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OF A NEW SPECIES FROM TASMANIA

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The taxonomic placement of Gadopsidae is discussed and an evaluation of its osteological relationships with related families is given. Similarities to the more primitive genera of the trachinoids, notothenioids, and uranoscopoids are noted and the inclusion of Gadopsidae in the Trachinoidea is recommended.

A description of the geological history of southeastern Australia, including marine invasions, climate, and tectonics, is presented in order to develop a hypothesis concerning the center of origin of the family. The suggestion that the Bass Strait region is the center of evolution for the family is supported by evidence concerning the distribution of other fishes and invertebrates.

Evidence, including geographical range, is presented to show that Gadopsidae is a primary division freshwater family. The absence of Gadopsidae from southern Tasmania and from the coastal rivers east and north of the Snowy River, Victoria, is of particular

interest.

Morphometric measurements (23) and counts of meristic characters (15) were made on 27 fish from four localities in Tasmania and 107 fish from six localities in Victoria, Australia. On the basis of differences, as shown by graphical analysis, the Tasmanian fish are shown to be distinct from the Victorian fish.

A new species Gadopsis tasmanicus is described. This species has greater numbers of branched caudal rays, total caudal rays, and vertebrae than G. marmoratus. It also has more pores along the lateral line and a slightly longer head in relation to the standard length than G. marmoratus.

The presence of 19 principal caudal rays suggests that G. tasmanicus is the more primitive of the two species. This character also differs from the condition synoptic of the Percoidei, 17 or less principal caudal rays.

A REVIEW OF THE GADOPSIDAE,
WITH A DESCRIPTION OF A NEW
SPECIES FROM TASMANIA

by

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A REVIEW OF THE GADOPSIDAE, WITH A DESCRIPTION
OF A NEW SPECIES FROM TASMANIA

I. INTRODUCTION

The uncommon combination of primitive and advanced characters exhibited by Gadopsidae, its wide geographical range with suggestive marine limitations, and its lack of closely related forms, all contributed to a decision to begin a taxonomic study of the family. The work included an investigation of the variation within Gadopsis in the various geographical regions of Victoria and in Tasmania, and a general osteological study of Gadopsis to determine its relationships with other groups of fishes. In order to develop a hypothesis concerning its center of evolution and dispersion, it was imperative to include an extensive treatment of the geological history of southeastern Australia.

The field work began on February 13, 1964, while the author was sampling the fish fauna of the Wellington River, Victoria, Australia. At this time the river blackfish, Gadopsis marmoratus Richardson 1848, was taken only in pools, and particularly under rocks at the quiet lower end of pools. Because the sampling gear was a back-pack electric-shocker this pattern of occurrence was readily observed. The blackfish were quite numerous and large numbers of introduced brown trout, Salmo trutta Linnaeus 1758,

along with several smelt, Retropinna victoriae Stokell 1941, were also collected. However, the native galaxias, Galaxias sp., and grayling, Protroctes maraena Günther 1864, apparently had been exterminated by the trout. The blackfish probably survived by not being close competitors of the trout. Its niche, at least in mountain streams, is quite similar to the cottids in trout waters of the Northern Hemisphere, and could have prevented Gadopsis from being heavily preyed upon by trout.

The Gadopsidae, an "aberrant" monotypic family, has an interesting combination of advanced and primitive characters. It has true spines and jugular pelvic fins reduced to I, 1; yet has cycloid scales and, in the Tasmanian forms, 19 principal caudal rays.

Recent workers in zoogeography, Myers (1938), de Beaufort (1951), and Darlington (1957), have stated consistently that the only primary freshwater fish families, as defined by Myers (1938), in Australia are the lungfish and an osteoglossid. They have been concerned only with the spread of these fish to Australia and have neglected the possibility of freshwater fishes arising in Australia. The only exception to this is de Beaufort (1964) who has suggested that the Melanotaeniidae is a primary freshwater family which arose in Australia. Günther (1880) included the Gadopsidae in his list of true freshwater fish families and Ogilby (1913) remarked

that though sometimes taken in the brackish water of tidal rivers, Gadopsis is incapable of existence in pure sea water. The interesting distribution of Gadopsis, to be stated later, is perhaps the best example available to describe how the dispersion of a freshwater fish is limited by geographical barriers. I consider the Gadopsidae to be a primary division freshwater family.

McCoy (1879) described two species of Gadopsis, G. gracilis and G. gibbosus, and Steindachner (1884) described G. fuscus. These three are the only species of the Gadopsidae to be described after Richardson established G. marmoratus. McCoy (1879) stated that G. gracilis from the Yarra River, Victoria, differed from G. marmoratus in having a more slender and smaller head, and having 11 to 12 dorsal spines. His G. gibbosus from the Bunyip River in eastern Victoria was distinguished only by 12 dorsal spines. He stated that G. marmoratus was said to have 10 dorsal spines.

Ogilby (1913) showed that specimens from eastern Victoria and Tasmania had a range of 10 to 12 dorsal spines, and that the range in head length of Gadopsis from Queensland, Victoria, and Tasmania was large enough to discredit the variation in head length of G. gracilis. After Ogilby's work it was accepted that there was only one species of Gadopsis. However, Ogilby did say, "The western form of Gadopsis has apparently a more slender body and fewer dorsal spines than its south-eastern prototype."

II. CLASSIFICATION OF THE GADOPSIDAE

Varied Placement of the Family

The varied placement of the genus Gadopsis is reviewed by Ogilby (1913). The original author (Richardson, 1884) considered it to belong to the Blennidae. From here Günther (1862), placed it at the head of his Anacanthini Gadoidei. According to Ogilby (1913), Steindachner (1866) reasserted its affinity with the blennies, and he was subsequently supported by Gill (1893). Günther (1880), however, retained his original opinion. Boulenger (1904) and Goodrich (1909) both referred Gadopsis to the Blennidae, not even giving it family rank. Regan (1913b) established a percoid division for Gadopsis with the following statement:

Gadopsis scarcely differs from the Perciformes in osteology, but there is no mesopterygoid and there are 2 radials on the hypercoracoid and 2 on the hypocoracoid. The pelvic fins are jugular; each reduced to a small spine and a bifid ray. Against Blennioid relationships are the intervention of the prootic between parasphenoid and alisphenoid, the 3 anal spines, the dorsal and anal rays more numerous than the corresponding myotomes. Vertebrae 21 + 26; ribs except the first 2 or 3 on strong parapophyses.

This separated Gadopsis from Regan's division Trachiniformes mainly by the presence of three anal spines, and having the ventrals consisting of one spine and a bifid ray each rather than one spine

and five rays. They were separated from the Nototheniformes by the presence of four actinosts on the pelvic girdle and by having two nostril openings on each side. The Nototheniformes have only three actinosts, a single nostril on each side, and usually have the principal caudal rays reduced. Gadopsis differs from Regan's division Champsodontiformes in that the latter have the base of the pectoral fin oblique and have large pelvics. In some of the Trachini-formes, that is, Leptoscopidae, the mesopterygoid is lacking and it is small and narrow in the Uranoscopidae, while in the Trachinidae and Percophiidae the mesopterygoid is broad. The Champsodonti-formes also lack the mesopterygoid.

Jordan (1905) considered the Gadopsidae to be allied with the blennies but later followed Regan (1913b) and considered it to be a series under the percoid fishes (Jordan, 1923). Berg (1947) followed Regan in delegating Gadopsis to a separate superfamily under the Percoidei with the notation, "ventral fins jugular, I, 1." Berg altered the superfamily Trachinoidea by adding the Owstoniidae and Oxudercidae and by making the Leptoscopidae, Dactyloscopidae, and Uranoscopidae a separate superfamily Uranoscopoidae. This superfamily Berg characterized as having the ascending wing of the parasphenoid meeting the descending wing of the frontal excluding the alisphenoid and prootic from the orbital fontanelle. The ventrals are in front of the pectorals and consist of either I, 5 or I, 3.

Starks (1923) first utilized this relationship between these families, and Berg (1947) used Starks' work as a footnote to support his superfamily. However, elsewhere in the same work Starks remarks that the character of the ascending wing of the parasphenoid in front of the prootic cannot be used in defining large groups, but is only of value in defining groups of family value or less.

Osteological Relationships with Other Groups

The major character that separates the groups just discussed from typical Percoidei is their jugular pelvic fins and resultant alterations in pelvic and pectoral girdles.

Of the 22 families comprising Berg's (1947) superfamilies Gadopsoidae, Trachinoideae, Uranoscopoidae, Champsodontoidae, and Notothenoidae, 19 are found in the Southern Hemisphere and 10 are endemic to the Southern Hemisphere. The endemic families are entirely cold-water fishes prevented from extending into the Northern Hemisphere by temperature requirements. Thus, it seems that the center of evolution of these fishes was in the Southern Hemisphere, and the large number of monogeneric or digeneric families (11) would suggest that this was an extremely diversified group which is now at least partially relict.

The Gadopsidae are most similar to the more primitive forms of each taxonomic group mentioned. The primary shoulder girdle

has four actinosts, with several pectoral rays articulating with the edge of the scapula near the pectoral condyle, and the scapular foramen wholly contained by the scapula. Regan (1913b) characterized Gadopsis as having two actinosts on the scapula and two on the coracoid. In this work, two actinosts were found to articulate with the scapula; one articulated between the scapula and the coracoid and the fourth articulated with the coracoid. The position of the actinosts as seen in this work is identical to the description given by Starks (1930) of the shoulder girdle of the leptoscopid Crapatalus novae-zelandia. The Uranoscopidae and Dactyloscopidae both have a scapular foramen opening against the cleithrum (Starks, 1930). Starks suggests that the typical percoid condition has the scapular foramen contained entirely within the scapula which has a pectoral condyle to receive the upper pectoral rays.

