight; size small to medium, length up to 12 inches. The two species of this genus are found in the western portion of the Mississippi Valley, one species ranging as far north as Saskatchewan. A single species is here listed from Colorado, this in the Arkansas River. The record of Cope,[1] under the name *Pogonichthys communis* Girard from Pueblo, is placed under *Platygobio physignathus* (Cope), as subsequent collections from the Arkansas, at Pueblo and above, have yielded only that species of *Platygobio*. *Pogonichthys communis* Girard was described from the upper Missouri and is considered a synonym of *Platygobio gracilis* (Richardson). If it should be shown by more extended collections that two species of *Platygobio* are found in the Arkansas at Pueblo, Cope's record would have to be transferred to *P. gracilis* (Richardson). Since there is a possibility that these two species do occur together in the Arkansas, or that *P. gracilis* occurs in the Platte drainage, as it is a species of the upper Missouri, the following key for their separation is given:

a. Dorsal, pectoral and ventral fins deeply falcate; length of the free portion at the tip of the dorsal 2 or 3 times the diameter of the eye in length . . . *P. gracilis* (Richardson)

aa. Dorsal, pectoral and ventral fins slightly falcate; length of the free portion at the tip of the dorsal about equal to the diameter of the eye in length. . . . *P. physignathus* (Cope)

Platygobio physignathus (Cope)

THICK-JAWED CHUB (Fig. 30)

Ceratichthys physignathus Cope—COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 651, 1875 (Arkansas River, Pueblo).

Platygobio physignathus (Cope)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 17, 1889 (Fountain Creek, Pueblo; Arkansas River, Canyon City); JORDAN AND EVERMANN, *Bull. 47, U.S. Nat. Mus.*, p. 326, 1896 (Arkansas River, Pueblo).

[1] *Wheeler Survey*, Vol. V, p. 653, 1875.

Pogonichthys communis Girard—Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 653, 1875 (Pueblo).

Body rather elongate, compressed to somewhat fusiform; depth 4 to 4.6 in the length to the base of the caudal; head rather broad, slightly flattened dorsally, in males with fine tubercles; length of the head 4.3 to 4.6 in the length; dorsal and ventral profiles sloping evenly to the tip of the snout; snout broad and blunt, but slightly overhanging the mouth, length of the snout 3 in the head; eye moderately large and prominent, its center nearer to the tip of the snout than to the posterior margin of the operculum, its diameter 4.8 to 5.5 in the head, 1.5 or a little more in the snout, about 2 in the interorbital distance; nostrils prominent, double, situated less than half the diameter of the eye directly in front of the eye, each divided by a broad vertical septum, the anterior chamber circular in outline and larger than the posterior; mouth ventral, slightly oblique, angle of the mouth reaching almost or distinctly to the level of the eye; barbel in the axil just posterior to the angle of the mouth, prominent, its length 2 in the diameter of the eye; lips fleshy but not sucker-like; premaxillaries protractile; dorsal fin short and rather high, length of its base about 1.5 in the length of its longest ray, posterior margin distinctly but not deeply emarginate, base of the first ray on a level with or slightly in front of the ventrals; pectorals large, length equal to or slightly exceeding that of the head, posterior margin more or less emarginate at the tip, tip of the pectorals not reaching the ventrals; length of the ventrals 1.5 in the pectorals, ventrals barely if at all reaching the anal opening; anal small, of 7, usually 8 rays, slightly emarginate; caudal peduncle broad, its least depth about 2 in the head; caudal rather deeply forked; scales large, 5 to 7, 50–65, 4.

Color above the lateral line olivaceous, below cream color to silvery white; an indistinct lead gray lateral stripe extending from the posterior margin of the operculum along the lateral line to the base of the caudal; no caudal spot; sides somewhat silvery, upper half of the sides sprinkled with minute blue-black dots; fins hyaline, rays, especially those of the caudal, outlined with dusky; top of the head dark. Size small; length to 6 inches.

Colorado specimens.—*University Museum:* Arkansas River, Salida, May 8, (165 mm.), No. 376; Sells Lake, Canyon City, September, 1913 (2 specimens, 75–125 mm.), F. A. Reidel, No. 377; Grape Creek near Canyon City, November 8, 1913 (120 mm.), A. G. Vestal and M. M. Ellis, No. 378; *reported* very abundant at Salida by Cockerell.

Genus **RHINICHTHYS** Agassiz

The Black-nosed Dace

Rhinichthys Agassiz, *Lake Superior*, p. 353, 1850.

Body elongate, fusiform, very slightly compressed; head rather long and conical; mouth small, ventral and sucker-like; premaxillaries not protractile, the upper lip being continuous with the skin of the top of the head, forming a broad frenum; a very small maxillary barbel on each side at the junction of the upper and lower jaws; alimentary canal short; scales quite small; lateral line complete; size rather small, length under 5 inches.

The species of this genus inhabit the cool, rapidly moving streams of northern United States and southern Canada, ranging from coast to coast.[1] This genus is represented in Colorado by the Dulcis Minnow, a species abundant in the mountain streams east of the Continental Divide.

Rhinichthys cataractae (Cuvier and Valenciennes)

LONG-NOSED DACE

Gobio cataractae Cuvier and Valenciennes, *Hist. Poiss.*, Vol. XVI, p. 315, 1842 (Niagara Falls).

This species is represented in Colorado by the western subspecies *Rhinichthys cataractae dulcis* (Girard), which may be separated from the true *Rhinichthys cataractae* by the sharper snout and the position of the dorsal fin, the first ray of the dorsal being nearer the base of the caudal fin than to the tip of the snout, equidistant from the nostril and the base of the caudal. The location of the base of the first ray of the dorsal is subject to some variation (see Table IV).

Rhinichthys cataractae dulcis (Girard)

DULCIS MINNOW, WESTERN LONG-NOSED DACE (Fig. 31)

Argyreus dulcis Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 185, 1856 (Sweetwater River, Nebraska).

Rhinichthys maxillosus Cope—COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 44, 1875 (Twin Lakes; Colorado Springs).

Rhinichthys transmontaus Cope, *Amer. Nat.*, p. 441, 1879 (Rio Grande in Colorado).

Rhinichthys dulcis (Girard)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, pp. 8, 11, 16, 22, 1889 (Denver; South Platte at Hartsels Springs; Bear Creek above Morrison; Pueblo; Lake Creek at Granite; Arkansas at Leadville; Twin Lakes; Alamosa; Del Norte; Rio Conejos fifteen miles south of Alamosa).

Rhinichthys cataractae dulcis (Girard)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder); JUDAY, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes).

Body elongate, slightly compressed; depth 4.5 to 5.5 in the length to the base of the caudal fin; head depressed, long and pointed, its length 3.5 to 4 in the length; dorsal profile of the head sloping anteriorly, ventral profile almost straight; snout produced, overhanging the mouth, length of the snout 2.6 to 3 in the length of the head; eye prominent, situated near the center of the side of the head, its diameter about 2 in the snout, 1.8 to 2 in the interorbital distance, and 5 in the head; nostril large, just in front of and somewhat dorsal to the eye; mouth ventral, sucker-like; lips large and fleshy, the upper recurved around the angle of the mouth; a small but distinct barbel in a slight depression at the angle of the mouth, which is about level with the posterior margin of the nostril; pre-

[1] SNYDER, *Bull. U.S. Fish Com.*, Vol. XXVII, p. 178, 1907, reports *R. dulcis* (Girard) from Corvallis, Oregon.

maxillaries not protractile; frenum equal to the diameter of the eye; dorsal fin rather short, the length of its longest ray greater than that of the base of the fin, inserted in the posterior half of the body behind the origin of the ventrals, the distance from the base of the first ray of the dorsal to the base of the caudal equalling the distance from the base of the first ray to the nostril (Table IV); dorsal rays 8, rarely 7; pectorals moderately large, larger in the males than in the females, inserted low on each side, not reaching the ventrals; ventrals smaller than the pectorals, not reaching the anal by the diameter of the eye or more; anal of much the same size and shape as the dorsal, anal rays 7, rarely 8; caudal moderately forked, its width when spread greater than the depth of the body; scales small and closely imbricated, with both dorsal and apical radii, 11 to 14, 58–72, 9 to 12; lateral line complete, little if at all decurved.

TABLE IV

Locality	No. of Specimens with Dorsal nearer Tip of Snout	No. of Specimens with Dorsal Midway between Tip of Snout and Caudal	No. of Specimens with Dorsal nearer Base of Caudal
South Platte Drainage—			
Boulder	....	1	130
Cherry Creek	1 (D.7; A.7)	4	1 (D.8; A.8)
West Plum Creek	....	1	17
Arkansas Drainage—			
Twin Lakes	....	....	3
Canyon City	....	....	1
Rio Grande Drainage—			
Alamosa	....	....	2
Del Norte	....	....	1
Creede	....	1	12
Total	1	7	167

General color above greenish brown to dusky, mid-dorsal region with at least the indication of a dusky stripe; sides lighter, especially in large specimens which are often somewhat silvery, profusely spotted with dark brown, spots fewer below the lateral line; body below the pectorals without markings, white, cream-colored, yellowish, often with a pinkish cast; head dark, almost black above, lighter and spotted on the sides, yellowish or pinkish below, a narrow black stripe usually present extending from the tip of the snout to the anterior margin of the eye; in small specimens continuing through the eye to the posterior margin of the operculum, in very small specimens often continuing along the lateral line as a lateral stripe; specimens of all sizes with a rather conspicuous caudal spot; rays of the fins, especially of the dorsal and anal, usually outlined with black; males in the spring with the lips and under parts of the head orange-red to crimson, bases of the pectorals, ventrals and anal, and the small tubercles just above the origins of the pectorals and ventrals, orange-red to vermilion, fins and entire ventral portion of the body with more or less pink. Length of average specimens two to four inches, maximum size about five and a quarter inches.

The variation of this species has been given considerable attention since several species now placed in its synonymy have been described. Three of these nominal species have been reported from Colorado, *Rhinichthys dulcis* (Girard), *Rhinichthys maxillosus* Cope and *Rhinichthys transmontanus* Cope, the first two from the region east of the mountains and the third from the Rio Grande Valley. Table IV gives the results of an examination of the Colorado specimens as to position of the dorsal fin.

In Girard's original description of *R. dulcis* he says of the dorsal fin:[1] "Its anterior margin is nearer the extremity of the snout than to the insertion of the caudal fin." Cope in describing *R. maxillosus* states that "from the base of the caudal to the base of the front ray of the dorsal equal from latter point to opposite the middle of the orbit."[2] Later in writing of this same species from the Rio Grande in Colorado under the name of *Rhinichthys transmontanus* he says:[3] "It differs from the more eastern species in having the dorsal fin equidistant between the base of caudal and the end of the muzzle, and in having the longitudinal series of scales below the lateral line more numerous (12 to 13), and equal to the number of scales above." Disregarding the other points of these descriptions which have seemed similar enough to warrant the placing of all of these species in the same synonymy by several authors, these three species differ in the position of the dorsal fin. As may be seen from Table IV, but one of the specimens examined can be referred to *R. dulcis* as defined by Girard and seven to Cope's *R. transmontanus*. The remaining one hundred and sixty-seven specimens are all clearly referable to *R. maxillosus* Cope. There seems to be no relation between the variation of the position of the fin and the locality from which the fish were collected, for but one of the specimens from the Rio Grande is of the *R. transmontanus* type. The following table (V) shows that there is not the correlation between the number of scale rows and the position of the dorsal fin that has been suggested by Cope. In general the scales of the specimens from the Rio Grande are slightly smaller although the two series of counts overlap. The other variations looked for were those of the fin rays. Two specimens only were found irregular in number of fin rays and these have been mentioned in Table IV discussing the position of the dorsal fin.

From the material at hand it seems that the three species *R. dulcis* (Girard), *R. maxillosus* Cope and *R. transmontanus* Cope are synonymous since all three types have been found in the Platte drainage and two in the Arkansas and Rio Grande drainages, in which case the oldest name applies. It is quite possible that the examination of a large series of specimens of this fish from the Sweetwater in Nebraska, the type locality of *R. dulcis*, would show a preponderance of individuals with the base of the first ray of the dorsal nearer to the tip of the snout than to the base of the caudal, in which case the name *R. dulcis* should be restricted

[1] *Proc. Acad. Nat. Sci. Phila.*, p. 185, 1856.

[2] *Ibid.*, p. 278, 1864.

[3] *Amer. Nat.*, p. 441, 1879.

to the fishes of that type and our single specimen of this kind regarded as a variation. In this case the name of the subspecies found in Colorado should stand *R. cataractae maxillosus* (Cope).

TABLE V

Scale Formulae of 10 Random Specimens Creede, Rio Grande	Scale Formulae of 10 Random Specimens Boulder Creek, Boulder
12–67–12	11–62–11
12–68–11	11–59–11
12–69–11	12–58– 9
12–70–11	12–64–10
12–70–12	12–66–10
13–66–11	12–67–12
14–61–10	13–65–11
14–68–11	13–63–11
14–69–12	13–59–12
14–71–12	14–60–12

Scales above lateral line	11	12	13	14
No. of specimens, Creede	..	5	1	4
No. of specimens, Boulder	2	4	3	1
Scales below lateral line	9	10	11	12
No. of specimens, Creede	..	1	5	4
No. of specimens, Boulder	1	2	4	3

Scales in the lateral line	58	59	60	61	62	63	64	65	66	67	68	69	70	71
No. of specimens, Creede	..	..	..	1	..	..	..	..	1	1	2	2	2	1
No. of specimens, Boulder	1	2	1	..	1	1	1	1	1	1	..	..	..	..

The Dulcis Minnow, although of the carnivorous group of Cyprinids, feeds to a considerable extent on plant material. The stomach contents of 20 specimens from Boulder Creek near Boulder showed that the algae and brown diatomaceous slime so generally eaten by herbivorous Cyprinids are important elements in the food of this minnow, forming about two-thirds of the material. Small crustaceans, insect larvae, small snails and water-logged material comprised the remaining third. It is known that the Dulcis Minnow also eats the spawn of the trout. On the other hand, the Dulcis Minnows are eaten by the trout, making the presence of these minnows in the mountain streams of value. This species is also used as live bait. *Rhinichthys cataractae dulcis* spawns in the early spring.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (56 specimens, 65–80 mm.), C. Juday and J. Henderson, No. 11; Twin Lakes, August, 1903 (3 specimens, 100–105 mm.), C. Juday, No. 34; West Plum Creek near Castle Rock, June 8, 1912 (18 specimens, 35–70 mm.), A. G. Vestal and M. M. Ellis, No. 379; Cherry Creek near Frankton, June 9, 1912 (5 specimens, 65–85 mm.), A. G. Vestal and M. M. Ellis, No. 380; Boulder Creek six miles east of Boulder, July 25, 1912 (138 specimens, 35–85 mm.), M. M. Ellis, No. 381; Rio Grande, Alamosa, July 27, 1912 (2 specimens, 50–55 mm.), M. M. Ellis, No. 382; Rio Grande, Creede, July 28, 1912 (13 specimens, 65–95 mm.), M. M. Ellis, No. 383; four miles west of Cripple Creek, July, 1913 (2 specimens, 100 and 115 mm.), F. A. Hassenpflug, No. 384; Grape Creek, near Canyon City, November 8, 1913 (5 specimens, 70–90 mm.), A. G. Vestal and M. M. Ellis, No. 386; Sells Lake, Canyon City, September, 1913 (90 mm.), F. A. Reidel, No. 385; *State Teachers' College Museum:* Cache la Poudre, Greeley, and twenty miles above Antonito, A. E. Beardsley; *Colorado State Historical and Natural History Museum:* South Platte River near Denver, August 3, 1900 (2 specimens, 65–75 mm.), W. C. Ferril.

Genus **AGOSIA** Girard

The Western Dace

Agosia Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 186, 1856.

General characters the same as *Rhinichthys* from which this genus differs in the protractile premaxillaries. Premaxillaries protractile, upper lip not continuous with the skin of the top of the head, no frenum. Species of the Rocky Mountain region on the west slope, ranging northward through the Great Basin into the Pacific region and south through the Colorado River drainage. Size small, length 5 inches or less.

Agosia yarrowi Jordan and Evermann

Yarrow's Dace (Figs. 32 and 33)

Agosia yarrowi Jordan and Evermann, *Bull. U.S. Fish Com.*, Vol. IX, p. 28, 1889 (Tomichi Creek and Gunnison River, Gunnison; Uncompahgre, Delta; Eagle River, Gypsum; Rio d. l. Animas; Rio Florida; Lightner's Creek).

Apocope oscula (Girard)—Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 647, 1875 (Pagosa), wrongly identified.

Body elongate, subterete, slightly compressed; depth 4.25 to 5.5 in the length to the base of the caudal; head slightly depressed, long and pointed, its length 3.5 to 4.5 in the length; dorsal profile of the head sloping anteriorly, ventral profile rather straight; snout produced, overhanging the mouth; eye prominent, situated near or slightly above the center of the head, its diameter 2 to almost 3 in the snout, 1.5 to 2 in the interorbital distance, 4.5 to 6.5 in head; nostril large and prominent, just in front of and somewhat dorsal to the eye; mouth ventral, sucker-like, lips large and fleshy, the upper recurved around the angle of the mouth; a small but distinct barbel in the depression at the junction of the upper and lower jaws; premaxillaries protractile, no frenum connecting the upper lip with the skin of the top of the head (a narrow frenum sometimes present); dorsal fin rather short, length of its base less than the length of its longest ray, base of the first ray of the dorsal nearer to the base of the caudal than to the tip of the snout, inserted just above or slightly behind the level of the origin of the ventrals, dorsal rays 7–9; pectorals medium to small, not quite or just reaching the ventrals; ventrals smaller than the pectorals, reaching the anal; anal fin of much the same size and shape as the dorsal, of 7 or 8 rays; scales usually about 14 to 16, 77–89, 13 to 15; lateral line complete or interrupted, little if at all decurved; size rather small, length 5 inches or less.

Three distinct color patterns and the combination of these were found:

1. General color above olive-brown to dark gray, darker along the mid-dorsal region, giving at least indications of a dark mid-dorsal stripe; a distinct, dark,

TABLE VI

TABLE OF VARIATIONS IN *Agosia yarrowi*

	Distance from the Base of the First Ray of the Dorsal to the Base of the Caudal Fin Reaching Forward to			Diameter of the Eye in the Length of Head		Dorsal Rays			Lateral Line Interrupted	Plain	Spotted	First Lateral Stripe	Second Lateral Stripe
	Beyond Nostril	Nostril	Eye	4-5	5-6.5	7	8	9					
Durango (Station II)	×	......	......	......	×	......	×	......	......	×	......	......	......
	......	......	×	×	......	......	×	......	......	......	×	×	×
	×	......	......	×	......	......	×	......	......	......	×	×	×
	×	......	......	×	......	......	×	......	......	......	×	×	×
	......	×	......	×	......	......	×	......	......	......	×	×	×
	×	......	......	×	......	......	......	×	......	......	×	×	×
	×	......	......	×	......	×	......	......	......	......	×	×	×
Durango (Station I)	......	×	......	......	×	......	×	......	......	×	......	......	......
	......	×	......	......	×	......	×	......	......	......	×	×	×
	......	......	×	×	......	......	×	......	......	......	×	×	......
	......	×	......	......	×	......	×	......	......	......	×	......	......
	......	×	......	......	×	......	×	......	......	×	......	......	......
	×	......	......	......	×	......	......	×	......	......	×	×	×
	......	......	×	......	×	......	×	......	......	......	×	×	×
	......	×	......	×	......	......	×	......	......	......	×	×	......
	......	×	......	......	×	......	×	......	......	×	......	......	......
	......	......	×	......	×	×	......	......	......	×	......	......	......
Montrose	......	......	×	......	×	......	......	×	......	......	×	×	......
	......	......	×	......	×	......	......	×	......	×	......	......	......
	......	×	......	×	......	......	......	×	......	......	×	×	×
	......	×	......	×	......	......	......	×	......	......	×	×	×
	......	×	......	×	......	......	......	×	......	×	......	......	......
	......	×	......	×	......	......	......	×	......	......	×	......	......
	......	×	......	×	......	......	......	×	......	......	×	×	×
	......	......	×	......	×	......	×	......	......	......	×	×	×
	......	×	......	×	......	......	×	......	......	......	×	×	×
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lateral stripe along the lateral line; region from the origin of the pectorals to the base of the anal, below the lateral stripe, with a dusky shading which is usually distinct enough to form a second, incomplete, lateral stripe; all of the markings made up of fine, longitudinal lines which give the whole an engraved appearance.

2. The same as first type with the addition of numerous strong black spots in and above the lateral stripe, especially posterior to the origin of the dorsal.

3. All markings wanting or represented by blurred clouds; body rather uniform adobe-color, darker dorsally.

These three color types may represent either extremes of a continuous series of variations in color pattern, i.e., this species may have three modes as regards color and markings; or there may be three or more distinct races of this species the interbreeding of which gives the various recombinations of these color patterns found. This matter is deserving of more attention when larger collections are available.

Because of the variations found in the specimens examined and the close relation of *Agosia yarrowi* to *Agosia couesii* (Yarrow) and *Agosia oscula* (Girard) a table of variations seen is presented (Table VI).

From Table VI it may be seen that the variation in the specimens of *Agosia yarrowi* examined is such that the three species *A. oscula*, *A. yarrowi* and *A. couesii* as defined by Jordan[1] are distinguishable only on the basis of scales. Material was not at hand to study the scales of the other two species.

Colorado specimens.—*University Museum:* Uncompahgre, Montrose, August 8, 1912 (79 specimens, 25–110 mm.), J. Henderson and M. M. Ellis, No. 387; Durango, August 11, 1912 (12 specimens, 90–120 mm.), J. Henderson and M. M. Ellis, No. 388; *State Teachers' College Museum:* Gunnison River, Delta, A. E. Beardsley.

Subfamily Plagopterinae

Genus **PLAGOPTERUS** Cope

Plagopterus Cope, *Proc. Amer. Phil. Soc. Phila.*, p. 301, 1874.

Body scaleless; dorsal fin with a double dorsal spine, the anterior spine with a groove in which the posterior spine is received; inner margin of the ventral fins adherent to the sides of the body; maxillary barbel present; a single species known only from the Colorado River drainage.

Plagopterus argentissimus Cope

Plagopterus argentissimus Cope, *Proc. Amer. Phil. Soc. Phila.*, p. 301, 1874 (San Luis Valley, Colorado) (wrongly ascribed to the Rio Grande).

In his discussion of this remarkable species Cope, *l.c.*, states that this fish is found in the Colorado Basin in western Colorado. It has subsequently been taken only in the lower Colorado drainage at Ft. Yuma, and is probably not a member of the Colorado fauna.

[1] *Bull. 47, U.S. Nat. Mus.*, pp. 309–310, 1896.

Superorder *PHYSOSTOMI*

Air bladder connected with the alimentary canal by a *ductus pneumaticus;* no Weberian apparatus.

Order Isospondyli[1]

Herring, Salmon, the Smelts and Related Deep-Sea Forms

Maxillaries and premaxillaries distinct; barbels wanting; shoulder girdle connected with the skull by the postemporal bone.

This order is represented in Colorado by the Grayling, Trout and Whitefish, all of which are game fishes.

Family *THYMALLIDAE*

The Graylings

Dorsal fin high and long, of 19 to 24 rays; adipose fin present; general form trout-like; parietal bones meeting mesially; frontal bones not reaching the supra-occipital bone.

This family includes five species all referable to the genus *Thymallus*, found in the cold clear waters of northern America and the Arctic regions. As food fishes and from the standpoint of the fisherman the Graylings are among the best of the fresh-water fishes. In both general appearance and habits the Graylings are much like the Trout, but the high dorsal fin and the striking colors of the former are quite distinctive. The name *Thymallus* is derived from a Greek word referring to the odor of thyme which is supposed to be quite evident when the Grayling is first taken from the water, a belief which Izaak Walton credited, for he wrote of the Grayling, "and some think he feeds on water thyme for he smells of it when first taken from the water." It seems, however, that sportsmen do not agree in this matter, for Henshall[2] says of the Grayling that "however it may have been in days of old, it is not so now, though an odor of cucumbers is sometimes perceptible when it is first out of the water."

Genus **THYMALLUS** Cuvier

The Graylings

Thymallus Cuvier, *Regne Animal*, ed. II, Vol. II, p. 306, 1829.

Body somewhat compressed; head short; teeth on the premaxillaries, maxillaries and lower jaw; air bladder very large; scales small, about 90 in the lateral line; species brightly colored, dorsal fin with orange, red or purplish spots; caudal fin distinctly forked; represented in Colorado by a single introduced species.

[1] Since the Isospondylous fishes found in Colorado, both native and introduced forms, have been planted in as many streams of the state as possible, the Colorado specimens examined are not listed, unless for particular reasons, as they do not contribute to the understanding of the natural distribution of these species.

[2] *Bass, Pike, Perch and Others*, p. 175, 1903, New York.

Thymallus montanus Milner

MONTANA GRAYLING

Thymallus montanus Milner, *Rept. U.S. Fish Com.*, Vol. II for 1872–73, p. 741, 1874 (tributaries of the Missouri at Camp Baker).

Body somewhat elongate and compressed, not much elevated; depth 4.5 to 5 or a little more in the length; head rather short, its length about equal to the greatest depth of the body; diameter of the eye equalling the length of the snout, 3.5 to 4 in the head; dorsal fin long and rather high, length of its base equalling or slightly exceeding the length of the head, length of the longest dorsal ray barely equal to or usually a little less than the length of the base of the dorsal, dorsal rays 19 to 22; pectorals small, tip of the pectorals not reaching the base of the ventrals by the length of the pectorals; ventrals about the same size as the pectorals, base of the first rays of the ventrals on or slightly in front of the level of the last dorsal ray; anal rays 10 or 11; scales small and loose, 8 or 9, 80–90, 9 or 10; reaching the weight of 2 pounds or more.

General color grayish to silvery, shading dorsally into rather dark grayish blue or purple, below the lateral line pinkish shading into silvery white ventrally; sides with a lilac or purplish reflection; sides of the body above the pectoral fins with several small irregular black spots, each covering portions of from one to four scales; dorsal fin rather dark greenish gray, margined with rose-pink, crossed by five or more rows of orange-red or pinkish spots some of which are distinctly ocellated with white, upper posterior portion of the dorsal with a few reddish blotches; ventral fins with three rose-red stripes; pectoral and anal fins white with a pinkish or brownish cast.

The Montana Grayling is a native to the Missouri and its tributaries above the Great Falls, inhabiting the clear streams with rock or gravel bottoms. As this region was traversed by the Lewis and Clark expedition, the earliest record of this species occurs in their journal,[1] although the fish was not named at that time. It has been introduced in various parts of the country with but fair success.

Thymallus montanus spawns in April and May, the eggs being much like those of the trout except that they are smaller.

In Colorado the Grayling has been introduced on both sides of the Continental Divide by the United States Fish Commission, the State Fish Commission and by local fishing clubs.[2] In 1901,[3] 100,000 fry and fingerlings were liberated in Colorado by the United States Fish Commission alone, yet the Grayling is not well established in the state at present.

Many of the reports of Grayling in Colorado which have been received by

[1] *Bass, Pike, Perch and Others*, p. 182, 1903, New York.

[2] See Reports of the United States Fish Commission; of the Colorado Commissioner of Game and Fish; and reports of American Fisheries Society.

[3] *Rept. U.S. Fish Com. for 1901–1902*, p. 101.

the writer were shown to be reports of Williamson's Whitefish, *Coregonus williamsoni* Girard, which is often confused, locally, with the Grayling.

Family *SALMONIDAE*

The Trout, Charrs, Whitefish, and Salmon

Dorsal fin moderate, of 15 or fewer rays; adipose fin present; parietal bones not meeting mesially but separated by the anterior portion of the supraoccipital which joins the frontals.

The numerous species of *Salmonidae* are confined to the northern two-thirds of the northern hemisphere, ranging into the Arctic regions. Most of the Salmonids are fresh-water forms and even the larger species of Salmon which spend a considerable portion of their lives in salt water ascend rivers to spawn. In this family are included some of the best-known game fishes, the Trout and Charrs, as well as other species of large commercial value. Several million pounds of the Lake Whitefish, *Coregonus clupeiformis* (Mitchill), are taken annually from the Great Lakes, and the large species of Salmon, *Oncorhynchus tschawytscha* (Walbaum) and related forms, which are so abundant in the Columbia River region, have become the center of a large industry.

Viewed from a purely commercial standpoint the Salmonid fishes of Colorado, particularly the Trout, are the most important fishes in the state, forming a valuable natural asset. The presence of Trout in the mountain streams of Colorado adds annually several thousands of dollars to the general wealth of the state. The additional value of these fishes to the residents of the state cannot be reckoned so easily but it is certainly large, so that the care of the Trout and their artificial propagation well repay the funds so invested.

Four genera of *Salmonidae* are represented in Colorado by either native or introduced species, or both. Three of these genera are so closely related that technical characters must be used for their separation, although the markings and colors of the Colorado species are added to facilitate rapid determination. The young of most species of Salmonids are marked with several vertical, dusky bars, known as "parr marks."[1] These parr marks gradually disappear as the fish grows older, although they may persist in almost full-grown individuals, and are not to be confused with the black spots mentioned in the key.

a. Jaws usually without teeth; teeth if present extremely minute; scales rather prominent; lower jaw shorter than the upper by which it is partly included; Colorado species silvery, bluish above, without spots, fins margined with black, parr marks only in the young.
Coregonus (Artedi) Linnaeus, p. 74

aa. Jaws strongly toothed; scales small, often more or less obscure; species spotted with black; parr marks persisting in rather large individuals.

[1] See Fig. 37.

b. Vomer flat; American species spotted with black but not with red, pink or gray; introduced European species spotted with black and scarlet, the scarlet spots being more or less ocellated with white, adipose fin tipped with bright orange-yellow, general color above brownish. *Salmo* (Artedi) Linnaeus, p. 75

bb. Vomer boat-shaped; species spotted with red, pink or gray, but without ocellated scarlet spots.

c. Vomer without a raised crest; species much spotted with bright red; anterior margins of lower fins white . . . . *Salvelinus* Richardson, p. 84

cc. Vomer with a raised crest extending posteriorly from the head of the bone; species spotted or mottled with gray or rarely pale grayish pink, but without bright red spots. *Cristivomer* Jordan and Gill, p. 85

Subfamily Coregoninae

Genus **COREGONUS** (Artedi) Linnaeus

The Whitefish

Coregonus Artedi, *Genera Piscium*, p. 9, 1738.
Coregoni Linnaeus, *Systema Naturae*, ed. X, p. 310, 1758.

Body compressed; head rather short and somewhat conical; mouth small, angle of the mouth barely if at all reaching the level of the anterior portion of the eye; scales not extremely small, but rather prominent.

Species of this genus are found in both the old and new worlds and most of them are food fishes of value. A single species is fairly abundant in northwestern Colorado.

Coregonus williamsoni Girard

Williamson's Whitefish, Rocky Mountain Whitefish

Coregonus williamsoni Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 136, 1856 (Deschutes River, Oregon); Evermann and Smith, *Rept. U.S. Com. Fisheries for 1893–94*, p. 293, 1896 (Meeker, Colorado).

Body compressed and somewhat elongate, its depth 4 to 5 in the length; head rather short and conical, its dorsal profile sloping rather abruptly, ventral profile almost straight, length of the head about equal to or a little less than the greatest depth of the body; eye large, nearer to the tip of the snout than to the gill opening, situated in the upper half of the head, diameter of the eye less than the length of the snout, 4 or more in the head; snout rather short and blunt in females and young, in breeding males somewhat produced and upturned at the tip; mouth small, slightly ventral, angle of the mouth barely reaching the level of the anterior margin of the orbit; lower jaw shorter than the upper, by which it is partly included; dorsal fin rather short and high, length of its longest ray almost or just equalling the length of the base of the dorsal, which is about 1.5 in the head; dorsal rays 12 to 14, base of the first ray of the dorsal about midway between the tip of the extended pectoral and the origin of the ventrals; pectorals short, separated from the ventrals by about their own length; ventrals much the same size as the pectorals, origin of the ventrals on a level with about the tenth ray of the dorsal; anal fin almost as large as the dorsal, of 11 to 13 rays; adipose fin large and prominent, its tip reaching beyond the level of the last anal ray; caudal peduncle narrow, its least depth about 3 in the head; caudal fin deeply forked; scales not very small, 8 to 10, 80–90, 8 to 10, those on the sides of the body of breeding males with tubercles.

Color above dark grayish or greenish blue shading into silvery on the sides and grayish white below; dorsal fin dark, adipose and caudal grayish blue to steel-blue, pectoral, ventral and anal fins dusky, outer portion of all fins margined with black; young with dusky parr marks. Size moderate, reaching a length of 12 inches or more and a weight of 5 pounds, average specimens about a pound.

Williamson's Whitefish is a species of the western slope of the Rocky Mountains, ranging from Colorado northwestward through Utah and Idaho to the Pacific Coast and British Columbia. A variety, *C. williamsoni cismontanus* Jordan, is known from the tributaries of the Upper Missouri east of the Continental Divide. In cold deep lakes the Whitefish finds its favorite habitat, running into small streams during the spawning season, the late fall and early winter.[1] As a game fish this species is much like the trout, taking both the fly and still bait. Its flesh is excellent. In Colorado this fish is found in the Yampa and White River drainages and has been reported to the writer as quite abundant in several localities. It is known locally as the "Grayling," which it resembles superficially, but from which it may be easily separated by the small dorsal fin and the absence of several rows of bright orange spots on the dorsal fin and the three pink stripes on the ventrals, these markings being characteristic of the true Grayling, *Thymallus montanus.* The Whitefish is also known as the "Rocky Mountain Herring."

Subfamily SALMONINAE

Genus **SALMO** (Artedi) Linnaeus

The Salmon and Trout

Salmo Artedi, *Genera Piscium*, 1738.
Salmo Linnaeus, *Systema Naturae*, ed. X, p. 308, 1758.

Body moderately elongate and compressed; mouth large, its angle reaching to or beyond the level of the center of the eye; lower jaw equal to or barely exceeding the upper, lower jaw of breeding males often upturned at the tip; teeth on the tongue, palatine bones, vomer and both jaws; vomer flat; pyloric coeca numerous; scales small.

Since the species of this genus, particularly the trout, are so closely related, the variation in the measurements usually given is less in some cases between different species of Salmonids than that between individuals of species of some other groups. Accordingly the technical descriptions of the Salmonids found in Colorado are omitted and the general description given under this head.

[1] EVERMANN AND SMITH, *Rept. U.S. Com. Fisheries*, p. 293, 1896.

Depth 3.7 to 4.5, head 4 to 5 in the length; dorsal rays 10 to 12; anal rays 10 to 12; scales small, 20 or more between the base of the dorsal fin and the lateral line; 120 or more cross-rows of scales.

This genus includes both marine and fresh-water species. The Atlantic Salmon, *S. salar* Linnaeus, the Sebago or Landlocked Salmon, *S. sebago* Girard, and the Trout of the Rocky Mountain and Pacific regions are the North American representatives. All of the species, particularly the fresh-water forms, are closely related, yet many rather definite types are found native in independent rivers or drainages. Some of these trout, as the Loch Leven Trout, *S. fario levenensis* (Walker), have been shown to be merely well-defined races resulting from peculiar local conditions, forms which when placed under slightly different conditions return to the original type from which they were derived.[1] Other types apparently maintain their identity although closely resembling other trout with which they may be associated. As a result some ichthyologists believe the species of trout to be few and the varieties numerous, while others hold each form to be a distinct species. The fact of large importance is that differences do exist between the trout of separate streams and drainages, and this should be recognized. The trinomial nomenclature is used in this report since it points out both the relationships and the differences for the forms considered.

Eleven types of trout are to be found in Colorado and excepting two species, the Eastern Brook Trout, *Salvelinus fontinalis* (Mitchill), and the Mackinaw Trout, *Cristivomer namaycush* (Walbaum), all are members of the genus *Salmo.* Four of the forms belonging to this genus are native in Colorado, the Green-backed Trout, *S. clarkii stomias* (Cope), the Rio Grande Trout, *S. clarkii spilurus* (Cope), the Colorado River Trout, *S. clarkii pleuriticus* (Cope), and the Yellow Finned Trout, *S. clarkii macdonaldi* (Jordan and Evermann), the last-mentioned species occurring only in Twin Lakes. These four trout are known collectively in Colorado as "Native Trout" or "Natives." In addition to the indigenous trout, five other forms may be taken, the Landlocked Salmon, *S. sebago* Girard, the Rainbow Trout, *S. irideus shasta* (Jordan) and *S. rivularis* Ayres, the Steel-head Trout, introduced from various parts of North America; and the Brown Trout, *S. fario* Linnaeus, and the Loch Leven Trout, *S. fario levenensis* (Walker), introduced from Great Britain.

Both native and introduced trout have been carried from one drainage to another so that often several forms occur in the same stream. It is at once seen that this condition makes possible both competition and hybridization between species which would not be associated under natural conditions. In general the introduced Eastern Brook Trout is the most successful form, although the demand for this species and the resultant interest in its artificial propagation must be considered in this connection. As regards the hybridization of the trout there

[1] Jordan, *Science*, N.S., Vol. XXII, p. 714, 1905.

are almost no data from either Colorado fishermen or Colorado collections. The belief is current that the various native trout cross with the introduced Rainbow Trout and several reports of such hybrids have reached the University. The writer was also assured that Steelheads and Eastern Brook Trout crossed when kept in a lake near Durango. As opposed to such reports Jordan states that he "has examined many thousands of American *Salmonidae*, both of *Oncorhynchus* and *Salmo*," and "while many variations have come to his attention, and he has been compelled more than once to modify his views as to specific distinctions, he has never yet seen an individual which he had the slightest reason to regard as a 'hybrid.'" On the next page he quotes Günther as writing that "hybrids between the salmon and other species are very scarce everywhere." That hybrids between some species of the genus *Salmo* are possible when the eggs are artificially fertilized is established by experiment, and Mr. S. E. Land of the Colorado State Fish Commission told the writer that such an artificial cross had been successfully made between the "Native" and the Rainbow at the Denver Hatchery. No specimens of authentic hybrids either from nature or from artificial fertilization have been examined in the present study.

Trout are primarily fishes of the mountain streams and lakes since they are physiologically adjusted to live in cold clear water with a high oxygen content. All are carnivorous, feeding as adults for the most part on other fishes and to some extent on insects and other stream animals. Aside from man the chief enemies of the trout are the Sculpin,[1] *Cottus punctulatus*, the Dulcis Minnow, *Rhinichthys dulcis*, Yarrow's Dace, *Agosia yarrowi*, and the suckers, all of which destroy trout eggs. Of these fishes the Sculpin is the most harmful since it is rarely eaten by the trout yet feeds upon both the young trout and trout eggs. Between the suckers, Dulcis Minnow and Yarrow's Dace, and the trout there exists a compensating relation which makes each group of value to the other. The former eat trout eggs but the young suckers and both young and adults of the Dulcis Minnow and Yarrow's Dace collectively form one of the most important items in the food of the adult trout. It has been shown that trout do not thrive in streams in which young or small fish are not available for food. In lakes where the supply of insects is greater the presence of small fishes is not so essential but they nevertheless form a considerable portion of the food of the adult trout whenever present. Other factors limiting the number of trout in Colorado streams are overfishing, the introduction of mine and mill waste into the trout streams and the deflection of water for power or irrigation purposes.

The species of trout found in Colorado may be separated by the following key. Since the various colors and markings of the trout vary with the individual and to some extent with the immediate environment as well as the season, it is difficult to give characters which will cover all specimens. Typical specimens

[1] See pp. 64, 68, and 114.

in full color are quite distinct. Occasionally long slim individuals known as "Racers" are caught, the coloration of which is strikingly peculiar in some respects. A large racer with a bright red stripe along each side of the body below the lateral line was recently reported to the writer from Grand Lake. In using the key the red blotches due to the breaking-up of the lateral red band are not to be confused with the bright-red, well-defined spots of the Eastern Brook Trout and the Brown Trout. Parr marks are to be disregarded unless mentioned. The scale cross-rows mentioned below refer to the oblique bands of scales which cross the body dorso-ventrally. These bands should be counted from the gill opening posteriorly to the base of the caudal fin, and may best be followed just above the lateral line. The scales in the lateral line are not to be counted unless mentioned specifically. Both color and anatomical characters are given, the more important of each being italicized. The species groups followed are those of Jordan.[1]

a. *Pyloric coeca 65 or more; scales large, about 120 in the lateral line and 23 between the base of the dorsal and the lateral line; vomer feebly toothed;* color above brownish, sides silvery with numerous black spots some of which are almost as large as the pupil of the eye, but *without red spots;* five or more large, black spots on the operculum; sides of the body in breeding males with several suffuse reddish patches; *no red on the throat near the inner edge of the lower jaw; dorsal, ventral and anal fins not tipped with white or yellowish;* young with 11 or more parr marks; breeding males with the lower jaw hooked; flesh salmon red; *tail without black spots.*

S. sebago Girard, "Landlocked or Sebago Salmon"

aa. *Pyloric coeca 40 to 60, usually about 45; vomer strongly toothed; 120 or more cross-rows of scales;* parr marks of the young usually less than 11; *tail with black spots.*

b. *Sides without red spots,* although red clouds or a lateral red band may be present.

c. *About 125 cross-rows of scales;* general color dusky or greenish; sides of the body in the lateral line region with a *broad orange or red band,* which is sometimes reduced to a series of reddish clouds; body, head and fins with numerous, small, rather uniform, black spots, which are especially close together dorsally and on the caudal and dorsal fins; usually *no red on the throat near the inner edge of the lower jaw; ventral, anal and dorsal fins tipped with white or yellow;* dorsal fin dusky, pectoral, ventral and anal fins more or less yellowish or even orange; sides of the body below the lateral line often with a bluish or lilac iridescence; scales of adults somewhat brassy.

S. irideus shasta (Jordan), "Rainbow Trout"

cc. *150 to 200 cross-rows of scales; dorsal, ventral and anal fins not tipped with white or yellowish.*

d. *No red on throat near the inner margin of the lower jaw; about 150 cross-rows of scales;* general color silvery, bluish dorsally and quite blue on the top of the head and in the mid-dorsal region; body above the lateral line, top of the head, dorsal and caudal fins rather closely spotted with black; ventral and anal fins dusky.

S. rivularis Ayres, "Steelhead Trout"

dd. *A bright red mark on each side of the throat along the inner edge of the lower jaw,* this mark often somewhat concealed by the edge of the dentary bone but usually rather prominent; scales small, usually 160 or more cross-series.

e. *Pectoral, ventral and anal fins red, reddish or pale, but not bright yellow; region along the lateral line more or less reddish, often bright red.*

[1] *Fishes* ("Amer. Nature Series"), p. 319, 1907, New York.

f. *Spots numerous, many below the lateral line; a pink or red lateral band usually present;* in some specimens the head and region in front of the dorsal fin may be quite free from spots.

g. *Scales rather prominent, about 160 cross-rows; general color light, often silvery,* darker dorsally; *sides iridescent,* with a light pink band which may be quite red and prominent or almost wanting; spots more abundant back of the dorsal fin than in front of it . . *S. clarkii spilurus* (Cope), "Rio Grande Trout"

gg. Scales smaller than the preceding form, *about* 185 cross-rows; *general color greenish to dusky; a distinct, red, lateral band; black spots usually rather large and quite numerous over the entire body, both in front of and posterior to the dorsal fin; lower fins bright red;* some individuals with the fins and lateral band orange-red; many specimens with a brassy luster.
S. clarkii pleuriticus (Cope), "Colorado River Trout"

ff. *Spots large and not numerous except on the caudal peduncle, few if any below the lateral line and in the region in front of the dorsal fin; general color green, quite dark to almost black dorsally; lateral red band wanting or represented by but a few red clouds;* pectoral, ventral and anal fins reddish, in breeding males bright red; *red on the throat quite prominent; flesh usually red or pink;* about 180 cross-rows of scales. . . . *S. clarkii stomias* (Cope), "Green-backed Trout"

ee. *Pectoral, ventral and anal fins bright yellow; a broad, yellowish area along the lateral line; no red on the head, fins or body excepting the red mark on each side of the throat near the inner margin of the lower jaw;* black spots small, *almost confined to the posterior half of the body above the lateral line.* *S. clarkii macdonaldi* (Jordan and Evermann), "Yellow-finned Trout of Twin Lakes"

bb. *Sides of the body with red spots,* which are more or less ocellated with white; *tail without black spots.*

h. *Adipose fin edged with orange-yellow; general color brownish;* red spots numerous; black spots large and margined with light gray or white; sides of the body somewhat silvery.
S. fario Linnaeus, "Brown or Von Behr Trout"

hh. *Adipose fin very slightly if at all edged with orange yellow; red spots few* or rarely entirely wanting; black spots few; general color brownish, sides quite silvery.
S. fario levenensis (Walker), "Loch Leven Trout"

Salmo sebago Girard

Landlocked Salmon, Sebago Salmon

Salmo sebago Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 380, 1853 (Sebago Lake, Maine); Juday, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes).

Salmo salar sebago (Girard)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 16, 1889 (Twin Lakes).

The Landlocked Salmon is a native of the lakes of northern Maine, Lake Sebago, and other lakes, although it is derived, by becoming permanently landlocked, from the Atlantic Salmon, *Salmo salar* Linnaeus, of the eastern coast. The differences between the Sebago Salmon and the Atlantic Salmon are so slight that the former is often regarded as but a variety of the latter. The Landlocked or Sebago Salmon was introduced into Twin Lakes about 1885 and other shipments of this fish have been planted there subsequently, one of the largest being made in 1902. It has become established in the two lakes but is not very abundant. Juday[1] states that "one was caught weighing 6 and another $4\frac{1}{2}$ pounds" in

[1] *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906.

Twin Lakes, and during his investigations at these lakes during the summers of 1902 and 1903 he took 24 specimens of the Landlocked Salmon, the largest of which was 23.5 inches in length. In Maine this fish reaches a weight of over 20 pounds. It is valued as a game fish, although less interesting to the sportsman than some of the other Salmonids. The flesh of the Landlocked Salmon is red, of a firm consistency and a very acceptable flavor.

Salmo sebago lives in deep water which it leaves in the fall when it runs in small streams to spawn. Its food consists of small fishes, insect larvae and other aquatic invertebrates.

Salmo irideus Gibbons

RAINBOW TROUT, COAST RANGE TROUT

Salmo irideus Gibbons, *Proc. Cal. Acad. Nat. Sci.*, p. 36, 1855 (San Leandro Creek, Alameda County, California).

The Rainbow Trout and its varieties are natives of the Pacific Coast region, ranging from southern California north into Alaska. The Rainbow Trout which has been so generally introduced into the streams of the Rocky Mountains is a variety of the true Rainbow Trout. This variety, *S. irideus shasta* (Jordan), is a native of the streams of the Sierra Nevada Mountains in the vicinity of Mount Shasta. Since this trout is quite abundant in the McCloud River and has been distributed from that stream by the United States Fish Commission it has come to be known as the McCloud River Rainbow Trout as distinguished from the true Rainbow Trout.

Salmo irideus shasta (Jordan)

MCCLOUD RIVER RAINBOW TROUT, LOCALLY "RAINBOW TROUT" (Figs. 37 and 38)

Salmo gairdneri shasta Jordan, *Thirteenth Bien. Rept. Fish Com. of California*, p. 142, 1894 (McCloud River at Baird, California).

Salmo irideus shasta (Jordan)—JUDAY, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes).

Salmo irideus Gibbons—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, pp. 6 and 16, 1889 (Twin Lakes).

The McCloud River Rainbow Trout differs from the true Rainbow Trout in having slightly smaller scales, in the more frequent presence of a red coloration on the throat and in not running into salt water. It also reaches a larger size.

The excellent game qualities and general hardiness of the Rainbow Trout have given them widespread popularity and have led to their successful introduction in many parts of the country. From the standpoint of the sportsman the true Rainbow is perhaps the most interesting of the trout, and the McCloud River variety is but little less of a fighter. It has been stated by several writers[1] that Rainbow Trout take fewer small fishes and correspondingly more insect larvae,

[1] JORDAN AND EVERMANN, *Amer. Food and Game Fishes*, p. 198, 1902, New York; *Chambers Journ. Nat. Fish Cult. Assoc. England*, Vol. I, 1889.

small worms and crustaceans than other trout. Juday,[1] however, in the examination of the stomach contents of 106 specimens of this species taken at Twin Lakes found young suckers to form a very considerable item in the food taken.

The Rainbow Trout in Colorado spawns in the late spring and early summer, from May to July, depending upon the altitude; the higher the station the later the spawning time. The young fish are quite active and grow very rapidly. Jordan and Evermann[2] give the following data regarding the relation of size to age under favorable conditions, for this fish:

1 year	¾ to 1 ounce
2 years	8 to 10 ounces
3 years	1 to 2 pounds
4 years	2 to 3 pounds

They add that this species continues to grow until it is eight to ten years old, the rate of growth decreasing with the age of the fish.

Many large individuals have been taken in Colorado since the introduction of this species. In the Museum of the University of Colorado there is a specimen of the McCloud River Rainbow 22½ inches in length which was caught in Stapp's Lake, Boulder County, August 22, 1912, by President James H. Baker. Several records of "Rainbows" caught recently, weighing over 5 pounds, have been received. In favorable conditions, particularly in warmer water than that of the mountain streams of Colorado, this species reaches the weight of 10 pounds or more.

Salmo rivularis Ayres

Steelhead Trout, "Salmon Trout"

Salmo rivularis Ayres, *Proc. Cal. Acad. Nat. Sci.*, p. 43, 1855 (Martinez, California). This is the *Salmo gairdneri* of many writers.

The Steelhead Trout is a large migratory species native in the Pacific Coast region, ranging north into Alaska. Along the coast it spends a considerable part of its life in the ocean and runs upstream to the headwaters of the Columbia, Snake and other coastwise rivers to spawn. The sea-going individuals become quite large, reaching a weight of 20 pounds or more, but those permanently landlocked do not grow so large. Wherever found this trout is a voracious species.

Several plantings of Steelheads have been made in Colorado, by both federal and state fish commissions, 14,000 being placed in St. Vrain Creek near Lyons in 1902. No reports of recent catches of this species have been received.

Salmo clarkii Richardson

Columbia River Trout

Salmo clarkii Richardson, *Fauna Boreal. Amer.*, Vol. III, p. 225, 1836 (Cathlapootl River).

This species and its subspecies are known collectively as the Cutthroat Trout because of the red mark on each side of the throat near the inner margin of the

[1] Juday, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 166, 1906.

[2] *Amer. Food and Game Fishes*, p. 199, 1902, New York.

lower jaw. Four of these forms are found in Colorado as Native Trout. They were originally restricted to particular drainages until transported by man, but are now scattered over the state regardless of drainage boundaries. These Native Trout spawn in the early spring.

Salmo clarkii spilurus (Cope)

Rio Grande Trout

Salmo spilurus Cope, *Hayden Geological Survey of Montana for 1871*, p. 470, 1872 (Sangre de Cristo Pass).

Salmo mykiss spilurus (Cope)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 14, 1889 (Rio Grande).

This species is native only in the Rio Grande drainage. In general coloration it is the lightest of the native species, although individuals vary greatly. Some specimens of this form taken from the Rio Grande at Creede in 1912 were quite silvery and had very small black spots; the lateral band was of a pale rose-red color. An individual caught in Boulder Creek where it has been introduced was, on the other hand, quite dusky. The Rio Grande Trout reaches a length of over 26 inches.

Salmo clarkii pleuriticus (Cope)

Colorado River Trout

Salmo pleuriticus Cope, *Hayden Geological Survey of Montana for 1871*, p. 471, 1872 (headwaters of Green River in Wyoming); Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 693, 1875 (Ft. Garland, Rio Grande; Pagosa).

Salmo mykiss pleuriticus (Cope)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, pp. 14, 28, 1889 (Trappers Lake; Eagle River; Canyon Creek; Sweetwater Lakes; Gunnison River; Rio Florida); Jordan and Evermann, *Bull. 47, U.S. Nat. Mus.*, p. 496, 1896 (Eagle and Gunnison rivers).

The Colorado River Trout is a native of the headwaters of the Colorado River, being quite abundant in Grand Lake, Trappers Lake, and the upper Grand River. Average specimens are quite dark with numerous rather large black spots which are rather uniformly distributed over the body. The red lateral band is usually very prominent in this form. Size moderately large, reaching a weight of 3 pounds or more. This trout and the Rio Grande trout have been considered almost if not quite identical by some writers.

Salmo clarkii stomias (Cope)

Green-backed trout

Salmo stomias Cope, *Hayden Geological Survey of Wyoming for 1870*, p. 433, 1871 (South Platte River); Juday, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes); Cockerell, *Univ. Colo. Studies*, Vol. X, p. 174, 1908 (Boulder Creek, Boulder).

Salmo mykiss stomias (Cope)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Bear Creek above Morrison).

The Green-backed Trout is the native trout of the Arkansas and Platte drainages. It is a small species, average individuals rarely exceeding a pound in weight. Specimens caught in Boulder Creek which weighed almost a pound have been examined. This species spawns in early spring and according to Jordan[1] prefers the water from melting snow to that of springs when running to spawn.

Salmo clarkii macdonaldi (Jordan and Evermann)

YELLOW-FINNED TROUT OF TWIN LAKES

Salmo mykiss macdonaldi Jordan and Evermann, *Proc. U.S. Nat. Mus. for 1889*, p. 453, 1890 (Twin Lakes); JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 11, 1889 (Twin Lakes).

Salmo macdonaldi (Jordan and Evermann)—JUDAY, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (no specimens).

This trout is a large form known only from Twin Lakes, where it inhabits the deep water, running into the adjoining streams to spawn in the early spring when the water begins to rise from the melting snows. The largest specimen of this form recorded weighed 8 pounds 11½ ounces. Although it was reported abundant in 1889 it is apparently very rare in these lakes at present. No specimens were obtained by Juday during the summers of 1902 and 1903 and Mr. Irwin Simonson, who made inquiry of several persons who fish regularly in Twin Lakes, reports that no Yellow-finned Trout have been caught for several years.

Salmo fario Linnaeus

BROWN TROUT, VON BEHR TROUT

The Brown Trout or Von Behr Trout is the trout of England concerning which much has been written both by anglers and by others. It has been introduced into many parts of the United States. Plantings of this species and its variety, the Loch Leven Trout, were made in Colorado in 1894 and 1901 by the United States Fish Commission.[2] This trout is easily distinguished from the other species of the genus *Salmo* found in Colorado by the bright red spots which are more or less ocellated with white or pale pink, together with the bright orange tip of the adipose fin and the general brown color. The red spots might cause this species to be mistaken for the Eastern Brook Trout, *Salvelinus fontinalis*, which may be recognized by the broad white edging of the anterior margins of the pectoral, ventral and anal fins. No specimens of this trout collected in Colorado have been examined in the present study, although it has been reported to the writer from the Gunnison River.

Salmo fario levenensis (Walker)

LOCH LEVEN TROUT

This variety of the preceding species is a native of Loch Leven, Scotland. It was introduced into Colorado in 1894. This fish differs from the Brown Trout in having fewer spots, the red spots being entirely absent in some specimens, and

[1] *Bull. U.S. Fish Com.*, Vol. IX, p. 13, 1889.

[2] See *Repts. U.S. Fish Com.* for 1894–95 and 1901–02.

in the loss of the orange tip to the adipose fin. It has been noted[1] that the Loch Leven Trout when introduced into the streams of Yosemite Park reverted to the typical Brown Trout with bright-red spots and orange-tipped adipose. It is entirely possible that such a change may have taken place in the Loch Leven Trout planted in this state so that any caught will probably be the true Brown Trout as regards markings. No specimens of this trout taken in Colorado have been examined by the writer.

Genus **SALVELINUS** Richardson

The Charrs

Salvelinus Richardson, *Fauna Boreal. Amer.*, Vol. III, p. 169, 1836.

Species of this genus in general appearance are much like those of the genus *Salmo*, from which they may be separated by the boat-shaped vomer, the smaller scales, of which there are 200 or more cross-rows, by the round, bright-red or crimson spots on the sides of the body, and the white or orange edgings to the anterior margins of the pectoral, ventral and anal fins. Pyloric coeca 35 to 50. Species of this genus are known from both the Old and the New World, inhabiting cold and rapid waters of small streams. *Salvelinus* is represented in Colorado by the Eastern Brook Trout, an introduced species.

Salvelinus fontinalis (Mitchill)

Eastern Brook Trout, Speckled Trout (Figs. 39, 40, 41, 42 and 43)

Salmo fontinalis Mitchill, *Trans. Litt. Phil. Soc. N.Y.*, Vol. I, p. 435, 1815 (near New York City).

Salvelinus fontinalis (Mitchill)—Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 16, 1889 (reported as introduced into Twin Lakes); Juday, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes); Cockerell, *Univ. Colo. Studies*, Vol. V, p. 175, 1908 (Allen's Park, Boulder County).

Head 4 to 4.5, depth about 4.4 in the length; dorsal rays 10 or 11, anal rays 9.

General color dusky to dark green, sides lighter, shading to pale yellow or reddish below; top of the head quite dark; body above the lateral line dark, mottled and marbled with dark olive-green but without spots except near the lateral line; two or more irregular rows of black and crimson spots, the latter being smaller than the pupil of the eye, in the lateral line region; ventral parts lighter, varying from pale yellow, to bright orange-red in breeding males; pectoral, ventral and anal fins with a rather broad, yellowish or orange area along their anterior margins, this area edged posteriorly with black or dusky; lower margin of the caudal fin marked in much the same manner; dorsal fin dusky, quite dark at the base, crossed by several irregular and broken bars of black or dusky; parr marks in the young quite distinct, often persisting as faint dusky, vertical bands on fair-sized individuals; size small to moderately large, average specimens usually 12 inches or less; in Maine specimens have been taken weighing 6 pounds or more.

[1] Jordan, *Science*, N.S., Vol. XXII, p. 714, 1905.

This trout is one of the most handsome of the fresh-water fishes, and its brilliant coloration, the rugged situations from which it is usually taken and the splendid sport it offers have combined to make it one of the most prized game fishes. It is quite hardy, an additional factor contributing to its wide introduction throughout the Rocky Mountain region. The Eastern Brook Trout is a native of northeast United States and southern Canada east of the Mississippi River, ranging south along the Appalachian Mountains into northern Georgia, yet so completely is it established in the streams of the Rocky Mountains, it seems part of the native fauna of Colorado.

Salvelinus fontinalis in Colorado spawns from late October to early December, the eggs for the fish hatcheries being collected in November. The eggs are deposited on the gravel bottom of small, shallow streams and do not hatch until the water begins to get warm in the spring.

Genus **CRISTIVOMER** Gill and Jordan

The Great Lakes Trout

Cristivomer Gill and Jordan, in JORDAN, *Manual of Vertebrates Eastern U.S.*, ed. II, p. 356, 1878.

The species of this genus differ from those of the genus *Salvelinus* in the type of vomer; this bone in *Cristivomer* has a raised crest. The species of *Cristivomer* are also more elongate and are without red spots, the sides of the body being much mottled and blotched with gray or rarely pinkish gray. This genus is represented in Colorado by the single introduced species, the Mackinaw Trout.

Cristivomer namaycush (Walbaum)

GREAT LAKES TROUT, MACKINAW TROUT

"Namaycush Salmon"—PENNANT, *Arctic Zoology*, Introd., p. 191, 1792 (Hudson Bay).

Salmo namaycush Walbaum, *Artedi Piscium*, p. 68, 1792 (Hudson Bay).

Cristivomer namaycush (Walbaum)—JUDAY, *Bull. U.S. Fish Com.*, Vol. XXVI, p. 162, 1906 (Twin Lakes).

Body distinctly elongate; head long, 4 to 4.5, depth 4 or a little less in the length; caudal peduncle rather narrow, its least depth about 3 in the head; dorsal rays 11, anal rays 11.

General color dusky or dark gray, lighter ventrally; head and mid-dorsal region quite dark; sides, dorsal and caudal fins much mottled with irregularly rounded, pale-gray or rarely pinkish-gray spots; the largest of the trout reaching a weight of over 100 pounds.

The Mackinaw Trout is a native of the Great Lakes and of the larger lakes in northeastern United States and Canada, ranging from Maine into Alaska. Its odd specific name "Namaycush" is that by which it is known among the Canadian Indians, who prize it as a food fish. In the Great Lakes this trout lives in the deep water, spawning in the late fall on the shoals and reefs. The food of this fish, as given by the several writers who have studied it, consists of almost anything which comes the way of the fish. It has a voracious appetite and feeds to a considerable extent on small fishes.

