# The Mesozoic Pelecypods *Otapiria* Marwick and *Lupherella* Imlay, New Genus, in the United States

GEOLOGICAL SURVEY PROFESSIONAL PAPER 573-B

# The Mesozoic Pelecypods *Otapiria* Marwick and *Lupherella* Imlay, New Genus, in the United States

*By* RALPH W. IMLAY

CONTRIBUTIONS TO PALEONTOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 573-B

*Presents the first records of*
Otapiria *and* Lupherella *in the United States*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 25 cents (paper cover)

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# THE MESOZOIC PELECYPODS *OTAPIRIA* MARWICK AND *LUPHERELLA* IMLAY, NEW GENUS IN THE UNITED STATES

By Ralph W. Imlay


## ABSTRACT

The pelecypod genera *Otapiria* Marwick and *Lupherella* Imlay, n. gen., both resembling the late Triassic genus *Monotis*, are recorded for the first time from Mesozoic beds in the United States. *Lupherella* is represented by *L. boechiformis* (Hyatt) from beds of Pliensbachian age in eastern Oregon and California. It has not been found elsewhere. One species of *Otapiria*, named *O. tailleuri* Imlay, n. sp., has been found in northern Alaska associated with or directly underlying *Inoceramus* cf. *I. lucifer* Eichwald, whose presence indicates an early Middle Jurassic or late Early Jurassic age not older than Toarcian. Another species, referred to as *O.* sp. undet., has been found as float in the upper Yukon Valley in east-central Alaska. Its age is unknown, but the presence of the crinoid *Pentacrinus subangularis* var. *alaska* Springer in the same float indicates that beds of Early Jurassic age are present in the area. *Otapiria* has been found previously in Upper Triassic to Upper Jurassic beds in New Zealand, Lower Jurassic beds in New Caledonia, and Upper Triassic to Lower Jurassic beds in northeastern Siberia.


## INTRODUCTION

The recent discovery of a monatidlike pelecypod in northern Alaska prompted the preparation of this paper. This pelecypod was found in a thin unit of organic shale directly overlying Upper Triassic beds and directly underlying, at least locally, Lower Cretaceous beds containing *Buchia* of Valanginian age. It showed considerable resemblance to the genotype species of *Otapiria* Marwick (1935, p. 303; 1953, p. 95) from basal Jurassic beds in New Zealand (Trechmann, 1923, p. 270, pl. 15, figs. 6–9; Marwick, 1953, p. 95, pl. 11, figs. 7, 8) and to a species of *Otapiria* from basal Jurassic beds in northeastern Siberia (Zakharov, 1962, p. 25–29, pl. 1, figs. 1–16, pl. 2). Further study showed that the generic assignment to *Otapiria* was correct and that the genus has a fairly wide distribution in Upper Triassic and Jurassic beds of the Indo-Pacific and Arctic regions.

The paper also includes a description of a new genus of another monotidlike pelecypod from beds of late Early Jurassic (Pliensbachian) age in Oregon and California. This pelecypod, herein named *Lupherella* n. gen., greatly resembles *Otapiria* and appears to be closely related to that genus. Attempts over many years to determine the generic and family relationships of *Lupherella* made the writer familiar with the characteristics of *Otapiria* and led to the identification of *Otapiria* soon after its discovery in Alaska.

Many thanks are due to Mr. J. A. Jeletsky of the Geological Survey of Canada for his aid in locating pertinent Russian publications. Mr. Ian Speden of the New Zealand Geological Survey kindly furnished rubber imprints and descriptive data of *Otapiria marshalli* (Trechmann), the type species of *Otapiria*.

## CHARACTERISTICS OF *OTAPIRIA*

The genus *Otapiria* was defined by Marwick in 1935 (p. 302), and *Pseudomonotis marshalli* (Trechmann) (1923, p. 270, pl. 15, figs. 6–9) from the Jurassic of New Zealand was designated the type species (pl. 1, figs. 24, 25). Detailed comparisons were made with the pelecypods *Entomonotis* Marwick (1935, p. 298) and *Echinotis*. Marwick's definition, based solely on the type species, was modified slightly in 1953 (p. 95) when he included in the genus two other species from New Zealand. The modified definition is as follows:

> Shell of moderate size, obliquely ovate, inequivalve, right valve less inflated than left, posterior wing well developed. Sculpture of numerous close wavy radials, left [sic right] valve with weaker radials or smooth. Right valve with small anterior ear, bounded by a deep groove without a deep notch.

This definition does not mention the characteristics of the hinge area which Marwick (1935, p. 302) had described in his original definition as follows:

> Hinge area narrow, edentulous. Ligament set in a strongly and regularly grooved triangular-pit, the base of which is about half the length of the posterior dorsal margin. Left valve with the hinge margin sinused upwards and inwards immediately in front of the umbo, but further forward the margin projects outwards and bears several deep grooves.

These characteristics of the hinge area of *Otapiria marshalli* (Trechmann) were depicted in drawings (Marwick, 1935, pl. 36, figs. 28–32, 34, 35) for comparisons with similar drawings of *Entomonotis* (Marwick, 1935, pl. 35, figs. 13–17, pl. 36, figs. 18–24, 33), and *Echinotis* (Marwick, 1935, pl. 36, figs. 25–27). They have not yet been found as well preserved on any other species of *Otapiria.*

The additional species of *Otapiria* subsequently discovered in northeastern Siberia (Pchelintseva, 1955, p. 213; Zakharov, 1962, p. 25–29; Vozin and Tikhomirova, 1964, p. 18) and in Alaska (table 1) show that the genus is characterized by an obliquely elongate form, a weakly convex to flat right valve, wavy radial ribs of irregular strength and spacing, low broad irregularly spaced concentric ribs, a narrow endentulous hinge, a small byssal ear on the right valve, and a fairly distinct posterior wing that merges evenly with the body of the shell. The posterior wing ranges in length from fairly short to moderate.

TABLE 1.—*Distribution of* Otapiria *in space and time*

| *Species of* Otapiria | *Distribution* | *Age* |
|---|---|---|
| *O. ussuriensis* (Voronetz) | Northeastern Siberia | Late Triassic (Karnian). |
| *O. dissimilis* (Cox) | New Zealand | Late Triassic (Rhaetian). |
| *O. marshalli* (Trechmann) | New Zealand and New Caledonia. | Early Jurassic (Hettangian and Sinemurian). |
| *O. limaeformis* Zakharov | Northeastern Siberia | Early Jurassic (Hettangian and Sinemurian). |
| *O. tailleuri* Imlay, n. sp. | Northern Alaska | Early Jurassic to middle Bajocian. |
| *O. masoni* Marwick | New Zealand | Late Jurassic (Kimmeridgian). |
| *O.* sp. undet | East-central Alaska | Unknown. |

## CHARACTERISTICS OF *LUPHERELLA* IMLAY, N. GEN.

*Lupherella* is characterized by a broadly ovate to obliquely ovate form, a gently convex right valve that is slightly less convex than the left valve, highly variable radial and concentric ribs, fairly long posterior wings, a weak anterior wing on many left valves, a byssal ear on the right valve, and a fairly long dorsal margin. The hinge is probably edentulous, considering that the right and left valves have not been found together. The type species of *Lupherella* is *Daonella boechiformis* Hyatt (1894, p. 415; Crickmay, 1933, p. 53, pl. 14, figs. 8–13). The genus is named in honor of Ralph L. Lupher in recognition of his excellent pioneering studies of the Jurassic sedimentary rocks in east-central Oregon.