Regan (1914) stated that all of the notothenioids have three actinosts, and this would seem to remove them from consideration as similar to the ancestors of Gadopsis. However, Gregory (1933) shows Cottoperca gobio with four actinosts. He notes that the Pinguipes, Berg's (1947) Mugiloididae, have several characters suggestive of the primitive notothenioids. The small occipital crest, indistinct parietal crests, and expansion of the skull behind the orbits are similar to Cottoperca. The form of the pectoral girdle and actinosts in Pinguipes are suggested by Gregory (1933) to

make an ideal starting point for the primary pectoral girdle of Cottoperca. It is noteworthy that Gregory's figure of the pectoral girdle of Pinguipes could be used to describe that found in Gadopsis and the description of features of the skull given for Pinguipes is also typical of Gadopsis.

With the realization that the cold-water fishes discussed previously are undoubtedly relicts from a period in which the southern seas were colder than at present and considering the similarities between Gadopsis and the more primitive representatives discussed above, I cannot see the advantage or necessity of placing Gadopsis within a separate division or superfamily.

The characteristics which have prevented the inclusion of Gadopsidae in the trachinoids have not prevented others from being included. Gadopsis lacks the mesopterygoid but so do the Leptoscopidae (Regan, 1913b). The Champsodontiformes and the Chaenichthyidae of the notothenioids also lack the mesopterygoid (Regan, 1913a, b). The fact that the ventrals are reduced to I, 1 also is used to isolate Gadopsis; however, Berg (1947) includes the Oxudercidae in the trachinoids and it lacks ventral fins. Other than these two characters Gadopsis is similar to many of the trachinoids, uranoscopids, and notothenioids, and should be placed along with the other more generalized forms in the Trachinoidea.

III. GEOLOGICAL HISTORY OF SOUTHEASTERN AUSTRALIA

Fossil History

In order to give an account of the probable evolutionary history of Gadopsis and to explain the basis for its present distribution, it is necessary to describe the geological history of southeastern Australia and Tasmania.

There are apparently no published accounts of fossil Gadopsis so we must look to related forms to establish the earliest period in which Gadopsis could have evolved. The earliest fossil records of fishes near Gadopsis are of Callipteryx, a trachinoid from the Upper Eocene of Italy. In addition, three extinct genera of Uranoscopidae are known from the Upper Miocene of Sicily, Tuscany, and the Early Pliocene of Spain (Woodward, 1901). Fossils of primitive percomorphs are known in Australia from the beginning of the Tertiary (Hills, 1934, 1943, 1958).

Considering the small amount of work that has been expended on Australian fossil fishes, it is not surprising that fossils of Gadopsis have not been found and described. Adding to this, the upland stream habitat preference of Gadopsis does not make it likely to become fossilized. Rayner (1958) has noted that the places best suited for producing fossil fishes are the uninhabited, perhaps

poisoned, bottom waters. Thus, the fact that Gadopsis lives primarily in regions with relatively steep stream gradients makes it unlikely for individuals to get to the better fossil-producing areas. Large-scale mortalities with resultant increased chances of fossilization (which occur due to encroachments of salinity, poisoned waters, or low dissolved oxygen) are likely to be avoided by upland dwelling fishes.

Marine Invasions, Climate, and Tectonics

The geology of Australia has been extensively reviewed by David (1950) and most of the material following is from this source.

The extensive Romo and Tambo seas of Central Australia which reached across the continent to provide a connection to the Tethys Sea during the Cretaceous had almost completely withdrawn by the beginning of the Tertiary. Australia remained an intact continent from the beginning of the Tertiary with only minor marine invasions.

Marine conditions appeared in the Otway region of Victoria early in the Eocene and remained in some form during the Oligocene and Miocene. During the Oligocene, estuarine swamps alternating with shallow seas spread across the Victorian lowlands as far as East Gippsland; however, Tasmania remained connected to continental Australia. In western Victoria and South Australia lakes and

swamps marked the sites of the future Murravian and Adelaide gulfs (Figure 1).

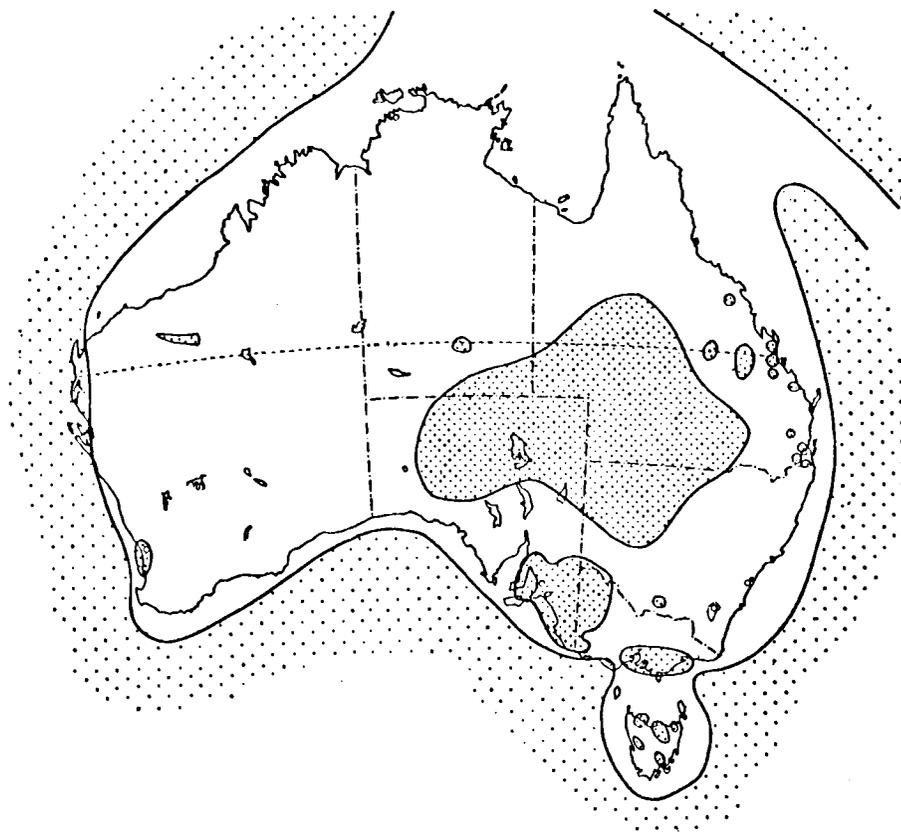


Fig. 1-- Land and sea in early Oligocene time.
(From David, 1950)

The Miocene was a period of sinking and was characterized by some marine transgressions in southeastern Australia. There was probably a low, narrow, swampy isthmus in central and eastern Victoria which broadened out to the south but the sea covered the Bassian Islands and the northwest corner of Tasmania from Wynyard

to the Arthur River (Figure 2). In the Murravian and Adelaide gulfs the waters spread far inland extending north almost to Broken Hill.

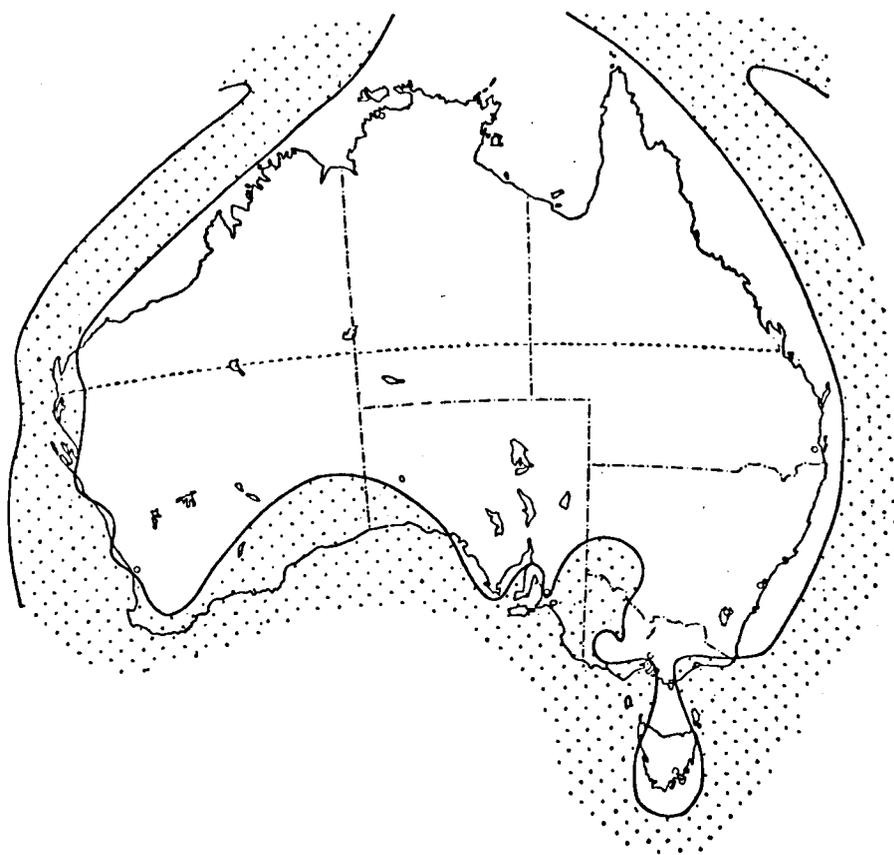


Fig. 2-- Land and sea in Miocene time.
(From David, 1950)

Toward the end of the Miocene, epeirogenic uplift in the southeast began to shallow the seas and some of the sediments were faulted, tilted, and gently folded. They apparently rose above the sea as some erosion occurred before the sea returned. In southern Victoria part of the site of the former Miocene sea became a piedmont area and was buried beneath fans of gravel and sand brought

down by swift mountain streams.

Uplifts which occurred in the late Pliocene drove the sea completely out of eastern Victoria. However, the sea had spread across the Mallee country of northwest Victoria and to the Murray River in South Australia. The tectonic uplifts which occurred in Victoria in the Upper Miocene and again in the late Pliocene resulted in some gain of land at the expense of the sea, but there was compensating down-faulting or sagging whereby Bass Strait was formed, and by the end of the Tertiary Tasmania had been completely severed from the mainland.