Cristivomer namaycush was introduced into Twin Lakes about twenty years ago with success, some very large specimens having been taken from those lakes in the past few years. Juday[1] states that a number of individuals weighing from 15 to 20 pounds were caught during the summer of 1903, the fishermen using large hooks baited with pieces of suckers. Mr. Irwin Simonson secured for the writer the weight and measurements of a large specimen of this species caught in Twin Lakes on June 1, 1907, by Mr. W. W. Fay of Buena Vista. This fish weighed 20¼ pounds and was 39½ inches in length; the head measured 8½ inches in length, greatest circumference 21⅜ inches, tail when spread 10½ inches. A live minnow was used for bait. The Mackinaw Trout has been reported by several fishermen as the most abundant large fish now in Twin Lakes and it has been suggested that the increase of this fish is correlated with the decrease of the Yellow-finned Trout.

Order Haplomi

The Pike-like Fishes, including the Mud Minnows, the Pickerel, the Killifishes and the Cave Blindfishes

Family *POECILIIDAE*

The Killifishes and Top-minnows

Body somewhat elongate, more or less terete in the anterior half, distinctly compressed posteriorly; top of the head usually flattened; mouth terminal and broad, lower jaw projecting in many species; scales large, cycloid; lateral line wanting or represented by but a few pores; sexual dimorphism pronounced in most species, many being ovoviviparous; size small; colors of tropical species brilliant and varied.

The *Poeciliidae* are small fishes of the fresh waters of Europe, Asia, Africa and the Americas. A few species are marine and many are quite abundant in the brackish water of salt-marshes. Because of their small size and ability to live in warm and rather impure water they are often very numerous in small streams and ditches. One species, *Acanthophacelus reticulatus* (Peters) and several closely related forms, known collectively as "Barbadoes Millions," have become of considerable economic importance recently as destroyers of mosquitos in the West Indies and South America. These little fishes are able to live in the shallow trenches of the sugar plantations and even the ditches in the streets of the small towns, feeding upon the mosquito larvae. The "Millions" have proven very effective enemies of the young mosquitos, contributing in this way to the control

[1]*. U . Fish Com.*, Vol. XXVI p. 162, 1906.

of malarial fever.[1] Several North American Poeciliids feed upon the young of mosquitos as well as other insects and are of value in reducing the numbers of these pests.

A single genus, *Fundulus*, is represented in Colorado.

Subfamily Fundulinae

Genus **FUNDULUS** Lacépède

The Killifishes and Top-minnows

Fundulus Lacépède, *Hist. Nat. Poiss.*, Vol. V, p. 37, 1803.

Anal fin of the male not modified to function as an intromittent organ; species oviparous; jaws with two or more rows of fine teeth; lower jaw projecting beyond the upper; caudal fin rounded.

This genus includes a great variety of species, some of which are marine. It has been broken up by various ichthyologists into numerous genera and subgenera, but the characters of the several groups of species intergrade to such an extent that these separations are possible only with the extreme species. Two species of this genus, referable to different subgenera, are known from Colorado, these being very abundant in the plains streams of the eastern part of the state.

a. Dorsal fin of 14 or 15 rays; base of the first ray of the dorsal on or in front of the level of the first ray of the anal fin; body crossed by 11 to 21 vertical dusky bars.
F. (*Fontinus*) *zebrinus* Jordan and Gilbert

aa. Dorsal fin of 10 or 11 rays; base of the first ray of the dorsal behind the level of the first ray of the anal; color plain, olivaceous, fins edged with red . *F.* (*Zygonectes*) *floripinnis* (Cope)

Fundulus zebrinus Jordan and Gilbert

Zebra Fish, Zebra Top-minnow (Figs. 44, 45 and 46)

Fundulus zebrinus Jordan and Gilbert, "Synopsis," *Bull. U.S. Nat. Mus. No. 16*, p. 891, 1883 (after Girard, *Hydrargyra zebra* Girard, *Proc. Acad. Nat. Sci. Phila.*, p. 60, 1859, name preoccupied in *Fundulus*); Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 17, 1889 (pond at Canyon City; Fountain Creek at Pueblo); Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder; Longmont).

Fundulus multifasciatus (Cuvier)—Cope and Yarrow, *Wheeler Survey*, Vol. V, p. 695, 1875 (Pueblo), name preoccupied in *Fundulus*.

Body rather short and deep, much compressed back of the pectorals, depth 4.4 to almost 5 in the length to the base of the caudal; head long and depressed, 3.3 to 3.8 in the length of the body; top of the head with the skin thickened into plate-like structures; snout blunt; eye prominent, its dorsal margin even with the top of the head, its diameter 2 or a little more in the interorbital distance, about 2.5 in the length of the snout and 5.5 to 6 or a little more in the head; interorbital distance 2.5 to 3 in the head; nostrils small, dorsal, placed in front of the dorsal margin of the eye; mouth terminal and somewhat dorsal, large and broad; upper

[1] Ballou, *Pamphlet Ser. 55, Imperial Dept. Agric. West Indies*, 1908.

jaw short and included by the projecting lower jaw; angle of the mouth about equidistant from the tip of the lower jaw and the anterior margin of the eye; premaxillaries protractile; dorsal fin longer than high, inserted in the posterior half of the body, slightly in front of the origin of the anal fin, the distance from the base of the first ray of the dorsal to the base of the caudal reaching forward to the posterior margin of the eye; dorsal rays 14 or 15, occasionally 16; pectorals not reaching (females) or barely reaching (males) the ventrals; ventrals barely reaching the anal fin; scales small, circular, circuli large and few, basal radii 8 to 12, apical radii none; lateral line wanting or represented by an occasional pore only; scales 58 to 64 along the middle of the side, in 18–21 rows between the dorsal and ventral fins; length under 6 inches.

General color above greenish, shading from dark olive green to silvery white below; sides yellowish to bright orange-yellow; a dark mid-dorsal spot just in front of the dorsal fin; sides crossed by 11 to 21, usually 14 or 15, dusky vertical bars which are generally narrower than the light interspaces, and in many individuals, particularly females, each alternate bar is lighter and narrower than two adjacent to it; under parts of the head yellowish white; dorsal and caudal fins more or less dusky; pectoral and ventral fins yellowish white; anal fin yellowish to orange-yellow. The variation in the number of lateral bars is shown by the following table, which includes the data from 111 specimens collected at one station on the South Platte River at Julesburg, July 19, 1912:

Bars	11	12	13	14	15	16	17	18	19	20	21
Specimens	1	6	16	23	26	15	12	8	2	1	1
Percentage			14	21	23	14	10				

In this series 82 per cent of the 111 individuals had from 13 to 17 bars, the gamut of variation being from 11 to 21 bars.

This species, as the name Top-minnow implies, feeds to a considerable extent upon surface insects, Entomostraca and floating matter. For such feeding the upturned mouth is well adapted. On the other hand, the Zebra Fish is able to take small snails, worms, insect larvae and diatoms, especially when placed under conditions which limit the supply of surface food. The stomachs of specimens collected at Julesburg in July from the South Platte River, then almost dry, were filled with masses of diatoms, the sandy pools in which *F. zebrinus* had taken refuge as the river receded containing at that time large quantities of brown diatomaceous slime and few if any surface insects. The data concerning the stomach contents of seventeen specimens are given below:

South Platte River, Julesburg, July 19, 1912. Sandy pools.
70 mm., brown diatomaceous slime, 100 per cent.
50 mm., " " " , 75 per cent. Not full.
65 mm., " " " , 95 per cent; Entomostraca 5 per cent.
80 mm., " " " , 100 per cent.

45 mm., brown diatomaceous slime, 60 per cent. Not full.
50 mm., " " " , 80 per cent; one small gastropod.
60 mm., " " " , 100 per cent.
47 mm., " " " , 90 per cent; two Dytiscid beetles.

Small weedy stream near Republican River, Wray, October 25, 1912.

70 mm., Entomostraca, 60 per cent; gastropods, 40 per cent.
75 mm., " , 80 per cent. Not full.
60 mm., " , 10 per cent; vegetable débris, 90 per cent.
50 mm., " , 75 per cent; 4 small gastropods and a few diatoms.

Boulder Creek, 6 miles from Boulder, July 52, 1912. Rapid stream with gravel bottom and shore vegetation.

85 mm., Chironomid larvae, 100 per cent.
75 mm., " " , 10 per cent; Entomostraca, 50 per cent. Not full.
80 mm., " " , 5 per cent; small gastropods, 15 per cent; two small annelids.
65 mm., Entomostraca, 10 per cent; diatoms, 20 per cent. Not full.
80 mm., " , 5 per cent; " , 5 per cent; two Dytiscid beetles.

This species ranges from South Dakota to Mexico in the western tributaries of the Mississippi. It is a species of the shallow streams of the plains, coming up to but not entering the true foothill streams. *F. zebrinus* is known locally as "Dogfish" in eastern Colorado.

Colorado specimens.—*University Museum:* Boulder Creek, Boulder, October, 1903 (65 specimens, 40–80 mm.), C. Juday and J. Henderson, No. 37; St. Vrain Creek, Longmont, October 17, 1903 (2 specimens, 100–110 mm.), C. Juday and D. W. Spangler, No. 38; South Platte River, Sterling, June 10, 1910 (4 specimens, 70–90 mm.), H. G. Smith, No. 389; Boulder Creek 6 miles east of Boulder, July 25, 1912 (12 specimens, 55–80 mm.), M. M. Ellis, No. 390; South Platte River near Denver, spring 1912 (2 specimens, 70–80 mm.), F. A. Reidel, No. 391; South Platte River, Julesburg, July 19, 1912 (769 specimens, 21–100 mm.,) J. Henderson and M. M. Ellis, No. 392; Lodgepole Creek near Ovid, July 20, 1912 (72 specimens, 20–90 mm.), J. Henderson and M. M. Ellis, No. 393; Republican River, Wray, October 26, 1912 (153 specimens, 35–70 mm.), A. G. Vestal and M. M. Ellis, No. 394; *Colorado State Historical and Natural History Museum:* Summitt Lake near Denver, August 11, 1900 (75 mm.), W. C. Ferril; South Platte River below Denver, May 26, 1901 (6 specimens, 40–85 mm.), C. F. Leach; Arkansas River, Holly, May 24, 1907 (11 specimens, 25–75 mm.), H. G. Smith; *Colorado College Museum:* East Bijou Creek, Elbert County, E. R. Warren; Ft. Collins, E. R. Warren; *State Teachers' College Museum:* Greeley, A. E. Beardsley.

Fundulus floripinnis (Cope)

LITTLE RED FIN, LITTLE GREEN TOP-MINNOW (Fig. 47)

Haplochilus floripinnis Cope, *Wheeler's Survey*, Vol. V, p. 695, 1875 (Cherry Creek, Arkansas River[1] and South Platte River at Denver).

Fundulus floripinnis (Cope)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder, Longmont).

Zygonectes floripinnis (Cope)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Denver).

Body short and heavy, rather compressed back of the pectorals, distinctly so in the caudal region; depth 4.3 to 5 in the length to base of the caudal; head depressed, quadrate in cross-section, top quite flat; length of the head 3.7 to 4 in

[1] Cherry Creek is a tributary of the South Platte and not of the Arkansas River.

the length of the body; eye large and prominent, situated a little nearer the tip of the snout than to the posterior margin of the operculum, rather high on the side of the head; dorsal margin of the eye on a level with or slightly above the flat portion of the top of the head; diameter of the eye 3.5 to 4 in the head, 1.5 to 2 in the interorbital distance, and 1 to 1.2 in the snout; nostrils very small, dorsal, on a level with the anterior margin of the eye; mouth terminal and horizontal; upper jaw small, included by the large, projecting lower jaw; premaxillaries protractile; angle of the mouth about midway between the tip of the lower jaw and the center of the eye; dorsal fin small, low, its longest ray being almost equal to the base of the fin in length, inserted well back in the posterior half of the body; base of the first ray of the dorsal almost on a level with the first ray of the anal fin (females) or distinctly posterior to the first ray of the anal (males); dorsal rays usually 10, often 9 or 11; pectorals small, not reaching the ventrals; ventrals very small, just reaching the anal opening (females) or the first anal rays (males); anal fin as large (females) or larger than (males) the dorsal fin; anal rays 12 or 13; caudal fin large, fan-shaped and not forked, its greatest width equal to or slightly less than that of the body; scales rather large, 28 to 33 along the middle of the side, 10 to 12 rows from the dorsal fin to the ventral; lateral line wanting; scales roughly circular, circuli large, basal radii 10 to 15.

General color greenish gray to olivaceous, darker dorsally, shading into white or cream color below and having a narrow but distinct dark mid-dorsal band; fins hyaline, dorsal greenish; pectorals, ventrals and especially the anal yellow, broadly edged with cherry-red to crimson; scales outlined with yellowish brown.

This little fish is a true top-minnow and may often be observed swimming just under the surface. Individuals kept in an aquarium at the University were found to spend most of the time at the surface with the tip of the snout just breaking the surface film. In this position they remained absolutely quiet for many minutes at a time or moved slowly back and forth across the tank. There was no evidence that this species swims in pairs as the name *Zygonectes* implies. The position of the fish at the surface was the same in light and dark, as they were always found at the surface late in the night as well as in the middle of the day. When disturbed or at night when the room was suddenly illuminated they immediately darted to the bottom, resting on the floor of the tank in the more shaded portions.

The data concerning the stomach contents of twelve specimens of this species show both surface forms and bottom forms to be included in the food of *F. floripinnis*.

South Platte River, Julesburg, July 19, 1912.

50 mm., four gastropods, largest 4 mm., *Physa* sp., 100 per cent. (Probably the young of *Physa forsheyi* Lea, det. J. Henderson.)

45 mm., nine caddis-fly larvae, 75 per cent; two large adult muscid diptera, one being a housefly; three cladocerans.

55 mm., caddis-fly larvae, 100 per cent.

55 mm., Dytiscid beetles, 100 per cent.
60 mm., Dytiscid beetles, 50 per cent; adult diptera, 50 per cent.
45 mm., caddis-fly larvae, 25 per cent. Not full.
50 mm., ostracods and cladocerans, 50 per cent; one large caddis-fly larva.
45 mm., Entomostraca, 25 per cent. Not full.
50 mm., caddis-fly larvae, 50 per cent. Not full.
50 mm., caddis-fly larvae, 100 per cent.

St. Vrain Creek, Longmont, October 17, 1903.
90 mm., twelve gastropods, *Physa* sp., 100 per cent.
60 mm., seven gastropods, *Physa* sp., 100 per cent.

Two females, 45 and 50 mm., from Julesburg, July 19, contained large and well-formed eggs.

Fundulus floripinnis is a species of the western portion of the South Platte drainage. It has been wrongly ascribed to the Arkansas drainage since the collection from which it was described was stated by Cope (*l.c.*) to be from Cherry Creek near Denver, a tributary of the Arkansas; this creek flows, however, into the South Platte, not into the Arkansas.

Colorado specimens.—*University museum:* St. Vrain Creek, Longmont, October 17, 1903 (10 specimens, 55–95 mm.), C. Juday and D. W. Spangler, No. 22; Boulder Creek, Boulder, October, 1903 (15 specimens, 30–50 mm.), C. Juday and J. Henderson, No. 40; Boulder Creek 6 miles east of Boulder, July 25, 1912 (7 specimens, 35–55 mm.), M. M. Ellis, No. 395; South Platte River, Julesburg, July 19, 1912 (53 specimens, 30–50 mm.), J. Henderson and M. M. Ellis, No. 396; Lodgepole Creek near Ovid, July 20, 1912 (20 specimens, 50–60 mm.), J. Henderson and M. M. Ellis, No. 397; Boulder Lake near Boulder, October 16, 1913 (20 specimens, 30–50 mm.), M. M. Ellis.

Order Apodes

The Eels and Eel-like Fishes

Shoulder girdle free from the skull; ventral fins wanting; premaxillaries reduced or wanting; caudal fin confluent with the dorsal and anal fins; body elongate, snake-like.

Family *ANGUILLIDAE*

True Eels or Scaly Eels

Scales very small, imbedded in the skin; teeth in bands on both jaws and vomer.

The true eels are quite abundant in both fresh and brackish water, being found in tropical and temperate regions throughout the world except on the Pacific slope of the Americas and the islands of the Pacific. They are quite abundant in the West Indies. The family is represented by but a few living species all referable to the genus *Anguilla*. The several species are quite closely related and may perhaps be reduced to three, one found in Europe, one in Asia and one in the Americas.

Genus **ANGUILLA** Shaw

The Eels

Anguilla Shaw, *General Zoölogy*, Vol. IV, p. 15, 1804.

Anguilla chrysypa Rafinesque

American Eel, Fresh-Water Eel

Anguilla chrysypa Rafinesque, *Amer. Monthly Magazine*, p. 120, 1817 (Lake George; Hudson River; Lake Champlain).

Anguilla tyrannus Girard, *U.S. and Mexican Boundary Survey*, p. 75, 1859 (Rio Grande).

Body terete, much elongate; head long and conical; teeth small, in irregular bands on both jaws and vomer; lower jaw slightly longer than the upper; size large, length up to 5 feet.

General color greenish or bluish brown above, shading to golden yellow or yellowish white below.

The American eel is a carnivorous fish, feeding upon small crustaceans and upon other fishes. Because of the excellent flavor and the firm consistency of its flesh it is a food fish of considerable importance in the localities where it is abundant. From a zoölogical standpoint its life-cycle is of particular interest. The adult eels migrate in the fall from fresh water to the ocean. At this time they become quite silvery in color and the eyes of the male greatly enlarged. These eels returning to the salt water migrate in large schools traveling largely at night. After they reach salt water their course has not been followed and their spawning habits are not known. Smith[1] states that the eggs are laid in water at least 1,000 meters deep and that the eggs hatch at or near the surface where they are carried by their natural buoyancy. From the number of immature eggs taken from adult eels in fresh water it seems probable that each female produces over 10,000,000 eggs. The young eels do not have the same form as the adult, being thin transparent animals living near the surface of the ocean well out from land. The larval eels known as Leptocephali spend the first year of their life in salt water, growing to a size of about three inches. After this stage is reached they gradually assume the adult shape, enter fresh water and migrate upstream. Only the female eels continue this migration to the headwater streams, the males remaining in the lower waters. Large schools of the young eels known as "Elvers" are regularly seen at the mouth of the Mississippi and other large rivers.

The adult eel has been reported from the Rio Grande in Colorado frequently but unfortunately no specimens collected in this state have been preserved to verify the records. In July, 1912, while in Alamosa, Colorado, the writer was told by several fishermen that the eel is occasionally taken from the Rio Grande at that point and that it is more abundant farther south near the New Mexico line. Professor A. E. Beardsley of the State Teachers' College also states that on several occasions he was assured by local fishermen that there were eels in the Rio Grande

[1] *National Geographic Magazine*, Vol. XXIV, p. 1143, 1913.

at Alamosa. That eels are found in the Rio Grande farther south is well established, Girard in 1859 having described specimens from the Rio Grande under the name of *Anguilla tyrannus*. Judging from the remarkable distances covered by migrating eels, the distance from the Colorado line to the mouth of the Rio Grande would not be a prohibiting factor to the presence of the eel in Colorado. It is here provisionally included in the Colorado fauna.

Superorder *ACANTHOPTERI*

The Spiny-rayed Fishes

Vertebrae just back of the head not fused; no Weberian apparatus; air bladder in adults usually without a *ductus pneumaticus;* scales usually ctenoid; dorsal, pectorals, ventrals and usually the anal with spines.

The majority of the species of this group, which is quite heterogeneous, are marine fishes. Several large families of Spiny-rayed fishes are, however, composed entirely of fresh-water species, notably the *Cichlidae* in Central and South America and the *Centrarchidae* in North America. Although represented in the Mississippi Valley by a large number of species, but four of this order occur native in Colorado and all of these east of the Continental Divide.

Order PERCOIDEA

Family *CENTRARCHIDAE*

The Sunfishes and Bass

Spinous and soft dorsals united; scales ctenoid or cycloid; body strongly compressed and usually quite deep; mouth large, premaxillaries protractile; species carnivorous, known only from the fresh waters of North America.

The species of this family form one of the most characteristic groups of North American fishes, particularly since they are found only in the fresh waters of this continent. Practically all of the thirty or more species of Centrarchids are caught for food and two, the Black Bass, are among the best known of game fishes. A single species of this family occurs native in Colorado, *Lepomis cyanellus* Rafinesque, the Green Sunfish. Six other species have been introduced into the state with varying success.

KEY TO CENTRARCHIDAE REPRESENTED IN COLORADO

a. Anal spines V to VIII; dorsal fin not twice the length of the anal fin.
  b. Dorsal spines V to VIII; anal and dorsal fins of about the same size and shape; eye blue or brown . . . . *Pomoxis* Rafinesque, p. 94
  bb. Dorsal spines XI to XIII; dorsal fin longer than the anal; length of the base of the anal about 1.3 in the length of the base of the dorsal; eye red . *Ambloplites* Rafinesque, p. 95
aa. Anal spines III; dorsal fin about twice the length of the anal fin.
  c. Dorsal fin without a deep indentation at the junction of the spinous and soft portions; spinous dorsal broadly joined to the soft dorsal; scales ctenoid or cycloid.

d. Tongue with teeth. . . . . *Chaenobryttus* Gill, p. 96
dd. Tongue without teeth. . . . . *Lepomis* Rafinesque, p. 97
cc. Dorsal with a deep indentation at the junction of the spinous and soft portions; spinous dorsal narrowly joined to the soft dorsal; scales ctenoid. *Micropterus* Lacépède, p. 99

Subfamily Centrarchinae

Genus **POMOXIS** Rafinesque

The Crappies

Pomoxis Rafinesque, *Amer. Monthly Magazine*, p. 41, 1818.

Body strongly compressed and quite deep; anal and dorsal fins of about the same size and shape; operculum emarginate posteriorly. A genus of two closely related species, both of which have been introduced into Colorado.[1]

Pomoxis sparoides (Lacépède)

Calico Bass, Strawberry Bass, Black Crappie (Fig. 48)

Labrus sparoides Lacépède, *Hist. Nat. Poiss.*, Vol. III, p. 517, 1802 (South Carolina).
Pomoxis sparoides (Lacépède)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder).

Body much compressed, depth 2.25 to 2.5 in the length to the base of the caudal fin; back elevated; dorsal profile sloping abruptly upward from the supraocular region to the base of the first dorsal spine, forward from the supraocular region more gradually to the tip of the snout, giving the snout an upturned appearance; ventral profile arcuate, the lowest point at the base of the first anal ray; top of the head somewhat flattened, with a distinct elevation between the eyes; length of the head 3 or a little less in the length of the body; eye very large, its center nearer to the tip of the snout than to the posterior margin of the operculum, situated in the upper half of the head; diameter of the eye greater than the length of the snout, about 4 in the head, a little less than 1 in the interorbital distance; posterior margin of the operculum emarginate; nostrils small, lateral, longer than wide, on a level with and slightly in front of the dorsal margin of the eye; mouth large, terminal; lower jaw very slightly if at all longer than the upper; angle of the mouth when closed barely or not quite reaching the level of the anterior margin of the eye; premaxillaries protractile; spinous and soft dorsals broadly united, of VII rarely VIII spines, and 15 or 16 rays, the last of which is usually rudimentary; length of the base of the combined dorsals equalling or slightly exceeding the length of the base of the anal fin; pectorals short, 1.5 to 1.75 in the head; ventrals shorter than the pectorals, base of the spine of the ventral on a level with the last ray of the pectoral, and separated from it by a little less than the diameter of the eye; anal fin long, of VI spines and 17 or 18

[1] After this report had been set up word was received of the successful introduction of the White Crappie, *Pomoxis annularis* Rafinesque, into lakes near Denver and Pueblo during 1912. This fish, which is much like the Calico Bass in form and coloration, may be recognized by the V or usually VI dorsal spines and the vertical, dusky green bars on the sides which take the place of the dark green blotches on the sides of the Calico Bass. These vertical bars are usually about 10 in number. Since this record was received so late the White Crappie is not included in the tables and discussion of distribution.

rays, base of the first spine but slightly behind the level of the base of the first dorsal spine; caudal peduncle broad, exceeding in width the diameter of the eye; caudal fin long and broad, not deeply forked; scales large, closely imbricated, feebly ctenoid in the anterior portion of the body, strongly ctenoid in the posterior; scales 6, 38–44, 12.

Color light green, darker dorsally; body, caudal, dorsal and anal fins, and to some extent the posterior portion of the head, mottled with dark-green blotches, each blotch covering parts of from two to five scales; ventral parts light green to almost white, somewhat washed with dusky; ventrals and pectorals dusky; outer portion of the caudal and soft dorsal fins with numerous white spots; top of the head dark olive-green; eye bright blue, with a purplish reflection.

The Calico Bass ranges from southern Canada south into Alabama and west into Kansas. It is regarded as a valuable food fish throughout its range, taking almost any sort of bait and having some of the fighting qualities of the true bass. *Pomoxis sparoides* reaches a weight of a pound and thrives well in small ponds, two points favoring its introduction into ponds and reservoirs. It has been introduced into Colorado through several independent plantings, one of the first of these being made in 1894 when twenty-five adults and yearlings were placed in Stevens Lake near Cuchara.[1]

Colorado specimens.—*University Museum:* Boulder Lake near Boulder, October 29, 1903 (8 specimens, 160–170 mm.), C. Juday and J. Henderson, No. 42.

Subfamily Lepominae

Genus **AMBLOPLITES** Rafinesque

The Rock Bass

Ambloplites Rafinesque, *Ichthyologia Ohiensis*, p. 37, 1820.

Body oval in outline, moderately compressed and moderately deep; operculum emarginate; tongue with teeth; anal spines VI. A genus of a single species.

Ambloplites rupestris (Rafinesque)

Rock Bass

Bodianus rupestris Rafinesque, *Amer. Monthly Magazine*, p. 120, 1817 (lakes of New York, Vermont, and Canada).

Body oval in outline, deep and moderately compressed; depth 2 to 2.5 in the length to the base of the caudal fin; greatest width of the body about 2 in the greatest depth; head 2.5 to 2.8 in the length; eye very large and prominent, its diameter 3.5 to 4 in the length of the head; interorbital distance about 4 in the head; operculum emarginate posteriorly; mouth large, lower jaw slightly longer than the upper; angle of the mouth when closed reaching the level of the center of the eye; dorsal fin long, of XI or XII spines and 10 to 12 rays, base of the first spine of the dorsal almost on a level with the spines of the ventrals; pectorals

[1] *Rept. U.S. Com. Fisheries for 1894–95*, p. 71, 1896.

short, about 1.75 in the head; ventrals almost as long as the pectorals; anal long, but shorter than the dorsal; length of the base of the anal 1.3 to 1.5 in the length of the base of the dorsal; anal spines VI, rays 10 or 11; scales ctenoid, 6 to 8, 38–45, 11 or 12.

General color olivaceous, body above the lateral line irregularly mottled with dark green; central portions of most of the scales with dark green or dusky spots which collectively form interrupted longitudinal stripes coincident with the scale rows; top of the head dark green; eye deep crimson; fins greenish, more or less speckled. Size moderately large, reaching 12 inches, weight up to about 2 pounds.

The Rock Bass ranges from Vermont south into Louisiana and west through the Great Lakes region into the Des Moines and Kansas rivers. The first published record found concerning the introduction of this species into Colorado shows that one hundred adults and yearlings were sent to Colorado by the United States Fish Commission in 1895.[1]

Genus **CHAENOBRYTTUS** Gill

The Warmouth Bass

Chaenobryttus Gill, *Amer. Journ. Sci. Arts*, p. 92, 1864.

Much the same as *Ambloplites;* tongue with teeth; operculum not emarginate but broadly rounded posteriorly; anal spines III. This genus includes the single species, *C. gulosus* (Cuvier and Valenciennes).

Chaenobryttus gulosus (Cuvier and Valenciennes)

Warmouth or Warmouth Bass

Pomatis gulosus Cuvier and Valenciennes, *Hist. Nat. Poiss.*, Vol. III, p. 498, 1829 (Lake Pontchartrain).

Body somewhat elongate, moderately compressed; depth 2 to 2.5 in the length to the base of the caudal fin; greatest width of the body about 2.3 in the greatest depth; head large, 2.25 to 2.75 in the length; eye large, its diameter 4 to 4.75 in the length of the head; angle of the mouth when closed reaching to the level of the center of the eye; dorsal fin long, of X or XI spines and 9 to 11 rays; anal short, length of its base 2 or a little more in the length of the base of the dorsal of III spines and 8 to 10 rays; scales feebly ctenoid, 6 or 7, 38–45, 11 or 12.

General color olivaceous with a slightly brassy luster, sides mottled or indistinctly barred with bluish or dusky; ventral parts yellowish or greenish; four or five bluish or reddish streaks radiating from the posterior margin of the eye across the operculum; top of the head dusky gray; eye crimson to purplish; fins grayish to olivaceous, more or less irregularly speckled. Length 6 to 10 inches.

The Warmouth Bass ranges from the Great Lakes south through the Mississippi Valley into Texas and Florida, inhabiting ponds with mud bottoms

[1] *Rept. U.S. Com. Fisheries for 1895–96*, p. 73, 1897.

and the more sluggish streams. It is quite abundant in the southern states. This species was introduced into Colorado in 1894 by the United States Fish Commission.[1]

Genus LEPOMIS Rafinesque

The Sunfishes

Lepomis Rafinesque, *Journ. de Physique*, p. 402, 1819.

Body strongly compressed and quite deep, slightly if at all elongate; posterior margin of the operculum with a convex bony or membranous flap; tongue without teeth; anal spines III.

This genus includes about 15 of the species of sunfish found in the Mississippi Valley, and is represented in Colorado by one native and one introduced species.

a. Posterior portion of the operculum bearing the black opercular spot stiff and bony; posterior margin of the opercular spot not reaching the free margin of the operculum, but separated from it by one-fourth the diameter of the eye or more; cheeks with many bright blue markings. *L. cyanellus* Rafinesque

aa. Posterior portion of the operculum bearing the black opercular spot thin and flexible; opercular spot large, its posterior margin coincident with the free margin of the opercular flap; a bright blue stripe extending from the ventral margin of the opercular spot along the operculum and lower jaw to the angle of the mouth or beyond. . . . . . *L. pallidus* (Mitchill)

Lepomis cyanellus Rafinesque

GREEN SUNFISH, BLUE-SPOTTED SUNFISH (Fig. 63)

Lepomis cyanellus Rafinesque, *Journ. de Physique*, p. 420, 1820 (Ohio River); JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 17, 1889 (Canyon City).

Apomotis cyanellus (Rafinesque)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); JUDAY, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Longmont).

Body somewhat elongate, quite deep and much compressed; back slightly elevated; depth about 2.5 in the length to the base of the caudal; head large, its length 3 or a little more in the length of the body; eye moderately large, its center nearer to the tip of the snout than to the posterior margin of the operculum, situated in the upper half of the head; diameter of the eye 4 to 5 in the head, about 1.25 in the snout, and 1.5 or a little more in the interorbital distance; posterior margin of the operculum broadly rounded; opercular flap under the blue-black opercular spot, bony; mouth large and terminal, lower jaw very slightly longer than the upper, angle of the mouth when closed not reaching the level of the anterior margin of the eye; spinous and soft dorsals broadly united, the spinous being the lower, the height of its longest spine about one-half the length of the longest ray of the soft dorsal; dorsal of IX or X spines and 10 to 12, usually 11, rays; pectorals small, 1.75 to 2 in the head; ventrals equal to or a little less than the pectorals, base of the spine of the ventral on the level with or slightly behind the last pectoral ray and separated from it by a distance equal to 1.5 the diameter

[1] *Rept. U.S. Com. Fisheries for 1894–95*, p. 53, 1896.

of the eye; anal fin short, of III spines and 9 or 10 rays, the length of its base 2 or more in the length of the base of the entire dorsal, base of the first anal spine on a level with the last dorsal spine or the first ray of the soft dorsal; caudal fin broadly rounded and not deeply forked; caudal peduncle broad, abruptly joined to the body just posterior to the dorsal and anal fins; scales large, cycloid, 7 or 8, 45–50, 15 to 17, lateral line prominent, strongly arched dorsally.

General color yellowish green, darker dorsally, shading into almost orange below; top of the head, premaxillaries and preopercula dark bluish green, the opercular region marbled with numerous bright, light-blue blotches; lower jaw lighter; opercular spot dark blue to almost black, its posterior margin and that of the operculum edged with white; body sometimes crossed by 8 or more incomplete, dusky, vertical bars (these bars quite prominent in young specimens and usually very indistinct in adults); dorsal, anal and caudal fins greenish yellow to olivaceous; the last three to five rays of the dorsal and anal fins, crossed near their bases by broad, ill-defined black spots, that of the dorsal often quite suffuse; scales rather distinctly outlined with dusky, giving the body a reticulated pattern; eye bright red; length up to 7 inches.

The Green Sunfish ranges from the Great Lakes region south throughout the Mississippi Valley and west into Colorado.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (2 specimens, 75–80 mm.), C. Juday and D. W. Spangler, No. 19; Boulder Lake, Boulder, May 29, 1912 (9 specimens, 100–125 mm.), Philip Miller, No. 398; Lodgepole Creek near Ovid, July 20, 1912 (3 specimens, 60–110 mm.), J. Henderson and M. M. Ellis, No. 399; Rio Grande, Alamosa, July 27, 1912 (6 specimens, 50–65 mm.), M. M. Ellis, No. 400; Republican River, Wray, October 26, 1912 (69 specimens, 30–150 mm.), A. G. Vestal and M. M. Ellis, No. 401; Sells Lake, Canyon City, November 8, 1913 (4 specimens, 30–35 mm.), A. G. Vestal and M. M. Ellis, No. 402; *State Historical and Natural Nistory Museum:* Wray, from mouth of a large watersnake, June 16, 1900 (100 mm.), H. G. Smith; Sloans Lake, near Denver, August 4 and 7, 1900 (2 specimens, 100–115 mm.), W. C. Ferril; Summit Lake near Denver, August 11, 1901 (80 mm.), W. C. Ferril. *Reported* common near Greeley, A. E. Beardsley.

Lepomis pallidus (Mitchill)

BREAM; BLUE GILL (Fig. 49)

Labrus pallidus Mitchill, *Tran. Litt. Phil. Soc. N.Y.*, p. 407, 1815 (New York).

Body short, much compressed and quite deep, broadly oval in outline; depth 2 to 2.3 in the length to the base of the caudal; head large and short, 3 to 3.5 in the length; eye moderately large, its diameter about equal to the length of the snout, and 3.5 to 4 in the length of the head; posterior margin of the operculum broadly rounded, the portion bearing the black opercular spot thin and flexible; angle of the mouth when closed not reaching the level of the anterior margin of the eye; dorsal fin long, of X spines and 10 to 12 rays; pectorals about equal to the head in length; ventrals shorter than the pectorals, inserted on or slightly behind the level of the last rays of the pectorals; anal short, length of its base 2 or a little more in the length of the base of the dorsal, anal spines III, rays 10 to 12; scales cycloid, 6 or 7, 38–50, 13 to 15.

General color greenish yellow, shading to orange or orange red below; sides of the body crossed by 5 to 7 indistinct, greenish, vertical bars, each bar from 3 to 5 series of scales in width; top and sides of the head greenish to olivaceous, a broad, light-blue, crescent-shaped band extending from the mouth along the lower jaw and ventral margin of the opercular structures to the base of the opercular spot; opercular spot black; fins dusky or bluish; last five or six rays of the soft dorsal crossed by a row of dark-brown or black spots.

The Blue Gill is one of the largest of the sunfishes, reaching the length of 18 inches and the weight of a pound or more. As a food fish it is much prized, the flesh being excellent. *Lepomis pallidus* is found in schools in the deep water just beyond the weeds along shore. It may be caught with almost any sort of bait, a fact which makes this fish quite popular with the amateur fisherman. The enormous number of this species taken in some parts of the Mississippi Valley is well shown by the statement of Forbes[1] that between 200,000 and 500,000 pounds of Blue Gills are caught annually in Illinois.

Lepomis pallidus ranges from the Atlantic Coast throughout the Mississippi and Great Lakes region south and west into Texas. It is here considered as an introduced fish in Colorado, since the writer was told by several citizens of Alamosa of its introduction into the Rio Grande and neighboring lakes. A species of sunfish described by Baird and Girard[2] from Brownsville, Texas, as *Pomotis speciosus* but now considered as a synonym of *Lepomis pallidus* is found in the lower Rio Grande.

Colorado specimen.—*University Museum:* Rio Grande, Alamosa, July 27, 1912 (120 mm.), M. M. Ellis, No. 403; *introduced* by U.S. Fish Com. in ponds at Pueblo, 1912.

Subfamily MICROPTERINAE

Genus **MICROPTERUS** Lacépède

The Black Bass

Micropterus Lacépède, *Hist. Nat. Poiss.*, Vol. IV, p. 325, 1802.

Dorsal fin deeply emarginate at the junction of the spinous and soft portions; anal spines III; body rather elongate in large specimens. The two species of this genus are the well-known Black Bass. Both the Large-mouthed and Small-mouthed Black Bass have been introduced into Colorado.

a. Angle of the mouth reaching the level of the eye or beyond; sides with a lateral stripe or a series of blotches along the lateral line; scales on the cheeks in about 10 rows. *M. salmoides* (Lacépède)

aa. Angle of the mouth barely if at all reaching the level of the anterior margin of the eye; no lateral stripe; scales on the cheeks in 17 rows. . . . . . . *M. dolomieu* Lacépède

[1] FORBES AND RICHARDSON, *Ichthyology of Illinois*, p. 259, 1909.

[2] *Proc. Acad. Nat. Sci. Phila.*, p. 24, 1854.

Micropterus salmoides (Lacépède)

LARGE-MOUTHED BLACK BASS (Fig. 50)

Labrus salmoides Lacépède, *Hist. Nat. Poiss.*, p. 716, 1802 (South Carolina).

Micropterus salmoides (Lacépède)—JUDAY, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder); JUDAY, *Bull. U.S. Fish Com., for 1904*, p. 227, 1905 (Cubertson's Lake).

Body somewhat elongate, distinctly compressed; depth 3 to 3.25 in the length to the base of the caudal; head large, compressed; interorbital region somewhat flattened; length of the head 3 or a little less in the length of the body; eye large, situated in the anterior half of the head near the latero-dorsal margin, diameter of the eye 5 (young) to 7.5 in the length of the head; nostril small, situated slightly in front of the eye and a little below the dorsal margin of the eye; mouth quite large, terminal, angle of the mouth when closed reaching to behind the level of the anterior margin of the eye (adults), posterior margin of the maxillary reaching to behind the orbit, lower jaw slightly exceeding the upper; premaxillaries protractile; spinous and soft dorsals narrowly united at the base, the soft dorsal the longer and the higher, the length of its longest ray almost twice that of the longest spine; spines X, sometimes XI, rays 12 or 13; pectorals short, their length about 2 in the head; ventrals equal to or a little longer than the pectorals; base of the ventrals almost or quite confluent, inserted on a level with the last pectoral rays; anal short, length of its base less than that of the spinous dorsal, anal spines III, rays 10 or 11; caudal peduncle broad, somewhat upturned, caudal large, lunate; scales rather large, cycloid or feebly ctenoid in the suprapectoral region, becoming strongly ctenoid on the caudal peduncle, 7 or 8, 60–70, 14 to 17; lateral line prominent, distinctly arched dorsally.

General color olive-green, darker dorsally, sides with a metallic to almost brassy luster; a very strong, dark-green to almost black lateral stripe, covering portions of three or four rows of scales, extending from the base of the caudal to the posterior margin of the eye, continuous and very distinct in young specimens, more or less interrupted in medium-sized individuals and often quite indistinct in large adults; numerous small dusky spots, covering portions of two or three scales in the region below the lateral stripe, these spots being especially prominent in young and medium-sized individuals; under parts whitish, more or less overlaid with dusky in the region below the operculum and below the lower jaw; a light stripe crossing the operculum from the tip of the snout toward the pectoral; maxillary dark green above, lighter below; top of the head very dark green; eye dark red; caudal, pectorals and ventrals dusky, dorsal hyaline, spines and rays outlined with dusky, anal yellowish with dusky spines and rays.

The Large-mouthed Black Bass, or Straw Bass as it is often called, is one of the most important of the North American game fishes. From the standpoint of the angler it ranks among the very best while its general hardiness and rapid growth make it suitable for many types of inland waters. Besides it is a fish of good size, reaching in the southern states, where the waters are warm and the food supply optimum the year round, a weight of 14 to 20 pounds,[1] the maximum size in the northern states being about 8 pounds.

Micropterus salmoides ranges from the Red River of the North south into Florida and Mexico, inhabiting small lakes, the quieter portions of rivers and even the brackish waters of some salt marshes. It has been introduced with great success into the western states and into several European countries. The food of the adult bass consists of small fishes, including the young of its own species, crayfish, frogs, tadpoles and insects. Since the food taken is found most abundantly in weeds near shore, the deep water at the edge of this zone is the favorite habitat of the black bass, from which it may charge its prey. This fact is well known to anglers who find the deep water at the edge of the weeds a choice place for casting.

The Large-mouthed Black Bass spawns in spring, from April into June, laying its eggs preferably on a sandy bottom. The eggs are guarded with great zeal by the adult fish. The rapidity with which the young bass develop and the high rate of reproduction may be shown by the statement of Jordan and Evermann[2] that from seven or eight females the United States Fish Commission raised over 37,000 young bass 3 to 4 inches in length and 500 weighing about one-half pound in a single season, the fishes being kept in captivity from June until Thanksgiving. It is an introduced fish in Colorado.

Colorado specimens.—*University Museum:* Boulder Lake, Boulder, October 29, 1903 (10 specimens, 55–140 mm.), C. Juday and J. Henderson, No. 33; Lodgepole Creek near Ovid, July 20, 1912 (12 specimens, 90–110 mm.), J. Henderson and M. M. Ellis, No. 275; Republican River, Wray, October 26, 1912 (14 specimens, 30–170 mm.), A. G. Vestal and M. M. Ellis, No. 404; Youngman's Reservoir, Boulder, October 16, 1913 (180 mm.), M. M. Ellis; *State Teachers' College Museum:* Windsor Lake near Greeley, A. E. Beardsley.

Micropterus dolomieu Lacépède

SMALL-MOUTHED BLACK BASS, TIGER BASS

Micropterus dolomieu Lacépède, *Hist. Nat. Poiss.*, Vol. IV, p. 325, 1802 (probably South Carolina).

Body somewhat elongate, distinctly compressed; depth about 3 in the length to the base of the caudal fin; head large and compressed, its length 2.8 (young) to 3.5 in the length to the base of the caudal; top of the head not much flattened; eye moderately large, its diameter less than the length of the snout, 5.5 to 7 in the head; posterior margin of the operculum broadly rounded; nostrils small, situated slightly in front of the eye near the lateral margin of the side of the head; mouth terminal and large, angle of the mouth when closed reaching the level of

[1] HENSHALL, *Bass, Pike, Perch and Others*, p. 33, 1903, New York; JORDAN AND EVERMANN, *American Food and Game Fishes*, p. 358, 1902, New York.

[2] JORDAN AND EVERMANN, *ibid.*

the anterior margin of the eye; maxillary never extending behind the eye; premaxillaries protractile; lower jaw very slightly longer than the upper; spinous and soft dorsals narrowly united, the soft dorsal the higher, spinous dorsal of X, rarely XI spines, soft dorsal of 13 to 15 rays; pectorals about 1.5 in the head; ventrals slightly smaller than the pectorals, base of the ventral spine on a level with the last ray of the pectoral; anal short, the length of its base less than that of the soft dorsal; anal spines III, rays 10 to 12; caudal peduncle broad, somewhat upturned; caudal fin slightly notched; scales moderately large, feebly ctenoid, or rarely cycloid in the anterior portion of the body, becoming strongly ctenoid posteriorly; scales 10 to 12, 66–80, 19 to 21; lateral line prominent, strongly arched dorsally; scales in about 17 rows on the cheeks.

General color olivaceous with a silvery luster, dorsal parts darker, body above the lateral line with numerous faint, irregular, wavy streaks of dark olive-green; color shading to grayish or greenish white below; body below the lateral line crossed by twelve or more indistinct greenish bars; no distinct lateral stripe; cheeks with five or more olive-green bars radiating from the posterior margin of the eye, a greenish bar from the anterior margin of the eye extending to the tip of the snout; eye dark reddish brown; fins uniformly greenish. Color somewhat variable, bars and stripes more distinct in breeding females.

The Small-mouthed Black Bass or Tiger Bass excells the Large-mouthed Black Bass in the fighting qualities which make it so highly prized as a game fish. It is, however, a smaller fish than the latter and is restricted to colder and clearer water than that in which the Large-mouth may be found. The maximum size reached by the Tiger Bass is about 5 pounds.

Micropterus dolomieu ranges from southern Canada south into Arkansas. It has been widely introduced in many states and is quite successful where conditions are favorable. The only record obtained in the present study is from Canyon City, where the Tiger Bass has been planted.

Colorado specimen.—*University Museum:* Sells Lake, Canyon City, September, 1913 (90 mm.), F. A. Reidel, No. 405.

Family *PERCIDAE*

The Perch and Darters

Spinous and soft dorsal fins separate; scales strongly ctenoid; mouth large; species carnivorous; fishes of the fresh waters of the northern hemisphere.

The North American species of *Percidae* may be divided into two groups on the basis of size. The few large Percids include some of the favorite game and food fishes of the northern lakes, the Wall-eyed Pike, the Sauger and the Yellow Perch. The small perch are known as Darters, of which about one hundred species are recognized. These little fishes inhabit the small brooks and rapidly moving streams, avoiding the warm and stagnant waters. Most of the Darters are quite small, few exceeding three inches in length and some never reaching the length of one and a half inches. It is to this group that the three species of *Percidae* native in Colorado are referable. Two species of large Percids, the Wall-eyed Pike and the Yellow Perch, have been introduced into the lakes and reservoirs of eastern Colorado, so that in all four genera are now represented in the state.

Key to Percidae Represented in Colorado

a. Jaws with large canine teeth; size large, length up to three feet; body elongate. *Stizostedion* Rafinesque, p. 103

aa. Jaws without canine teeth; size smaller, length under 15 inches.

- **b.** Soft dorsal fin with II or III spines; depth 3 to 3.5 in the length; preoperculum with a serrate margin; dorsal spines XII to XVI; anal spines II; size large, length of adults exceeding 6 inches . . . . *Perca* (Artedi) Linnaeus, p. 104
- **bb.** Soft dorsal fin without spines; depth 4 to 6 in the length; preoperculum without a heavily serrate margin; dorsal spines VII to XV; anal spines I or II; adults always less than 6 inches in length.
  - **c.** Anal spines II; premaxillaries not protractile . . . *Etheostoma* Rafinesque, p. 107
  - **cc.** Anal spine I; premaxillaries protractile . . . . . *Boleosoma* DeKay, p. 110

Subfamily Luciopercinae

Genus **STIZOSTEDION** Rafinesque

The American Pike Perches

Stizostedion Rafinesque, *Ichthyologia Ohiensis*, p. 23, 1820.

Body elongate, size large; jaws with large canine teeth; premaxillaries protractile; scales small and strongly ctenoid.

This genus includes two large carnivorous perches, native in the upper Mississippi drainage, one species of which has been introduced into a few of the lakes of eastern Colorado.

Stizostedion vitreum (Mitchill)

Wall-eyed Pike

Perca vitrea Mitchill, *Supp. Amer. Month. Mag.*, Vol. II, p. 247, 1818 (Cayuga Lake, New York).

Body elongate and somewhat compressed; depth 4.25 to 5 in the length to the base of the caudal fin; head large and long, about 3.5 in the length of the body; eye large and prominent, its diameter 4.75 to 6 in the length of the head; center of the eye nearer to the tip of the snout than to the posterior margin of the operculum; mouth large, angle of the mouth reaching the level of the center of the eye, lower jaw slightly longer than the upper; both jaws with large canine teeth; spinous dorsal separated from the soft dorsal by a distance equalling the diameter of the eye, longest spine of the spinous dorsal exceeding in length the longest ray of the soft dorsal, base of the first spine of the dorsal on a level with the spine of the ventral, base of the first ray of the soft dorsal on a level with the first spine of the anal, dorsal spines XII to XIV, rays 19 to 22; anal spines II, rays 12 to 14; scales rather small, strongly ctenoid, 10 to 12, 80–100, 20 to 25; size large; reaching length of 3 feet and a weight of 10 pounds or more.

Color olivaceous above, shading to almost white below, sides brassy; region above the lateral line mottled with dusky spots; dorsals and caudal dusky, the soft dorsal and the caudal somewhat barred with rows of spots on the rays; eye brown, golden yellow near the center, cornea milky white, hence the name, "Wall-eye."

This species ranges throughout the central portion of the Mississippi Valley, being quite abundant in the northern lakes. It is a voracious fish feeding upon other fishes[1] and to some extent on crayfish. Because of its large size and vigorous fighting when hooked as well as its firm white flesh it is prized as a game fish of considerable importance. It is known in Colorado only from a few of the eastern lakes where it has been introduced from the East.

Subfamily PERCINAE

Genus **PERCA** (Artedi) Linnaeus

The River Perch

Perca (Artedi) Linnaeus, *Systema Naturae*, ed. X, 1758.

Body compressed, not much elongate; back elevated; spinous dorsal of XII to XVI spines; size moderately large.

The three species of this genus are known from the northern hemisphere only, one occurring in Asia, one in Europe and one in North America. They are locally quite abundant and are esteemed as food fishes. The American species has been introduced into the lakes and ponds of eastern Colorado and from these has escaped into some of the streams.

Perca flavescens (Mitchill)

YELLOW PERCH, RINGED PERCH

Morone flavescens Mitchill, *Rept. Fish. N.Y.*, p. 18, 1814.

Body somewhat elongate, distinctly compressed, especially in the posterior half, back elevated; depth 3 to 3.5 in the length to the base of the caudal; head large and compressed, its length equal to or slightly greater than the depth of the body; top of the head slightly depressed just above the eyes, making the snout rather prominent; snout 3.5 to 4 in the head; eye large, situated in the dorsal half of the head, nearer to the tip of the snout than to the posterior margin of the operculum; dorsal margin of the eye about one-fourth the length of the snout from

[1] Forbes, *op. c.*, pp. 273 and 274, states that "reckoning the average life of a pike at three years, the smallest reasonable estimate of food for each pike-perch would fall somewhere between eighteen hundred and three thousand fishes"; also that "the young [wall-eye] begin to practice their carnivorous instincts on each other when only about ten days old."

the top of the head; diameter of the eye about 5 in the head; middle of the posterior margin of the operculum produced to beyond the origin of the pectorals, with several irregular serrations; preoperculum strongly serrate posteriorly; nostril small; mouth large and terminal, angle of the mouth reaching to below the eye; lower jaw very slightly if at all longer than the upper; premaxillaries protractile; dorsal fins separate, the spinous dorsal the longer; spinous dorsal of XII to XIV spines, its base almost twice the length of the pectoral, the first spine on a level with the origin of the pectorals; soft dorsal of II or III spines and 12 to 14 rays, its base shorter than that of the spinous dorsal, about equal to the length of the pectoral; pectorals large, 1.5 to almost 2 in the head; ventrals about the same size as the pectorals or slightly larger, inserted well forward, the base of the first ray of the ventral a little more than the diameter of the eye from the base of the last ray of the pectoral; anal short, higher than long, its base about one-half the length of the pectoral, with II spines and 7 or 8 rays, base of the first spine posterior to the level of the first spine of the soft dorsal; caudal large, not deeply forked, and somewhat rounded, its greatest width very little less than the greatest depth of the body; scales moderately large, ctenoid, with 6 or more prominent basal lobes, basal radii 5 to 7, circuli regular and concentric to the margin of the scale, apical third of the scale with short strong teeth; lateral line complete, arched dorsally; scales 6 or 7, 55–70, 15 to 18; cheeks scaled.

Color brassy yellow shading into olive-green dorsally, ventral parts almost white; six or more vertical greenish bars four to ten scale series in width, extending from the mid-dorsal region to within four to six rows of scales of the mid-ventral line; top of the head bluish green; spinous dorsal dark grayish green, spines lighter; soft dorsal and caudal greenish; ventrals and anal hyaline to white, rays and spines yellowish to orange; pectorals greenish yellow. Size medium, length of average adults 9 to 12 inches.

The Yellow Perch ranges from Canada south into central Indiana and Illinois, along the Atlantic Coast to the Neuse River, west into South Dakota. It has been introduced with success into Montana and Colorado and the Pacific states. As a native fish it is particularly abundant in the Great Lakes and adjacent waters. This species is a general favorite with the common fisherman, since it will take almost any sort of bait and its size and flavor make it a very desirable food fish. In the Great Lakes it is caught more frequently perhaps than any other species. The enormous number taken may be shown by the statement of the Michigan Fish Commission that in 1908, 1,983,920 pounds of Yellow Perch were taken from Saginaw Bay, Michigan, alone.[1] The brightly colored ventral fins of this species are often used as a fly-bait for bass and wall-eyed pike in the northern lakes.

Perca flavescens is distinctly a lake fish. It is carnivorous, haunting the shore-weed zone, although it is rarely taken in less than three feet of water. In large

[1] LEATHERS, *Michigan Geol. Biol. Survey*, Publ. 4, Biol. Ser. 2, p. 247, 1911.

lakes it is usually quite abundant to a depth of twenty feet. The stomach contents of this species as examined by various writers in different parts of the country show the food of the adult perch to be made up of large insects and their larvae, crayfish and the young of other fishes, other food being taken as opportunity offers.[1] The Yellow Perch lays its eggs in long strings on a sandy bottom near shore. These egg strings are not infrequently found entangled in the vegetation near shore. The spawning takes place in the latter part of April and during May.

Colorado specimens.—*Colorado State Historical and Natural History Museum:* Sloans Lake near Denver, August 4, 1900 (125 mm.), W. C. Ferril; Berkley Lake near Denver, August 18, 1900 (180 mm.), W. C. Ferril; Barr Lake, Adams County, July 20, 1907 (5 specimens, 100–155 mm.), H. G. Smith; *State Teachers' College Museum:* Lakes near Greeley, A. E. Beardsley; *Colorado College Museum:* Cache la Poudre River near Greeley, I. C. Hall.

Subfamily ETHEOSTOMINAE

The Darters

The fishes of this group are found only in the cold clear brooks, small streams and shallow portions of the inland lakes of North America, particularly of the northern portion of the Mississippi drainage. The species, which number a hundred or more, are all of the same general shape and have the same type of behavior. Morphologically they differ from the other perches in the small, fusiform body, the large pectoral fins and the much-reduced air bladder. Derived from the true perch stock, they now occupy a very definite position in the ecology of the small streams and lakes, in that they have taken the otherwise little-used food supply existing under stones and on the bottom. By means of their well-developed pectoral fins darters are able to hold themselves on the bottom against a very rapid current of water, the much-reduced or almost functionless air bladder making such a position possible. In this way darters have reached the headwaters of many streams. The feeding habits and general activities of these interesting little fishes show them to be, as Forbes has written, not so much dwarfed as concentrated fishes. When undisturbed the darter remains quietly on the bottom with the pectoral fins braced, head upstream and the body often partly curled about a stone or some other object. Upon becoming alarmed or otherwise interested a sudden movement of the pectorals places the fish some inches upstream, where it immediately adjusts itself to the new surroundings, appearing as a permanent part of the whole. When taking food the darter approaches the prospective prey carefully and cautiously, darting upon it suddenly and as quickly resuming the absolute quiet which contrasts so strongly with its movements. The species of darters, the breeding activities of which have been studied, mate in the spring. At this time the males of some species have very elaborate nuptial colors. Few

[1] See HANKINSON, *Rept. Mich. Geol. Biol. Survey for 1907*, p. 215; FORBES AND RICHARDSON, *Fishes of Illinois*, p. 277, 1909.

groups of animals will prove more interesting to the patient observer, and of the three species recorded from Colorado detailed studies of the particular activities of but one, *Boleosoma nigrum*, have been made.

Genus **ETHEOSTOMA** Rafinesque

The Darters

Etheostoma Rafinesque, *Journ. de Physique*, p. 419, 1819.

Size small, species numerous and variable; distinguished from many of the closely related genera by the non-protractile premaxillaries.

Two species of this genus occur in Colorado.

a. Humeral region with a rather conspicuous black scale or process and a dusky spot; species of the Arkansas drainage. . . . . *E. cragini* Gilbert

aa. Humeral region without a black scale or process, although occasionally with a faint dusky spot; species of the South Platte drainage. . . . . *E. iowae* Jordan and Meek

Etheostoma cragini Gilbert

CRAGIN'S DARTER (Fig. 52)

Etheostoma cragini Gilbert, *Bull. Washburn College Lab.*, p. 99, 1885 (tributary of the Arkansas at Garden City, Kansas); JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 17, 1889 (pond at Canyon City).

Body elongate, distinctly compressed back of the pectorals; depth 4.25 to 5 in the length to the base of the caudal fin; head rather short, its length 3.5 to 4 in the length of the body; snout short and blunt, 4.5 to 5 in the length of the head; eye rather large, situated in the anterior half of the head, dorsal margin of the eye on a level with or slightly above the top of the head; diameter of the eye exceeding the length of the snout, 4 or a little more in the head; mouth moderately large, terminal, slightly oblique, angle of the mouth barely reaching the level of the anterior margin of the orbit; premaxillaries not protractile, frenum narrow, about one-half the diameter of the eye; spinous and soft dorsals separate, the soft dorsal being the higher, length of the base about equal to that of the spinous dorsal, spines VII to IX, rays 9 to 11; pectorals large, 1.25 to 1.5 in the length of the head; ventrals small; anal short, length of its base less than that of the soft dorsal, of II spines and 6 to 8 rays; scales ctenoid, 6, 45–55, 9 or 10; lateral line interrupted; cheeks naked or rarely with a few scales.

General color dark olivaceous above, lighter below; scales in the region above the lateral line outlined with dusky, giving that portion of the body a distinctly reticulated pattern; 7 to 10 very poorly defined, dusky blotches on the sides above the lateral line, some of the blotches being so indistinct that they are little more than faint W-shaped marks; a conspicuous dusky bar extending from the middle of the ventral margin of the orbit to the ventral margin of the side of the head, a second less distinct bar of about the same size extending backward from the middle of the posterior margin of the eye to the middle of the operculum where it breaks up into a suffuse dusky spot; posterior margin of the operculum with a dark spot; a small but distinct black humeral spot; sides of the body sprinkled with minute dots of blue or black; dorsal fins brick red, caudal reddish to orange, pectorals, ventrals and anal yellowish; rays of the fins crossed with several rows of black spots giving them a barred appearance, the 7 or 8 rows of spots on the caudal very conspicuous, the 4 or 5 rows on the soft dorsal quite prominent, the 4 or 5 rows crossing the pectorals rather indistinct, and the rows of spots on the ventrals and anal quite indistinct. Size very small; length under 2 inches.

Cragin's Darter is known only from the Arkansas River and its tributaries west of Garden City, Kansas.

Colorado specimens.—*University museum:* Outlet to Sells Lake, Canyon City, November 8, 1913 (5 specimens, 35–52 mm.), A. G. Vestal and M. M. Ellis, No. 406.

Etheostoma iowae Jordan and Meek

Iowa Darter

Etheostoma iowae Jordan and Meek, *Proc. U.S. Nat. Mus.*, p. 10, 1885 (Chariton River, Chariton, Iowa); Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Longmont); Cockerell, *Univ. Colo. Studies*, Vol. V, 1908 (Boulder Creek, Boulder); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Longmont).

Body elongate, compressed back of the pectorals, depth 4.75 to 6, usually about 5.25, in the length to the base of the caudal; head long and rather compressed, somewhat flattened dorsally, its length 3.25 to 4 in the length of the body; snout short and blunt; eye large, its center about twice as far from the posterior margin of the operculum as from the tip of the snout, situated above the middle of the side of the head, dorsal margin of the eye on a level with or slightly higher than the top of the head; diameter of the eye greater than the interorbital distance, equal to or usually greater than the length of the snout, and 4 to 5 in the head; nostrils small, just below the dorsal margin of the side of the head and about one-third of the distance from the tip of the snout to the eye in front of the eye; mouth moderately large, terminal and slightly oblique; angle of the mouth reaching the level of the nostrils; premaxillaries not protractile, frenum narrow, about one-half the diameter of the eye; dorsals separate, the soft dorsal slightly higher than the spinous dorsal, spine VIII or IX, rays 8 to 11, the first spine of the dorsal slightly behind the origin of the pectorals, first ray of the soft dorsal in front of the anal opening; pectorals rather large, a little more than 1 in the head; ventrals small; anal smaller than the soft dorsal, anal spines II, rarely I, rays 6 to 8, usually 7; scales small and strongly ctenoid, with 8 to 12 basal radii and 10 to 15 apical teeth; lateral line interrupted; scales 5 to 7, 55–61, 9 to 11; cheeks and opercula scaled; general body form much the same as that of young specimens of *Boleosoma nigrum*.

