

Cumacea of the NEP: equator to Aleutians and intertidal to the abyss

Part 1. **Introduction** and General Comments

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Introduction

The Order Cumacea is a relatively small one, much smaller than either the Order Amphipoda, or the Order Isopoda. Even so, over 1032 described species were listed in the order up to 1992 (Băcescu 1988, 1992), and that number has continued to swell. Most areas of the globe probably contain many undescribed species. If we use a multiplier based on the percentage of undescribed taxa known from the NEP, the world cumacean fauna would be expected to reach well above 1800 eventually. It's members are relatively uniform in size and external form, all looking like small balls or tubes on a stick. This structure results from the presence of a more or less globose carapace (which can become considerably flattened) combined with a tapering thoracic region, and a long narrow abdomen terminating in the two uropods. The flavor of the group is well presented by Stebbing (1893), which while rich in detail, is very readable. Cumaceans are relatively important members of the benthic community, being the second most abundant group of crustaceans retained on a 1mm screen (Barnard and Given 1961).

Definition

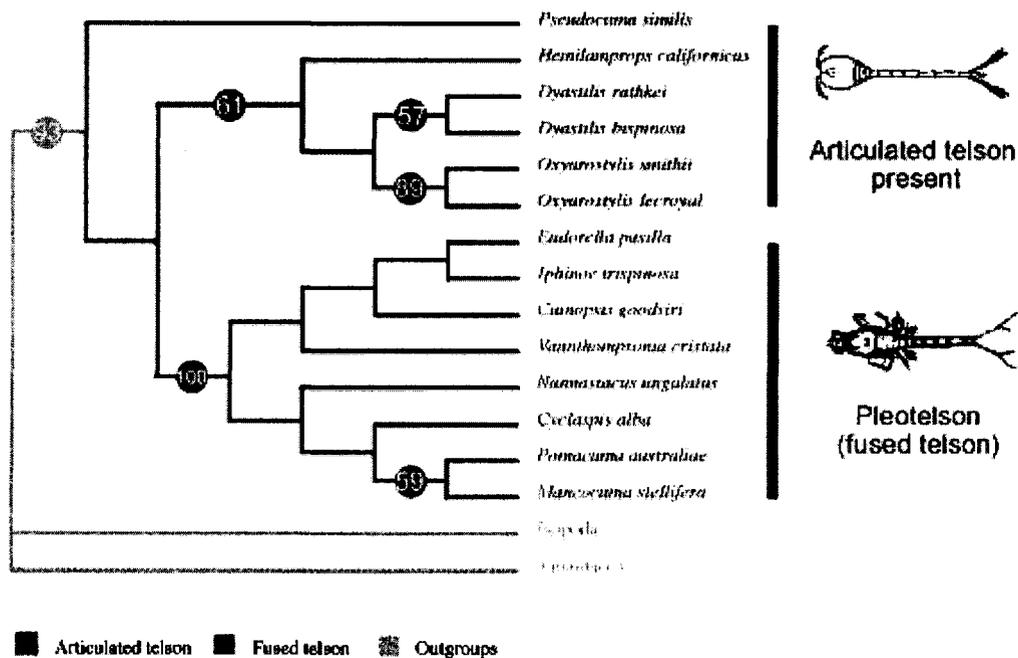
The definition of the order from Schram (1986) is: "Carapace short, fused to at least first three thoracomeres, can fuse with up to six, laterally enclosing a branchial cavity, with lateral lappets that extend anterior and medially to form a pseudorostrum; eyes generally fused, located on an anterior occasionally bell-shaped lobe; mandibles without palps; anterior three thoracopods as maxillipedes, the first with elaborately lobed branchial epipod and exopod extending forward under pseudorostrum as siphon, the second with fused coxae from which arise elongate endopods; posterior thoracopods often biramous; pleopods generally absent on females and sometimes reduced or absent on males; telson may be either free or fused with the sixth pleomere."

Relation to other Arthropods

Relationships with other groups are not settled, as is the case with all higher level arthropod systematics. Discussion of these issues are virtually endless, but useful reviews and analyses are provided by Schram (1986), Watling (1981, 1983), Wheeler et al (2004), and Schram and Koeneman (2004). It is likely that the closest relationship with extant groups is with the Tanaidacea. Bousfield (1995) presents an explicit classification which includes the extinct early forms (interpretation of which has severely complicated arthropod phylogeny), placing the Cumacea, along with the Tanaidacea, the Mictacea, and the Speleogriphacea in the superorder Hemicaridea.

