CONTRIBUTIONS TO PALEONTOLOGY

V

Upper Cretaceous Fish Remains from the Western Border of the San Joaquin Valley, California

LORE ROSE DAVID

With three plates and eleven text figures

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[ISSUED JANUARY 25, 1946]

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Upper Cretaceous Fish Remains from the Western Border of the San Joaquin Valley, California

Introduction

The only previously recorded Cretaceous fish fossils from California are four scales described by Cockerell (1919). These represent three types, *Chicolepis punctatus, Pomolobus? chicoensis,* and *Erythrinolepis chicoensis,* from the Moreno formation on the south side of Ortigalito Creek; and one additional form, *Echidnocephalus? pacificus,* possibly from the Moreno between Little Panoche and Ortigalito creeks in the middle Coast Ranges. Fortunately a much more considerable amount of Cretaceous fish fossil material is available for the present report. Most of this comes from oil-well cores from the middle San Joaquin Valley.

Only a limited number of localities yielded materials for study; this fact is the more unusual in that Cretaceous deposits are widespread in the state. Even so, the present collection does include many well preserved forms, some of which occur in great abundance. Fortunately the total collection gives a representative cross section of the piscine fauna and comprises such families as might be expected. A satisfactory representation of the genera likewise is found. The more important members of the Upper Cretaceous fish faunas of California appear to be found among forms from Panoche Creek, and these may well serve as a foundation for future studies of related fish types.

Considerable difference prevails between the fishes of the Cretaceous and those of the early Tertiary. Cockerell (1919, p. 169) emphasizes this fact when he states: "It ought to be possible as a rule to distinguish a Cretaceous from a Tertiary deposit by means of a single well preserved fish scale." Since the relationships of extinct Cretaceous forms to existing fish cannot be ascertained in many instances, an interpretation of the ecological conditions during the time of accumulation of Cretaceous faunas must be made with caution. If large assemblages are considered, however, it seems likely that some pertinent suggestions will be feasible. Considerable interest is being shown by geologists in the California Cretaceous, and investigation of Cretaceous fish may throw light on sedimentary problems and assist in the correlation of the marine deposits of this period. The present studies are regarded as only a beginning in this direction.

Many Cretaceous fish faunas are known from other parts of the world. Of these the more important are: English chalk (Woodward, 1902–1911), Westphalia (von der Marck, 1863, 1876; von der Marck and Schlueter, 1865–1868), Saxony (Geinitz, 1868), Bohemia (Fritsch, 1878), Mount Lebanon, Syria (Davis, 1887; Hay, 1903*a*; Woodward, 1942), various parts of North America (Hay,

1903*b*, 1929; Cockerell, 1919), and Brazil (Jordan and Branner, 1908; Woodward, 1907; Maury, 1930, 1936). These faunas are known for the most part by skeletal remains. In Geinitz' paper (1868) scales are occasionally shown. Scales, when preserved in association with and overlying skeletal material of fish, cannot be clearly recognized. In many cases, therefore, it is not certain whether a particular scale belongs to a type of fish described on the basis of skeletal remains. Careful comparison with known material may in time furnish definite proof of association. Cretaceous fish remains from North America and England are almost invariably fragmentary, whereas in Westphalia and in the platy chalk of Mount Lebanon complete fish are well preserved.

The present report, for the most part, describes fossil fish remains that occur in cores of oil wells drilled along the west side of the San Joaquin Valley, near Chowchilla and Panoche Creek. Only a single set of samples was used from each well. Each of these had been utilized previously in a study of the fossil foraminifera. Most of the fish remains occurring in the well cores are scales, although bones of gill covers, vertebrae, and teeth are found occasionally. For the most part only the scales have been studied. This material is described in the hope that use may be made of it in stratigraphic investigations. A detailed comparison and correlation of the Californian forms with fish types known from Cretaceous deposits in other parts of the world will doubtless be made in the future.

Most of the new genera are named for micropaleontologists of California.

Available Material

The core samples in which the fish remains occur were taken from the following wells: (1) Jergins Oil Company, Chaney Ranch No. 1, Panoche district, Sec. 29, T. 14 S., R. 13 E., Mount Diablo base line and meridian, total depth 9284 feet; (2) Western Gulf Oil Company, Lillis Welch No. 1, Firebough district, Sec. 26, T. 15 S., R. 12 E., Mt. Diablo B. and M., total depth 5624 feet; (3) Pure Oil Company, Chowchilla No. 1, Chowchilla district, Sec. 7, T. 10 S., R. 14 E., Mt. Diablo B. and M., total depth 8387 feet. Included in the report are also some large fish remains found in the Moreno formation of the Panoche Hills. From these deposits have come also remains of mosasaurs and plesiosaurs.

Description of Fish Fauna

ORDER SELACHII

Family LAMNIDAE. Mackerel Sharks

Corax sp.

(Text figure 1)

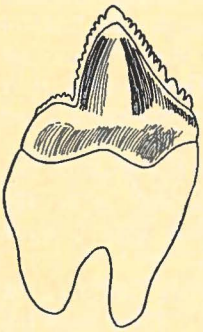

Fig. 1. *Corax* sp. Tooth 5 mm. long by 3.2 mm. wide. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6206 to 6215 feet. Moreno formation.

A small shark's tooth of the genus *Corax* was found in the Jergins Oil Co. well, Chaney Ranch No. 1, between the depths of 6206 and 6215 feet in the Moreno shale. The specimen measures 5 mm. in length, including the root, and 3.2 mm. in width.

The tooth is moderately broad; crown almost erect, moderately convex, emarginate at the base. Cutting edges serrated; serrations much stronger on straight edge than on indented side.

This form seems to be distinguished from known species of the genus by a slightly different shape; one side is strongly indented and the other is concave. It differs also in having a very long, bifurcated root, and in having strong serrations on one side only, the opposite edge, including the indentation, being only feebly serrated. The tooth does not appear to belong to any known form, and probably represents a new species. Since *Corax* is not otherwise known from California, and since only one specimen has been found so far, it does not appear advisable to establish a new type. *Corax* is typical of the Cretaceous, but occurs occasionally in the Eocene.

ORDER HOLOSTEI

Family PACHYCORMIDAE

Protosphyraena sp.

A large pectoral fin of this genus, no. 10125, Calif. Inst. Tech. Vert. Pale. Coll., was found at C.I.T. locality 355 (north branch of Moreno Gulch, NW. ¼ Sec. 11, T. 14 S., R. 11 E., Mt. Diablo B. and M.). *Protosphyraena* Leidy is abundantly represented in the Niobrara of Kansas and is known also from the Benton and Pierre.

ORDER OSTARIOPHYSI

Family ERYTHRINOLEPIDAE

Erythrinolepis cf. **chicoensis** Cockerell

(Plate 2, figure 5)

Description. Specimens show the following variable proportions of length to depth (in millimeters): 15 to 13, 13 to 13, 12 to 12.5, 10 to 10. Differences between the two sides of a scale are well defined. Outer side smooth except for strong, irregular grooves; inner side with very fine circuli, the grooves visible only as fine lines. Grooves on smooth side wide, very irregular, originating for the most part in region of nucleus, sometimes shorter, broken or anastomizing. Majority of grooves in basal region, those on apical part fewer and thinner. Basal

margin sometimes crenated, but more so on distorted specimens. Coarse side of scale with very fine concentric circuli, 32 in 1 mm. distance near outer border of specimen of 12 mm. diameter (a large number considering the size of the scales of this form); circuli somewhat coarser in larger scale. Circuli not recognizable in apical region. Fine, irregular tuberculations visible on anterior part of apical region; feeble apical radii probably also present. Grooves on smooth side present only as simple dividing lines; on coarse side, dividing circuli into foldlike sections; these lines are not strong, nor do they project vertically as on smooth side. Nucleus above lower third of scale. Scales evidently delicate, thinner than the average Cretaceous scale of this size. Scale rarely well preserved; when present it is usually preserved as a mold of smooth side, showing the grooves mentioned above as strong ridges.

Occurrence. *Erythrinolepis* is found nowhere in abundance, but it occurs occasionally in the Moreno as well as in the Panoche formation in wells in the Big Panoche Creek region. The only well preserved specimen comes from a depth of 7137 to 7144 feet in the Jergins Oil Co. well, Chaney Ranch No. 1.

Relationships. Cockerell's species *E. chicoensis* was established on comparatively few specimens from the Moreno formation of Ortigalito Creek. These were not available for comparison with the material described in the present paper. It is not certain, therefore, that both occurrences represent the same species. Cockerell (1919) described another species of the genus from the Mowry shale of Wyoming. He considers *Erythrinolepis* to be most closely related to the Erythrininae, freshwater fishes of South America.

Scales of the Wyoming Upper Cretaceous species are smaller than the present material, the circuli are considerably coarser, and there is a definite difference in the structure of the apical region. The latter in *E. mowriensis* shows a very fine circuli-like ornamentation into which the coarse circuli of the basal region change abruptly. The apical lines have an anteroposterior direction in the middle of the apical part and are transverse in the dorsal and ventral sectors of the apical region, whence they gradually change their direction toward the anteroposterior central lines. This structure of the apical pole is probably not unique in *Erythrinolepis mowriensis.* Indication of a similar structure was observed in *Holcolepis transversus* Cockerell. In the latter form it occurs in the nuclear center above the region where the coarse apical radii are formed, but is noticeable only in well preserved scales. This may indicate relationship between the two scales. In typical specimens of *H. transversus,* however, the basal part is never divided into folds as in *Erythrinolepis.* Typical scales of *Erythrinolepis* never show an indication of the coarse apical structure seen in *H. transversus.* An apical structure similar to that shown in *E. mowriensis* is also found in scales of the Heteromi, a group far removed from the two genera to which reference has been made. It may be a structure shown by a number of primitive forms, including those mentioned above.

The California scales here described do not show a similar apical structure. The apical region has only faint radii and tubercles. The scales resemble those of *E. mowriensis* in having very strong, irregular basal radii, vertically projected on the smooth side, but less conspicuous on the coarse side of the scale. This latter character seems to be the outstanding feature common to the species of this peculiar fossil genus.

Relationships of the fossil genus are uncertain. There is undoubtedly a similarity

to the Recent Erythrininae, but whether this is due to descent or not cannot be determined. The Erythrininae have basal radii of the same structure, but differ in other characters. The fossil scales do not show a division of their central part into irregular cells, as is the case generally among the Erythrininae; the structure of the apical pole is also totally different.

ORDER ISOSPONDYLI

Family PACHYRHIZODONTIDAE

Pachyrhizodus sp.

(Plate 1, figure 2)

Material and location. A number of large skeletal fragments evidently belong to this genus. These include: A caudal fin together with the end of the vertebral spine, no. 10126, Calif. Inst. Tech. Vert. Pale. Coll., from C.I.T. locality 362, Moreno formation of the Tumey Hills. A left half of a jaw, no. 10123 C.I.T., from diatomaceous beds in the lower part of Quail Canyon, Panoche Hills, C.I.T. locality 358. A large pectoral fin and several jaw fragments, no. 10124 C.I.T., from C.I.T. locality 359, at 150 feet above base of Moreno in first canyon north of Reptile Ridge. Isolated vertebrae of this genus are also present.