General color greenish to olivaceous, darker dorsally; mid-dorsal region with 7 or more blotches of dark brown; lateral line region crossed by 8 or more irregular bars of dark brown or blackish brown, each of which is more or less connected with one of the dorsal blotches and covers portions of 5 to 7 rows of scales; the space between the dorsal blotches and lateral line bars forming an irregular, somewhat interrupted longitudinal stripe, lighter than the adjacent bars and blotches; spaces between the bars crossing the lateral line light chocolate brown in color; sides of the body below the lateral line markings yellowish or greenish, sometimes with a well-defined stripe of burnt orange extending from the origin of the pectorals to the anal fin; ventral parts yellowish white; top of the head dark to almost black, sides of the head much mottled with black and brown; a very distinct wedge-shaped bar of black or dark brown extending from the middle of the ventral margin of the orbit to the ventral margin of the side of the head; mouth and sides of the premaxillaries light yellow to whitish; fins hyaline, often dusky, the rays crossed by several series of dark-brown dots which give the fins as a whole a barred appearance, these bars most distinct on the caudal which is crossed by 6 or 7 rows, quite distinct on the soft dorsal which has 4 to 6 rows, and usually very faint on the other fins; males in breeding colors with all the markings just described quite prominent and in addition the membranous portion of the spinous dorsal between the rays is colored lilac or purple in the basal half of the fin and vermilion in the outer half, the outer margin edged with bright blue, the ventral parts also have more yellow or orange; size small; not exceeding two inches and a half in length.

The Iowa Darter has been taken in northern Illinois and as far north as Fort Qu'Appelle, Canada. The Colorado records are the most westerly for *Etheostoma iowae.* This darter is a species of the cold rapid streams and lakes of the northwestern portion of the Mississippi drainage. It seems to be one of the most hardy species of the group, since it has been taken farther north and west than any other darter and at the same time as far south as Arkansas.

The stomach contents of six specimens from Longmont, October 17, 1903, showed the food of this species to be of the same type as that of other species of the genus.[1] The data are given below:

45 mm., caddis-fly larvae, 100 per cent.
47 mm., " " " , 50 per cent; Chironomid larvae, 25 per cent. Not full.
47 mm., " " " , 50 per cent; small annelids, 25 per cent; gastropods, 25 per cent.
50 mm., Chironomid larvae, 100 per cent.
50 mm., " " , 50 per cent; small gastropods, 50 per cent.
50 mm., " " , 75 per cent; small annelids, 10 per cent; a few Entomostraca; one small gastropod.

A specimen of this darter taken from West Plum Creek near Castle Rock, June 8, 1912, was in breeding colors.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (6 specimens, 45–55 mm.,), C. Juday and D. W. Spangler, No. 29; West Plum Creek near Castle Rock, June 8, 1912 (2 specimens, 35–45 mm.), A. G. Vestal and M. M. Ellis, No. 407.

[1] See Forbes and Richardson, *Ichthyology of Illinois*, p. 279, 1909.

Genus **BOLEOSOMA** DeKay

The Tessellated Darters

Boleosoma DeKay, *New York Fauna*, "Fishes," p. 20, 1842.

Much like *Etheostoma;* premaxillaries protractile; breeding males not so brightly colored as in *Etheostoma;* represented in Colorado by but a single species.

Boleosoma nigrum (Rafinesque)

Johnny Darter

Etheostoma nigrum Rafinesque, *Ichthyologia Ohiensis*, p. 37, 1820 (Green River, Kentucky); Jordan, *Bull. U.S. Fish Com.*, Vol. IX, p. 8, 1889 (Denver).

Boleosoma nigrum (Rafinesque)—Juday, *Univ. Colo. Studies*, Vol. II, p. 113, 1903 (Boulder; Longmont); Juday, *Bull. U.S. Fish Com. for 1904*, p. 227, 1905 (Boulder; Longmont).

The Johnny Darter is a very widely distributed species ranging over the whole of northern and central United States east of the Rocky Mountains. As might be expected from its range and the variation of closely related species, several subspecies of *B. nigrum* have been recognized. All of the Colorado specimens examined in the present study differ from the typical *B. nigrum* in having smaller eyes and a greater number of bands crossing the soft dorsal and the caudal fins. This difference in the size of the eye places the Colorado specimens in the subspecies *B. nigrum mesaeum* (Cope) as redescribed by Jordan and Evermann,[1] in which the diameter of the eye is 5 in the length of the head. This subspecies was founded by Cope on a single specimen collected from the Platte River, Fort Kearney, Nebraska. The type unique was exceptional in having a ventral fin formula of I, 4, a count verified by Jordan and Evermann (*l.c.*). All of the Colorado specimens counted had a ventral fin formula of I, 5, and since this is the typical formula for all *Etheostominae*, Cope's specimen may have been abnormal in that respect. In other characters the Colorado specimens of *B. nigrum* agree fairly well with Cope's *B. mesaeum*, although from the appended table (VII) it may be seen that a variation exists from the *B. mesaeum* type to the typical *B. nigrum*. The reduction in the diameter of the eye, on the other hand, may be merely a character of western specimens, since individuals of this species have been described from Big Stone Lake, Minnesota, by Jordan and Evermann,[2] with an eye diameter of 4 to 4.5 in the head.

Concerning the number of bands of spots crossing the soft dorsal and caudal fins no data are given for *B. nigrum mesaeum* (Cope) by Jordan and Evermann, so the relation of that species to the Colorado specimens cannot be discussed as regards this character. The Colorado specimens have 5 or 6 rows of bars crossing the soft dorsal and 6 to 8 rows crossing the caudal. A typical *B. nigrum* from Illinois as figured by Forbes[3] has four rows of bars on the soft dorsal and four crossing the caudal fin.

[1] *Bull. 47, U.S. Nat. Mus.*, p. 1059, 1896. [2] *Ibid.*, p. 1056.

[3] Forbes and Richardson, *Ichthyology of Illinois*, pl., p. 296, 1909.

TABLE VII

VARIATION IN COLORADO SPECIMENS OF *Boleosoma nigrum*

ST. VRAIN CREEK, LONGMONT, OCTOBER 17, 1903

Length	Diameter of Eye in Head	Dorsal Spines VIII	Dorsal Spines IX	Cheeks	
				Scaled	Naked
70...........	4.6	×	....	×	....
70...........	4.6	×	....	....	×
65...........	4.5	×	....	×	....
65...........	4.25	....	×	....	×
62...........	4.5	....	×	×	....
60...........	4.0	×	....	....	×
50...........	4.0	....	×	×	....
35...........	4.75	....	×	×	....
		4	4	5	3

BOULDER CREEK, BOULDER, OCTOBER, 1903

Length	Diameter of Eye in Head	Dorsal Spines VIII	Dorsal Spines IX	Cheeks Scaled	Cheeks Naked
60...........	4.5	....	×	....	×
55...........	4.5	....	×	×	....
55...........	4.25	×	....	×	....
55...........	4.2	×	....	×	....
40...........	4.1	....	×	×	....
35...........	3.5	×	....	×	....
		3	3	5	1

BOULDER CREEK, BOULDER, JULY 25, 1912

Length	Diameter of Eye in Head	Dorsal Spines VIII	Dorsal Spines IX	Cheeks Scaled	Cheeks Naked
55...........	4.2	×	....	×	....
55...........	4.25	×	....	×	....
55...........	4.25	×	....	....	×
55...........	4.25	×	....	×	....
55...........	4.5	×	....	....	×
		5	0	3	2

WEST PLUM CEEEK NEAR CASTLE ROCK, JUNE 8, 1912

Length	Diameter of Eye in Head	Dorsal Spines VIII	Dorsal Spines IX	Cheeks Scaled	Cheeks Naked
70...........	5.0	....	×	×	....
60...........	4.75	×	....	×	....
60...........	5.0	×	....	×	....
55...........	4.5	×	....	×	....
45...........	4.5	....	×	×	....
40...........	4.0	×	....	....	×
		4	2	5	1
Total, 25 specimens		16	9	18	7

Considering the data, it seems proper to refer the Colorado specimens to the subspecies *Boleosoma nigrum mesaeum* (Cope).

Boleosoma nigrum mesaeum (Cope) (Fig. 51)

Poecilichthys mesaeus Cope, *Proc. Acad. Nat. Sci. Phila.*, p. 232, 1864 (Platte River near Fort Kearney, Nebraska).

Boleosoma nigrum mesaeum (Cope)—Jordan and Evermann, *Bull. 47, U.S. Nat. Mus.*, p. 1059, 1896.

Body elongate, not much compressed; depth 4.6 to 6 in the length to the base of the caudal; head rather large and broad; top of the head somewhat flattened, width of the head 1.5 to almost 2 in the length of the head, which is 3.8 to 4.25 in the length of the body; eye large, situated above the middle of the side of the head, center of the eye nearer to the tip of the snout than to the posterior margin of the operculum by almost the length of the snout; dorsal margin of the eye higher than the flattened top of the head; diameter of the eye greater than the interorbital distance, barely equal to or usually less than the length of the snout, 3.5 to 5, usually 4.25 to 4.5 (see Table VII), in the length of the head; snout short and blunt; mouth terminal, slightly oblique, lips rather fleshy, lower included by the upper; angle of the mouth barely if at all reaching the level of the anterior margin of the eye; premaxillaries protractile; operculum with a heavy spine, directed caudally on a level with the lateral line;[1] base of the spinous dorsal shorter than that of the soft dorsal, soft dorsal scarcely separated from the spinous dorsal, base of the first ray of the soft dorsal inserted slightly behind the level of the ventrals, spines VIII or IX, rays 12 or 13; pectorals large; ventrals small, of I spine and 5 rays; anal small, of I spine and 8 or 9 rays, base of the spine behind the level of the first ray of the soft dorsal; caudal large, fan-shaped, not forked; scales rather small, closely imbricated, strongly ctenoid, with about 16 basal radii, 4 or 5, 42–54, 7 to 9; cheeks scaled or naked.

Color above greenish brown to dusky; mid-dorsal region with 4 or 5 saddle-shaped bands of dark brown which extend down each side for two or three rows of scales; lateral line crossed by 10 or more irregular black marks which often resemble the letters W, M or N; below this row of marks another of smaller blotches usually present, these alternating with those crossing the lateral line; most of the scales above the lateral line and many below it outlined with dusky, giving the entire fish more or less of a reticulate pattern; ventral parts yellowish or pinkish white, somewhat sprinkled with dusky; top of the head dark; a rather conspicuous dusky bar extending from the tip of the snout to the anterior margin of the eye and a less prominent bar below the middle of the ventral margin of the eye; opercular region dusky, usually with a dusky spot; rays of the soft dorsal, caudal, and to some extent the ventrals, crossed by rows of dusky spots which give

[1] One indvidual, 65 mm., Boulder Creek 6 miles east of Boulder, July 25, 1912, had a normal spine on the left operculum, while that on the right operculum was directed ventrally at an angle of about sixty degrees from the normal position.

the fins a barred appearance, 5 to 7 rows on the soft dorsal and 7 to 9 rows on the caudal; ventrals and anal but faintly marked. Males in breeding season with the fins and head dark to almost black.

This interesting little fish is one of the best known of the darters. Like the other species of this subfamily, it feeds and is generally found on the bottom of the stream. Here it moves rapidly about among the small stones, often using the pectoral and ventral fins as supports by resting them on the bottom. When disturbed it darts away or it may almost bury itself in fine sand which it stirs up with the caudal fin. Although generally occurring in shallow, rapid streams or in lakes, it was found to be rather abundant in a deep broad pool with a silt bottom, back of a beaver dam on West Plum Creek.

Colorado specimens.—*University Museum:* St. Vrain Creek, Longmont, October 17, 1903 (9 specimens, 40–70 mm.), C. Juday and D. W. Spangler, No. 39; Boulder Creek, Boulder, October, 1903 (59 specimens, 20–60 mm.), C. Juday and J. Henderson, No. 35; Boulder Creek 6 miles east of Boulder, July 25, 1912 (7 specimens, 55–60 mm.), M. M. Ellis, No. 408; West Plum Creek near Castle Rock, June 8, 1912 (13 specimens, 40–60 mm.), A. G. Vestal and M. M. Ellis, No. 409; *State Teachers' College Museum:* Greeley, A. E. Beardsley. *Reported* very common at Greeley before the advent of the sugar factories, by A. E. Beardsley.

Order Loricati

The Rockfishes, Sea Robins and Sculpins

Scales present or wanting; body often with bony scales or plates; a bony process extending across the cheek from below the eye to the preoperculum.

Family *COTTIDAE*

The Sculpins

Body rather elongate, more or less fusiform; head large, broad and depressed; scales wanting in most species (some species are irregularly scaled above the lateral line), skin often rough and covered with minute prickles; lateral line present and prominent; third suborbital bone connected with the preoperculum by a bony stay; air bladder usually wanting.

The Sculpins are rather small fishes found in both fresh and salt waters, many species living along the rocky coasts. Other forms inhabit rather deep water, as the species of *Triglopsis*, the Deep-water Sculpins of the Great Lakes. The more common fresh-water sculpins are species of the cold, rapidly moving brooks and mountain streams with rock or gravel bottoms. The food of such sculpins as have been studied shows the *Cottidae* to be voracious carnivorous forms often quite destructive to the eggs and young of other fishes. Both individuals and species are quite variable, and as Jordan and Evermann[1] state, "almost every species has an individuality of its own, and among the marine forms it is necessary to recognize

[1] *Bull. 47, U.S. Nat. Mus.*, p. 1880, 1898.

almost as many genera as species." This variability has resulted in the publication of descriptions of several probably synonymous species. A single species of Sculpin occurs in Colorado.

Subfamily COTTINAE

Genus **COTTUS** (Artedi) Linnaeus

The Fresh-Water Sculpins

Cottus Artedi, *Genera Piscium*, p. 49, 1738.
Cottus Linnaeus, *Systema Naturae*, ed. X, p. 264, 1758.

Scales wanting; skin rather smooth; prickles when present most abundant near the axils of the pectoral fins; each ventral fin with I short, concealed spine and 4 soft rays.

The species of this genus occur in the fresh waters of North America, Asia and Europe.

Cottus punctulatus (Gill)

ROCKY MOUNTAIN BULLHEAD, SCULPIN (Figs. 53 and 54)

Potamocottus punctulatus Gill, *Proc. Boston Soc. Nat. Hist.*, p. 40, 1861 (Bridger's Pass, Wyoming).

Cottopsis semiscaber Cope, *Hayden's Survey of Montana for 1871*, p. 476, 1872 (Fort Hall, Idaho).

Uranidea vheeleri Cope, *Proc. Amer. Philos. Soc.*, p. 138, 1847 (Bear River, Utah); COPE AND YARROW, *Wheeler Survey*, Vol. V, p. 696, 1875 (Pagosa, Colorado).

Cottus bairdi punctulatus (Gill)—JORDAN, *Bull. U.S. Fish Com.*, Vol. IX, p. 29, 1889 (Eagle River; Roaring Fork; Gunnison, Delta; Rio Florida; Leitner's Creek; Rio de las Animas Perdidas).

Cottus semiscaber (Cope)—JORDAN AND EVERMANN, *Bull. 47, U.S. Nat. Mus.*, p. 1949, 1898 (Eagle River, Gypsum).

Body elongate, somewhat compressed posterior to the origin of the pectorals; depth about 5 in the length to the base of the caudal; head large, broad and distinctly depressed, its width almost equal to its length, which is 3 to 3.25 in the length to the base of the caudal, depth of the head 2 or a little more in its breadth; eye large, 5.5 to 6.5 in the head, directed latero-dorsally; nostrils small, widely separated, each borne by a short, elevated tube, the posterior being about half the diameter of the eye in front of the eye and the anterior about the same distance below the posterior, the tube of the posterior longer and more elevated, its posterior margin produced and pointed; snout broad and flat; mouth broad and very large, angle of the mouth reaching the level of the anterior margin of the eye; premaxillaries protractile; opercular structure firm and bony, a well-developed, somewhat elevated preopercular bony process; spinous and soft dorsals separate, base of the spinous dorsal 1.75 in the base of the soft dorsal; dorsal spines VIII or IX, 17 or 18; pectorals very large, reaching to or beyond the level of the last dorsal spine, equal to the length of the head, tips of the first nine rays curved upward and exceeding the web of the fin, thus producing a serrate margin; ventrals small, the spine bearing a thick pad on its ventral surface; anal long, length of its base exceeding that of the spinous dorsal, of 11 or 13 rays the tips of which exceed the webbing of the fin; caudal peduncle slender, its least depth varying from the diameter of the eye to the length of the snout (the length of the snout equals the diameter of the eye in young specimens); caudal fin broad and fan-shaped, outer margin rounded and not forked; scales wanting, lateral line prominent; skin tough and leathery, varying from quite smooth to rather rough, as the prickles are developed or not.

General color bluish or brownish gray, mottled with irregular blotches of dark brown or black; ventral parts white with a bluish or yellowish cast, under parts of the head, the sides, the pectoral fins and the ventral surface posterior to the anal opening dusky with numerous minute black dots; fins dusky, rays and spines dark, crossed by several series of white bars. Small specimens much lighter than adults, rather uniformly covered dorsally with minute black dots.

Because of the variation in the markings, the depth of the caudal peduncle and the development of the prickles in the skin, several nominal species of sculpins have been described from the Rocky Mountain region. These characters intergrade and extreme types may often be taken in the same collection. Considering the extremes to represent subspecific types, three may be recognized, although intergradations are found.

a. Skin smooth.
  b. Caudal peduncle slender, its depth slightly exceeding the diameter of the eye. *Cottus punctulatus punctulatus*
  bb. Caudal peduncle deeper, its depth almost equalling that of the snout. *Cottus punctulatus vheeleri*
aa. Skin with prickles, especially in the axils of the pectorals. . *Cottus punctulatus semiscaber*

The Rocky Mountain Bullhead or "Blob" as it is locally known reaches the length of six inches, although average specimens are usually about three and one-half inches long. In Colorado it is very abundant in the headwaters of the Colorado River drainage, particularly in the Rio Florida and the Rio Las Animas near Durango. It is found, however, on both sides of the range in the small mountain streams. As its name implies, it is a species of the Rocky Mountain region ranging from northern Montana south into New Mexico on both sides of the Continental Divide, and west into the Great Basin in Idaho and Utah.

This species is of considerable economic importance because of its feeding habits. It moves about from stone to stone on the bottom of the stream, feeding upon the small fish which take refuge under the stones, caddis-fly larvae and snails. During the spawning season of the trout the Bullhead also consumes quantities of trout eggs. This destruction of young trout and trout eggs is a positive loss to the trout, for the young Bullheads are rarely if at all eaten by the trout, there being no compensating relation between these two fishes like that between the trout and the suckers; the suckers eat trout eggs but in turn large numbers of young suckers are eaten by the trout.

Colorado specimens.—*University Museum:* Big Beaver Creek, Rio Blanca County, July 9, 1907 (90 mm.), E. R. Warren and J. W. Frye, No. 410; Lightner's Creek, Durango, August 10, 1912 (11 specimens, 20–30 mm.), M. M. Ellis, No. 411; Rio Florida, near Durango, August 11, 1912 (8 specimens, 55–140 mm.), J. Henderson and M. M. Ellis, No. 412; *Colorado College Museum:* Grand River near McCoy, Eagle County, Grand River 12 miles above Glenwood Springs, San Juan River, Pagosa Springs, E. R. Warren; *State Teachers' College Museum:* Pueblo and Durango, A. E. Beardsley.

TABLE VIII

SUMMARY OF SPECIES KNOWN AT PRESENT FROM COLORADO

Family	Platte-Arkansas		Rio Grande		Colorado		Total	
	Native	Introd.	Native	Introd.	Native	Introd.	Native	Introd.
Siluridae..........	2	1	?	....	....	1	2	1
Catostomidae......	3	....	1	....	3	....	7	....
Cyprinidae........	19	2	2	1	3	2	23	2
Thymallidae.......	....	1	....	....	....	1	....	1
Salmonidae........	2	9	1	2	2	4	5	7
Poeciliidae........	2	....	....	....	....	....	2	....
Anguillidae........	....	....	?	....	....	....	....	....
Centrarchidae.....	1	6	1	2	....	1	1	7
Percidae..........	3	2	....	....	....	....	3	2
Cottidae..........	1	....	....	....	1	....	1	....
Total...........	33	21	5	5	9	9	44	20

DISTRIBUTION OF FISHES IN COLORADO

RELATIONS TO RIVER SYSTEMS

Within the state the distribution of the fishes of Colorado is best shown by a comparison of the fauna of the four drainages and of the altitudinal zones. Barring the introduction of species by man, natural barriers as mountain ranges and arid areas are quite effective against the migration of fishes, so that in general the more isolated two river systems are the more diverse their fish fauna. Two of the four drainages of Colorado are entirely independent, the Rio Grande and the Colorado River. The Platte and the Arkansas form a third unit independent of the first two. Thus there are three different fish faunas represented, correlated with these three drainage units. As the mountains are approached there are abrupt changes in the nature of the streams and the temperature of their waters, rendering them unsuitable for certain fishes and making possible the presence of others. In this way there is an intra-drainage distribution correlated

TABLE IX

Altitudinal Distribution of Colorado Fishes

Name	Below 5,000 Ft.	5,000 to 7,000 Ft.	7,000 to 9,000 Ft.	Above 9,000 Ft.
Ameiurus melas	×	×	.....	.....
nebulosus	×	×	.....	.....
Ictalurus punctatus	×	.....	.....	.....
furcatus	.....	.....	?	.....
Carpiodes velifer	×	.....	.....	.....
Catostomus commersonii sucklii	×	×	×	×
griseus	×	×	.....	.....
latipinnis	×	×	.....	.....
Pantosteus plebius	.....	.....	×	.....
delphinus	×	×	×	.....
Xyrauchen texanus	×	.....	.....	.....
Cyprinus carpio	×	×	×	.....
Carassius auratus	×	.....	.....	.....
Campostoma anomalum	×	×	.....	.....
Chrosomus erythrogaster dakotensis	×	×	.....	.....
Pimephales promelas	×	×	×	×
Hybognathus nuchalis	×	×	.....	.....
Phenacobius mirabilis	×	×	.....	.....
Richardsonius pulchellus	.....	.....	×	.....
evermanni	.....	×	.....	.....
Notropis cayuga	.....	×	.....	.....
piptolepis	×	×	.....	.....
scylla	×	×	.....	.....
horatii	×	.....	.....	.....
cornutus	×	×	.....	.....
universitatis	.....	×	.....	.....
lutrensis	×	×	×	.....
Ptychocheilus lucius	×	×	.....	.....
Gila robusta	×	×	×	.....
Semotilus atromaculatus	×	×	.....	.....
Couesius dissimilis	.....	×	.....	.....
Hybopsis tetranemus	×	.....	.....	.....
kentuckiensis	×	×	.....	.....
Platygobio physignathus	×	×	×	.....
Rhinichthys cataractae dulcis	×	×	×	×
Agosia yarrowi	×	×	×	?
Plagopterus argentissimus	.....	?	.....	.....
Thymallus montanus	.....	?	?	.....
Coregonus williamsoni	.....	×	?	.....
Salmo sebago	.....	.....	?	×
irideus shasta	×	×	×	×
rivularis	.....	×	×	?
clarkii spilurus	.....	×	×	×
pleuriticus	.....	×	×	×
stomias	×	×	×	×
macdonaldi	.....	.....	.....	×
fario	.....	×	×	.....
levenensis	.....	×	×	×
Salvelinus fontinalis	×	×	×	×
Cristivomer namaycush	.....	.....	×	×
Fundulus zebrinus	×	×	.....	.....
Fundulus floripinnis	×	×	.....	.....
Anguilla chrysypa	.....	.....	?	.....

TABLE IX—*Continued*

Name	Below 5,000 Ft.	5,000 to 7,000 Ft.	7,000 to 9,000 Ft.	Above 9,000 Ft.
Pomoxis sparoides	×	×	....	....
Ambloplites rupestris	×	....	....	....
Chaenobryttus gulosus	×	....	....	....
Lepomis cyanellus	×	×	×	....
pallidus	....	....	×	....
Micropterus salmoides	×	×	×	....
dolomieu	....	×	....	....
Stizostedion vitreum	×	....	....	....
Perca flavescens	×	×	....	....
Etheostoma cragini	....	×	....	....
iowae	×	×	....	....
Boleosoma nigrum mesaeum	×	×	....	....
Cottus punctulatus	×	×	×	×
Total 66	44	47	24	13

× = Printed or specimen record for a Colorado locality.
? = Probable distribution in Colorado. See discussion of species so marked.

with the altitude of the stream. In considering the distribution within the state, native species are of much more importance than introduced forms. The presence of an introduced fish at a given station speaks only of the ability of that fish to survive in a new environment, since the obstacles which have prevented its reaching the particular locality have been removed by man. The native fish, on the other hand, have reached the particular station presumably as a result of their ability both to overcome the obstacles and to endure the present environment.

The Rio Grande has fewer native fishes than any of the drainages in Colorado. Five native species are known from the Colorado portion of this system at present. One of these, *Rhinichthys cataractae dulcis*, the Dulcis Minnow, is found on both sides of the Continental Divide and is a fish of wide distribution west of the Mississippi River. No specimens of this Dace have been taken from the Colorado River drainage in Colorado, although it is known from as far west as Corvallis, Oregon. Three of the five native species are peculiar to the Rio Grande, occurring only in that system; they are the Rio Grande Trout, *Salmo clarkii spilurus*, the Rio Grande Sucker, *Pantosteus plebius*, and the "Pescadito," *Richardsonius pulchellus*. These fishes are western types and their nearest relatives occur in the Colorado

TABLE X

DISTRIBUTION OF COLORADO FISHES BY DRAINAGES

Name	Platte	Arkansas	Rio Grande	Colorado
Ameiurus melas	n	n		i
nebulosus	i			
Ictalurus punctulatus	n	n		
furcatus			?	
Carpiodes velifer	n			
Catostomus commersonii sucklii	n	n		
griseus	n			
latipinnis				n
Pantosteus plebius			n	
delphinus				n
Xyrauchen texanus				n
Cyprinus carpio	i	i	i	i
Carassius auratus	i			i
Campostoma anomalum	n	n		
Chrosomus erythrogaster dakotensis	n			
Pimephales promelas	n	n		
Hybognathus nuchalis	n	n		
Phenacobius mirabilis	n			
Richardsonius pulchellus			n	
evermanni	n			
Notropis cayuga	n			
piptolepis	n			
scylla	n	n		
horatii	n			
cornutus	n			
universitatis	n			
lutrensis	n	n		
Ptychocheilus lucius				n
Gila robusta				n
Semotilus atromaculatus	n			
Couesius dissimilis	n			
Hybopsis tetranemus		n		
kentuckiensis	n			
Platygobio physignathus		n		
Rhinichthys cataractae dulcis	n	n	n	
Agosia yarrowi				n
Plagopterus argentissimus				?
Thymallus montanus	i			i
Coregonus williamsoni				n
Salmo sebago		i		
irideus shasta	i	i	i	i
rivularis	i	i		i
clarkii spilurus	i	i	n	i
pleuriticus		i		n
stomias	n	n		
macdonaldi		n		
fario		i		
levenensis		i		
Salvelinus fontinalis	i	i	i	i
Cristivomer namaycush		i		
Fundulus zebrinus	n	n		
Fundulus floripinnis	n			
Anguilla chrysypa			?	

TABLE X—*Continued*

Name	Platte	Arkansas	Rio Grande	Colorado
Pomoxis sparoides	i	i	....	....
Ambloplites rupestris	....	i	....	....
Chaenobryttus gulosus	....	i	....	....
Lepomis cyanellus	n	n	n	....
pallidus	....	i	i	....
Micropterus salmoides	i	i	i	....
dolomieu	....	i	....	....
Stizostedion vitreum	i	i	....	....
Perca flavescens	i	i	....	....
Etheostoma cragini	....	n	....	....
iowae	n	....	....	....
Boleosoma nigrum mesaeum	n	....	....	....
Cottus punctulatus	....	n	....	n
Native 44	28	17	5	9
Introduced 19	12	16	5	8
Doubtful 3	....	....	2	1
Total, not including doubtful 63	40	34	10	17

n = native.
i = introduced.
? = doubtful.

River drainage. So closely related are the Rio Grande and Colorado River Trout that their identity has more than once been suggested, and both *Pantosteus* and *Richardsonius* are western genera whose species are for the most part native to the Rocky Mountain region or the Great Basin. The remaining native species of the Rio Grande in Colorado is the Green Sunfish, *Lepomis cyanellus*, a fish of eastern relationships. The Centrarchids are among the most characteristic fishes of the Mississippi Valley, so that *Lepomis cyanellus* is to be regarded as an immigrant from the East. With four of the five native species of the Rio Grande in Colorado western forms, the fish fauna of that drainage is more closely related to the fish fauna of the Colorado River than to that of the Mississippi Valley.

The small number of native species in the Rio Grande in Colorado may be the result of several limiting conditions, but from a comparison with the number of species of other drainages at the same altitude it seems that altitude is perhaps the important factor in this connection.

TABLE XI

NUMBER OF NATIVE SPECIES IN EACH ALTITUDINAL ZONE

Drainage	Below 5,000 Ft.	5,000 to 7,000 Ft.	7,000 to 9,000 Ft.	Above 9,000 Ft.
Platte	24	25	6	4
Arkansas	14	14	8	6
Rio Grande	....	....	5	2
Colorado	7	8	4	2

Colorado River Drainage.—This drainage has but nine native species of fish in Colorado, although it includes nearly half of the total area of the state. With the exception of one species all of these are Great Basin forms and peculiar to the Colorado River system; the sculpin, *Cottus punctulatus*, is a species of the Great Basin streams, but, since it inhabits the small creeks of the high mountains, it is found on both sides of the Continental Divide. The species of the western slope are noteworthy in two respects: with the exception of Yarrow's Dace, *Agosia yarrowi*, which reaches the length of five inches, all are moderately large fishes; and with the exception of the Sculpin, they are species of three of the more primitive families, the *Catostomidae*, the *Cyprinidae* and the *Salmonidae*.

Drainage east of the Continental Divide and the Sangre de Cristo Range.—The Platte and Arkansas rivers, being part of the same major drainage, although separated in Colorado by the Platte-Arkansas Divide, have very similar fish faunas, twelve species occurring in both streams. A comparison is tabulated below.

TABLE XII

NATIVE SPECIES IN THE PLATTE AND ARKANSAS RIVERS IN COLORADO

Platte Total	Platte Only	Platte and Arkansas	Arkansas Only	Arkansas Total	Total East of Continental Divide	Total West of Continental Divide
28	16	12	5	17	33	9

Three-fourths of the native species of the state, 33 in all, are found east of the Continental Divide and but one of these, the Sculpin, *Cottus punctulatus*, is found native on both east and west slopes in Colorado. The Dulcis Minnow, *Rhinichthys cataractae dulcis*, occurs west of the Divide but has not been taken in western Colorado where it is replaced by Yarrow's Dace, *Agosia yarrowi*. Omitting the Dulcis Minnow and the Sculpin, the fishes of the Platte and Arkansas drainages are species of the mountain front region or with eastern affinities, many ranging rather generally throughout the Mississippi Valley, or being closely related to Mississippi Valley forms. Although the majority of the species of eastern Colorado belong to the *Cyprinidae*, the Minnows, the higher fishes are represented by both native *Centrarchidae* and *Percidae* (see p. 120).

Relations to Altitude

Considering the fishes of the state as a whole, two distinct groups of species may be recognized, those of the mountain streams and those of the plains streams. In the foothill region both are found, the local conditions determining the relative abundance of each.

The 6,500-foot contour on the east side of the Continental Divide and the 7,000-foot contour west of the Divide bound roughly a central area the streams of which are quite different as fish habitats from the streams of the lower eastern and western portions of the state. The streams thus included in the central portion of the state are the mountain streams, those popularly known as "trout streams," while the streams of the lower flatter areas are the plains streams.

Mountain Streams

The exact altitudinal boundary of the mountain streams varies locally to a considerable extent but even in the San Luis Valley, which is the largest area of high flat land in the state, all of the streams above the 8,000-foot contour are clearly of this class. The mountain streams, regardless of the river system to which they belong, are characterized by several features. Fed the year round by melting snow, they are of clear cold water, the annual thermal variation being rather small. Flowing over igneous rock for the most part the percentage of contained solid, either in solution or suspension, is very low. Since these streams have their sources high up in the mountains their fall is very abrupt, and this taken with the usual rocky stream bed makes them turbulent, at the same time giving maximum opportunity for aeration of the water. Mountain streams are subject to sudden and considerable changes in the volume of water to be carried. During a warm spring day large quantities of snow may be melted on rocky slopes where loss of water by absorption is slight. Thus there is a flooding of canyons and gulches.

The combined action of all of these factors results in limiting the fish fauna of the mountain streams to a few well-adapted species. Fishes to live in such streams must be hardy, able to endure constantly cold water. They must be strong swimmers capable of moving against the strong current of these streams. Indirectly, but effectively, the nature of the mountain streams prohibits certain types of fishes, since the feeding-grounds required by these species are not possible under mountain stream conditions. The rapidly moving mountain stream has little or no fringe of aquatic shore vegetation (see Fig. 55), since such plants as might gain a foothold during the low water of the summer season would be swept away by the fall and spring rises. This removes a very important feeding-ground for many species, since the zone of vegetation near shore shelters snails, insect larvae and small crustacea, forms which taken collectively comprise the main food of sunfishes, top-minnows and many minnows. The strong current in itself and by the removal of silt and water-logged material from the bottom of the stream also limits the possible food for fishes in the stream proper to small snails, caddis-fly larvae and neuropterous larvae of various sorts, and the green and brown slime, algae and diatoms, on the stones.

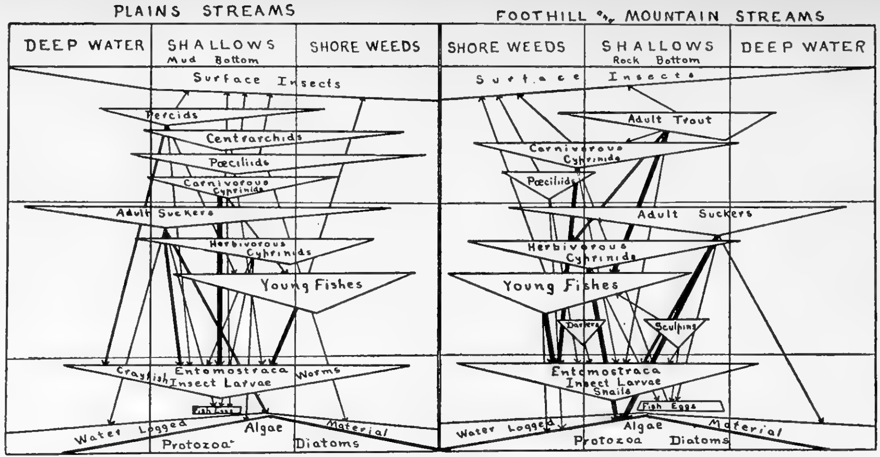
The census of the fish fauna of these mountain streams shows it to consist of the two Dace, *Rhinichthys cataractae dulcis* and *Agosia yarrowi;* of suckers of the genus *Pantosteus* and of *Catostomus commersonii sucklii* which feed upon the algal and diatomaceous slime, insect larvae and small snails; of the sculpin, *Cottus punctulatus*, which feeds upon insect larvae, snails and small fishes; and of the several species of trout which feed upon small fishes, surface insects and larvae of the larger aquatic insects. In addition to these species the Darters, *Boleosoma nigrum mesaeum* and *Etheostoma iowae*, are found in the lower portions of the mountain streams in the foothill region east of the Divide in the Platte drainage. Besides these there are various species of minnows whose abundance depends upon local conditions. These last-mentioned species are always found either in the lower courses of the stream where they come in from the plains or in the more quiet parts back of beaver dams and other obstructions. Still other species may be taken near the outlets of high mountain lakes, as *Pimephales promelas*.

Above the foothill region and below the region of the high mountain lakes, the fishes of the average mountain stream are, however, the Dace, Suckers, Sculpins (these are abundant only west of the Divide) and the Trout. The first three forms feed upon trout eggs when these are available, but this injury to the trout is offset by the fact that the young suckers and both young and adult Dace are eaten by the adult trout. The Sculpins are a disturbing factor in this balance, since their young are rarely eaten by the trout.

The major interrelations of the fishes of the mountain and foothill streams are shown in the diagram on p. 125. In this diagram the average conditions are considered and it is to be borne in mind that with local complications these interrelations are not so simple as the diagram suggests. In general there is a progressive elaboration of the food material from the slime and protozoa, through small crustaceans and insect larvae, young fishes and adult suckers to the higher carnivorous forms like the trout. As has been pointed out by several writers, the trout are normally carnivorous fishes but like any other group of animals they feed upon the available food material when the supply of that regularly taken falls short of the demand.

Plains Streams

The plains streams are larger and broader than the mountain streams and with much less fall. Near the foothills, plains streams have beds of gravel or small stones, the results of sorting by the mountain streams, but away from the foothills the stream beds are sand or clay except where changed by local conditions. Flowing through a semi-arid region of low rainfall, the volume of water carried is subject to periodic variations correlated with fall rains and, in the spring, melting of the snow. In spring and late fall with the increase



Schematic representation of the interrelations of the groups of species found in the two common types of Colorado streams. The diagram as drawn considers only typical conditions, local complications being omitted. The lateral extent of each triangle shows the distribution within the stream of the group it represents, and the depth of the triangle at any point indicates the relative abundance of the group in that part of the habitat. The organisms found in the stream may be resolved into five classes, in the diagram separated by the horizontal rulings. The first of these, that at the bottom of the diagram, composed of algae, diatoms and protozoa, and the fifth, composed of surface insects, are rather independent of the other three, although the latter are dependent upon the first and fifth. The ultimate source of food for the individuals of the first class is the unelaborated inorganic material handled by the plants, and the land insects which fall into the water, although a fairly constant item in the summer and fall, are chance additions only to the general food supply. The aquatic surface insects feed upon individuals of classes one and two. The three middle classes, two, three and four, are composed of species whose food for the most part consists of the individuals of the class or classes below them. These last three classes hold only as regards the bulk of food, since many species utilize several types of food, especially when that which they usually take is lacking. The arrows point from the group of species to the food eaten by it and the width of the shaft of the arrow is in general indicative of the importance of the item to which the arrow points.

in volume of water the percentage of solid material contained, especially in suspension, is high, since the plains soil is easily washed. In mid-summer the streams become clear but very shallow so that the relatively small quantity of water is easily heated by the sun. As compared with the fairly constant temperature of the mountain streams the fishes of the plains streams are subjected to a wide range of temperatures; the water in a small pool in the South Platte at Julesburg, from which several hundred specimens of *Fundulus zebrinus*, *Notropis scylla* and *Semotilus atromaculatus* were taken on July 19, 1912, was heated to 84° F., although connected by a small stream of running water with the main channel. The periodic change of stream level and the arid climate limit, indirectly, the fish fauna through the elimination of the shore zone of aquatic vegetation. Plants so common along streams in the Mississippi Valley are almost entirely lacking along the plains streams in eastern Colorado. Such shore vegetation would be killed by drying, when the water recedes in the summer, since the margin of the stream does not remain moist as it does in more humid regions, or if there were any such vegetation it would be swept away by the current during the high water of the spring. The importance of this shore vegetation comes from the fact that it shelters small crustaceans, insect larvae and other forms which are food for Centrarchids and various species of minnows. It is interesting in this connection to note that at Wray and Ovid—localities in the eastern "rainbelt" of Colorado—some of this aquatic shore vegetation was found along the streams in more favored places. Here, as expected, it contained Centrarchids, Percids and large numbers of minnows.

The fish fauna of the true plains streams in eastern Colorado is strikingly different from that of the mountain streams. The suckers, the top-minnows, *Fundulus floripinnis* and *Fundulus zebrinus*, and the various species of true minnows, particularly *Notropis scylla*, *Notropis piptolepis* and *Semotilus atromaculatus*, are the forms regularly found. In the larger streams may be added the catfish.

In the plains lakes and reservoirs are found the optimum conditions for Sunfishes, Perch and Catfishes, since the rather constant water level makes possible a broad zone of aquatic shore vegetation (Fig. 56), and the absence of a current allows the deposition of silt and water-logged material. Into these lakes various species of eastern *Centrarchidae* and *Percidae* have been introduced with success. Other lakes have been stocked with catfish.

Changes in the Fish Fauna of Colorado

From geological data it is known that portions of Colorado have been covered with salt water at times. Traces of the marine faunas occurring during these inundations are now found in fossil oysters, fishes and other animals taken from the rocks. The earlier of these deposits contain remains of sharks and chimeras. From more recent deposits in a fresh-water lake, existing at one time near Florissant, remains of several species of suckers and of two species of bowfins have been collected. These fossils show that there have been changes in even the fresh-water fish fauna of Colorado.[1]

Observations on the changes in the fish fauna of the western part of the United States since the advent of man are very few and the data existing have no large value in relation to the evolutionary changes, since they have been collected in rather recent times only. Chief among the disturbing factors in recent years has been civilization. In Colorado, man has changed the fish fauna in at least the following ways: (*a*) by removing large numbers of native fishes for food without properly restocking the streams; (*b*) by deflecting water for irrigation, leaving the streams low or even dry in some seasons; (*c*) by allowing the fishes to run into unscreened ditches only to become stranded and die in the fields; (*d*) by the introduction of mine and mill waste, the poisons from which often kill large numbers of fishes in a single day; (*e*) by the introduction of other fishes which become competitors of the native species.

The first item, overfishing, affects the trout more than the other species, and need be discussed but briefly. It is a matter of general knowledge that trout were once abundant in many streams where

[1] For a list of the fossil fishes of the Rocky Mountain region see Cockerell, *Univ. Colo. Studies*, Vol. V, pp. 161 f., 1908.

they are now very scarce. Through the efforts of the state and federal fish commissions many of the better trout streams are quite well restocked and others will doubtless be restocked in the future. The changes resulting from the use of water for irrigation cannot be helped, as the use of the water for this purpose is undoubtedly just. The useless destruction of fishes attendant upon the deflection of water in unscreened ditches, however, can be, and to a large measure in recent years has been, avoided by the proper screening of the main ditches at the point of withdrawal.

The introduction of mine and mill waste has been very destructive to the fishes of the state. In 1907 all of the fishes in several miles of Boulder Creek, near Boulder, were killed in this way. So complete was the destruction that for several days the stream carried large numbers of floating fish. Fortunately collections had been made from this creek in 1903 by Juday, and a comparison of the fish fauna as now re-established with that existing in 1903 is possible. The most apparent changes in the fauna are shown in the accompanying table (XIII).

TABLE XIII

COMPARISON OF FISH FAUNA OF BOULDER CREEK IN 1903 AND 1912

	Specimens Taken in 1903	Specimens Taken in 1912
Couesius dissimilis	Numerous	None
Semotilus atromaculatus	Few	Numerous
Hybopsis kentuckiensis	Several	None
Richardsonius evermanni	Three	None
Notropis cayuga	Several	None
Catostomus commersonii sucklii	Several	Numerous
griseus	Numerous	Several
Etheostoma iowae	Several	None

Two species have apparently become more abundant, while others have been completely exterminated or are not yet re-established, judging from existing data (for number of specimens see the specimen lists for the several species). The larger streams have also suffered from the introduction of mill and mine waste. The writer has been told by several of the older fishermen of the abundance of Gizzard Shad, *Dorosoma cepedianum* (LeSueur),[1] as far west as Pueblo in the

[1] A species of the *Dorosomidae*. No specimens of this fish taken in Colorado have been examined in this study, and there are no printed records of its occurrence in the state. It has been taken, however, in the Arkansas at Wichita, Kansas, by Jordan (*Bull. U.S. Fish Com.*, Vol. IX, p. 18, 1889), and may occur in the Arkansas in eastern Colorado. If found, it may be recognized by its compressed body, serrate ventral surface, peculiar dorsal fin of 12 rays, the posterior margin of the dorsal and its last ray being greatly elongated.

Arkansas River and also of the abundance of several species of fishes in the Cuchara River, in the early days before there were large mills and coal mines along these streams. The removal of water for irrigation must be considered in this connection as a factor co-ordinate with the introduction of mill waste, since a little waste material would have a higher concentration in a stream carrying little water.

The introduction of other species into the state has changed the relative abundance of some of the native species, but as far as is known none has been exterminated in this way. One particular case is deserving of attention in this connection. The Yellow-finned Trout, *Salmo clarkii macdonaldi*, known only from Twin Lakes and once abundant there, is rapidly becoming scarce. Paralleling the decrease in the number of Yellow Fins is a marked increase in the introduced Mackinaw Trout, *Cristivomer namaycush*. Both are species of the deep water and it may be that the Yellow Fin is an unsuccessful competitor of the introduced Mackinaw, although there may be some other cause for the reduction of the number of Yellow Fins.

Economic Species

Several species found in Colorado, other than the trout, have value as food fishes, although the combination of food fishes and game fishes furnished by the Salmonids makes them by far the most important group in the state from an economic standpoint. The ease with which trout may be successfully raised has also contributed to the general popularity of these fishes. The ripe adults may be safely and rapidly stripped and the large non-adhesive eggs fertilized in the field, the tough coats of the individual eggs making their safe shipment to the hatcheries possible. Here they are placed in rectangular trays (see Fig. 42) and kept in the hatching-tanks. The removal of the dead eggs is facilitated by their opacity, which makes them quite conspicuous in the black trays among the good eggs. During the year 1912, 11,280,000 young trout were distributed from the Colorado state hatcheries.[1]

[1] *Bien. Report State Game Fish Com. for 1911–12*, p. 28.

The fishes raised in Colorado which are commonly marketed in the state are the Catfish and Carp from the ponds and private lakes. The small native catfish bring a good price and are successful competitors of the salt-water fishes shipped from the coast. The Carp along with the White Salmon from the Colorado drainage and the Suckers from the Arkansas and Colorado drainages are sold extensively to the local markets near the points of capture.

Glossary

Adipose fin. A small median fin between the caudal fin and the dorsal fin. (See Fig. 43.) Not present in all fishes.

Anal fin. A median fin on the ventral surface of the body just back of the posterior opening of the alimentary canal. (See Fig. 43.)

Anal opening. The posterior opening of the alimentary canal.

Apical radii. Grooves in the free or exposed portion of a scale, running from the center of the scale to its margin. (See Fig. 61.)

Barbels. Cylindrical, membranous processes extending from the angle of the mouth or the top of the head. Best shown in the catfish. (See Fig. 1.)

Basal fulcra. Rudimentary, spine-like or bony rays at the base of the caudal fin. (See Fig. 36.)

Basal radii. Grooves in the basal or covered portion of a scale. Opposed to apical radii. (See Fig. 57.)

Caudal fin. The large fin at the posterior end of the body; the tail. (See Fig. 43.)

Caudal peduncle. The narrowed portion of the body bearing the caudal fin. (See Fig. 43.)

Cheeks. The sides of the head.

Ctenoid. Scales with teeth on the apical portion.

Cycloid. Scales of bony fishes, without apical teeth. Opposed to ctenoid.

Dentary bone. The anterior portion of the lower jaw.

Depressed. Flattened dorso-ventrally.

Dorsal profile. The dorsal outline of the body when seen from the side.

Ductus pneumaticus. A small duct connecting the air bladder with the alimentary canal.

Emarginate. Slightly forked or cut away along the margin.

Entire. With the margin complete and not forked.

Falcate. Scimitar-shaped along the margin; deeply but irregularly forked, one lobe being longer than the other.

Fingerling. A young fish, about the length of one's finger or less.

Fontanelle. An opening between two or more bones of the skull.

Frontal bone. That forming the front of the top of the head.

Fusiform. Spindle-shaped.

Gill opening. That just back of the posterior margin of the operculum.

Interorbital distance. That across the top of the head between the upper margins of the two orbits.

Intromittent organ. A male reproductive organ developed in some viviparous fishes from the modified anal fin.

Lateral line. A series of pores, usually in the scales, along the middle of each side of most fishes, connected with special nerves.

Maxillary barbel. That barbel attached to the edge of the maxillary bone.

Maxillary bone. That forming the lower portion of the upper jaw of most fishes.

Ocellated. With a central round spot; usually of one large spot which contains a central spot of another color.

Operculum. The large shield-shaped bone covering the gills, on the side of the head. (See Fig. 43.)

Ovoviviparous. Producing eggs which hatch within the body of the female but are independent of the female.

Opercular flap. A membranous flap at the posterior margin of the operculum, supported in some species by a bony stay.

Palatine bones. Bones on each side of the roof of the mouth.

Parietal bones. Bones on each side of the top of the head, just back of the frontal.

Parr marks. Vertical bars of dusky or black on the sides of the young of most species of trout, whitefish and other species of Salmonid fishes. (See Fig. 37.)

Pearl organs. Small tubercles developed on the scales of males of some fishes during breeding season. Their function is to aid in keeping the two fishes alongside during spawning.

Pectoral fins. Those just back of the gill opening. (See Fig. 43.)

Peritoneum. The membranous lining of the abdominal cavity.

Pharyngeal bones. Bones at the beginning of the esophagus just back of the last pair of gills on each side. (See p. 46.)

Poikilothermous. Having a temperature of the surrounding medium, popularly known as "Cold-blooded."

Predorsal region. The region along the middle of the back just in front of the dorsal fin.

Premaxillary bones. Those forming the front and median portion of the upper jaw, in most fishes.

Preoperculum. The anterior portion of the operculum.

Pyloric coeca. Small blind tubes at the lower end of the stomach.

Radii. Grooves in the scales of many bony fishes.

Scale formulae. Scales are to be counted in oblique series from the base of the first ray of the dorsal fin to the lateral line, the scale in the lateral line not being included; next, those in the lateral line from the origin of the lateral line just back of the gill opening to the base of the caudal fin; the third count is of the scales in oblique series between the lateral line and the base of the first ray or spine of the anal fin, the scale of the lateral line not being included. These counts are conventionally given as 5, 67–70, 3 or 4, meaning 5 scales in oblique series between the base of the dorsal fin and the lateral line, 67 to 70 in the lateral line and 3 or 4 in oblique series between the lateral line and the base of the anal fin.

Septum of the nostril. The elevated membranous partition between the two halves of the nostril.

Snout. The portion of the head in front of the eye and above the mouth. (See Fig. 43.)

Soft dorsal fin. Opposed to spinous dorsal, the supporting structures being soft rays.

Spinous dorsal fin. The anterior portion of the dorsal fin which is either separate from the posterior soft dorsal or joined with it into a single fin. The supporting structures in the spinous dorsal are bony spines.

Suborbital bones. A chain of more or less connected bones below the eye.

Supraocular region. That just above the eye.

Terete. Rather cylindrical, having a more or less circular outline in cross-section.

Ventral fins. Paired fins on the ventral surface of the body in front of the anal fin and behind or below the pectoral fins. (See Fig. 43.)

Ventral profile. The ventral outline of the body when seen from the side.

Vomer. The front part of the roof of the mouth.

Weberian apparatus. A chain of small bones connecting the air bladder with the inner ear.

Species Index

PLATE I

Fishes of Colorado

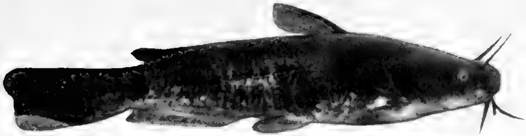


Fig. 1.—*Ameiurus melas.* Black Bullhead (p. 16). Adult.

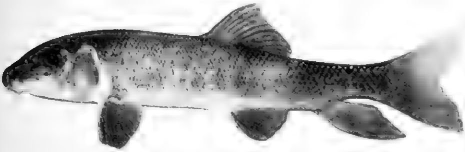


Fig. 2.—*Catostomus commersonii sucklii.* Suckley's Sucker (p. 22). Adult in feeding position.

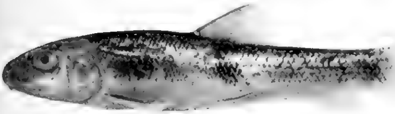


Fig. 3.—*Catostomus commersonii sucklii.* Suckley's Sucker (p. 22). Young showing the three lateral spots.

Fig. 4.—*Ameiurus nebulosus.* Common Bullhead (p. 17). Young dorsal view.

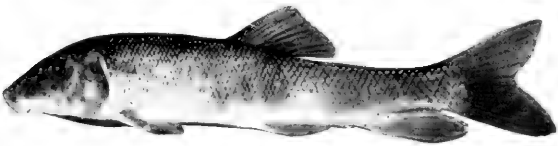


Fig. 5.—*Catostomus commersonii sucklii.* Suckley's Sucker (p. 22). Adult in resting position.

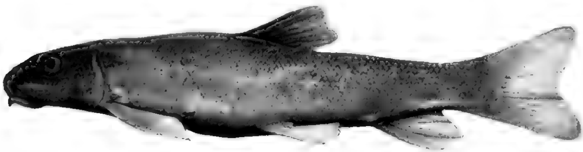


Fig. 6.—*Catostomus griseus.* Gray Sucker (p. 25). Adult.

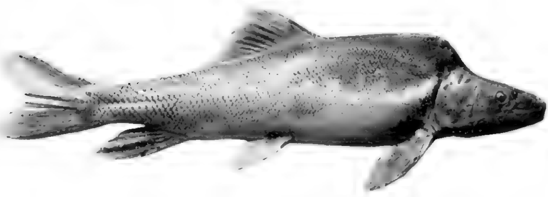


Fig. 7.—*Xyrauchen texanus.* Humpbacked Sucker (p. 30). Adult.

PLATE II

FISHES OF COLORADO

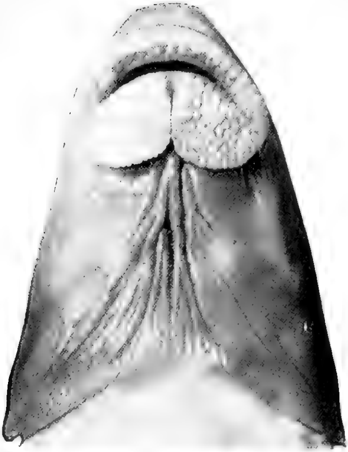


FIG. 8.—*Catostomus commersonii sucklii.* Suckley's Sucker (p. 22). Head, ventral view showing the papillose lips.

FIG. 9. *Pantosteus delphinus.* Western Chisel-mouthed Sucker (p. 29). Head, ventral view showing the papillose lips and the chisel-edged jaws.

FIG. 10.—*Cyprinus carpio.* German Carp (p. 34). Scaled variety.

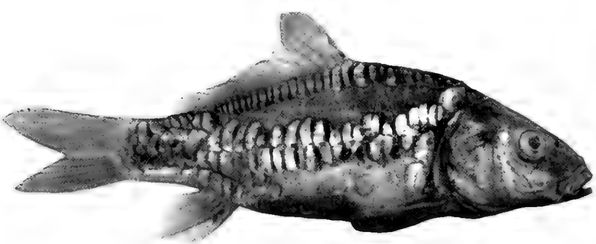


FIG. 11.—*Cyprinus carpio.* German Carp (p. 34). Mirror Carp.

PLATE III

Fishes of Colorado

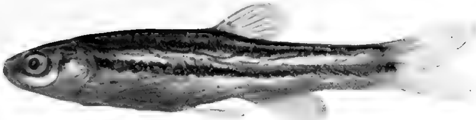


Fig. 12.—*Chrosomus erythrogaster dakotensis.* Western Red-bellied Dace (p. 38).

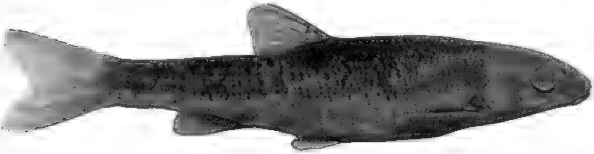


Fig. 13.—*Campostoma anomalum.* Stone-roller (p. 37). Young.

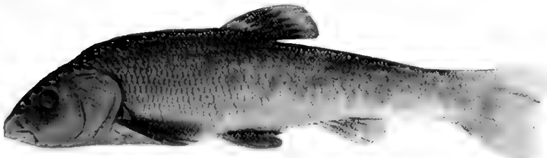


Fig. 14.—*Campostoma anomalum.* Stone-roller (p. 37). Breeding male.

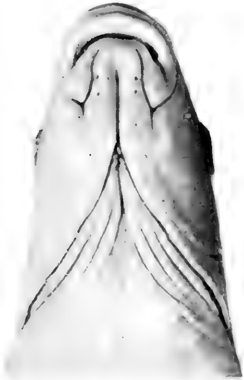


Fig. 16.—*Campostoma anomalum.* Stone-roller (p. 37). Head, ventral view, showing the sucker-like mouth.*

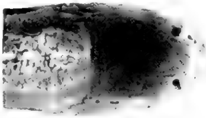


Fig. 15.—*Pimephales promelas.* Black-headed Minnow (p. 41). Top of head of breeding male.

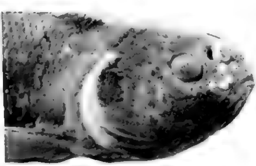


Fig. 17.—*Pimephales promelas.* Black-headed Minnow (p. 41). Side view of head of breeding male showing tubercles.

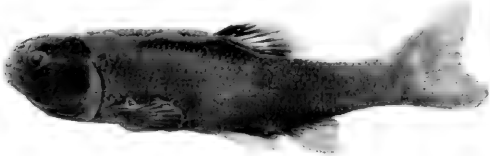


Fig. 18.—*Pimephales promelas.* Black-headed Minnow (p. 41). Breeding male.

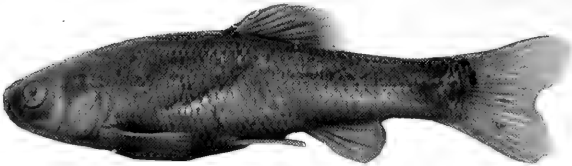


FIG. 19.—*Pimephales promelas.* Black-headed Minnow (p. 41). Female.

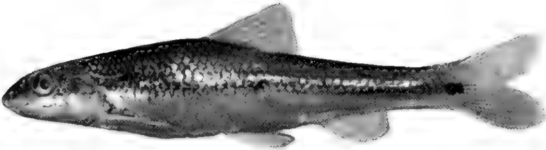


FIG. 20.—*Phenacobius mirabilis.* Sucker-mouthed Minnow (p. 45).

FIG. 21.—*Phenacobius mirabilis.* Sucker-mouthed Minnow (p. 45). Side view of head.

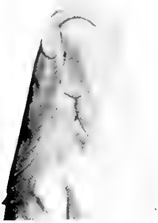


FIG. 22.—*Phenacobius mirabilis.* Sucker-mouthed Minnow (p. 45). Ventral view of head showing sucker-like mouth.

FIG. 23.—*Phenacobius mirabilis.* Sucker-mouthed Minnow (p. 45). Top view of head.

FIG. 24.—*Phenacobius mirabilis.* Sucker-mouthed Minnow (p. 45). Ventral view of the head, mouth open.

PLATE V

Fishes of Colorado

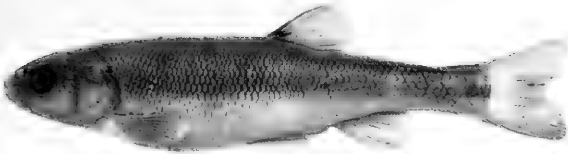


Fig. 25.—*Semotilus atromaculatus.* Horned Dace (p. 57). Adult.

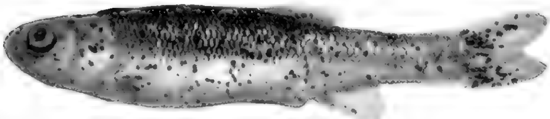


Fig. 26.—*Semotilus atromaculatus.* Horned Dace (p. 57). Young. The black spots are parasitic worms, Trematodes.

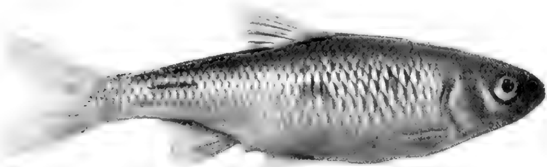


Fig. 27.—*Notropis cornutus.* Common Shiner (p. 52).

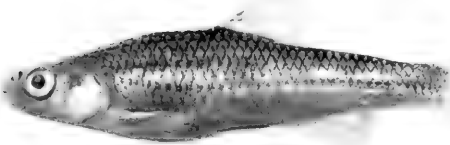


Fig. 28.—*Notropis scylla.* Western Shiner (p. 50).

Fig. 29.—*Notropis lutrensis.* Redfin (p. 53).