*Lupherella* resembles the genus *Otapiria* Marwick in most respects. It differs by having a smaller and less obliquely elongate shell, a much longer dorsal margin relative to the shell length, a longer posterior wing, finer and more numerous concentric ribs, and a small anterior wing on many left valves. *Lupherella* differs from *Monotis* mainly by having a less obliquely elongate shape, more conspicuous concentric ribbing, and less prominent radial ribbing. It differs from *Meleagrinella* by being somewhat larger, by having an obliquely elongate instead of orbicular or subquadrate outline, a more convex and more strongly ribbed right valve, more wavy radial ribbing, more conspicuous concentric ribbing, and a long instead of a short posterior wing. An anterior wing on the left valve, as in *Lupherella,* is present on some left valves in both *Monotis* (Marwick, 1935, p. 298) and *Meleagrinella* (Cox, 1940, p. 90, 91).

## BIOLOGICAL RELATIONSHIPS

*Otapiria* and *Lupherella* resemble each other so much that they may reasonably be placed in the same family, but that family assignment is uncertain. *Otapiria* was placed in the Pteriidae by Marwick (1935, p. 302; 1953, p. 53, 94) and by Cox and Arkell (1948, p. 7) and in the Monotidae by Zakharov (1962, p. 23–25), and was discussed under the Monotidae by Ichikawa (1958, p. 166–168). The genus was not assigned to the Monotidae by Ichikawa (1958, p. 198) because it has a deep ligamental pit, which according to Ichikawa (1958, p. 166 and footnote at bottom of p. 168) is probably absent in the Monotidae. *Otapiria* was compared by Marwick (1935, p. 302) with the genera *Entomonotis* Marwick (1935, p. 298) and *Echinotis* Marwick (1935, p. 301). Of these, *Entomonotis* is now considered a subgenus of *Monotis* by Ichikawa (1958, p. 170) and a synonym of *Monotis* by most authorities (Muller, 1938; Marwick, 1953, p. 57; Tozer, 1961, p. 107; Westermann, 1962, p. 756). *Echinotis* is recognized as a synonym of *Meleagrinella* Whitfield (1885, p. 71; Cox, 1941; Marwick, 1953, p. 94).

The biological affinities of *Otapiria* were stated by Marwick (1935, p. 302) as follows:

> *Otapiria* is nearest to *Entomonotis* in general characters and may be the Jurassic descendent of that stock. *Otapiria* has much finer sculpture, an exceptionally ovate shape, and the hinge of the left valve has a sinus instead of a projection immediately in front of the ligament and beak. The ligament-pit is more deeply entrenched than that of *Entomonotis,* thus resembling *Echinotis,* but the well incised parallel grooves increase the affinity with *Entomonotis.*
>
> The anterior ear of the right valve of *Otapiria* shows important differences from that of *Entomonotis* being set more in the plane of the disc, the upper edge of which is consequently not bent inwards.

Concerning these comparable genera, *Meleagrinella* (equals *Echinotis* of Marwick) differs from *Otapiria* by being much smaller and by having an orbicular or subquadrate instead of obliquely elongate outline, much less wavy radial ribbing, less conspicuous concentric ribbing, and a much shorter posterior wing. The genus *Monotis* resembles *Otapiria* considerably in size and shape. It differs by not having a deep ligamental pit, by its posterior ears generally merging less gradually with the body of the shell, by its radial ribs being coarser, more regular in strength and spacing, and much less wavy, and by its concentric ribs being fewer and less conspicuous.

Another comparable genus is *Pleuromysidia* Ichikawa (1954, p. 52–54), based on a single species, *P. dubia Ichikawa*, from the Upper Triassic of Japan. This genus, according to its author, differs from *Monotis* by having a more convex right valve and much finer radial ribbing and consequently was assigned questionably to the Monotidae. Zakharov (1962, p. 25), however, considered *Pleuromysidia* to be a synonym of *Otapiria* under the family Monotidae. Subsequently, some similar appearing pelecypods from the Upper Triassic of Siberia were assigned to *P. dubia Ichikawa* without reference to *Otapiria* (Vozin and Tikhomirova, 1964 p. 18, pl. 7, figs. 4–6). These specimens, as well as the type specimens of *P. dubia* Ichikawa, differ from any described species of *Otapiria* by having an inflated right valve that is more convex than the left valve.

## COMPARISONS OF SPECIES

The seven species of *Otapiria* listed herein may be differentiated readily by the features shown in table 2, which is based on published descriptions and on observations. In addition, enough data are available for several species and for *Lupherella boechiformis* (Hyatt) to make the statistical comparisons shown in table 3. Such data are particularly valuable in comparing ratios, numbers, and dimensions. The most useful features in differentiating the species include the degree of convexity of the right valves, the strength and density of the radial and the concentric ribs, and the presence or absence of radical ribs on the right valves. Comparisons of all these features make sharp distinctions between the species possible.

For example, *Otapiria ussuriensis* (Voronetz) greatly resembles *O. limaeformis* Zakharov and *O. tailleuri* Imlay, n. sp. in size, shape, and ribbing, but it has a much more convex right valve. *O. dissimilis* (Cox) differs from *O. marshalli* (Trechmann) by having a nearly smooth right valve. It differs from *O. masoni* Marwick by being more obliquely elongate and by having faint radial ribs on the right valve. *O. marshalli* (Trechmann) is characterized by its large size, strong posterior elongation, and moderately strong but densely spaced ribs on both valves. *O. tailleuri* Imlay, n. sp. differs from *O. limaeformis* Zakharov by having distinct radial ribs on its right valve, much denser radial ribbing on its left valve, and a less variable shape. *Lupherella boechiformis* Hyatt is readily distinguished from all species of *Otapiria* by its long dorsal margin.

## SYSTEMATIC DESCRIPTIONS

### Family MONOTIDAE Fischer, 1887

### Genus OTAPIRIA Marwick, 1935

### Otapiria tailleuri Imlay, n. sp.

Plate 1, figures 1–23; plate 2, figure 32

This species is represented in collections from northern Alaska by 40 right valves, 70 left valves, and many small immature specimens and fringements. Almost all right and left valves occur separately.

The shell is smaller than average size for the genus. It is strongly inequilateral, weakly inequivalve, obliquely ovate in outline, moderately to strongly extended posteriorly, and is compressed but attains maximum inflation in the dorsal fourth of the umbonal region.

The left valve ranges from gently to weakly convex, is a little larger and more convex than the right valve, and is most convex in the umbonal region. Its length exceeds it height on all specimens. The ratio of height to length, based on some of the largest and best preserved left valves, ranges from 70.5 to 96.5. The beak is ⅓–¼ the length of the shell from the anterior end. It is projecting, strongly incurved, pointed, and directed slightly anteriorly. The dorsal margin is straight and is a little less than half as long as the length of the shell. The anterior end is moderately to narrowly rounded and projecting. The ventral margin is broadly rounded. The posterior margin ranges from broadly to rather narrowly rounded. A posterior wing, visible only on three left valves, is moderately short and merges evenly with the body of the shell.

The right valve ranges from weakly convex to nearly flat. The ratio of height to length of the largest specimens ranges from 68.9 to 90.9. The beak is inconspicuous and barely projects above the dorsal margin. The outline of the right valve is nearly the same as that of the left valve. A posterior wing is well developed. An anterior byssal ear, preserved only on two small right valves (pl. 1, figs. 10, 12), is moderate in size and is separated from the main body of the shell by a deep groove. One of the specimens (pl. 1, fig. 10) also bears an indentation that is probably a byssal notch. An anterior ear is not visible on any of the large right valves.