Description of scale. The large scale figured in plate 1, figure 2 may belong to this genus. It measures 20.5 mm. long by 23 mm. deep, and was found in the Moreno shale of the Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4954 to 4960 feet. The basal part seems badly squeezed or damaged by small pieces of gravel, and no circuli or other structures are recognized. The strengthened basal margin is well preserved, however, showing a distinct median notch. The apical pole shows well preserved tuberculate radii comparatively near to each other, divided by shallow grooves, about 15 in a distance of 5 mm. Upper border of apical pole rounded, lower margin partly fragmented, evidently rounded to pointed. Apical radii resemble those found in *Holcolepis transversus,* but are finer and closer together; the tubercles are much smaller and do not protrude as much above the surface of the radii.

Discussion. The scale of *Pachyrhizodus* is said to have tuberculate radii in the apical pole comparable to those of *Holcolepis,* and a smooth basal region. *Pachyrhizodus subulidens* (Owen), a small species from the English chalk, as figured by Woodward (Fishes of the English chalk, 1908), has a scale much longer than deep, whereas the California scale is deeper than long. Such proportions, however, may differ considerably in different species of one genus.

Family ELOPIDAE. Tarpons and Ten-pounders

Holcolepis nodulatus, n. sp.

(Plate 2, figure 4)

Type. No. 10333, Calif. Inst. Tech. Vert. Pale. Coll. Scale 13 mm. deep, preserved part 10 mm. long, uppermost border missing.

Type locality. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4387 to 4396 feet. Moreno shale, Upper Cretaceous.

Description. Type is a mold of coarse side of scale, with greater part of apical region of actual scale preserved. About 4 feebly marked basal folds present. Circuli

in crescentic lines around nucleus, twice as wide as high; circuli comparatively fine in nuclear region, 30 to 32 in 1 mm. distance, coarser toward outer border, with 22 in 1 mm. distance. Nucleus probably near middle of scale, immediately above uppermost point of apical section. Apical region broad, occupying basal border completely, forming a triangle with its upper angle of nearly 120° directed toward nucleus. Apical region composed of coarse tuberculate ridges, slightly less than 5 in 1 mm. Disk-shaped nodules spaced on upper surface of ridges, nodules with round cavities at their tips. Fine tubercles in area below nucleus and around uppermost ends of apical radii, tubercles increasing in size toward apical area, the uppermost part of which is more densely occupied with them. Scale pyritized.

Relationships. The scale is fragmentary along its basal margin; otherwise it shows the characteristics of *Holcolepis* von der Marck. Among the species of the genus it appears to have the greatest affinity to *H. transversus* Cockerell, a form abundant in the Benton and Mowry shale of Wyoming and Colorado. *Holcolepis nodulatus* has finer circuli than any other known species of the genus. It is also distinguished by the structure of the apical radii, which are quite broad and resemble in this respect *H. transversus.* The radii are continuous, however, and not as in *H. transversus,* where they are subdivided into overlapping sections, the lower ones sometimes pointed at the apical ends in the manner of spines. In *H. nodulatus* disk-shaped nodules are spaced on the apical radii, distinguishing this form from all other known species. So far, only the type scale has been assigned to the species. Some of the less well preserved scales attributed tentatively to *Erythrinolepis* show some similarity to the type and may belong here.

The genus *Holcolepis* is well known from the Upper Cretaceous of continental Europe and the English chalk, as well as from Syria. It was a medium-sized fish related to the modern tarpons.

Holcolepis angulatus, n. sp.

(Plate 2, figure 6)

Type. No. 10334, Calif. Inst. Tech. Vert. Pale. Coll. Scale 12.4 mm. long by 14 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6654 to 6663 feet. Moreno shale, Upper Cretaceous.

Description. Scale almost round, with an average diameter of 13 mm. Basal region with a number of very indistinct folds. Circuli very strong, coarse, 17 to 18 in 1 mm. distance, curving upward from apical section in half circles to right and left and meeting in acute angles in middle of basal part of scale; bisecting line of angles not quite in center of scale, but deviating slightly toward ventral side. Sides of angles widely curved before meeting in apex. Nucleus above lower two-fifths of scale, exactly above center of apical section. Apical part forms a small triangle, with upper angle of 60°; comparatively dense tuberculate ridges are present, 12 in 1 mm. distance, 60 in number. Region below nucleus and uppermost point of apical section ornamented with closely spaced tubercles.

Relationships. Holcolepis angulatus has a large, well characterized scale with strong, rounded circuli, distinctly angular in a median diameter, and with dense tuberculate apical ridges ornamenting the small triangular apical pole. The new species is nearly related to *H. pulchellus* Cockerell, described from a locality in Colo-

rado believed to be of Benton shale age. *Holcolepis angulatus* is distinguished by the robustness of the scale, the coarser circuli, and their pronounced median angles.

Laimingia plicata, n. g. and n. sp. TEN-POUNDER

(Plate 1, figures 3, 4; text figure 2)

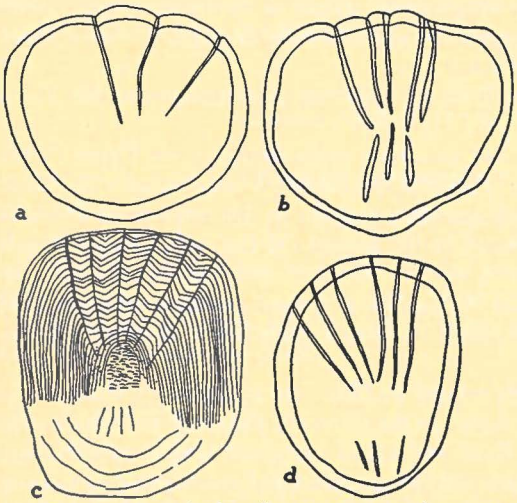

FIG. 2. *Laimingia plicata,* n. g. and n. sp. (*a*) Smooth side of ovoid scale 3 mm. long by 3.5 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4396 to 4400 feet. Moreno formation. (*b*) Mold of smooth side of rounded scale, counterpart of specimen shown in plate 1, figure 4; 4 mm. long by 4.1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6605 to 6608 feet. Moreno formation. (*c*) Coarse side of pyritized elongate scale 3 mm. long by 2.8 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6437 to 6443 feet. Moreno formation. (*d*) Smooth side of elongate scale 2.9 mm. long by 2 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4396 to 4400 feet. Moreno formation.

Genotype. No. 10307, Calif. Inst. Tech. Vert. Pale. Coll. Scale 3.2 mm. long by 4.1 mm. deep.

Type locality. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4436 to 4451 feet. Moreno formation.

Description. Scales quite variable in shape and structure, smooth and coarse sides very different. Length and depth (in millimeters) of ovoid scales, 4.9 by 5, 4.2 by 5, 3.2 by 4.8, 3 by 4.3, 2.3 by 3, 2.2 by 3, 2.1 by 3, 2 by 2.9; of elongate scales, 4.5 by 4, 4 by 3, 3.9 by 2.9, 3 by 2.5, 2.8 by 2.5; of rounded scales, 3.1 by 3.9, 3.1 by 3.1, 3 by 3. Scales small compared with those of other Cretaceous forms belonging to the family. Largest scales ovoid (pl. 1, fig. 3; text fig. 2*a*), probably belonging to midlateral and dorsal series on anterior part of fish. Ventral scales smaller, elongate (text fig. 2*c, d*) to rounded (text fig. 2*b*; pl. 1, fig. 4). Scales of posterior half of body evidently also decrease in size; probably of rounded type; lateral-line scales small, not conspicuous. Basal part of scale with robust circuli variously plicated, apical part smooth, central part reticulated. Scales comparatively thick, smooth side almost entirely even, marked only by a variable number of grooves on basal side which indicate the ridges of the plications of the basal folds; three short grooves generally present on apical part of smooth side in elongate and rounded scales, these not so well marked as basal ones. Ovoid scales with robust, almost completely transverse circuli. Few plications on ovoid scales, usually only 2 folds; 12 to 13 circuli in 1 mm. distance in middle part of type, 16 to 17 in a larger specimen of 5.5 mm. depth from Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Reticulations form a broad transverse band throughout width of scale, band deeper in center. Apical region

completely smooth. Elongate and rounded scales with circuli rounded, 20 to 21 in 1 mm. distance on basal part of scale, turning toward apical region at dorsal and ventral margins and approaching each other. About 30 circuli in 1 mm. distance dorsally and ventrally to nucleus. Apical region free of circuli. A variable number of plications in basal region, usually 3 to 6; plications of variable width; circuli plicated in acute angles. Reticulation restricted to center of scale. Apical pole smooth except for a small number of short longitudinal ridges in its center. In pyritized scales the apical region is a deep brown, the upper two-thirds a golden color; scales when not pyritized have dark-brown color.

The new genus is named for Mr. Boris G. Laiming, paleontologist of the Texas Company, California.

Occurrence. This is one of the most abundant scales found in the Upper Cretaceous of the Big Panoche Creek area. Pyritized specimens are often found with *Kleinpellia* in the Moreno formation and abundantly again in the uppermost Panoche with *Driverius* and *Paraberyx*. It occurs in the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6231 to 6300 feet, 6437 to 6616 feet, and 7096 to 7144 feet. In the Western Gulf Oil Co. well, Lillis Welch No. 1, it occurs downward from 4375 feet. A few scales were found at depths from 5010 to 5083 feet in the Pure Oil Co. well, Chowchilla No. 1.

Laimingia is evidently more closely related to *Elops,* the ten-pounder, than to any other of the numerous elopine fishes found in the Cretaceous deposits over the world. It shows a similar arrangement of basal and apical poles and central reticulations. The circuli in *Elops* are finer, the plications are rounded and much more numerous, and apical radii are present. The majority of the Cretaceous Elopidae seem to have much larger scales, similar to those of *Holcolepis.* Closely related to *Laimingia* seem to be *Trissopater* Guenther and *Rhacolepis* Agassiz, both with scales of moderate size. Neither of these forms has the strong plications seen in *Laimingia. Rhacolepis* is more primitive than *Laimingia* and shows less similarity to the scale of *Elops;* the circuli show few plications in the basal region and form very acute basolateral angles; the circuli are more widely spaced in *Rhacolepis* than in *Laimingia,* but are not so coarse. The reticulation markings are more widely spaced than the circuli and are arranged in lines. They are not readily distinguishable from the circuli above the nucleus.

Elops, the only surviving genus of this family today, lives in warm seas near shore, frequents lagoons, and enters the mouths of rivers. The numerous elopid fishes of the Cretaceous probably occupied a wider variety of habitats, and, like the tarpon of today, of the related family Megalopidae, were not so restricted to near-shore environments. There is not much doubt that they all were inhabitants of warm coastal seas.