PLATE VI

FISHES OF COLORADO

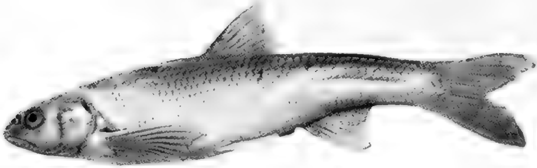


FIG. 30.—*Platygobio physignathus.* Thick-jawed Chub (p. 62).

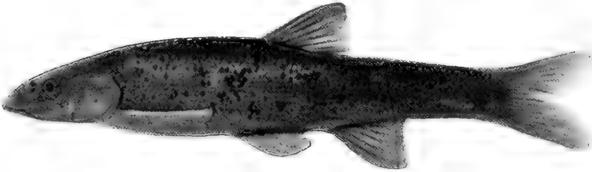


FIG. 31.—*Rhinichthys cataractae dulcis.* Western Long-nosed Dace (p. 64).

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FIG. 33.—*Agosia yarrowi.* Yarrow's Dace (p. 68). Side view of head. The barbel may be seen at the angle of the mouth.

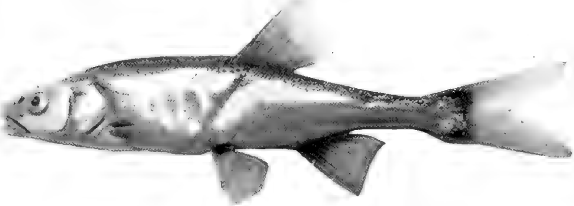

FIG. 34.—*Gila robusta.* Bony Tail (p. 56).

PLATE VII

FISHES OF COLORADO

FIG. 35.—*Gila robusta*. Bony Tail (p. 56). Side view of head.

FIG. 36.—*Gila robusta*. Bony Tail (p. 56). Caudal fin showing the enlarged basal fulcra.

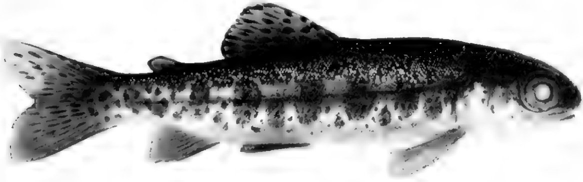

FIG. 37.—*Salmo irideus shasta*. McCloud River Rainbow Trout (p. 80). Young with parr marks.

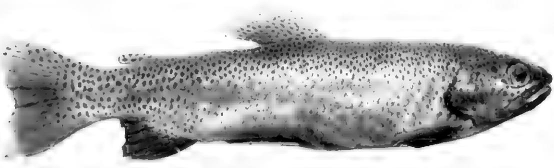

FIG. 38.—*Salmo irideus shasta*. McCloud River Rainbow Trout (p. 80). Adult.

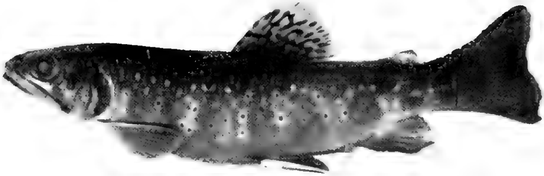

FIG. 39.—*Salvelinus fontinalis*. Eastern Brook Trout (p. 84). Young.

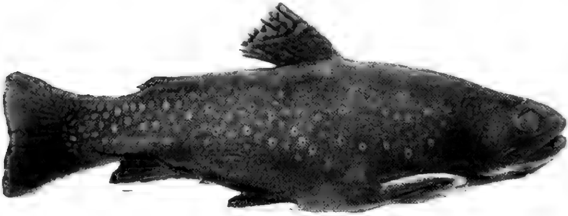

FIG. 40.—*Salvelinus fontinalis*. Eastern Brook Trout (p. 84). Adult.

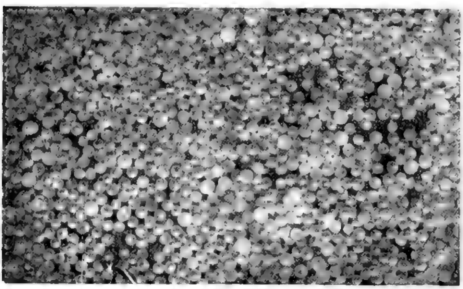

FIG. 41. Eggs of Eastern Brook Trout.

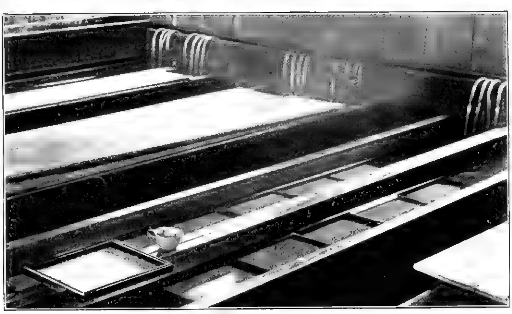

FIG. 42.—Egg trays and hatching-tanks, Denver Hatchery. The trays are filled with eggs of the Eastern Brook Trout.

PLATE IX

Fishes of Colorado

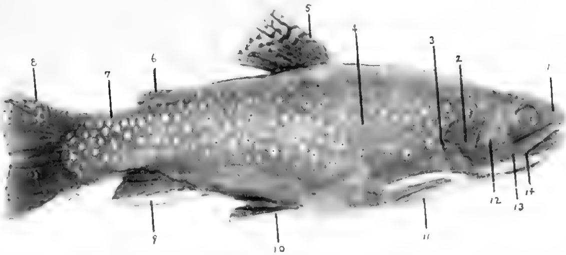

Fig. 43.—*Salvelinus fontinalis.* Eastern Brook Trout (p. 84). 1, snout; 2, operculum; 3, gill opening; 4, lateral line; 5, dorsal fin; 6, adipose fin; 7, caudal peduncle; 8, caudal fin; 9, anal fin; 10, ventral fins; 11, pectoral fin; 12, preoperculum; 13, maxillary; 14, angle of the mouth.

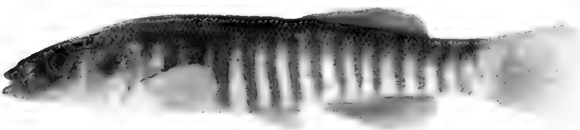

Fig. 44.—*Fundulus zebrinus.* Zebra Top-minnow (p. 87).

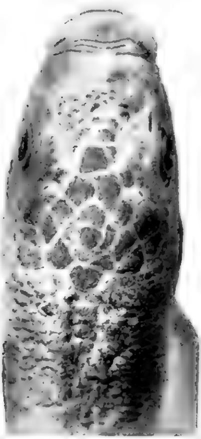

Fig. 46.—*Fundulus zebrinus.* Zebra Top-minnow (p. 89). Top of head, showing the plate-like structure of the skin.

Fig. 45.—*Fundulus zebrinus.* Zebra Top-minnow (p. 87). Side view of head.

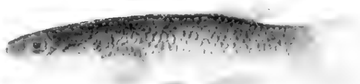

Fig. 47. *Fundulus floripinnis.* Little Green Top-minnow (p. 89).

PLATE X

FISHES OF COLORADO

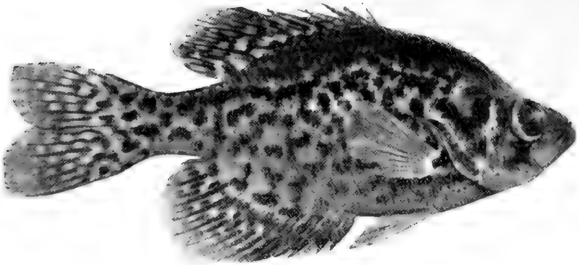

FIG. 48.—*Pomoxis sparoides.* Calico Bass (p. 94).

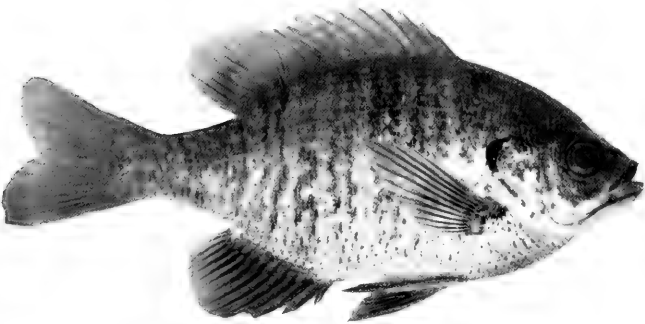

FIG. 49.—*Lepomis pallidus.* Blue Gill (p. 98).

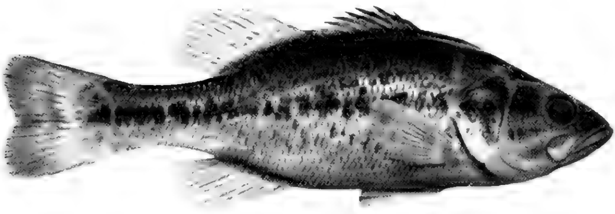

FIG. 50.—*Micropterus salmoides.* Large-mouthed Black Bass (p. 100).

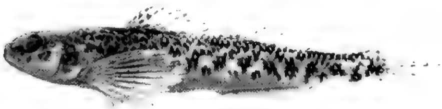

FIG. 51.—*Boleosoma nigrum mesaeum.* Johnny Darter (p. 112).

FIG. 52.—*Etheostoma cragini.* Cragin's Darter (p. 107).

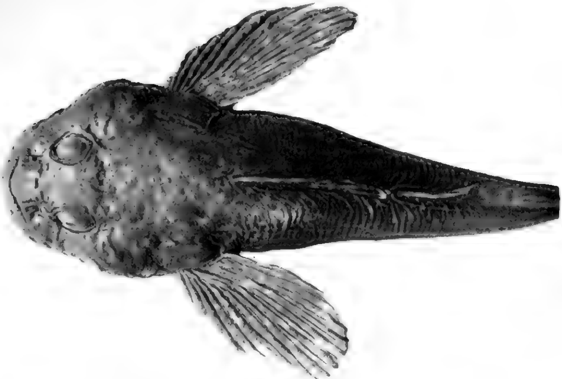

Fig. 53.—*Cottus punctulatus.* Sculpin (p. 114). Dorsal view of the anterior two-thirds of the body.

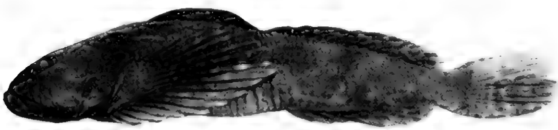

Fig. 54.—*Cottus punctulatus.* Sculpin (p. 114).

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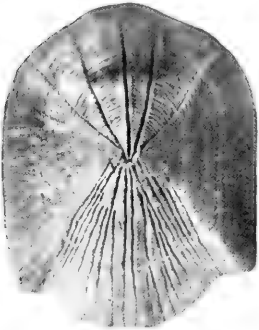
Fig. 58.—Scale of *Catostomus commersonii sucklii.* Suckley's Sucker (p. 22). Regenerated scale.



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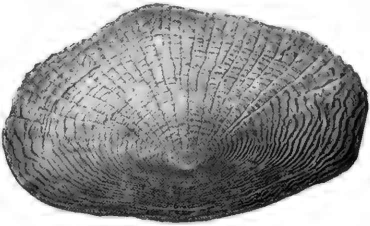

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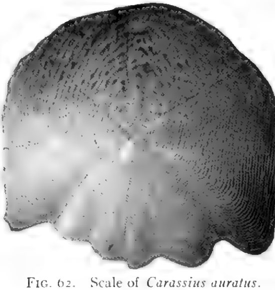

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VOLUME XI NUMBERS 2 AND 3

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FRANCIS RAMALEY
EDITOR

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CONTENTS

FOREIGN DRAMA ON THE ENGLISH AND AMERICAN STAGE (SCANDINAVIAN AND HUNGARIAN)

By Charles C. Ayer

V. SCANDINAVIAN DRAMA

Though the foreign plays known on the English and American stage are mostly from French[1] and German[2] sources, with only occasionally a piece borrowed from some other European[3] language, Norway has produced one dramatist whose name transcends all others in the history of the modern theater—Henrik Ibsen (1828–1906). This distinguished poet, playwright, and thinker has passed from earth so recently that his influence is still keenly alive with us. His plays have not yet all been given on the stage in English, but the majority of them have become familiar to us in book form. Ibsen's conquest of the stage is a simple but interesting story. Germany, the real connoisseur, discovered him first. England and America became interested and then France took him up, though with the uncomfortable feeling that he was something foreign and therefore not quite comprehensible unless perhaps to the frequenters of Antoine's *Théâtre Libre*. Within very recent years too some of Ibsen's plays have been given in Japan by the foremost of Japanese actresses, Sada Yacco. It is therefore clear that no dramatist has ever had a wider influence than Ibsen, and yet no dramatist has been more misrepresented than he. In Germany at the outset he was received with frankness and understanding, and why not? There is nothing in Ibsen which need frighten a person. Nevertheless, thirty years ago when his name was first heard in this country it was a synonym for what, in

[1] See "Foreign Drama on the English and American Stage," I. French Drama, *University of Colorado Studies*, Vol. VI, No. 4, pp. 287–97, June, 1909.

[2] See "Foreign Drama on the English and American Stage." II. German Drama, *University of Colorado Studies*, Vol. VII, No. 1, pp. 63–71, December, 1909.

[3] See "Foreign Drama on the English and American Stage," III. Italian Drama, IV. Spanish Drama, *University of Colorado Studies*, Vol. X, No. 3, pp. 149–59, November, 1913.

our present day slang, we term "high brow." Ibsen was supposed to be super-intellectual. People who read him were suspected of posing. The Ibsenites were the legitimate successors of the Browningites as the butt of the jokes of the funny man. But Ibsen survived the scoffer. His plays have an ethical and didactic tendency, it is true. They are written with a purpose—in the ponderous sense of that word—but in such a masterly style as to hold the interest of whoever witnesses them, be he closet scholar or plain ordinary theater-goer. Ibsen is not beyond the comprehension of the average person of intelligence. He shows us people of the middle class confronted by problems which any person may some day be called upon to meet. In *A Doll's House* (1879) we see an ill-assorted marriage, the serious, self-centered husband and the doll wife; in *Hedda Gabler* (1890) we find another unhappy marriage between a brilliant but heartless and morbid woman and a well-meaning but uncongenial, scholarly husband; in *Ghosts* (1881) we have an enthralling study of heredity. These plays are frankly pessimistic, but are to the point. They are the best known and the most popular of Ibsen's plays on the American stage. They have enlisted and will continue to enlist the talents of our leading actresses. Among the best-known interpreters of the rôle of Nora in *A Doll's House* are Mrs. Fiske, Mme Alla Nazimova, and Miss Ethel Barrymore. In the rôle of Hedda Gabler there have appeared Mrs. Fiske, Mme Nazimova, Miss Blanche Bates, Miss Nance O'Neil, and Mrs. Patrick Campbell. In *Ghosts* Miss Mary Shaw has been the finest impersonator in English of the grief-stricken mother.

The plays of Ibsen were produced in London in the following order: *A Doll's House* and *The Pillars of Society* in 1889; *Hedda Gabler*, *The Lady from the Sea*, *Ghosts*, and *Rosmersholm* in 1891; *The Master Builder* and *An Enemy of the People* in 1893; *Little Eyolf* in 1896. In the spring of 1913 *The Pretenders*, one of Ibsen's historical dramas, quite different from those above mentioned, was produced in London by Sir Beerbohm Tree, but soon withdrawn. It was in the repertory of the Burgtheater of Vienna as far back as 1891. In London the chief producer of Ibsen has been an American, Miss Elizabeth Robins, the well-known authoress, who when a young woman also achieved a high reputation as an actress in the stock company of the Boston Museum. In the season of 1906–7, the late Richard Mansfield gave a fine production of the only poetic drama of Ibsen known on our stage, *Peer Gynt*. When Mr. Mansfield had finished with the piece, it was taken up by the late Louis James and presented in the smaller places the country over.

As a contemporary of Ibsen of compelling power as a dramatist must be mentioned Björnstjerne Björnson (1832–1910). His play, *Beyond Human Power*, dealing with the question of faith healing, was presented a few years ago by Mrs. Patrick Campbell.

One more Scandinavian dramatist remains to be mentioned, August Strindberg (1849–1912). His plays, strong, morbid, and gloomy, are not likely to become popular on the stage. They have for several years been accessible in English translation and have been read by advanced readers. Some of them, like *The Stronger* and *Mother Love*, have been given semi-public production by literary clubs. In the spring of 1913 *Countess Julia* was presented at a series of four matinées in New York.

VI. HUNGARIAN DRAMA

It is hard to realize, but it is nevertheless a fact that some of our best recent plays are of Hungarian origin. Though Buda Pesth is one of the intensely modern, up-to-date cities of twentieth-century Europe, the land of Hungary suggests to us rather the wild and impassioned rhapsodies and dance rhythms of Liszt and Brahms and the romantic atmosphere of Franz Lehar's "Gypsy Love" than it does modern drama, such as we should look for in France, Germany, or England. Nevertheless, since the twentieth century came in, three plays by Hungarian authors have made their way to America. They are *The Devil*, by Franz Molnar (1878–); *Seven Sisters*, by Ferenz Herczegh; and *The Typhoon*, by Menyhert Lengyel. That these plays are of positive merit and quite out of the ordinary is proved by the fact that they have been played all over the United States, and the first two have been given by many of the stock companies; and *Seven Sisters* has been converted into an operetta for Mme Fritzi Scheff under the title *The Love Wager*. The plays are furthermore so different from one another from every point of view that, in order to show the variety in the present-day dramatic output in Hungary, it will be worth while to outline briefly their plots.

The Devil in its general purport has much in common with *El Gran Galeoto* (*The World and His Wife*) of the Spanish dramatist Echegaray. In the Spanish play the catastrophe is precipitated by the breath of scandal. A young married woman, adored by her husband, and of blameless character, happens to cross the public square in Madrid with a young man who is a close friend of the family. The couple are seen by an evil-minded person. A malicious rumor is started, which out of nothing nevertheless gathers such proportions that the once happy family is wrecked. At last the innocent couple, overwhelmed by the charges and being equally unable to prove or disprove anything, are forced to rally each to the support of the other. Left alone, deserted by all, they are forced to fly together to begin life anew.

In *The Devil*, the element of evil appears in the form of the devil himself. In this play a young married woman and a young artist, who is painting her portrait, are tempted by the devil, and quite against their will, to sin. The young woman is happily married and trusted by her husband, whom she adores. The artist has a sweetheart and has no wish to wrong the husband of the lady who comes to his studio. Both parties are honest at heart. Nevertheless temptation, in the allegorical form of the devil in modern garb, besets them. At every juncture he turns up, suave and insinuating, to tempt them. Both struggle, but in vain. The devil wins, and as the distracted couple flee at last together he stands in the red and green light, rubbing his hands in glee. *The Devil* as a play is frankly pessimistic, but it is interesting and brilliant as to situations and dialogue. Moreover, it is not untrue to the actual facts of life as we know them. The devil does triumph, not always, to be sure, but often. There is not a day that the newspaper does not register some new victory for him.

At the time that *The Devil* was produced in this country in the fall of 1908, the yellow press, taking advantage of the rather daring and original title, made capital and copy out of it, and succeeded, as invariably happens, in baiting a certain well-meaning but gullible element of the people, so that protests against the piece were not long in appearing. These, as usual, had the result of advertising the play and of making it a success financially. As a play it deserved success for its dramatic merits and for the brilliant acting of Mr. George Arliss in the title-rôle. After all, the devil of Molnar was only the Mephistopheles of Goethe in a modern society setting. The old idea of the morality play is as potent now as it was in the Middle Ages.

Seven Sisters deals with the rigid Hungarian custom that the oldest daughter in a family must be married first. Mrs. Gyurkovics, mother of the seven, finds herself in a predicament, as her fourth daughter, Mici, aged seventeen, has just been sent home from the convent in disgrace, having been caught by one of the nuns in the act of flirting with a handsome young lieutenant, Count Feri Horkoy. The distracted mother, with this unruly beauty on her hands, sees no way of solving her problem except by putting the seventeen-year-old Mici in short skirts and long hair and calling her fourteen. The young count appears upon the scene and is at first dismayed, but comprehending the situation, he takes courage and wagers Mici three kisses that he will get her three older sisters married and out of the way within the year. Of course he wins his wager. This is the golden thread of the story, which is spun out to a four-act farce, filled with capital text and laughable incidents. The theme is, to be sure, as old as love itself, but fortunately in this instance the Hungarian farce has not been Americanized and is served to us with the real home flavor. Instead of the usual exaggerated horse play of farce, as we know it, we find the fun supplied by individual characterization of natural types and by the peculiar customs of the country. There are many charming touches of Hungarian home life. Altogether *Seven Sisters* furnishes a choice evening's entertainment of innocent merriment. It does not leave the spectator pessimistic and cynical as does *The Devil*, nor does it thrill and haunt him for a long time after as does the tragic story of *The Typhoon*.

In the latter the dramatist has shown in thrilling and impressive fashion the struggle that is going on between the Orient and the Occident, founded on deep prejudices of race, religion, tradition, and habit. He takes a number of Japanese students and civil servants and places them on alien soil to work for the welfare of their native land. The scene is laid in Berlin, though any of the world's great capitals would have served as well. The Hungarian dramatist has shown extraordinary insight into oriental ideals and Japanese life in particular, as is shown in the development of the following story: Tokeramo, a young Japanese nobleman, has been assigned by the Mikado to a special diplomatic mission at Berlin. While there he falls into the toils of a beautiful adventuress who nearly succeeds in wresting his government's secrets from him. Warned by his comrades against this dangerous woman, and finally convinced of her perfidy, he casts her off. She, in revenge, denounces the diplomat, and Tókeramo, goaded on to fury, strangles her to death. Immediately, in order to save him because of his value to Japan, one of his fellow-countrymen takes the responsibility of the crime upon himself, and is sent to prison. Tokeramo is thus saved, but the guilty diplomat soon dies of remorse. This is the briefest outline of one of the most powerful plays seen on the American stage in many years. It met with great success, which was also due largely, it should be said, to the superb acting of Mr. Walker Whiteside in the leading part.

These three plays, so varied in theme, treatment, and setting, show us that Hungary is a force to be reckoned with in the drama.

The most recent play of Hungarian origin to reach America in English translation is a delicate little comedy by Molnar, author of *The Devil.* Under the title *Where Ignorance Is Bliss,* it was produced at the Lyceum Theater, New York, September 3, 1913. In a German version under the title *Der Leibgardist* it was given at the Irving Place Theater, February 23, 1914, with greater success than when given in English. This play, somewhat after the style of *The Devil,* deals with types rather than individuals. We do not learn their names, but are told by the program that they are the Actor who is a jealous husband; the Actress, his wife, who gives him cause for jealousy; and the Critic, who is a friend of the family. These three characters furnish the material for the plot of a drama which is brilliant and witty after the style of *The Devil.*

A second play by the author of *The Typhoon*, entitled *Prophet Percival,* was announced for production in London at Easter, 1913. It has not been given in America as yet, and in any case has not attracted as much attention as did *The Typhoon.*

COMMON LAW AND MODERN CODES

By John D. Fleming

I

About the year 1613, the year in which he was made Chief Justice of the King's Bench, Sir Edward Coke wrote these words by way of comment upon Littleton's exhortation to his student to have regard to the science of *well pleading:* "Here is to be observed the excellency of good pleading, and Littleton's grave advice that the student should employ his courage and care for the attaining thereof, which he shall attain unto by these means, first, by *reading;* secondly, by *observation;* and thirdly, by *use and exercise.* For in ancient times the sergeants and apprentices of the law did draw their own pleadings, which made them good pleaders." And he adds one of his quaint etymologies to the effect that *placitum,* a pleading (observe that he is speaking not in terms of prophecy), is derived from *placendo,* "because it *pleases* everybody"![1]

Coke refers the perfection of the art of pleading to the reign of Edward III. "In the reign of Edward III," he says, "pleadings grew to perfection *without lameness and curiosity.*" And Lord Hale observes that though pleadings in the time of some later sovereigns were "far shorter than afterwards, especially after Henry VIII, yet they were much longer than in the time of King Edward III; and the pleaders, yea and the judges, too, became somewhat *too curious* therein; so that art or dexterity of pleading, which in its use, nature and design was only to *render the fact plain and intelligible, and to bring the matter to judgment with a convenient certainty* began to degenerate from its primitive simplicity, and the true use and end thereof, and to become a piece *of nicety and curiosity.*" And Lord Hale accounts for this needless length and nicety in part by the fact that the pleadings were mostly drawn by the clerks who were paid *according to their length* and therefore took care not to study brevity.[2]

[1] 3 *Co. Lit.* p. 376.

[2] 4 *Min. Inst.* p. 608.

What is the inherent difficulty in these mutual altercations between the plaintiff and defendant? Their obvious purpose is to analyze the merits of the cause, and to ascertain the precise subject of controversy preparatory to trial. We are told that the sergeants and apprentices in the old days drew their own pleadings. After the abandonment of alternate allegations by word of mouth by the parties or their counsel they would naturally fall into certain *formulae*, and we gather from Reeve's *History of English Law* that as early as the time of Edward I the declaration was drawn with form and precision and was liable to be excepted to if deficient in either of these qualities.[1] But certain logical processes have not changed in all these centuries; and with all our progress and the demands of an advanced civilization certain necessities survive. For example: A holds B's bond for $500, and proposes to institute suit upon it. Being a teacher of law, I once asked a group of young men, novitiates in the subject, to draw up and submit to me, not necessarily in the dialectics of pleading, a statement of that cause of action. It was surprising how closely the best of them approached the accepted formula:

> This man B owes me, A, $500, as witness his bond here, which I now show to the court; yet he has not paid me.

Surprising, I say, even to the making of profert, about which these young men had received no instruction; and they were put upon honor against consulting the precedents or seeking outside assistance. Some failed, of course, but all sought for the essential allegations, and, what is to the point, having found them, as they thought, stowed them away for future use. With what joy they read the case of Henry Hawe![2] Henry Hawe, on Sunday, August 21, 1664, was at church in the parish of Wockingham, and during the service kept his hat on, when John Planner, who was one of the churchwardens, requested him to take his hat off, which Hawe refused to do; whereupon Planner took it off, and Hawe brought this action.

I suspect that under the modern codes the complaint in the case of this resolute Quaker under different hands would have shown a widely varying intensity of thought, feeling, and expression. But

[1] 2 *Reeve's Hist. Eng. Law* p. 264.

[2] 1 *Saund.* p. 10; 4 *Min. Inst.* p. 603.

how majestically the old declaration of *trespass vi et armis* marches along!

> Henry Hawe complains of John Planner of a plea of trespass, for that he, on the 4th of September, 1664, with force and arms, made an assault upon the plaintiff, and beat, wounded and ill-treated him, so that his life was greatly despaired of, and other wrongs to him did, against the peace of the King, and to the damage of the plaintiff in £700; and therefore he brings his suit.

Five lines upon the printed page! Mighty causes have thus arisen and been decided. The *Dred Scott Case*, which inflamed half a great nation, and perhaps provoked a war, but never a shot at the pleadings, was a simple action of trespass; likewise *Luther against Borden* (Dorr's *Rhode Island Rebellion*) which enriched both precedent and history, and saved the day for the reformers, for the time at least, if it did not furnish models for their pleadings, three-quarters of a century later in Oregon's initiative and referendum case;[1] while the *Dartmouth College Case*, decided in 1819, spite of the storms and criticisms of a century, such as perhaps no other case ever called down, stands today firmly rooted in a declaration of trover.

Does the garb of these pioneers, trover, trespass, case, assumpsit, offend you? Would you cut out now as vanity such phrases as "so that his life was greatly despaired of" as above or "against the peace of the King" or people? Remember the buttons on the tails of your coats. Aside from their historical significance, of which the young have ever to be reminded, these embellishments in old pleadings have for me a peculiar charm even when their utility is no longer perceived. So with their respective defenses, to be presently briefly noted, not omitting the special traverse of the *absque hoc*. I recall an answer served upon me by a gentleman of the old school some years ago in an action for damages for taking timber from the public domain. It began:

> The defendant, by J. Sam Brown, his attorney, comes and defends the wrong and injury when and where it shall behoove him, and the damages and whatsoever else he ought to defend, and says—

Did I move to strike any of that out? No; for several considerations. I may not have been able before Judge Hallett. Besides, it worked

[1] "Pac. States etc. Co. v. Oregon," 223 *U.S.* p. 118.

no harm, and did not add much to the record. Then, too, that old common-law formula of "full defense," standing there at the top of the page apprised me of the fact that I was to be met by no demurrer or dilatory plea, but by a plea to the merits, and, moreover, it fired my imagination, like "doubloons," or "pieces of eight," in a story book.

I once ran across a record of a mining claim called the *Nisi Prius*. I knew that a lawyer had been there in the mountains or thereabouts.

I should here explain perhaps that it is not the purpose of this paper to advocate a return to the system of common-law procedure, with all its special pleas, its feigned matters, such as, for example, that intricate and subtle fiction which the term "express color" came to represent. It were well, indeed, if a certain residuum of these old forms were not lost sight of. But my present object is mainly to refresh the recollection and to show that some of these things are really not so absurd as they seem.

Consider for a moment the much-aspersed *special traverse*. I may be pardoned if I remind the reader that its essential requisites were (1) an inducement containing an averment of new matter constituting an indirect denial of some material allegation in the adverse pleading; (2) the *absque hoc* or *et non* clause, constituting a direct denial of the same material allegation in the language in which it is made; (3) the conclusion, or offer of verification. For example, if in an action of debt on a bond the defendant should plead that he executed the bond under *duress*, the plaintiff may reply alleging new matter by way of inducement, to the effect that the defendant executed it of his own free will, and for a valuable consideration, without this (*absque hoc*) that he executed it by duress.[1] A learned author justly says that "this method of controverting a point by argument occurs in everyday disputation. Any person inexperienced in pleading would naturally meet the point of duress in the example mentioned by saying in behalf of the plaintiff (if the facts were at his command), 'the plaintiff paid full value to the defendant for the bond, which is a fact inconsistent with and repugnant to the pre-

[1] *Gould, Pl.* ch. vii, secs. 7–8.

tended fact of duress, and therefore I say it was not executed under duress.'"[1]

I heard two boys disputing. One said to the other:

"You swiped my sled at the Hill School yesterday." Plea by the other: "I never was at the Hill School in my life, and I didn't take your old sled, and I can prove it."

Now, here was the "special traverse" with a vengeance—the indirect and direct denial, then the verification—everything complete, and issue joined, and trial at once by battle. No mystery or lawyer's trick about this. And so, out of its naturalness, or its human qualities perhaps, the special traverse took its place.

II

Once upon a short time a man had a numerous family of children, with good old-fashioned names, John and Rebecca and Samuel and William and Mary Jane. Seized by the spirit of reform he resolved to abolish these names as utterly useless and confusing. But one day he wanted one of them, and he said to his eldest-born, but with some hesitation, "Here—you—you boy that I used to call John—come up here." Did he hope to save time and trouble by his expedient, or to escape the essential and enduring, if distracting, distinctions between William and Mary Jane?

If one wrongfully took and detained my horse, I had at common law the choice of redress in four forms of action, perhaps five, especially if the horse were sold—trespass, trover, detinue, replevin, assumpsit. My punishment was swift and deserved if from professional indolence or negligence I chose the wrong one, or sought to avoid the trouble necessary to such a perfect understanding of the case as would be requisite to adapt the declaration, or failed to consider the pleas according to the particular circumstances existing in it.

An idle attorney besought a brother
For something to read, some novel or other,
That was really fresh and new.
"Take Chitty," replied his legal friend,
"There isn't a book that I could lend
Would prove more novel to you."—J. G. Saxe.

[1] *Mor. Civ. Proc. C.L.* p. 239 note.

Judge Gibson of Pennsylvania declared that known modes of procedure according to the common law ought never to be changed but to avoid some practical mischief or serious inconvenience,[1] while another distinguished judge of that state thought that the Pennsylvania act abolishing pleading a *fruitful source of writs of error*.[2] I should pass hurriedly over this field, but I cannot refrain from quoting from yet another Pennsylvania case, a later one, 1889. A quantity of *hams* had been sold and delivered to one *Sides*. Mr. Justice Mitchell, declaring that the plaintiff's statement was at least three times as long as a declaration in the established forms need have been, said:

> This case affords one among many examples of the failure of the so-called reformed procedure to accomplish anything towards the brevity, the clearness, the accuracy or the convenience of legal forms. So long as the fundamental principles of our remedial jurisprudence shall be, that upon conflicting evidence the jury shall ascertain the facts, and upon ascertained facts the judges shall pronounce the law, so long will it be a cardinal rule of pleading, by whatever name pleading shall be called, that the line of distinction between facts and the evidence to prove them shall be kept clear and well defined. The notion of the reforming enthusiast that the average litigant or his average lawyer can make a shorter, clearer, or less redundant statement of his case if left to his own head, than if directed and restrained by the settled forms, sifted, tested and condensed as they have been by generations of the accutest intellects ever devoted to a logical profession, is as vain as that of any other compounder of panaceas.[3]

Influenced by such considerations, perhaps, many lawyers to this day prefer to have even a power of attorney begin, "Know all men by these presents."

From Kentucky come the same criticisms;[4] while this stricture is from the Supreme Court of the United States in a case which came up from Texas. Mr. Justice Grier:

> Had this case been conducted on the principles of pleading and practice known and established by the common law, a short declaration in *assumpsit*, a plea of *non-assumpsit*, and of *non-assumpsit infra sex annos*, would have been sufficient to prepare the cause for trial on its true merits. But unfortunately the District Court (of Texas) has adopted the system of pleading and code of practice of the

[1] 2 *Penrose and W.* p. 494.

[2] 8 *Searg. and R.* p. 265; 4 *Min. Inst.* p. 609.

[3] "Hubbard v. Tenbrook," 124 *Pa. St.* p. 291.

[4] 14 *B. Mon.* 85.

state courts; and the record before us exhibits a most astonishing *congeries* of petitions and answers, amendments, demurrers, and exceptions—a wrangle extending over more than twenty pages, and continued nearly two years, in which the true merits of the case are overwhelmed and concealed in a mass of worthless pleadings and exceptions, presenting some fifty points, the most of which are wholly irrelevant, and serve only to perplex the court, and impede the due administration of justice. The merits of the case, when extricated from the chaos of demurrers and exceptions in which it is enveloped, depend on two or three questions, simple and easily decided.[1]

III

Have the judges in Colorado had any experience with those who, disdaining the trammels of custom, have sought "out of their own heads" to do things? Let us see. It is a far cry through these three centuries from the days of Edward III, when pleadings were "without lameness and curiosity." "Old Time hath a wallet on his back into which he puts alms for oblivion." The distinctions between actions at law and suits in equity, and the distinct forms of actions and suits theretofore existing, were abolished in Colorado in 1877, and one form, the same for law and equity, denominated a civil action, was ordained for the enforcement or protection of private rights and the redress or prevention of private wrongs.[2] True, the distinction between contract and tort apparently remains in the constitution,[3] from which it will probably refuse to be driven by the legislature; but the names of our old friends debt and detinue, assumpsit, trover, trespass, case, replevin, ejectment, forcible entry and detainer, still appear in the registry of the general statutes, enacted before and since the Code,[4] and all come up on occasion to be voted, unconscious of the fact that they are dead; forcible entry and detainer even to this day boisterously advancing "with strong hand and multitude of people," the dress that he wore, or the identical company that he kept, in the 5th of Richard II in the year 1381![5]

The answer to my query is found in the response, tentative perhaps, but courageous, of our Supreme Court to the act of the General

[1] "Randon v. Toby," 11 *How.* p. 517.

[2] *Colo. Code, '77*, sec. 1.

[3] *Colo. Bill Rights*, sec. 12.

[4] *Rev. St. Colo. 1908*, secs. 4061, 4065, 7258.

[5] *Bac. Abr. For. Ent.* A. 321; *Mills' Ann. St.*, sec. 1970.

Assembly of 1913 empowering the court to prescribe rules of practice and procedure in all courts of record and to change and rescind the same.[1] This act was the subject of an interesting paper at the last meeting of the Colorado Bar Association, by Mr. Thomas H. Hood, entitled "Unshackling the Courts";[2] and the rules themselves, adopted by the Supreme Court on the 19th of June last, have been printed and went into effect the second Monday in September. Mr. Hood thought that a precedent for the act substantially was found in the English Judicature Act of 1873. This is no doubt true; but the English in these matters have passed from precedent to precedent.

A short reference to some of these may not be out of place. It has been aptly said that in the old days the maxim of the common-law courts seemed to be "No writ, no remedy"; but in extenuation it may be added that in the age of Glanvill if the clerks in chancery had no writ to suit the case they got busy and made one; made them, that is, until restrained by the Provisions of Oxford in 1258 in the turbulent reign of Henry III, which commanded the chancellor to issue no more writs, except writs "of course," without direction of the King and his council. This in turn a few years later (1285) occasioned the Statute of Westminster II, which provided that—

> Whensoever from henceforth it shall fortune that in one Case a Writ is found, and in like Case falling under like Law, and requiring like Remedy, is found none the Clerks of the Chancery shall agree in making the Writs.

Or, if the plaintiff and the clerks cannot agree, the matter shall be referred to the next parliament, when—

> by Consent of Men learned in the Law, a Writ shall be made, lest it might happen after that the Court should long time fail to minister Justice to Complainants.[3]

Says a late learned work, speaking of the period prior to the Provisions of Oxford: "A new form of action might easily be created. A few words said by the Chancellor to his clerks—'Such writs as this are to be issued for the future as of course'—would be as effectual as the most solemn legislation. As yet there would be no jealousy between the justices and the chancellor, nor would they be easily induced to quash his writs."[4]

[1] *Sess. Laws, 1913* p. 447.

[2] *Rep. Colo. Bar Assn. 1913* p. 283.

[3] 13 *Edw. I* ch. 24; *Imp. Eng. Stat.* p. 16.

[4] *Pol. & Mait.* p. 149.

We may be pardoned a simple illustration showing how the Statute of Westminster II worked out. Thus, before the statute, if A threw a stick at B and it hit him, A was guilty of a trespass. But if A simply threw a stick in the road and B fell over it and barked his shins, A was not guilty of a trespass. The statute gave a remedy in the second case as well as the first. And the new action was called "Trespass on the Case"; and lies to recover damages for the indirect or consequential result of the force applied. So out of this statute grew up "Trespass on the Case on Promises," or "Assumpsit," as it came to be called.

A tramp strolling by a hay field saw the laborers there vainly striving to get the hay under shelter against an approaching storm. He jumped over the hedge and the hay by his help was safely housed. He had not been asked. Could the tramp recover for his labor? No—not before the Statute of Westminster.[1] Reflecting on the justice and conscience of a plaintiff's cause, such as this, induced Lord Mansfield to say that the action upon the case was in the nature of a bill in equity, and, in effect, is so.[2]

The act of 1833 delegated to the judges in England the same task of reform which now seems committed to ours, and in pursuance of that statute, though all was not done which was permitted, were promulgated the celebrated Hilary Rules of 1834. Among other reforms those rules still further abbreviated the pleadings, and greatly narrowed the scope of the general issue in pleas, substituting allegations better adapted to ascertaining with definiteness the subject of dispute.[3]

There is to be perceived here in this imperfect sketch of the growth of the procedural law of England, sometimes retarded, sometimes aided by legislation, a tendency over all to leave it to those "learned in the law," to the judges, to work out that better maxim, "No right without a writ," "No wrong without a remedy," which finally became the boast of its jurisprudence. Pity it was, perhaps, that in the process the courts of the common law did not work out that remedy so as to make it "plain, adequate and complete" for all the altercations

[1] *Keene's Cases on Pl.* p. 144.

[2] "Bird v. Randall," *3 Bur.* p. 1345.

[3] 4 *Min. Inst.* p. 609.

of men. Blackstone, referring to the action of trespass on the case, says that this "provision (with a little accuracy in the clerks of Chancery, and a little liberality in the judges, by extending rather than narrowing the remedial effects of the writ) might have effectually answered all the purposes of a court of equity; except that of obtaining a discovery by the oath of the defendant."[1] Nor is there wanting a more modern witness. Austin says, characteristically, that "Equity arose from the sulkiness and obstinacy of the common-law courts, which refused to suit themselves to the changes which took place in the opinion and in the circumstances of society." Nor yet one other more ancient and grave: Fairfax, a very learned judge of the time of Edward IV, was of the opinion that the *subpoena* (in chancery) would not have been half so much in use if the common-law judges had been alert and "maintained" their jurisdiction.[2]

There were other common-law writs besides that of Case which performed the function of a bill in equity. Such was the writ of *Ne injuste vexes*, for example, which *restrained* a grasping landlord from distressing his tenant; the writ of *Curia claudenda*, which *compelled* an adjoiner to put up and keep up his part of a line fence; and the more familiar writ of *Estrepment* for the *prevention* of waste. These writs, it will be observed, were *personal* and *coercive* rather than *compensatory* or *in rem;* and their history appears to justify Blackstone's strictures. Suppose, in the case of the last-mentioned, the judges had extended its remedial function to the protection of shade and ornamental trees, as, it seems, they might, instead of narrowing it for the preservation of timber trees alone, as in fact they did—would not some fish been spared the chancery net? These digressions need not be pursued; but in this connection it perhaps remains to be said that if the only equity quality lacking in these common-law writs was their power to compel a discovery, as intimated by the great English commentator, then one line of statute law could have added that power, unless, indeed, some judge had been previously found to screw his courage to the sticking point. Then in due time would the age-long controversy between law and equity

[1] 3 *Bl. Com.* p. 51.

[2] 2 *Chitty, Bl.* p. 42, note citing *Y.B.* 21 *Edw. IV* p. 23.

have been settled, at least so far as the forum and methods of procedure for the prosecution of suits are concerned, and the great judge whose name is mentioned at the beginning of this paper would have been spared the humiliation of having his judgments at law justly arrested by an injunction from a chancellor by no means his peer in learning or virtue and after a contest the bitterest in judicial history.

It is neither desirable nor necessary for me to comment upon all the recent rules; but one especially is in accord with the spirit of my theme. It is rule 7, as follows:

> When it appears that the issues of fact are not clearly defined by the pleadings, the parties before trial, on motion of either, or by order of the court or judge, may be directed to prepare and sign a statement defining such issues. If they do not agree, such issues shall be settled by the court or judge. The trial of facts shall be limited to those thus fixed. The statement of such issues shall be filed with the clerk, and with the exceptions thereto, if any, duly noted thereon, signed by the judge, shall become a part of the record in the cause. Such statement may be amended.

In the opinion of the writer, rule 7 above justifies the act of 1913, and the solicitude of the Colorado Bar Association in the progress of the law authorizing it, through the legislature. The rules do not change the forms of actions, nor effect any radical changes in pleadings. They seek to expedite justice, to reduce the number of cases brought before the Supreme Court, to minimize the number of errors in those cases which are to be considered there, and to impress upon trial courts and members of the bar, as well as the community at large, a clearer appreciation of their responsibilities. If I read the act which authorizes these reforms aright, and understand the motives of those who fostered it, we have here an attempt to "get back," to use a phrase of the president of the Colorado Bar Association in his annual address of last year, "to the original traditions of the common law."

It is hoped that the rules will not be greatly multiplied. Imperfect as the Colorado Code of Civil Procedure is, with its 478 sections, as any human product must be, it is incomparably superior (because simpler) to that of any of the other state codes with which I am familiar. The Illinois Practice Act, which is the common law slightly tempered by statute, is to many desirable. But "the merits of the New York Code will have to be diligently sought for in nearly four thousand sections of statute law, burdened with a gloss of countless decisions."[1] Missouri, its eldest daughter in the code system, has twice as many sections as Colorado. Ohio, California—but why enumerate? Their acts are "as the stars for multitude." Of the new English system of procedure, writing a few years ago, a learned author says: "Its merits will have to be ascertained from the Annual Practice Compilation, which presents to the student an intricate and tangled net of statutory provisions, court orders, and judicial interpretations."[2] One of the distinguished gentlemen who participated in the formulation of these rules told the writer recently that after inviting suggestions, upon the passage of the act by the legislature, from eminent jurists and practitioners the country over, his committee was surprised at the number of recommendations received which had been anticipated and carried out in the Colorado Code more than thirty years before.

Time, perhaps a short time, will test the merits of the new rules. But there should be a division of responsibility in their working out. "The excellence of a procedural system is to be tested by the ease with which it lends itself to practical use. As practice discloses weakness in its fabric the practitioners themselves should be free to devise amendments and changes calculated to remedy such defects. The users should be also the designers and adjusters."[3] I do not speak with authority, but I venture to say that the judges will themselves welcome all proper suggestions in this behalf.

To what end? To the end that "old father antic, the law," to use Falstaff's phrase, may be cured of his "lameness" and strike a steady pace.

[1] *Mar. Civ. Proc. C.L.* p. 339. [2] *Ibid.*

[3] SUNDERLAND, in *Rep. Am. Bar Assn.* Vol. XXXVIII, p. 911.

AN APOLOGY FOR THE CHURCH'S PERSECUTION OF SCIENCE

By Donald McFayden

The incessant conflict between science and religion is a phenomenon which must interest every student of history. The story of this conflict in the Christian centuries has been told by Dr. Andrew D. White in two fascinating and learned volumes.[1] But most accounts of the struggle, not excepting even Dr. White's, leave the reader unsatisfied. He rises from their perusal with a sense of bewilderment. Why should this thing be? Just why has nearly every advance that science has made encountered the church's opposition? Few historians, not even Dr. White himself, give an adequate explanation. One gets the impression from them that the church simply has been criminally stupid. Now no man is ever consciously stupid and no good man is ever consciously a criminal. Any tendency which has been shared by any considerable body of intelligent and conscientious men must have had some justification, real or apparent, in both reason and morality. The justification (not the folly) of the church's opposition to science has been the cause of that attitude. It is necessary, therefore, for the historian to try to understand that justification. For lack of such understanding the ordinary books upon the subject are wanting both in truth and in interest. They degenerate from tragedy to melodrama. They represent the struggle as one between light and darkness; truth and error; absolute right and absolute wrong; whereas it has been in reality a struggle between two rights, two methods of approaching truth, two vital human interests.

It is the purpose of this paper to point out three causes for the church's intellectual conservatism: (1) a marked divergence in aim and interest between science and the church; (2) an unfortunate but very natural misapprehension on the part of the church as to the

[1] White, Andrew Dickson, *A History of the Warfare of Science with Theology in Christendom.* New York, 1896.

essential nature of her teaching; (3) a fundamental difference in premises and logical method between scientific and religious thought.

I

The heart of the conflict centers around the claim which every church makes for its doctrinal standards. Every church insists that its essential teachings are ultimate truths. To take a concrete example: All churches of the Catholic order and all or almost all churches which originated in the Reformation era insist, explicitly or implicitly, upon the inerrancy of the Nicene Creed. Orthodox Christianity holds that every statement in that famous document is absolute and final truth; and that no doctrine which is out of harmony with any statement of the Nicene Creed can possibly be true. It insists that human science and philosophy is ever in a state of flux; that scientific theories are framed and gain acceptance only to be overthrown by the scientists of succeeding generations, but the creed abides and will abide. However strong the evidence for any idea which is opposed to any article of the creed may be, and however imposing the array of authorities may be, that accept such a doctrine, more accurate thinking or the discovery of new evidence will ultimately cause men to reject it and will bring them back to the teaching of the creed. In the meantime wisdom as well as duty demands that we hold fast the faith once (and for all) delivered to the saints.

"It is magnificent; but it is not war," exclaimed the French commander at Balaklava as he watched the charge of the Light Brigade. The confidence with which the church reposes upon the Nicene Creed is magnificent; but, the scientist is apt to urge, it is absurd. Would anyone dream of making such a claim for any other ancient document? There are Platonists in plenty among us; but what Platonist thinks of asserting that his master was inerrant? Historians regard Thucydides with unbounded admiration; but they do not hesitate to question his conclusions. No one but a fool would maintain the inerrancy of Galen. Philosophy and science and historical method have made many advances since ancient times, and the goal is not yet. No scientist, whatever his branch, ventures to regard his views as beyond revision. Every true scientist takes for granted that succeeding generations will know more than he and will make over his ideas. Is it common-sense then to ascribe inerrancy to any document of the fourth century or of the sixteenth?

Is it not in the highest degree pernicious? Has not the church's insistence on the inerrancy of her creeds been the chief barrier in the path of the onward march of thought? What else interrupted the progress of discovery during the thousand years of the Middle Age? The outburst of scientific discovery which characterizes modern times dates from the overthrow of the principle of authority by the men of the Renaissance. Fortunately the church's attempt to hold thought still cannot permanently succeed. For truth is mightier than the church. The course of human thought is strewn with the wrecks of once-accepted ideas, theological as well as scientific. But if experience is unable to convert the church from her futile opposition to all intellectual change, ought not reverence itself to teach her that

Our little systems have their day,
They have their day and cease to be;
They are but broken types of Thee,
And Thou, O Lord, art more than they.

To all of which the church is apt to reply that the scientist is confusing two entirely distinct things. There is a wide difference between the Nicene Creed, for instance, and other documents which have come down to us from ancient times. The works of the ancients which the scientist cites are human production; whereas the Nicene Creed is not, in the last analysis, a human product at all. It is the embodiment of a divine revelation and as such should be implicitly accepted. Reduced to a syllogism, the church's argument for the inerrancy of the Nicene Creed is as follows:

Error inheres in the products of the human mind.
But the Nicene Creed is not the product of the human mind.
Therefore the Nicene Creed is inerrant.

(The attitude of any church toward any of its authoritative formularies may be reduced to a similar syllogism.) It is not too much to say that not a single member of this syllogism, its major premise, its minor premise, its conclusion, not even its logical correctness, will be admitted by a historically trained unbeliever.

The minor premise he instantly denies. The history of the Nicene Creed is too well known. The steps in the process of its formulation can be followed in considerable detail. They form a logical chain. Nowhere is the historian obliged to posit a divine interference with the human thought-process to account for the result. There is nothing to show that the creed is not as truly a product of human minds (and hearts) as any other document which has come down to us from the ancient world.

The conclusion of the syllogism appears equally unable to stand examination. It seems quite clear that as a matter of fact the Nicene Creed does contain errors. It asserts for example that Jesus the third day after the crucifixion "rose again according to the Scriptures and ascended into the heavens and sitteth on the right hand of the Father." Honestly interpreted—interpreted, that is, according to their original meaning—these articles of the creed assert that on the third day Jesus' soul rose from a repository of dead souls beneath the surface of the earth (see the Apostles' Creed) and rejoined his body in the grave. His reunited person then (after an interval of forty days) ascended through the (seven) concentric heavenly hemispheres which overarch this (flat) earth to where, at the zenith, God the Father sits enthroned. These assertions of the creed are clearly erroneous. No one any longer believes that the souls of the dead are assembled in a cavern within the earth; and no one any longer believes in the seven heavenly hemispheres or that God is enthroned at the zenith. ("Which zenith?" the modern man pertinently asks.) Jesus simply cannot have done what the creed says he did. Copernicus has made its assertions forever incredible. To the church's contention that the creed cannot possibly contain errors, the historian answers that the fact is that it does!

Passing over for the moment the major premise (we shall see later on that it is at best only a half-truth, fortunately for the church and for us all), let us proceed to examine the logic of the argument. What does the churchman mean by his minor premise? If the creed be not a product of the human mind, how was it produced? The churchman's account of the origin of the Nicene Creed is this: God the Father, realizing on the one hand man's inherent inability to arrive at absolute truth unaided, and, on the other, man's need of truth, sent to earth the Second Person of the Blessed Trinity. God the Son revealed to his apostles the truth that man needs. The truth thus received the apostles handed on to their successors. The latter handed it to their successors in turn, the Holy Spirit who presides over the Catholic church safeguarding the correctness of the transmission meanwhile; until finally the divine message found clear and permanent formulation in the Nicene Creed. But that God is triune, that Jesus was the Second Person of the Trinity incarnate, that there is a Holy Ghost and a Catholic church are some of the very things the creed was drawn up to assert. The truth of these assertions therefore is assumed in the premise of the argument intended to prove their inerrancy. That argument in fact reduces itself to this: The Nicene Creed is true; therefore it cannot be false! It involves a *petitio principii;* and the calmness with which the unbeliever always ignores the argument proves that he feels even when he cannot define the fallacy.

The fact is that the famous argument which we have been examining is really not an argument at all but a confession of faith, a formal expression of the church's conviction that her teachings are finalities. That conviction all Christians share. It is an integral part of the Christian faith. But to the unbeliever it is unmeaning, if not absurd. To many it seems a priori impossible that Christian doctrine or any other doctrine should be final. To them Christian certainty appears intellectual Bourbonism, a futile and hateful thing, the source of countless persecutions, the buttress of error and the foe of honest thinking; Christian theology, a bundle of exploded errors; and Christianity itself something which must pass away and give place to something better; which will pass away in its turn.

Let us grant for the moment that history and logic are wholly on the side of the unbeliever. The historian is not thereby absolved from the task of studying and accounting for the church's belief in the finality of her teachings: for that belief is one of the most pregnant of historical facts. Out of it has come, for one thing, the whole conflict with which we are here concerned.

II

An explanation of the church's insistence upon the inerrancy of her teachings is suggested by the passion which Christian apologists always bring to their defense. Men's opinions can often be explained from their interests. What manufacturer of a protected article ever believed in free trade? Beliefs often have motives as well as logical grounds. May it not be that there is some religious interest to which the idea of inerrancy appeals?

The oft-made suggestion that the church's insistence upon the inerrancy of her teachings is due to her desire to dominate men's souls—is simply a piece of priestcraft in other words—will not suffice. Priestcraft, good or bad, has often been, and still is, a determinant in the church's policy. But no sane historian and no sane observer of life is any longer content to account for any deep-seated feature of the church's life by the simple explanation which satisfied Voltaire. Religion simply cannot be an invention of the priests. Moreover, the church's opposition to science has not been confined to her priests. The devout layman has often shown himself at least equally hostile. The foes of modern biblical science, for example, are at present more numerous among the laity than among the clergy. There must be some craving in the hearts of the religious man as such which the doctrine of inerrancy satisfies, some interest of the religious life as such which the denial of that doctrine imperils.

That interest is not difficult to discern. There is an obvious human craving which belief in the inerrancy of the church's teaching satisfies. All men crave for certainty, for a rock of absolute truth upon which they can rest their lives in serene confidence that no advance in the tide of knowledge can ever overtop it or sweep it away. That craving corresponds to a real need. Men need convictions. Where there is no conviction there can be no restfulness of heart, no vigor of life, no courage, and no character. Now it is the function of a church to breed in men peace and courage and character. She can perform that function in no other way than by furnishing men convictions. It is not enough that she teach helpful doctrines. She must, if she is to succeed in her task, teach her members that those doctrines are absolute truths. The inerrancy of the church's teaching is for her a *locus standi aut cadendi.* Unless she holds her teaching to be inerrant, and convinces her converts that it is inerrant, she must fail in her mission and be uprooted as a cumberer of the ground. She will always find those who will gladly share her assurance. Those who find in her doctrines solace and salvation will be eager to accept and defend their inerrancy.

One root of the conflict between the church and science is here laid bare. Science and the church have different interests. The scientist is in search of wider knowledge and a deeper understanding of things. His animating conviction is that he does not know. Doubt is the very life-breath of science. The implicit acceptance of existing conceptions means for science paralysis. On the other hand, doubt is the paralysis of the soul. Conviction is the only possible fount of human activity and peace. The church, as the physician of the soul, must war upon doubt as upon the soul's chief disease. The opposition in interest between science and the church could hardly be more radical. What wonder if it has often led to open conflict? When we recall the effect of doubt upon character, the church's frequent efforts to inculcate intellectual Bourbonism become intelligible. They seem almost salutary.

III

But no belief can be accounted for simply by the will to believe. The most alluring belief cannot be entertained unless in some measure it satisfies the intellect as well as the heart. At the very least it must be thinkable. If widely held by rational men, it cannot be utterly absurd. The inerrancy and finality of the Christian faith has in all ages been widely held by rational men. We are impelled to inquire whether the finality of Christian doctrine is after all so inconceivable as it is sometimes represented. For once the field of formal logic seems attractive. We are tempted to explore it that we may ascertain where, if anywhere, finality resides and whether by any chance Christian doctrine belongs in the same locality. It is worth while for us, even as historians, to make clear to ourselves the essential nature of the Christian faith, to classify it logically and to determine the logical method by which Christian assurance is arrived at.

It is not in the religious sphere alone that man needs convictions. Conviction plays a necessary part in the most mundane affairs of life. A half-mile or so from where I sit there is an irrigating ditch. On that irrigating ditch depends in part the fertility of a beautiful valley. The existence of that irrigating ditch is due to a conviction, the conviction, namely, that water can be depended upon to run down hill. Should that conviction be shaken, the ditch would quickly be allowed to fall into ruin. The illustration is typical. Every act of man grows out of a belief. I go home to dinner because I believe that dinner awaits me. The discovery that certainty is irrational would be the most terrible calamity which could happen to the race. It would put a stop to all human activity and mankind would perish in a day. Of course there is little danger. Common-sense protests that there are some things of which we can be absolutely sure. We know, for instance, that water always runs down hill. There are a multitude of facts of which we can be absolutely certain; and science is constantly adding to their number.

"Science is constantly adding to their number." In that assertion—which the scientist unhesitatingly accepts—there stands revealed a curious self-contradiction on the part of the scientist. One moment he declares all his conclusions open to doubt. The next he asserts for some conclusion of his a finality quite equal to that which the most ardent churchman asserts for his creed. This contradictory attitude of science toward its results challenges understanding; for an examination of the nature of the inerrancy which the scientist claims, and justly claims, for some of his results may throw some light upon the sort of inerrancy which the church may, without absurdity, assert of her creeds.

The explanation of the fact that the scientist sometimes disclaims and sometimes insists upon the inerrancy of his results is that his results are of two kinds. Science has two distinct aims. The primary and professed aim of science is to understand the world in which we live. Science endeavors to describe and explain all that happens or has happened. In other words, she tries to conceive things as they really are, or were. But the scientist's interest in the world is not purely theoretical. Human researches are not always prompted by mere curiosity. Men seek knowledge often for reasons which are practical. They investigate nature that they may be able to comply with her laws and thus secure her co-operation in their enterprises. *Natura enim non nisi parendo vincitur.*

This second aim of science has proved in part attainable. It has enabled her to frame rules or working hypotheses which serve as unerring guides to the accomplishment of human ends. On the other hand, that which we have termed primary and professed aim of science can never be fully accomplished. Final conceptions—conceptions, that is, which correspond in all points with the realities they represent—are probably forever beyond our reach.

Consider the conditions which a final conception must fulfil: (1) It must cover all there is to know about the reality to which it corresponds. (2) It must be in harmony with the true and final conception of everything else and with the true conception of the universe. (3) It must give the true explanation of all the characteristics of its object by exhibiting them in their true relations. It is obvious that these conditions imply omniscience. Only God himself can have an adequate conception of the simplest thing. Man is doomed to be ever learning but never able to arrive at full knowledge of any truth.

When, however, man turns from the vain effort to comprehend fully the world to his real business of living in it, all is changed. He finds solid ground beneath his feet. He finds himself in touch with realities, stable and trustworthy. These realities we are ever more accurately comprehending. The full comprehension of them is a goal infinitely remote; but already we can recognize them, and many of their relations and their effects. For practical purposes our knowledge of certain facts is adequate and cannot be increased. Already we are in possession of working hypotheses which, as working hypotheses, are final.

There is an interesting resemblance between the attitude of science toward the facts she discovers and the attitude of the church toward Christian doctrine.

1. A fact once discovered is discovered once for all. The discovery can never be invalidated. The church believes that the faith was delivered once (for all) to the saints.

2. Facts are the touchstones by which theories are tried. Science holds that no theory which is out of harmony with a single fact can possibly be true. The church similarly insists that her faith is a touchstone of truth, a finality which every theory must allow for and the true philosophy include.

3. The functions of religion and of practical science are similar. The function of both is the guidance of life. For "theology," as a great American theologian has recently said, "is a practical discipline." Religion must heal men's hearts and mold their conduct, or it amounts to nothing.

4. The sense in which Christian faith and scientific rules of art can be said to survive the downfall of scientific systems is identical. The two classes of working hypotheses are alike in the nature of their finality. This last point requires to be elaborated.

A trustworthy working hypothesis once discovered is a permanent acquisition of the race. It stands fast amid the wreck of systems. But it is not the conception of its first discoverer that survives. That conception is of necessity adjusted to the *Weltanschauung* of which it is a part. All the conceptions of a man or of an age are linked together. They form an organism. Each fits into every other. Any change in any one of a man's ideas is likely to involve a change, minute or revolutionary, in every other. The mental picture by which a fact or a belief is represented can never be permanent. When the history of any working hypothesis which has had a history is studied, its unity dissolves before our eyes. It resolves itself into a series of conceptions which are alike only in this, that they furnish the same practical guidance.