Cumacean Phylogeny

The molecular phylogeny of the order has been preliminarily explored using CO1 gene sequences. The results largely conform to the morphology based expectations. The analysis placed the Pseudocumatidae as the sister group to all other cumaceans, with the remaining families split into two primary clades. The first, with articulated telsons, contains the Lampropidae and Diastylidae, the second, with the telson fused to the last abdominal somite, contains the Leuconidae, the Bodotriidae, and the Nannastacidae.



Families with no members sampled for this analysis are presumed to follow the trend shown by the sampled taxa, with the Gynodiastylidae joining the first clade, and the Ceratocumatidae joining the second. The taxon sampling of the analysis was limited, and the results are probably subject to refinement. Bodotriids were much more heavily sampled than other families, and showed evidence of polyphyly. The three subfamilies of the Bodotriidae were divided between the two major subclades of clade 2, with the Vaunthompsoniinae joined with the Leuconidae, and the Mancocumatinae joined with the Nannastacidae. The bodotriid subfamily Bodotriinae had representatives split between the two subclades. This initial analysis needs to be repeated, with either a broader sampling of taxa (also more evenly distributed among families), and/or use of information from other molecules. Additional information on various phylogenetic hypotheses for the Cumacea are discussed in Haye (2002).

History of Investigation

Information on this group is very scattered. The older literature has been analyzed (Băcescu 1973), but since then no similar compilation is available. A useful resource is provided by Băcescu in the Cumacea sections of the Crustaceorum Catalogus (1988, 1992) which covers all taxa described to that point. Investigations of cumacean taxonomy and ecology have, at best, been infrequent in North America. S. I. Smith worked on the eastern seaboard on cumaceans late in the 19th century. No other work was done by researchers here until 1912, when Calman evaluated the holdings of the U.S. National Museum. Additional work was done by Zimmer, another European, somewhat later (1936, 1943). Not until the 1930's did an indigenous researcher appear, Josephine Hart in Canada. Her early papers described a number of forms. Western North Pacific and Arctic forms were investigated by Russian workers, with Natalie Lomakina (1958) providing a most useful monograph (in Russian) covering that fauna. Not long after, Sigeo Gamô began a long series of investigations of the Japanese fauna, some of which have relevance to NEP taxa.

This set the stage for a young student looking for a subject; Robert Given, who pursued research into the cumaceans of California as his thesis work at USC. This was at the time of considerable ferment in peracarid systematics and ecology centered at USC and led by Robert Menzies and J. Laurens Barnard. The strenuous efforts of Olga Hartman in investigating the polychaete annelids from this area paralleled and augmented the crustacean investigations. Shortly after Given submitted his thesis, enactment of the Clean Water Act jump-started environmental sampling in the nation's nearshore waters. The growth of environmental consulting firms which derived from this fueled further investigations of cumaceans. My mentors, Bruce Benedict and Brad Myers, both then at Marine Biological Consultants, identified and prepared capsule descriptions and drawings of many undescribed species from California waters encountered during environmental monitoring surveys. They utilized the information in Givens thesis, and expanded upon it. Early on (in 1974) they created a handbook of the described and provisional cumacean taxa they had encountered. This was widely distributed and led to the stabilization of much of the nomenclature of local cumaceans. Many of their provisional names are still in use, although some have been superceded by formal descriptions. Other than the forms described by Given (1961, 1964), Lie (1969, 1971) and Gladfelter (1975), the known fauna persisted as provisional species until Watling and McCann (1997) described a number of common local species. While species have been formally described often in recent years (i.e. Gerken 2005a/b, Donath-Hernández 2011), the number of undescribed provisional species remains high, and grows whenever underexplored habitats are investigated. Of the six families which occur in the NEP, there are three where described forms outnumber provisionals, one where they equal them, and two in which provisionals outnumber described forms. Nearly half the species known from the coverage region remain to be described.

General Morphology, Sexual Dimorphism, Ontogeny

Morphology of cumaceans is fairly uniform. A standard introduction, such as that of Stebbing (1913) or Schram (1986) should be consulted for description of the features of the group, although Watling and McCann (1997) also provide a good summary of their morphology. The cumacean website (<http://nature.umesci.maine.edu/cumacea.html>) can also be reviewed. In nearly all Cumacea there is substantial sexual dimorphism in external morphology. For this reason most new species descriptions provide descriptions of both males and females, and it is important to understand how to differentiate the sexes. There are some consistent trends which can be relied upon in interpreting specimens: males are usually larger than females, male carapaces are usually less inflated, and consequently longer for their diameter, than female carapaces; males and females will differ in the number of thoracic appendages bearing epipods; males in some families have pleopods lacking in the female; antenna two is greatly enlarged in sexually mature males, and goes through a series of elongations during the juvenile preparatory molts.. There is also considerable difference related to growth. A good discussion of the changes which occur with successive molts is given by Bishop (1982).