Helmintholepis sp.

(Plate 3, figure 1)

A very large scale, measuring 16.5 mm. long by 21 mm. deep, was recovered from the Jergins Oil Co. well, Chaney Ranch No. 1, at a depth from 6605 to 6608 feet. Moreno formation.

Description. Basal region, where actual scale is preserved, with concentric circuli, fine for size of scale (30 in 1 mm. distance at basal margin) and grouped close together. Nucleus in or near center of scale. Fine apical radii indistinctly present on

mold of original scale; radii wavy, not close together. Basal margin of scale with strengthened rim, indented in median line. Smooth side of scale with numerous fine tubercles.

Discussion. This scale is tentatively assigned to Cockerell's genus *Helmintholepis.* It has similar characters, although the apical radii are more closely set in Cockerell's species *H. vermiculatus,* and the scales are longer than deep. Some similarity likewise exists between the California scale and that of the large genus *Hypsodon.* It is doubtful to which family *Helmintholepis* belongs.

Family ALBULIDAE. Ladyfishes

Kleinpellia morenoensis, n. g. and n. sp.

(Plate 1, figure 1; text figure 3*a, b*)

Type. No. 10304, Calif. Inst. Tech. Vert. Pale. Coll. Scale 7.2 mm. long by 7 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6595 to 6605 feet. Moreno formation.

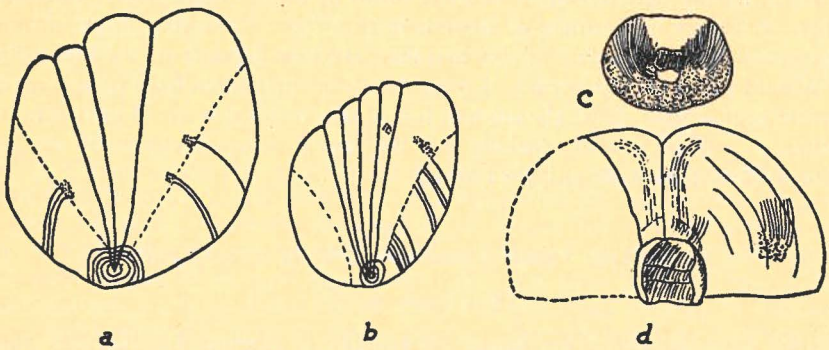

Fig. 3. *Kleinpellia morenoensis,* n. g. and n. sp. (*a*) Type, no. 10304 C.I.T. Scale 7.2 mm. long by 7 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6595 to 6605 feet. Moreno formation. (See also pl. 1, fig. 1.) (*b*) Scale 6 mm. long by 4.2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6492 to 6497 feet. Moreno formation. (*c*) Lateral-line shield of *Kleinpellia*?, 4 mm. long by 3 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 4977 to 5049 feet. Panoche formation. (*d*) Lateral-line shield of *Kleinpellia*?, 5 mm. long by 8.4 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 4737 to 4751 feet. Panoche formation.

Description. Scales longer than deep. Measurements (in millimeters) of length and depth in typical scales: 7.5 by 6.8, 7 by 6, 6 by 4.2. Two to 4 long basal folds present, extending toward apical focus. Folds of irregular width, the central one often much broader than others. Basal and apical borders and, to a lesser extent, dorsal and ventral borders rounded. Basal border scalloped; scallops slight, rounded. Longitudinal circuli present in apical part of scale, rounded toward median line and continuing through three-quarters length of scale on outer borders. Circuli comparatively coarse, 17 in 1 mm. distance on scale 7.5 mm. long. Basal part and entire middle covered by tuberculations comparable to those found in the living *Albula*

and *Dixonina,* but much less regularly arranged. Nucleus apical, surrounded by a number of circuli that form almost a complete circle; longitudinal circuli in dorsal and ventral parts of apical pole terminate directly in apical border. In *Albula* and *Dixonina* a thin, smooth border continues scale at apical pole. This border may have been lost in the fossils.

The new genus is named for Mr. Robert M. Kleinpell, paleontologist.

Occurrence. Kleinpellia is abundant in certain sections of the Moreno formation near Big Panoche Creek, and is found occasionally in the Panoche formation. It occurs in cores of the following wells: Jergins Oil Co., Chaney Ranch No. 1, at depth from 6287 to 6292 feet, and more abundantly between 6437 and 6605 feet; Western Gulf Oil Co., Lillis Welch No. 1, at depth from 4436 to 4451 feet; Pure Oil Co., Chowchilla No. 1, at depth from 4977 to 5010 feet. Specimens from the first two wells were found in the Moreno formation, those from the third well in the Panoche formation. Most of the scales were pyritized.

This scale is more similar to scales of living albulids than any fossil found before. The basal border of the scale is not so strongly scalloped, however, and the scallops are not pointed. There are differences in the reticulations and tuberculations and in the formation of the apical pole, as is mentioned above. The albulids represent primitive types of fishes among the Isospondyli, the two surviving genera, *Albula* and *Dixonina,* having been regarded as relict forms of a once more widely distributed family. Existence of a variety of albulids in the Upper Cretaceous might therefore be expected. It is interesting to note that the California deposits are the first to yield true albulid forms for this period. Living Albulidae are known from pelagic regions of warm coastal seas. Since the modern forms have retained many of their primitive features, it may be safe to conclude that the family occupied essentially the same habitat in Cretaceous time as it does today.

Lateral-Line Shields Tentatively Referred to Kleinpellia

(Text figure 3*c, d*)

Certain bony structures are found occasionally in stratigraphic horizons where *Kleinpellia* also occurs. These show an ornamentation similar to that of the scale of *Kleinpellia,* and may be lateral-line scutes of this form. These structures have different dimensions; the scutes probably varied in size in the same specimen, decreasing in diameter toward the caudal end. Measurements (in millimeters) of length and depth of individual scutes vary as follows: 5 by 8.4, 4 by 3, 2 by 2.5.

The largest scute shows the following characters: Posterior end smooth, notched in middle line, posterior border of both halves rounded; anterior border almost straight or slightly concave, interrupted by very prominent cavity for lateral-line channel. Circuli originate at some distance from posterior border, curve forward, and are lost anteriorly in a group of densely placed irregular tubercles. This ornamentation closely resembles that found on scales of *Kleinpellia.* Smaller scutes show smooth apical region restricted to middle of apical pole, or missing. Lateral-line cavity varies in position.

Occurrence. Moreno formation at depth from 6507 to 6514 feet, Jergins Oil Co. well, Chaney Ranch No. 1. Panoche formation at depth from 4737 to 4751 feet and from 4977 to 5049 feet, Pure Oil Co. well, Chowchilla No. 1.

Family ICHTHYODECTIDAE

Ichthyodectes sp.

One small fragment representing not quite half a scale, from the Pure Oil Co. well, Chowchilla No. 1, at depth from 4977 to 5010 feet, in the Panoche formation. The original scale measured approximately 4 mm. long by 9 mm. deep. The scale shows numerous short grooves in the basal region; concentric circuli are present in the basal part. The apical part is smooth except for indistinct reticulations.

Family CLUPEIDAE. Herrings

Driverius cretaceus, n. g. and n. sp.

(Plate 3, figures 3, 4; text figure 4)

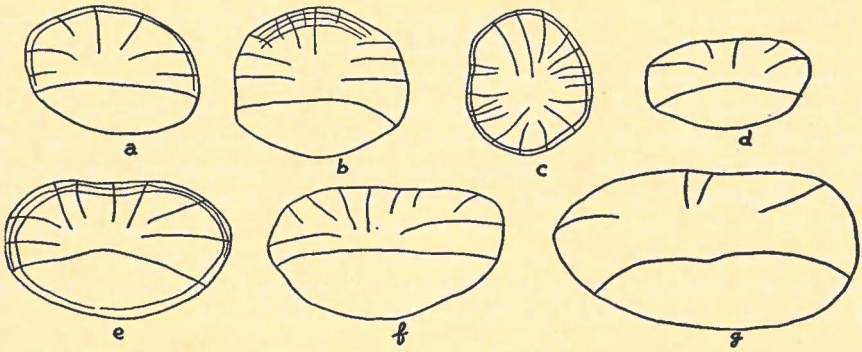

Fig. 4. *Driverius cretaceus,* n. g. and n. sp. (*a*) Scale 3 mm. long by 4 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 5060 to 5065 feet. Panoche formation. (*b*) Scale 3.5 mm. long by 4 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7130 to 7137 feet. Panoche formation. (*c*) Scale 3.5 mm. long by 3 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. (*d*) Scale 2.2 mm. long by 3.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7086 to 7095 feet. Panoche formation. (*e*) Scale 3.8 mm. long by 5.2 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 5060 to 5065 feet. Panoche formation. (*f*) Scale 3.9 mm. long by 5.1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7130 to 7137 feet. Panoche formation. (*g*) Scale 4 mm. long by 7 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7086 to 7095 feet. Panoche formation.

Type. No. 10305, Calif. Inst. Tech. Vert. Pale. Coll. Scale 3 mm. long by 4 mm. deep.

Cotype. No. 10306, Calif. Inst. Tech. Vert. Pale. Coll. Scale 4.1 mm. long by 7 mm. deep.

Type locality. Type from Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Cotype from the same well, at depth from 7003 to 7009 feet. Panoche formation.

Description. Scales oval, much deeper than long. Measurements (in millimeters) of length and depth of typical specimens: 5 by 6, 4 by 7, 3 by 5, 3.5 by 4.25, 3 by 3.5. Circuli in basal region almost entirely transverse, basal circuli finer near nuclear area, much coarser at lateral margins, 30 to 32 circuli in 1 mm. distance at dorsal margin;

34 to 36 in 1 mm. distance dorsal to nucleus in average scale 3 mm. long by 5 mm. deep. Three to 9 basal radii, spreading in various directions; apical and basal parts of scale divided by a transverse radius. One or 2 paired transverse radii present, very rarely more; 1 to 7 longitudinal basal radii directed toward nucleus, their direction variable. Apical pole smooth, structureless. One to 3 folds on outer border of scale in majority of scales. Ventral scutes, typical of the true herrings, found with scales.

The new genus is named for Mr. Herschel L. Driver, paleontologist of the Standard Oil Company of California.

Occurrence. This scale is extremely abundant in the uppermost layers of the Panoche formation in the region of Big Panoche Creek. It occurs abundantly in the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7003 to 7144 feet, and in the Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4886 to 5242 feet.

This species is clearly related to the group of Clupeidae characterized by a long tail part, long anal fin, and short head and thoracal part of body. Representatives of this group are the genera *Pellona, Opisthopterus, Pristigaster, Pliosteostoma.* Like these, *Driverius* has oval scales that are deeper than long. Furthermore, vertical basal radii are present in variable number and direction, whereas paired transverse radii are reduced in number. No close relationship to any one species can be established. *Driverius* shows similarity to *Pliosteostoma lutipinnis,* which lives today along the Pacific coast of Mexico. In the former type, however, the scale has a smooth apical pole, the circuli are more strictly transverse, and the basal radii are straighter and differently arranged. All the types belonging to this group of herrings are inhabitants of warm coastal waters, especially near river mouths.