Take, for example, the principle of the irrigating ditch. That principle was discovered when men's thoughts were still animistic. The first irrigator of Babylonia must have expressed the principle in some such terms as this: "Father Euphrates is marching toward the sea; if we induce or compell him to pass through our fields he will bless them." After long ages animism passed away. Men learned to think of matter as inanimate. The primitive conception of the principle of irrigation therefore of necessity likewise passed. It shared the death of the body of ideas of which it formed a part. But the principle itself survived. It rose again embodied in a new idea; the idea that water always runs down hill. That idea was eventually seen to be a particular case of a more general principle, that most things if unsupported fall to the earth. Then Newton taught the world that the force of gravity is exerted, not by the earth alone, but by every particle of matter, and set forth the laws which govern its working. At present we seem to be on the verge of a new conception of gravitation. The new conception of matter which physical chemistry has recently evolved demands one.

Thus the principle of the irrigation ditch, when its history is studied, resolves itself into at least four successive conceptions; with a fifth conception just below the horizon. The bond which unites these conceptions is an identity of usefulness. All enforce upon the irrigator identical injunctions. All embody the same working hypothesis. The useful working directions which the irrigators of ancient Babylonia derived from their idea of the habits of Father Euphrates are equally derivable from Newton's theory of gravitation. They will be equally derivable from the new conception of gravitation which scientists are laboring to evolve. The language in which the ancient Babylonian farmer expressed his working hypotheses, the conceptions in which he pictured it to himself, were inadequate. Our description of the truth upon which all successful irrigation rests is but little less inadequate. Only omniscience, as we have seen, can adequately conceive any reality. But every builder of a successful irrigating ditch, as he builds, is acting in harmony with reality; as is proved by his success. A valid rule of art, once discovered, abides as a permanent possession of the race; though the conceptions in which men picture that rule of art to themselves must change from time to time as their conception of the world changes.

The persistence of the Christian faith through the Christian centuries has been of a similar order. What has persisted has not been the conceptions of the primitive church. The fact that nearly all churches, more or less, retain ancient formulas must not deceive us. No man today, however orthodox, conceives the faith as the apostles conceived it. The conceptions were adjusted to the *Weltanschauung* of the Jews of the first century. That *Weltanschauung* has passed away and with it the conceptions of the Christian faith which presupposed it.

To illustrate by but one aspect of one Christian belief: The primitive conception of the ascension of Jesus we have already outlined. It was that he rose through the clouds and the heavenly hemispheres to the zenith, there to sit at the right hand of a literal throne of God. That conception presupposes astronomical conceptions which have passed away. No intelligent Christian can any longer hold it.

At the very time that the Nicene Creed was being framed these astronomical conceptions were already being disputed. Christianity was already penetrating into upper classes in society and was coming into contact with Greek philosophy. Greek philosophy had long ago learned that the earth is not flat but round. A new conception of the universe was therefore demanded. There was a bitter conflict in the church between the two cosmogonies. The conflict outlasted the Reformation; but many theologians as early as the fourth century accepted the rotundity of the earth. "It is a matter of no interest to us," declared Basil of Caesarea (329–379 A.D.) "whether the earth is a sphere or a disk or concave in the middle like a fan." A new conception of the universe was eventually evolved, the conception usually known as the Ptolemaic. According to this conception the earth is round and surrounded by ten transparent revolving spheres; eight of them carrying respectively the moon, Mercury, Venus, the sun, Mars, Jupiter, Saturn, and the fixed stars; the ninth being the *primum mobile* which carries the others around; and the tenth, the Empyrean, where, in light unapproachable, sits Holy Trinity. A perceptible though not a very great change in the conception of the ascension was involved. Christ was conceived of as passing through nine, not seven (or six), heavens.

Then came Copernicus. The new astronomy which he and his followers evolved destroyed the last vestiges of the primitive idea of the ascension. The Ptolemaic astronomy had left the primitive idea of the ascension practically intact. The earth being regarded as immovable, it was still possible to conceive of God as enthroned at the zenith above Jerusalem. It was believed that the antipodes were not inhabited. It was still conceivable, therefore, that every eye should behold the Lord when, at his second advent, he should descend in the clouds. Thus in all essentials the primitive idea of Christ's fate still persisted. Now, however, it was learned that the earth revolves on its axis. There is therefore no fixed zenith, no one place for God "above the bright blue sky." Columbus and Magellan proved that the antipodes were inhabited. It became impossible therefore to believe that every physical eye should behold a physical descent of Christ from the heavens. It is fair to ask whether the teaching of the apostles still persists; whether the gospel of the primitive church has not passed away.

If we are to answer that question, it is important in the first place that we bear in mind one distinction, the distinction between the current ideas which the primitive church assumed and the new faith which it proclaimed. The first-mentioned determined the form but they were no part of the content of the gospel message. "What counted in the Christian religion, then or now, is not the old vocabulary but the new message."[1] That the earth is flat, that it is overarched by seven hemispheres, and that God is seated at the zenith, the primitive Christians took for granted. These were the accepted scientific ideas of their day and nation and the apostles assumed them, just as a modern preacher assumes the scientific ideas of his day. The apostles were not teaching this cosmogony. They did not need to. Their hearers already accepted it. They were concerned only to

[1] MACKINTOSH, H. R., *Expositor*, February, 1914, p. 124.

proclaim what their hearers did not already know or accept, namely, that Jesus rose through the heavens to the throne of God.

But we have not even yet recovered the essence of the apostolic teaching. The apostolic teaching was in all its parts a gospel. It was practically helpful. It was essentially a working hypothesis, if that cold-blooded term may be pardoned. Being a working hypothesis, its essence can be discerned only by considering its practical import. The full practical import of the doctrine of the ascension of Christ we cannot here set forth. Space forbids and it is not necessary for our argument. It will be sufficient if we select but one aspect of it, choosing the simplest aspect that occurs to us.

It will be remembered that the New Testament quite as frequently says that Jesus was raised by God as that Jesus rose; using the passive rather than the active voice. The ascension thus conceived furnished among other things the apostolic answer to the perplexing question why Jesus was allowed by God to suffer and fail. He had been, his followers believed, a perfectly good man. He had tried, as no one else had ever dared to try, the experiment of trusting himself wholly to God and righteousness. He had spurned all alliance with the devil, even when the devil offered him all the kingdoms of the world and the glory of them. Apparently his trust was disappointed. His enemies cried about the cross, "He trusted in God that he would deliver him. Let him deliver him *now*." The primitive Christians believed that God met the challenge: that God raised Jesus to his right hand, the place of honor and most intimate communion, there to await a final and complete triumph.

Modern Christianity shares in its essentials this primitive conviction. Modern Christians, too, believe that the agony of the cross was but a gate to glory; that Jesus still lives with God and that he will yet overthrow his enemies. They draw from that conviction the same inspiration that the apostles did. They share the apostles' working hypothesis that God and righteousness can be absolutely trusted and that God will surely justify his faithful servants. The primitive gospel therefore does still persist. Men are still Christians. But the conceptions in which the apostles presented their gospel have passed away forever. No intelligent man any longer conceives of God as enthroned in the sky. That crude conception of the location of God, thanks largely to Copernicus, has given away to a conception much more enthralling: "Closer is He than breathing, and nearer than hands or feet."

5. The parallel between the working hypotheses which science furnishes and that great group of working hypotheses which we call the Christian faith can be traced one step farther before its lines diverge. Both are held to represent objective truth. The magnificent confidence which the church reposes in the creeds we have already described. The scientist is apt to exclaim at it. Yet it is precisely parallel to his own confidence in the truth of certain of his own convictions. When, however, we proceed to examine the grounds of scientific certainty and of religious certainty respectively, the parallel between practical science and religion at last breaks down. Scientific conviction and religious conviction are arrived at by very different logical processes and rest upon very different premises.

For no religious doctrine is susceptible of rigid scientific proof. It is true that theologians in all ages have labored to evolve a scientific demonstration of their teachings. In the Middle Ages, Anselm endeavored to construct a scientific proof of the existence of God. Few realize how much of the New Testament itself is taken up with attempts to prove Christian doctrine by the logical methods of contemporary Jewish scholarship.[1] In our own day there is issuing from the press a flood of books whose aim is to prove the reasonableness of the Christian faith and to show that it is in harmony with modern knowledge.

But no scientific argument which amounts to a rigid demonstration has ever been evolved for any Christian doctrine. The reason is that the content of the Christian doctrine and the content of the working hypotheses which science evolves are dissimilar. The scientist evolves working hypotheses by registering occurrences and noting their correlations. The working hypotheses which he evolves are always predictions such as this: If a certain volume of hydrogen and a certain

[1] SCOTT, E. F., *The Apologetic of the New Testament*, New York, 1907.

volume of oxygen are brought together under a certain pressure and at a certain temperature, they will unite to form a definite amount of water. The doctrines of practical science, in other words, are statements as to the interdependence of individual phenomena. Religion, on the other hand, is concerned with the universe as a whole, its attitude toward man and man's destiny in it.

Now man's destiny and the attitude of the universe toward him are beyond the reach of strict scientific investigation. The only rigid method of proof that science knows is the inductive method. The working hypotheses of science are susceptible of inductive proof. They concern the order in which phenomena occur and that order can be observed and reobserved until an inductive proof of it can be built up. That these working hypotheses "work," that they furnish infallible means of prediction, is absolute proof that they correspond to something real. The doctrines of religion, however, are clearly beyond the reach of inductive proof. The inductions necessary are too vast and too complicated.

For instance: "We know," says St. Paul, "that all things work together for good to them that love God." But St. Paul's knowledge did not rest upon an inductive basis. When, for example, he spent a night and a day in the deep, he could hardly have been conscious that it was effecting his good. Even after he was rescued, the most mature reflection could not discern all the bearings of his experience upon his welfare. We cannot list the divine dealings as a scientist lists his phenomena, determine the full bearing of each upon human welfare, and so arrive at an assured generalization as to the bearing of all. In the case of certain Christian doctrines, the very materials for an inductive proof are beyond our reach. We have no experience of the fate of men beyond the grave. Lastly, Christian doctrine does not lend itself to inductive proof for the very reason that it deals not with individual phenomena and their interrelations but with the world as a whole. Its subject-matter is not the subject-matter of inductive science but of philosophy.

Philosophy however is equally incapable of furnishing a demonstration of religious doctrine. Philosophy is incapable of demonstrating even its own conclusions. The conclusions of philosophy notoriously lack finality. The accepted philosophy of today is revised or rejected tomorrow. For the outcome of philosophical investigation is a conception: and conceptions, as we have seen, are fleeting things. Philosophy, therefore, can furnish no secure premises for demonstrating anything. To build a faith upon it would be to build upon the shifting sand. The church must seek a more secure foundation for her faith than philosophy can ever furnish her. She must have found some more secure foundation; for her conviction is a more deeply rooted conviction than philosophical reasoning could ever plant. Finally, the Christian faith is clearly not a product of philosophy, for the reason that it is not a body of conceptions. It is a body of working hypotheses which are ever being reconceived.

Two other grounds which have often been assigned as the grounds of Christian conviction must be briefly dismissed. The argument from revelation we have already seen to be no valid argument, for it in a large part begs the question. The argument from history for the most part also involves a *petitio principii*. To demonstrate the reality of the future life by reference to the resurrection of Christ, for example, is to be guilty of a *petitio principii*. For the major premise of all historical investigation is that the impossible never happened. Unless there be a life beyond the grave Jesus never rose. The records of his resurrection are incredible. Either the disciples never saw him, as the records say they did, or they were victims of a hallucination. The records on which this argument for a future life are based are credible only if that which they are used to prove is assumed.

The real ground of the Christian's confidence in the truth of the working hypotheses on which his life is based is that those working hypotheses always furnish a reliable basis for life. In that respect at least they are like any working hypothesis of science. They can always be depended upon to "work." Those, for example, who accept the doctrine of the ascension are always armed against temptation and disappointment, impelled to seek goodness, and eschew evil; and when goodness fails and evil triumphs and no visible ground for hope appears, they can recall that he who was better than they can ever hope to be passed through even greater darkness and God-forsakenness on his way to triumph. The ground of Christian certainty is therefore analogous to the ground of scientific certainty. In both cases it is to working hypotheses that certainty attaches. In both cases the ground of certainty is that by long experience these working hypotheses have been proved to be reliable as working hypotheses.

But the similarity conceals a fundamental difference. The reliability of the working hypotheses of science is immediate proof that they correspond to some objective reality. The reliability of the working hypotheses of religion does not, however, immediately prove their truth. What we mean when we say that a religious working hypothesis always proves reliable is that it can always be depended upon to make him who accepts it a better and a happier man; that it is subjectively satisfying. Because a belief is subjectively satisfying it does not immediately follow that it is objectively true.

And yet the Christian takes that leap. He feels justified in taking it because he refuses to believe that things are not what a man must believe them to be if he is to realize his highest life. He refuses to believe that noble living is irrational, that any postulate which is necessary to motive it and justify it can possibly be false. He insists that it is precisely the highest types of manhood that are living in full accord with the nature of things.

This is not the place to argue the credibility of the religious premise. Perhaps "nothing worth proving can be proven, nor yet disproven." Our business as historians is only to see very clearly what the fundamental premise of religious faith is. For that which we have outlined is the underlying assumption of all religious faith, the basis of all religious conviction; albeit few perhaps, even of those who feel and respond to the appeal of religion, are ever conscious of the several steps of their logical processes. Religions spread, not because of any appeal they may make to the philosophic intellect, but because they satisfy the soul's needs.

To illustrate from the spread of Christianity itself: Primitive Christianity rested upon the doctrine of the resurrection. Now the doctrine of the resurrection was alien if not abhorrent to the gentile intellect, popular and philosophic alike. It was "to the Greeks foolishness." To the unphilosophic Greek it was an unheard of thing that a soul should ever return from the House of Hades and take body again in the upper air. To the Greek philosopher it was absurd to think that men in the higher existence should be burdened with a body. Yet the doctrine spread, and spread eventually in even a crasser and more Judaic form than St. Paul had preached it, in the form of a belief in resurrection of the flesh. Men believed in the teeth of their presuppositions and even in the teeth of their reason. Why? Because they found in the doctrine a gospel. It was good news to the slave that he should live again, no shade life but a real life in a real world in which justice and happiness should prevail. Those philosophers who became Christians found in the Christian hope a fuller hope than philosophy offered, a hope of a life spent not merely in contemplation, but also in activity and fellowship. A study of the logical method of the defense of the doctrine of the resurrection which is contained in the fifteenth chapter of First Corinthians is illuminating in this connection. St. Paul mentions the fact that the disciples and he himself had seen Jesus after his death; but he does not rest his case there. His testimony might be doubted. The argument on which he relies is that if there be no resurrection, Christ did not rise, and "if Christ be not risen your faith is without ground," "let us eat, drink and be merry, for tomorrow we die." St. Paul was fully conscious of his true ground of appeal. He refused to discuss "wisdom." He refused, that is, to use scientific argument. He was determined to "know only Christ and him crucified" and he found that his gospel, cast though it was in un-gentile forms of thought and expression, awakened a response in needy hearts and won those who were fitted to receive it.

It has ever been so. Argument may produce intellectual assent; but religious conviction resulting in an altered life seldom if ever results from mere argument. It results only from a felt need and the satisfaction of that need by the religious message.

IV

To return now to our problem. We have determined the logical classification of Christian doctrine, its function, the sense in which it can be said to survive the downfall of scientific systems, and the logical process by which Christian assurance is reached. We have discovered interesting analogies and interesting contrasts between the teachings of religion and the teachings of science. What light does our study of nature and characteristics of science and religion throw upon the incessant warfare between the two; a warfare, be it remembered, which is not confined to the Christian centuries. Witness the fates of Anaxagoras and Socrates.

One root of strife we have already laid bare: the fact that science and religion serve quite different interests. We are now in position to discern two others: one a blunder, the other a mutual lack of sympathy.

1. The church has ever been beset by an insidious confusion of thought. She has ever been tempted to identify her faith with the conceptions in which, for the time being, she pictures its assertions to herself. Theologians have too often entertained a quite impossible notion of the method of revelation. They have thought of revelation as consisting in God's inserting his own *ideas* into human minds. They have assumed, for example, that the apostles' conceptions of the truths upon which their faith laid hold were identical with the divine conceptions. That, however, is impossible. With all reverence be it said, God simply could not convey to man any one of his ideas in its entirety and completeness without conveying all. For the ideas present at any one time in any mind, human or divine, form an organism. Each is linked with every other. No one can be entertained without the rest. The divine ideas can have meaning only for omniscience. To have expressed the truth which Christians believe God did convey to man when He founded His church, in forms of the divine thought, would have been a futile thing. The message would have had no meaning. It is historically certain that this futile method of revelation was not the method God adopted. The conceptions in which the faith was embodied for the apostles were conceptions of their own day.

For instance, they expressed their faith and conceived their faith in terms of Jewish astronomy. The persistence of their faith through the ages has not been a persistence of their conceptions but of their practical convictions. The continuity at bottom has not been one of ideas but of life. It has been, in a word, the continuity characteristic of a working hypothesis.

The church's misunderstanding of the essential nature of her faith and of its finality has been the very taproot of her mistaken resistance to advancing thought. It must be admitted that, on her premises, her resistance has been scientifically justifiable. If the assertion that God "sitteth upon the circle of the earth and the inhabitants thereof are as grasshoppers" be an accurate statement of a divine idea, any idea of the solar system which does not harmonize with that statement must be false. The Copernican astronomy must be a mistake. It becomes scientifically untenable, for it is out of accord with a known truth.

But the church's opposition to ideas which threaten to subvert those in which her faith is enshrined has been due to a deeper reason than the fact that on her mistaken premises those ideas must be false. She has opposed them because they seemed to her to be pernicious; to undermine faith and therefore character.

It is easy for the historian to prove that the church's struggle against the tide of truth has always been in the long run unavailing; that the church's battle with science has been one long series of ignominious retreats. Nor is it difficult for the historian to prove that the church's dread of scientific discoveries has been groundless; that each new view of truth has only resulted in a refining of the Christian doctrine and in restatements of it in ever clearer and spiritually more efficient forms. These "lessons of history" are as obvious as they are important; but we must address ourselves to the harder task of trying to discover why the church has so persistently fallen into the misapprehension which has been the cause of her disastrous mistakes.

The explanation is, in the first place, that the Christian faith and the ideas in which it is embodied are intimately connected as soul and body. After all, men can think only thoughts; can hold a faith only by conceiving it. An identification of the faith with the ideas by which it is represented is very natural.

It is true that no scientist is ever guilty of confusing his working hypotheses with his conception of them. One reason is that he is professionally interested in conceptions. Reconstructing conceptions is a large part of business. If he were convinced that his conception of the facts he knows were adequate, he would cease to be a scientist; for there would be no more scientific work for him to do, unless perhaps the gathering of new facts. But there is another reason. The working hypotheses of science are based upon objective experiences.

Experiences are insistent things. The scientist feels sure that no one of his successful working hypotheses can possibly be overthrown by any theory; for that theory must meet and include all established facts or die before seeing the light. The church has not quite the same assurance, though perhaps she ought to have. Her working hypotheses are not statements of unvarying experience. Their subject-matter is the meaning of the universe for man and man's destiny in it. They deal with the unseen. It is perilously easy to regard the Christian faith as a philosophy, and therefore incapable of being translated into new forms of thought.

To take concrete examples: The rising and setting of the sun is a fact which we can see. The scientist feels very sure that no astronomical idea which negatives the fact can ever gain acceptance. The Copernican astronomy would never have been heard of if it did not give an adequate explanation of the rising and setting of the sun. On the other hand, the incarnation, the ascension of Christ, the second advent, and God's oversight of the deeds of man are not matters of immediate experience; though in the seventeenth century they were (as they still are) vital portions of the Christian faith. The Ptolemaic astronomy allowed for these portions of the Christian faith. It admitted of very definite conceptions of them. These conceptions the new astronomy destroyed and it was not clear at first that new conceptions could be constructed which should both be in harmony with the new astronomy and serve all the practical purposes of the old.

At first sight the new idea of the solar system seemed to have no place for God; to make the ascension and future descent of Christ unthinkable. By making this earth, not the center about which the whole universe revolves, but only one of many planets revolving about the sun, it made the sending of God's only begotten Son to earth seem a most improbable act of favoritism.

Of course all these difficulties have been surmounted. New and grander conceptions of these articles of the Christian faith have been constructed, which serve in our day all the purposes which the older conceptions served in theirs. But the translation of the faith into these new forms of thought took time. At first it was not evident how it could be accomplished or that it could be accomplished at all. The old ideas conveyed the old faith. The new astronomy for the time did not admit of it. It is not after all to be wondered at that the church identified the old conceptions with the old faith and fought for the astronomical system with which those conceptions were bound up as for her own life.

Nor was her resistance wholly misguided. Even had she foreseen that new ideas might be framed which would replace the old, it would have been pardonable in her, had she viewed the process of translation which was thrust upon her, not without misgiving. After all, what assurance was there that *all* her children would accomplish the translation; that none would lose their faith without regaining it. Even should this danger be surmounted, yet another must be faced; a disturbance in what the sociologists are teaching us to call the religious *mores;* an unsettling of religious habits. To illustrate from our own times: The crisis which has resulted from the application of historical methods to the Bible may fairly be said to be surmounted. A new view of the Bible and of revelation has been evolved which is truer than the old and quite capable of replacing it. In fact, the Bible is even more fitted than ever it was to be the guide and inspiration of life. But the sad fact is that it is not used. Even those who have reconstructed their faith in the Bible do not always read it as their fathers did. Their habits have been shaken in the revolution. It can scarcely be doubted that they are serious losers.

The historian cannot be expected to share the church's fondness for intellectual immobility. He is a student of progress and in consequence an inevitable believer in progress. But he should understand and sympathize with the church's attitude, even though he cannot share it; and even though he sees its evil results.

The church's effort to restrain thought has probably resulted in more evil than good. Not merely has mother church often stunted the intellectual growth of her children in her eagerness to preserve in them their childhood's faith, only to find nature too strong for her and to suffer the ignominy of defeat and incur her children's hate. She has imperiled and often lost sight of her real work. In the effort to defend the faith, which is after all a means, she has forgotten her end. She has often spent all her energy in defending obsolete ideas which once were useful to her, and neglected her proper interest of developing character and fostering the things of the spirit. She has degenerated, in a word, into a teacher of bad science and a deviser of fallacies. She has valued ignorance above virtue and allied herself with the powers of darkness rather than with forces which make for righteousness. She has appraised orthodox opinion above goodness, adherence to the ecclesiastical institution above purity of character.

Her efforts have seldom proved worth while. She has often succeeded for a time in preventing her members from casting aside the old ideas. But old ideas, separated from the body of ideas of which they originally formed a part, are mere *disjecta membra*, lifeless and incapable of performing their old function. The doctrine of the resurrection of the flesh, for example, in the second century expressed an inspiring hope. It was a valuable protest against the exclusive regard for intellectual joys which characterized Greek philosophy and the dreary outlook which the popular conception of the future life presented. Severed from its original content and grafted into our modern thought-world, it loses all its meaning. It becomes simply an absurdity. Instead of a support to life, it becomes a burden. It can be accepted only by wrenching truth. A putrifying member of a dead body of conceptions, it fails to function. Its only effect is to spread intellectual disease; for no man can entertain it and be honest in his thought.

Yet the historian, if he is to account for and accurately record the church's mistakes, must feel her temptation. The historian above all things must be fair; albeit fairness to all institutions and all sides of our humanity is an almost superhuman demand to make of any man.

2. It is hard for the scientist, however, to be fair to the church. He and his kin have suffered too much at her hand. The *mere* scientist can never understand the church. For his whole devotion is given to a different quest, the sacred quest for truth. "A fact is as sacred to him as a moral principle,"[1] and a fearless following out of logical conclusions a moral principle itself. He cannot but be impatient with the church's obscurantism and special pleading. He is impatient with men who believe what suits them instead of investigating the facts and either discovering the truth or leaving the question open, if the truth is not apparent. The contempt and active hostility which many scientists display toward religion is therefore readily understandable.

The church's unsympathetic attitude toward science is from her point of view equally understandable. The facts the scientist accumulates and the problems he studies often seem to her trivial in comparison with the great themes which her teaching treats and the vital human interests on which her eye is fixed. "It is not through ignorance of the things which excite their interest," remarks an early church father of the scientists of his day, "but through contempt of their useless labor, that we think little of these matters, turning our souls to better things." The scientist's recklessness as to the effect his teachings may have upon souls seems to the churchman monstrous. What has he to offer in place of the precious faith which he weakens or destroys? Moreover, his novelties are not certainties. His theories are confessedly transitory things. Yet the scientist denounces as fools those who do not implicitly accept them. The bigotry of the church is nothing to the pride of science; the church's

[1] As Agassiz is said to have remarked.

cruelty is fully matched by the inhumanity of the scientist's disregard for the interests of character and of the soul. So the church often is inclined to charge.

Science and the church confront each other with a mutual contempt and even mutual hate. From the serene viewpoint which history occupies we may deprecate but it is incumbent upon us to understand. For this mutual lack of sympathy is the cause of the acrimony of the struggle whose sources we are considering.

V

President Hyde says somewhere that the warfare between science and theology is over: its history has been written. We fear that we can agree with neither proposition.

The divergence in interest between science and religion, the difference in the logical method of their thought, are inherent and permanent differences. The mistaken identification of religious beliefs with the conceptions in which they are embodied is so natural that it is not likely to disappear for a long time to come. We fear that the old antagonism will be ever cropping out anew for many a year.

Nor can we regard, with President Hyde, Dr. White's two valuable volumes[1] as the final history of the great warfare. Dr. White views the conflict from only one side. He never forgets the ecclesiastical persecution to which Cornell University was subjected when he took charge of it. It seems a presumptuous thing to say of so great a historian, but Dr. White in his book displays little insight into the nature and history of Christian doctrine. He dwells at length upon the martyrdoms of science and the stupidity of the church. We gain from his book no sense of the embarrassments which science has caused the church.

Sometime, we hope, there will be written a new history of the warfare of science with theology in Christendom. That history, when it is written, will begin by setting forth the ideas which the apostles held and taught and show why they were a gospel, what their value was and why the promulgation of them brought new life to those who

[1] To which this paper is indebted for many of its quotations and illustrations.

accepted them. It will then proceed to show how science and philosophy rendered these ideas obsolete, while the practical convictions which they connoted remained; and how this process was repeated over and over again and is still going on. It will be a moving tale of pain and triumph on both sides, a tale in which the noblest and the most ignoble sides of human nature play alternate parts and ofttimes are intertwined.

It will be a tale worth the telling. For science will never be free from ecclesiastical opposition and the church will never have a well-grounded assurance of the finality of her teaching until that tale is adequately told and its lessons learned. There is great need of a new theology, new perhaps not so much in its content as in its method. Theology must learn to renounce once for all the task of gathering together traditional religious ideas as if these *disjecta membra* were her finalities. She must set herself to analyze the needs of the human soul and set forth the convictions which are eternally necessary, if these needs are to be satisfied. Those convictions the theologian does not need to invent; for the needs of the human soul have been satisfied. Few will deny that the Christian faith, whenever it has been genuinely held by a man in its purity and lived out, has satisfied that man's deepest needs. But it is necessary that the theologian should clearly perceive and never forget what the Christian faith is. The Christian faith is nothing more nor less than the postulates of the Christian life, those convictions upon which Christian character is founded, the assumptions which are necessary to make Christian conduct and Christian serenity rational. What those postulates are the theologian can learn only from the historian. Only the historian can place the historic creeds and doctrines of Christianity in their original setting and thus reveal their practical import. The practical import of a religious doctrine is its essence. It is that alone which is permanently valid. The meaning and permanent essence of the belief that Father Euphrates always seeks the sea comes out only as we watch primitive man acting on that belief. So likewise we can never discern the essence of the primitive Christian faith until we determine how it differed from other contemporary ideas and what support it lent to life. These things it is the historian's province to ascertain. It is to the historian, therefore, that we must look for the recovery of the most precious heritage that antiquity has left us, the faith once delivered to the saints.

This high task, of course, must be the work of specialists, of professed church historians. But the general historian, more particularly those whose work it is to write upon and teach the history of the Roman Empire, the Middle Ages, or the Reformation, may fairly be required to have an adequate understanding of Christianity and the history of its thought. They ought, indeed, to have had some training in historical theology. It is true that they may never have had an opportunity directly to impart their knowledge in formal courses. The heavy hand of ecclesiastical jealousy and ecclesiastical obscurantism still rests upon our colleges, even upon our state-supported universities. But the teacher of history can hardly avoid the subject altogether. References to it should be intelligent. An understanding of historical theology is of value to the college teacher, if only that it may enable him to avoid running counter to ecclesiastical prejudices.

Some day, let us hope, the history of the greatest spiritual movement in history, the chief factor in long reaches of the development of our civilization, will be as freely taught in our universities as any other portion of history. It will be a valuable discipline. The history of ideas is universally recognized to be an indispensable part of a liberal education. But the student of the history of philosophy or of science is met at the outset by a serious difficulty. He must be something of a philosopher or a scientist if he is to understand the history of philosophy or science. The student of the history of religion requires for the understanding of his subject only a human heart. The problems with which religious thinking deals are the universal human problems which every man must face. The historic solutions of these problems can be made to appeal to anyone. Moreover, a study of these solutions resolves itself into a study of human character, which is a deeper and a more valuable study than the study of the human intellect. It is a study which brings the student into the company of the saints and makes him, not merely keener and more intelligent, but also more sympathetic, and a better man. Sometimes in our day-dreams we see great revolutions resulting from a general study of the history of Christianity; the divisions of Christendom vanishing before the spread of a scientific, because historically grounded, theology, and all that is vital and permanent in Christianity incorporated into the convictions of every educated man.

BERGSON'S CONCEPTION OF DURATION

By Lorena Underhill

The most recurrent theme in Bergson's works[1] is his conception of duration. The root of all his views lies in his idea of duration as contrasted with that of mathematical time or time spatially symbolized, or taken as the measure of change in organic nature. It was the most prominent idea in his mind when he wrote his Doctor's thesis—*Time and Free Will.*[2] This book offers a new theory of the will, namely, that *duration is will,* and also a new method of philosophizing. It proves what has never been proved before: that the will is free, that the duration of the *ego* is the ultimate truth of existence and needs no further proof than that of immediate experience. Not, to be sure, the experience that is represented to us by the intellect, but the inner experience of feeling and volition, where we see the true nature of duration in constant, never-ending change. It is ever changing and ever new, because it carries the past along with it, as a rolling snowball grows.

Conscious States Not Quantitative

In the first chapter of *Time and Free Will,* Bergson deals with the intensity of conscious states and says that it is impossible to "measure" the intensity of states of consciousness, that when we apply magnitudes to feelings we proceed on a false assumption which inevitably leads to a denial of free will. Sensations, feelings, etc., differ in quality but not in quantity. The multiplicity of conscious states is qualitative, "and," he proceeds, "we shall no longer consider states of consciousness in isolation from one another, but in their concrete multiplicity in so far as they unfold themselves in duration." This unfolding multiplicity of sensation is duration in the true sense. "We shall now have to inquire what the multiplicity of our inner states becomes, and what

[1] *Time and Free Will* (English translation by F. L. Pogson), London, 1910; *Matter and Memory* (English translation by Nancy Margaret Paul and W. Scott Palmer), London, 1911; *Creative Evolution* (English translation by Arthur Mitchell), New York, 1911.

[2] Published in French in 1889.

form duration assumes when the space in which it unfolds is eliminated."

Bergson then proceeds to show that there are two kinds of multiplicity: first, that of material objects counted in space, and, second, that of conscious states not countable unless symbolically represented in space. He illustrates this by saying,

We Cannot Form an Image or Idea of Number without the Accompanying Intuition of Space

> Let us now even set aside the fifty sheep themselves, and retain only the idea of them. Either we include them all in the same image, and it follows as a necessary consequence that we place them side by side in an ideal space, or else we repeat fifty times in succession the image of a single one, and in that case it does seem, indeed, that the series lies in duration rather than in space. And there is no doubt that in this way we have counted moments of duration rather than points in space; but the question is whether we have not counted the moments of duration by means of points in space.[1]

Some people count the strokes of a distant bell by arranging the sounds in an ideal space, and then they think they are counting them in pure duration. "If the sounds are separated, they must leave empty intervals between them. If we count them, the intervals must remain, though the sounds disappear: how could the intervals remain, if they were pure duration and not space? It is in space, therefore, that the operation takes place."

Homogeneous time is the medium in which conscious states form discrete series. They are arranged alongside one another as in space. Time is reducible to space in so far as it is a homogeneous medium; in fact, it is nothing but space, and pure duration is something different. When we make time a homogeneous medium, and conscious states unfold themselves in it, we assume that time is given all at once, or, in other words, that we abstract it from duration. The philosophers who have regarded the idea of time as simple and have tried to reduce the ideas of time and space to each other have thought that they could make extensity out of duration.

> Pure duration is the form which the succession of our conscious states assumes when our *ego* lets itself *live*, when it refrains from separating its present state

[1] *Time and Free Will*, p. 77.

from its former states. For this purpose, it need not be entirely absorbed in the passing sensation or idea; for then, on the contrary, it would no longer endure. Nor need it forget its former states: it is enough that in recalling these states it does not set them alongside its actual state, as one point alongside another, but forms both the past and the present states into an organic whole, as happens when we recall the notes of a tune, melting, so to speak, into one another.[1]

In this way, succession can be thought of without distinction as a mutual penetration of heterogeneous moments, each of which represents the whole and cannot be distinguished from it, except by abstract thought. Bergson says that this is the account of duration which a being would give who had no idea of space, and who was ever the same and ever changing. As a rule, we project time into space, and express duration in terms of extensity, while succession becomes a continuous line whose parts touch but do not interpenetrate. We cannot speak of an order of succession in duration, nor of the reversibility of this order, because it would not be pure succession but succession as it is developed in space; and to introduce order among terms, we must first distinguish the terms and then compare the places which they occupy.

When the movement of my finger along a surface or line provides me with a series of sensations of different qualities, one of two things happens: either I picture these sensations to myself as in duration only, and in that case they succeed one another in such a way that I cannot at a given moment perceive a number of them as simultaneous and yet distinct; or else I make out an order of succession, in which case I display the faculty not only of perceiving a succession of elements, but also of setting them out in line after having distinguished them: in a word, I already possess the idea of space. Hence, the idea of a reversible series in duration, or even simply of a certain order of succession in time, implies the representation of space, and cannot be used to define it.[2]

Suppose that a material point, *A*, were moving on a straight line of unlimited length. It would not perceive succession in the line, unless it could rise above the line and perceive several points in juxtaposition simultaneously; but by so doing it would form the idea of space of three dimensions, and it would perceive the changes which it undergoes in space and not in duration. Bergson says that it is here that we find the mistake of those who regard duration as similar

[1] *Op. cit.*, p. 100. [2] *Ibid.*, p. 102.

to space, but of a simpler nature. In a word, pure duration might well be nothing but a succession of qualitative changes which melt into and permeate one another, without precise outlines, without any tendency to externalize themselves in relation to one another, without any affiliation with number: "it would be pure heterogeneity . . . . from the moment you attribute the least homogeneity to duration, you surreptitiously introduce space." Pure duration is wholly qualitative. It cannot be measured, unless symbolically represented in space. It must be reckoned among the so-called intensive magnitudes, if intensities can be called magnitudes. It is not a quantity, and when we measure it we replace it by space.

Pure Duration Is Wholly Qualitative

It is very difficult to think of pure duration. This is probably owing to the fact that other objects endure as well as ourselves, and from this point of view time has the appearance of a homogeneous medium. This duration seems to be homogeneous and measurable; the moments seem to be external to one another, like bodies in space. Time, as used by astronomers and physicists seems to be measurable and homogeneous. If, as suggested in the previous paragraph, duration cannot be measured, what is it that is measured by the movements of the pendulum? We are merely counting simultaneities, not measuring duration.

Astronomical Time Is Not Pure Duration

> Withdraw the *ego* which thinks these successive oscillations, and there will never be more than a single oscillation, and, indeed, only a single position of the pendulum, and hence no duration. Withdraw the pendulum and the oscillations, and there will be no longer anything but the heterogeneous duration of the ego, without movements external to one another, without relation to number.[1]

The successive phases of our conscious life correspond individually to an oscillation of the pendulum which occurs at the same time; and because the oscillations are sharply distinguished from one another we get into the habit of making a distinction between the successive moments of our conscious life. "The oscillations of the pendulum break it up, so to speak, into parts, external to one another; hence

[1] *Time and Free Will*, p. 108.

the mistaken idea of a homogeneous inner duration, similar to space, the moments of which are identical and follow without penetrating one another."

Simultaneity Is the Link between Duration and Space

There is a real space aside from duration where phenomena appear and disappear simultaneously with our states of consciousness, and there is a real duration, the heterogeneous moments of which permeate each other. Each moment is contemporaneous with a state in the external world, and can be brought into relation with it; and because of this, it can be separated from the other moments. Because these two realities are compared, we get a symbolical representation of duration derived from space. The connecting link between space and duration is simultaneity, or the intersection of time and space.

Science Would Not Need to Change Its Formulae if the Motions of the Universe Were Faster or Slower

In analyzing motion, which is the living symbol of this seemingly homogeneous duration, we shall make a similar distinction. There are two elements in motion: the space traversed, which is homogeneous and divisible, and the act of traversing, indivisible and real only for consciousness. The successive positions of the moving body really do occupy space, but the process of moving from one position to another occupies duration and eludes space, and is not real except to the conscious spectator. Motion is a progress, and is therefore unextended and psychic. This confusion between motion and the space traversed gives rise to the paradoxes of Zeno. There is no necessity to resort to metaphysical hypotheses about the nature of space, time, and motion, when we know through intuition that motion is within duration, and duration is outside of space. The movements of bodies cannot occupy space, for they are duration rather than extent, quality rather than quantity; but science has to eliminate mobility from motion and duration from time before it can deal with them. Science cannot take account of the interval of duration; for instance, if all the motions of the universe were twice as fast, no change would be necessary in formulae or figures. Science would never be able to notice the change—it would be perceptible to duration only.

The very essence of duration and motion is that they are *unceasingly* being done. Algebra can represent results and positions, but not duration and motion themselves. Mathematics can make the intervals very small, but however small they may be, mathematics places itself at the extremity of the interval and leaves duration and motion entirely out of the question, because they are mental syntheses and not objects. Duration has no identical moments, or moments that are external to one another; it is heterogeneous, continuous, and in no way resembles number. There is neither duration nor succession in space, that is if we give these words the meanings which consciousness does. Space is homogeneous, and belongs to the external world, while duration and succession belong to the conscious mind. Suppose that several conscious states are organized, that they interpenetrate and become richer in content. They thus might give anyone ignorant of space the feeling of duration. But the use of the word "several" shows that these states were isolated, set side by side; in other words, we are compelled even by language to set forth time in the terms of space.

It is chiefly through motion that duration assumes the form of a homogeneous medium, and that time is projected into space. But even if we leave out motion, any repetition of an external phenomenon would suggest the same mode of representation: for instance, the series of blows of a hammer instead of being a progress becomes cut up into phases which are identical, and "this multiplicity of elements no longer being conceivable except by being set out in space (since they have now become identical), we are necessarily led to the idea of a homogeneous time, the symbolical image of pure duration."

Sensations Are Closely Akin to the External World and Share Its Nature

Our *ego* comes in contact with the external world at its surface; our sensations retain something of the mutual externality, and in this way our superficial psychic life comes to be represented as set out in a homogeneous medium. But there is a deeper self which forms one and the same person with the superficial *ego*, and the two endure in the same way. If we eliminate the superficial self, we can no longer perceive a homogeneous time, or measure duration, but we feel it as a quality. "That our ordinary conception of duration depends on a gradual incursion of space into the domain of pure consciousness is proved by the fact that in order to deprive the *ego* of the faculty of perceiving a homogeneous time it is enough to take away from it this outer circle of psychic states which it uses as a balance-wheel." Sleep alters the communicating surface of the *ego* because the organic functions are relaxed, and here we no longer measure duration, we feel it; it becomes a quality instead of a quantity. Bergson believes that through daily experience we ought to be able to distinguish between the real duration of quality, which is probably what animals perceive, and time materialized, which has become quantity by being set out in space. For instance, sometimes we do not notice the number of strokes of a distant clock until several have sounded and we find that they have melted into one another instead of being set out side by side, like a musical phrase. In reconstructing this phrase, our imagination makes one, two, or three strokes, but our feelings say that *the total effect was qualitatively different*, and we feel that four was the number of strokes sounded. In its own way, the mind had ascertained the number of strokes and not by a process of addition or juxtaposition. "In a word, the number of strokes was perceived as a quality and not as a quantity: it is thus that duration is presented to immediate consciousness, and it retains this form so long as it does not give place to a symbolical representation derived from extensity."

Duration a Musical Phrase

Thus we should distinguish two kinds of multiplicity and two very different kinds of duration. There is the homogeneous duration, the extensive symbol of duration; and there is the heterogeneous duration, whose moments permeate each other. Likewise there is the numerical multiplicity of conscious states and a qualitative multiplicity: the self with well-defined states, and the self whose succeeding states melt into each other. We can expect, then, every conscious state to assume a different aspect, according as we consider it within a discreet multiplicity or a confused multiplicity, in time as quantity or time as quality. The fleeting duration of our *ego* is fixed by its projection into space, just as our constantly changing impressions take on the definite outlines and immobility of the external object which is their cause. We distort the feelings of immediate consciousness as soon as we distinguish a numerical multiplicity in their confused mass. The feeling lives because the duration in which it develops is a duration whose moments interpenetrate. On the surface, our conscious states obey the laws of association, but deeper down they interpenetrate and form a part of ourselves. When we break up the elements of an idea, and think that the separated parts are the genuine threads of the idea; when we substitute for the interpenetration of the real terms the juxtaposition of the symbols, we claim to make duration out of space and we fall into the mistakes of associationism. The duration which the deep-seated conscious states create is a duration whose moments do not constitute a numerical multiplicity.

The Laws of Association Explain Only Our Superficial Conscious States

The subject of free will brings into question the two rival systems of mechanism and dynamism. There are two kinds of determinism—physical and psychological; the former is reducible to the latter, and it rests on an inaccurate conception of the multiplicity of conscious states, or duration. To prove conscious states determined, we should have to show a connection between them and cerebral states, and Bergson tells us that there is no such proof. When we assume physical determinism to be universal, we also postulate psychological determinism. The determinist, deceived by a wrong conception of duration and causality, holds that the determination of conscious states is absolute. This is the origin of associative determinism. The principle of the conservation of energy is not universally valid, because it implies that a system can return to its original state, thus neglecting duration; hence it is not applicable to living beings and conscious states. The belief in the conservation theory is rooted in the fact that inert matter does not seem to endure or preserve any traces of past time. But in the realm of life, duration seems to act like a cause, and the idea of putting things back in their places is

A Thorough-going Associationism Must Deny Free Will

absurd when applied to living beings. "Such being the case, is there not much to be said for the hypothesis of a conscious force, or free will, which, subject to the action of time and storing up duration, may thereby escape the law of the conservation of energy?" The idea of the universality of conservation of energy depends upon a confusion between concrete duration and abstract time. We are led to believe that the real duration lived by consciousness is the same as the duration which passes over inert matter without penetrating it or altering it, because we observe ourselves through these forms borrowed from the external world. If we set up the principle of conservation of energy as universal, we identify true duration with apparent duration.

May Not the Will Be Precisely the Exception to the Law of the Conservation of Energy?

Psychological determinism depends on an associationist conception of mind; but associationism involves a false conception of the self, and fails to distinguish between the multiplicity of juxtaposition and that of fusion. A certain feeling, or idea, contains an indefinite plurality of conscious states, but this plurality is not noticed unless it is spread out in the homogeneous medium which some call duration, but which is really space. Associationism does not explain the deeper self; it is an inaccurate psychology, misled by language, and only our everyday acts obey the laws of association. At great crises, our decisions are really free, and express the deeper self. The error of determinism is based on a misconception of duration.

In Great Crises Our Decisions Are Free and Not Determined by Mere Associations

Suppose I hesitate between two possible actions, X and Y. My mental states may be divided into two groups, one inclined toward X, the other toward Y. "These opposite inclinations are two symbols by which I represent at their arrival, or termination-points, so to speak, two different tendencies of my personality at successive moments of duration." The living activity of the self in which we distinguish by abstraction two opposite tendencies will finally issue either at X or Y. If this symbolism represents the facts, the activity of the self has always tended in one direction, and

All Accounts of Acts of Will Deal with the Dead and Past Results of Willing and Not with the Living Process

determinism results. The symbols and figures give only the memory of the process and not the dynamic progress which issued in the act. If only one course of action were possible, why did we believe ourselves free? Both questions come back to this—Is time space?

It Is Meaningless to Ask Whether an Act Can Be Foretold

Bergson then asks if the prediction of an act is possible. But in order to predict an act we must know completely the antecedents and conditions of an action, and to know completely the antecedents and conditions of an action is to be actually performing it. We have not the right to cut short, even by a second, the different states of consciousness through which Paul is going to pass before Peter, "for the effects of the same feeling, for example, go on accumulating at every moment of duration, and the sum total of these effects could not be realized all at once unless one knew the importance of the feeling, taken in its totality, in relation to the final act, which is the very thing that is supposed to remain unknown." Therefore it is meaningless to ask whether an act can be foretold, given all its antecedents. Whenever we claim to foresee an action, we confuse time with space. Time does not require to be seen, but to be lived. Science seems to point to many cases where we anticipate the future, as in astronomical predictions. "Does not, then, the human intellect embrace in the present moment immense intervals of duration still to come?" But a prediction of this kind does not resemble in the least the prediction of a voluntary act.

If all the movements of the universe went twice as fast, there would be no change in astronomical phenomena or in mathematical equations; for time does not stand for duration, but for a relation between two durations, for a certain number of simultaneities. These simultaneities would still take place, but the intervals between them would have diminished. "These intervals are just duration *lived*, duration which our consciousness perceives, and our consciousness would soon inform us of a shortening of the day, if we had not experienced the usual amount of duration between sunrise and sunset." These intervals do not enter into the calculations of astronomical hypotheses, so that into a psychological duration of a few seconds may be put several years or centuries of astronomical time. Real duration remains outside the calculation, and could only be perceived by a consciousness capable of living through these intervals. But these units of time which make up living duration, and which are useless to the scientist, are just what concerns psychology; *for psychology deals with the intervals and not with the extremities of the interval.* Consciousness does not perceive time as a sum of units of duration—it has no way of measuring time, and no reason for measuring it; but a feeling which lasted only one day would for it lack richness of content. We give this feeling a certain name, and we believe that we can diminish its duration by half, and even halve the duration of all the rest of our history. It seems as though it would be the same life, reduced only to a smaller scale, but we forget that states of consciousness are *growing* processes, and that we cannot vary their duration without altering their nature. The orbit of a planet might be perceived all at once or in a very short time, because its position or results of movement are the only things of importance, and not the duration of the intervals between the positions. But in dealing with a feeling, we perceive no precise result, except its having been felt, and to estimate this result it would be necessary to have passed through all the phases of the feeling itself and to have taken up the same duration.

> And does the very possibility of seeing an astronomical period in miniature thus imply the impossibility of modifying a psychological series in the same way, since it is only by taking this psychological series as an invariable basis that we shall be able to make an astronomical period vary arbitrarily as regards the unit of duration?[1]

When we ask whether a future action could have been predicted, we identify the time of the exact sciences with real duration, which cannot be shortened by an instant without altering the nature of its content. Doubtless this false identification is made easier by the fact that in a great many cases we can deal practically with real duration as with astronomical time. When we have to determine future states of consciousness, we must view their antecedents as

[1] *Time and Free Will*, p. 197.

dynamic processes, because we are concerned with their influence alone. Their duration is this very influence, and consequently it will not do to shorten future duration in order to picture it beforehand; we are bound to live this duration while it is unfolding. *As regards deep-seated psychic states, there is no apparent difference between foreseeing, seeing, and acting.*

Now if duration is what we say, deep-seated psychic states are radically heterogeneous to each other, and it is impossible that any two of them should be quite alike, since they are two different moments of a life-story. While the external object does not bear the mark of the time that has elapsed, and thus in spite of the difference of time the physical can again encounter identical elementary conditions, duration is something real for the consciousness, which preserves the trace of it, and we cannot here speak of identical conditions, because the same moment does not occur twice.[1]

The Same Psychic States Never Occur Twice: Repetition Itself Modifies Experiences

The determinist argues that psychic phenomena are subject to the physical law—the same antecedents, the same consequents—but in inner states the same antecedents will never occur again. If it is asserted that the effect is bound up with the cause, it will mean either that the future action might have been foreseen, provided the antecedents were given, or the action having been performed, any other action under the same conditions would have been impossible. But we have seen that both these assertions are meaningless, because they involve a false conception of duration. Causality, meaning regular succession, does not apply to conscious states, and therefore cannot be used to disprove free will. Causality may be used as prefiguring in the case of mathematics.

The very movements by which we draw the circumference of a circle on a sheet of paper generate all the mathematical properties of this figure: in this sense, an unlimited number of theorems can be said to pre-exist within the definition, although they will be spread out in duration for the mathematician who deduces them.[2]

It is supposed that motion has something to do with consciousness, and that space is filled with simultaneities, and that the physicist must show us how to calculate these simultaneities and their relations

[1] *Op. cit.*, pp. 199–200.
[2] *Ibid.*, p. 204.

for any moment of our duration. Descartes built up an "instantaneous physics which was intended for a universe the whole duration of which might as well be confined to the present moment." Spinoza assumed that the "indefinite duration of things was all contained in a single moment, which is eternity." Everywhere we find the desire to establish a relation of logical necessity between cause and effect, to do away with active duration, and "to substitute for apparent causality a fundamental identity." The more cause and effect are bound up together the more we try to put the effect in the cause itself and thus eliminate the effect of duration. We do not behave today as we did yesterday under the same conditions because we change, we endure. The more we believe in causality the more inclined we are to think of duration as subjective, and that *things* do not endure like ourselves. That the prefiguring of the future in the present is easily conceived under a mathematical form is due to a certain conception of duration which is familiar to common-sense. If we accept the dynamic conception of causality, we ascribe to things a duration like our own, whatever may be the nature of duration. The principle of causality involves two contradictory conceptions of duration, each of these by itself safeguards freedom; but taken together they destroy it. Sometimes all phenomena, physical and psychical, are regarded as ending in the same way that we do. Sometimes, on the other hand, duration is regarded as the form of conscious states, and in this case things no longer endure as we do.

Now, each of these two hypotheses when taken by itself safeguards human freedom; for the first would lead to the result that even the phenomena of Nature are contingent, and the second, by attributing the necessary determination of physical phenomena to the fact that things do not endure as we do, invites us to regard the self, which is subject to duration, as a free force.[1]

The trouble is that we take the principle of causality in both senses at the same time.

Sometimes we think of the regular succession of physical phenomena and of the kind of inner effort by which one becomes another; sometimes we fix our mind on the absolute regularity of these phenomena, and from the idea of regularity we pass by imperceptible steps to that of mathematical necessity, which excludes duration understood in the first way.[2]

[1] *Ibid.*, p. 215. [2] *Ibid.*, p. 216.

Although our deepest conscious states do not include numerical multiplicity, we yet break them up into parts, and although the elements of duration interpenetrate, yet duration expressed in terms of extensity shows distinct moments. Deep-seated psychic states can never occur more than once. Psychological phenomena led us to this conclusion, and a study of causality and duration has confirmed it. Things can be analyzed, but not processes; extensity can be broken up, but not duration. But if we persist in analyzing processes, they become things, and duration becomes extensity. If we define the free act by saying that it might have been left undone, we imply an equivalence between concrete duration and its spatial symbol; and as soon as we admit this equivalence we are led to the most rigid determinism. If we define the free act as "that which could not be foreseen, even when all the conditions were known in advance," we place ourselves at the moment when the act is being performed, for that is what we mean by dealing with concrete duration; else we must admit that the matter of psychic duration can be pictured symbolically in advance, and that means treating time as a homogeneous medium or reasserting the equivalence of concrete duration with its spatial symbol, and this once more brings us to determinism. If we define the free act by saying that it is not of necessity determined by its cause, we mean that the same inner causes will not always call forth the same effects, and we admit that the psychic antecedents of a free act can be repeated, that freedom is displayed in a duration whose moments resemble one another and that time is a homogeneous medium like space. Once more we are brought back to the idea of equivalence between duration and its spatial symbol and led to determinism.

Causation and Freedom Explained

Every demand for explanation in regard to freedom comes back, without our suspecting it, to the following questions: "Can time be adequately represented by space?" to which we answer: Yes, if you are dealing with time flown; no, if you speak of time flowing. Now the free act takes place in time which is flowing and not in time which has already flown. Freedom is therefore a fact, and among the facts which we observe there is none clearer. All the difficulties of the problem, and the problem itself, arise from the desire to endow duration with the same attributes

Freedom Is the Clearest of Facts

as extensity, to interpret a succession by a simultaneity, and to express the idea of freedom in a language into which it is obviously untranslatable.[1]

The empirical school of today carries analysis still farther than Kant, and tries to make the extensive out of the intensive, space out of duration, and externality out of inner states. Psychic states seem to be more or less intense; looked at in their multiplicity, they unfold in time and constitute duration, and in their relations to one another they seem to determine one another. The three ideas of intensity, duration, and voluntary determination had to be purged of all that they owe to the sensible world or the idea of space. All of these preliminary considerations have been necessary in order for us to be able to take up the principal subject, the analysis of the ideas of duration and voluntary determination. Duration within us is a qualitative multiplicity and has no likeness to number. It is an organic evolution, but yet does not increase in quantity. It is a pure heterogeneity with no distinct qualities, or the moments of inner duration are not external to one another. Duration existing outside us is the present or simultaneity, and their moments do not succeed one another, except for a consciousness which keeps them in mind. If we put duration in space, we thereby place succession within simultaneity and contradict ourselves. Consequently "we must not say that external things endure, but rather that there is in them some inexpressible reason by virtue of which we cannot examine them at successive moments of our own duration without observing that they have changed." While our consciousness thus introduces succession into external things, these external things externalize the successive moments of our inner duration in relation to one another. Thus we get the mixed idea of a measurable homogeneous time in space, and duration in so far as it is succession, or the idea of measurable time arises from compromise between the ideas of succession and externality. When science makes a close study of external things, it tears apart extensity and duration; for it keeps nothing of duration but simultaneity, and nothing of motion but immobility, or the position of the moving body. The separation here is very close,

[1] *Time and Free Will*, p. 221.

and space gets the best of it, so that we shall have to make another separation in favor of duration, when inner phenomena are developing and make up the continuous evolution of a free person. Duration thus brought back to its purity will appear as a qualitative multiplicity a heterogeneity of elements that interpenetrate. One party has been led to deny freedom, and the other party to define it, and this leads involuntarily to a denial of free will, because they have not made the necessary foregoing separation. When they ask whether the act could or could not be predicted if all the conditions were given (and whether they assert it or deny it, they assume that all the conditions might ideally be given in advance), they treat duration as homogeneous and intensities as magnitudes. There are two explanations that may be given: either that the act is determined by its conditions, thus using the word causally in a double sense, and giving to duration two forms which are mutually exclusive; or by appealing to the principle of the conservation of energy the inner world is made equivalent to the external world. Whenever freedom is denied, it is done on the basis of identifying time with space. *Experience refutes determinism*, and any attempt to define freedom leads the way to determinism. This separation is favorable to science because science cannot forecast and measure unless things are assumed to be stable, and not changing and enduring as we are. So the breach comes about naturally between quality and quantity, true duration and pure extensity. But our conscious states have everything to gain by keeping up the illusion of reciprocal externality. They can be objectified and thrown out into society. Hence we see there are two different selves, one of which is the external, spatial, or social representation of the other, which is the inner or fundamental self, reached only by deep introspection. Here we see the inner states as constantly becoming, interpenetrating; and their succession in duration has nothing in common with juxtaposition in space. But such moments when we really grasp ourselves are very rare, and consequently we are rarely free. Most of the time we live outside ourselves and perceive only a colorless ghost of ourselves

Most of the Time We Are Not Free

which duration projects into homogeneous space. "Hence our life unfolds in space rather than in time; we live for the external world rather than for ourselves; we speak rather than think; we are acted upon rather than act ourselves. To act freely is to recover possession of one's self, and to get back into pure duration."

To Act Freely Is to Be One's Self

Kant's great mistake was to take time as a homogeneous medium; he did not understand that real duration was made up of interpenetrating, heterogeneous moments, and that it was not a homogeneous whole. He clung to freedom but put the self outside both space and time. He thought that psychic states were perceived in juxtaposition, and forgot that such a medium would be space and not duration. Because he believed so thoroughly in freedom, he put it in the sphere of noumena, and because he confused duration with space he made this free self not only outside of space, but outside of duration and beyond our faculty of knowledge. As a rule, we live and act outside our own selves, in space and not in duration, yet we can always get back into pure duration where a cause cannot repeat its effect because it cannot repeat itself. Both the strength and weakness of Kant lie in this confusion of duration with its symbol. If time, that is as duration, were homogeneous, science could deal with it, but we have tried to prove that duration, as duration, and motion, as motion, elude the grasp of mathematics, and this is what the Kantians failed to perceive. Besides, if duration were assumed to be homogeneous, the same states of consciousness could occur over and over again, and causality would imply necessary determination, and all freedom would be impossible. But if Kant had concluded from this that true duration is heterogeneous, the latter difficulty would have been cleared up; but instead he puts freedom outside time and space and makes an impassable barrier between phenomena and things-in-themselves. But the barrier is really easier to cross than he supposed. For if the moments of true duration permeate each other,

Kant Treated Time Like Space as a Homogeneous Medium

Cause and Effect Are Pretty Stable in Mere Habits, but Causes Are Never Repeated in Duration

instead of lying side by side, and form a heterogeneity where the meaning of necessary determination is lost, then our deeper self is a free cause, and we have absolute knowledge of ourselves. But since this deeper self cannot be expressed in words, except by changing its nature, it is doubtless a great temptation to apply the distinctions of outer life to its own life, and to replace the qualitative multiplicity by a numerical plurality, set side by side and expressed by words. We thus get a homogeneous time instead of a heterogeneous duration. And this mechanism which we invented to explain our conduct will end by controlling it, and we shall have automatism instead of freedom; all difference between duration and extensity, succession and simultaneity, will be abolished. But we should see that if our past states cannot be expressed in words or reconstructed in juxtaposition, it is because they are phases of our real and concrete duration, a heterogeneous duration and a living one; also that the idea of determination loses its meaning, that there is no question of foreseeing the act, or reasoning about the possibility of a contrary act after it has once been performed; for to have the conditions given is, in concrete duration, to place one's self at the very moment the act is being performed. We must try to understand the illusion which makes one party deny freedom and the other define it. It is because the steps from concrete duration to symbolical duration are gradual, because we are seldom willing to get back into our real selves and be free, and because even when the action is free we cannot reason about it, without setting its conditions out in space and no longer in duration. The problem of freedom has sprung from a misunderstanding, and "has its origin in the illusion through which we confuse succession and simultaneity, duration and extensity, quality and quantity."

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CONTENTS

ANIMALS AND PLANTS DESCRIBED AS NEW FROM COLORADO IN 1912, 1913, AND 1914

By T. D. A. Cockerell

The present list of new forms described from Colorado is in continuation of that given in the *University of Colorado Studies*, Vol. IX, May, 1912, pp. 75–89. Every species described as new, the description based wholly or in part on Colorado specimens, is included. For the year 1914, it has seemed best to include everything in the volumes of periodicals bearing that date, although some of the last numbers were not actually issued until early in 1915. The abbreviations are the same as those of the former list; t. l. = type locality, while extinct species are marked †.

The size of the list is surprising, and shows the richness of Colorado in new materials, as well as the activity of workers. In spite of the conspicuous progress made, the work remaining to be done is very great; in certain large groups of invertebrates, in particular, hardly anything has been done on the Colorado fauna. In palaeontology, the field is extremely rich and interesting. Innumerable species of cryptogamic plants remain unrecorded, while even among the higher plants critical work reveals much that is novel.

The present record is concerned only with a single phase of biological activity; it is hardly necessary to remark that the description of a new animal or plant is only the beginning of our knowledge of its natural history.

PLANTAE

Order *AGARICALES*

Family AGARICACEAE

Melanoleuca praemagna Murrill, *N. Am. Flora*, Vol. X, Pt. 1 (1914). T. l. in Saskatchewan, but also found near Gunnison, Colo., under sage brush (E. Bartholomew).