The shell is ornamented with sharp fine closely spaced radial ribs and with low broad irregularly spaced concentric ribs. The radial ribs are appreciably stronger on left valves than on right valves. On both valves they are sharpest and most closely spaced on immature

TABLE 2.—*Comparisons of Triassic and Jurassic species of* Otapiria

| Species of *Otapiria* | Dimensions of largest known left valves (mm) | | | Ratio of length of dorsal margin to length of shell | Convexity of right valve | Posterior elongation of left valve | Radial ribbing | | Concentric ribbing | | Position of beak from anterior end | Length of posterior wing | | Source of data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Length | Height | Convexity | | | | Left valve | Right valve | Left valve | Right valve | | Left valve | Right valve | |
| *O. ussuriensis* (Voronetz). | 34 | 38 | 7.5 | About 41 | Slightly less than left valve. | Moderate | Fine, dense | Faint | Broad and sparse. | Fairly broad | ¼–⅓ | Fairly short. | Fairly short. | Pchelintseva (1955, p. 213, pl. 1, figs. 1–10, pl. 2, figs. 1–2). |
| *O. dissimilis* (Cox). | 33 | 28 | 5.0 | About 42 | Less than left valve. | Strong | Coarse irregular, dense. | Faint | Low, broad, irregular, sparse. | Weak round, irregular. | ⅓–⅖ | Fairly short. | Fairly short. | Marwick (1953, p. 59, pl. 3, figs. 10–12). |
| *O. marshalli* (Trechmann). | 54 | 37 | 7.0 | 34–50 | Less than left valve. | Strong | Moderate in strength, very dense. | Moderate, dense. | Low, broad, sparse. | Weak | ⅓ | Moderate | Fairly short. | I. G. Speden (written commun. March, 1965). |
| *O. limaeformis* Zakharov. | 28 | 25 | Unknown | Unknown | Weakly convex to nearly flat. | Varies from ovate to moderately elongate. | Fine, dense | Faint or absent. | Low, broad, sparse. | Weak, sparse | ⅓–½ | Moderate | Moderate | Zakharov (1962 p. 25–29, 1 pl. 2 text-figs). |
| *O. tailleuri* Imlay, n. sp. | 26.2 | 18.5 | 2.2 | 40–45 | Weakly convex to nearly flat. | Moderate to strong. | Fine, dense | Finer than on left valves, dense. | Low, broad, moderately dense. | Same as on left valve. | ¼–⅓ | Fairly short. | Fairly short. | Presented herein. |
| *O. masoni* Marwick. | 33 | 29 | 4.0 | About 47 | Less than left valve. | Moderate | Moderate in strength, irregular, dense. | Absent | Low, broad, sparse. | Wide, flat, separated by deep grooves. | ¼–⅓ | Short | Not known. | Marwick (1953 p. 95, pl. 11, figs. 10, 11) |
| *O.* sp. undet | 17 | 16 | Unknown | Unknown | Less than left valve. | Moderate | Fairly fine and dense. | Similar to that on left valve. | Fairly low, broad, sparse. | Same as on left valve. | About ⅓ | Fairly short. | Fairly short. | Presented herein. |

TABLE 3.—*Comparisons of measurements of some Jurassic species of* Otapiria *and* Lupherella

| Characters | *Otapira marshalli* (Trechmann) | *Otapiria limaeformis* Zakharov | *Otapiria tailleuri* Imlay, n. sp. | *Lupherella boechiformis* (Hyatt) |
|---|---|---|---|---|
| Maximum dimensions (mm): | | | | |
| Length: | | | | |
| Left valve | 54.1 | 28.6 | 26.2 | 13.2 |
| Right valve | 57.0 | 23.0 | 20.0 | 16.0 |
| Height: | | | | |
| Left valve | 36.9 | 25.0 | 18.5 | 22.4 |
| Right valve | 34.7 | 20.8 | 16.5 | 13.1 |
| Length of dorsal margin (mm): | | | | |
| Left valve | 12.0–18.5 | [1] NK | 6.0–7(?) | 4.6–8.2 |
| Right valve | 7.6–14.2 | NK | 5.5–9.2 | 4.8–10.5 |
| Ratio of width (convexity) to length: | | | | |
| Left valve | 12.8–18.5 | NK | 5.5–18.1 | 15.0–23.2 |
| Right valve | 8.2–16.4 | NK | 4.8–8.5 | 8.1–14.7 |
| Ratio of height to length: | | | | |
| Left valve | 60.9–83.3 | 55.0–167.0 | 70.5–96.5 | 86.3–93.9 |
| Right valve | 60.8–76.2 | 59.0–156.0 | 69.0–91.0 | 81.8–100.0 |
| Number of radial ribs: | | | | |
| Left valve | 54–105 | 90–100 | 105–170 | 38–77 |
| Right valve | 52–95 | ([2]) | 80–120 | 36–85 |
| Number of concentric ribs: | | | | |
| Left valve | 7–11 | 7–10 | 11–17 | 16–32 |
| Right valve | 7–10 | 6–10 | 9–13 | 17–44 |
| Width of radial interspaces compared with ribs | ⅓–½ | [3] 1.0 | [3] 1.0 | 1–1 to 3–1 |

[1] Not known.
[2] Absent or faint.
[3] Or slightly wider.

specimens and on the umbonal and anterior parts of adult shells. On these parts the radial ribs are separated by interspaces that are about as wide as the ribs, but posteriorly the ribs become weaker and more widely spaced, and gradually become indistinct near the postero-dorsal margin. The radial ribs are fairly straight on the umbones and on specimens with few concentric ribs, but are generally wavy where they cross the concentric ribs. New radial ribs arise mostly by intercalation, but some arise by bifurcation. The number of radial ribs ranges from 105 to 170 on left valves and from 80 to 120 on right valves. The number of concentric ribs ranges from 11 to 17 on left valves and from 9 to 13 on right valves. The number of radial or concentric ribs is clearly related both to size and to individual variation. The largest specimens have the most ribs, but some small specimens have more ribs than other, somewhat larger ones.

The ligamental area and muscle scars are unknown. The shell, represented by a few fragments, is very thin.

The immature left valves of this species are all fairly convex, whereas only a few adult specimens are as convex and then only in the umbonal region. Most of the large left valves, however, have been crushed, and some of the beaks have been sharply bent. It seems probable, therefore, that most of the large specimens were more convex in life than they are now.

The immature specimens of *O. tailleuri* Imlay, n. sp. show considerable resemblance to *Melegrinella*. The resemblance is closest in those specimens that have few concentric ribs and, consequently, fairly straight radial ribs. However, such specimens are generally associated with others that have many concentric ribs and rather wavy radial ribs, features which are characteristic of *Otapiria*.

The Alaskan species closely resembles *O. limaeformis* Zakharov (1962, p. 25–29, pl. 1, figs. 1–16, pl. 2) from the basal Jurassic of northeastern Siberia in size and in the fine ribbing of its left valve. It differs by being a little smaller, by having a much less variable shell outline, by its right valve bearing distinct radial ribs instead of being smooth or bearing only faint radial ribs, and by its left valve having much denser radial ribbing. These differences, as shown in tables 2 and 3, are greater than is suggested by visual comparisons of the illustrations of the two species. For example, the left valves of *O. limaeformis* bear 90–100 ribs, whereas the left valves of *O. tailleuri* bear 105–170 ribs. Concerning variation in shell outline, the left valves of *O. limaeformis* have a ratio of height to length that ranges from 55.0 to 167.0, whereas in *O. tailleuri* the range is from 70.5 to 96.5. The greatest difference between the two species, however, is in the absence to near absence of radial ribs on the right valves of *O. limaeformis*.

This difference cannot reasonably be ascribed to defective preservation of the right valves of *O. limaeformis* Zakharov because all illustrated valves appear to be fairly well preserved, and more than 300 specimens of both valves were available for study (Zakharov, 1962, p. 26). Furthermore, several other species of *Otapiria* besides *O. limaeformis* have similarly ornamented right valves. Thus, *O. dissimilis* (Cox) (Marwick, 1953, p. 59, pl. 3, figs. 10–12) and *O. ussuriensis* (Voronetz) (Pchelintseva, 1955, p. 213, pl. 1, figs, 1–10, pl. 2, figs. 1–2; Vozin and Tikhomirova, 1964, p. 18, pl. 7, figs. 1–3) bear only faint radial ribs on their right valves, and *O. masoni* Marwick (1953, p. 95, pl. 11, figs. 10, 11) bears no radial ribs on its right valve.