Bramlettia cf. **chicoensis** (Cockerell)

(Text figure 5)

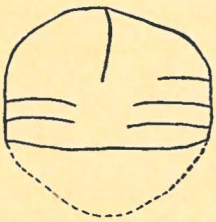

FIG. 5. *Bramlettia* cf. *chicoensis* (Cockerell). Basal part of scale 5.5 mm. long by 8 mm. deep; apical part restored. Pure Oil Co. well, Chowchilla No. 1, at depth from 4737 to 4856 feet. Panoche formation.

Pomolobus chicoensis Cockerell (1919).

Description. Only two scales of this form have been found. Basal part of larger one measures 5.5 mm. long by 8 mm. deep. In this specimen the apical pole is missing. Smaller scale measures 4 mm. by 4.5 mm. Scale ovoid, slightly deeper than long. Circuli almost entirely transverse in basal region; comparatively coarse, but finer in small area near nucleus; 24 to 25 circuli in 1 mm. distance near upper border of large scale, 36 to 37 in region dorsal to nuclear center. Apical and basal parts of scale divided by almost straight transverse radius; 2 to 3 pairs of transverse radii present, parallel to lower border of basal part. Two lower pairs of transverse radii close together, upper one slightly oblique and farther removed. Upper two-fifths of basal region without transverse radii; a median longitudinal fold distinct.

The new genus is named for Dr. M. N. Bramlette, of the U. S. Geological Survey.

Occurrence. Both scales were found in the Pure Oil Co. well, Chowchilla No. 1, in the Panoche formation, at depth from 4737 to 4856 feet.

The scale described by Cockerell as *Pomolobus chicoensis,* from the Moreno formation of Ortigalito Creek, may be specifically identical with the scales described above. The Panoche Creek form, however, is not comparable to the living *Pomolobus.* The latter is larger than the fossil described by Cockerell and shows a more detailed sculpturing. *Bramlettia* differs from the living *Pomolobus* in the arrangement and in the smaller number of paired transverse radii, and in the large size of that part of the basal pole free of such radii. Small scales of *Bramlettia chicoensis* appear to resemble the young of *Pomolobus pseudo-harengus,* but more clearly defined differences appear in the larger scales.

Family ENCHODONTIDAE

Enchodus sp.

Upper and lower jaws as well as parts of the vertebral column of an enchodontid fish, evidently a species of the genus *Enchodus* Agassiz, were found associated with the skeleton of a mosasaur, no. 2750, Calif. Inst. Tech. Vert. Pale. Coll., at C.I.T. locality 331, 440 feet above the base of the Moreno formation exposed in NW. ¼ Sec. 36, T. 14 S., R. 12 E., Mt. Diablo B. and M. This fish had served as food for the marine reptile.

Family SALMONIDAE. Salmons

Natlandia ornata, n. g. and n. sp.

(Plate 2, figures 1, 3)

Type. No. 10308, Calif. Inst. Tech. Vert. Pale. Coll. Scale 7.7 mm. long by 5.2 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6507 to 6514 feet. Moreno formation.

Description. Comparatively large ovoid to round scales, longer than deep. Measurements (in millimeters) of length and depth vary as follows: 9 by 6.9, 7.2 by 6, 6.3 by 6, 6.9 by 5.9, 5.5 by 6.1, 5.2 by 4.4, 4.1 by 3.2, 3 by 2.5. No basal folds. Uniform concentric circuli occupy basal, dorsal, and ventral parts of scale; apical region almost smooth. Nucleus high, situated above center but slightly below upper third of scale. Nucleus surrounded by more or less complete circuli that form a keystone or oval shape. Circuli thin and widely spaced, becoming increasingly coarser toward outer margin. Circuli end abruptly toward apical pole; central ones shortest, increasingly longer toward exterior margin of scale, outermost circuli almost reach apical margin. Apical region therefore forms a high triangle with acute upper angle, in contrast with that in related living scales, where circuli end in almost a straight line toward apical region. Twelve to 14 circuli in 0.5 mm. distance in nuclear region, circuli here separated by distances greater than their width; 20 to 21 in 1 mm. distance at outer margin of scale in type. Circuli very coarse here, closely set. Focal point of scale in center of nucleus free of circuli. Ornamentation present in nuclear region, spreading toward apical pole, where it is much denser; upper part of apical region often smooth. Outer margin of scale often folded 2 to 3 times; posterior border generally broken off. Comparatively feeble apical radii may be present toward outer margin of apical

pole. Some scales show entire center of scale free of circuli; possibly these are regenerated or otherwise atypical scales.

Scale figured in plate 2, figure 1 probably is a lateral-line scale of this species. The circuli are finer, however, 27 in 1 mm. distance near outer margin; center of scale and apical region free of circuli; short apical radii present, central 2 strengthened. This scale may represent a different species, characterized by finer circuli. A number of additional scales (length and depth 7 by 6.5, lateral-line scale; 6.7 by 6.2, 4 by 5 mm.) seem also to show finer circuli than others. These scales seem comparatively deeper in proportion to length, but they are never well preserved. Both types occur together in the same horizons, and for the time being it does not seem advisable to assign them to different species.

The new genus is named for Mr. M. L. Natland, paleontologist of the Richfield Oil Corporation, California.

Occurrence. This form is very abundant in the Moreno and uppermost Panoche formations of the Big Panoche Creek area. It occurs in the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 7137 feet, and in the Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4396 to 4789 feet.

Relationships. The scale shows near relationship to those of the living salmons. The arrangement of circuli on basal and apical poles is very similar. The nucleus of the Cretaceous form, however, is situated higher; the arrangement and shape of the nuclear circuli are different; the circuli also reach farther apicad at the outer margin of the scale, and do not show the straight-cut lower border found in Recent salmons. The Cretaceous scales are thicker and have a coarser ornamentation in the form of a reticulation of the apical region, especially marked in the center of the scale. This ornamentation is especially marked on pyritized scales, where it has a golden color, whereas other parts of the apical pole are a dark, glossy brown. Ichthyologists and geologists would be particularly interested in knowing the individual ages these Cretaceous salmons attained, and whether they actually were migratory fish as are the living salmons. A statement concerning these questions is difficult to make in view of the state of preservation of the fossil scales. There is also no information available as to the size of the fish and as to the specific environment in which it occurred. Both items are of significance in an attempt to interpret the habits of present-day salmon on the basis of scales. Leo Shapavalov, senior fisheries biologist of the Division of Fish and Game, State of California, who has devoted particular attention to the study of salmon, examined the Cretaceous scales and kindly furnished the following statement (letter of April 7, 1943): "The scales are all too fragmentary or regenerated for me to feel justified in attempting to state ages. Two or three show one or two checks that have the appearance of annuli, but other annuli may be obscured or obliterated. In none of the scales do I see sharply differentiated growth, as we find in present-day salmon and trout that have spent a part of their life in fresh water and a part at sea. On this basis I would say that I have no indication that the fish represented by the present scales migrated from fresh water to the sea, but I would not state positively that they had not. The more or less uniform growth in the different scales indicates that the fish had spent their lives in a similar environment." It is apparent that the environment was marine during the Upper Cretaceous time when the sediments containing the fish scales were deposited. Thus the conclusion may be reached that the Cretaceous salmon spent their entire life in the sea or possibly in brackish water. It is also likely that the majority of the fossil scales are from fish older than 1 year and probably from individuals 2 to 4 years old.

Goudkoffia delicata, n. g. and n. sp.

(Plate 2, figure 2)

Type. No. 10309, Calif. Inst. Tech. Vert. Pale. Coll. Scale 4.2 mm. long by 4 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation.

Description. Scale rounded to oval, length and depth (in millimeters) 3.1 by 3, 4.5 by 3, 3.8 by 3. Scales generally very thin and delicate, preserved only under favorable conditions, where shale is not too strongly compressed. Basal region almost evenly rounded, showing a very faint, irregular folding; 3 to 4 vertical radii present, dividing circuli of basal region. Circuli comparatively fine, concentric, rounded in basal region, meeting in acute angle in median line of apical pole; 28 in 1 mm. distance at outer margin of basal region, those at apical pole much finer, 34 in 1 mm. distance. Nucleus almost central or sometimes above center of scale. Apical pole may be continued with smooth triangular part prolonging scale posteriorly into a thin appendage; this, however, is folded and not preserved in original condition.

The new genus is named for Dr. Paul P. Goudkoff, paleontologist, of Los Angeles, California.

Occurrence. The scale is found occasionally in the stratigraphic sequence from the Lower Moreno to uppermost Panoche formation of the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6507 to 7144 feet.

Relationships. Goudkoffia is not unlike the preceding form except for the smaller size, the finer circuli, and the continuation of the circuli into the upper section of the apical pole, where they meet in an acute angle. The extreme posterior margin of *Goudkoffia* may be smooth, whereas in *Natlandia* the entire apical region is free of circuli, showing reticulations in places. *Goudkoffia* is probably a salmon-like fish, smaller and more delicate than the preceding form. All living salmon scales are unlike *Goudkoffia* in lacking an apical pole with angular circuli, although a number of forms have uninterrupted concentric circuli. Some of the living Anacanthini show scales similar to the fossil; all of these are degenerate small scales, much thinner than the specimen described here. Anacanthini have not been described from the Cretaceous.

ORDER INIOMI

Family CHLOROPHTHALMIDAE

? **Sardinioides californicus,** n. sp.

(Text figures 6, 7)

Type. No. 10313, Calif. Inst. Tech. Vert. Pale. Coll. Scale 5 mm. long by 6 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Moreno formation.