Order *SPHAEROPSIDALES*

Calopactis (new genus) **singularis** Sydow, *Ann. Myc.*, Vol. X (1912). On *Quercus*. Palmer Lake (E. Bethel).

Order *MELANCONIALES*

Coryneum megaspermum Sydow, t. c. On *Quercus*. Palmer Lake (E. Bethel).

Order *HYSTERIALES*

Hysterographium acerinum Peck, *Bull. 167, N.Y. Museum*, 1913. On *Acer glabrum*. Boulder (Bethel and Bartholomew).

Order *MONILIALES*

Cercospora eustomae Peck, *Bull. 157, N. Y. Museum*, 1912, p. 45. On living leaves of *Eustoma andrewsii*. Denver (Bethel).

Cercosporella mirabilis Peck, l. c. On living leaves of *Crataegus rivularis*. Morrison, Colo. (Bartholomew and Bethel).

Order *UREDINALES*

Peridermium betheli Hedgcock and Long, *Phytopathology*, Vol. III (1913), p. 251. On *Pinus contorta* at Lake Eldora, Colo.; also collected at Tolland, Allenspark, and Arrow on this host; also on *Pinus scopulorum* at Allenspark, though the latter is not included in the description (Bethel, litt.). Arthur and Kern, *Science*, Vol. XLIII (1913), refer it to *P. pyriforme* Peck.

Puccinia pseudocymopteri Holway, *N. Am. Uredineae*, Vol. I, Pt. IV (1913). T. l., Ouray, Colo. (Bethel); also collected at Eldora (Bethel).

P. tardissima Garrett, *Mycologia*, Vol. VI (1914), p. 251. On *Arenaria*. T. l. in Utah, but also found at Ouray (E. Bethel).

Aecidium abroniae A. G. Johnson, *Proc. Indiana Acad. Sci.* for 1911 (1912), p. 384. Fort Collins, on *Abronia*. The name is taken from Ellis and Everhart MSS; no description is given.

Order *EQUISETALES*

Family EQUISETACEAE

Equisetum kansanum Schaffner, *Ohio Naturalist*, November, 1912, p. 21. Type from Kansas, but also found at Mancos, Colo. This has been confused with *E. laevigatum*, but is distinguished by aerial stems annual, smooth; cones without a point.

Order *POALES*

Family GRAMINEAE (Poaceae)

Festuca sororia Piper, *Contr. U.S. Nat. Herb.*, Vol. XVI (1913), p. 197. Type from Arizona, but also from Pagosa Peak (Baker) and Durango (Tweedy) in Colorado. Has passed as *F. fratercula* Rupr.

†**Phalaris** (?) **geometrorum** Cockerell, *Torreya*, April, 1913, p. 76. Florissant (G. N. Rohwer).

Family CYPERACEAE

Carex heliophila Mackenzie, *Torreya*, January, 1913, p. 15. Type from Missouri, but also found in Colorado, at Horsetooth Gulch (Crandall), Veta Pass (Rydberg and Vreeland), Crystal Park (Clements), Larimer Co. (Crandall), Ojo (Rydberg and Vreeland), headwaters of Pass Creek (Rydberg and Vreeland), Fort Collins (Cowen), Dixon Canyon (Crandall), New Windsor (Osterhout), and Colorado Springs (Jones) It has passed as *C. pennsylvanica* L.

Order *LILIALES*

Family LILIACEAE

Brodiaea paysonii Nelson, *Bot. Gazette*, July, 1913, p. 63. Montrose, Colo. (E. E. Payson).

Family SMILACACEAE

†**Smilax labidurommae** Cockerell, *Torreya*, August, 1914, p. 135. Florissant (W. P. Cockerell).

Order *AMARYLLIDALES*

Family IRIDACEAE (Ixiaceae)

Sisyrinchium juncellum Greene, *Leaflets*, Vol. II (1912), p. 272. Gunnison National Forest, in a marsh at 9,100 ft. (Wm. H. Mast). "A strongly marked subalpine species, with short foliage and a peculiarly reedy aspect, though of a pale green herbage." Flowers deep blue.

Order *SALICALES*

Family SALICACEAE

Populus andrewsii Sargent, *Trees and Shrubs*, Vol. II (1913), p. 212. Near Boulder (D. M. Andrews) and Walsenburg (Bethel and Sargent). This is considered to be a hybrid *P. acuminata*×*sargentii*.

Order *URTICALES*

Family ULMACEAE

Celtis rugosa Rydberg, *Bull. Torr. Bot. Club*, Vol. XXXIX (1912), p. 304. Golden (Rydberg, Shear), gulch west of Pennock's Mountain Ranch (Crandall). The name is twice preoccupied, and will have to be changed.

Order *RANALES*

Family RANUNCULACEAE

Delphinium pinetorum Tidestrom, *Proc. Biol. Soc. Washington*, Vol. XXVI (1913), p. 121. Type from Arizona, but also found on the Uncompahgre Plateau near Ridgway, Colo. (Mellenthin).

Order *PAPAVERALES*

Family **FUMARIACEAE**

Capnoides engelmannii; *Corydalis engelmannii* Fedde, *Rep. Sp. Nov.*, Vol. X; cf. *Bot. Centralbl.*, 1914, p 92. Near Empire (?), Colo., 8,500–9,000 ft.

Capnoides macrorrhiza; *Corydalis macrorrhiza* Fedde, l. c.; cf. t. c., p. 93, southern Colorado.

Order *ROSALES*

Family **HYDRANGEACEAE**

Fendlera falcata Thornber, *Contr. U.S. Nat. Herb.* Vol. XVI (1913), p. 129. Type from New Mexico, but also in Colorado, at Dolores (Crandall), Cerro Summit (Baker), Bayfield (Cary), and Mancos (Baker).

F. tomentella Thornber, l. c. Type from Arizona, but also from Los Pinos, Colo. (Baker).

Family **ROSACEAE**

Cercocarpus argenteus Rydberg, *N. Am. Flora*, Vol. XXII (1913), p. 422. Type from Texas, but also occurs in Colorado.

Geum decurrens Rydberg, t. c., p. 404. Type from Arizona but also found in Colorado.

Family **FABACEAE**

Astragalus macer Nelson, *Bot. Gazette*, July, 1913, p. 65. Paradox Valley, Colo. (E. P. Walker). Allied to *A. lonchocarpus* Gray; according to the Rydbergian system, it will be called *Homalobus macer*.

Lupinus habrocomus Greene, *Leaflets*, Vol. II (1912), p. 235. Cochetopa Forest Reservation, in aspen groves at 8,500 ft. (E. F. Clark).

†**Robinia mesozoica** Cockerell, *Torreya*, February, 1912, p. 32. Paleocene, north of Whitely Peak, Colo. (N. E. Hinds).

Order *MYRTALES*

Family **ONAGRACEAE** (Epilobiaceae)

Chylisma walkeri Nelson, *Bot. Gazette*, July, 1913, p. 66. Paradox Valley, Colo. (E. P. Walker). Flowers yellow, 2 mm. long.

Oenothera cockerelli Bartlett; de Vries, *Gruppenweize Artbildung*, 1913, p. 56. Boulder, Colo. (T. D. A. Cockerell).

Oe. procera Wooton and Standley, *Contr. U.S. Nat. Herb.*, Vol. XVI (1913), p. 156. Type from New Mexico, but it is said to be part of Rydberg's *Oe. strigosa* of *Flora of Colorado*.

Gaura induta Wooton and Standley, t. c., p. 153. Type from New Mexico, but it is "most, if not all" of the *G. glabra* of Rydberg, *Flora of Colorado*.

Order *UMBELLALES*

Family AMMIACEAE

Cogswellia concinna Osterhout, *Muhlenbergia*, Vol. VIII (1912), p. 44. Paonia, Colo. (Osterhout).

Order *ERICALES*

Family PYROLACEAE

Chimaphila occidentalis Rydberg, *N. Am. Flora*, Vol. XXIX (1914), p. 30. Type from Idaho, but also occurs in Colorado.

Family ERICACEAE

Azaleastrum warrenii Nelson, *Bot. Gazette*, July, 1913, p. 67. Lower slope of Mt. Zirkel, Colo., 9,275 ft. (E. R. Warren).

Order *PRIMULALES*

Family PRIMULACEAE

Androsace carinata mut. *nelsoni* Cockerell, *Torreya*, December, 1913, p. 270. Above timber line, Long's Peak trail (Cockerell).

Order *GENTIANALES*

Family GENTIANACEAE

Gentiana polyantha Nelson, *Bot. Gazette*, July, 1913, p. 68. Iron Springs, Mesa, Colo. (E. P. Walker). According to Rydberg's system, this will be *Amarella polyantha*.

Order *ASCLEPIADALES*

Family APOCYNACEAE

Apocynum cervinum Greene, *Leaflets*, Vol. II (1912), p. 174. Deer Run, Gunnison River region (Baker). Confused with *A. cannabinum*.

Order *POLEMONIALES*

Family POLEMONIACEAE

Callisteris violacea Greene, *Rep. Spec. Nov.*, Vol. XIII (1914), p. 320. Colorado. *Callisteris* is a subgenus of *Gilia*.

Leptodactylon brevifolium Rydberg, *Bull. Torr. Bot. Club.*, Vol. XL (1913), p. 475. Type from Utah, but a doubtful specimen (without flower) from Gunnison, Colo. (Baker). Allied to *L. pungens*.

Phlox tenuis Wooton and Standley, *Contr. U.S. Nat. Herb.*, Vol. XVI (1913), p. 161. Type from New Mexico, but apparently this species from Cerro Summit, Colo. (Baker).

Polemonium confertum mut. *albiflorum* Cockerell, *Torreya*, December, 1913, p. 270. Above timber line on Long's Peak trail (Cockerell).

Family **HYDROPHYLLACEAE** (Hydroleaceae)

Ellisia nyctalea var. *coloradensis* Brand, *Pflanzenreich*, Hydrophyllaceae, 1913, p. 39. Gunnison watershed, Cerro Summit (Baker), between Colorado Springs and Denver (Jones), Horsetooth Gulch (Crandall).

Hydrophyllum capitatum v. *pumilum*, subv. *densum* Brand, t. c., p. 33. Colorado (Warren).

Phacelia cenulata v. *bakeri* Brand, t. c., p. 79. Ouray and Cimarron (Baker).

P. glandulosa subsp. *euglandulosa* v. *australis* Brand, t. c., p. 83. Manitou (Clements), near Lake City, Hinsdale Co. (Purpus), near Cumbres, San Juan Mts., Conejos Co. (Baker).

P. magellanica subsp. *barbata* f. *angustifolia* Brand, t. c., p. 98. Horsetooth Mt. (Cowen). Leaves linear-lanceolate.

P. magellanica subsp. *barbata* f. *ballii* Brand, t. c., p. 99. Manitou (Ball).

P. magellanica subsp. *barbata* f. *griseophylla* Brand, *Univ. Calif. Publ., Botany*, Vol. IV (1912), p. 218. In *Pflanzenreich* this is cited from Routt Co., Rabbit Ear Range (Goodding), and Clear Creek (Parry).

P. neomexicana v. *euneomexicana* Brand, *Pflanzenreich*, Hydrophyllaceae, 1913, p. 83. Near Salida (Baker, Earle and Tracy), Platte Canyon near Cassel's, Park Co. (Mrs. and Miss Henry).

P. neomexicana v. *miophylla* Brand, t. c., p. 84. Canyon City (Brandegee).

Family **BORAGINACEAE**

Mertensia refracta Nelson, *Bot. Gazette*, July, 1913, p. 69. Wagon Wheel Gap, 9,000 ft. (A. A. Griffin).

Oreocarya paradoxa Nelson, l. c. Paradox Valley (E. P. Walker).

Family **SCROPHULARIACEAE** (Rhinanthaceae)

Pentstemon griffinii Nelson, t. c., p. 70. Rio Grande Valley, Colo., 8,200 ft. (Alfred A. Griffin).

Order *RUBIALES*

Family **CAPRIFOLIACEAE**

†**Sambucus ellisiae** Cockerell, *Torreya*, April, 1913, p. 75. Florissant (U. of Colo. Exped.).

Order *CARDUALES*

Family **CARDUACEAE**

Chaenactis alpina leucopsis; *C. leucopsis* Greene, *Leaflets*, Vol. II (1912), p. 221. Needle Mts., southwestern Colorado, 11,500 ft. (Whitman Cross).

Cirsium arcuatum; *Carduus arcuatus* Osterhout, *Muhlenbergia*, April, 1913, p. 55. Paonia (Osterhout). Remarkable for its stout spines. Flowers whitish.

C. modestum; *Carduus modestus* Osterhout, t. c., p. 54. Thompson R. Canyon just east of Estes Park (Osterhout). Distinguished by the small heads and long thickened bracts, which are not at all fimbriate. Flowers whitish.

Erigeron callianthemus Greene, *Leaflets*, Vol. II (1912), p. 197. Northern Colorado (Parry), southern Colorado (Baker), Little Ouray Mt. below Marshall Pass (Greene). Has been called *E. salsuginosus*.

E. eastwoodiae Wooton and Standley, *Contr. U.S. Nat. Herb.*, Vol. XVI (1913), p. 183. Type from New Mexico; but probably is the *E. bellidastrum* cited by Rydberg from McElmo Canyon, Colo.

E. iodanthus Greene, *Leaflets*, Vol. II (1912), p. 209. Southern Colorado, 10,500 ft. (F. H. Knowlton).

E. rubicundus Greene, t. c., p. 208. Near Silverton (Alice Eastwood).

Gnaphalium decurrens glandulosum Osterhout, *Muhlenbergia*, Vol. VIII (1912), p. 45. Estes Park (Osterhout); also Sulphur Springs, Grand Co.

Helianthus aridus v. *citrinus* Cockerell, *Science*, August, 21, 1914, p. 284. Between Boulder and Goodview (T. and W. Cockerell).

H. coloradensis Cockerell, *Proc. Biol. Soc. Wash.*, Vol. XXVII (1914), p. 6. East of Boulder (Cockerell), and about Windsor (Osterhout).

H. coloradensis v. *andrewsi* Cockerell, t. c., p. 7. Boulder (D. M. Andrews).

H. lenticularis v. *primulinus* Cockerell, *Science*, August 21, 1914, p. 284. Near Goodview (T. and W. Cockerell).

Machaeranthera pulverulenta v. *vacans* Nelson, *Bot. Gazette*, July, 1913, p. 70. Paradox, Coventry, and San Miguel Canyon, Colo. (E. P. Walker).

Senecio rosulatus v. *primulinus* Cockerell, *Torreya*, December, 1913, p. 272. Estes Park Village (Cockerell).

Family CICHORIACEAE

Agoseris apiculata Greene, *Rep. Sp. Nov.*, Vol. XIII (1914), p. 320. Colorado.

Taraxacum fasciculatum Nelson, *Bot. Gazette*, July, 1913, p. 71. Wagon Wheel Gap; Blue Park (A. A. Griffin). None of the involucral bracts reflexed.

Tragopogon porrifolius×dubius Cockerell, *Torreya*, October, 1912, p. 245. Boulder (Cockerell).

ANIMALIA

Phylum PROTOZOA

Subphylum MYCETOZOA

Didymium anomalum Sturgis, *Colo. Coll. Publ.*, Vol. LXVIII (1913), p. 444. T. l., Colorado Springs, Colo. (Sturgis). On inner bark of *Populus*.

Enerthenema syncarpon Sturgis, t. c., p. 448. T. l., Pagosa Springs, Colo. (Sturgis). On decayed wood of *Pinus*.

Fuligo media Macbride, *Mycologia*, Vol. VI (1914), p. 147. "Repeatedly taken in Colorado."

F. megaspora Sturgis, t. c., p. 443. T. l., Cheyenne Mt., Colorado Springs (Sturgis). On dead bark of *Abies* and *Pinus*, and on twigs on the ground; also from Lake Albert Edward, Africa!

Physarum betheli Macbride; in Lister, *Mycetozoa*,2d ed., p. 57. Tolland, Colo.

Subphylum SPOROZOA

Order *GREGARINIDA*

Amphorocephalus (new genus) **amphorellus** Ellis, *Zool. Anzeiger*, March 14, 1913, p. 462. Near Boulder (Ellis). In *Scolopendra heros.*

Gregarina consobrina Ellis, *Trans. Amer. Micr. Soc.*, Vol. XXXII (1913), p. 267. Near mouth of Boulder Canyon. In *Ceuthophilus valgus.*

Stenophora robusta Ellis, *Zool. Anzeiger*, Vol. XL (1912), p. 8. Green Mountain, near Boulder (Ellis); Boulder (Rosamond Patton, Cockerell). In *Parajulus* and *Orthomorpha.*

Stylocephalus giganteus Ellis, *Zool. Anzeiger*, January 3, 1912, p. 25. Boulder (Ellis) In *Eleodes.*

Phylum ECHINODERMATA

Family CIDARIDAE

†**Miocidaris cannoni** Jackson, *Mem. Bost. Soc. Nat. Hist.*, Vol. VII (1912), p. 247. Near Denver; Millsap Formation, Lower Carboniferous (George Day).

Phylum VERMIDEA

Class NEMATHELMINTHIA

Osteragia bullosa Ransom and Hall, *Proc. U.S. Nat. Mus.*, Vol. XLII (1912), p. 176. T. l., Wells Ranch, Resolis, Colo. (Ransom). In sheep.

Rictularia splendida Hall, *Proc. U.S. Nat. Mus.*, Vol. XLVI (1913), p. 77. T. l., Amo, Colo. (Hall). In intestine of *Canis nebrascensis.*

Class CHAETOPODA

Cambarincola (new genus) **macrodonta** Ellis, *Proc. U.S. Nat. Mus.*, Vol. XLII (1912), p. 481; *U. of Colo. Studies*, Vol. IX (1912), p. 51. Boulder (Margaret Hawkins and E. Bethel). On *Cambarus diogenes.*

Phylum BRACHIOPODA

†**Schizambon manitouensis** Walcott, *Monog. U.S. Geol. Surv.*, Vol. LI, Pt. 1 (1912), p. 623. (Received February, 1913.) T. l., Williams Canyon, Manitou, Colo.; Lower Ordovician (T. W. Stanton).

Class CRUSTACEA

Family BRANCHIPODIDAE

Branchinecta packardi Pearse, *14th Rept. Mich. Acad. Sci.*, 1912 (pub. 1913), p. 192. T. l., La Junta, Colo. (G. S. Dodds). Later taken by Dr. Max M. Ellis at St. Vrain, Colo., in company with *Streptocephalus texanus*. It was determined by Dr. Dodds.

Class DIPLOPODA

Family PARAIULIDAE

Paraiulus garius Chamberlin, *Ann. Ent. Soc. Amer.*, Vol. V (1912), p. 167. Tolland, Colo., August, 1911 (Cockerell).

Class CHILOPODA

Family LITHOBIIDAE

Arenobius coloradanus Chamberlin, t. c., p. 141. Manitou, Colo. (Chamberlin).

Sozibius pungonius Chamberlin, t. c., p. 152. Marshall, Colo. (Cockerell).

Class ARACHNIDA

Order *ACARINA*

Tetranychus weldoni Ewing, *Ann. Ent. Soc. Amer.*, December, 1913 (pub. January, 1914), p. 457. Grand Junction, Colo. (G. P. Weldon). On apple, prune, and cottonwood.

Order *ORTHOPTERA*

Family MANTIDAE

†**Eobruneria** (new genus) **tessellata** Cockerell, *Proc. U.S. Nat. Mus.* Vol. XLIV (1913), p. 343. Florissant (G. Hambach).

†**Lithophotina costalis** Cockerell, *Entomologist*, 1914, p. 34. Florissant (Wickham).

Family ACRIDIIDAE

†**Tyrbula scudderi** Cockerell, *Entomologist*, 1914, p. 33. Florissant (Wickham).

Family LOCUSTIDAE

†**Amblycorypha** (?) **perdita** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for December, 1914, p. 636. Florissant (Wickham).

Order *NEUROPTERA*

Family RAPHIDIIDAE

†**Raphidia pulveris** Cockerell, *Jour. of Geology*, Vol. XXII (1914), p. 714. Florissant (Wickham).

Family CHRYSOPIDAE

†**Palaeochrysa fracta** Cockerell, t. c., p. 716. Florissant (Wickham).

†**P. wickhami** Cockerell, t. c., p. 717. Florissant (Wickham).

Order *ARCHIPTERA*

Family EPHEMERIDAE

Heptagenia coxalis Banks, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 615. Clear Creek, Colo. (Oslar).

Order *ISOPTERA*

Family TERMITIDAE

†**Parotermes scudderi** Cockerell, *Entom. News*, Vol. XXIV (1913), p. 8. Florissant (W. P. Cockerell).

Order *ODONATA*

Family AGRIONIDAE

Agrion aequabile coloradicum Cockerell, *Psyche*, 1913, p. 173. Overland Lake, Boulder Co., Colo. (G. Hite).

Family AESHNIDAE

†**Oplonaeschna lapidaria** Cockerell and Counts, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913). p. 577. Florissant (S. A. Rohwer).

Order *COLEOPTERA*

Family CICINDELIDAE

Cicindela audax Casey, *Mem. Coleop.* Vol. IV (1913), p. 29. Colorado.

C. formosa luxuriosa Casey, t. c., p. 24. T. l., near Denver (Soltau).

C. lantzi E. D. Harris, *Jour. N.Y. Ent. Soc.*, Vol. XXI (1913), p. 69. T. l., "in Jefferson, Colo." (D. E. Lantz).

C. limbalis eldorensis Casey, t. c., p. 23. T. l., Eldora, Colo.

C. purpurea auguralis Casey, t. c., p. 21. Colorado.

C. purpurea inducta Casey, t. c., p. 22. Colorado.

Family CARABIDAE

Agonoderus obliqulus Casey, *Mem. Coleop.* Vol. V (1914), p. 297. T. l., in Utah, but a slightly varietal form from Fort Collins, Colo.

Agonoleptus (new genus) **parviceps** Casey, t. c., p. 285. T. l., Colorado Springs (Wickham).

†**Amara cockerelli** Wickham, *Bull. Lab. N.H. Univ. Iowa*, Vol. XLIV (1912), p. 7. Florissant (Cockerell).

†**Bembidium florissantense** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 6. Florissant (Wickham).

Bothriopterus laxicollis Casey, *Mem. Coleop.*, Vol. IV (1913), p. 142. Colorado.

B. saxatilis Casey, l. c., "Abundant in Boulder Co., Colo."

Calathus coloradensis Casey, t. c., p. 157. T. l., Boulder Co., Colo.

C. reductus Casey, t. c., p. 158. Colorado (Levette collection).

Carabus patulicollis Casey, t. c., p. 57. "Probably taken in Colorado."

C. serratus vegasensis Casey, t. c., p. 59. T. l., in New Mexico; but also a specimen, "possibly from southern Colorado."

Cymindis rupimontis Casey, t. c., p. 183. T. l., Boulder Co., Colo.

Discoderus hesperus Casey, *Mem. Coleop.* ,Vol. V (1914), p. 163. "Kansas, Texas, and Colorado (Boulder)."

Harpalus aequabilis Casey, *Mem. Coleop.*, Vol. V (1914), p. 100. T. l., Buena Vista, Colo. (Wickham).

H. coloradensis Casey, t. c., p. 111. Boulder Co., Colo.

H. curticornis Casey, t. c., p. 124. Salida, Colo. (Wickham).

H. egregius Casey, t. c., p. 88 (*alienus* Lec., preocc.). Boulder Co., Colo.

H. lecontei Casey, t. c., p. 117 (*oblitus* Lec., not Dej.). New Mexico, Colorado, and Arizona.

H. macilentus Casey, t. c., p. 96. T. l., Boulder Co., Colo.

H. mobilis Casey, t. c., p. 112. T. l., Boulder Co., Colo.

H. paululus Casey, t. c., p. 110. T. l., Eldora, Colo.

H. perspicuus Casey, t. c., p. 101. T. l., Boulder Co., Colo.

H. probatus Casey, t. c., p. 119. New Mexico and Colorado.

H. seclusus Casey, t. c., p. 106. T. l., Colorado (Levette).

H. sejunctus Casey, t. c., p. 126. T. l., Eldora, Colo.

Nebria catenata Casey, *Mem. Coleop.*, Vol. IV (1913), p. 49. Colorado (Levette collection).

N. incerta Casey, t. c., p. 53. Colorado (Levette collection).

N. mobilis Casey, t. c., p. 50. Colorado (Levette collection).

Nothopus obtusus Casey, *Mem. Coleop.*, Vol. V (1914), p. 56. Colorado.

Notiophilus evanescens Casey, *Mem. Coleop.*, Vol. IV (1913), p. 47. T. l., Boulder Co., Colo.

Pasimachus acuminatus Casey, t. c., p. 88. "Probably taken in Colorado."

P. angustulus evanescens Casey, t. c., p. 84. "Probably collected in Colorado."

Philophuga puella Casey, t. c., p. 176. T. l., Boulder Co., Colo.

†**Platynus florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 7. Florissant (Wickham).

Selenophorus scolopaceus Casey, *Mem. Coleop.*, Vol. V (1914), p. 150. Colorado.

Stenolophus capitosus Casey, t. c., p. 281. T. l., Boulder Co., Colo.

†**Tachys haywardi** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 7. Florissant (Wickham).

†**Trechus fractus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 6. Florissant (U. of Colo. Exped.).

Family DYTISCIDAE

†**Agabus charon** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 8. Florissant (U. of Colo. Exped.).

†**A. florissantensis** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 285. Florissant.

†**Bidessus laminarum** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 426. Florissant (Scudder).

†**Coelambus miocenus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 7. Florissant (George N. Rohwer).

†**Hydroporus sedimentarum** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 427. Florissant (Scudder).

Family HYDROPHILIDAE

†**Creniphilites** (new genus) **orpheus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 8. Florissant (Wickham).

†**Hydrobius titan** Wickham, t. c., p. 7. Florissant (Wickham).

Family SILPHIDAE

†**Anisotoma sibylla** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 285. Florissant.

†**Hydnobius tibialis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 9. Florissant (Wickham).

†**Miosilpha** (new genus) **necrophiloides** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 9. Florissant (W. P. Cockerell).

†**Silpha beutenmuelleri** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 428. Florissant (Scudder).

Family PAUSSIDAE

†**Paussopsis secunda** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 10. Florissant (George N. Rohwer).

Family STAPHYLINIDAE

†**Aleocharopsis** (new genus) **caseyi** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 286. Florissant.

†**A. secunda** Wickham, t. c., p. 287. Florissant.

†**Atheta** (?) **florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 9. Florissant (Wickham).

†**Deleaster grandiceps** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 12. Florissant (George N. Rohwer).

†**Homalium antiquorum** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 11. Florissant (Wickham).

†**Lathrobium antediluvianum** Wickham, t. c., p. 10. Florissant (Wickham).

†**Miolithocharis** (new genus) **lithographica** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 289. Florissant.

†**Oxytelus subapterus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 11. Florissant (Wickham).

†**Paederus adumbratus** Wickham, t. c., p. 10. Florissant (Wickham).

†**Quedius mortuus** Wickham. *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 11. Florissant (S. A. Rohwer).

†**Staphylinus vulcan** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 288. Florissant.

FAMILY **COCCINELLIDAE**

†**Coccinella florissantensis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 429. Florissant (Scudder).

†**C. sodoma** Wickham, *Ann. Ent. Soc. Amer.*, 1913, p. 360. Florissant (Princeton Exped.).

FAMILY **EROTYLIDAE**

†**Tritoma diluviana** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 430. Florissant (Scudder).

†**T. materna** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 13. Florissant (S. A. Rohwer).

†**T. submersa** Wickham, l. c. Florissant (U. of Colo. Exped.).

FAMILY **COLYDIIDAE**

†**Cicones oblongopunctata** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 12. Florissant (Wickham).

Lasconotus tuberculatus E. J. Kraus, *Proc. Ent. Soc. Wash.*, Vol. XIV (1912), p. 35. Type from S. Dakota, but also in Colorado (Palmer Lake).

L. subcostulatus E. J. Kraus, t. c., p. 40. Type from Idaho, but also at Boulder, Colo.

†**Phloeonemites** (new genus) **miocenus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 13. Florissant (W. P. Cockerell).

†**Rhagoderidea** (new genus) **striata** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 431. Florissant (Scudder).

FAMILY **CUCUJIDAE**

†**Lithocoryne arcuata** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 290. Florissant.

†**L. coloradensis** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 258. Florissant (Wickham).

FAMILY **CRYPTOPHAGIDAE**

†**Antherophagus megalops** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 360. Florissant (Princeton Exped.).

†**Cryptophagus bassleri** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 290. Florissant.

†**C. scudderi** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 432. Florissant (Scudder).

Family **MYCETOPHAGIDAE**

†**Mycetophagus exterminatus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 13. Florissant (Wickham).

†**M. willistoni** Wickham, t. c., p. 12. Florissant (Wickham).

Family **DERMESTIDAE**

†**Attagenus aboriginalis** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 361. Florissant (Princeton Exped.).

†**Dermestes tertiarius** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 14. Florissant (W. P. Cockerell).

†**Orphilus dubius** Wickham, t. c., p. 15. Florissant (W. P. Cockerell).

Family **NITIDULIDAE**

†**Amartus petrefactus** Wickham, l. c. Florissant (U. of Colo. Exped.).

†**Colastus pygidialis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 13. Florissant (Wickham).

†**Cychramites** (new genus) **hirtus** Wickham, t. c., p. 14. Florissant (Wickham).

Family **LATHRIDIIDAE**

†**Corticaria aeterna** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 259. Florissant (Wickham).

†**C. egregia** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 433. Florissant (Scudder).

†**C. occlusa** Wickham, l. c. Florissant (Scudder).

†**C. petrefacta** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913. Florissant (Wickham).

Family **TEMNOCHILIDAE**

†**Tenebrioides corrugata** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 291. Florissant.

Family **BYRRHIDAE**

Byrrhus canterius Casey, *Mem. Coleop.*, Vol. III (1912), p. 27. T. l., Leadville (Wickham).

B. explicatus Casey, l. c. T. l., Leavenworth Valley, Colo., 10,000–11,000 ft. (Wickham).

B. vafer Casey, t. c., p. 30. T. l., Leadville (Wickham).

†**Chelonarium montanum** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 434. Florissant (Scudder).

Cytilus alternatus longulus Casey, *Mem. Coleop.*, Vol. III (1912), p. 18. "Washington State and British Columbia to Colorado; those from the last-named region more sober in coloration."

Eulimnichus analis coloradensis Casey, t. c., p. 47. T. l., Denver.

Simplocaria subnuda Casey, t. c., p. 16. "Colorado."

Family **PARNIDAE**

†**Dryops tenuior** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 16. Florissant (W. P. Cockerell).

†**Lutrochites** (new genus) **lecontei** Wickham, l. c. Florissant (W. P. Cockerell).

Family **DASCYLLIDAE**

†**Ectopria laticollis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 15. Florissant (Wickham).

†**Miocyphon** (new genus) **punctulatus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 437. Florissant (Scudder).

†**Protacnaeus** (new genus) **tenuicornis** Wickham, t. c., p. 436. Florissant (Scudder).

Family **ELATERIDAE**

†**Eucnemis antiquatus** Wickham, t. c., p. 437. Florissant (Scudder).

Family **THROSCIDAE**

†**Pactopus americanus** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 259. Florissant (Wickham).

Family **BUPRESTIDAE**

†**Agrilus praepolitus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 442. Florissant (Scudder).

†**Anthaxia exhumata** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 292. Florissant.

†**Buprestis florissantensis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 438. Florissant (Scudder).

†**B. scudderi** Wickham, t. c., p. 439. Florissant (Scudder).

†**Chrysobothris coloradensis** Wickham, t. c., p. 441. Florissant (Scudder).

†**C. suppressa** Wickham, t. c., p. 440. Florissant (Scudder).

†**Dicerca eurydice** Wickham, t. c., p. 438. Florissant (Scudder).

†**Melanophila cockerellae** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 17. Florissant (W. P. Cockerell).

†**M. handlirschi** Wickham, l. c. Florissant (S. A. Rohwer).

†**M. heeri** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 260. Florissant (Wickham).

†**Ptosima abyssa**; *Acmaeodera abyssa* Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 19. Florissant (U. of Colo. Exped.).

†**P. schaefferi**; *Acmaeodera schaefferi* Wickham, t. c., p. 18. Florissant (W. P. Cockerell).

†**P. silvatica** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 441. Florissant (Scudder).

Family **LAMPYRIDAE**

†**Miocaenia** (new genus) **pectinicornis** Wickham, t. c., p. 443. Florissant (Scudder).

†**Podabrus florissantensis** Wickham, t. c., p. 44. Florissant (Scudder).

†**P. fragmentatus** Wickham, l. c. Florissant (Scudder).

†**Polemius crassicornis** Wickham, t. c., p. 445. Florissant (Scudder).

†**Pyropyga prima** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 19. Florissant (W. P. Cockerell).

†**Telephorus hesperus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 445. Florissant (Scudder).

†**T. humatus** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 362. Florissant (Princeton Exped.).

†**Trypherus aboriginalis** Wickham, l. c. Florissant (Princeton Exped.).

Family **MALACHIIDAE**

Collops discretus Fall, *Jour. N. Y. Ent. Soc.*, December, 1912, p. 261. T. l., Troublesome, Colo. No collector cited, but it was collected by S. A. Rohwer.

†**C. priscus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 446. Florissant (Scudder).

†**C. desuetus** Wickham, t. c., p. 447. Florissant (Scudder).

†**C. extrusus** Wickham, l. c. Florissant (Scudder).

†**Eudasytites** (new genus) **listriformis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 19. Florissant (S. A. Rohwer).

†**Trichochrous miocenus** Wickham, t. c., p. 20. Florissant (W. P.Cockerell).

Family **CLERIDAE**

†**Enoclerus florissantensis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 448. Florissant (Scudder).

†**E. pristinus** Wickham, t. c., p. 449. Florissant (Scudder).

Hydnocera lecontei Wolcott (*subaenea* Lec., not Spinola), *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 62. Many localities, including Greeley, Georgetown, Colorado Springs, Ouray, and Salida, Colo.

†**H. wolcotti** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 15. Florissant (Wickham).

†**Necrobia sibylla** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 261. Florissant (Wickham).

Family **PTINIDAE**

†**Ernobius effetus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 450. Florissant (Scudder).

†**Oligomerus florissantensis** Wickham, t. c., p. 451. Florissant (Scudder).

†**O.** (?) **duratus** Wickham, l. c. Florissant (Scudder).

†**Vrilletta tenuistriata** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 16. Florissant (Wickham).

†**Xestobium alutaceum** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 363. Florissant (Princeton Exped.).

†**Gastrallanobium** (new genus) **subconfusum** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XI (1914), p. 261. Florissant (Wickham).

Family BOSTRICHIDAE

†**Amphicerus subtaevis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 452. Florissant (Scudder).

†**Dinoderus cuneicollis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 16. Florissant (Wickham).

†**Protapate** (new genus) **contorta,** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 20. Florissant (Mrs. C. Hill).

†**Xylobiops lacustre** Wickham, t. c., p. 21. Florissant (S. A. Rohwer).

Family LUCANIDAE

†**Lucanus fossilis** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 293. Florissant.

Family SCARABAEIDAE

†**Aphodius aboriginalis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 22. Florissant (W. P. Cockerell).

†**A. restructus** Wickham, l. c. Florissant (U. of Colo. Exped.).

†**A. shoshonis** Wickham, t. c., p. 23. Florissant (U. of Colo. Exped.).

†**A. granarioides** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 293. Florissant.

†**A. inundatus** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 262. Florissant (Wickham).

†**A. praeemptor** Wickham, *Bull. Lab. N.H. Univ. Iowa*, 1913, p. 17. Florissant (Wickham).

†**A. mediaevus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 455. Florissant (Scudder).

†**A. senex** Wickham, t. c., p. 456. Florissant (Scudder).

†**Anomala exterranea** Wickham, t. c., p. 459. Florissant (Scudder).

†**A. scudderi** Wickham, t. c., p. 460. Florissant (Scudder).

†**Diplotaxis aurora** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 294. Florissant.

†**D. simplicipes** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 25. Florissant (U. of Colo. Exped.).

†**Hoplia striatipennis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 457. Florissant (Scudder).

†**Ligyrus effetus** Wickham, t. c., p. 461. Florissant (Scudder).

†**Listrochelus puerilis** Wickham, t. c., p. 459. Florissant (Scudder).

†**Macrodactylus pluto** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 24. Florissant (Walter Reed).

†**M. propheticus** Wickham, t. c., p. 25. Florissant (U. of Colo. Exped.).

†**Miolachnosterna** (new genus) **tristoides** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 458. Florissant (Scudder).

†**Oxymus nearcticus** Wickham, t. c., p. 453. Florissant (Scudder).

†**Serica antediluviana** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 23. Florissant (W. P. Cockerell).

†**S. cockerelli** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 262. Florissant (Wickham).

†**Strategus cessatus** Wickham, *B.M.C.Z.*, Vol. LVII (1914), p. 461. Florissant (Scudder).

Family CERAMBYCIDAE

†**Acanthoderes lengii** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 265. Florissant (Wickham).

Acmaeops aurora Casey, *Mem. Coleop.*, Vol. IV (1913), p. 244. Magnolia, Colo. (Mrs. T. L. Casey).

A. coloradensis Casey, l. c. Magnolia, Colo.; also Fraser, Colo. (C. A. Frost).

A. obsoleta Casey, t. c., p. 243. Colorado (Levette collection).

A. parkeri Casey, t. c., p. 242. Boulder Co., Colo. (F. Y. Parker).

A. puncticeps Casey, t. c., p. 243. Colorado (Levette collection).

Anocomis (new genus) **lignea parvicollis** Casey, *Mem. Coleop.*, Vol. III (1912), p. 272, Colorado.

Asemum parvicorne Casey, t. c., p. 260. Boulder Co., Colo.

Brachyleptura boulderensis Casey, *Mem. Coleop.*, Vol. IV (1913), p. 252. Boulder Co., Colo.

B. subquadrata Casey, t. c., p. 251. Colorado (Levette collection).

Brachysomida (new genus) **lanatula** Casey, t. c., p. 224. Colorado.

B. morata Casey, t. c., p. 222. Summit of Mt. Arapahoe, nearly 13,000 ft. alt.

Calloides biformis Casey, *Mem. Coleop.*, Vol. III (1912), p. 358. New Mexico and Colorado.

C. coloradensis Casey, l. c. Colorado.

†**Callidiopsites** (new genus) **grandiceps** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 364. Florissant (U. of Colo. Exped., also Princeton Exped.).

†**Clytus florissantensis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 464. Florissant (Scudder).

Criocephalus asperus impressus (Casey), *Mem. Coleop.*, Vol. III (1912), p. 264. Boulder Co., Colo. This and the next were published by Casey under *Nothorhina*, but he added a footnote stating that they really constituted a section of *Criocephalus*, true *Nothorhina* not occurring in America.

C. spissicornis (Casey), l. c. Boulder Co., Colo.

C. spissicornis longicornis Casey, l. c. Boulder Co., Colo.

C. cavicollis Casey, t. c., p. 266. Colorado (James F. Kemp).

Crossidius submetallicus Casey, t. c., p. 341. Boulder Co., Colo.

Dectes alticola Casey, *Mem. Coleop.*, Vol. IV (1913), p. 342. Colorado, Montana, and New Mexico. Food-plant, sunflower; see Cockerell, *Entomologist*, 1914, p. 195.

†**Elaphidion extinctum** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 463. Florissant (Scudder).

†**Gaurotes striatopunctatus** Wickham, t. c., p. 465. Florissant (Scudder).

Hammoderus amplipennis Casey, *Mem. Coleop.*, Vol. IV (1913), p. 295. Colorado (Levette).

Homaesthesis debiliceps Casey, *Mem. Coleop.*, Vol. III (1912), p. 255. Colorado (J. F. Kemp).

H. pubicollis Casey, t. c., p. 254. Colorado.

†**Hylotrupes puncticollis** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 264. Florissant (Wickham).

Hyperplatys montana Casey, *Mem. Coleop.*, Vol. IV (1913), p. 325. Boulder Co., Colo.

Judolia trajecta Casey, t. c., p. 250. Boulder Co., Colo.

Leptacmaeops (new genus) **alticola** Casey, t. c., p. 239. Veta Pass, Colo. (Schwarz).

L. punctiventris Casey, t. c., p. 238. Colorado (Levette), and New Mexico.

†**Leptostylus scudderi** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 469. Florissant (Scudder).

†**Leptura antecurrens** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 295. Florissant.

L. aureola Casey, *Mem. Coleop.*, Vol. IV (1913), p. 268. Colorado (Levette); also Boulder Co., Colo.

†**L. ingenua** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 467. Florissant (Scudder).

†**L. leidyi** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 364. Florissant (Princeton Exped.).

†**L. nanella** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 466. Florissant (Scudder).

†**L. petrorum** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 26. Florissant (W. P. Cockerell).

†**L. ponderosissima** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 295. Florissant.

L. (**Cosmosalia** new subgenus) **praestans** Casey, *Mem. Coleop.*, Vol. IV (1913), p. 267. Colorado.

Moneilema nubecula Casey, t. c., p. 282. Kansas and Colorado.

M. rector Casey, t. c., p. 287. Colorado.

Monochamus monticola Casey, t. c., p. 293. Rocky Mts., of Colorado; also Montana and Oregon.

M. strenuus Casey, l. c. Colorado (Levette).

Ophistomis ochreipennis Casey, t. c., p. 278. From the Levette collection, perhaps from Colorado.

O. simulans Casey, l. c. Colorado (Levette).

†**Palaeosmodicum** (new genus) **hamiltoni** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 264. Florissant (Wickham).

†**Phymatodes miocenicus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 462. Florissant (Scudder).

Pogonocherus carinatus Casey, *Mem. Coleop.*, Vol. IV (1913), p. 346. Colorado.

P. emarginatus Casey, t. c., p. 347. Colorado.

Prionus consors Casey, *Mem. Coleop.*, Vol. III (1912), p. 240. Boulder Co., Colo., abundant.

P. solidus Casey, t. c., p. 238. Colorado (Levette).

†**Protipochus** (new genus) **vandykei** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 468. Florissant (Scudder).

†**Protoncideres** (new genus) **primus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 18. Florissant (Wickham).

Rhagium montanum Casey, *Mem. Coleop.*, Vol. IV (1913), p. 197. Fraser and Boulder Co., Colo.; also in New Mexico.

†**Scaptolenopsis** (new genus) **wilmattae** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 263. Florissant (W. P. Cockerell).

†**Stenosphenus pristinus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 463. Florissant (Scudder).

Strangalia minuscula Casey, *Mem. Coleop.*, Vol. IV (1913), p. 260. Colorado (Levette).

Strophiona (new genus) **bellina** Casey, t. c., p. 265. Colorado.

Tetraopes junctus Casey, t. c., p. 380. "Probably from Colorado."

T. robustus Casey, t. c., p. 381. Levette collection; probably from Colorado.

T. vestitus Casey, t. c., p. 378. Colorado.

Typocerus confluens Casey, t. c., p. 272. Kansas and Colorado.

Xylotrechus inflaticollis Casey, *Mem. Coleop.*, Vol. III (1912), p. 360. Boulder Co., Colo.

Family CHRYSOMELIDAE

†**Colaspis diluvialis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 471. Florissant (Scudder).

†**C. proserpina** Wickham, t. c., p. 472. Florissant (Scudder).

†**Crioceridea** (new genus) **dubia** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 27. Florissant (George N. Rohwer).

†**Cryptocephalus miocenus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 18. Florissant (Wickham).

†**Diabrotica bowditchiana** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 473. Florissant (Scudder).

†**D. florissantella** Wickham, t. c., p. 474. Florissant (Scudder).

†**D. uteana** Wickham, t. c., p. 473. Florissant (Scudder).

†**Donacia primaeva** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 26. Florissant (S. A. Rohwer).

†**Haltica renovata** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 476. Florissant (Scudder).

†**Lema fortior** Wickham, t. c., p. 470. Florissant (Scudder).

†**L. lesquereuxi** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 266. Florissant (Wickham).

†**Luperodes submonilis** Wickham, l. c. Florissant (Wickham).

†**Metachroma florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 28. Florissant (U. of Colo. Exped.).

†**Odontota americana** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 479. Florissant (Scudder).

†**Plectrotetrophanes** (new genus) **hageni** Wickham, t. c., p. 477. Florissant (Scudder).

†**Prochaetocnema** (new genus) **florissantella** Wickham, t. c., p. 478. Florissant (Scudder).

†**Systena florissantensis** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 296. Florissant.

†**Trirhabda majuscula** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 475. Florissant (Scudder).

†**T. megacephala** Wickham, l. c. Florissant (Scudder).

†**T. sepulta** Wickham, t. c., p. 474. Florissant (Scudder).

Family BRUCHIDAE

†**Bruchus aboriginalis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 482. Florissant (Scudder).

†**B. bowditchi** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 30. Florissant (S. A. Rohwer).

†**B. carpophiloides** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 482. Florissant (Scudder).

†**B. dormescens** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 297. Florissant.

†**B. exhumatus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 29. Florissant (T. D. A. Cockerell).

†**B. florissantensis** Wickham, t. c., p. 30. Florissant (S. A. Rohwer).

†**B. haywardi** Wickham, t. c., p. 31. Florissant (George N. Rohwer and W. P. Cockerell).

†**B. henshawi** Wickham, t. c., p. 28. Florissant (U. of Colo. Exped.).

†**B. osborni** Wickham, t. c., p. 32. Florissant (W. P. Cockerell).

†**B. primoticus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 480. Florissant (Scudder).

†**B. scudderi** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 31. Florissant (S. A. Rohwer).

†**B. submersus** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 481. Florissant (Scudder).

†**B. succintus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 19. Florissant (Wickham).

†**B. wilsoni** Wickham, l. c. Florissant (Wickham).

†**Sphermophagus pluto** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 480. Florissant (Wickham).

Family TENEBRIONIDAE

Asidopsis (new genus) **obsidiana** Casey, *Mem. Coleop.*, Vol. III (1912), p. 193. Colorado.

A. servilis Casey, t. c., p. 199. Salida, Colo. (Wickham).

A. tensa Casey, t. c., p. 197. Colorado (Schaupp).

†**Blapstinus linelli** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 298. Florissant.

Euschides advena Casey, *Mem. Coleop.*, Vol. III (1912), p. 143. Colorado (Schaupp).

Glyptasida (new genus) **aegra imperfecta** Casey, t. c., p. 102. "Probably taken in Colorado."

G. sordida porcatula Casey, t. c., p. 97. Colorado (F. G. Schaupp).

Gonasida (new genus) **aucta** Casey, t. c., p. 122. La Junta, Colo.

†**Miostenosis** (new genus) **lacordairei** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 297. Florissant.

†**Platydema antiquarum** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May 1912, p. 32. Florissant (U. of Colo. Exped.).

†**P. bethunei** Wickham, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 299. Florissant.

†**Proteleates** (new genus) **centralis** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 267. Florissant (Wickham).

†**Protoplatycera** (new genus) **laticornis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 484. Florissant (Scudder).

†**Ulus minutus** Wickham, *Trans. Amer. Ent., Soc.*, Vol. XL (1914), p. 267. Florissant (Wickham).

Family CISTELIDAE

†**Capnochroa senilis** Wickham, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 365. Florissant (Princeton Exped.).

†**Cistela antiqua** Wickham, l. c. Florissant (Princeton Exped.).

†**C. vulcanica** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 485. Florissant (Scudder).

†**Hymenorus haydeni** Wickham, t. c., p. 486. Florissant (Scudder).

†**Isomira florissantensis** Wickham, l. c. Florissant (Scudder).

†**I. aurora** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 268. Florissant (Wickham).

Family PYTHIDAE

†**Pythoceropsis** (new genus) **singularis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 21. Florissant (Wickham).

Family OEDEMERIDAE

†**Copidita miocenica** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 487. Florissant (Scudder).

†**Paloedemera** (new genus) **crassipes** Wickham, t. c., p. 488. Florissant (Scudder).

Family MORDELLIDAE

†**Mordella stygia** Wickham, t. c., p. 489. Florissant (Scudder).

†**Mordellistena florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 33. Florissant (S. A. Rohwer).

†**M. nearctica** Wickham, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 268. Florissant (Wickham).

†**M. protogaea** Wickham, t. c., p. 269. Florissant (Wickham).

†**M. scudderiana** Wickham, t. c., p. 268. Florissant (Wickham).

†**M. smithiana** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 21. Florissant (Wickham).

†**Tomoxia inundata** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 487. Florissant (Scudder).

Family ANTHICIDAE

†**Brachytarsus** (?) **dubius** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 27. Florissant (Wickham).

†**Corphyra calypso** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 491. Florissant (Scudder).

†**Lithomacratria** (new genus) **mirabilis** Wickham, t. c., p. 490. Florissant (Scudder).

Family MELOIDAE

†**Cantharis lithophilus** Wickham, t. c., p. 492. Florissant (Scudder).

†**Epicauta subneglecta** Wickham, l. c. Florissant (Scudder).

†**Nemognatha exsecta** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 34. Florissant (W. P. Cockerell).

†**Tetraonyx minuscula** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 491. Florissant (Scudder).

Family RHYNCHITIDAE

†**Auletes florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, Vol. VI, May, 1913, p. 22. Florissant (Wickham).

†**Docirhynchus ibis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 34. Florissant (George N. Rohwer).

Euclyptus sejunctus Fall, *Trans. Amer. Ent. Soc.*, Vol. XXXIX (1913), p. 45. Colorado, from Mr. Blanchard.

†**Eugnamptidea** (new genus) **tertiaria** Wickham, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 42. Florissant (S. A. Rohwer).

Rhynchites bicolor wickhami Cockerell, *Entom. News*, Vol. XXIII (1912), p. 82. Boulder (Cockerell). It is an important pest of roses, killing the bud.

†**Trypanorhynchus exilis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 23. Florissant (Wickham).

†**T. minutissimus** Wickham, t. c., p. 22. Florissant (Wickham).

†**T. obliquus** Wickham, t. c., p. 23. Florissant (Wickham).

Family OTIORHYNCHIDAE

Cimbocera pauper sericea Pierce, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 379. T. l. in Utah, but also from Canyon City, Garland, and Grand Valley, Colo.

†**Cyphus florissantensis** Wickham, *B.M.C.Z.*, Vol. LVIII (1914), p. 493. Florissant (Scudder).

Epicaerus wickhami Pierce, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 414. T. l. in New Mexico, but also from Colorado.

†**Ophryastes championi** Wickham, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 44. Florissant (W. P. Cockerell).

†**Ophryastites miocenus** Wickham, l. c. Florissant (S. A. Rohwer).

Family CURCULIONIDAE

†**Acalles exhumatus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 24. Florissant (Wickham).

†**Anthonomus rohweri** Wickham, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 48. Florissant (S. A. Rohwer).

A. sphaeralceae Fall, *Trans. Am. Ent. Soc.*, Vol. XXXIX (1913), p. 55. (The name was printed in error "sphaeralciae.") Type from Arizona, but the author referred to the same species specimens collected by Cockerell on the University Campus, Boulder, in September, and at Halfway House, Pike's Peak. The data are imperfectly recorded in the original publication.

†**Balaninus extinctus** Wickham, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 53. Florissant (W. P. Cockerell).

†**B. florissantensis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1913, p. 26. Florissant (Wickham).

†**Baris cremastorhynchoides** Wickham, t. c., p. 25. Florissant (Wickham).

†**B. florissantensis** Wickham, t. c., p. 24. Florissant (Wickham).

†**B. hoveyi** Wickham, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 52. Florissant (S. A. Rohwer).

†**B. schucherti** Wickham, l. c. Florissant (W. P. Cockerell).

†**Cleonus estriatus** Wickham, t. c., p. 47. Florissant (W. P. Cockerell).

†**Coniatus differens** Wickham, t. c., p. 46. Florissant (W. P. Cockerell).

†**Conotrachelus florissantensis** Wickham, t. c., p. 49. Florissant (W. P. Cockerell).

†**Cryptorhynchus coloradensis** Wickham, t. c., p. 50. Florissant (George N. Rohwer).

†**C. falli** Wickham, t. c., p. 51. Florissant (W. P. Cockerell).

†**Dorytomus vulcanicus** Wickham, t. c., p. 48. Florissant (W. P. Cockerell).

Gerstaeckeria tessellata Pierce, *Proc. U.S. Nat. Mus.*, Vol. XLII (1912), p. 162. T. l. in Wyoming, but also from Colorado Springs (Wickham).

Magdalis lecontei tenebrosa Fall, *Trans. Amer. Ent. Soc.*, Vol. XXXIX (1913), p. 28. New Mexico, Colorado, and California.

†**Pachybaris rudis** Wickham, *Bull. Lab. N.H. Univ. Iowa*, May, 1912, p. 35. Florissant (U. of Colo. Exped.).

Family IPIDAE

Dryocoetes confusus Swaine, *Canad. Entom.*, December, 1912 (pub. January, 1913), p. 351. Colorado.

D. minutus Swaine, t. c., p. 352. Colorado.

D. pubescens Swaine, t. c., p. 350. Colorado.
These three species described by Swaine are in the Cornell University collection, with the number 302. Professor J. C. Bradley kindly gives me the following information; "Under lot 302 I find the following statement: The Roberts collection of Scolytidae purchased from J. D. Sherman, Jr., November, 1906, originally constituted the greater part of the Juelich collection named by E. A. Schwarz. Sub. 37 [*D. pubescens*] was named *D. granicollis;* sub. 35 [*D. confusus*] was named *D. septentrionis;* sub. 94 must have been an error, as there is no such number recorded."

†**Hylastes americanus** Wickham, *Bull. Lab. N.H. Univ. Iowa*, Vol. VI (May, 1913), p. 27. Florissant (Wickham).

†**Hylurgops piger** Wickham, l. c. Florissant (Wickham).

Ips pilifrons Swaine, *Canad. Entom.*, December, 1912, p. 353. Colorado.

†**Xyleborites** (new genus) **longipennis** Wickham, *Bull. Lab. N.H. Univ. Iowa,* May, 1913, p. 26. Florissant (Wickham).

Order *HYMENOPTERA*

Family ICHNEUMONIDAE

Campoplex hellulae Viereck, *Proc. U.S. Nat. Mus.*, Vol. XLII (1912), p. 631. Type from California; but also found at Rocky Ford, Colo. (H. O. Marsh).

C. (**Campoletidea** new subgenus) **caradrinae** Viereck, t. c., p. 634. Rocky Ford, Colo. (H. O. Marsh). Parasitic on *Caradrina exigua.*

Angitia plutellae Viereck, *Proc. U.S. Nat. Mus.*, Vol. XLIII (1912), p. 583. Rocky Ford, Colo. (H. O. Marsh). Parasitic on *Plutella omissa.*

Pezomachus coloradensis Strickland, *Ann. Ent. Soc. Amer.*, Vol. V (1912), p. 122. Colorado.

Family OPHIONIDAE

Ophion bilineatus elongatus C. W. Hooker, *Trans. Amer. Ent. Soc.*, Vol. XXXVIII (1912), p. 30. Colorado.

Thyreodon fernaldi C. W. Hooker, t. c., p. 131. "Mexico, Arizona, Colorado."

Family BRACONIDAE

Meteorus mamestrae Viereck, *Proc. U.S. Nat. Mus.*, Vol. XLVI (1913), p. 364. Rocky Ford (H. O. Marsh). Parasitic on *Mamestra trifolii.*

Ascogaster olethreuti Viereck, *Proc. U.S. Nat. Mus.*, Vol. XLII (1912), p. 617. Type from Pullman, Wash., but one specimen from Colorado (Baker).

Sympha nigricornis Rohwer, *Entom. News*, Vol. XXV (1914), p. 170. Colorado.

†**Alysia ruskii** Cockerell, *Canad. Entom.*, July, 1913, p. 231. Florissant (Willard Rusk).

Family TORYMIDAE

Megastigmus lasiocarpae Crosby, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 163. Rye, Colo., reared from seeds of *Abies lasiocarpa* received from O. S. Mackelfresh.

Family PERILAMPIDAE

Perilampus anomocerus Crawford, *Proc. Ent. Soc. Wash.*, Vol. XVI (1914), p. 72. Colorado (Baker).

P. bakeri Crawford, l. c. Colorado (Baker).

P. similis Crawford, t. c., p. 73. Colorado (Baker).

Family EULOPHIDAE

Derostenus pictipes Crawford, *Proc. U.S. Nat. Mus.*, Vol. XLIII (1912), p. 180. Fort Collins (C. N. Ainslie). Reared from *Hordeum.*

Notanisomorpha ainsliei Crawford, t. c., p. 185. Fort Collins (Ainslie). Reared from *Agromyza* on *Agropyron.*

Zagrammosoma flavolineata Crawford, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 255. Colorado.

Family SCELIONIDAE

†**Palaeoteleia** (new genus) **oxyura** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 638. Florissant (Wickham).

Family FORMICIDAE

Formica bradleyi Wheeler, *Bull. Mus. Comp. Zool.*, Vol. LIII (1913), p. 423. Georgetown, Colo. (P. J. Schmitt).

F. cinerea var. *altipetens* Wheeler, t. c., p. 523. Florissant and Cheyenne Mt. (Wheeler).

F. emoryi Wheeler, t. c., p. 419. Broadmoor, near Colorado Springs (Wheeler).

F. exsectoides var. *hesperia* Wheeler, t. c., p. 484. Cheyenne Canyon, near Colorado Springs (Wheeler).

F. fusca var. *gelida* Wheeler, t. c., p. 505. Ward (Cockerell), timberline on Arapahoe Peak (W. P. Cockerell), Long's Peak, at about 11,500 ft., given erroneously as 12,500 ft. (Cockerell), Cripple Creek (Wheeler), Cheyenne Mountain (Wheeler). Canyon City (Schmitt).

F. (Proformica) limata Wheeler, t. c., p. 541. Florissant, Cheyenne Canyon (Wheeler).

F. microgyna subsp. *rasilis* var. *spicata* Wheeler, t. c., p. 469. Florissant (Wheeler).

F. microgyna var. *recidiva* Wheeler, t. c., p. 467. Florissant (Wheeler).

F. truncicola subsp. *integroides* var. *coloradensis* Wheeler, t. c., p. 440. Florissant (Wheeler), Wild Horse and Woodland Park (Wheeler), Ward (Cockerell), Boulder and Breckenridge (Schmitt).

F. truncicola subsp. *mucescens* Wheeler, t. c., p. 442. Colorado Springs (Wheeler), Colorado City, Malvern, Wild Horse, and Manitou (Wheeler), West Cliff (Schmitt).

Family MUTILLIDAE

Dasymutilla blawa Rohwer, *Proc. U.S. Nat. Mus.*, Vol. XLI (1912), p. 457. Type from Iowa, but also from Colorado (Baker).

D. coloradella Rohwer, t. c., p. 458. Boulder and Florissant (Rohwer).

Family PHILANTHIDAE

Cerceris gnarina Banks, *Bull. Am. Mus. N. Hist.*, Vol. XXXII (1913), p. 237. T. l. in Oklahoma, but also from Colorado Springs (Wickham) and Chimney Gulch, Golden, Colo. (Oslar).

Family LARRIDAE

Dryudella millsi Cockerell, *Entom. News*, January, 1914, p. 32. Long's Peak Inn, Colo. (Cockerell).

Family PSAMMOCHARIDAE

Aporinellus laticeps Banks, *Jour. N. Y. Ent. Soc.*, "December, 1911" (pub. March, 1912), p. 230. Boulder (Rohwer). Type taken September 8, 1908.

A. rufus Banks, l. c. Boulder and Florissant (Rohwer). Type from Boulder, August 8, 1908.

†**Cryptocheilus hypogaeus** Cockerell, *Jour. of Geology*, Vol. XXII (1914), p 718. Florissant (Wickham).

Pompiloides consimilis Banks, *Jour. N. Y. Ent. Soc.*, Vol. XIX, p. 228. Florissant (Rohwer). Mr. Rohwer writes that he also took it at Boulder, June 1.

P. parvulus Banks, t. c., p. 227. Boulder and Florissant (Rohwer).

Family ANDRENIDAE

Andrena agricolarum Viereck and Cockerell, *Proc. U.S. Nat. Mus.*, Vol. XLVIII (1914), p. 29. Fort Collins (Colo. Agric. College).