The Alaskan species also resembles *Otapiria ussuriensis* (Voronetz), just mentioned, in the density of ribbing on its left valves; but it is much less elongate posteriorly, has a less convex right valve, and has much stronger ribbing on its right valve. The only other similar species is *O. marshalli* (Trechmann) (1923, p. 270, pl. 15, figs. 6–9; Marwick, 1935, p. 302, figs. 10, 12, 28, 32, 34, 35; 1953, p. 95, pl. 11, figs. 7, 8) from the basal Jurassic of New Zealand and New Caledonia. That species resembles *O. tailleuri* Imlay, n. sp. in variability of shell outline, in convexity, and in the presence of conspicuous ribbing on its right valves. It differs, however, by being, on the average, twice as large, by having much sparser and coarser radial ribbing, and by having ribs two to three times wider than the interspaces instead of about equal in width.

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The fossils found with *Otapiria tailleuri* Imlay, n. sp. in northern Alaska include *Inoceramus*, *Lima*?, *Oxytoma*, ammonite fragments, fish scales, and Radiolaria. In addition, belemnites are fairly common in some associated shales. The best preserved *Inoceramus* at USGS Mesozoic locality M2451 are from beds approximately 35 feet higher than the beds containing *Otapiria*, but *Inoceramus* shell prisms are abundant in thin sections of slabs that bear *Otapiria* (Mesozoic locs. M2318 and 24060). One ammonite also occurs in the same slab as *Otapiria* (Mesozoic loc. 29282). These associations indicate that *Otapiria* belongs to the same assemblage as *Inoceramus* and the ammonites.

The age of the beds containing *Otapiria tailleuri* Imlay, n. sp. is either late Early Jurassic (Toarcian) or early Middle Jurassic (Bajocian), or both. An age not older than Toarcian is shown by the association of *Otapiria* in the same beds with true *Inoceramus*, which according to Hayami (1960, p. 292, 294; 1961, p. 317) did not originate until Toarcian time. An age not younger than early middle Bajocian is shown by the close resemblance of some of the *Inoceramus* (USGS Mesozoic locs. 24060 and M2451) to *I. lucifer* Eichwald, which in southern Alaska occurs only in the lower part of a sequence of Bajocian age (Imlay, 1955, p. 86; 1964, p. B18).

A Toarcian to early Bajocian age for the *Otapiria*-bearing beds is also indicated by the presence of certain fragmentary ammonites at USGS Mesozoic localities 29281 and 29282. These ammonites are highly evolute and have strong, straight, simple, widely spaced, radial-trending ribs. In lateral view they resemble *Tmetoceras* of early Bajocian age and *Catulloceras* or *Dumortieria* of late Toarcian age. Unfortunately, the preservation of the ammonites does not permit positive generic determination. Their presence is excellent evidence, however, that the beds bearing *Otapiria* are not older than Jurassic.

In summation, the presence of *Inoceramus* cf. *I. lucifer* Eichwald is good evidence of an early to middle Bajocian age for at least part of the thin unit of organic shale containing *Otapiria*. As the best preserved specimens of *Inoceramus* were obtained from slightly higher beds than *Otapiria*, it is possible that other ages are represented. Nonetheless, the presence of *Inoceramus* shell prisms in the same slabs as *Otapiria* indicates an age not older than Toarcian. An age near the Toarcian-Bajocian boundary is indicated also by the ammonites associated with *Otapiria*.

The species is named in honor of I. L. Tailleur of the U.S. Geological Survey, who collected most of the specimens now available for study.

*Types.*—Holotype USNM 153276; paratype USNM 153272–153275, 153277–153294.

*Occurrences.*—*Otapiria tailleuri* Imlay, n. sp. has been obtained in northern Alaska from organic shale that directly overlies fossiliferous Upper Triassic beds and has generally been mapped as part of the Shublik Formation. The species occurs at the U.S. Geological Survey Mesozoic localities described below. Numbers 1–5 preceding the locality descriptions refer to numbers shown in figure 1, an index map of Alaska. The letter "M" preceding the Mesozoic locality number shows that the fossils are recorded at the Menlo Park office.

1. Mesozoic loc. 24060 (51 ATr 94). I. L. Tailleur, 1951. Limestone on east side of Ipnavik River. Lat 68°40.50′ N., long 157°03.75′ W.
2. Mesozoic loc. M2451 (64 T 305 and 64 AS 321). Sigmund Snelson and I. L. Tailleur, 1964. Organic shale, chert, and limestone about 60 feet thick which may be conformable downward with the Shublik Formation and which is less than 20 feet below a clay shale unit that contains *Buchia* of Early Cretaceous (Valanginian) age. Lat 68°37.62′ N., long 156°43.05′ W., NE¼ sec. 36 T. 9 S., R. 21 W., Howard Pass quad.
2. Mesozoic loc. 29280 (65 ATr 73.5). I. L. Tailleur, 1965. Same locality data as Mesozoic loc. M2451.
3. Mesozoic loc. M2318 (64 APa 224). W. W. Patton, Jr., 1964. Cutbank on east side of Tiglukpuk Creek, south flank of Tiglukpuk Creek anticline. Lat 68°21.24′ N., long 151° 52.35′ W., Chandler Lake quad.
3. Mesozoic loc. 29281 (65 ATr 123B). I. L. Tailleur, 1965. Talus on cutbank at Mesozoic loc. M2318.
3. Mesozoic loc. 29282 (65 ATr 149.4). I. L. Tailleur, 1965. Float on southwest wall of Firestone Creek (tributary of Tiglukpuk Creek) just north of mountain front, about 5 miles south-southeast of loc. 29281. Lat 68°18.32′ N., long 151°48.3′ W., Chandler Lake quad.
4. Mesozoic loc. M2317 (64 APa 206). W. W. Patton, Jr., 1964. Cutbank on east side of Erratic Creek. Lat 68°23.25′ N., long 150°52.05′ W., Chandler Lake quad.
4. Mesozoic loc. 29284 (65 ATr 152.2.2). I. L. Tailleur, 1965. Calcareous layer and lens 6 feet above top of Triassic beds. Cutbank on west side of Erratic Creek in anticlinal nose. Lat 68°23.05′ N., long 150°52.1′ W., Chandler Lake quad.
4. Mesozoic loc. 29287 (65 ATr 153.2). I. L. Tailleur, 1965. Dark limestone and shale apparently within 10 feet of top of Triassic beds. Outcrop on east wall of Erratic Creek, about half a mile downstream from Mesozoic loc. 29284 at about same location as M2317.
5. Mesozoic loc. 29285 (65 ATr 159.2). I. L. Tailleur, 1965. Lower 6 feet of shale directly overlying the Triassic. Cutbank and cliff in north side of Atigun Gorge. Lat 68°29.0′ N., long 149°14′ W., Phillip Smith Mountains quad.