Description. Type a comparatively large, thin scale, irregularly twisted and bent in rock. Part of ventral edge missing. Other, and for the most part smaller, specimens from the same locality and horizon measure (length and depth, in millimeters): 3 by 2.5, 2 by 1.9, 2.5 by 1.9, 4 by 2; lateral-line scales, probably of same species, measure 2 by 2.5, 2.2 by 2.5 mm.; and a single scale, probably of a related species,

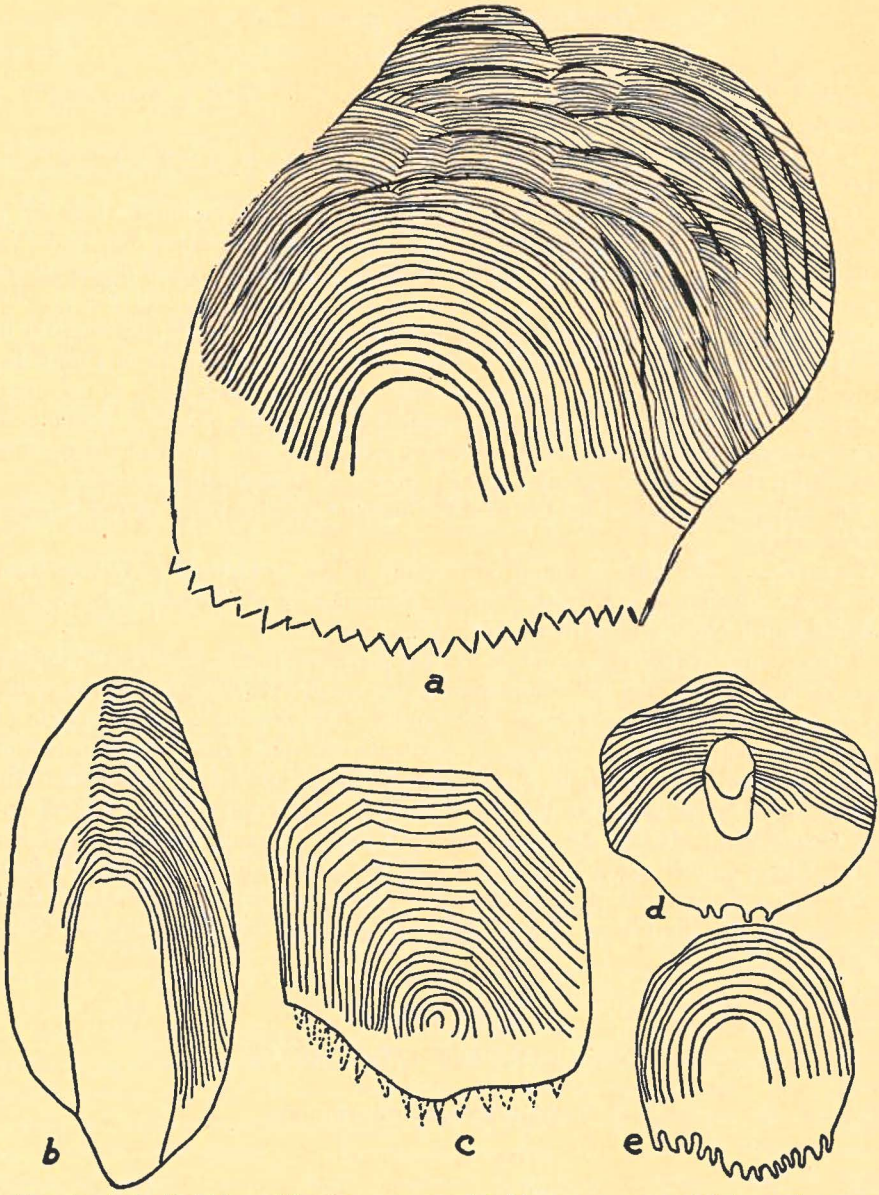

FIG. 6. ? *Sardinioides californicus*, n. sp. (*a*) Type, no. 10313 C.I.T. Scale 5 mm. long by 6 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Moreno formation. Scale distorted, spines incompletely preserved. (*b*) Scale 4 mm. long by 2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Moreno formation. (*c*) Scale 2 mm. long by 1.9 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Moreno formation. (*d*) Scale 2 mm. long by 2.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6605 to 6608 feet. Moreno formation. (*e*) Scale 3 mm. long by 2.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Moreno formation.

FIG. 7. ? *Sardinioides* sp. Scale 2.2 mm. long by 3 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 4629 to 4636 feet. Panoche formation.

from the Pure Oil Co. well, Chowchilla No. 1, at depth from 4629 to 4636 feet, measures 2.2 by 3 mm. Basal region without definite folds; circuli in some scales concentric, evenly rounded, in others showing definite curvature in 2 or 3 diagonal lines through basal part. Circuli restricted to basal part of scale, forming fine lines, characteristically separated by large distances in center of scale and more and more close-set toward outer margin. Circuli quite dense at basal margin of type. In figured scales (fig. 6) distances do not vary much. In the type there are 13 circuli in 1 mm. distance at center of scale, 32 at basal margin. In the scale shown in figure 7 there are 22 circuli in 1 mm. distance. Apical pole smooth, with one row of serrations on its margin; these are more or less flat, not well formed spines, and form a direct continuation of scale; number and shape of serrations irregular. Lateral-line scales are typical for family and for the Iniomi in general: very fine circuli, more or less transverse, restricted to basal border of scale, those around center of scale shortening rapidly; circuli directed obliquely apicad at dorsal and ventral borders; serrations few and usually in middle of apical border.

Occurrence. The scales described above were found occasionally at several horizons, nowhere in great numbers. Some occur in the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6287 to 6292 feet. Lateral-line scales probably of the same species occur in the same well at depth from 6605 to 6608 feet, and in the Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4960 to 4965 feet. A single scale was found in the Pure Oil Co. well, Chowchilla No. 1, at depth from 4629 to 4636 feet.

Relationships. All scales described above belong to the order Iniomi, which includes a wholly bathyal group of fishes. All these scales were found in small numbers at different horizons, and it is doubtful if they all belong to one species. The single scale found in the Pure Oil Co. well, Chowchilla No. 1, probably belongs to a different species and may even belong to another family of the order, the Myctophidae, or lantern fishes. All the remaining scales described probably belong to one species. They show the typical characters of the Chlorophthalmidae, with widely spaced circuli around the nucleus and very fine circuli at the basal margin in the larger scales, the circuli being evenly rounded in some scales, curved to indistinct folds in others, and the apical border having one row of serrations. Also the lateral-line scales (fig. 6*d*) are typical of *Chlorophthalmus*. The scales in this genus show considerable variation in different parts of the body, and an extreme type is represented in figure 7. The latter scale, however, seems to have stronger serrations at the apical pole, and the circuli around the nucleus are not so widely spaced. Characteristic of all these deep-water types of the Iniomi is the fineness of the circuli, representing fine, shallow grooves, quite different from the coarse, elevated ridges seen in scales of some of the other families.

Fishes of the order Iniomi are found abundantly in Cretaceous deposits of other parts of the world. Nearly all of these have been attributed to the Myctophidae (= Scopelidae). Woodward, however, (1902, p. 33), although assigning the genus *Sardinioides* von der Marck to the Scopelidae, demonstrates its close relationship to the Chlorophthalmidae, *Chlorophthalmus* and *Aulopus*. The scales found in the Moreno of California certainly show a relationship to *Chlorophthalmus*, and it

is not unlikely that the California form is identical with *Sardinioides,* to which it is provisionally assigned. *Sardinioides* is common in the Upper Cretaceous of Westphalia, Mount Lebanon, and the English chalk. No doubt the Iniomi were represented by a number of families in the Upper Cretaceous. The genera *Sardinius, Leptosomus,* and *Rhinellus* are known from Cretaceous deposits of the United States.

ORDER ANACANTHINI

? Superfamily MACROUROIDEA

Rankinia macrouriformis, n. g. and n. sp.

(Text figure 8)

Fig. 8. *Rankinia macrouriformis,* n. g. and n. sp. Type specimen, no. 10314 C.I.T. Scale 4 mm. long by 4.2 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 5010 to 5048 feet. Panoche formation. Dorsoapical part, bent upward in rock. (Drawn from photograph.)

Type. No. 10314, Calif. Inst. Tech. Vert. Pale. Coll. Scale 4 mm. long by 4.2 mm. deep; slightly bent in the rock.

Type locality. Pure Oil Co. well, Chowchilla No. 1, at depth from 5010 to 5048 feet. Panoche formation.

Description. Scales quadrangular to rounded, delicate. No definite folds in basal part of scale. Circuli bent in laterobasal diagonals and through median line, but not very prominently; otherwise basal circuli evenly rounded and concentric. Nucleus little below center of scale (type shown in figure 8 is shortened in apical part, since apicodorsal part is bent upward into the rock). Circuli are fine lines, 26 in 1 mm. distance in center of scale, distances between circuli much wider than width of circuli. Circuli in apical pole continuous with basal ones, but divided in a series of acutely angled serrations. Apical border serrated following the lines of the outermost circuli.

The new genus is named for Mr. Wilbur D. Rankin, paleontologist, of Los Angeles, California.

Relationships. Rankinia is a well defined and characteristic type of scale. As yet no recent scale has been seen which agrees with it. It seems likely that the fossil belongs to the Anacanthini, and it is tentatively referred to the macrouriform fishes. Delicate cycloid scales of the type of *Rankinia,* with circuli in part concentric and in part with irregular zigzag patterns, are found in this group among the Bathygadinae, but the circuli in scales of the latter group seem to be directed perpendicularly to the apical and basal borders. Many macrourid fishes show a series of serrations of the circuli in the apical pole and concentric curved basal circuli, showing more or less distinctly marked angles in the diagonals of the scale, like those seen in *Rankinia;* but they all either are ctenoid or at least show strong ribbing. It is quite possible that *Rankinia* is an extinct ancestor of some group of the Anacanthini, possibly intermediate between Gadoidea and Macrouroidea. For the present, however, there is no certain character to prove this relationship. All the Recent fishes mentioned above are deep-sea forms.

ORDER BERYCOMORPHI

Family HOLOCENTRIDAE

Paraberyx californica, n. g. and n. sp.

(Plate 1, figures 5, 6; text figure 9)

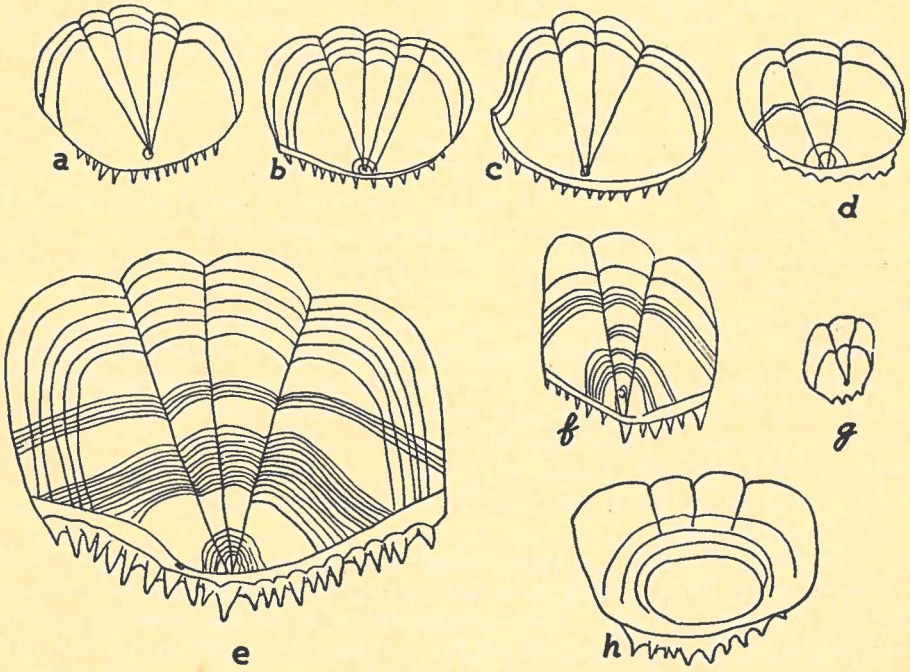

FIG. 9. *Paraberyx californica,* n. g. and n. sp. (*a*) Coarse side of scale 3.1 mm. long by 4 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. (*b*) Smooth side of scale 3 mm. long by 3.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7086 to 7095 feet. Panoche formation. (*c*) Smooth side of scale 3.1 mm. long by 3.9 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7077 to 7086 feet. Panoche formation. (*d*) Mold of smooth side of scale 2.5 mm. long by 3 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. (*e*) Type specimen, no. 10310 C.I.T. Coarse side of scale 2.9 mm. long by 3.2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. (*f*) Cotype, no. 10311 C.I.T. Scale 2 mm. long by 2.1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7095 to 7104 feet. Panoche formation. (*g*) Coarse side of scale 1.5 mm. long by 1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. (*h*) Mold of smooth side of scale 3.5 mm. long by 4.8 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7077 to 7086 feet. Panoche formation.