A. antonitonis V. and C., t. c., p. 56. Antonito, Colo. (Gillette).

A. argentiniae trichomelaena Cockerell, *Ann. Mag. Nat. Hist.* October, 1913, p. 376. Florissant (S. A. Rohwer.)

A. ashmeadi V. and C., *Proc. U.S. Nat. Mus.*, Vol. XLVIII (1914), p. 45. Colorado (Baker).

A. bebbiana V. and C., t. c., p. 39. Boulder (S. A. Rohwer).

A. berkeleyi V. and C., t. c., p. 19. Berkeley, Colo. (Baker).

A. brachycarpae V. and C., t. c., p. 55. Florissant (S. A. Rohwer). At flowers of *Salix.*

A. campanulae V. and C., t. c., p. 38. Palmer Lake, Colo.

A. canadensis oslarella V. and C., t. c., p. 28. Denver (Oslar).

A. candidiformis V. and C., t. c , p. 33. T. l., Boulder, Colo., in canyon near town, May 23, 1896 (C. P. Gillette). This was recorded from "Colorado," but Miss E. Robinson has kindly looked up the exact data for this and some other species in the record book at the Agricultural College.

A. colletoides V. and C., t. c., p. 27. Colorado (Snow).

A. coloradina V. and C., t. c., p. 53. Colorado (Baker).

A. costillensis V. and C., t. c., p. 50. Eldora, Colo. (T. and W. Cockerell).

A. crataegiphila V. and C., t. c., p. 7. Boulder (Cockerell and S. A. Rohwer).

A. davisiana V. and C., t. c., p. 6. Boulder (J. M. Davis).

A. durangoensis V. and C., t. c., p. 36. Durango (Oslar).

A. ellisiae Cockerell, *Ann. Mag. Nat. Hist.*, July, 1914, p. 9. Boulder (Mrs. M. D. Ellis). At flowers of *Lepidium.*

A. fernaldiella V. and C., *Proc. U.S. Nat. Mus.*, Vol. XLVIII (1914), p. 34. Florissant (S. A. Rohwer).

A. fulvihirta V. and C., t. c., p. 54. T. l., six miles west of Fort Collins, miscellaneous sweeping, May 4, 1896 (C. P. Gillette).

A. (merriami var.?) **fulvinigra** V. and C., t. c., p. 42. Fort Collins (Gillette).

A. interrogationis V. and C., t. c., p. 35. Colorado (Baker).

A. laminibucca V. and C., t. c., p. 37. Topaz Butte, Colo. (S. A. Rohwer).

A. martialis V. and C., t. c., p. 5. Boulder (G. M. Hite).

A. moesticolor V. and C., t. c., p. 31. Long's Peak Inn, Colo. (T. and W. Cockerell). South Park.

A. montrosensis V. and C., t. c., p. 48. Montrose (Gillette).

A. nigritarsis V. and C., t. c., p. 53. Boulder, May 27 (S. A. Rohwer).

A. padoucorum V. and C., t. c., p. 38. Evergreen, Colo. (Dunning).

A. paenefulva V. and C., t. c., p. 51. Colorado.

†**A. percontusa** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 640. Florissant (Wickham).

A. polygoni V. and C., *Proc. U.S. Nat. Mus.*, Vol. XLVIII (1914), p. 18. Florissant (Cockerell).

A. profundiformis V. and C., t. c., p. 8. Fort Collins (Gillette).

A. purpurina V. and C., t. c., p. 16. Colorado.

A. pyrrhacita coloradensis V. and C., t. c., p. 39. Berkeley, Colo.

A. ribifloris V. and C., t. c., p. 32. Florissant (S. A. Rohwer).

A. salicicola V. and C., t. c., p. 52. Halfway House, Pike's Peak (Cockerell). At flowers of *Salix.*

A. salicinellina V. and C., t. c., p. 17. Clear Creek, Colo.

A. sphecodiniformis V. and C., t. c., p. 6. Platte Cañon (Baker).

A. subaustraliformis V. and C., t. c., p. 28. T. l., Boulder, in canyon near town, May 23, 1896 (C. P. Gillette).

A. submariae V. and C., t. c., p. 4. T. l. in Kansas; a doubtful variety (? female of *martialis*) from Clear Creek, Colo. (Baker).

A. tacitula grossulariae V. and C., t. c., p. 9. Topaz Butte, Colo. (S. A. Rohwer).

A. titusi V. and C., t. c., p. 12. Fort Collins (Titus).

A. vestali Cockerell, *Ann. Mag. Nat. Hist.*, January, 1913, p. 64. Five miles east of Boulder (A. G. Vestal). At flowers of *Viola.*

A. washingtoni manitouensis V. and C., *Proc. U.S. Nat. Mus.*, Vol. XLVIII (1914), p. 31. Manitou (T. and W. Cockerell).

Halictus crassiceps M. D. Ellis, *Entom. News*, Vol. XXV (1914), p. 103. T. l. in New Mexico, but also (not quite typical) from Colorado Springs and Boulder (W. P. Cockerell).

H. euryceps M. D. Ellis, t. c., p. 98. T. l. in New Mexico, but also from Green Mountain Falls (J. W. Frey) and Copeland Park (S. A. Rohwer).

H. lazulis M. D. Ellis, *Entom. News*, Vol. XXIV (1913), p. 207. Florissant (S. A. Rohwer).

H. pavoninus M. D. Ellis, t. c., p. 206. Tolland.

H. perpunctatus M. D. Ellis, t. c., p. 210. Boulder (Cockerell, Hite, Rohwer).

H. succinipennis M. D. Ellis, t. c., p. 205. Florissant (S. A. Rohwer).

H. tenuis M. D. Ellis, t. c., p. 208. Sugar Loaf Mountain, Colo. (S. A. Rohwer).

H. zophops M. D. Ellis, *Entom. News*, Vol. XXV (1914), p. 97. Boulder (M. D. Ellis).

Family PANURGIDAE

†**Libellulapis wilmattae** Cockerell, *Proc. U.S. Nat. Mus.*, Vol. XLIV (1913), p. 344. Florissant (W. P. Cockerell).

Family NOMADIDAE

Nomada (Micronomada) aureopilosa Swenk, *Univ. of Nebraska Studies*, Vol. XII, "January, 1912" (pub. January, 1913), p. 111. Ute Creek, Costilla Co., Colo. (R. W. Dawson).

N. (Gnathias) utensis Swenk, t. c., p. 97. Ute Creek, Colo. (R. W. Dawson).

Family ANTHOPHORIDAE

Melissodes helianthophila Cockerell, *Ann. Mag. Nat. Hist.*, November, 1914, p. 361. Boulder (Cockerell). At flowers of *Helianthus*.

Tetralonia cordleyi orophila Cockerell, *Ann. Mag. Nat. Hist.*, March, 1914, p. 284. Boulder (Cockerell).

Family MEGACHILIDAE

Anthidium astragali Swenk, *Univ. of Nebraska Studies*, Vol. XIV, "January, 1914" (pub. December, 1913), p. 16. T. l. in Nebraska, but also from Ute Creek, Colo. (L. Bruner).

A. incurvatum Swenk, t. c., p. 22. Ute Creek, Colo. (H. S. Smith).

A. praedentatum trianguliferum Swenk, t. c., p. 18. Fort Garland (L. Bruner).

Coelioxys erysimi Cockerell, *Canad. Entom.*, June, 1912, p. 166. Rifle, Colo. (S. A. Rohwer).

C. grindeliae denverensis Cockerell, l. c. Denver (Mrs. C. Bennett).

Dianthidium perpictum coloradense Swenk, *Univ. of Nebraska Studies*, Vol. XIV, p. 32. Colorado Springs.

†**Heriades saxosus** Cockerell, *Canad. Entom.*, July, 1913, p. 2333. Florissant (W. P. Cockerell).

Family BOMBIDAE

Psithyrus consultus Franklin, *Trans. Amer. Ent. Soc.*, Vol. XXXVIII (1913), p. 459. Pagosa Peak, Ward, and Manitou Park, Colo.

Family VESPIDAE

†**Palaeovespa wilsoni** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 640. Florissant (Wickham).

Family EUMENIDAE

†**Odynerus percontusus** Cockerell, t. c., p. 639. Florissant (Wickham).

†**O. wilmattae** Cockerell, l. c. Florissant (W. P. Cockerell).

Family SIRICIDAE

Tremex columba race *aureus* Bradley, *Jour. of Entom. and Zoöl.*, Vol. V (1913), p. 26. Clear Creek, Berkeley, Denver, and Ft. Collins.

Family ORYSSIDAE

Oryssus relativus Rohwer, *Proc. U.S. Nat. Mus.*, Vol. XLIII (1912), p. 155. Colorado (Baker).

Family XYELIDAE

Xyela brunneiceps Rohwer, *Proc. U.S. Nat. Mus.*, Vol. XLV (1913), p. 269. Sugar Loaf Mt., Boulder Co. (Rohwer).

X. coloradensis Rohwer, t. c., p. 272. Colorado (Baker).

X. salicis Rohwer, t. c., p. 266. Graham's Peak, Rio de los Pinos, Colo. (Baker).

Family CEPHIDAE

†**Janus disperditus** Cockerell, *Proc. U.S. Nat. Mus.*, Vol. XLIV (1913), p. 346. Florissant (W. P. Cockerell).

Family TENTHREDINIDAE

†**Cladius petrinus** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 641. Florissant (Wickham).

†**Eriocampa celata** Cockerell, t. c., p. 642. Florissant (Wickham).

Macrophya xanthonota Rohwer, *Proc. U.S. Nat. Mus.*, Vol. XLIII (1912), p. 218. Ft. Collins.

†**Tenthredella toddi** Cockerell, *Canad. Entom.*, January, 1914, p. 32. Florissant (J. H. and J. C. Todd).

Tenthredo (Labidia) alienatus Rohwer, *Proc. U.S. Nat. Mus.*, Vol. XLIII (1912), p. 224. Silverton, Colo., 12,000 ft.; also "Russell County, Colo." (H. S. Smith).

T. anomus Rohwer, t. c., p. 225. Colorado (Baker).

T. opimus coloradensis Rohwer, t. c., p. 224. Short Creek, Colorado. No collector is cited, but it was collected by Cockerell, and recorded by him as *Labidia opimus* in *Trans. Amer. Ent. Soc.*, Vol. XX (1893), p. 345.

Order *LEPIDOPTERA*

Family NYMPHALIDAE

Brenthis aphirape alticola Barnes and McDunnough, *Contr. Nat. Hist. Lep. N. A.*, Vol. II, No. 3, p. 98. April, 1913, T. l., Hall Valley, Colo. (Barnes). This is the Colorado so-called *triclaris*.

Phyciodes camillus ab. *tristis* Cockerell, *Entomologist*, 1913, p. 308. T. l., Jim Creek, Boulder Co., Colo. (S. A. Rohwer).

P. camillus ab. *rohweri* Cockerell, l. c. T. l., North Boulder Creek, Colo. (S. A. Rohwer).

FAMILY HESPERIIDAE

Thanaos burgessi Skinner, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 203. T. l. in Arizona, but also Durango, Colo. (Oslar), and Platte Canyon, Colo. (Oslar). The Colorado specimens are only "tentatively associated "with the Arizona form. Allied to *N. brizo*, but genitalia quite distinct.

FAMILY HEMILEUCIDAE

Automeris io coloradensis Cockerell; PACKARD, *Mem. Nat. Acad. Sci.*, Vol. XII, p. 99, 1914. T. l., Boulder.

Coloradia pandora loiperda Dyar, *Proc. Entom. Soc. Wash.*, Vol. XIV (1912), p. 105. T. l., Glenwood Springs, Colo. (Barnes).

Pseuzohazis eglanterina uniformis Cockerell; PACKARD, t. c., pp. 132, 134. T. l., Island Lake, Boulder Co., Colo., 11,000 ft. (S. A. Rohwer).

FAMILY SATURNIIDAE

Telea polyphemus ab. *olivacea* Cockerell; PACKARD, t. c., p. 206. T. l., Boulder (O. Wangelin).

†**Attacus** (?) **fossilis** Cockerell; PACKARD, t. c., p. 271. T. l., Miocene, Florissant (U. of Colo. Exped.).

FAMILY NOCTUIDAE

Feltia venerabilis arida Cockerell, *Entom. News*, Vol. XXIV (1913), p. 30. T. l., Boulder (Cockerell).

Parastichtis atrosuffusa Barnes and McDunnough, t. c., p. 113. T. l. in Arizona, but also from Poncha Springs and Durango, Colo.

P. grotei Barnes and McDunnough, *Contr. Nat. Hist. Lep. N. A.*, Vol. II, No. 5 (1914), p. 199. T. l. in Arizona, but also found in Colorado.

Anomis serrata Barnes and McDunnough, *Contr. Nat. Hist. Lep. N.A.*, Vol. II, No. 4 (1913), p. 169. T. l. in Florida, but a worn male is labeled (possibly in error?) Glenwood Springs, Colo.

FAMILY LIPARIDAE

Olene vagans grisea Barnes and McDunnough, *Contr. Nat. Hist. Lep. N. A.*, II, No. 2 (1913), p. 63. T. l. in Utah, but also (not typical) from Glenwood Springs and Oak Creek Canyon, Colo.

FAMILY GEOMETRIDAE

Petrophora salvata Pearsall, *Bull. Brooklyn Ent. Soc.*, Vol. VIII (1913), p. 58. T. l., Chimney Gulch, Colo. (Oslar); also southwestern Colo. (Oslar). This has passed as the European *P. incursata*.

Philobia versitata Pearsall, *Jour. N. Y. Ent. Soc.*, Vol. XXI (1913), p. 191. T. l., Clear Creek, Colo. (Oslar); also Rico and Chimney Gulch, Colo.

Family PYRAUSTIDAE

Titanio alticolalis Barnes and McDunnough, *Contr. Nat. Hist. Lep. N.A.*, Vol. II, No. 6 (1914), p. 238. T. l., Silverton, Colo., 10,000 ft. Allied to *T. ephippialis* from Norway.

T. laetalis Barnes and McDunnough, l. c. Arizona, Cal., and also Denver, Colo. (Oslar).

T. lutosalis Barnes and McDunnough, l. c. T. l. in New Mexico, but also Boulder, Colo. (Osler).

Orenaia coloradalis Barnes and McDunnough, t. c., p. 236. T. l., Silverton, Colo. (McDunnough).

O. trivialis Barnes and McDunnough, l. c. T. l., Silverton, Colo. (McDunnough).

Evergestis subterminalis Barnes and McDunnough, t. c., p. 230. T. l. in California, but worn specimens from Glenwood Springs may be this species.

E. vinctalis Barnes and McDunnough, t. c., p. 231. T. l. in New Mexico, but also at Glenwood Springs, Colo.

E. obscuralis Barnes and McDunnough, t. c., p. 232. T. l., Silverton, Colo., 10,000 ft.

Family PYRALIDAE

Diathrausta nerinalis ab. *harlequinalis* Dyar, *Ins. Ins. Menst.*, August, 1913, p. 100. T. l. in Mexico, but also from Chimney Gulch (Oslar), Fort Collins (Gillette), and Boulder (Cockerell), Colo.

Family YPONOMEUTIDAE

Plutella armoraciae Busck, *Proc. Ent. Soc. Wash.*, Vol. XIV, p. 219. T. l., Rocky Ford, Colo. (H. O. March). Bred from horse-radish.

Order *TRICHOPTERA*

†**Phryganea miocenica** Cockerell, *Psyche*, 1913, p. 96. Florissant.

†**P. wickhami** Cockerell, *Jour. of Geology*, Vol. XXII (1914), p. 714. Florissant (Wickham).

Holocentropus orotus Banks, *Canad. Entom.* (1914), p. 257. Clear Creek and Chimney Gulch, Golden, Colo. (Oslar).

Order *DIPTERA*

Family TIPULIDAE

Tipula nigrocorporis Doane, *Ann. Ent. Soc. Amer.*, Vol. V (1912), p. 45. T. l., Estes Park, Colo.

Tipula ingrata Dietz, *Trans. Amer. Ent. Soc.*, Vol. XL (1914), p. 355. (Actually published January, 1915.) T. l., Denver (Oslar); also from Bear Creek and Chimney Gulch, Colo.

Dicranomyia nelliana Alexander, *Proc. Acad. Nat. Sci. Phila.* for 1914 (1915), p. 579. Colorado.

Erioptera lucia Alexander, t. c., p. 584. Colorado and New Mexico.

E. microcellula Alexander, t. c., p. 585. Colorado.

Family CECIDOMYIIDAE

Aplonyx sarcobati Felt, *Jour. Entom. and Zoöl.*, June, 1914, p. 93. T. l., Canyon City, Colo. (Bethel). Reared from oval swellings on leaves of *Sarcobatus.*

Contarinia coloradensis Felt, *Jour. N. Y. Ent. Soc.*, December, 1912, p. 240. "From Professor E. Bethel, Denver, Colo., ... and the same gall from Professor C. P. Gillette, of Fort Collins, Colo." Reared from a large, bud-like deformity on *Pinus scopulorum.*

Cordylomyia americana Felt, *28th Rept. N. Y. State Entomologist* (1913), p. 199. T. l., Boulder, Colo. (Cockerell).

C. coloradensis Felt, l. c. T. l., Boulder, Colo. (Cockerell).

Dasyneura cercocarpi Felt, *Jour. N. Y. Ent. Soc.*, Vol. XXI (1913), p. 215. T. l., Golden, Colo., from imbricated bud gall on *Cercocarpus parvifolius.*

Janetiella coloradensis Felt. *Jour. N. Y. Ent. Soc.*, Vol. XX (1912), p. 148. T. l., Denver, Colo. (Bethel). Reared from oval swellings at bases of pine needles.

Microcerata iridis Cockerell, *Jour. Economic Entomology*, December, 1914, p. 460. T. l., D. M. Andrews nursery, near Boulder (Cockerell).

Oligotrophus betheli Felt, *Jour. N. Y. Ent. Soc.*, Vol. XX (1912), p. 148. T. l., McCoy, Colo. (Bethel). Reared from a fleshy, conical gall on *Juniperus utahensis.*

Perrisia stanleyae Cockerell, *Jour. Entom. and Zoöl.*, Vol. VI (December, 1914; pub. January, 1915), p. 241. T. l., four miles north of Boulder (T. and W. Cockerell). Bred from flower-gall on *Stanleya.*

Prionellus montanus Felt, *28th Rept. N. Y. State Entomologist* (1913), p. 182. T. l., Boulder, Colo. (Cockerell).

Family MYCETOPHILIDAE

Coelosia gracilis Johannsen, *Bull. 196, Maine Agric. Exp. Sta.* (dated 1911; issued March, 1912). "Cal. (Bradley); Col. (W. M. Wheeler)."

†**Mycomya cockerelli** Johannsen, *Am. Jour. Sci.* (August, 1912), p. 140. Florissant (U. of Colo. Exped.).

†**M. lithomendax** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 647. Florissant (Wickham).

Family SIMULIIDAE

Simulium hunteri Malloch, *Tech. Bull. 26, Bur. Ent., Dep. Agric.* (1914), p. 59. T. l., Virginia Dale, Colo. (Bishopp).

S. bivitattum Malloch, t. c., p. 31. T. l., in New Mexico; but also from Virginia Dale, Colo., on a cow (Bishopp).

Family BIBIONIDAE

†**Bibio wickhami** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 647. Florissant (Wickham).

†**Plecia axeliana** Cockerell, t. c., p. 646. Florissant (Wickham).

Family PHORIDAE

Platyphora coloradensis Brues, *Psyche*, April, 1914, p. 79. T. l., Boulder (W. P. Cockerell).

Family LEPTIDAE

†**Atrichops hesperius** Cockerell, *Canad. Entom.*, March, 1914, p. 101. Florissant (S. A. Rohwer).

†**Xylomyia moratula** Cockerell, l. c. Florissant (S. A. Rohwer).

Family MYDAIDAE

†**Mydas miocenicus** Cockerell, *Entomologist*, July, 1913, p. 208. Florissant (George N. Rohwer).

Family ASILIDAE

†**Asilus wickhami** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 648. Florissant (Wickham).

†**Cophura antiquella** Cockerell, *Entomologist*, July, 1913, p. 213. Florissant (George N. Rohwer).

†**Saropogon oblitescens** Cockerell, *Canad. Entom.*, March, 1914, p. 102. Florissant (U. of Colo. Exped.).

Family EMPIDIDAE

†**Empis florissantana** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 645. Florissant (Wickham).

†**E. miocenica** Cockerell, l. c. Florissant (Wickham).

Family THEREVIDAE

Psilocephala nigrimana Kröber, *Stett. Ent. Zeit.*, Vol. LXXIII (1912), p. 238. Colorado.

Thereva albopilosa Kröber, t. c., p. 256. Colorado.

T. aurofasciata Kröber, t. c., p. 263. Colorado.

T. cingulata Kröber, t. c., p. 267. Colorado.

T. ustulata Kröber, t. c., p. 265. Colorado.

Family BOMBYLIIDAE

†**Alomatia** (new genus) **fusca** Cockerell, *Jour. of Geology*, Vol. XXII (1914), p. 721. Florissant (Wickham).

†**Geronites** (new genus) **stigmalis** Cockerell, *Bull. Amer. Mus. N. Hist.*, Vol. XXXIII, p. 230. Florissant (U. of Colo. Exped.).

†**Geron** (?) **platysoma** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 643. Florissant (Wickham).

†**Protolomatia** (new genus) **antiqua** Cockerell, *Jour. of Geology*, Vol. XXII, p. 723. Florissant (Wickham). See also *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 643.

†**Protophthiria** (new genus) **palpalis** Cockerell, t. c., p. 720. Florissant (Wickham).

Spogostylum occidentale C. W. Johnson, *Bull. Amer. Mus. N. Hist.*, Vol. XXXII (1913), p. 56. "Colorado, Washington." The Colorado specimen was taken by Oslar at Denver, May 8, 1897 (Johnson, litt.).

†**Verrallites** (new genus) **cladurus** Cockerell, *Canad. Entom.*, July, 1913, p. 230. Florissant (U. of Colo. Exped.).

Family TRYPETIDAE

Acidia johnsoni Thomas, *Canad. Entom.*, December, 1914, p. 426. Colorado.

Eutreta simplex Thomas, t. c., p. 425. Sunset, Colo., 8,000 ft. (VanDuzee).

Urellia apicata Thomas, t. c., p. 428. Colorado.

Family OSCINIDAE

Chlorops sordidella Becker, *Ann. Mus. Hung.*, Vol. X (1912). Colorado.

Family AGROMYZIDAE

Agromyza auriceps Melander, *Jour. N. Y. Ent. Soc.*, Vol. XXI (1913), p. 262. Moscow, Idaho; but also Colorado (C. F. Baker).

A. burgessi Malloch, *Ann. Ent. Soc. Amer.*, Vol. VI (1913), p. 323. T. l. in Mass., but also in Colorado.

A. coloradensis Malloch, t. c., p. 297. T. l., Florissant (S. A. Rohwer).

A. coquilleti Malloch, t. c., p. 295. T. l., Fort Collins, Colo. (C. N. Ainslie). Bred from oats and *Hordeum jubatum.*

A. inconspicua Malloch, t. c., p. 310. T. l., Fort Collins, Colo. (C. N. Ainslie). Bred from *Agropyron.*

Hemeromyia nitida Malloch, *Proc. U.S. Nat. Mus.*, Vol. XLVI (1913), p. 146. T. l., Florissant, Colo. (Cockerell).

Family HELOMYZIDAE

†**Heteromyiella miocenica** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 644. Florissant (Wickham).

Family ANTHOMYIIDAE

†**Anthomyia atavella** Cockerell, *Entom. News*, Vol. XXIV (1913), p. 295. Florissant (W. P. Cockerell).

Lispa patellata Aldrich, *Jour. N. Y. Ent. Soc.* (1913), p. 141. T. l., Moscow, Idaho; but also from Boulder, Colo. (Aldrich).

Family TACHINIDAE

Phasiopteryx montana Townsend, *Jour. N. Y. Ent. Soc.*, Vol. XX (1912), p. 114. The adult appears not to differ externally from the Mexican *P. bilimeki*, but the larva differs. Colorado.

Family SARCOPHAGIDAE

Sarcophaga kellyi Aldrich, *Jour. Agric. Research*, Vol. II (1914), p. 443. T. l. in Kansas, but also from Colorado.

Order *HEMIPTERA*

Suborder *HETEROPTERA*

Family CAPSIDAE

Calocoris uhleri VanDuzee (*tinctus* Uhler, preocc.), *Bull. Buffalo Soc. Nat. Sci.* Vol. X (1912), p. 490. T. l., Estes Park, Colo., on *Pinus* (Gillette).

Dichrooscytus irroratus VanDuzee, t. c., p. 482. T. l., Rifle, Colo. (VanDuzee); also a variety near Manitou, on *Sabina* (VanDuzee).

Largidea (new genus) **marginata** VanDuzee, t. c., p. 480. Salida, Colo., on *Quercus* (VanDuzee).

Poeciloscytus rosaceus VanDuzee, t. c., p. 488. Manitou and Ft. Collins (VanDuzee).

Family ARADIDAE

Aradus funestus Bergroth, *Canad. Entom.*, 1913, p. 4. "Common in Canada, as well as in the Northern U.S. from the Atlantic to the Pacific Ocean, and I have also seen a specimen from Colorado."

A. montanus Bergroth, t. c., p. 1. Leadville, Colo. (Wickham).

Family TINGIDIDAE

†**Tingis florissantensis** Cockerell, *Jour. of Geology*, Vol. XXII (1914), p. 719. Florissant (U. of Colo. Exped.).

Family CORIXIDAE

Palmacorixa (new genus) **gillettii** J. F. Abbott, *Entom. News* (1912), p. 337. Ft. Collins (Gillette).

Suborder *HOMOPTERA*

Family FULGORIDAE

†**Petropteron** (new genus) **mirandum** Cockerell, *Canad. Entom.* (1912), p. 94. Pierre Cretaceous, Boulder (Terry Duce).

Family DELPHACIDAE

Laccocera bicornata D. L. Crawford, *Proc. U.S. Nat. Mus.*, Vol. XLVI (1914), p. 582. Colorado (Baker).

Megamelanus frontalis Crawford, t. c., p. 593. Colorado (Baker).

Megamelus constrictus Crawford, t. c., p. 610. Colorado (Baker).

M. indistinctus Crawford, t. c., p. 619. Pagosa Springs, Colo. (Baker).

M. magnifrons Crawford, t. c., p. 614. Colorado (Baker).

M. magnus Crawford, t. c., p. 627. Colorado (Baker).

M. nigridorsum Crawford, t. c., p. 620. Colorado (Baker).

M. nigrigaster Crawford, t. c., p. 621. Colorado (Baker).

M. notulus flavus Crawford, t. c., p. 609. Colorado (Baker).

Family PSYLLIDAE

Aphalara nubifera Patch, *Bull. 202, Maine Agric. Exper. Sta.* (1912), p. 216. Foothills near Ft. Collins (Gillette). On *Sophia*, causing abnormal development of foliage in dense mass.

Arytaina fuscipennis D. L. Crawford, *Bull. 85, U.S. Nat. Mus.* (1914), p. 125. Colorado (Baker). On *Ceanothus*.

A. pubescens Crawford, t. c., p. 131. Colorado (Baker). On *Purshia tridentata.*

A. robusta Crawford, t. c., p. 124. Colorado (Baker). On *Ceanothus*.

Calophya dubia Crawford, t. c., p. 51. Colorado. Other members of the genus occur on *Rhus*.

Livia caricis Crawford, t. c., p. 23. Boulder, on *Carex* (E. Bethel).

L. coloradensis Crawford, t. c., p. 20. Colorado (Baker).

Pachypsylla tridentata Patch, *Bull. 202, Maine Agric. Exper. Sta.* (1912), p. 224. Canyon City, in galls on *Celtis*.

Psylla americana flava Crawford, *Bull. 85, U.S. Nat. Mus.*, p. 148. Pagosa Springs (Baker).

P. americana minor Crawford, t. c., p. 147. Boulder (Rohwer); Colorado, on *Salix* (Gillette).

P. astigmata Crawford, t. c., p. 155. Manitou (Gillette). Occurs on *Prunus demissa* in California.

P. caudata Crawford, t. c., p. 157. Tolland, Colo., on *Alnus* (Cockerell); Pagosa Springs (Baker).

P. fibulata Crawford, t. c., p. 140. Colorado (Baker).

P. gilletti Patch, *Bull. 202, Maine Agric. Exp. Sta.*, p. 221. Occurs on *Salix*. Fort Collins (Gillette), Soldier Canyon (Gillette), Dixon Canyon (Gillette), Camp Carter (Gillette), Howes Gulch (Gillette), Bellvue (Emma Gillette), Horsetooth Gulch, and Trinidad.

P. coryli Patch, t. c., p. 223. Steamboat Springs and Manitou (cf. Gillette and Baker, *Hemip. Colo.*, p. 113).

P. ribis Patch, t. c., p. 222 on *Ribes*. Marshall Pass and Fort Collins.

P. maculata Crawford, *Bull. 85, U.S. Nat. Mus.*, p. 141. Colorado (Baker).

P. magnicauda Crawford, t. c., p. 149. Arboles, Colo. (Baker); also Wyoming.

P. minuta Crawford, t. c., p. 142. On *Purshia*. Colorado.

P. sinuata Crawford, t. c., p. 140. Pagosa Springs (Baker); also in Labrador.

†**Psyllites** (new genus) **crawfordi** Cockerell, *Proc. Acad. Nat. Sci. Phila.* for 1914, p. 637. Florissant (Wickham).

Trioza forcipula Patch, *Bull. 202, Maine Agric. Exp. Sta.*, p. 227. Fort Collins (E. D. Ball). At Ottawa, Canada, it occurs on *Ulmus*.

Family APHIDIDAE

Asiphum sacculi Gillette, *Ann. Ent. Soc. Amer.*, Vol. VII (1914), p. 65. T. l., near Halfway House, Pike's Peak (Gillette). Also Estes Park, on *Populus tremuloides* (Gillette), and about 20 miles west of Fort Collins (Gillette).

†**Echinaphis** (new genus) **rohweri** Cockerell, *Canad. Entom.* (1913), p. 229. Florissant (S. A. Rohwer).

Family COCCIDAE

Trionymus violascens Cockerell, *Jour. Econ. Ent.*, Vol. VI (1913), p. 143. On *Agropyron*, Glenwood Springs, Colo. (Bethel and Cockerell).

Phylum MOLLUSCA

Class PELECYPODA

†**Alula** (new genus) **squamulifera** Girty, *Ann. N. Y. Acad. Sci.*, Vol. XXII (1912), p. 3. Lykins Formation, Heygood Canyon, and Perry Park, Colo. (R. M. Butters).

Class GASTROPODA

Family PLEUROTOMARIIDAE

†**Murchisonia buttersi** Girty, t. c., p. 6. Lykins Formation, Heygood Canyon, Colo. (R. M. Butters).

Family ZONITIDAE

†**Omphalina oreodontis** Cockerell and Henderson, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 232. Oreodon Beds (Oligocene), Pawnee Buttes, Colo. (Am. Mus. N.H. Exped.).

Family HELICIDAE

Oreohelix haydeni betheli Pilsbry and Cockerell, *Nautilus*, April, 1913, p. 144. North side of Grand R., Glenwood Springs (Bethel, Henderson, and Cockerell).

O. haydeni betheli var. *alta* Pilsbry, l. c. South side of Grand R., Glenwood Springs (Bethel, Henderson, and Cockerell).

O. hendersoni Pilsbry, *Nautilus*, July, 1912, p. 29. North bank of Little Thompson Creek, Colo. (A. Dakan).

O. hendersoni dakani Henderson, *Nautilus*, June, 1913, p. 38. Northwest corner of Peeble's Ranch, near Newcastle, Colo. (A. Dakan); also nine miles east of Meeker and at Glenwood Springs (Henderson).

Family PUPILLIDAE

Pupilla muscorum xerobia Pilsbry, *Nautilus*, Vol. XXVIII (1914), p. 38. T. l. in New Mexico, but also from Trinidad (Pilsbry and Ferris), Magnolia (D. M. Andrews), Estes Park (Ashmun), Black Lake Creek (Cockerell), and near Golden (E. E. Hand).

Phylum VERTEBRATA

Class REPTILIA

†**Animasaurus** (new genus) **carinatus** Case and Williston, *Amer. Jour. Sci.*, April, 1912, p. 345. Near Animas, Colorado (Baldwin).

Class AVES

Family TETRAONIDAE

Lophortyx gambelii sanus Mearns, *Proc. Biol. Soc. Wash.*, July 10, 1914. Olathe, Montrose Co., Colo. (C. S. Slocum).

Family CHORDEILIDAE

Chordeiles virginianus howelli Oberholser, *Bull. 86, U.S. Nat. Mus.* (1914), p. 57. T. l. in Texas, but also from the following Colorado localities: Loveland (E. A. Preble), Wray (M. Cary), San Luis Valley (Kreuzfeldt), Colorado Springs, Barr, Rio Grande, Denver, and mountains west of Denver.

Class MAMMALIA

Family OCHOTONIDAE

Ochotona figginsi J. A. Allen, *Bull. Amer. Mus. N. Hist.*, Vol. XXXI (1912), p. 103. Pagoda Peak, Rio Blanco Co., Colo. (J. D. Figgins).

Family SCIURIDAE

Marmota flaviventer luteola Howell, *Proc. Biol. Soc. Wash.*, Vol. XXVII (1914), p. 15. T. l. in Wyoming, but occurs in northern Colorado, south to Park Co.

M. f. obscura Howell, t. c., p. 16. T. l. in New Mexico, but also in southern Colorado, Sangre de Cristo and San Juan Ranges.

M. f. warreni Howell, l. c. T. l., Crested Butte, Colo. (E. R. Warren); also found at Mud Springs (Garfield Co.), Sapinero, and Cochetopa Pass.

Family URSIDAE

Ursus bairdi Merriam, *Proc. Biol. Soc. Wash.*, Vol. XXVII (1914), p. 192. Blue River, Summit Co., Colo. (Warren collection); also in Wyoming.

U. navaho Merriam, t. c., p. 191. T. l. in Arizona; but also found in Navaho Range, near Cromo, Colo.

U. shoshone Merrian, t. c., p. 184. T. l., Estes Park, Colo.; also in Wyoming.

Family CHALICOTHERIIDAE

†**Moropus matthewi** Holland and Peterson, *Mem. Carnegie Museum*, Vol. III, p. 230. Near Pawnee Buttes (Middle Miocene).

Family TALPIDAE

Scalopus aquaticus caryi Jackson, *Proc. Biol. Soc. Wash.*, Vol. XXVII (1914), p. 20. T. l. in Nebraska, but "appears to be the mole from Central Nebraska west to Eastern Colorado."

Family VESPERTILIONIDAE

Myotis longicus interior Miller, *Proc. Biol. Soc. Wash.*, Vol. XXVII (1914), p. 211. T. l. in New Mexico, but also found at Grand Junction and Coventry, Colo.

AMPHIBIA AND REPTILIA OF COLORADO PART II[1]

By Max M. Ellis and Junius Henderson

During the past two years many Colorado amphibians and reptiles (including specimens of the Red-spotted Toad, *Bufo punctatus* Baird and Girard, a species not previously recorded from this state) have been added to the University Museum collections. The data from these collections, together with the data concerning specimens in the museum of Colorado College kindly sent us by Mr. E. R. Warren, form the basis of this report.

The numbers in parenthesis after certain records are the University of Colorado Museum numbers of the specimens so listed. Specimens in the Colorado College Museum are marked (C.C.).

Class AMPHIBIA

Family Ambystomidae

Ambystoma tigrinum (Green)

Tiger Salamander

Boulder, October 8, 1913 (290); Canyon City, November, 1913; larvae, University Lake, Boulder, November, 1913, and March, 1914; larvae and adults, near Alma, Park County, above 10,000 ft., August, 1914; Nederland, Boulder County, above 9,000 ft., 1914; larvae, Lake Moraine, El Paso County (C.C.); reported by Warren from Crested Butte, Gunnison County, above 7,000 ft., and from Colorado Springs.

Reports from all parts of the state show this species to be very abundant in ponds, lakes, and reservoirs. Mr. Sam Bloomfield, of Denver, informs us that he has found "waterdogs," as the young of this salamander are locally known, in most of the lakes and ponds in eastern Colorado in which he has seined for fish. That the tiger salamander winters in Colorado in both the larval and adult stages is shown by the capture of several large specimens of the larvae of this

[1] Publication of the Colorado Biological Survey Number 17. Part I appeared in the *University of Colorado Studies*, Vol. X, pp. 39–129, 1913.

species, 300 to 400 mm. in length, in the University Lake at Boulder both in November and the following March. Hibernating adults of this species are often found in midwinter. One of the enemies of the tiger salamander was found to be the snapping turtle, *Chelydra serpentina* (Linnaeus), which promptly seized and devoured large larvae of *Ambystoma tigrinum* when placed in the same tank. The behavior of this turtle suggests a possible method of removal of the young tiger salamanders from reservoirs in which that species has become too abundant.

Family Bufonidae

Bufo boreas Baird and Girard

Columbian Toad

Tolland, 9,000 ft., May, 1913 (429); Buena Vista, 8,500 ft., June 5–9, 1914 (459 and 460); Cottonwood Springs near Buena Vista, 9,000 ft., June 6, 1914 (489); Hortense Hot Springs near Buena Vista, 8,500 ft., June 10, 1914 (490); near Alma, above 10,000 ft., August, 1914 (491); Estes Park, July 31, 1904 (C.C.); near Twin Lakes, June 7, 1914 (492).

This species was very abundant at Buena Vista in June, 1914. At night the adults were found in numbers under the street lights and in the grass near irrigation ditches. During the day few adults were seen, but many juvenile specimens were collected about roadside pools and in the short grass in the overflowed areas along Cottonwood Creek and its tributaries. These juvenile specimens were feeding actively during the middle of the day, although exposed to direct sunlight, and individuals were observed frequently capturing spiders and small Diptera among the grass stems. At Hortense Hot Springs large numbers of juvenile individuals less than 30 mm. in length were found about the overflow pool in water at 23° C. Following the stream back from the overflow pool toward the springs the water increased in temperature rapidly, the young toads continuing abundant until the water was at 34° C. Above this point few toads were seen, although one small individual was taken from water at 45° C. quite near one of the springs. This toad was swimming very rapidly at the time and may have been endeavoring to reach cooler water.

In this connection it may be noted that the pools of very hot water near several of the hot springs were death-traps for *Bufo boreas* and several other animals. From one such pool, the water of which was at 54° C., three large specimens of this toad and several insects were taken, the flesh of all being thoroughly cooked.

Bufo punctatus Baird and Girard

RED-SPOTTED TOAD (Figs. 8 and 9)

Bufo punctatus Baird and Girard, *Proc. Adac. Nat. Sci. Phila.*, Vol. VI, p. 173, 1852 (Rio San Pedro of the Rio Grande del Norte).

Head moderately broad, its width equaling or slightly exceeding its length; length of the head about 3.5 in the total length; bony crests wanting on the top of the head, or sometimes feebly developed (in alcoholic material the skin of the head may be so shriveled as to render the crests of the head quite apparent); parotoid glands somewhat elevated, subtriangular and small, not much larger than the eyes and not equal to the width of the head; a small bony ridge between the ear and the eye on each side of the head; general outline when seen from above ovoid, the entire animal being rather more elongate and less globose than the heavier species of toads (as *Bufo cognatus* Say); neck region rather well defined; body not much wider than the head and somewhat depressed.

Ground color grayish or reddish brown, varying to greenish; dorsal surface of the body rather uniformly covered with small warts which are tipped with bright red or orange; bases of the warts more or less dusky; ventral surface of the body yellowish to orange; throat of the male dusky.

Size rather small, length 2 to 3 inches.

This toad is included here in the herpetological fauna of Colorado for the first time, specimens having been taken on Basin Creek near the northern line of San Miguel County, about six or eight miles from Naturita, Colorado, at an elevation of about 6,500 feet. These specimens were captured by Mr. Henderson and Roy Coffin on June 19, 1914. This record of the red-spotted toad extends its range about 150 miles north and about 350 miles north and northeast up the Colorado River drainage, as the most northern locality from which this species has been recorded previously is the floor of the Grand Canyon of the Colorado between Kaibab and Cocanini Plateaus.[1]

Bufo punctatus ranges across southwestern United States and northern Mexico from central Texas through southern New Mexico and Arizona into Lower California. Stejneger, l.c., states that

[1] STEJNEGER, *N. Amer. Fauna*, No. 3, p. 117, 1890.

"this is a southern species which extends northward along the Colorado River." Little is known concerning the habits and habitat relations of this species. Ruthven,[1] who records *Bufo punctatus* from Alamogordo, New Mexico, suggests that "it is possibly a canyon form which has extended its range on to the desert floor by way of irrigating ditches." The Colorado specimens were captured in Basin or Dry Creek, a small, alkaline stream, where it cuts through a low mountain range. This stream is probably entirely without water in dry seasons except for a few very small pools. Basin Creek drains into the San Miguel, which in turn, by way of the Dolores River, finally drains into the Colorado River, the water ultimately passing through the Grand Canyon locality mentioned by Stejneger, l.c. Hence the toad may be expected along other western Colorado streams. On Basin Creek *Bufo punctatus* was associated with *Bufo woodhousei* Girard.

In the key to the *Bufonidae* of Colorado[2] *Bufo punctatus* would run to *Bufo debilis* Girard, to which it is very closely related. These two species may be separated as follows:

a. Warts tipped with red or orange; length of the hind leg from the base to the heel reaching forward to the front of the eye or beyond; parotoid rather small. *Bufo punctatus* Baird and Girard

aa. Warts not tipped with red or orange, or at least very slightly so; length of the hind leg from the base to the heel reaching forward to the ear; parotoid glands large. . . . . *Bufo debilis* Girard

Bufo woodhousei Girard

Woodhouse's Toad

Greeley, August 13, 1902 (C.C.); Naturita, June 15, 1914 (453); Basin Creek, six miles west of Naturita, June 19, 1914 (454); reported common from Naturita to Gypsum Creek in 1914 by Henderson.

Bufo cognatus Say

Western Toad

Medano Ranch, Costilla County, July, 1909 (C.C.).

[1] *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIII, p. 507, 1907.

[2] *Univ. Colo. Studies*, Vol. X, p. 52, 1913.

PLATE I


FIG. 1


FIG. 2


FIG. 3


FIG. 4

Chorophilus triseriatus. Three-lined Tree Frog. Variation in color pattern of specimens from a single pool (page 257).

PLATE II

Fig. 5.—*Crotaphytus collaris baileyi.* Bailey's Collared Lizard (page 259)

Fig. 6.—*Acris gryllus.* Cricket Frog, dorsal view (page 258)

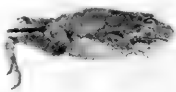

Fig. 7.—*Acris gryllus.* Cricket Frog, side view (page 258)

Fig. 8.—*Bufo punctatus.* Red-spotted Toad. Head; dorsal view (page 255)

Fig. 9. *Bufo punctatus.* Red-spotted Toad. Head; side view (page 255)

Family HYLIDAE

Chorophilus triseriatus Wied

THREE-LINED TREE FROG (Figs. 1–4)

Boulder, May 1–10, 1914; near Alma, Park County, above 10,000 ft., August, 1914 (493).

Eggs and adults of this little frog were taken in temporary pools formed by the melting snow along a railroad right-of-way near Boulder, during the first ten days of May, 1914. On May 9 eggs were collected in the four-celled stage and kept out of doors in water from the pool in which they were found. The development of these eggs was very rapid, a fact which may be correlated with the use of temporary pools as the spawning grounds by this species. On the 11th all of the eggs were in the elongated stage preceding hatching, and during the 12th most of the eggs hatched. The tadpoles of *Chorophilus triseriatus* immediately after leaving the eggs were very black and about 8 mm. in length, resembling the tadpoles of the common toad in outline.

Since the adults of this species were so abundant about the pools near the University during the spring spawning season, a study of the variation in the color pattern was made. The color pattern has been used by several writers in connection with certain anatomical characters for the separation of the subspecies of *Chorophilus nigritus* LeConte, and *Chorophilus triseriatus* (Wied) is considered as one of these subspecies by some writers. The data collected from 40 adults taken from a single pool about ten feet across, are given below:

Back with stripes only; spots if present, on the eyelids only		9
No spots on the eyelids	1	
Spot on each eyelid free	5	
Spot on each eyelid fused with the mid-dorsal stripe	3	
Stripes and spots both present on the back		27
No spots on the eyelids	2	
Spot on each eyelid free	15	
Spot on each eyelid fused with mid-dorsal stripe	10	
Spots only		4
No spots on the eyelids	1	
Spot on each eyelid	3	

It may be seen from the above that the three types of color pattern given as characteristics for *Chorophilus nigritus* LeConte, *Chorophilus feriarum* Baird, and *Chorophilus triseriatus* Wied, by Hay,[1] as well as several other combinations of these characters, occurred in this single collection. All of these specimens were of the same proportions, having the length of the body 1.3 to 1.5 in the length of the hind leg, the anatomical character diagnostic of *Chorophilus triseriatus* Wied.

Acris gryllus (LeConte)

CRICKET FROG (Figs. 6 and 7)

Wray, August, 1913.

Family RANIDAE

Rana pipiens Schreber

LEOPARD FROG

Greeley, September 28, 1902 (C.C.); Medano Ranch, Costilla County, June 24, 1902 (C.C.); Buena Vista, 8,500 ft., June, 1914; Alma, Park County, above 10,000 ft., August, 1914 (494); Lake George, 8,000 ft., September 28, 1914 (495); Florissant, 8,200 ft., September 28, 1914 (496).

The Leopard Frog has been reported as very abundant near all of the ponds and lakes in eastern Colorado by numerous correspondents.

Rana catesbeana Shaw

BULLFROG

This species of frog has been introduced from the East into several ponds and reservoirs in the upper South Platte valley during the past two years. At present the results seem rather discouraging to those interested in introducing this frog because of its economic importance, as the species is not well established. If found, the adults of this species are easily recognized by their large size, large individuals frequently reaching the length of 12 inches from tip of snout to tip of the outstretched hind leg. Bullfrogs of any size may be distinguished from the Leopard frog by the absence of the lateral folds of skin so prominent on the edges of the back of the Leopard frog;

[1] *Rep. State Geol. Ind.*, for 1891, p 470, 1892.

by the very large ear; and by the rather uniform yellowish-olive color, the back of the Bullfrog being mottled with brown, or dusky, instead of being distinctly spotted with black, as is the Leopard frog.

Class REPTILIA

Family Iguanidae

Crotaphytus collaris baileyi (Stejneger)

Bailey's Collared Lizard (Fig. 5)

Naturita, June 11 and 15, 1914 (444 and 445); 5 miles west of La Plata-Montezuma County line at Mancos Spring, June, 1913 (284).

This species was common from Naturita south and west in 1914, and was especially abundant in the rocky bluffs and ridges bordering the Paradox Valley and Basin Creek. It was seldom seen far from rocky ledges. The figure of this species shows the characteristic attitude of this species when surprised or disturbed among the sage-brush.

Sceloporus consobrinus Baird and Girard

Yellow-banded Swift

Bedrock, Dolores River, April 17–19, 1908 (C.C.); Coventry, Montrose County, 6,800 ft., April 24, 1908 (C.C.); Boulder foothills, above 6,000 ft., August 6, 1913, April 21, 1914, and May 10, 1914 (286, 434, and 435); Gypsum Creek, tributary to the Dolores River, July, 1914 (448); Tapagausche Creek, San Miguel County, August 1, 1914 (449).

Specimens of this swift from southwestern Colorado have been referred to the species *Sceloporus elongatus* Stejneger, a form stated by Stejneger[1] to be quite close to *Sceloporus consobrinus*. The specimens examined by us from southwestern Colorado do not differ in any tangible character from specimens of *Sceloporus consobrinus* taken in other parts of Colorado, unless it be in the carination of the scales. The specimens from southwestern Colorado have the keels of the scales a little less evident and a little more restricted to the apical portions of the scales than some of the specimens collected in the foothills near Boulder. Stejneger, l.c., has pointed out this difference between *Sceloporus elongatus* and *Sceloporus consobrinus*,

[1] *N. Amer. Fauna*, No. 3, p. 112, 1890.

stating that, "the scales (of *Sceloporus elongatus*) are not so strongly carinated, the keel being lower and mostly confined to the terminal half of the scale." Since similar variations were found among specimens of the swifts collected in eastern Colorado, all of our Colorado specimens are here listed as *Sceloporus consobrinus*.

Several of the specimens of this swift in the museum of the University of Colorado have small red mites clinging to various parts of the body, particularly to the sides of the head in the lateral folds.

Sceloporus graciosus Baird and Girard

SAGEBRUSH SWIFT

Bedrock, Dolores River, 5,150 ft., April 17, 1908 (C.C.); Howard, San Miguel County, June 10, 1909 (C.C.).

Holbrookia maculata Girard

SPOTTED LIZARD

Greeley, April 28, 1902 (C.C.); Barr, May 29 and 30, 1908 (C.C.).

Phrynosoma hernandesi ornatissumum (Girard)

HORNED TOAD

Bedrock, April 19, 1908 (C.C.); Coventry, April 19, 1908 (C.C.); Boulder, September, 1913 (414); Naturita, June 11, 1914 (446); Gypsum Creek, tributary of the Dolores River, July, 1914 (447); Marshall, Boulder County, June 2, 1913 (282).

Phrynosoma hernandesi hernandesi (Girard)

HORNED TOAD

Greeley, August 8, 1902 (C.C.); 2 miles southeast of Medano Ranch, Costilla County, 7,700 ft., July 5, 1909 (C.C.); 3 miles from Muddy Creek, on Gardner-Silver Cliff Road, Huerfano County, July 15, 1909; Trinidad, September 25, 1909 (C.C.); Colorado Springs, May 18, 1903 (C.C.); between Douglas Spring and Snake River, Moffat County, June 29, 1907 (C.C.).

Family TEIIDAE

Cnemidophorus sexlineatus (Linnaeus)

RACE RUNNER

Barr, June 1, 1908 (C.C.); Canyon City, July, 1913; Joe Davis Gulch, Dolores River, August 8, 1914 (451); reported as common in Dolores Canyon and north and south of Paradox Valley in 1914 by Henderson.

Family Colubridae

Thamnophis radix (Baird and Girard)

Plains Garter Snake

This garter snake and *Thamnophis parietalis* (Say) are the first snakes to appear in the spring about Boulder. They are found together near the temporary pools, feeding upon the little tree frog, *Chorophilus triseriatus* (Wied), which also frequents these pools. We have not taken the Plains Garter Snake in any situation above 6,500 feet near the foothills.

The Plains Garter Snake has a fatal habit of coming on the railroad track during the early days to enjoy the heat of the bare ballast and the iron rails. On one occasion seven dead, but recently killed, specimens of this snake were found on a half-mile of track, immediately after the passing of a train.

Thamnophis parietalis (Say)

Red-barred Garter Snake

Boulder, April 15, May 10 and 17, 1914 (433, 436, and 439).

Thamnophis megalops (Kennicott)

Pine River, La Plata County, fall of 1906 (C.C.).

Thamnophis elegans (Baird and Girard)

Western Garter Snake

Bedrock, April 24, 1908 (C.C.); Chambers Ranch, near Glenn Eyrie, El Paso County, May, 1908 (C.C.); Dolores River, San Miguel County, August, 1914 (442); Naturita, June 12, 1914 (443).

Ophibolus doliatus genitilis (Baird and Girard)

Red King Snake

Flagstaff Mountain, Boulder, above 6,000 ft., May 18, 1914 (438).

Pityophis catenifer sayi (Schlegel)

EASTERN BULL SNAKE

Greeley, June 15, 1902 (C.C.); Marshall, Boulder County, May 19, 1914 (441); Hortense Hot Springs, near Buena Vista, about 9,000 ft., June 8, 1914 (497).

This bull snake is quite common in the upper Arkansas River valley near hot springs. Several persons assured us that large specimens of this species were often seen about the Hortense and Cottonwood Springs late in November.

Pityophis catenifer bellona (Baird and Girard)

GREAT BASIN BULL SNAKE

Douglas Spring, Moffat County, June 25, 1907 (C.C.); Naturita, June 15, 1914 (457); reported as fairly common from Naturita to Little Gypsum Creek in 1914 by Henderson.

Tropidonotus sipedon fasciatus (Linnaeus)

WATER SNAKE

Greeley, May 12, 1903 (C.C.).

Liopeltis vernalis (DeKay)

LITTLE GREEN SNAKE

Several reports of this little snake have reached us from the upper South Platte River valley and Park County. One of these reports, which seemed reliable in every detail, mentions this snake as occurring above 9,500 feet. We have no specimens from this part of the state, although we have previously recorded this snake from Palmer Lake, El Paso County.[1] There is a specimen of this snake in the Museum of the State Agricultural College, from Steamboat Springs, Colorado.

Zamenis constrictor flaviventris (Say)

BLUE RACER

Boulder, September 11, 1913 (289).

[1] *Univ. Colo. Studies*, Vol. X, p. 100, 1913.

Tantilla nigriceps Kennicott

TEXAS BLACK-HEADED SNAKE

LaJunta, data incomplete (C.C.); Boulder, December, 1914 (500).

The Boulder specimen of this snake was taken from a trench which was being dug for pipe lines in the city limits. Just how far below the surface the snake was when uncovered was not learned. The record of this species in Boulder is apparently the most northern for the species, and places it nearer the mountains than it has previously been taken.[1]

Family CROTALIDAE

Crotalus confluentus Say

PRAIRIE RATTLESNAKE

Near Paradox Valley, June 1914 (452); Paradox Valley, June 15, 1914 (455); Gypsum Creek, tributary of the Dolores River, June, 1914 (456); reported common in the San Miguel and Dolores River regions, south and west of Naturita in 1914 by Henderson.

Family CHELYDRIDAE

Chelydra serpentina (Linnaeus)

SNAPPING TURTLE

Several specimens of this turtle have been taken in the tributaries of Boulder Creek near Boulder during the past two years. One specimen, brought to the Museum of the University of Colorado during March, 1914, had been dug out of a straw pile where it was wintering, and was quite stupid when received. After being placed in the tank in the building it soon became active and remained so, although it was several weeks before active turtles were found out of doors.

Family TESTIDINIDAE

Chrysemys belli (Gray)

BELL'S PAINTED TURTLE

Greeley, March 9, 1903 (C.C.); Wray, June, 1914.

Bell's Turtle is reported as common, often abundant, in many of the ponds and lakes of eastern Colorado.

[1] *Univ. Colo. Studies*, Vol. X, p. 106, 1913.

A KEY TO THE ENTOMOSTRACA OF COLORADO

By G. S. Dodds

Editor's Note.—This study was begun in 1907 when the author was a member of the Faculty of the University of Colorado. During the past three summers Professor Dodds has been in charge of the zoölogical work at the Mountain Laboratory, Tolland, Colorado. His detailed laboratory studies have been made at the University of Missouri.

One would not at first thought turn to the semi-arid conditions of the states of the Rocky Mountain region for a favorable opportunity to study aquatic animals. Colorado has, however, proved to be a rich and interesting field for the study of plankton Crustacea. Though there are no large lakes and the total water surface of the state is not great, there exist many small bodies of water—lakes; ponds, and pools—in both plains and mountain areas. These, on account of the wide range of climatic conditions found within this area, support an interesting and diversified fauna. For this reason, study here is of greater interest than it would be in an area of the same size in the lowlands of the Mississippi Valley. Here is an area especially suited for the study of ecological relations and problems of distribution.

The data on which the following key is based were, in the main, accumulated during ecological studies of the Entomostraca, the main results of which will appear in a later paper. My collections include material from 124 lakes and ponds, the majority in the mountain region west of Boulder, but some also from stations on the plains. Most of this collecting was done during three summers at the Mountain Laboratory of the University of Colorado, at Tolland. I am also indebted for material to Professor Max M. Ellis and Mr. L. C. Bragg. These collections have yielded 55 species. To these I have added all other species known to occur in the state, making a total of 72 species. This list is fairly full, but the collector need not be surprised to find representatives of other species.

The Entomostraca form a rather poorly defined group, not recognized by all authorities, including many of the lower forms of Crustacea. Nearly all are of small size. They form by far the greater part of the zoöplankton of both fresh and salt waters, are much more abundant in standing water than in streams, and find most favorable conditions in small bodies of water with much plant growth, or in shallow margins of larger bodies that present similar conditions. So common are these forms that every lake and pond has its entomostracan fauna.

Aside from their general scientific interest, the Entomostraca are of considerable economic importance. Many young and small fishes in both salt and fresh water feed almost exclusively upon these forms, and they are an important part of the diet of many of the larger ones. Also they are fed upon largely by certain insect larvae. The small fish and the insect larvae are in turn eaten by larger fish. The Entomostraca themselves feed almost exclusively upon microscopic plant forms which are abundant in all waters and furnish the ultimate source of food for aquatic animals. Thus Entomostraca furnish the first link in the utilization of this fundamental food supply.

It is by no means possible in a few pages to give an adequate account of the structure of so large and diverse a group and I shall merely attempt to include a few facts necessary for a general understanding of specimens and identification of species. In the key, at appropriate places, will be found more detailed accounts of certain peculiarities of each group.

In common with all Crustacea, the Entomostraca have a definitely segmented body in which head and trunk regions may be recognized. In by no means all, however, is the trunk definitely divided into thorax and abdomen. The carapace, or covering of the body, is variously developed, and takes diverse forms, so that the different subdivisions of the group present a wide range of possibilities as to general appearance.

The appendages of the Entomostraca, especially those of the trunk, are primitive. Those of the head are five in number, as in all Crustacea—in each group modified in a characteristic manner. The two pairs of *antennae* serve as sensory or as locomotor organs; and either or both pairs may be well developed or much reduced. In the males they may be peculiarly modified to serve as clasping organs.

The *mandibles* are the most constant pair and, as in other Crustacea, are the chief jaws. The two pairs of *maxillae* are, on the whole, not greatly developed, though in all groups one or both pairs serve to some extent as accessory jaws. The appendages of the trunk are of special interest. In all the Branchiopoda they are typically flattened, and their primitive function is that of swimming organs. They have the special peculiarity that the base of each one is modified on the medial side as a *gnathobase*, or chewing base, so that even the appendages far from the mouth assist in capturing, in carrying to the mouth, and in chewing the food. In the more primitive groups this type is closely adhered to, but in the more specialized types there are varying degrees of departure. The primitive forms have a large number of similar, foliaceous trunk appendages, whereas in the more advanced groups they are fewer and more diversified. In the Copepods they have lost the primitive foliaceous form and are definitely rounded and biramous. The Ostracods show the greatest reduction, there being but two pairs in the trunk region. For a tabulated comparison of appendages of the different groups see Table I.

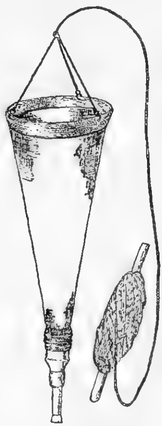

FIG. 1.—Net used in making collections.

The common means of collecting Entomostraca is with a net of fine muslin or, better, of bolting cloth (No. 10 is fine enough). A good form is a conical net with an opening of about 5 inches and a length of 15 inches. The material which collects in the bottom of the net can be washed out by everting the net into a wide-mouthed bottle or other vessel. A better plan is to have in the small end of the net a little funnel which may be stopped with a cork. Such a net may be towed behind a boat by means of a cord; or if the funnel is weighted with about 2 oz. of lead, it may be thrown out from the shore 50 to 75 feet when no boat is available.

The material may be studied alive or in fresh condition with best results, but when necessary it may be preserved. Although 70 per

TABLE I

COMPARISON OF APPENDAGES OF ENTOMOSTRACA AND CRAYFISH

	Appendages of Head					Appendages of Trunk													
	1st Antenna "Antennule"	2d Antenna "Antenna"	Mandible	1st Maxilla	2d Maxilla	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Notostraca..........	Small	Vestigial or wanting	Well-developed jaws	With setose biting edge	Simple plate outside of mouth	Flattened swimming appendages with gnathobases. As many as 68 pairs. Back of 11th, there are more than 1 pair on each segment.										Brood-sac in ♀			
Anostraca...........	Small	♂ Claspers ♀ Small, flat				Flattened swimming appendages with gnathobases, 19 pairs in Polyartemia. All others have 11 pairs.													
Conchostraca........	Small	Biramous swimming organs				Flattened swimming appendages with setose gnathobases. Claspers in ♂	10–28 pairs.												
Cladocera...........	Small	Large biramous swimming organs		Small	Wanting in adult	4–6 pairs; foliaceous; with gnathobases. 1 and 2 prehensile in most.													
Copepoda...........	Swimming organs 6–25 joints	Short, biramous		Small	Small, "Outer maxillipede"	"Inner maxillipede"	Biramous swimming feet. Normally developed				Reduced								
Ostracoda...........	Sensory and locomotor	Locomotor		Accessory jaws	Small	1st leg	2d leg												
Crayfish............	Sensory	Sensory	Jaws	Accessory jaws		Maxillipedes			Chelipede	Walking legs				Swimmerets					Uropod

cent alcohol is commonly recommended, my practice has been to use formalin, adding a few drops to the water when the collection is bottled. Small vials are convenient for storing material. Collections should be carefully labeled at the time they are made.