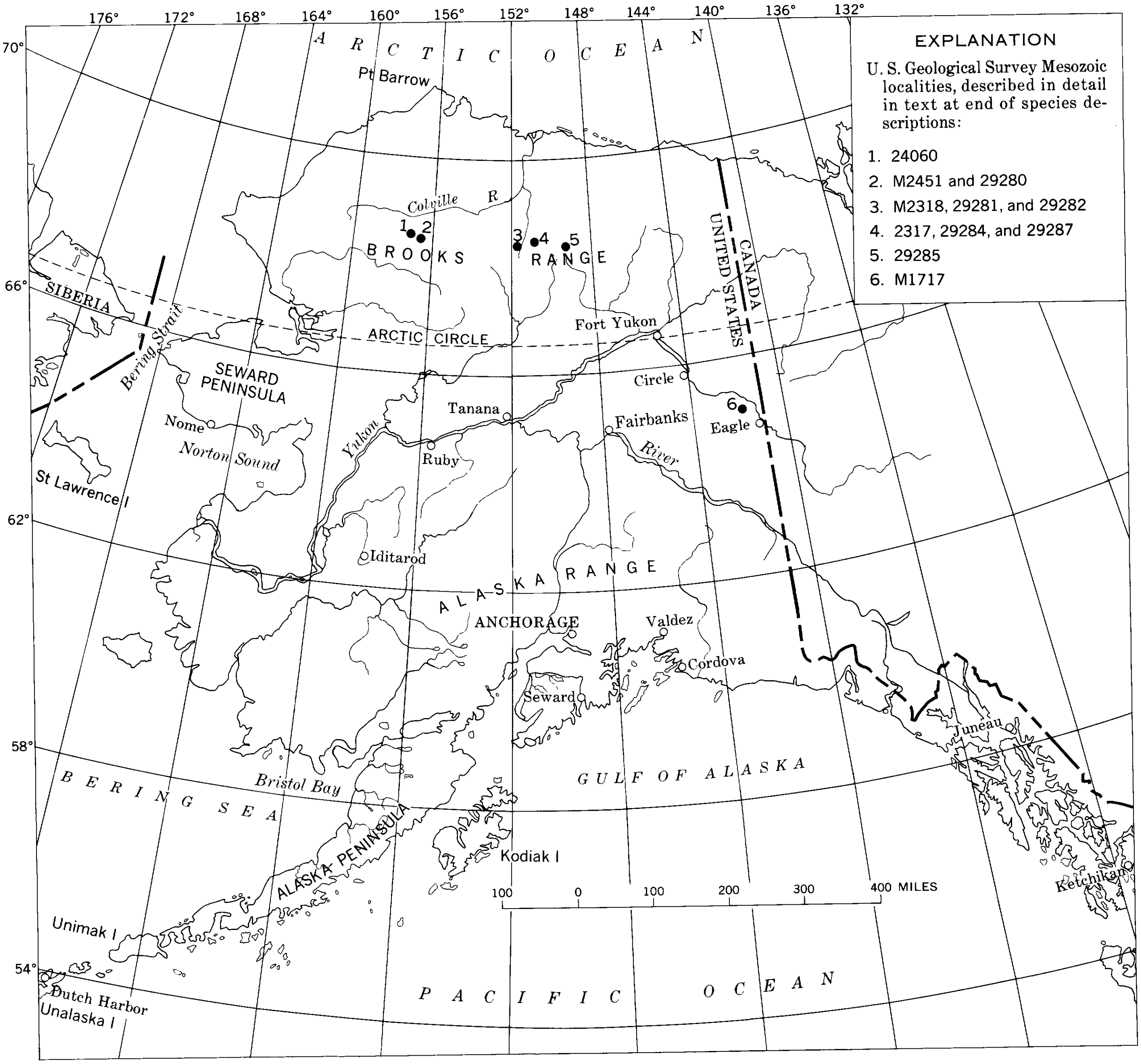


FIGURE 1.—Occurrences of the pelecypod *Otapiria* in Alaska.

**Otapiria sp. undet.**

Plate 2, figures 28–31

*Otapiria* is represented in collections from southeast of Nation in east-central Alaska by seven fairly well preserved left valves and five right valves. All left and right valves occur separately.

The shell closely resembles that of *O. tailleuri* Imlay, n. sp. in size, shape, and convexity, and in the presence of a byssal ear on the right valve. It differs mainly by having much stronger and fewer radial ribs, slightly stronger concentric ribs, and ribbing on the right valve as strong as that on the left valve. On the two left valves illustrated, the larger has about 78 radial ribs and the smaller about 85 radial ribs. These numbers are well below the range of variation of 105–170 for *O. tailleuri* Imlay, n. sp. (table 3). One of the two small right valves illustrated has about 50 and the other about 35 radial ribs. These numbers are somewhat less than on comparable small right valves of *O. tailleuri.* The width of the radial interspaces compared to the width of the ribs is about the same on both species.

The greater coarseness of ribbing of the specimens of *Otapiria* from east-central Alaska suggests that they are different at least subspecifically from *O. tailleuri* Imlay, n. sp. from northern Alaska, but not enough specimens are available to show their range in variation. The specimens, however, do suggest that the coarseness in ribbing is intermediate between that of *O. tailleuri* and *O. marshalli* (Trechmann).

The age of the specimens of *Otapiria* from east-central Alaska is not known because the specimens were obtained as float on a mudslide. Nonetheless, their resemblances to *O. tailleuri* Imlay, n. sp. suggest a similar Jurassic age. Also, the presence on the same mudslide of the crinoid *Pentacrinus subangularis* var. *alaska* Springer (identified by Porter M. Kier of the U.S. National Museum) indicates that rocks of Early Jurassic age exist in the area. Such an age is based on the fact that this crinoid in northern Alaska has been found only near the base of the Jurassic Kingak Shale, and on the Canning River it occurs (Mesozoic loc. 21025) many hundreds of feet below beds that have furnished fossils (Mesozoic loc. 24035) of early Bajocian age (Imlay, 1952, p. 983; Keller, Morris, and Detterman, 1961, p. 192, 193).

*Figured specimens.*—USNM 153295.

*Occurrence.*—U.S. Geological Survey Mesozoic loc. M1717. N. J. Silberling, 1962. Mudslide on west side of Michigan Creek about 300 yards upstream from prominent outcrop of Tahkandit limestone. Center S¼NE¼NE¼ sec. 23, T. 4 N., R. 29 E., about 3 miles east-southeast of Nation, Charley River A–2 quad. (1:63,360), upper Yukon Valley, Alaska. This locality is shown as number 6 in figure 1.

### Genus LUPHERELLA Imlay, n. gen.

#### Lupherella boechiformis (Hyatt)

Plate 2, figures 1–27

*Daonella boechiformis* Hyatt, 1894 Geol. Soc. America Bull., v. 5, p. 415.

*Daonella cardinoides* Hyatt, 1894, Geol. Soc. America Bull., v. 5, p. 416.

*Daonella boechiformis* Hyatt. Crickmay, 1933, U.S. Geol. Survey Prof. Paper 175–B, p. 53, pl. 14, figs. 8–13.

*Daonella cardinoides* Hyatt. Crickmay, 1933, U.S. Geol. Survey Prof. Paper 175–B, p. 53, pl. 14, figs. 18–23.

This species in the collections of the U.S. Geological Survey is represented by a few specimens from partially metamorphosed noncalcareous siltstone in the Sailor Canyon Formation of east-central California, by a few specimens from noncalcareous mudstone in the Wallowa Mountains in northeastern Oregon, and by hundreds of specimens from the Nicely Formation of Lupher (1941) in east-central Oregon. In the Nicely Formation the species occurs in black calcareous concretions and in calcareous mudstones. The specimens from California are all distorted, and those from the mudstones in Oregon appear to be somewhat crushed. In contrast, the specimens from concretions are undeformed and well preserved.

The shell is inequilateral, slightly inequivalve, obliquely ovate to elliptical in outline, slightly extened posteriorly, and gently convex.

The left valve is slightly more convex than the right valve and is most convex in the umbonal region. Its length exceeds its height on all specimens. The ratio of height to length, based on measurements of 10 well-preserved specimens, ranges from 86.3 to 96.5. The beak is situated ¼–⅖ of the length of the shell from the anterior end. It is pointed, projects forward and inward, and rises slightly above the hinge line. The dorsal margin is straight and is about two-thirds as long as the shell. The anterior margin is evenly rounded and slightly projecting. The ventral margin is broadly convex. The posterior margin is generally more broadly rounded than the anterior margin. The left valve has a posterior wing that is moderately long, merges evenly with the body of the shell, and is rather indistinct on most specimens. A short weak anterior wing is present on many small left valves and is separated from the body of the shell by a shallow round depression.

The right valve is similar in size and shape to the left valve, but is rounder in outline, has a smaller and less projecting beak, and is a little less convex. The lesser convexity of the right valve, however, is based on measurements of many single valves because complete shells have not been found together. The right valve has a moderately long but weakly defined posterior wing and a small anterior ear that is bounded by a deep groove. The anterior ear has been noted on 20 specimens.