The isolation of Tasmania from the mainland was broken at least once and probably twice during the Pleistocene. A study of Figure 3 shows that a fall in sea level of 30 fathoms would join Tasmania and Victoria. It is generally accepted that the sea level dropped at least 40 fathoms during the Mindel glacial period and at least 50 fathoms during the Riss glacial period. Thus, at least once during the Pleistocene there was a drainage pattern between Victoria and Tasmania which fishes could easily utilize. As the sea level fell, the trough in Bass Strait would have become a bay open on its western side, then a closed brackish lake which would slowly have become a freshwater lake as the runoff waters from

Tasmania and Victoria gradually diluted the saline waters.

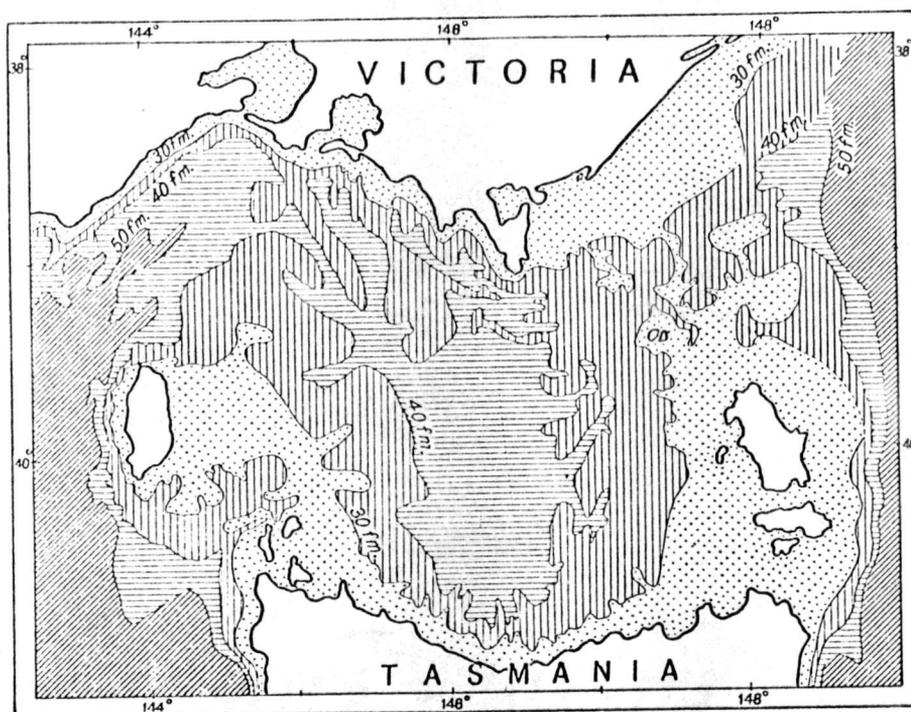


Fig. 3--Submarine contours in Bass Strait
(From David, 1950)

In Middle and Upper Pleistocene uplifts occurred in western Victoria forming the Murray Ridge and backing up the Murray River to form Lake Nawait. Probably by the beginning of Recent time the Mallee Ridge was breached at its lowest level; Lake Nawait had been partially drained and the Murray River below Loxton brought into existence. The Glenelg River in western Victoria, possibly an antecedent stream, was rejuvenated and lengthened by the upbowing of the ridge.

The present cycle of river erosion throughout most of southeastern Australia was initiated by the uplifts that occurred during

the Kosciusko epoch in late Pliocene.

During the Eocene and continuing through the Oligocene and until the Middle Miocene the climate of Australia was quite tropical and humid. From the late Miocene to the present a climatic zoning resembling that of the present day is suggested by the simultaneous existence of a tropical marine fauna in the north and a cold-water type in the south. Ekman (1953) suggested that the average age of the present day echinoid genera in southeastern Australia extends from the Middle or late Oligocene. Following the uplifts in the late Miocene and Pliocene the climate became much colder than it had been previously and apparently somewhat colder than at the present time. During the Pleistocene glacial periods the climate became very much colder than at present and three separate glacial stages are recognized in Tasmania and New South Wales, while during the interglacial periods the climate was warmer than at present.

With the beginning of Recent times the climate became quite hot and arid conditions spread over Central Australia producing vast deserts. The great interior lakes shrank and disappeared and the extensive Pleistocene land-fauna which had spread across the interior was severely restricted. Many forms became extinct but others which inhabited, or were able to retreat to, the moister coastal belts were able to survive. About 3,000 years ago the climate became somewhat cooler and moister and this has continued to the present day.

IV. EVOLUTIONARY HISTORY OF THE GADOPSIDAE

The Gadopsidae probably arose from a trachinoid ancestral type dwelling along the southern coast of Australia during or after the Middle Miocene. The majority of these fishes are cold-water forms and it was not until the Middle Miocene that cold marine waters occurred along the southern coast of Australia.

During one or more of the gradual changes from marine to freshwater conditions which occurred over extensive areas of southern Victoria and Bass Strait, I suggest that the ancestors of the present-day Gadopsis were able to adapt themselves or progressively evolve into freshwater fish. Along with this adaptation they lost their ability to live in sea water.

Once adapted to freshwater, Gadopsis could have ascended the tributaries to both Tasmania and Victoria. These populations were then separated by the down-faulting which produced Bass Strait. This isolation could have been as complete in separate river systems within Victoria and Tasmania as between the Victorian and Tasmanian populations.

This evolution could have occurred either during the late Miocene or during the Pliocene, but it would have had to have been accomplished before the end of the Kosciusko epoch in late Pliocene in order for Gadopsis to utilize this tectonic occurrence to cross the

Great Divide via stream capture.

Because the Kosciusko epoch was largely restricted to eastern Victoria and the adjacent New South Wales region, the fish which managed to cross the divide were from populations in eastern Victoria.

The Victorian population of Gadopsis may have mixed with the Tasmanian population during the Pleistocene glaciations. Drainage patterns that would have resulted from a drop in sea level in Bass Strait could have facilitated this mixing (Figure 3). These populations have been isolated again since the end of the Riss glacial period. The subsequent Würm Glaciation did not result in a sufficient drop in sea level to provide a land bridge between Victoria and Tasmania.

The present distribution of Gadopsis fully supports the foregoing hypothesis. According to Ogilby (1913), in continental Australia Gadopsis occurs from the Torrens and Onkaparinga rivers in South Australia to the Snowy River in western Victoria. It does not occur in the Brodribb, Genoa, or other rivers between the Snowy River and Cape Howe. It occurs in the highlands and upper reaches of the Murray River as far north as the Condamine River in the vicinity of Warwick in southern Queensland. Johnston (1882), in describing the range of Gadopsis in Tasmania, was the first to notice that it is restricted to the rivers flowing into Bass Strait, although it has been successfully introduced elsewhere in Tasmania (Figure 4).

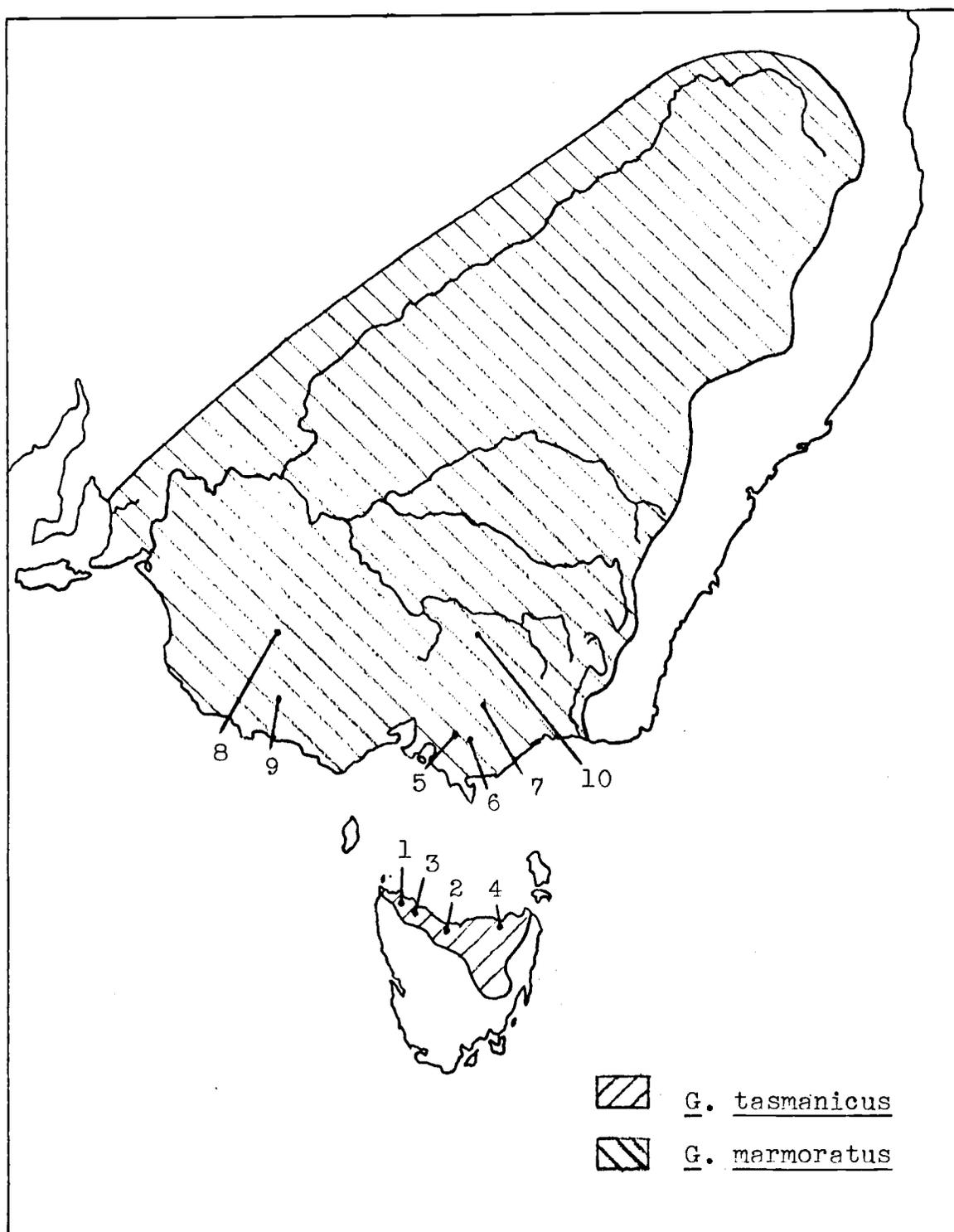


Fig. 4--Geographical range of *Gadopsis* including the localities of ten collections. (Numbers refer to descriptions on pages 20 and 21).