Type. No. 10310, Calif. Inst. Tech. Vert. Pale. Coll. Scale 2.9 mm. long by 3.2 mm. deep.

Type locality. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation.

Cotype. No. 10311, Calif. Inst. Tech. Vert. Pale. Coll. Scale 2 mm. long by 2.1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7095 to 7104 feet.

Description. Scales small, oval to semirounded, larger scales fan-shaped, very small ones quadrangular. Average scale sizes (length and depth, in millimeters): 3.9 by 5, 3.9 by 4, 3.2 by 4, 3.1 by 3.9, 3 by 3.1, 2.1 by 3, 1.9 by 2, 1.5 by 1. Two to 3 very pronounced folds pass through basal part of scales, deeply scalloping the basal margin; these extend almost through entire scale to subapical nucleus. Circuli coarse and close-set, 30 in 1 mm. distance in central part of type, 28 in apical region of a larger scale, 38 toward basal margin in the same specimen. Basal circuli transverse, slightly curved, ending at ventral and dorsal margin of scale; circuli more curved toward apical region, most central ones form half circle around nucleus and end near apical border. Marginal ends of circuli sometimes straight, generally curved upward (pl. 1, fig. 5). All circuli follow curves of central folds; course of circuli in basomarginal region variable, following exterior shape of scale. In smaller scales, only the stronger curved central circuli present. Nucleus very low, almost on apical border. Apical part restricted to posterior border, which is smooth and free of circuli, equipped with a row of strong, compact spines. Apical margin corrugated where spines are attached. Apical margin thickened with an elevated rim on smooth side of scale (pl. 1, fig. 5; text fig. 9*b, c*). Outer margin of scale folded concentrically with 2 or 3 or more folds; these folds partly due to annual growth of scale, folding evidently increased by compression of scale in rock. Dividing line of vertical folds indented on smooth side of scale (pl. 1, fig. 5). Atypical scales of the form show center free from circuli and surrounded by large oval lines, the folds marked only in marginal basal region.

Occurrence. This scale is extremely abundant in the horizons in which *Driverius cretaceus* occurs, that is, mainly in the uppermost strata of the Panoche formation in the Big Panoche Creek area. Numerous specimens have been preserved in cores of the Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7086 to 7141 feet; and in the Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4886 to 5065 feet.

Relationships. Paraberyx has the typical structure seen in Cretaceous berycomorph fishes, with the subapical nucleus, a small number of strong vertical folds extending through scale toward nucleus, and compact spines. Numerous berycomorph fishes have been described from Cretaceous deposits, and pectinated scales of similar structure are known from the Cthenothrissoidea. Several other genera, for example, *Pseudoberyx* Pictet and Humbert, referred to the Clupeidae by some authors, are also said to have pectinated scales of similar type. The scales of *Paraberyx* are small but show the robust structure of adult fish. Indications of annual rings and folding of the exterior margin of the scale seem to show ages of several years in most cases. The scales undoubtedly belong to a small genus with bercycomorph relationship. They do not show a broad, thickened apical region, only the exterior margin of the apical pole being elevated. The apical spines are almost completely without keels. The scales are, therefore, not closely related to *Beryx* or *Haplopteryx. Ctenothrissa* also has the apical pole thickened through a larger area. Shape and attachment of the apical spines are reminiscent of the Holocentridae, but they are not at all or only slightly extended in apical keels. Holocentric fishes are the most primitive Berycomorphi, as Cockerell states (1919, p. 187), and *Paraberyx* is

evidently related to this group. Hussakoff (1929) described a small holocentrid form from the Niobrara of Kansas, namely, *Kansius sternbergi*. The Californian form may be a related type. For the time being it does not seem possible to attribute the Californian scale to a distinct genus of the Berycomorphi. This order was well developed in the Cretaceous and showed greater diversity of type than it does today. The Percomorphi have probably taken the place of the Berycomorphi in some habitats. The recent Berycomorphi are to a large extent deep-water forms, the Holocentridae abounding in coral reefs and other rocky parts of warm seas. *Paraberyx* evidently was a shallow-water form, as is indicated by the coarse structure of the scale and its relationships.

Family TRACHICHTHYIDAE

Rothwellia trachichthyiformis, n. g. and n. sp.

(Text figure 10)

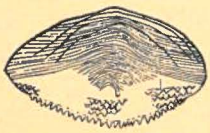

FIG. 10. *Rothwellia trachichthyiformis,* n. g. and n. sp. Type, no. 10312 C.I.T. Scale 2.5 mm. long by 4 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 4955 to 4974 feet. Panoche formation.

Type. No. 10312, Calif. Inst. Tech. Vert. Pale. Coll. Scale 2.5 mm. long by 4 mm. deep.

Type locality. Pure Oil Co. well, Chowchilla No. 1, at depth from 4955 to 4974 feet. Panoche formation.

Description. Scale oval, much deeper than long, and evidently from the midlateral series on the fish. Scale quite delicate, broken or fragmentary. Basal part with slightly curved circuli, but not marked by distinct folds. Circuli present in basal part only, comparatively fine shallow grooves, at some distance apart; about 24 in 1 mm. distance through median line of scale. Circuli nearest to basal margin transversely rounded, ending in dorsal and ventral margins of scale. Distance between adjacent circuli widening toward margin of scale; this is especially true for lowermost circuli, which end much more obliquely in dorsal or ventral margin. Circuli nearing center of scale curve around nucleus; these are short and end free toward apical pole. Apical region with several rows of staggered broad, flat spines, upper rows inserted above bases of next lower row. One row of fine spines along apical margin. Basal margin folded concentrically several times.

The new genus is named for Mr. W. Thomas Rothwell, Jr., paleontologist of the Richfield Oil Corporation, California.

Discussion. Only one scale of this delicate form has been found. The impression of the smooth side is complete; the scale is fragmentary in places. It undoubtedly belongs to a berycomorph form and is probably nearly related to the Trachichthyidae of today, a family of the deep-water Berycomorphi. Woodward (1902, p. 29) described the genus *Trachichthyoides* from the English chalk; it resembles *Trachichthys* and *Gephyroberyx*. The delicacy of the scale and its structure indicate that *Rothwellia* lived in at least a bathyal habitat. In the Trachichthyidae the length-depth proportions of the scales are quite variable, the mid-lateral scales being deepest. It is likely that the Cretaceous genus showed similar differences in shape of its scales, and that the scale described here belongs to the lateral series.

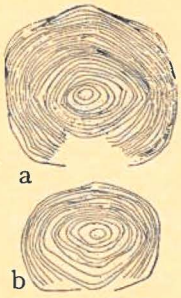

FIG. 11. Incertae sedis (Carangoidea?) (*a*) Scale 2.8 mm. long by 3 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6292 to 6297 feet. Moreno formation. (*b*) Scale 1.7 mm. long by 2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6437 to 6443 feet. Moreno formation.

ORDER PERCOMORPHI

SERIES CARANGIFORMES

Incertae sedis

(Text figure 11)

Description. Scales quadrangular to rectangular; length and depth (in millimeters): 2.8 by 3.2, 2.2 by 2.8, 2 by 2, 1.5 by 2. Circuli concentric; those around focus widely spaced, irregular in shape, sometimes bent in places. Circuli in outer two-thirds of scale closer and more regularly concentric. Apical pole evidently lost; it may have been smooth and less resistant. Ornamentation in form of tubercles or very short lines in middle of scale and toward apical pole.

Discussion. Small scales like those described above and generally pyritized are found in the Moreno formation. All are somewhat distorted and incomplete. They remind one of the living Carangidae. The scales are thicker than the degenerate carangoid scales found in modern forms. The circuli are more irregularly arranged, and reticulations are present. Evidently these scales are less resistant to wear than the larger specimens, and are preserved only under favorable conditions, if pyritized. They occur with *Natlandia ornata,* and may be atypical scales of that form. The circuli, however, are arranged differently, and become finer toward the outer margin. Carangiformes have been described from Cretaceous deposits elsewhere, and it is quite possible that the scales here described belong to this order.

ANALYSIS OF PISCINE ASSEMBLAGES

The following fish forms have been identified thus far in the Upper Cretaceous of California:

A. Large skeletal fragments from the Moreno formation of the Panoche Hills

Protosphyraena sp.	Enchodus sp.
Pachyrhizodus sp.	Vertebrae of large selachians

B. Scales from subsurface sections of the Moreno formation in Panoche Creek and in the Firebough area

	Rare, poorly preserved	Moderately abundant	Abundant, well preserved
Corax sp.	+	?	..
Erythrinolepis cf. chicoensis	..	+	..
Holcolepis angulatus	..	+	..
Holcolepis nodulatus	..	+	..
Laimingia plicata	..	..	+
Helmintholepis sp.	+	..	..
Kleinpellia morenoensis	..	..	− +
Natlandia ornata	..	..	+
Goudkoffia delicata	..	+	..
? Sardinioides californicus	..	+	..
Carangoidea	..	+	..

C. Scales from subsurface sections of uppermost Panoche formation (shale deposits) in the Panoche and Firebough districts

	Rare, poorly preserved	Moderately abundant	Abundant, well preserved
Erythrinolepis cf. chicoensis	+	..	..
Laimingia plicata	..	..	+
Kleinpellia morenoensis	+	..	..
Driverius cretaceus	..	..	+ +
Natlandia ornata	..	+	..
Goudkoffia delicata	+	..	..
? Sardinioides californicus	+	..	..
Paraberyx californicus	..	..	+ +

D. Scales from subsurface sections of the Panoche formation in the Chowchilla district (mostly sandy deposits and sandy shales)

Laimingia plicata	+	..	..
Kleinpellia morenoensis	+	..	..
Ichthyodectes sp	+	..	..
Bramlettia chicoensis	..	+	..
? Sardinioides sp	..	+	..
Rankinia macrouriformis	..	+	..
Rothwellia trachichthyiformis	..	+	..