For the study of many parts used in the identification of species it is necessary to make dissections. On account of their small size, most specimens must be dissected with needles under a lens or a binocular dissecting microscope. This is best done on a slide in a drop of glycerin. For the study of these forms, a compound microscope is, of course, necessary. For permanent mounting of specimens, glycerin may be used, but unless the cover is well sealed the preparation will not last long. I have used glycerin jelly with good results. This medium has the disadvantage that it requires to be heated when used, and the compensating advantage that it becomes solid when cool, giving a more durable mount. The cover should, however, be cemented. Specimens may also be dehydrated, cleared, and mounted in balsam, but in this process cuticular structures are likely to be deformed, and some preparations also become too transparent.

The figures used in the following key were either drawn from nature or redrawn from the sources indicated in the legend. Mr. George T. Kline made Figs. 1–6, 9, 10, 12–18, 20, 26, 32, 34, 36–41, 45, 47, 54, 60, 61. For opportunity to make the collections, I am indebted to Professor Francis Ramaley of the University of Colorado, who placed at my service facilities provided for the summer field work of the University. During the course of the work, valuable suggestions were received from Professors Chancey Juday and A. S. Pearse of the University of Wisconsin. Of great service to me were proofs of certain chapters of Ward and Whipple's *Fresh-Water Biology*, which I secured through the courtesy of the publishers, John Wiley & Sons.

Classification and Index to Key

Key to the Entomostraca of Colorado

1 (100, 139) Feet varying in number; usually foliaceous. Carapace usually present. Paired compound eyes usually present (in the Cladocera they are fused to form a single median mass). . Sub-class **BRANCHIOPODA** 2

2 (33) Post-cephalic appendages 10 or more. Animals usually of some size (6–40 mm. or more). 3

In the sub-class Branchiopoda the three following orders—Anostraca, Notostraca, and Conchostraca—are often classed together as a single order, Phyllopoda; and though they differ widely in appearance, because of diverse development of the carapace, they are so much alike in general organization that they form a very convenient group when combined. The appearance and structure of these animals are sufficiently illustrated in Figs. 2, 5, 9, and 13, and the number and nature of the appendages, in Table I.

None of the Phyllopods are marine, though one species, *Artemia salina*, lives in salt pools of very much greater concentration than sea-water. Though some Phyllopods are found in permanent lakes, they belong pre-eminently to transient pools, those which form in rainy weather and last, at most, for but a few weeks. In this short time there mature, from eggs lying dormant in the dry earth, individuals which produce eggs that are to withstand another period of dryness. They are of sporadic occurrence, being found only in certain pools in a locality, and in them not every year. Under favorable conditions they may crowd a pool in enormous numbers. Most species of Phyllopods have a very limited range. Of the 42 species known from North America, almost all are confined exclusively to that area. Of the 42 North American species, 16 have been reported from Colorado, and 25 of them are confined to the states west of the meridian of Kansas City. In the semi-arid plains of this region, which seem to offer specially favorable conditions for Crustacea of this type, they form a larger part of the Entomostracan fauna than in other parts of North America. The relatively small amount of exploration, and the probability that future work will add considerably to the number of species from this region, place further emphasis on the importance of this part of the aquatic fauna of the great plains.

Most of the Phyllopods hatch as a nauplius (Fig. 61), a small swimming larva with an unpaired eye and three pairs of appendages (1st and 2d antennae and mandibles), or as a metanauplius with the beginnings of segmentation farther back. The males of most species are much less abundant than the females and for some species they are unknown. In many species parthenogenesis is by no means uncommon at certain times.

3 (13) Carapace wanting. Body elongated. The "fairy shrimps."
Order **Anostraca** 4

All of ours have 11 pairs of swimming feet. Usually swim on back. Second antenna of male always large and used as a clasping organ, which is important in distinguishing species. Corresponding organs in the female are small and do not differ greatly in different species (Figs. 2–8).

4 (10) Clasping antenna of male 2-jointed 5

5 (9) Head of male with no frontal process. All of ours have 9 posterior segments without limbs. . . . . . . Family BRANCHINECTIDAE
Genus *Branchinecta* 6

6 (7, 8) Basal segment of male clasping antenna unarmed on inner margin, except for a swollen, spiny area near the base. Length: male, 13.6; female, 12.8 mm. . . . . *Branchinecta lindahli* Packard

Greeley; 4,600 ft. [Kansas, Nebraska, Wyoming.]

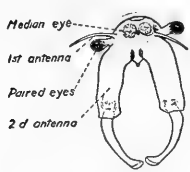

FIG. 2.—*Branchinecta lindahli.* Male. (After Shantz.)

FIG. 3.—*Branchinecta coloradensis.* Male.

7 (6, 8) Inner margin of basal segment of male clasping antenna with an elevated spiny area near middle and a prominent tubercle near the base. Length: male, 18; female, 17 mm. . *Branchinecta coloradensis* Packard

Abundant in mountain regions of Colorado, especially above 11,000 ft. Has been considered a type of a strictly alpine form, but material collected by Ellis at St. Vrain (5,100 ft.), well outside the mountain area, contains specimens which I would without hesitation refer to this species, were they collected in the mountains.

8 (6, 7) Inner margin of basal segment of male clasping antenna with a prominent spiny process at about the middle, and two short, finger-like processes near base. Length: male, 16; female, 17.2 mm.

Branchinecta packardi Pearse

La Junta (type locality), St. Vrain. Known only from plains of Colorado.

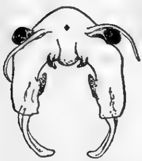

FIG. 4.—*Branchinecta packardi*. Male.

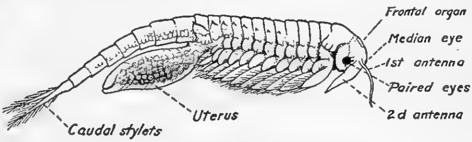

FIG. 5.—*Branchinecta packardi*. Female.

9 (5) Head of male with one or two frontal processes.

Family CHIROCEPHALIDAE

Frontal process of male long and much branched. End of abdomen flattened in both sexes. Second joint of male clasping antenna curved and tusk-like. Female second antenna long and oar-like. Genus *Thamnocephalus* Only one species known. Length: male, 23; female, 26.5 mm.

Thamnocephalus platyurus Packard

Near Denver, La Junta. [Plains of Colorado and Kansas.]

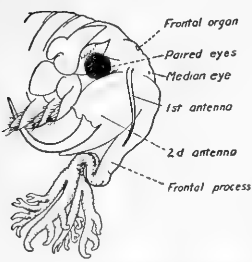

FIG. 6.—*Thamnocephalus platyurus*. Male.

10 (4) Clasping antenna of male 3-jointed and much bent.

Family STREPTOCEPHALIDAE

Genus *Streptocephalus* 11

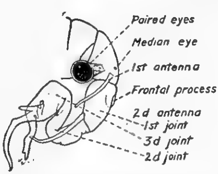

FIG. 7.—*Streptocephalus texanus*. Male.

FIG. 8.—*Streptocephalus coloradensis*. Male.

11 (12) Distal digit of male clasping antenna flattened, undulate, and bifid at the tip. Frontal process less than one-half first joint of antenna. Length: male, 16.2; female, 14 mm. . . . *Streptocephalus texanus* Packard

Denver, St. Vrain, Mesa de Maya. [Plains of Texas, Colorado, Kansas and Nebraska.]

12 (11) Distal digit of male clasping antenna with a slight, uniform curvature and pointed at the tip. Frontal process more than one-half first joint of antenna. Length: male, 22; female, 23 mm.
Streptocephalus coloradensis Dodds

Eldora (type locality), Ward, Ft. Collins; 5,000–8,500 ft.

13 (3) A well-developed carapace present 14

14 (24) Carapace shieldlike, covering anterior portion of body only. About 60 pairs of appendages. Back of 11th, there are more than one pair of appendages on a segment. . . . . Order **Notostraca**
Family Apodidae 15

15 (21) End of telson without a flat process. . . . Genus *Apus* 16

16 (17) Carapace as long as exposed portion of body. Segments exposed back of carapace: male, 11; female, 9. Telson with 2 median and 2 paired dorsal spines. Length, 29 mm. . . . . . *Apus aequalis* Packard

La Junta. [Mexico, Lower California, Texas, Nebraska, Kansas, Colorado.]

17 (16) Carapace shorter than exposed portion of body 18

18 (19, 20) Telson with 3 median and 2 paired dorsal spines. Segments exposed back of carapace, 29. Segments back of last appendages: male, 11; female, 9(?). Length, 50 mm.
Apus newberryi Packard

Greeley. [Colorado and Utah.]

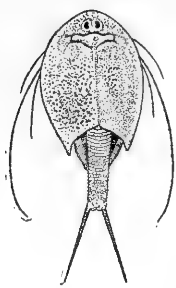

Fig. 9.—*Apus aequalis.*

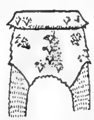

Fig. 10.—*Apus newberryi.* Telson. (After Packard.)

Fig. 11.—*Apus lucasanus.* Telson. (After Packard.)

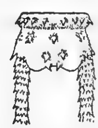

Fig. 12.—*Apus longicaudatus.* Telson. (After Packard.)

19 (18, 20) Telson with 1 median and 2 paired dorsal spines. Segments exposed back of carapace: male, 33; female, 29. Segments back of last appendages: male, 13; female, 11. Length about 50 mm. Measurements in Packard's description are about half as great, and agree with my Montclair specimens. Those from Ft. Collins are much larger but agree in details of structure. . . . . *Apus lucasanus* Packard

Ft. Collins, Montclair. [Kansas, Colorado, Lower California.]

20 (18, 19) Telson with 1 median and 4 paired dorsal spines. Segments exposed back of carapace: male, 32; female, 28. Segments back of last appendages: male, 14; female, 10. Length, 40 mm.

Apus longicaudatus Leconte

[Records of Hayden Survey from Colorado, Nebraska, Texas, "near Yellowstone River."]

21 (15) End of telson with a long paddle-like process. Genus *Lepidurus* 22

22 (23) Process of telson notched at the end. Length: male, "including caudal stylets, 48 mm."; female, "length of body 35 mm." . *Lepidurus bilobatus* Packard

Po Canyon on Vermillion River, Colorado.

FIG. 13.—*Lepidurus bilobatus.* (After Packard.)

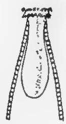

FIG. 14.—*Lepidurus couesii.* (After Packard.)

23 (22) Process of telson not notched but elongated and keeled. Length, 20 mm.

Lepidurus couesii Packard

[Montana and Utah. To be expected in Colorado.]

24 (14) Carapace of two valves inclosing body and appendages.

Order **Conchostraca** 25

25 (32) Both head and body entirely inclosed within carapace. Carapace with concentric lines of growth, resembling those of a mollusk shell. First and second post-cephalic limbs prehensile in the male.

Family LIMNADIDAE 26

26 (27) Not more than 4 or 5 lines of growth on shell. Frontal organ pediculated. 18 pairs of feet. Branches of 2d antenna 9-jointed.

Genus *Eulimnadia*

Shell with 5 lines of growth. Telson with 16 fine teeth on dorsal side.

Length, 7 mm.

Eulimnadia texana Packard

La Junta. [Nebraska, Kansas, Colorado, Texas.]

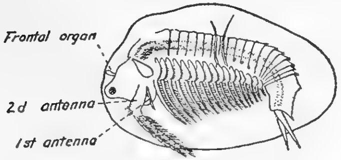

FIG. 15.—*Eulimnadia texana.* (After Packard.)

27 (26) Shell with 18–22 lines of growth. Frontal organ not pediculated. 24–27 pairs of feet. Branches of 2d antenna 15- to 20-jointed.

Genus *Estheria* 28

28 (29) Shell long and narrow. Umbones small and at about $\frac{1}{5}$ length from anterior end. Telson with many equal, fine teeth. Length, 11.0 mm.

Estheria compleximanus Packard

Ft. Collins, Montclair. [Kansas, Colorado, Lower California.]

29 (28) Shell not greatly elongated. 30

30 (31) Hinge-line straight, ending in a definite angle behind. Umbones prominent and shell full. Length, 10–12 mm. *Estheria morsei* Packard

La Junta. [South Dakota, Nebraska, Colorado.]

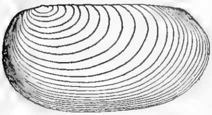

FIG. 16.—*Estheria compleximanus.*

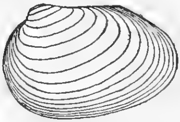

FIG. 17.—*Estheria morsei.*

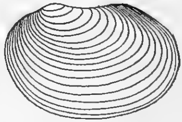

FIG. 18.—*Estheria mexicana.*

31 (30) Hinge-line slightly curved and not ending in an angle behind. Umbones less prominent than in above species, and shell flatter. Length, 10.2 mm. . . . . *Estheria mexicana* Claus

La Junta, Greeley. [Lake Winnipeg to Mexico and from Ohio to the Rocky Mountains.]

32 (25) Head not inclosed within valves, but with a separate shield, ending in a prominent beak below. Valves without concentric growth markings. Family LIMNETIDAE

Genus *Limnetis*

One species in Colorado. Length, 3.0 mm. *Limnetis gouldii* Baird

Tolland region; 8,500–9,500 ft. [Northern United States and Canada.]

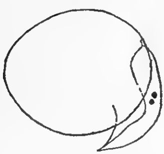

FIG. 19.—*Limnetis gouldii.*

33 (2) Post-cephalic appendages, 4–6. Body and feet usually covered with a bivalve carapace. Small animals usually less than 2.0 mm. in length. The "water fleas."

Order **Cladocera** 34

The key to the Cladocera is based upon the characters of the mature female.

The Cladocera form a large part of the zoöplankton of both salt and fresh water. They will be found to constitute by far the greater part of plankton collections from most fresh-water lakes and pools. The general structure of a typical cladoceran is illustrated by the drawing of *Daphnia pulex* (Fig. 26) and the nature and number of the appendages are given in Table I. The trunk and its appendages, but not the head, are inclosed within a bivalve carapace, of characteristic shape in each genus. The large *eye* with numerous lenses, so conspicuous in the head, is composed of two lateral eyes fused into one mass. Below it, in nearly all forms, is the *ocellus*, representing the nauplius eye. The constant motion of the trunk appendages keeps a continuous current of water circulating between the valves, bringing in food and oxygen and removing wastes. The food, chiefly of algae, is fed forward by the gnathobases of the legs to the mouth, where, within the labrum, it is worked upon by the mandibles. The second antennae are powerful organs of locomotion.

Back of the appendages, the body is continued as the freely movable *post-abdomen* with two terminal *claws* used to remove foreign substances from among the legs. Near its base, on the dorsal side, it bears a pair of long sensory hairs, the *abdominal setae*, and farther back, on either side, a row of teeth, the *anal spines*. On each claw, near its base, are usually one or two spines, the *basal spines;* or a series of them, the *pecten*. Between the dorsal surface of the trunk and the carapace is a space which, in the females, serves as a *brood-chamber*.

The males are of much the same form as the females, but much smaller. They are much less abundant than the females and for some species they are unknown. The following key, based upon the characters of the female, cannot be used to determine males. They are commonly distinguished from the female, among other features, by the larger antennules. In most collections no males will be found, and they will seldom be so numerous as to cause confusion. They can usually, with little uncertainty, be referred to the proper females in the collection.

The life-history of Cladocera is of interest. During the summer months there follow each other several generations composed entirely of females. They produce repeated broods of parthenogenetic "summer eggs," which are carried in the brood-chamber until the young have attained essentially the form of the adult. Toward the close of the summer, or other period favorable for growth, some males are also produced. At this time the females produce "winter eggs," which require fertilization. These also pass into the brood-chamber where, in most forms, they are protected by special thickening of the carapace. In the Daphnidae, this takes the form of a highly developed structure, the ***ephippium***, which is shed as a protective covering for the eggs. On the return of suitable conditions the eggs hatch.

The individual species of Cladocera, unlike the Phyllopoda, as a rule have a wide geographical range, many of them being essentially cosmopolitan.

34 (37) 6 pairs of feet, all foliaceous and similar. Tribe *CTENOPODA* 35

35 (36) Shell of ordinary cladoceran type. Antenna 2-branched, with many large setae. Family SIDIDAE

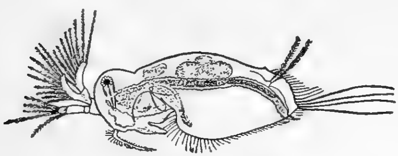

FIG. 20.—*Latona setifera*. (After Birge.)

Dorsal branch of antenna 2-jointed, with a lateral expansion on first joint. Genus *Latona*

Lateral expansion of first joint large, reaching at least to middle of second joint. Length, 2–3 mm.

Latona setifera (O.F.M.)

Twin Lakes, Tolland region. Never abundant. [Known in northern United States and Europe. A northern and mountain form.]

36 (35) Shell inclosed in a large drop of transparent jelly. Antenna unbranched, with three terminal setae.

Family HOLOPEDIDAE

FIG. 21.—*Holopedium gibberum*.

Only one genus, including a single species. Length, to 2.0 mm. Jelly mass about three times the diameter of the body of the animal.

Holopedium gibberum Zaddach

Tolland region; 9,500–10,900 ft. Sporadic. [From Colorado northward along Rocky Mountains. Northern United States (probably in Canada), Newfoundland, Greenland, Iceland, Northern Europe, Alps.]

37 (34) 5 or 6 pairs of feet. First two pairs not foliaceous but prehensile.

Tribe *ANOMOPODA* 38

38 (69) Ventral branch of antenna 3-jointed; dorsal branch 4-jointed (first joint may be very short). Intestine usually without convolution . 39

39 (60) A pair of blind diverticula at anterior end of gut (Fig. 26). Antennules usually small and inconspicuous. 5 pairs of feet.
Family DAPHNIDAE 40

40 (53) Head beaked below; never sharply separated from body above. Eye of only moderate size. 41

41 (48) Shell with sharp spine at upper posterior angle. Genus *Daphnia* 42

42 (45) Claw of post-abdomen with pecten. Anal spines not increasing very greatly in length toward end of series. 43

43 (44) Front of head about evenly curved to end of beak; head of young crested. Fornix with spine just back of base of antenna and extended well back on side of carapace. Distal pecten of about 15 spines not sharply distinct from the finer spines extending to end of claw. Post-abdomen with many clusters of fine spines on sides. Length up to 2.8 mm.
Daphnia psittacea Baird

La Junta, in cattle ponds. [Nebraska, Colorado. From Greenland to Algiers and Palestine.]

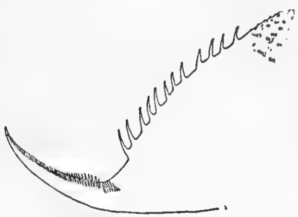

FIG. 22.—*Daphnia psittacea*. Post-abdomen.

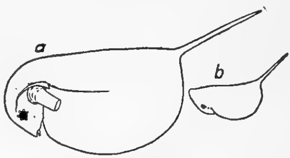

FIG. 23.—*Daphnia psittacea*. *a*, mature female; *b*, young female.

44 (43) Front of head concave between eye and beak. Fornix without spine Distal pecten of 4–11 very distinct spines. Very. variable in form and size. Local varieties very different from figures may commonly be expected. Many forms now considered as varieties have been described as distinct species. Immature specimens of some varieties have an angle or a crest bearing teeth on the carapace above the heart. Length up to 2.5 mm.
Daphnia pulex De Geer

In all parts of state from plains to highest mountain lakes. [World-wide.]

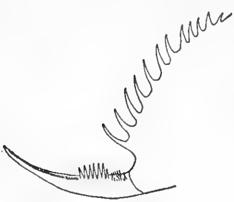

FIG. 24.—*Daphnia pulex*. Post-abdomen.

45 (42) Claw of post-abdomen without pecten. Anal spines increasing much in length toward end of series. 46

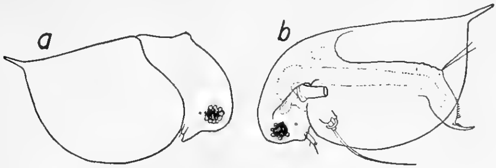

FIG. 25.—*Daphnia pulex.* *a*, crested female; *b*, male.

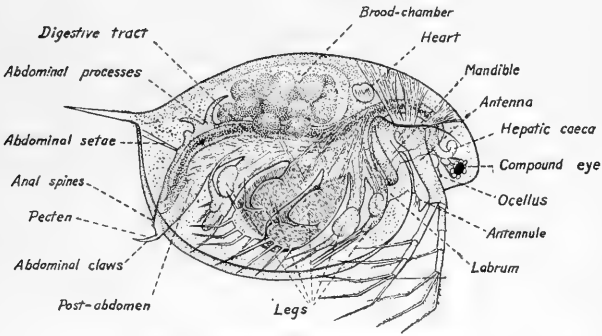

FIG. 26.—*Daphnia pulex.* Female bearing summer eggs.

46 (47) Head not helmeted. Form of body very much like that of *pulex* and a very similar series of varietal forms exists. Length up to 2.0 mm.

Daphnia longispina O.F.M.

From western edge of plains to moderately high mountain lakes; most abundant in mountain lakes of intermediate elevation; 5,200–11,350 ft. [Widespread, essentially cosmopolitan.]

Var. *longispina* form *Friedeli* Hartwig. A small form with spine very short or wanting. Silver Lake; 10,200 ft. First time recorded in America. [Reported from near Berlin.]

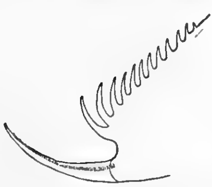

FIG. 27.—*Daphnia longispina.* Post-abdomen.

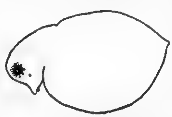

FIG. 28.—*Daphnia longispina* var. *longispina* form *Friedeli.*

47 (46) Head helmeted; eye remote from margin of head. Size and form of helmet exceedingly variable. Often considered a variety of *longispina*. Length, 1.5 mm. . . . *Daphnia hyalina* Leydig

Boulder, Twin Lakes; 5,200–9,200 ft. [Widespread in Old and New Worlds.]

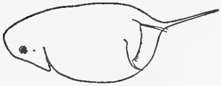

FIG. 29.—*Daphnia hyalina.*

48 (41) No sharp spine at upper posterior angle of shell. 49

49 (50) A sharp, backwardly directed spine at lower posterior margin of each valve. . . . . Genus *Scapholeberis*

One species with us. Length 1.0 mm.

Scapholeberis mucronata (O.F.M.)

Greeley, Boulder, Tolland, Twin Lakes; 4,600–9,600 ft. [Common in America and in Old World from arctic to tropical regions.]

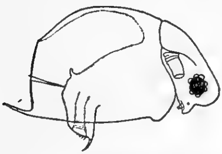

FIG. 30.—*Scapholeberis mucronata.*

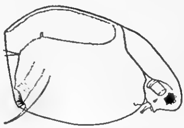

FIG. 31.—*Simocephalus vetulus.*

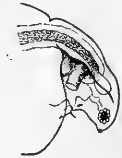

FIG. 32.—*Simocephalus serrulatus.* (After Birge.)

50 (49) Lower posterior margin of valves rounded. Blunt spine or angle at upper posterior margin. Beak obscure. . . Genus *Simocephalus* 51

51 (52) Head rounded in front of eye. Length up to 3.0 mm.

Simocephalus vetulus (O.F.M.)

La Junta, Boulder, Greeley, Tolland, Twin Lakes region. In weedy margins of lakes and ponds. [Common in Eastern and Western Hemispheres from northern to southern portions.]

52 (51) Head with spiny angle in front of eye. Length, 3.0 mm.

Simocephalus serrulatus (Koch)

Pikes Peak; 11,000 ft. Doubtful record from plains near Boulder. [General distribution about the same as *vetulus*.]

53 (40) Head not beaked; separated from body by depression above. . 54

54 (57) Head small and depressed; eye large. Antennules small.

Genus *Ceriodaphnia* 55

55 (56) Abdominal claw with pecten. Hexagonal markings of shell with simple contours. Head not inflated in front of antennules. Length, 1.4 mm.

Ceriodaphnia reticulata Jurine

La Junta, Boulder, Greeley, Tolland, Pikes Peak; 4,100–11,185 ft. [Widespread in America and from northern Europe to Africa.]

56 (55) Abdominal claw smooth. Shell markings with double contours. Head inflated in front of antennules. Length, 0.7 mm.

Ceriodaphnia pulchella Sars

Twin Lakes; 9,200 ft. To be expected lower. [Distribution about same as *reticulata*.]

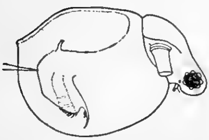

FIG. 33.—*Ceriodaphnia reticulata.*

FIG. 34.—*Ceriodaphnia pulchella.* (After Lilljeborg.)

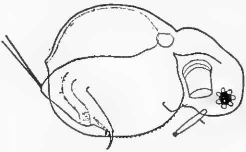

FIG. 35.—*Moina brachiata.*

57 (54) Head of ordinary size and not depressed. Antennules long and freely movable. . . . . Genus *Moina* 58

58 (59) Ephippium with two eggs. Abdomen with one bident and 7–11 simple spines. Length, 1.5 mm. . . . . . . *Moina brachiata* (Jurine)

La Junta; 4,100 ft. In muddy ponds. [Wisconsin, Nebraska, Colorado, Missouri. Europe, except extreme north, to Egypt.]

59 (58) Ephippium with one egg and reticulated all over. In other respects very much like preceding species and *M. rectirostris*. Length, 1.0 mm.

Moina affinis Birge

Greeley; 4,600 ft. ["Wisconsin to Louisiana": Birge.]

60 (39) No diverticula at forward end of gut. Antennules large. . . 61

61 (62) Antennules many-jointed, tapering, and curved backward, with sensory hairs near the middle. Short spine at lower posterior margin of each valve. . . . . . Family BOSMINIDAE

A small family of two genera.

Only one species reported from Colorado. Sensory hairs of antennules a little short of the middle. Abdominal claw with a basal series of teeth beyond which, to end of claw, is a series of very fine teeth (these latter wanting in other species of the genus). Form of shell exceedingly variable. Length, 0.5 mm.

Bosmina longirostris (O.F.M.)

La Junta, Boulder; 4,100–5,400 ft. May be expected in mountains. [Common in America and in Europe from north to south.]

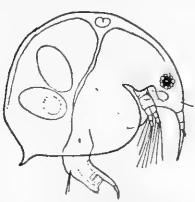

FIG. 36.—*Bosmina longirostris.*

62 (61) Antennules 1-jointed and not tapering. Sense hairs terminal. No spine at lower posterior margin. . . Family MACROTHRICIDAE 63

63 (64) Dorsal margin of valves with short, backwardly directed tooth about middle. Intestine convoluted. . . . . . . Genus *Depanothrix*

Only one species in America. Length, 0.7 mm.

Depanothrix dentata (Euren)

Twin Lakes; 9,200 ft. [Michigan, Minnesota, Wisconsin. Europe, except southern portion.]

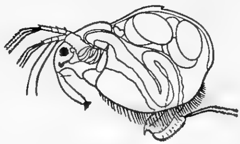

FIG. 37.—*Depanothrix dentata*. (After Lilljeborg.)

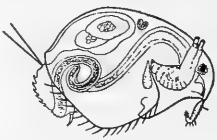

FIG. 38.—*Streblocerus serricaudatus*. (After Birge.)

64 (63) Dorsal margin of valves smooth. 65

65 (66) Antennules sharply bent near the end. Intestine convoluted. Genus *Streblocerus*

One species in Colorado. Pre-anal part of post-abdomen with serrate dorsal margin. Length, 0.5 mm. . . *Streblocerus serricaudatus* (Fischer)

Tolland; 9,600 ft. [Widespread but rare in United States. In Europe except extreme north.]

66 (65) Antennules not bent. Intestine not convoluted. Genus *Macrothrix* 67

67 (68) Conspicuous folds on dorsal surface between head and body. Length, 0.5 mm. . . . . *Macrothrix montana* Birge

Pikes peak; 11,000 ft. [California and Colorado.]

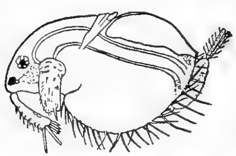

FIG. 39.—*Macrothrix montana*. (After Birge.)

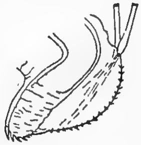

FIG. 40. — *Macrothrix montana*. Post-abdomen. (After Birge.)

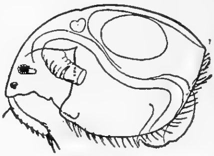

FIG. 41.—*Macrothrix hirsuticornis*.

68 (67) No dorsal folds. Post-abdomen bilobed. Antennules with about 6 rows of hairs on anterior side. Length, 0.5 mm.

Macrothrix hirsuticornis N. and B.

Boulder, Tolland, Twin Lakes region; 5,400–12,000 ft. [Colorado, Rhode Island. Greenland, Spitzbergen, Northern Europe to Africa.]

69 (38) Both branches of antenna 3-jointed. Intestine convoluted.
Family CHYDORIDAE 70

70 (71) Anus terminal. Post-abdomen very broad and flattened; armed with more than 100 close-set teeth on dorsal margin. Two caecae at anterior end of gut. . . . Genus *Eurycerus*

One species in United States. Length, 3.0 mm.
Eurycerus lamellatus (O.F.M.)

Tolland, Twin Lakes region; 8,100–10,800 ft. [Northern parts of United States and Europe. A northern and alpine form.]

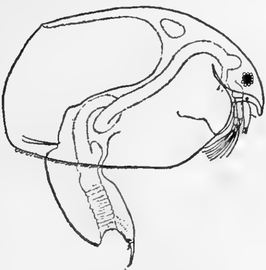

FIG. 42.—*Eurycerus lamellatus*.

71 (70) Anus not terminal but on dorsal margin. Post-abdomen usually narrow and armed with spines or tufts of bristles, or both, on post-anal portion. 72

72 (77) Abdominal claw, in addition to the usual basal spine, has a second small one near the middle. . . 73

73 (76) Head distinctly keeled, i.e., the eye is remote from margin of head. Beak short and blunt. 74

74 (75) Post-abdomen very long and narrow; armed with about 20 spines and a corresponding number of tufts of fine bristles. . . Genus *Camptocercus*

One species in Colorado. Length, 1.0 mm.
Camptocercus rectirostris Schoedler

Tolland, Twin Lakes; about 9,000 ft. [Common in America and in Europe but probably not in extreme north or south.]

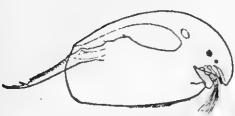

FIG. 43.—*Camptocercus rectirostris*.

FIG. 44.—*Acroperus harpae*.

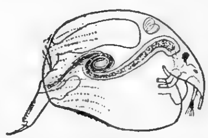

FIG. 45.—*Kurzia latissima*. (After Birge.)

75 (74) Post-abdomen not extremely narrow; armed with a row of about 12 tufts of bristles. . . . . Genus *Acroperus*

One species in Colorado. Length, 0.8 mm. *Acroperus harpae* Baird

Tolland; 8,100–10,000 ft. [Common in United States and in northern Europe.]

76 (73) Head not keeled. Beak long and slender. . . Genus *Kurzia*
One species in United States. Length, 0.6 mm.
Kurzia latissima (Kurz)

Sometimes listed as *Alonopsis latissima* Kurz. Greeley; 4,600 ft. [Widespread in United States and Europe.

77 (72) Claw without spine in middle. 78

78 (79) Beak directed forwards and somewhat turned up at the end, forming a sort of snout. Head broader than body.
Genus *Graptoleberis*
But one species in the genus. Length, 0.7 mm.
Graptoleberis testudinaria (Fischer)

Boulder, Tolland, Twin Lakes; 5,250–10,800 ft. [Common all over United States and Europe.]

FIG. 46.—*Graptoleberis testudinaria.*

79 (78) Beak directed downward. Head not broader than body. 80

80 (87) Free posterior margin of valves but little less than greatest height of shell. 81

81 (82) Post-abdomen broad and rounded and armed with many long and slender spines. . . Genus *Leydigea*
One species in Colorado. Claw of post-abdomen with a small basal spine. Setae on keel of labrum small. Length, 0.9 mm.
Leydigea quadrangularis (Leydig)

Boulder; 5,200 ft. [All parts of United States and Europe but not abundant.]

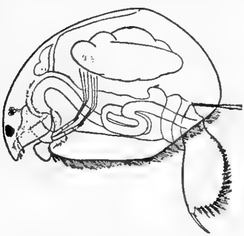

FIG. 47.—*Leydigea quadrangularis.* (After Lilljeborg.)

82 (81) Post-abdomen not unusually broad nor are the spines of great length.
Genus *Alona* 83

83 (86) Post-abdomen rounded at the end and armed with a row of spines and a corresponding number of tufts of bristles. 84

84 (85) About 9 spines; the bristles long, some of them reaching well beyond the margin of the post-abdomen. Length, 0.4 mm.
Alona rectangula Sars

Boulder, Tolland; 5,400–11,250 ft. [Widespread in United States and Europe.]

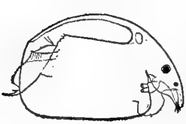

FIG. 48.—*Alona rectangula.*

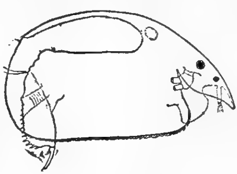

FIG. 49.—*Alona affinis.*

85 (84) About 14 spines. Bristles extending little, if at all, beyond margin of post-abdomen. Abdomen broadly rounded at end. A row of fine spines at base of claw. Shell less arched than in preceding species. Length, 1.0 mm. . . . . *Alona affinis* (Leydig)

Tolland; 8,100–11,185 ft. [Common in America and in Old World from the extreme north southward.

86 (83) Post-abdomen angled and armed with spines only (8–10 in number). Form of shell much like *reticulata*. Length, 0.4 mm. *Alona guttata* Sars

Probably equivalent to *A. glacialis* Birge, reported from Greeley; 4,600 ft. [Widespread in New and Old Worlds.]

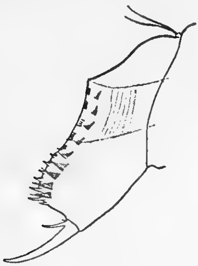

FIG. 50.—*Alona rectangula*.

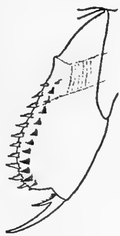

FIG. 51.—*Alona affinis*.

FIG. 52.—*Alona guttata*.

87 (80) Free posterior margin of valves decidedly less than greatest height of shell. 88

88 (99) Outline of body as seen from the side, somewhat elongated . . 89

89 (90) Marginal spines of post-abdomen inconspicuous. Groups of very small spines scattered on sides of abdomen. Claw with single basal spine. A single curved tooth at lower posterior margin of each valve. Genus *Dunhevedia*

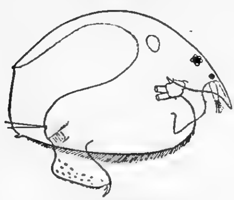

FIG. 53.—*Dunhevedia crassa*.

Only one species in Colorado. Dorsal margin of shell much arched. Keel of labrum not serrated. Length, 0.5 mm. *Dunhevedia crassa* King

Probably the same as *D. setiger* Birge. Boulder, Tolland; 5,400–8,675 ft. [United States, Europe, Australia. Widespread but not common.]

90 (89) Marginal spines of post-abdomen of the usual type. Claw with two basal spines. 91

91 (96) Beak long and slender. In our species the shell is marked with striations that have a somewhat radial arrangement. . Genus *Pleuroxus* 92

92 (93) Beak curved sharply forward and upward at the tip. Teeth along entire posterior margin of valves. Length, 0.5 mm.

Pleuroxus procurvatus Birge

Tolland, Twin Lakes; 8,150–9,200 ft. [Northern United States.]

93 (92) Beak not curved upward. Small teeth at lower posterior margin of valves only. 94

94 (95) Post-abdomen rounded at posterior margin; 9–12 spines. Length, 0.6 mm. . . . . *Pleuroxus aduncus* (Jurine)

Boulder; 5,200 ft. [Colorado and California. Northern Europe to Algiers and Syria.]

95 (94) Post-abdomen with prominent angle at posterior margin. Length, 0.6 mm. . . . . *Pleuroxus denticulatus* Birge

Boulder; 5,200 ft. [Common in all parts of United States.]

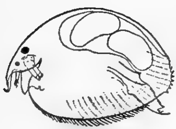

FIG. 54.—*Pleuroxus procurvatus.*

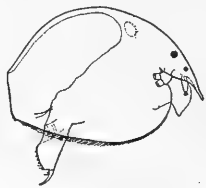

FIG. 55.—*Pleuroxus aduncus.*

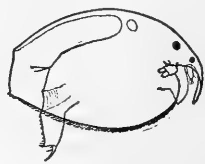

FIG. 56.—*Pleuroxus denticulatus.*

96 (91) Beak short and blunt. Shell with markings more or less definitely hexagonal. . . . . Genus *Alonella* 97

This describes only part of the genus. Other species not included in our fauna would not fall under 96. The genus is poorly defined.

97 (98) Valves with distinct, fine longitudinal striations as well as hexagonal reticulations. Lower posterior margin of valves with rounded teeth. Post-abdomen of this species commonly described as angled at apex but in most of my specimens it was rounded as figured. Length, 0.5 mm.

Alonella excisa (Fischer)

Tolland; 8,100–8,475 ft. [Common in United States, Greenland and all of Europe.]

98 (97) Valves with hexagonal markings only. Teeth at lower posterior margin

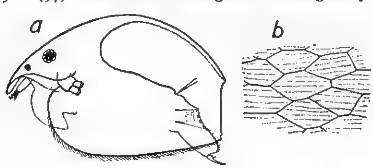

FIG. 57.—*Alonella excisa.* *a*, female; *b*, markings of valve.

FIG. 58.—*Alonella exigua.*

of valves more pronounced than in preceding species and not rounded. Post-abdomen rounded. Length, 0.35 mm. *Alonella exigua* (Lilljeborg)

Tolland; 9,500 ft. [Wisconsin, Michigan. All parts of Europe.]

99 (88) Outline of body as seen from the side, nearly circular. Genus *Chydorus*

Only one species in Colorado. Length, 0.5 mm. *Chydorus sphaericus* (O.F.M.)

Found in all parts of state where collections have been made. [The most widespread cladoceran, being found all over the world.]

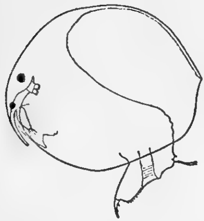

FIG. 59.—*Chydorus sphaericus.*

100 (1, 139) Five pairs of biramous, non-foliaceous feet. Body moderately elongated and distinctly segmented. No paired eyes. Antennae usually of good size. . . Sub-class **COPEPODA**

Next to the Cladocera, the Copepoda orm the most important part of our fresh-water plankton Crustacea. The general form of the body and the number and nature of the appendages are shown in Fig. 60 and Table I. To determine the species of Copepods it is necessary to make dissections to separate out the necessary parts.

Males and females are about equally common. They may be readily distinguished by the fact that the males have one or both antennae enlarged and geniculate, to serve as a clasping organ. The fifth feet (sixth trunk limbs) are of importance in determining species. They are always reduced and are usually alike in male and female, though in *Diaptomus* they differ in the two sexes. The eggs during development are carried by the female in one or two brood-pouches attached to the abdomen. The young emerge from the egg in the nauplius stage (Fig. 61). Very many nauplei as well as other immature forms are often found in collections in so great numbers as to cause confusion to the beginner. They cannot be determined by these keys and it is possible for the student merely to remember that they are young forms, probably of some one of the mature forms found in the same collection.

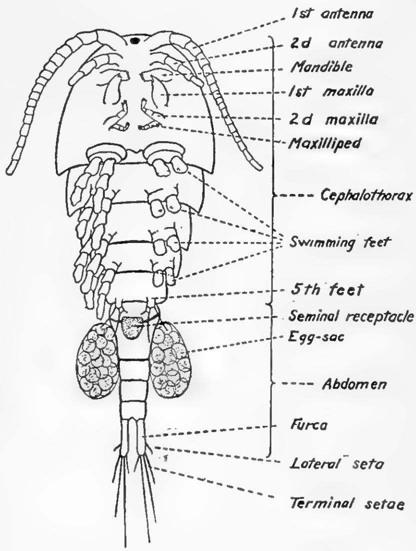

FIG. 60.—Female *Cyclops*. Ventral view. (After R. Hertwig.)

101 (134) Abdomen much more slender than the cephalothorax, from which it is sharply separated. 102

102 (126) Antennae very long (23–25 segments), often reaching to the end of the body. In males the right antenna is enlarged and geniculate. 5th feet of female similar and small; of male the right one is much larger. Female carries a single egg-sac. . . . . Family CENTROPAGIDAE

Only one genus represented in Colorado records. Antennae 25-segmented. Right 5th foot of male ends in a more or less sickle-shaped hook. Endopodites of swimming feet 2–3–3–3-segmented. Genus *Diaptomus*

The key to the genus *Diaptomus* is based upon the characters of the adult male. Determinations are not easily made from female specimens, but they may be without difficulty referred to the proper males in the same collection.

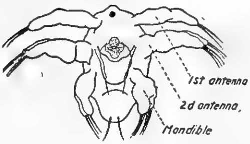

FIG. 61.—Nauplius larva of a Copepod. (After Groben from Lang's *Comparative Anatomy*.)

The various species of this genus form an important part of the Copepod fauna of fresh waters throughout the world. Many of them are conspicuous on account of their bright colors. The individual species are extremely restricted in their distribution. Of the 36 species known to occur in North America, not one extends beyond the bounds of the continent and most of them have a very much more restricted range than that. Of the 13 species that have been found in Colorado, nearly all have a range not extending beyond the Rocky Mountain region. The genus is one in which success has been attained by means of many species, each with a limited range.

103 (120, 123) Antepenultimate segment of right antenna with terminal process. 104

104 (111) Terminal process straight. 105

105 (108) Terminal process shorter than penultimate segment. . . . 106

106 (107) Terminal process much shorter than penultimate segment and tapered at end. Endopodite of right 5th foot shorter than first segment of exopodite. Length: male, 0.9; female, 0.93 mm. *Diaptomus judayi* Marsh

Twin Lakes; 9,200 ft. Only record for this species.

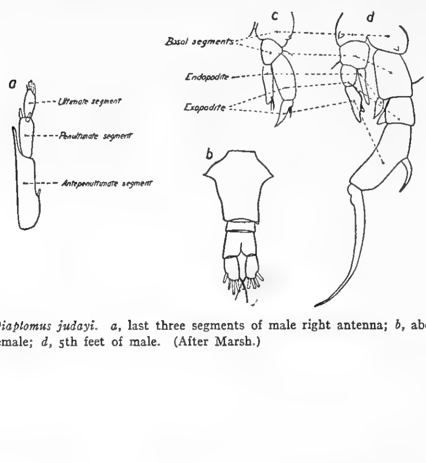

FIG. 62.—*Diaptomus judayi*. *a*, last three segments of male right antenna; *b*, abdomen of female; *c*, 5th foot of female; *d*, 5th feet of male. (After Marsh.)

107 (106) Terminal process nearly as long as penultimate segment and slightly enlarged at tip. Endopodite of right 5th foot decidedly longer than first segment of exopodite. Length: male 1.15; female 1.25 mm.

Diaptomus siciles Forbes

Greeley; 4,600 ft. [Great Lakes, Wisconsin, Yellowstone region, Nebraska, Colorado.] A cold-water form.

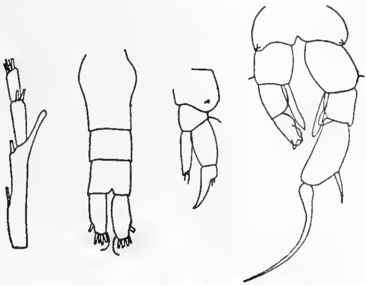

FIG. 63.—*Diaptomus siciles*. (After Marsh.)

108 (105) Terminal process longer than penultimate segment . . . 109

109 (110) Terminal processes of last segment of exopodite of 5th foot long—nearly as long as combined length of last two segments. Length: male, 1.7; female, 2.1 mm. . . . . . . *Diaptomus arapahoensis* Dodds

Tolland region (type locality); 10,750–11,135 ft.

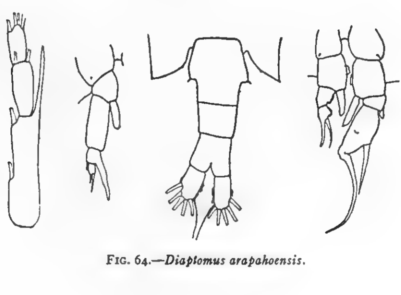

FIG. 64.—*Diaptomus arapahoensis*.

110 (109) Terminal processes of last segment of expodite of 5th foot short. Length: male, 2.5; female, 2.9 mm. . . *Diaptomus shoshone* Forbes

Tolland, Pikes Peak; 9,250–12,188 ft. [Yellowstone region and Colorado mountains.]

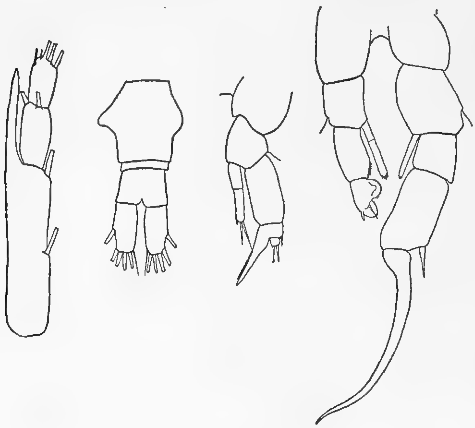

Fig. 65.—*Diaptomus shoshone.*

111 (104) Terminal process curved. 112

112 (113) Endopodite of right 5th foot very small—almost rudimentary. First segment of right exopodite long. Last segment of exopodite of left 5th foot much more slender than first. Length about 2.0 mm.

Diaptomus lintoni Forbes

Tolland; 9,600 ft. [Yellowstone region and Colorado mountains.]

113 (112) Endopodite of right 5th foot not very small—nearly as long as the short first segment of exopodite. Last segment of left exopodite about as thick as first. 114

114 (115) Lateral spine of second segment of right exopodite long—about half as long as terminal hook. Length: male, 1.58; female, 1.76 mm.

Diaptomus albuquerquensis Herrick

La Junta, Hugo; 4,100–5,000 ft. [Mexico to Colorado.]

115 (114) Lateral spine of second segment of right exopodite of only moderate size. 116

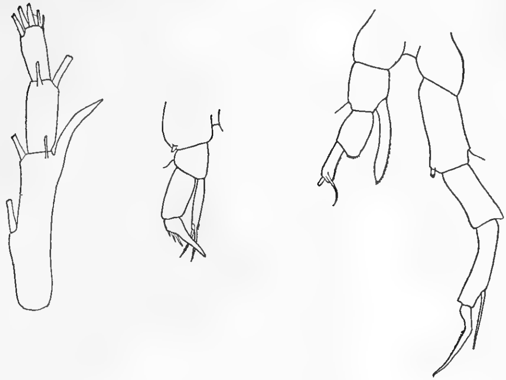

FIG. 66.—*Diaptomus lintoni.*

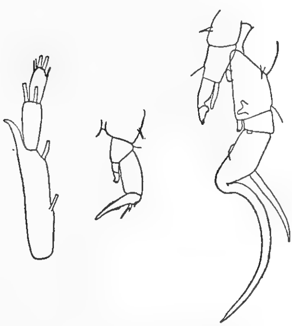

FIG. 67.—*Diaptomus albuquerquensis.*

116 (119) A hyaline appendage on first segment of exopodite of right 5th foot. 117

117 (118) Hyaline appendage at inner distal angle of segment. Length: male, 0.9; female, 0.93 mm. . . . . . *Diaptomus signicauda* Lilljeborg

Boulder; 5,200 ft. [California and Colorado.]

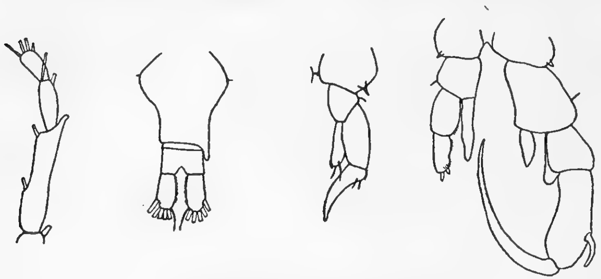

FIG. 68.—*Diaptomus signicauda*. (After Marsh.)

118 (117) Hyaline appendage on inner distal half of segment. Length: male, 1.11; female, 1.22 mm. . . . . . *Diaptomus siciloides* Lilljeborg

La Junta, Hugo; 4,100–5,000 ft. [California, Colorado, Kansas, Nebraska, Missouri, Wisconsin, Illinois, Indiana.]

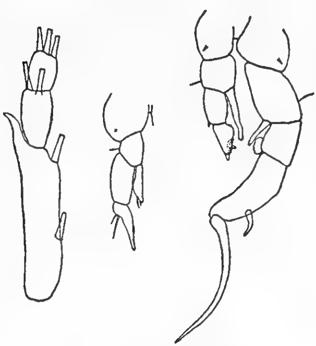

FIG. 69.—*Diaptomus siciloides*.

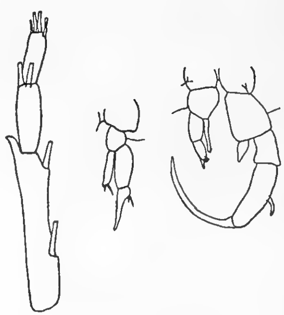

FIG. 70.—*Diaptomus nudus*.

119 (116) No hyaline appendage on first segment of exopodite of right 5th foot. Length: male, 1.11; female, 1.32 mm. *Diaptomus nudus* Marsh

Pike's Peak, Tolland, Boulder; 5,200–11,000 ft.

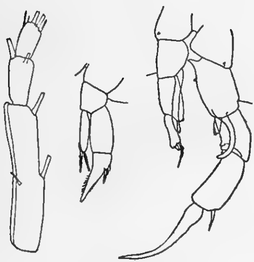

FIG. 71.—*Diaptomus claviceps.*

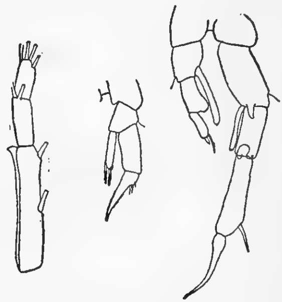

FIG. 72.—*Diaptomus leptopus* var. *piscinae.*

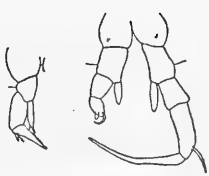

FIG. 73.—*Diaptomus pallidus.*

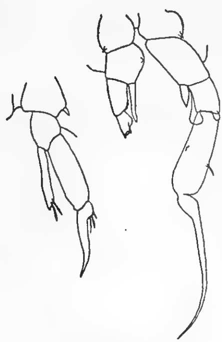

FIG. 74.—*Diaptomus coloradensis.*

120 (103, 123) Antepenultimate segment of right antenna with lateral hyaline lamella. 121

121 (122) Hyaline lamella rounded at distal end and not extended beyond end of segment. Endopodite of right 5th foot short. Length: male, 1.8; female, 2.0 mm. . . . . *Diaptomus claviceps* Schacht

La Junta, Boulder, Greeley; 4,100–5,400 ft. [Colorado, Iowa, Nebraska.]

122 (121) Hyaline lamella with distinct angle at distal end or rounded at end and extending beyond end of segment. Length: male, 1.7; female, 1.8 mm. *Diaptomus leptopus* Forbes

All Colorado specimens seem to belong to the variety *piscinae* Forbes. The figures and distribution refer to this variety. Boulder, Tolland; 5,400–10,950 ft. [Colorado, Montana, Manitoba, Alberta.]

123 (103, 120) Antepenultimate segment of right antenna without appendage. 124

124 (125) Inner terminal process of second segment of left exopodite falciform. Length: male, 1.0; female, 1.2 mm. . . *Diaptomus pallidus* Herrick

La Junta, Pueblo; 4,100–4,600 ft. [Lowlands of Mississippi Valley, Colorado.]

125 (124) Both terminal processes of second segment of left exopodite digitiform. Length: male, 1.23; female, 1.38 mm. *Diaptomus coloradensis* Marsh

Tolland, Kremmling, Mt. Carbon; 7,500–11,350 ft.

126 (102) Antennae short (6–17 segments), never reaching beyond end of cephalothorax. In male both antennae are enlarged and geniculate. Fifth feet small and similar in male and female. Female carries two egg-sacs.

Family CYCLOPIDAE

Genus *Cyclops* 127

Cyclops, like *Diaptomus*, forms a large part of the fresh-water Copepod fauna of all parts of the earth. Unlike the latter genus, *Cyclops* includes relatively few species, nearly all of which have a very wide range, many of them practically world-wide. Of the five species recorded from Colorado, only one, *Cyclops ater*, is confined to North America.

127 (133) Antenna of 17 segments. 128

128 (129) Fifth foot of one segment; armed with one spine and two long setae. A large form; the female may be as long as 2.88 mm. *Cyclops ater* Herrick

Greeley; 4,600 ft. [Rather widely distributed in United States.]

129 (128) Fifth foot of two segments. 130

130 (131, 132) Second segment of 5th foot armed with seta and short spine. Lateral seta of furca well toward end—at or beyond two-thirds of its length. Several varieties, differing chiefly as to stoutness. The more slender forms are found in the larger bodies of water. Length of female, 1.5 mm. *Cyclops viridis* Jurine

In all parts of state where collections have been made; 4,100–11,600 ft. [Widespread in Old and New Worlds.]

131 (130, 132) Second segment of 5th foot armed with two setae—a long and a short one. Lateral seta of furca not much beyond middle; a cluster of fine

spines on outer margin of furca near base. Forms in small bodies of water are less slender than those in large. Length of female, 1.1 mm.

Cyclops bicuspidatus Claus

In all parts of state; 4,100–11,900 ft. [Northern United States, Canada, Northern Europe. A northern form.]

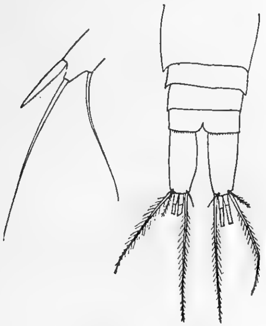

FIG. 75.—*Cyclops ater.* (After Marsh.)

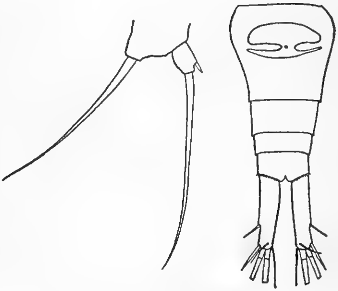

FIG. 76.—*Cyclops viridis.*

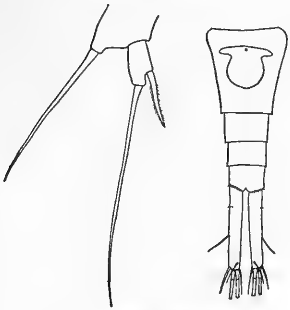

FIG. 77.—*Cyclops bicuspidatus.*

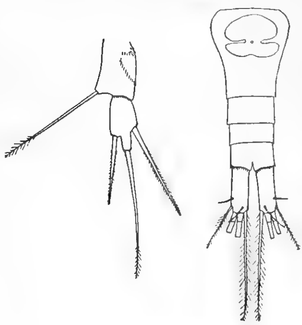

FIG. 78.—*Cyclops albidus.*

132 (130, 131) Second segment of 5th foot with three setae. Inner terminal seta more than twice as long as furca. Length of female, 1.5 mm.

Cyclops albidus Jurine

All parts of state; 4,100–11,000 ft. [Essentially cosmopolitan.]

133 (127) Antenna of 12 segments. Fifth foot of one segment armed with a spine-like seta and two long ones. Outer margins of furca serrated and the stout outer terminal seta stands out at an angle. Length of female, 1.25 mm. . *Cyclops serrulatus* Fischer

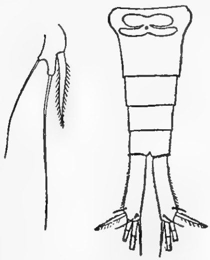

Fig. 79.—*Cyclops serrulatus.*

All parts of state; 4,100–11,150 ft. [World-wide.]

134 (101) Abdomen not sharply separated from cephalothorax. Antennae never of more than 8 segments. . . Family HARPACTIDAE 135

135 (136) Antenna of 6 segments. Genus *Marshia*

We have one species. Furca of female about two and a half times as long as broad; the two median furcal setae are fused at the base. Length, 0.8 mm. . . . *Marshia albuquerquensis* Herrick

Found in an alkaline marsh at La Junta. [General distribution (?).]

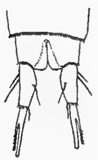

Fig. 80.—*Marshia albuquerquensis.*

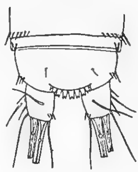

Fig. 81.—*Canthocamptus minutis.*

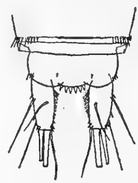

Fig. 82.—*Canthocamptus staphylinoides.*

136 (135) Antenna of 8 segments. . . . Genus *Canthocamptus* 137

Representatives of this genus are evidently widespread in Colorado but infrequently found and then in small numbers. Two species are listed here, but in my collections are a few specimens which cannot be placed in either of these.

137 (138) Furca short—very little longer than wide. Spines of anal plate double pointed. Length: male, 0.5; female, 0.6 mm.

Canthocamptus minutis Claus

Greeley, Silver Lake; 4,600–10,200 ft. ["Found everywhere in the northern continents": Marsh.]

138 (137) Furca about twice as long as broad. Spines of anal plate single pointed; 4–12 in number. Length of my specimens about 0.7 mm., but Pearse's measurements are: male, 0.9; female, 1.1 mm.

Canthocamptus staphylinoides Pearse

Specimens from 6 localities in the Tolland region are doubtfully referred to this species rather than to *staphylinus* Jurine. My specimens have fewer anal spines, the second segment of the 5th foot is shorter and stouter, and the last abdominal segment has no spine-like process caudad as in *staphylinus*. [Found also in Nebraska. *C. staphylinus* is found in both Old and New Worlds.]

139 (1, 100) Appendages much reduced—only two pairs of trunk appendages present. Small animals (about 1.0 mm.) entirely inclosed in bivalve shell. Poor swimmers, living near bottom. Common in all localities.

Sub-class **OSTRACODA**

I have made no special effort to collect Ostracods; nor have those in my collections been determined. The following have been reported by Beardsley as occurring in the state:

Candona acuminata (Fischer)
Cyclocypris laevis (O. F. M.)
Cypria mons (Chambers)
Cypridopsis newtoni B. and R.
Cypridopsis vidua (O. F. M.)
Cyprinotus grandis (Chambers)
Cypris altissima Chambers
Erpetocypris olivacea N. and B.
Iliocypris bradyi Sars

Important References

This list includes most of the papers in which records of Colorado species have appeared (marked *), and a few of the more useful general works on Entomostraca (marked †).

*Beardsley, A. E. "Notes on Colorado Entomostraca." *Trans. Am. Mic. Soc.*, Vol. XXIII, pp. 40–48, 1902.

*Cockerell, T. D. A. "The Fauna of Boulder County, Colorado. II." *Univ. Colo. Studies*, Vol. IX, pp. 41–52, 1912.

*Dodds, G. S. "Descriptions of Two New Species of Entomostraca from Colorado, with Notes on Other Species." *Proc. U.S. Nat. Mus.*, forthcoming issue.

†Douwe, C. van. "Copepoda." *Süsswasserfauna Deutschlands*, heft 11, Gustav Fischer, Jena, 1909. 69 pp., 310 text figures.

†Herrick, C. L. "Synopsis of the Entomostraca of Minnesota." *Second Report of State Zoölogist*, 1895. 337 pp., 81 pl.

*Juday, Chancey. "A Study of Twin Lakes, Colorado, with Especial Consideration of the Food of the Trouts." *Bulletin* 26 *of the Bureau of Fisheries*, pp. 147–78, 1907.

*———. "Studies on Some Lakes in the Rocky and Sierra Nevada Mountains." *Trans. Wis. Acad.*, Vol. XV, Part II, pp. 781–93, 1907.

†Keilhack, L. "Phyllopoda." *Süsswasserfauna Deutschlands*, heft 10, Gustav Fischer, Jena, 1909. 112 pp., 265 text figures.

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