The Gadopsidae are not the only freshwater animals found in northern Tasmania and not in southern Tasmania. Among the freshwater mussels the genus Hyridella is found in the coastal rivers of southeastern Victoria and northern Tasmania, while the south of Tasmania has no freshwater mussels (McMichael and Iredale, 1959). Among the crayfish the Engaeus group of genera occurs commonly in the northern half of Tasmania and in Victoria with an isolated species in the foothills at the northern end of the Australian Alps and another species in the Wallum swamps of southeast Queensland (Riek, 1959).

The Bass Strait region has also been suggested as the center of origin of the Australian Parastacidae. Riek (1959) suggests that the distribution of all the Australian species with the exception of Tenuibranchiurus would be readily understood if one assumed a common marine ancestor for the Victorian and Tasmanian species, an ancestor occurring in the shallow seas of the Bass Strait area.

The Bass Strait region was probably also the center of origin of the tupong, Pseudaphritis urvillei, which is the only freshwater member of the Nototheniformes and is considered by Regan (1914) to be the most similar of living fishes to the ancestral Nototheniiformes.

V. TAXONOMIC STUDY

Description of Localities

A total of 134 fish were examined in this study, 27 from Tasmania and 107 from Victoria. The collections are as follows:

1. Tasmania: Black River, near junction with track between Mawbanna and Mengha, July, 1965; 16 adults, 105-191 mm.
2. Tasmania: Farm dam at Lower Wilmot, July 14, 1965; 7 adults, 192-246 mm. The stock was obtained from the Wilmot River in 1961.
3. Tasmania: Flowerdale River, near Lapoinya, February 24, 1965; 3 adults, 104-192 mm.
4. Tasmania: Bird River, three miles above Birdport, March 22, 1965; 1 adult, 173 mm.
5. Victoria: Latrobe River, two miles south of Willow Grove, March 11, 1964; 15 adults, 87-146 mm.
6. Victoria: Narracan Creek, one-half mile above its junction with the Latrobe River, March 12, 1964; 15 adults, 69-134 mm.
7. Victoria: Wellington River, four miles below Lake Tarli Karng, February 13, 1964; 15 adults, 81-138 mm.
8. Victoria: Taylors Lake, May 28, 1960; 24 adults, 74-149 mm.

9. Victoria: Violet Creek, a tributary of the Wannon River near Hamilton, November 16, 1959; 30 adults, 68-158 mm.
10. Victoria: Broken River, eight miles below Benalla, December 5, 1963; 8 adults, 66-144 mm.

All of the Tasmanian collections were made under the direction of the Tasmania Inland Fisheries Commission. The six Victorian collections were made by members of the Victoria Fisheries and Wildlife Department, the first four of which were made by the author and the last two by other members of the staff. The collections from the Wellington River, Narracan Creek, and the Latrobe River are all from the same drainage, the Latrobe River system. The three other Victorian collections are from separate drainages.

The distance between the study areas is not great. The northernmost locality, Broken River, is only 330 miles north of the Tasmanian localities and the other five Victorian localities are between 230 and 260 miles north of the Tasmanian localities. The elevations of all the localities are low, with only the Wellington River sample area above 1,000 feet in elevation (2,600 feet).

Climatic conditions are very similar in the Latrobe River system localities and the Tasmanian localities. The average annual rainfall in northern Tasmania is 30 to 50 inches, and this

compares with all of the Latrobe River system and Broken River localities. Violet Creek and Taylors Lake receive approximately 25 and 15 inches of rain annually. Mean winter temperatures of 40 to 45 F. are common to all the localities, while mean summer temperatures of 55 to 60 F. are found in all the localities except for Violet Creek and Taylors Lake which have mean summer temperatures of 65 to 75 F. (Australia, 1952, 1953).

The small variance in latitude between the Tasmanian and Victorian localities as well as the very similar climatic conditions, especially between the Latrobe River system and the Tasmanian localities rule out the possibility that observed differences between the Tasmanian and Victorian populations are due to the existence of a cline. This is further borne out by the fact that several workers dealing with different groups of organisms have combined Gippsland (which includes the Latrobe River system) and northern Tasmania within the same zoogeographical region.

Iredale and Whitley (1938) divided Australia into nine fluvi-faunal regions. Their Lessonian region included the rivers of eastern New South Wales, Victoria, and northern Tasmania. McMichael and Iredale (1959) place southern Victoria and Tasmania into a Bassian Faunal Region on the zoogeography of Australian land mollusca. Riek (1959) also uses the Bassian Faunal Region for a description of the zoogeography of freshwater crustacea.

Methodology

Measurements and Meristic Counts

The 23 morphometric measurements (including standard length) performed on all the fish were made with two types of dividers, one with fine points on each wing and one with a fine point on one end and the other blunt and bent perpendicular to the plane of operation. In addition, large calipers were used to take the standard lengths of several of the large fish.

Many of the 15 meristic characters were not counted on all of the fish. Vertebrae, total caudal rays, caudal rays articulating with the hypural plate, dorsal soft-rays, and anal soft-rays were counted only on the specimens that were either cleared or X-rayed. Branchiostegals and gill-rakers were counted only on the cleared specimens. The fleshy covering of the dorsal fin and anal fin made accurate counts of soft-rays impossible in specimens which were not cleared. The small spines of the pelvic fins were only visible in cleared, stained specimens. Pyloric caeca counts were made on only a few specimens from each locality and nearly all specimens examined had eight pyloric caeca, four on each side; however, several specimens had nine or ten pyloric caeca. Pores on the lateral line were not counted in cleared specimens. In the pectoral, anal, and dorsal soft-rays all rays were counted. Unless otherwise

stated all measurements followed the methods suggested by Hubbs and Lagler (1958). A total of 30 fish was X-rayed, five each from the Violet Creek, Broken River, Wellington River, Taylors Lake, and Black River series, three from Narracan Creek, and two from the Latrobe River.

Twenty-five fish were cleared and stained following the procedure suggested by Hollister (1934). Five specimens from each of the Violet Creek, Wellington River, Taylors Lake, and Black River collections were cleared; three from the Latrobe River and two from the Narracan Creek sample were cleared.

The cranial structure of three specimens, one each from the Violet Creek, Wellington River, and Bird River collections, were examined and no significant variations were found between these skulls.

Graphical Analysis

The data obtained from morphometric measurements and meristic counts were analyzed graphically following the procedure developed by Hubbs and Perlmutter (1942) and the graphs used were those proposed by Hubbs and Hubbs (1953). These graphs include several parameters.

1. The range of variation, shown by a horizontal line.
2. The mean, represented by a vertical line.

3. One standard deviation on each side of the mean, shown by the darkened rectangle.
4. Twice the standard error on each side of the mean represented by the hollow rectangle.

When comparing the graphs of two samples the length and overlap of the rectangles representing four standard errors are the primary consideration. Hubbs and Perlmutter (1942) concluded

that considerable reliance can be placed on the significance of the difference between samples, if the corresponding rectangles are only slightly separated, or if the overlap is not more than about 33 per cent of the length of the shorter of the two rectangles. When the longer rectangle is 2 to 4 or more times as long as the shorter one, an overlap of 50 per cent or even 75 per cent does not negate the probability that a significant difference exists. If the gap between the rectangles exceeds 10 per cent of the length of the shorter, the significance of the difference between the populations may be regarded as demonstrated beyond any reasonable doubt (if we assume the samples to be representative).

When the overlap of two subequal rectangles exceeds one third of the length of the shorter rectangle, little or no reliance can rightly be placed on the significance of the difference. When the overlap is 50 per cent the odds of significance are less than 10 to 1 unless the length of one rectangle is more than 4 times that of the other. Such differences in the values for σ_m are very rare in comparable data. Ordinarily any very considerable overlap renders the significance of the difference very doubtful.

Hubbs and Hubbs (1953) included a graph which enables very

quick determination of the probable significance of the observed differences between any two graphed samples. This graph was utilized to give the \underline{t} values (the ratio of the difference between the means to the standard error of this difference) and the values of \underline{P} (the probability that the observed difference is due to chance) that are reported. The odds of significance corresponding to the \underline{t} values were obtained from the same source.

Variation in Characters

A total of 37 morphometric and meristic characters were compared for the fish concerned in this study. One of these characteristics, caudal rays, has been treated in several different ways. It has been graphed as branched caudal rays, total caudal rays, and caudal rays articulating with the hypural plate. The last two methods of counting the caudal rays were only possible with the cleared or X-rayed specimens.

The reason for devoting considerable space to the number of caudal rays is that this seems to be the most significant variation between the Tasmanian and Victorian samples. Part of Regan's (1913b) definition of the percoid fishes is they have 17 or less principal caudal rays. The principal caudal rays are the branched caudal rays plus two. The range observed in the Tasmanian examples was 19 to 20 principal caudal rays or 17 to 18 branched caudal rays (Figure 5). It is also noteworthy that a considerable number of the Victorian specimens have more than 17 principal caudal rays.