The fish fossils described here are for the most part new genera and species. This is to be expected in a geologic section such as that represented by the thick sequence of strata of the California Upper Cretaceous, which is almost unexplored for fish. Most of the new types are established on the basis of fish-scale characters, and it has been found possible, in almost all cases, to make a reliable identification of the families and genera, and to determine their relationships. Two species apparently belong to kinds of fish found previously in California, namely, *Erythrinolepis chicoensis* Cockerell and *Bramlettia chicoensis* (Cockerell). The scales of three additional genera agree with forms found commonly in other Cretaceous deposits, namely, *Holcolepis* ?, *Sardinioides,* and *Ichthyodectes.* The scales of most of the genera of Cretaceous fish that have been described from skeletal remains are not known. This is particularly true for the Cretaceous fish of North America. Later it may be possible to show that some of the genera herein named on the basis of scales belong to fish already described from skeletal remains.

The Cretaceous forms listed above can be grouped in different assemblages, according to their place of occurrence and their habitat. All these groups indicate faunas of coastal water, and none can be regarded as living in a true deep-sea habitat.

The geologic sections in the Panoche Creek and Firebough districts show two characteristic fish zones at different horizons: The upper fish zone is characterized by remains from the Moreno formation as listed under A and B (see above). The fish types inhabited a coastal sea and were evidently irregularly distributed over a large area. This is true for *Protosphyraena, Pachyrhizodus, Corax, Holcolepis, Kleinpellia,* and the Carangoidea; *Enchodus* may have preferred

slightly deeper water. *Erythrinolepis,* as stated by Cockerell, may be related to living fresh-water forms from South America, but it was evidently a marine type in the Cretaceous. *Laimingia* is nearly related to *Elops,* a fish genus that occurs now in near-shore waters and lagoons, and occasionally ascends rivers. *Natlandia* and *Goudkoffia* are related to the salmon, which are anadromous fishes today. ? *Sardinioides* is the only fish of these strata having a bathyal habitat, and scales of it occur infrequently. Most of the scales in section B are pyritized. The deposit undoubtedly was laid down in the neritic region of a coastal sea, with the fossils irregularly scattered over a large area of the sea bottom. Fish scales are not everywhere present in the section. In the Jergins Oil Co. well, Chaney Ranch No. 1, they occur at depths from 6206 to 6306 feet and from 6231 to 6988 feet. In the Western Gulf Oil Co. well, Lillis Welch No. 1, scales occur at depths from 3715 to 4792 feet.

A decided change occurs in the fish fauna at a deeper horizon in the stratigraphic succession. These strata have been determined by some students of foraminifera as lowermost Moreno in age and by others as uppermost Panoche. The latter determination is accepted in the present paper. The lower fish zone is very characteristic and occurs in a comparatively narrow stratigraphic interval in the section. The change in the fishes is shown best by the great abundance of two forms, *Driverius cretaceus* and *Paraberyx californicus.* Of these two, *Driverius* is closely related to a group of herrings now restricted to warm seas and generally known from coastal bays near river outlets. *Paraberyx* belongs in the group of shallow-water berycoids. *Laimingia* and *Natlandia* are quite abundant, and both forms may well be found at the mouth of a river, and therefore be deposited in a near-shore accumulation. None of the larger forms, not even *Holcolepis,* has been found as yet in the lower fish zone. They evidently are rare or absent here. Thus, the assemblage suggests a near-shore deposit accumulating apparently in the proximity of a river outlet. All the forms that are present could have lived in this kind of environment. Immediate burial of the assemblage did not occur at the place of accumulation. All the fish are completely decayed and few remains except scales are preserved. Since scales are small and light, they may have been held in suspension for some time and may have been transported by currents. Their ultimate deposition probably occurred in a deeper and quieter part of the sea. They are preserved in an organic slaty dark shale, brittle and with even splitting surfaces. The lower fish zone was found in the Jergins Chaney Ranch well at depths from 7003 to 7144 feet, and in the Western Gulf Lillis Welch well at depths from 4886 to 5242 feet.

The stratigraphic succession found in the Panoche formation of the Chowchilla region shows entirely different occurrences of fish remains. Fish forms are very rare, especially in the sandy parts, and are hardly abundant enough to provide data from which to draw many conclusions. In the subsurface interval from 4629 to 5083 feet in the Pure Oil Co. well, Chowchilla No. 1, scales were found at several horizons. Among these some are rather significant. The better-preserved scales, such as an Iniomi, *Rothwellia, Ichthyodectes,* and probably *Rankinia,* represent types living in deeper water. The strata from 4955 to 5048

feet in the section, although quite sandy, represent a bathyal deposit, and the region of accumulation was connected with the open sea.

The antiquity of the deep-sea fish fauna has been discussed by Woodward (1898). Many types related to deep-sea forms of today existed in Cretaceous times. Such deep-water types as the Iniomi and certain Berycomorphi were widely distributed. Some that are found in Cretaceous deposits may have been in a stage of transition between habitats of different bathymetric depth. Woodward (1911) states that some of the types show a more calcified skeleton than is usual in bathyal and abyssal fishes. Others were undoubtedly deep-water forms (*Tomognathus,* Woodward, 1936). There is not much doubt that the delicate scales listed above, for example, *Sardinioides* and the trachichthyiform *Rothwellia,* came from typical bathyal fish, because of their great similarity to scales of living types. The relationship of *Rankinia* is not well enough known to justify conclusions. The extinct *Ichthyodectes* is also considered a bathyal fish.

A warm climate is indicated by the majority of California Cretaceous fish. This is true for the Elopidae, Albulidae, and Holocentridae. It is especially true for *Driverius,* which seems to be related to forms now restricted to warm waters and largely distributed through the tropics. On the other hand, more or less distant ancestors of the Salmonoidea are well represented in the North American Cretaceous deposits. The California fish *Natlandia* does not seem to be far removed from the living forms. Salmonoidea are characteristically northern in habitat. This group evidently was not well established in Upper Cretaceous time, and its habitats may not have conformed to those of Recent types. Evidently *Natlandia* was not anadromous as most of the living salmons are. The Californian form, as yet known only from its scale, would represent the earliest known salmon, should it prove to be a true member of this family.

Upper Cretaceous fishes are known from a number of localities distributed over the world. Some of these localities have yielded quite diversified faunas, and progressive ages can be recognized. Upper Cretaceous faunas found in the Gabon Basin in Africa (Weiler, 1922; Arambourg and Schneegans, 1935) seem to correspond to strata of Brazil (Jordan, 1923; Jordan and Branner, 1908; Maury, 1930, 1936) and may possibly be of Cenomanian age or older. The deposits of the English chalk are of Turonian age. The strata of Westphalia and of Mount Lebanon, Syria (Woodward, 1942*a*) are Upper Senonian, the latter being slightly younger than the former. Danian fishes are found in Scandinavia (Davis, 1890) and in Persia (Priem, 1908), but neither one of these assemblages is well known. Still younger in the Cretaceous are the deposits of the Montian chalk of northern France (Priem, 1898); and the Lameta beds of India (Woodward, 1908) may be of earliest Tertiary age.

There are many indications that the Moreno and Panoche fishes occur in a late stage of the Cretaceous. The Ganoidea are represented only by *Protosphyraena.* This is the latest and largest pachycormid, common in the Upper Cretaceous of Europe and North America, and probably present also in Egypt and Patagonia. The Albulidae are represented by a form nearly related to Recent types, and not found anywhere else. The Elopidae are represented by

two species of *Holcolepis,* a genus found commonly in the English chalk, Westphalia, the Mount Lebanon deposits, and the North American interior basins. Likewise, *Laimingia* is a form much more closely related to the living *Elops* and farther developed than *Rhacolepis,* a fish of frequent occurrence in the Brazilian Cretaceous. Two true clupeids are present in California; such types are not found in the English chalk, nor in the Central American deposits, but a number of clupeids are abundant in Syria. *Diplomystus,* however, the double-armored herring, which may have had scales of clupeid type, was already present in the Lower Cretaceous of Brazil. Also salmon are represented by a form that seems to be more closely related to present-day members of this group than are those found anywhere else in the Cretaceous.

Fishes like *Pachyrhizodus, Enchodus,* and *Ichthyodectes* or nearly related genera are of common occurrence in all the better-known Cretaceous deposits. Iniomi also occur in great abundance and variety throughout Cretaceous formations. Berycomorphi, also commonly found in Cretaceous deposits, are represented in California by a small genus and a specialized form belonging to one of the deep-sea families. The large-scaled Berycomorphi, for example *Hoplopteryx,* so common in other Upper Cretaceous deposits, have not been found as yet in California. Cockerell (1919) states that the Berycomorphi are absent from the American Cretaceous of the interior regions. The acanthopterygians, or more advanced fishes, are represented in the Moreno and Panoche deposits of California by the Berycomorphi and generalized forms that are tentatively referred to the Carangoidea. No true Percomorphi are present.

The differences between the fish faunas of the various known Upper Cretaceous deposits are due only in part to changes occurring in the course of geologic time. Geographical distribution and differences in facies also account for some of the dissimilarity in the assemblages. The Californian deposits, with typical clupeids, advanced elopids, abundant albulids and Salmonoidea, and with the rare occurrence of ganoids, are certainly not older than the Senonian and are probably more advanced than that stage. Absence of true percomorph scales suggests an earlier stage than Uppermost Cretaceous, when these types of fishes are known to have been present. The first true percomorph fishes are found in deposits of the Montian chalk of France, and in the Lameta beds of India. Some early and primitive percomorph fishes are known to occur in the Upper Senonian beds of Mount Lebanon (Woodward, 1942*a,* 1942*b*). These latter seem to have smooth and cycloid scales of primitive character, not unlike those described above.

Bibliography

Arambourg, C., and D. Schneegans. 1935. Poissons fossiles du bassin sédimentaire du Gabon. Ann. Paléontol., vol. 24, pp. 139–160.

Cockerell, T. D. A. 1919. Some American Cretaceous fish scales. U. S. Geol. Surv. Prof. Paper 120, pp. 165–188.

Cope, E. D. 1875. Cretaceous vertebrata. Rept. U. S. Geol. Surv. Terr., vol. 2.

Cope, E. D. 1878. Descriptions of fishes from the Cretaceous and Tertiary deposits west of the Mississippi river. Bull. U. S. Geol. Surv. Terr., vol. 4.

Davis, J. W. 1887. The fossil fishes of the chalk of Mt. Lebanon in Syria. Trans. Roy. Dublin Soc., ser. 2, vol. 3, p. 584.

——— 1890. On the fossil fish of the Cretaceous formations of Scandinavia. *Ibid.*, vol. 4, pp. 417–427.

Fritsch, A. 1878. Die Reptilien und Fische der böhmischen Kreideformation. Prague.

Geinitz, H. B. 1868. Die fossilen Fischschuppen aus dem Planerkalke in Strehlen. Dresden, Gesellsch. Natur und Heilkunde.

Hay, O. P. 1903*a*. On certain genera and species of North American Cretaceous actinopterous fishes. Bull. Amer. Mus. Nat. Hist., vol. 19, pp. 1–95.