The shell is ornamented with highly variable radial and concentric ribs, of which the radial ribs predominate. The ribbing as a whole is nearly as strong on the right valve as on the left.

The radial ribs are mostly fine and sharp but they vary markedly in strength, width, and spacing both on the same specimens and on different specimens. They range also from nearly straight to rather wavy. Generally they are straightest and sharpest on the umbonal and medial parts of the shell, become broader and more wavy toward the margins, and fade out dorsally on the anterior and posterior margins. The radial ribs are most wavy where the concentric ribs are strongest and are somewhat stronger where they cross the concentric ribs than in the concentric interspaces. The width of the radial ribs ranges from a little more than the width of the interspaces to about one-third the width of the interspaces. New radial ribs arise by furcation and by intercalation in an irregular manner. The number of radial ribs, as seen on 20 specimens of various sizes, ranges from about 35 to 85 and differs considerably in specimens of the same approximate size, but it is greatest on the largest specimens. The number of radial ribs appears to be about the same on both valves.

The concentric ribs vary considerably in width, strength, spacing, and number. Near the beak they are rather fine and are widely but variably spaced. Toward the margins of the shell they become broad, closely spaced, and much wider than the interspaces. The concentric ribs are decidedly stronger and broader toward the posterior margin than toward the other margins, and are much more conspicuous on some specimens than on others. The number of concentric ribs, as based on counts of 20 specimens, ranges from 16 to 44 and differs considerably on specimens of the same approximate size, but it increases generally with increasing size and is greatest on the largest specimens.

The ligament area and muscle scars are unknown. The shell, represented by fragments on a few specimens, is very thin.

"*Daonella*" *boechiformis* Hyatt was assigned by Hyatt (1894, p. 415) to the Triassic genus *Daonella*, presumably on the basis of its general shape and ornamentation. The type specimens, however, are poorly preserved and distorted and do not show the hinge area. The much better preserved specimens from the Nicely Formation of eastern Oregon show that an assignment to *Daonella* is not possible because of the presence of fairly long posterior wings and of a small anterior bysal ear.

*Lupherella boechiformis* (Hyatt) in Oregon and California is associated with many ammonites of late Pliensbachian age, including the genera *Liparoceras* (*Becheiceras*), *Reynesoceras*, *Prodactylioceras*, *Arieticeras*, *Fontanelliceras*, and *Leptaleoceras*. In the Nicely Formation of east-central Oregon it is also commonly associated with rhynochonellid brachiopods and uncommonly with fish remains, ammonite aptychii, belemnite guards, small gastropods, and the pelecypods *Ostrea*, *Entolium*, *Camptonectes*, *Oxytoma*, *Modiolus*, and *Pinna*. All these occur both in concretions and in the surrounding black mudstone. The variety of organisms present is similar to that associated with *Otapiria* in Upper Triassic and Lower Jurassic beds in New Zealand (Marwick, 1953, p. 19, 20).

*Lupherella boechiformis* (Hyatt), on the basis of lithologic facies and faunal association, probably lived in a fairly shallow sea in which organic mud was accumulating and which locally in Oregon contained a considerable variety of mud-dwelling, attached, and free-swimming organisms.

*Types.*—Lectotype USNM 153296; syntypes USNM 30189, 30191; hypotypes USNM 153297–153316; hypotypes California Acad. Sci., 12778, 12779.

*Occurrences.*—*Lupherella boechiformis* (Hyatt) has been found only in two areas in eastern Oregon and in one area in California, as shown in figure 2. In northeast Oregon it occurs throughout about 520 feet of unnamed partially metamorphosed beds exposed on the northern front of the Wallowa Mountains about 5½ miles S. 54° W. of the center of Enterprise (No. 1 in fig. 2). In east-central Oregon near Izee it occurs throughout the thin Nicely Formation (No. 2 in Fig. 2). In east-central California it occurs about 2,000 feet above the base of the Sailor Canyon Formation in Sailor Canyon (No. 3 in fig. 2). The exact location in California is shown in figure 6.1 of a paper by Clark, Imlay, McMath, and Silberling (1962, p. B–16). Descriptions of the U.S. Geological Survey Mesozoic localities in which *L. boechiformis* (Hyatt) has been found are given below. The numbers 1–3 preceding the descriptions refer to the numbers shown in figure 2 and to the three areas just mentioned.

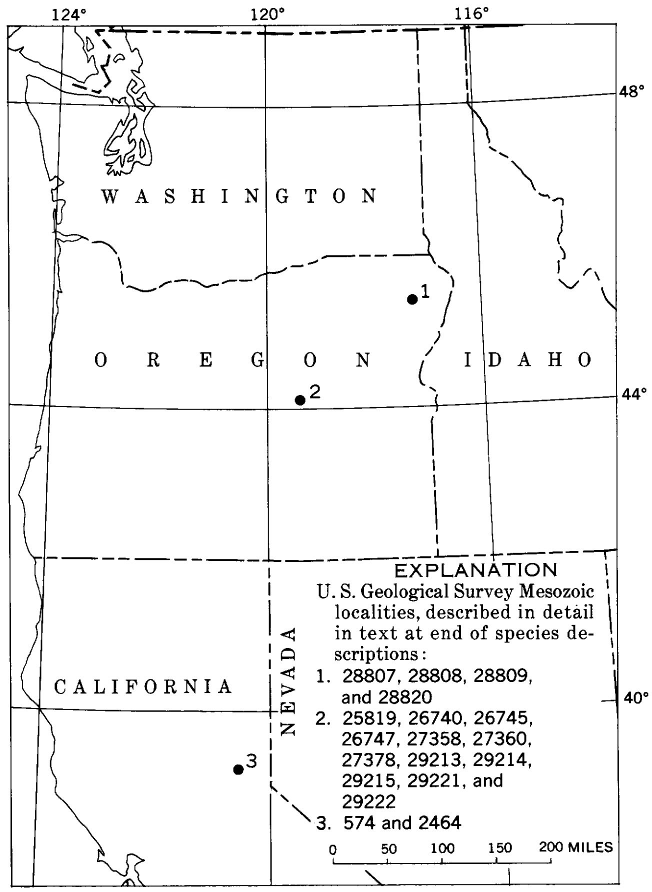


FIGURE 2.—Occurrences of *Lupherella boechiformis* (Hyatt) in Oregon and California.