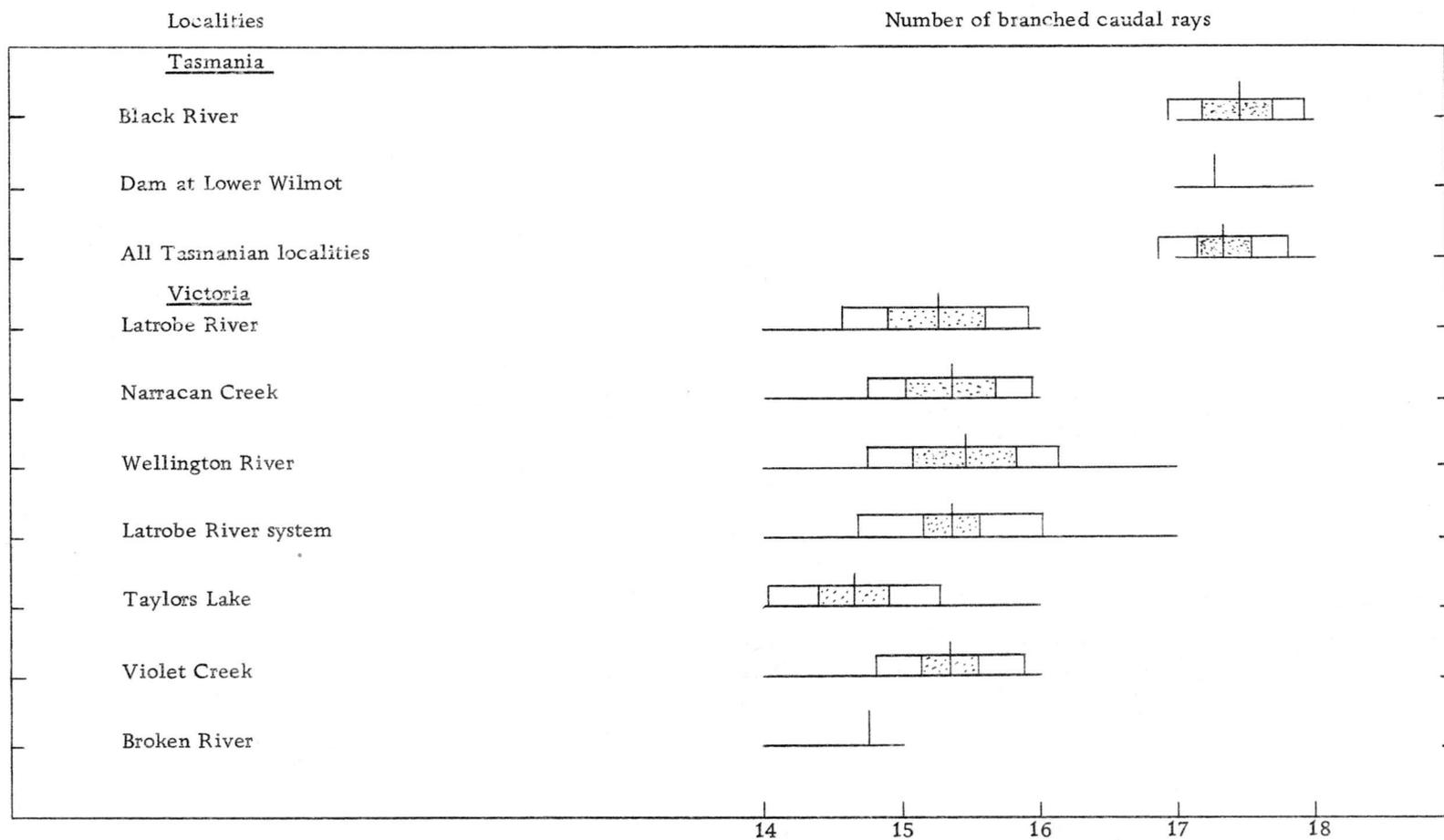


Figure 5. A comparison of the number of branched caudal rays in populations of Gadopsis from Tasmania and Victoria, Australia

There is a significant difference in the number of branched caudal rays between the Tasmanian and Victorian samples with values of t between the Tasmanian and Latrobe River system samples and between the Tasmanian and Wellington River samples being 7.6 and 4.4 respectively. Odds of significance for t values of 3, 4, and 6 are 369:1, 15,770:1, and 5×10^8 :1. It should be noted that the odds of significance corresponding to a P value of .05 (probability that the difference is not significant) are 20:1.

The range of total caudal rays in seven Black River, Tasmania adults was 33 to 34. Victorian specimens (33) varied between 27 and 31 total caudal rays. All nine Black River, Tasmania specimens had 17 caudal rays articulating with the hypural plate with nine articulating with the dorsal portion of the hypural plate and eight with the ventral portion. Specimens from Victoria (41) had either 15 or 16 rays articulating with the hypural plate. In 38 of these fish eight rays articulated with the dorsal part of the hypural plate and seven with the ventral portion (Figure 6).

Significant variance between the Tasmanian and Victorian collections is seen in head length, lateral line pores, vertebrae, and total pectoral rays. The Tasmanian collections have large values in each character. Values of t for differences in head length between the Tasmanian and Latrobe River system collections and between the Tasmanian and Wellington River collections are 6.6

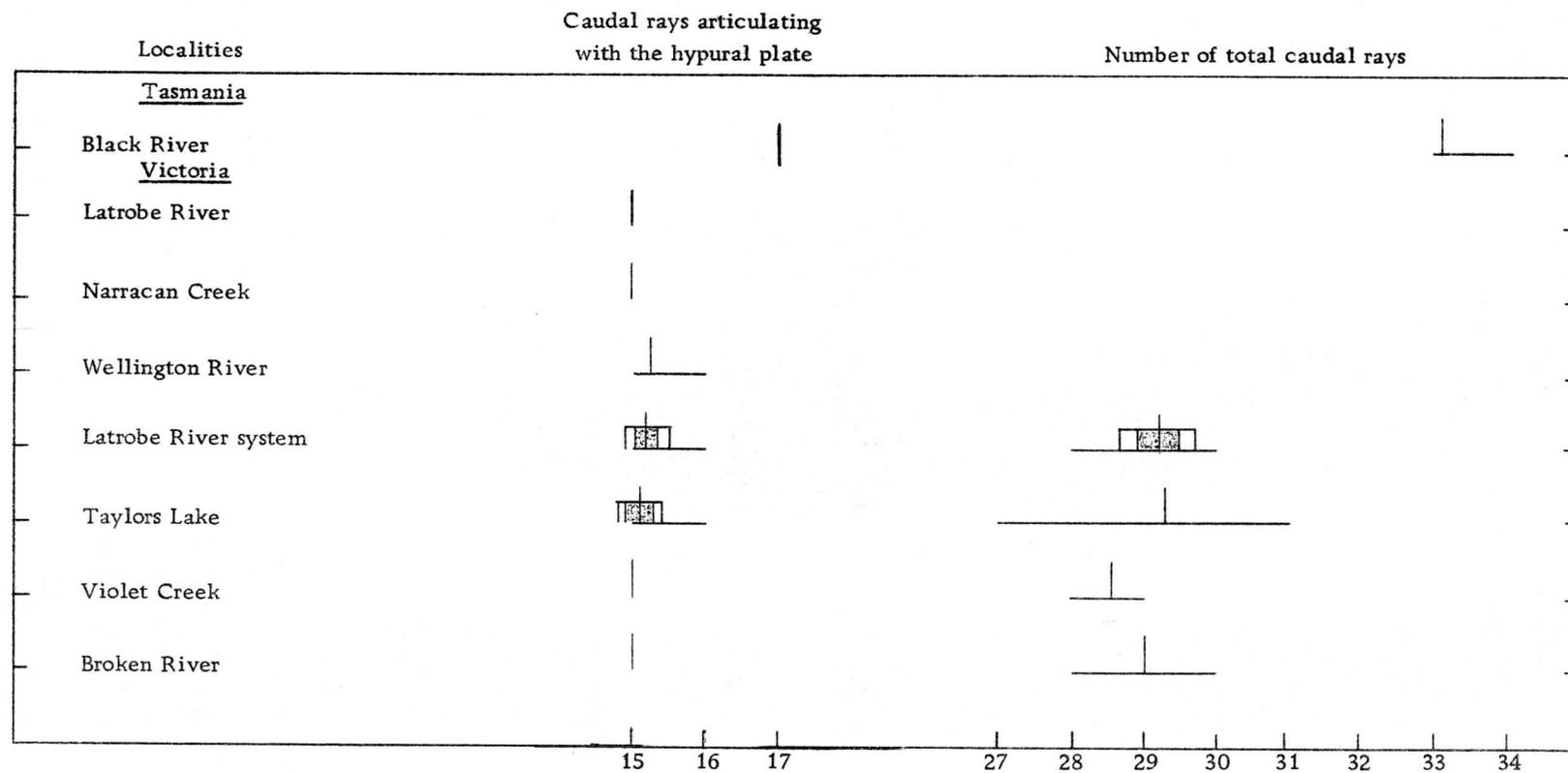


Figure 6. A comparison of the number of total caudal rays, caudal rays articulating with the hypural plate, in populations of Gadopsis from Tasmania and Victoria, Australia

and 3.7 (Figure 7). A variance in the number of lateral line pores between the Tasmanian and Latrobe River system samples and between the Black River and Wellington River samples is demonstrated by \underline{t} values of 7.6 and 2.6. The corresponding probability that the difference between the Black River and Wellington River is not significant is .01 (Figure 8).

The Black River sample has consistently more vertebrae than the Victorian samples. A \underline{t} value above 6.0 is found between the Black River sample and any of the Victorian samples (Figure 9). The Black River fish have 48 or 49 vertebrae, usually 22 + 26. Victorian specimens usually had 44 to 46 vertebrae with a range of 43-48, commonly 20 or 21 + 24 or 25.

The second most significant feature of the Tasmanian fish is their greater number of pectoral rays. All Tasmanian fish had 18 or 19 pectoral rays while the Victorian fish varied from 16 to 18 with only 6 out of 105 having 18 pectoral rays. The values of \underline{t} between the Black River sample and any of the Victorian samples is above eight (Figure 10).