——— 1903*b*. On a collection of Upper Cretaceous fishes from Lebanon, Syria. Bull. Amer. Mus. Nat. Hist., vol. 19, pp. 395–452.

——— 1929. Second bibliography and catalogue of the fossil vertebrata of North America. Carnegie Inst. Wash. Pub. 390.

Hussakoff, L. 1929. A new teleostean fish from the Niobrara of Kansas. Amer. Mus. Novit. No. 357, pp. 1–4.

Jordan, D. S. 1923. Peixes cretaceos. Monographias Serv. geol. e mineral. do Brasil, vol. 3, pp. 1–97.

——— and J. C. Branner. 1908. The Cretaceous fishes of Ceara, Brazil. Smithsonian Misc. Coll., vol. 52, pp. 15–25.

Marck, W. von der. 1863. Fossile Fische, Krebse und Pflanzen aus dem Plattenkalke der jüngsten Kreide in Westphalien. Palaeontographica, vol. 2, pp. 1–83.

——— 1876. Neue Beitraege zur Kenntnis der fossilen Fische und anderer Tierreste aus der jüngsten Kreide Westphaliens. Palaeontographica, vol. 22, pp. 55–74.

——— and A. Schlueter. 1865–1868. Neue Fische und Krebse aus der Kreide von Westphalen. Palaeontographica, vol. 15, pp. 269–305.

Martin, G. H. 1920. *Anguillavus hackberryensis*, a new species and genus of fish from the Niobrara Cretaceous of Kansas. Sci. Bull. Univ. Kans., vol. 13, no. 7, p. 95.

Maury, J. C. 1930. O Cretaceo da Parahyba do Norte. Monographias Serv. geol. e mineral. do Brasil, vol. 8, pp. 80–105.

—— 1936. O Cretaceo de Sergipe. Monographias Serv. geol. e mineral. do Brasil, vol. 2, pp. 49–57.

McClung, E. E. 1926. *Martinichthys* a new genus of Cretaceous fish from Kansas. Proc. Amer. Philos. Soc., vol. 65, pp. 20–26.

Pictet, F. J., and A. Humbert. 1866. Nouv. recherches poissons foss. Mt. Lebanon. Arch. sci. Génève, vol. 26.

Priem, F. 1898. Sur la faune ichthyologique des assises Montiennes du Bassin de Paris. Bull. Soc. géol. de France, ser. 3, vol. 26, pp. 399–412.

——— 1908. Mission de Morgan. Poissons fossiles de Perse. Paris.

Weiler, W. 1922. Die Fischreste aus den bituminösen Schiefern von Ibando bei Bata, Spanisch Guinea. Paläontol. Ztschr., vol. 5, pp. 148–160.

Woodward, A. S. 1898. The antiquity of the deep-sea fish-fauna. Nat. Sci., vol. 12, pp. 257–260.

——— 1907. Notes on some Upper Cretaceous fish remains from the provinces of Sergipe and Pernambuco, Brazil. Geol. Mag., ser. 5, vol. 4, pp. 193–197.

WOODWARD, A. S. 1908. On some fish remains from the Lameta beds at Dongargaon, Central Provinces, India. Paleontol. Indica, n. s., vol. 3, no. 3.

——— 1902–1911. The fishes of the English chalk. Monogr. Palaeontol. Soc. London, vols. 56–65.

——— 1936. On *Tomognathus,* a teleostean fish from the English chalk. Ann. Mag. Nat. Hist., ser. 10, vol. 17, pp. 305–306.

——— 1942*a*. On some new and little known Upper Cretaceous fishes. Ann. Mag. Nat. Hist., ser. 11, vol. 9, no. 56, pp. 537–568.

——— 1942*b*. The beginning of the teleostean fishes. Ann. Mag. Nat. Hist., ser. 11, vol. 9, no. 60, pp. 902–912.

PLATES

PLATE 1

FIG. 1. *Kleinpellia morenoensis,* n. g. and n. sp. Type, no. 10304. Scale 7.2 mm. long by 7 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6595 to 6605 feet. Moreno formation. Coarse side of scale, pyritized. (See also text fig. 3.)

FIG. 2. ? *Pachyrhizodus* sp. Scale 20.5 mm. long by 23 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4954 to 4960 feet. Moreno formation.

FIG. 3. *Laimingia plicata,* n. g. and n. sp. Type, no. 10307. Scale 3.2 mm. long by 4.1 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4436 to 4451 feet. Moreno formation. Coarse side of scale, pyritized.

FIG. 4. *Laimingia plicata,* n. g. and n. sp. Scale 4 mm. long by 4.1 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6605 to 6608 feet. Moreno formation. Coarse side of scale, smooth side preserved in part of apical region.

FIG. 5. *Paraberyx californica,* n. g. and n. sp. Scale 3.1 mm. long by 3.9 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth of 7086 feet. Panoche formation. Smooth side of scale.

FIG. 6. *Paraberyx californica,* n. g. and n. sp. Type, no. 10310. Scale 2.9 mm. long by 3.2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. Coarse side of scale.

Calif. Inst. Tech. Vert. Pale. Coll.

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2

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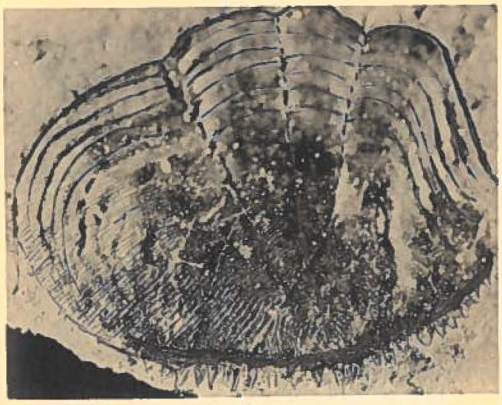

5

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PLATE 2

FIG. 1. *Natlandia ornata,* n. g. and n. sp. Lateral-line scale tentatively referred to this species, 7 mm. long by 6.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6451 to 6459 feet. Moreno formation. Coarse side of scale, pyritized.

FIG. 2. *Goudkoffia delicata,* n. g. and n. sp. Type, no. 10309. Scale 4.2 mm. long by 4 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. Coarse side of scale.

FIG. 3. *Natlandia ornata,* n. g. and n. sp. Counterpart of type, no. 10308. Scale 7.7 mm. long by 5.2 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6507 to 6514 feet. Moreno formation. Coarse side of scale, pyritized.

FIG. 4. *Holcolepis nodulatus,* n. sp. Type, no. 10333. Scale 10 mm. long by 13 mm. deep. Western Gulf Oil Co. well, Lillis Welch No. 1, at depth from 4387 to 4396 feet. Moreno formation. Coarse side of scale.

FIG. 5. *Erythrinolepis* cf. *chicoensis* Cockerell. Scale 12 mm. long by 12.5 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. Mold of smooth side of scale; actual scale preserved in places.

FIG. 6. *Holcolepis angulatus,* n. sp. Type, no. 10334. Scale 12.4 mm. long by 14 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6654 to 6663 feet. Moreno formation. Mold of coarse side of scale; small part of actual scale, which is pyritized, present at apical pole.

Calif. Inst. Tech. Vert. Pale. Coll.

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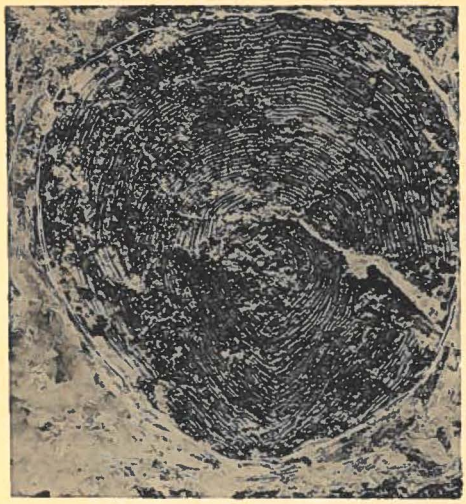

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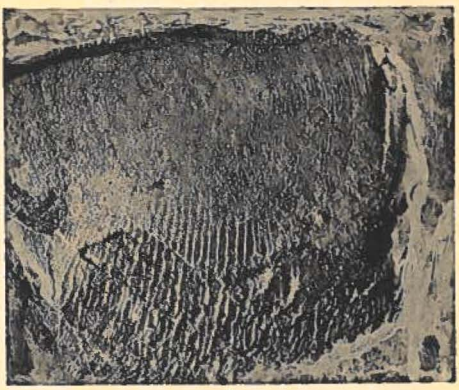

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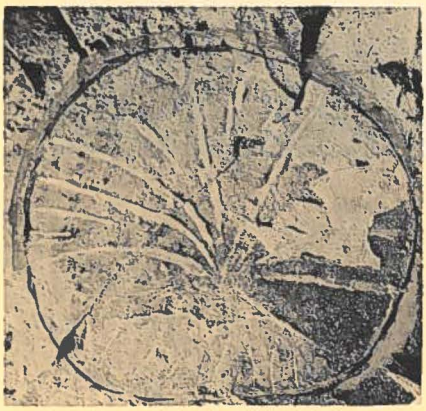
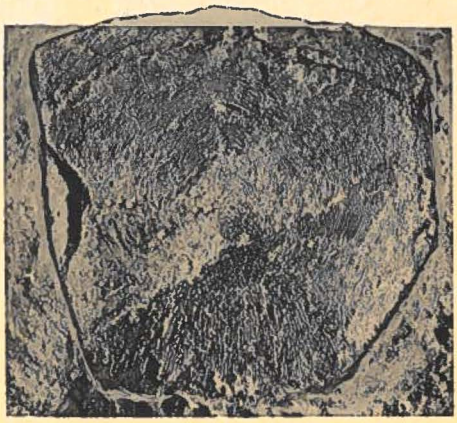


5



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1

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PLATE 3

FIG. 1. *Helmintholepis* sp. Scale 16.5 mm. long by 21 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 6605 to 6608 feet. Moreno formation.

FIG. 2. *Kleinpellia morenoensis,* n. g. and n. sp. Lateral-line shield tentatively referred to this species, 5 mm. long by 8.4 mm. deep. Pure Oil Co. well, Chowchilla No. 1, at depth from 4737 to 4770 feet. Panoche formation. External side of shield.

FIG. 3. *Driverius cretaceus,* n. g. and n. sp. Type, no. 10305. Scale 3 mm. long by 4 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7137 to 7144 feet. Panoche formation. Smooth side of scale; mold of coarse side visible in places where scale is fragmentary.

FIG. 4. *Driverius cretaceus,* n. g. and n. sp. Cotype, no. 10306. Scale 4.1 mm. long by 7 mm. deep. Jergins Oil Co. well, Chaney Ranch No. 1, at depth from 7003 to 7009 feet. Panoche formation. Mold of coarse side of scale; smooth side preserved in left half of basal region and in small part of apical region.

Calif. Inst. Tech. Vert. Pale. Coll.