1. Mesozoic loc. 28807. Bruce Nolf, Tracy Vallier, W. H. Taubeneck, and R. W. Imlay, 1963. Northeast side of Sheep Ridge near center NW¼NW¼ sec. 19 (unsurveyed), T. 2 S., R. 44 E., Wallowa County, Oreg. Unnamed beds from 820 to 1,030 feet above base of exposures. Highest elevation 6,960 feet.
1. Mesozoic loc. 28808. Same data as loc. 28807, but 760–820 feet above base of exposures.
1. Mesozoic loc. 28809. Same data as loc. 28807, but 510–710 feet above base of exposures.
1. Mesozoic loc. 28820. Bruce Nolf, 1962. Same data as loc. 28807, but probably from entire sequence from 510–1,030 feet above base of exposures.
2. Mesozoic loc. 25819. R. E. Wallace and J. A. Calkins, 1955. NE¼SE¼ sec. 36, T. 16 S., R. 28 E., Grant County, Oreg. Nicely Formation of Lupher (1941).
2. Mesozoic loc. 26740. W. R. Dickinson and W. R. Imlay, 1957. North slope of main fork of Rosebud Creek, SW cor. sec. 36, T. 16 S., R. 28 E., Grant County, Oreg. Nicely Formation. Scattered concretions in roadcuts and on surface of ground.
2. Mesozoic loc. 26745. R. W. Imlay, 1957. Head of west fork of Elkhorn Creek on Morgan Mountain, NE¼ sec. 14, T. 17 S., R. 27 E., Grant County, Oreg.
2. Mesozoic loc. 26747. R. W. Imlay, 1957. Roadcut in SE cor. sec. 29, T. 18 S., R. 26 E., Grant County, Oreg. Nicely Formation, lower third, about 50 feet south of contact with top of Suplee Formation.
2. Mesozoic loc. 27358. R. W. Imlay and H. R. Christner, 1958. Rosebud Creek, center SW¼ sec. 2, T. 17 S., R. 28 E., Grant County, Oreg. Nicely Formation, about 100 feet above base.
2. Mesozoic loc. 27360. R. W. Imlay, 1958. Ridge south of Caps Creek, SE¼NW¼ sec. 16, T. 17 S., R. 28 E., Grant County, Oreg. Nicely Formation, about 20 feet below top.
2. Mesozoic loc. 27378. R. W. Imlay, 1958. Southeast slope of Morgan Mountain at head of east fork of first small creek west of Elkhorn Creek, NE¼ sec. 14, T. 17 S., R. 27 E., Grant County, Oreg. Nicely Formation, about 120 feet above base.
2. Mesozoic loc. 29213. W. O. Ross and R. W. Imlay, 1965. Head of Rosebud Creek, on east side of road just north of sharp bend from west to north, NE cor. sec. 2, T. 17 S., R. 28 E., Grant County, Oreg. Nicely Formation, 50–60 feet above base.
2. Mesozoic loc. 29214. W. O. Ross and R. W. Imlay, 1965. Head of Rosebud Creek, on east side of a north-trending logging road near intersection with east-trending logging road, in NW cor. sec. 1, T. 17 S., R. 28 E., Grant County, Oreg. Nicely Formation.
2. Mesozoic loc. 29215. W. O. Ross and R. W. Imlay, 1965. East slope of canyon draining north from Hole-in-the-Ground, in NE cor. sec. 35, T. 17 S., R. 27 E., Grant County, Oreg. Nicely Formation, about 160 feet above base.
2. Mesozoic loc. 29221. W. O. Ross, 1965. Near top of ridge half a mile southwest of South Fork of John Day River in west-central part SW¼SE¼ sec. 25, T. 17 S., R. 27 E., Grant County, Oreg. Nicely Formation, 50–70 feet below top.
2. Mesozoic loc. 29222. W. O. Ross and R. W. Imlay, 1965. Concretion in old road in SE cor. sec. 29, T. 18 S., R. 26 E., Grant County, Oreg. Nicely Formation, about 35 feet above base.
3. USGS Mesozoic loc. 574. Waldemar Lindgren, 1890. Sailor Canyon near Sterretts mine (now called Trinidad mine on Royal Gorge 7½′ quad.) in SE¼ sec. 35, T. 16 N., R. 13 E., Placer County, Calif. Sailor Canyon Formation.
3. Mesozoic loc. 2464. Cooper Curtice, 1891. Sailor Canyon near Sterretts mine at same general location as Mesozoic loc. 574, Sailor Canyon Formation.

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# PLATES 1–2

## PLATE 1

[Figures 19, 24 and 25 are natural size. All others are twice natural size]

FIGURES 1–23. *Otapiria tailleuri* (Imlay), n. sp. (p. B3).

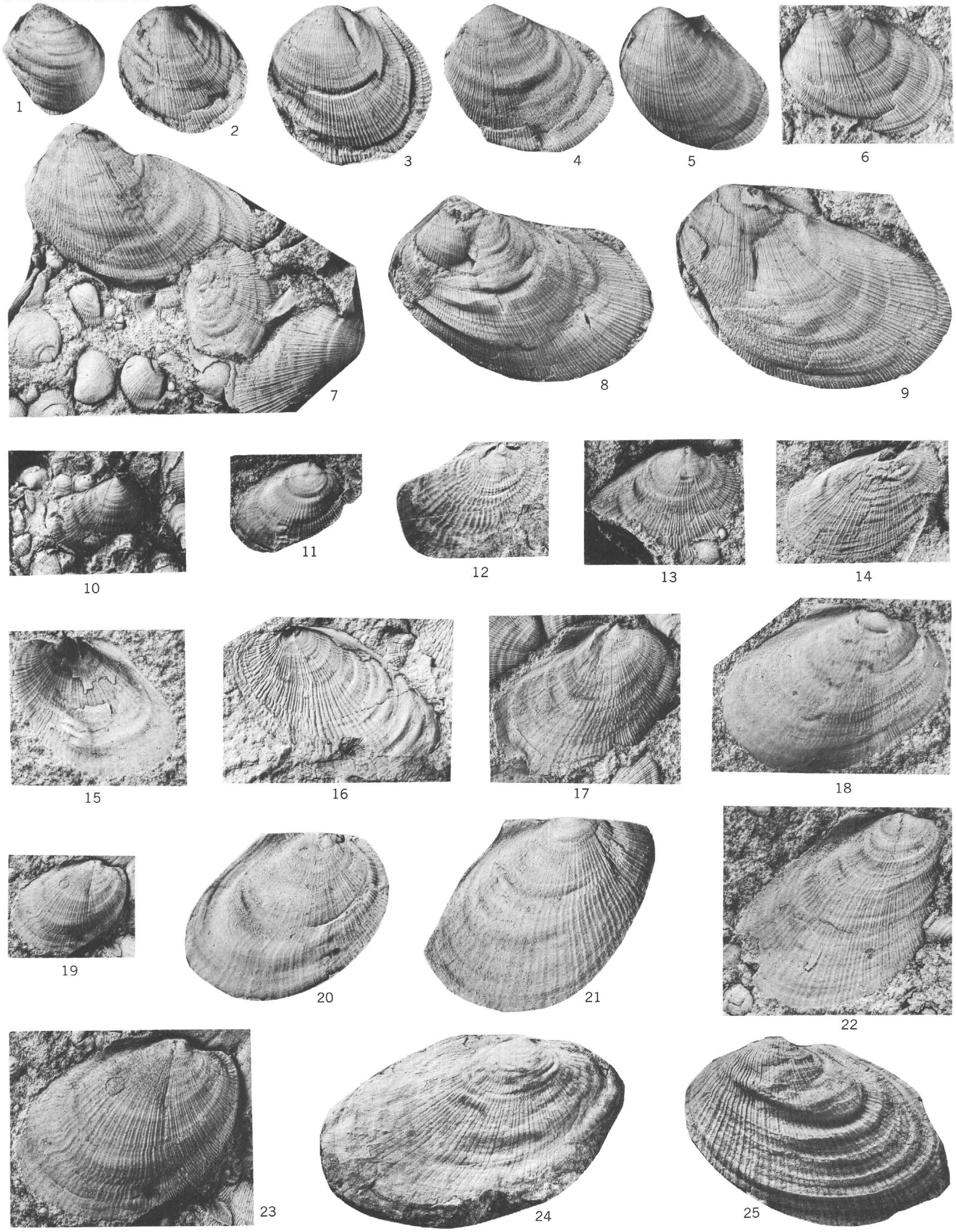
1. Paratype USNM 153272, left valve.
2. Paratype USNM 153273, left valve.
3. Paratype USNM 153274, left valve.
4. Paratype USNM 153275, left valve.
5. Holotype USNM 153276, left valve.
6. Paratype USNM 153277, left valve and several small left and right valves.
7. Paratype USNM 153278, left valve.
8. Paratype USNM 153279, left valve.
9. Paratype USNM 153280, left valve.
10. Paratype USNM 153281, right valve showing byssal ear.
11. Paratype USNM 153282, right valve.
12. Paratype USNM153283, right valve showing byssal ear.
13. Paratype USNM 153284, right valve.
14. Paratype USNM 153285, right valve.
15. Paratype USNM 153286, right valve showing interior.
16. Paratype USNM 153287, right valve showing interior.
17. Paratype USNM 153288, right valve.
18. Paratype USNM 153289, right valve.

19, 23. Paratype USNM 153290, right valve (× 1 and × 2).