The two western Victorian collections from Violet Creek and Taylors Lake have lower dorsal spine counts than the eastern Victorian and Tasmanian collections. Fish from Taylors Lake have from 8 to 12 dorsal spines and fall within the range of the other collections. However, the Violet Creek fish are not within the range of the western Victorian or Tasmanian collections, having 7 to 9 dorsal spines (Figure 11). Relatively recent connections between

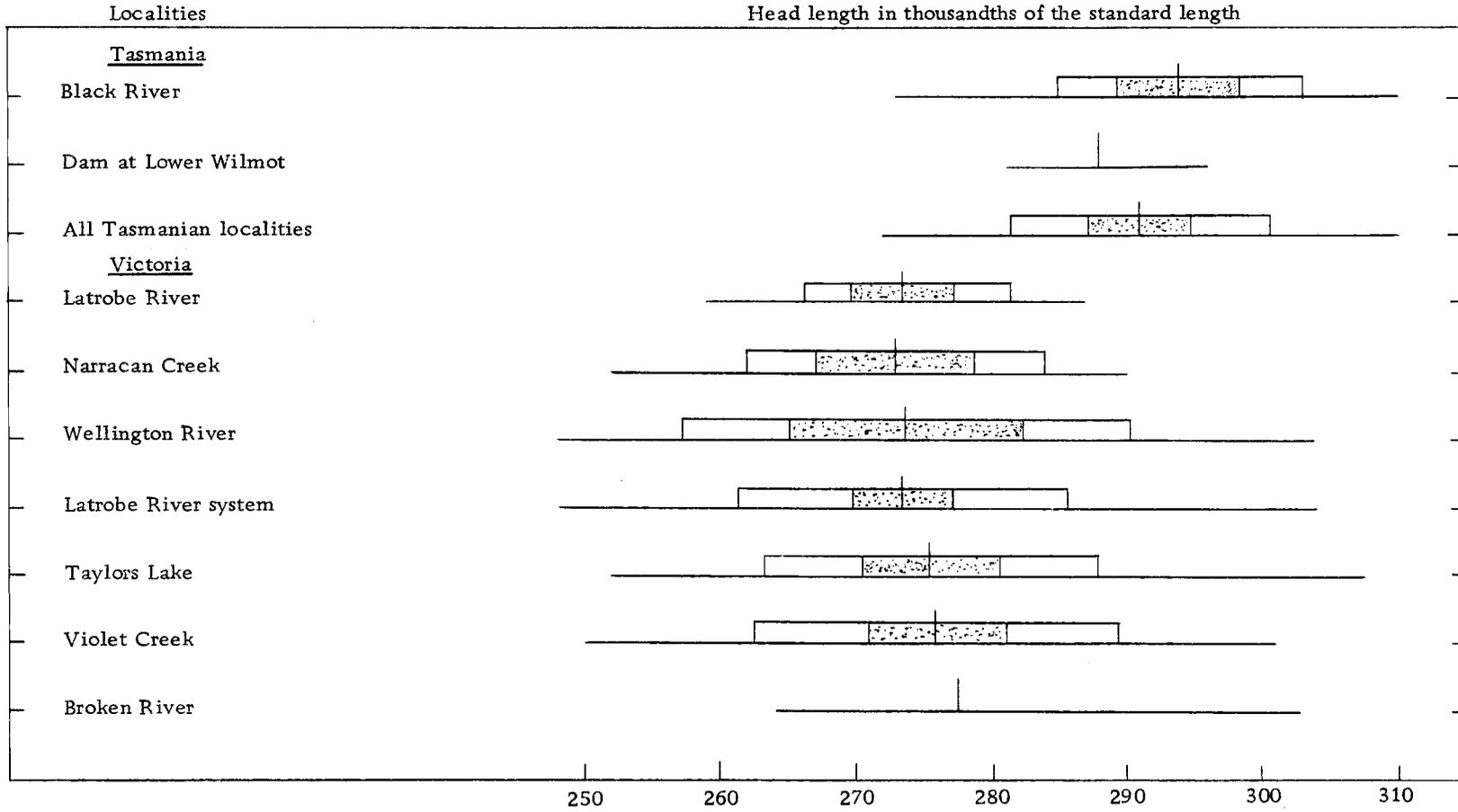


Figure 7. A comparison of head length, in thousandths of the standard length, in populations of *Gadopsis* from Tasmania and Victoria, Australia

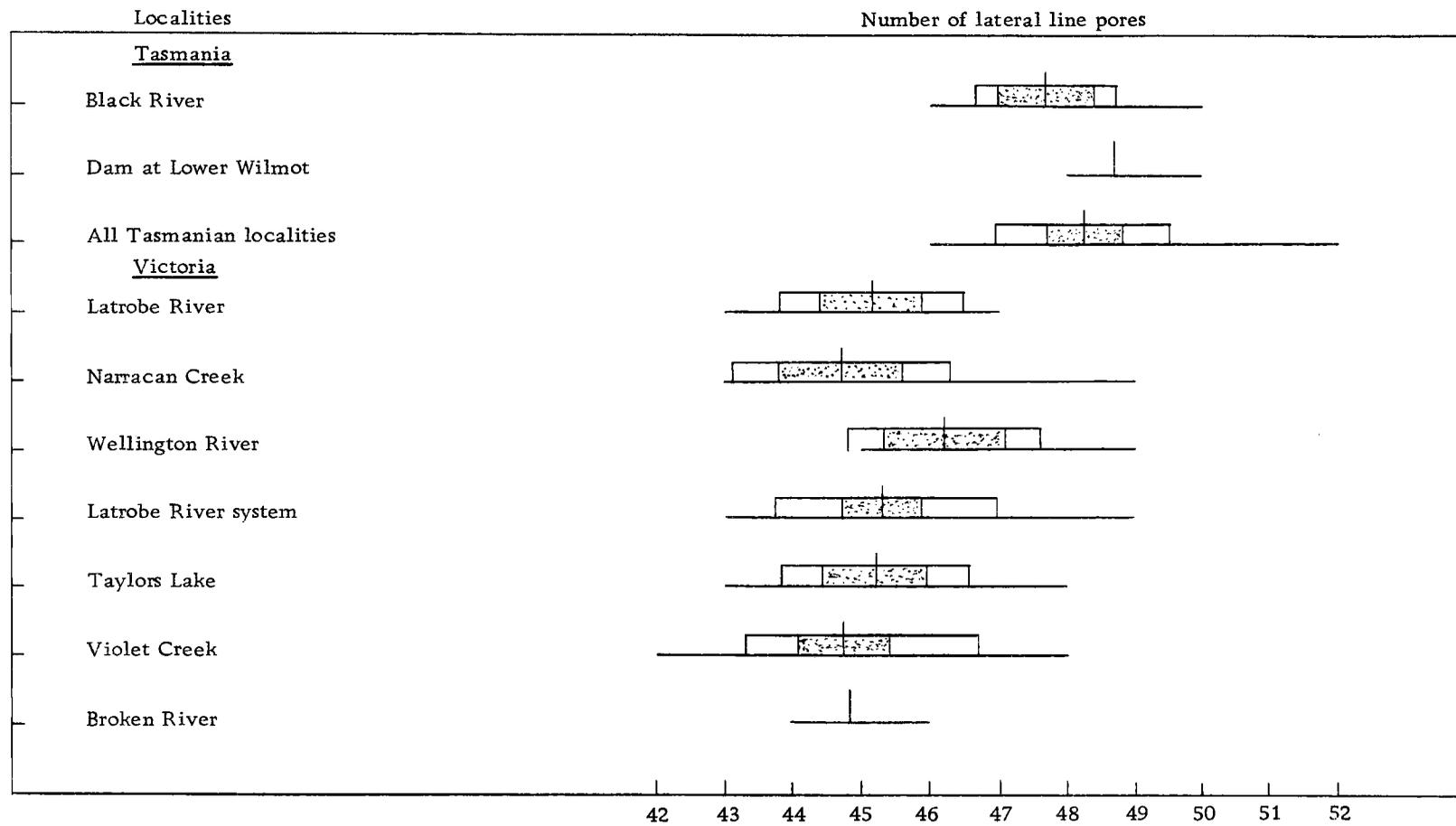


Figure 8. A comparison of the number of lateral line pores in populations of Gadopsis from Tasmania and Victoria, Australia