20. Paratype USNM 153291, right valve.
21. Paratype USNM 153292, right valve.
22. Paratype USNM 153293, right valve. All specimens shown in figures 1–9 are from USGS Mesozoic loc. M2317. Those in figures 11, 13, 15, 17–22 are from USGS Mesozoic loc. M2317. Those in figures 10 and 14 are from USGS Mesozoic loc. 24060. Those in figures 12 and 16 are from USGS Mesozoic loc. M2318. All these specimens are from organic shale directly overlying Upper Triassic beds in northern Alaska.

24, 25. *Otapiria marshalli* (Trenchmann), (p. B1).

24. Right valve, hypotype TM2390 from New Zealand Geological Survey loc. 348 on Otapiri Creek in Hokonui Hills, New Zealand. View made from plaster replica.
25. Left valve, hypotype TM2389 from New Zealand Geological Survey loc. 349 on Otapiri Creek in Hokonui Hills, New Zealand. View made from plaster replica.




*OTAPIRIA*

## PLATE 2

[All figures are twice natural size unless otherwise indicated]

FIGURES 1–27. *Lupherella boechiformis* (Hyatt), (p. B8).

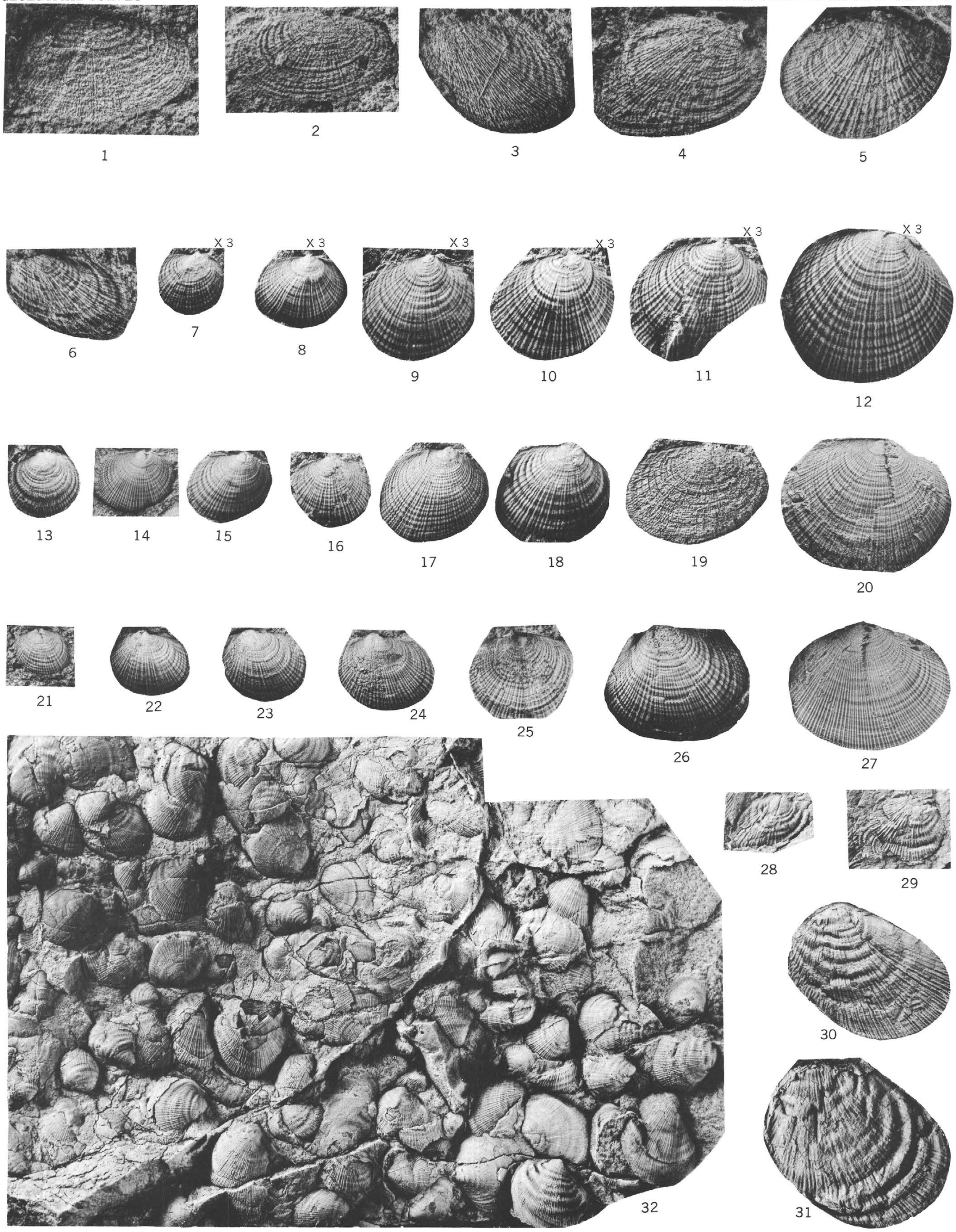
1. Syntype USNM 30189, left valve, view of rubber imprint.
2. Lectotype USNM 153296, right valve.
3–5. Cotypes USNM 30191 of "*Daonella*" *cardinoides* Hyatt. Figure 3 is a left valve. Figures 4 and 5 are right valves. This species is a synonym of *Lupherella boechiformis* (Hyatt).
6. Hypotype USNM 153297, left valve. Originally described as *Daonella* sp.(?) by Hyatt (1894, p. 416).
7. Hypotype USNM 153298, right valve (× 3).
8. Hypotype USNM 153299, right valve (× 3).
9. Hypotype USNM 153300, right valve (× 3).
10. Hypotype USNM 153301, right valve (× 3).
11. Hypotype USNM 153302, right valve (× 3).
12. Hypotype USNM 153303, right valve (× 3).
13. Hypotype USNM 153304, right valve.
14. Hypotype California Acad. Sci. 12778, right valve.
15. Hypotype USNM 153305, right valve.
16. Hypotype USNM 153306, right valve.
17. Hypotype USNM 153307, right valve.
18. Hypotype USNM 153308, right valve.
19. Hypotype USNM 153309, right valve.
20. Hypotype USNM 153310, right valve.
21. Hypotype USNM 153311, left valve.
22. Hypotype USNM 153312, left valve.
23. Hypotype USNM 153313, left valve.
24. Hypotype USNM 153314, left valve.
25. Hypotype USNM 153315, interior of right valve.
26. Hypotype USNM 153316, left valve.
27. Hypotype California Acad. Sci. 12779, right valve. All specimens shown on figures 1–6 are from the Sailor Canyon Formation at USGS Mesozoic loc. 2464, California. The specimens shown in figures 7–13, 15–18, 20–24 and 26 are from the Nicely Formation of Lupher (1941) at USGS Mesozoic loc. 29222, Oregon. Specimens shown in figures 14 and 27 are from the Nicely Formation at Lupher's loc. 125, Oregon. Figure 19 is from a rubber imprint of an external mold in brown mudstone of the Nicely Formation at USGS Mesozoic loc. 29326, Oregon. Figure 25 is from the Nicely Formation at USGS Mesozoic loc. 26740. Note anterior byssal ear shown in figures 7–12 and small anterior wing shown in figures 21–24 and 26.

28–31. *Otapiria* sp. undet. (p. B7).

Figured specimens USNM 153295. Figures 28 and 29 are right valves showing byssal ear and notch. Figures 30, 31 are left valves. All specimens shown in figures 28–31 from float at USGS Mesozoic loc. M1717 in the upper Yukon Valley, Alaska.

32. *Otapiria tailleuri* Imlay, n. sp. (p. B3).

Hypotype USNM 153294, from USGS Mesozoic loc. 24060, northern Alaska. Shows characteristic shape and ribbing of immature specimens.




*LUPHERELLA*, N. GEN. AND *OTAPIRIA*

U. S. GOVERNMENT PRINTING OFFICE : 1967 O - 237-493