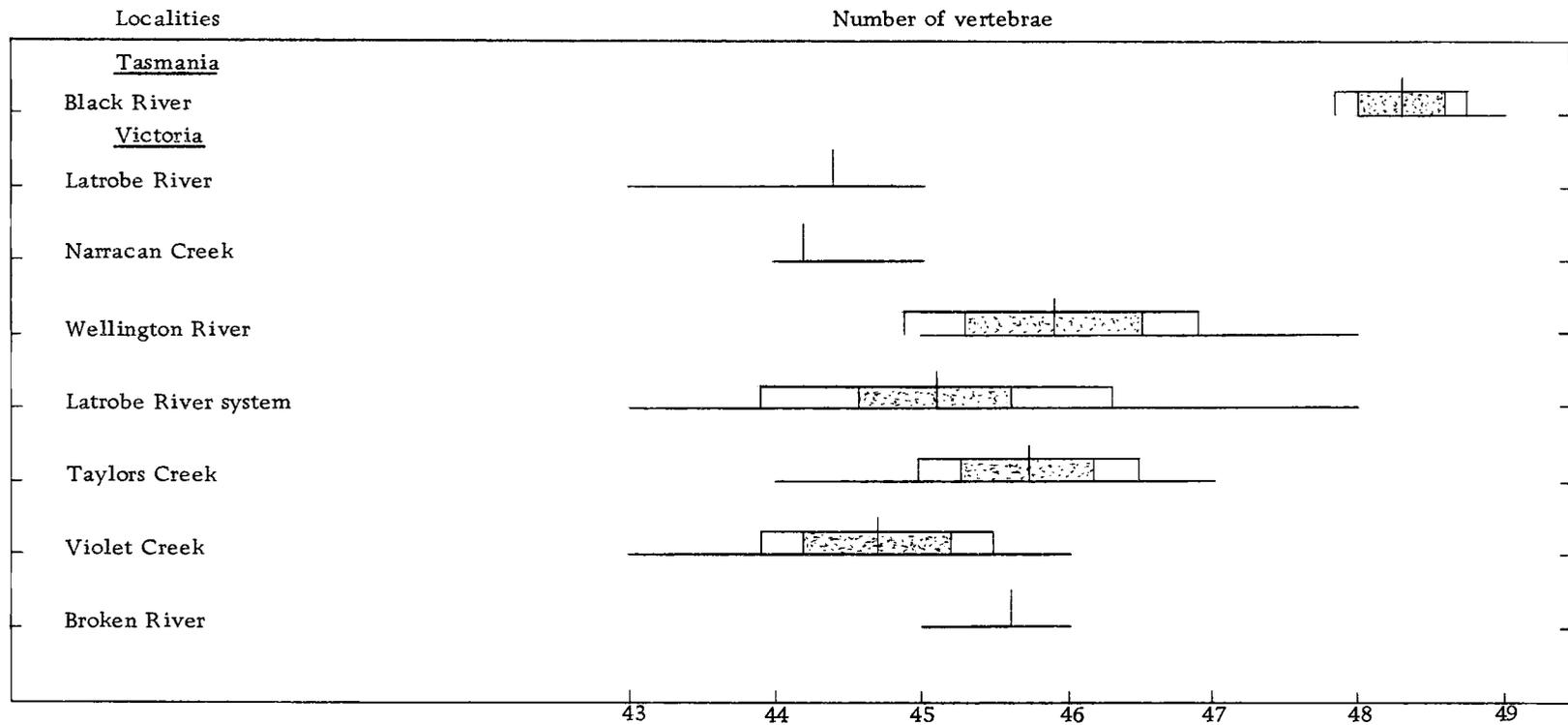


Figure 9. A comparison of the number of vertebrae in populations of Gadopsis from Tasmania and Victoria, Australia

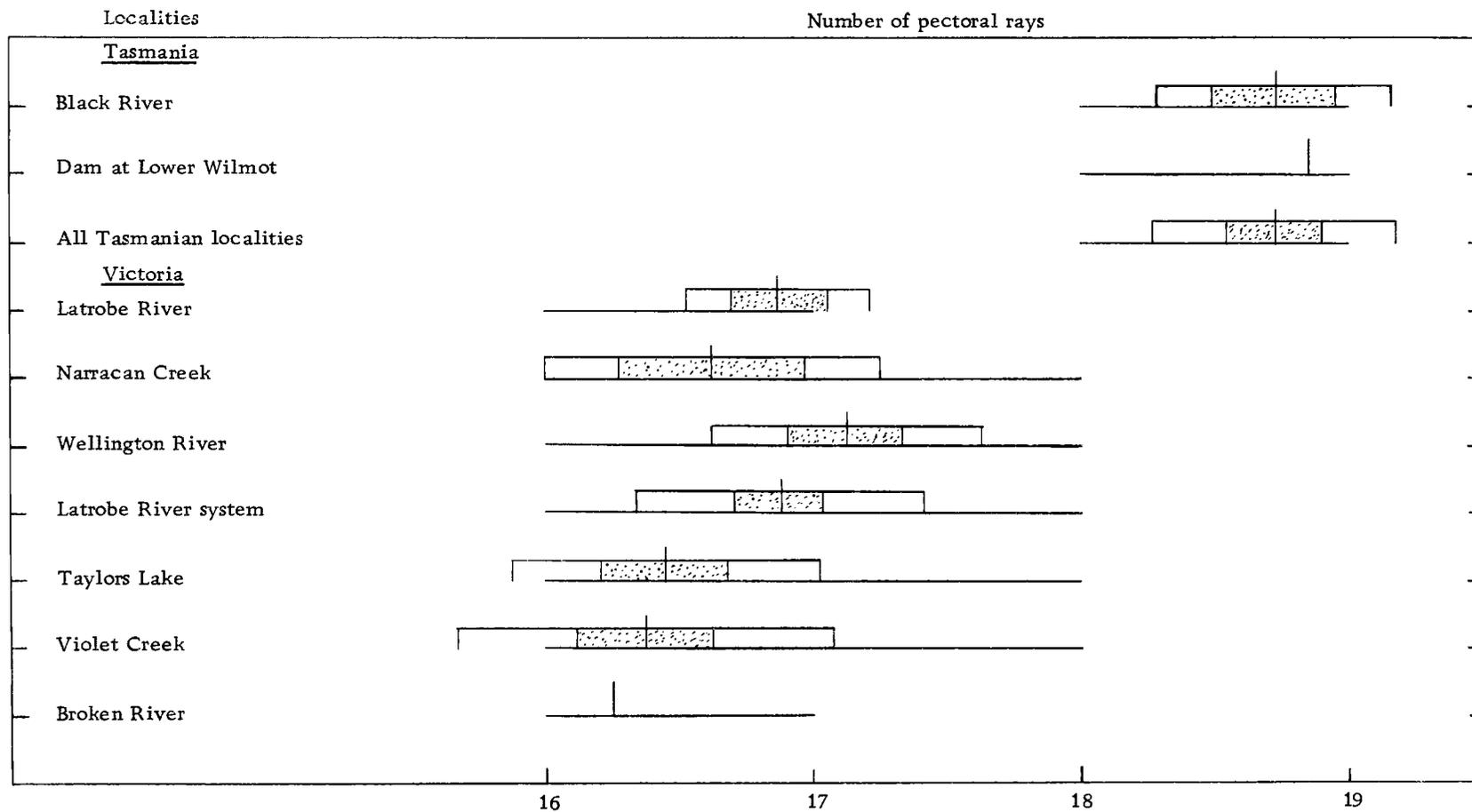


Figure 10. A comparison of the number of pectoral rays in populations of Gadopsis from Tasmania and Victoria, Australia

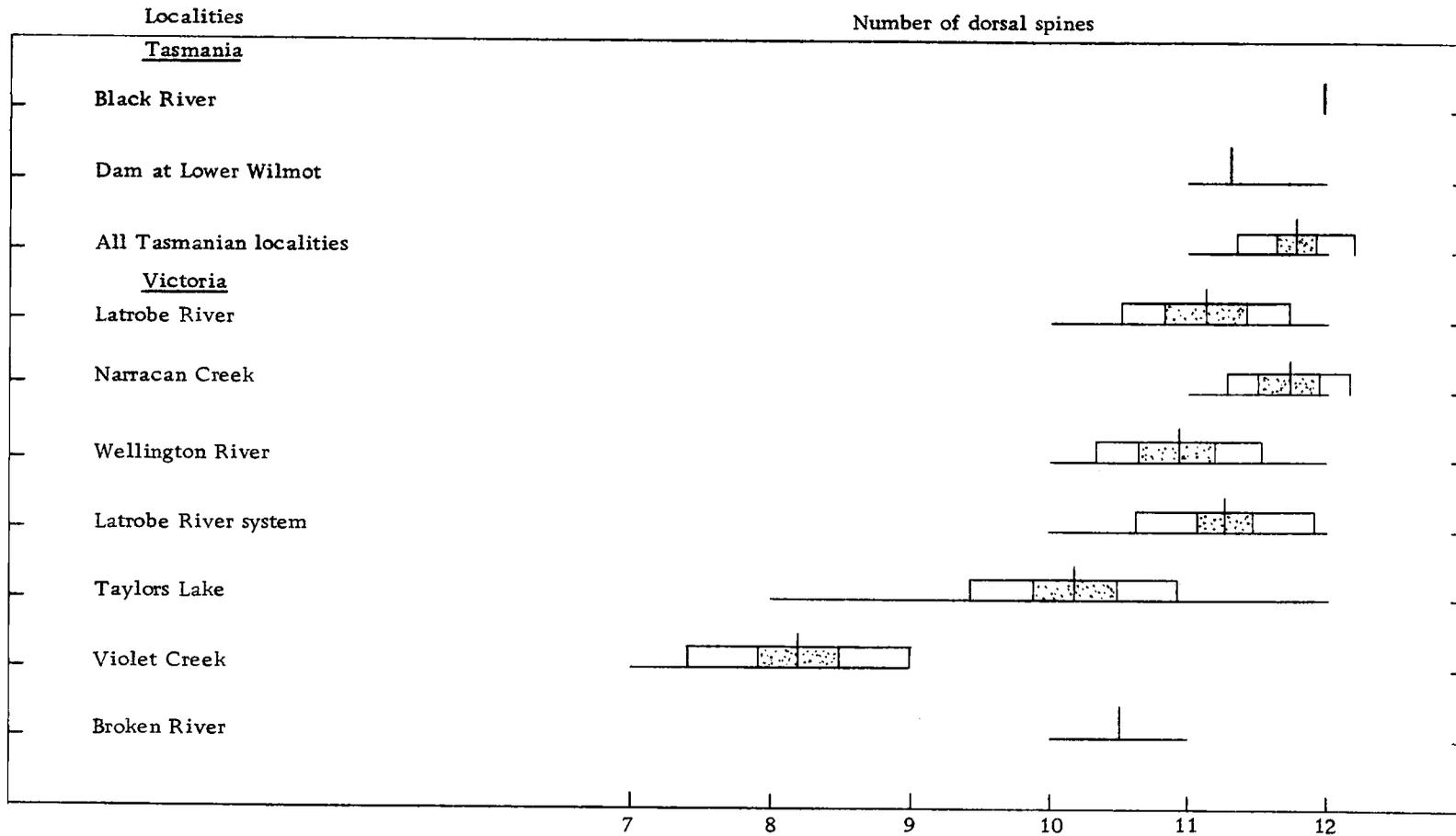


Figure 11. A comparison of the number of dorsal spines in populations of Gadopsis from Tasmania and Victoria, Australia

the Glenelg River (Violet Creek is a tributary within this river system) and Taylors Lake have been made by irrigation systems, through which fish can move between the Glenelg River and Taylors Lake via Rockland Reservoir.

However, regardless of the fact that Glenelg River stock could be present in Taylors Lake, there is a significant difference in the lower number of dorsal spines in the Violet Creek collection. Values of \underline{t} between the Violet Creek sample and all others are above eight. The Taylors Lake sample has \underline{t} values of 5.6 and 3.7 when compared to the Latrobe River system samples and to the Wellington River sample (Figure 11).

With regard to the evolution and spread of Gadopsis it is noteworthy that the Glenelg River is well to the west of the previously mentioned trough in Bass Strait and would have been isolated from both the Tasmanian and western Victorian populations for a long period of time, probably since the Pliocene. Slack-Smith in an unpublished work on blackfish in western Victoria found a range of 6 to 9 and a mean of 8.31 dorsal spines for fish from Violet Creek, a range of 6 to 10 and a mean of 8.94 for Kangaroo Creek which is a Victorian tributary of the unco-ordinated drainage near Naracoorte, South Australia. He found a range of 11 to 14 and a mean of 12.86 dorsal spines in Muston Creek, a tributary of the Hopkins River. The Hopkins River lies midway between the mouth of the Glenelg and the edge of the Bass Strait trough at Cape Otway. However, its headwaters are very close to drainages to the north and east.

Description of New Species

Gadopsis tasmanicus, new species

Tasmanian Blackfish

Gadopsis marmoratus (misidentifications). Günther, 1862:318

(redescription, Tasmania). Johnston, 1882:60 and 124

(northern Tasmania). Ogilby, 1913:72-74 (northern Tasmania).

Types. -- The holotype was taken in the Black River near its junction with a secondary road between Mawbanna and Mengha, Tasmania in July, 1965, under the direction of the Inland Fisheries Commission of Tasmania. Fifteen paratypes were taken with the holotype, five of which have been cleared and stained. The holotype, D748, 143 millimeters in standard length, four paratypes, D749-D752, and two cleared and stained paratypes, D753 and D754, will be returned to the Tasmania Inland Fisheries Commission for deposition in the Tasmanian Museum and Art Gallery (their collection numbers). Two paratypes and one cleared and stained paratype will be sent to the Victoria Fisheries and Wildlife Department for deposition in the National Museum, Melbourne. The remaining four paratypes and two cleared and stained paratypes will temporarily be deposited in the Oregon State University fish collection, OS 2167 and OS 2168.

Additional Material (all from northern Tasmania). -- OS 2170 (7), 192-246 mm., farm dam at Lower Wilmot, from stock obtained from the Wilmot River in 1961. OS 2171 (3), 104-192 mm., Flowerdale River, near Lapoinya. OS 2172 (1), 173 mm., Bird River, three miles above Birdport.

Diagnosis. -- A species of Gadopsis characterized by the large number of caudal rays; the principal caudal rays, 19-20, being greater than that descriptive of its order (17 or less). The species has 33-34 total caudal rays of which 17 articulate with the hypural plate; nine articulate with the dorsal section of the hypural plate and eight with the ventral section. Fin rays: Dorsal, XI or XII, 26-28; anal, III, 18 or 19; pectoral, 18 or 19; pelvic, I, 1. Body tapers slowly from near the origin of the dorsal, depth 19.4-24.8 percent of the standard length and width 11.2-13.3 percent of standard length; head of moderate length, 27.3-31.0 percent of standard length; lateral line curved, following the contour of the back with 46-50 pores.

Distinguishable from G. marmoratus by the larger number of branched caudal rays, pectoral rays, vertebrae, and lateral line pores. Additional characters of the holotype and descriptive statistics of the holotype and 15 paratypes are given in Tables I and II.

Etymology. -- Gadopsis tasmanicus is named after its locality.

Table I. Morphometric Characters Determined for 16 Type Specimens of Gadopsis tasmanicus
From the Black River, Tasmania

Character	Holotype	Holotype Plus 15 Paratypes			
		Range	Mean	Standard Deviation	Standard Error of the Mean
Standard length in millimeters	143	105-191	134	--	--
In thousandths of the standard length					
Head length	287	273-310	294	9.21	4.60
Snout length	84	83-100	92	5.07	2.53
Orbit width	56	52- 76	62	5.97	2.99
Upper jaw, length	126	122-144	129	5.27	2.63
Suborbital depth	28	27- 38	32	2.75	1.37
Least interorbital width	63	53- 76	64	5.91	2.96
Head width	133	119-144	129	6.25	3.12
Head depth	175	164-192	175	7.01	3.51
Body width	133	112-133	125	6.76	3.38
Body depth	217	194-248	219	13.03	6.51
Dorsal origin to snout tip	329	325-371	341	14.42	7.21
Dorsal origin to pectoral origin	154	146-175	159	8.32	4.16
Dorsal origin to anal origin	357	353-384	364	7.84	3.92
Dorsal origin to caudal base	692	647-707	676	15.58	7.79
Dorsal fin, basal length	588	543-599	572	15.49	7.74
Pectoral, length	168	164-181	170	6.00	3.00
Pelvic origin to lower jaw tip	182	159-212	187	13.95	6.97
Pelvic origin to snout tip	210	179-233	186	16.92	8.46
Pelvic origin to pectoral origin	112	112-129	122	4.31	2.16
Pelvic origin to anal origin	441	421-466	443	15.12	7.56
Anal fin, basal length	252	239-276	258	11.73	5.86
Caudal peduncle, length	147	134-168	147	7.75	3.87

Table II. Meristic Characters for Gadopsis tasmanicus from the Black River, Tasmania

Character	Holotype	Holotype Plus Paratypes				
		Number of Fish	Range	Mean	Standard Deviation	Standard Error of the Mean
Dorsal spines	12	16	12	--	--	--
Dorsal rays	28	7	26-28	27.0	--	--
Pectoral rays	19	15	18-19	18.7	0.442	0.228
Pelvic spines	1	5	1	--	--	--
Pelvic rays	1	16	1	--	--	--
Anal spines	3	16	3	--	--	--
Anal rays	19	7	18-19	18.9	--	--
Caudal rays, total	33	7	33-34	33.1	--	--
Caudal rays, branched	17	15	17-18	17.5	0.499	0.129
Caudal rays, articulating with hypural plate	17	9	17	--	--	--
Branchiostegal rays	--	5	7-8	7.2	--	--
Gill-rakers	--	5	7-9	8.0	--	--
Pyloric caeca	--	5	8-9	8.4	--	--
Vertebrae	49	10	48-49	48.3	0.458	0.290
Pores along lateral line	49	11	46-50	47.7	1.45	0.580

VI. SUMMARY AND CONCLUSIONS

Ogilby's (1913) excellent description of the morphology of the Gadopsidae must be altered to allow G. tasmanicus to be included. This is accomplished by the following: Pectoral, 16-19; anal, III or IV, 16-19; and principal caudal rays, 17-20. Ogilby stated that the scapula was without foramen. The 25 Victorian and five Tasmanian cleared specimens used in this work all had a scapular foramen wholly contained within the scapula. The specimens on which Ogilby based his description were from Queensland and they may differ from the Victorian and Tasmanian populations in this character.

Descriptions by Regan (1913b) and Ogilby (1913) of the primary pectoral girdle of Gadopsis were not valid in the examples utilized in this study. As seen in the present work, the primary pectoral girdle consists of the scapula, coracoid, and four actinosts which decrease in size toward the scapula. Two actinosts articulate with the scapula, one articulates between the scapula and the coracoid, and one articulates with the coracoid. The scapular foramen is wholly contained within the borders of the scapula, which also has a small pectoral condyle. The coracoid has a long, narrow projection to the cleithrum, leaving a large interosseous space, and a fine pointed posterior coracoid process.

Ogilby (1913, 1954) stated that Tasmania was the ancestral

home of Gadopsis; however, he does not state his reasons for believing this, with the exception that it grows to a much larger size in Tasmania. He cites the Queensland populations as examples of geographical degeneracy. The present work suggests that the Tasmanian species is the most primitive, because this species has a greater number of pectoral rays as well as having typically 19 principal caudal rays. However, the probable center of origin of the Gadopsidae was in the Bass Strait-southern Victoria region in the late Miocene or Pliocene. The eastern Victorian population of Gadopsis apparently crossed the Great Divide to colonize the Murray River. This is supported by the similar number of dorsal spines in the eastern Victorian and Murray River populations. The western Victorian populations from the Glenelg River, and including the unco-ordinated drainage near Naracoorte, South Australia, appear to have been isolated from the rest of the continental populations for a considerable length of time and a reduction in the number of dorsal spines has occurred here.

With regard to the evolution and evolutionary significance of Gadopsis, the similarity to the more primitive genera of the trachinoids, notothenioids, and uranoscopoids should be pointed out. The genus is more similar to the respective Pinguipes, Cottoperca, and Crapatalus in many respects than they are to the more highly evolved forms within their own groups.

Gregory (1933) suggested that the labrids, notothenioids, and trachinoids (which included the uranoscopoids at this time) may have diverged from a relatively primitive percoid type such as the Pinguipes or its ally Parapercis. The presence of 19 principal caudal rays suggests that Gadopsis is even more primitive than these two species. The significant similarities between Gadopsis and Pinguipes have been discussed and the specializations of Gadopsis from the primitive trachinoid type are largely adaptations to its special niche. Norman (1963) remarked that the ventral rays are often reduced or lost entirely in burrowing forms. Many of the other characters of Gadopsis such as the tiny, deeply embedded cycloid scales, heavy slime coating, fleshy covering of the dorsal fin and anal fin, as well as the fleshy mouth and snout can be explained by a consideration of its burrowing, benthic habitat.

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