The attainment of sexual maturity leads to difference in appearance from both the molts that precede, and those that follow the reproductive molt. Secondary sexual characters will tend to be undeveloped until one or two molts prior to the reproductive molt. In these last pre-adult forms morphology will be in transition, with the secondary sexual characters developing, but not fully formed. This is particularly evident in those families where males have pleopods. For several molts prior to the reproductive molt the juvenile males will be developing pleopods; first as peduncles only, then with both

peduncles and rami, and finally with fully developed setose pleopods. Similar development is seen in the transition from juvenile male to fully adult male in size and relative development of the epipods of the thoracic limbs, and in the length and setosity of antenna two. After the reproductive molt there may be one or more post-reproductive molts. In these the males tend to develop gerontic conditions of overornamentation, with development of elaborate setal diversity and accentuated sculpture of the carapace and abdomen. The setal diversity is particularly well developed on the uropods, where a gerontic male may boast five or six different types of setal elaboration on the peduncles and rami. These can be quite misleading as they alter the overall appearance of the animal considerably. Such gerontic individuals must be carefully evaluated to understand what species they actually represent.

Ecology of Cumaceans

Cumaceans are for the most part detritivores, filtering fine organic particulates from interstitial or bottom boundary layer waters, or from resuspension of bottom sediments during forward burrowing. Zimmer (1933) reports on the life position of several species in sediments. In the examples he used, the animals maintained a connection with the sediment surface, with the pseudorostrum and the siphon formed between it and the maxillipeds open to the bottom waters. The rest of the animal was buried beneath the surface of the sediments. Animals in sandy sediments may be more completely buried in the sediments, with only the tips of the uropods and the tip of the pseudorostrum exposed (Hale 1943). This difference is probably related to the greater abundance and oxygenation of water in coarse sand sediments than in muddy bottoms. A subset of the group, including many of the bodotriids, are not detritivores, but micrograzers. They pick up individual grains of sand and rotate them in the mouthparts, licking off the associated microflora and fauna with mouthpart setae (Hale 1943).

In their turn cumaceans are fed upon by predators of many types, including polychaete worms, nemerteans, other arthropods, and fishes. According to Băcescu and Lima de Quiroz (1985), who surveyed the previous literature on consumption of cumaceans by fishes, they form an important portion of the gut contents of several species of rays, in addition to the flatfishes, gadids, and acipenserids previously reported from European waters (Zimmer 1941). Personal observations on the contents of light traps show that both isopods (cirolanids) and ostracods (cypridinids) will eat cumaceans while confined in the collection container. They tend to consume the carapace and thorax, and leave the abdomen behind (like eating a popsicle and tossing the stick).

Nicotheid copepods (genus *Sphaeronella*) are about the only organisms reported to parasitize cumaceans. Hansen (1920) reported five species of *Sphaeronella* brood parasites from various cumaceans.

Swimming is very common in cumaceans, particularly in males (Champalbert and Macquart-Moulin 1970). Females also take off from the bottom on excursions into the water column, but these are generally of shorter duration (Fage 1945). Males and females may also swim at different times, with only a brief overlap when both are in the water column. Different groups segregate themselves by preferred swimming time (Hale 1953) during the hours of darkness.

Movements on and in the bottom are of several types. Burrowing can be either downward or backward into sandy sediments, depending on species (Hale 1943). Such motions are extremely rapid and hard to observe. In muddy sediments, forward motion may be undertaken with the gradual loosening and resuspension of sediments by movements of the maxillipeds during deposit feeding, followed by slow movement

forward into the cavity created. Hale (1943) observed some bodotriids “hopping” across the surface of the sand. I have observed such hopping or springing behavior in the nannastacid *Cubanocuma* in shallow dishes. They will sit quiescent on the bottom for a minute or two, then “pop” into the water column, probably by a strong flexure of the abdomen and uropods, and swim about in a frenzied manner.

Constituent Families

The order contains eight recognized families: Bodotriidae, Ceratocumatidae, Diastylidae, Gynodiastylidae, Lampropidae, Leuconidae, Nannastacidae, and Pseudocumatidae. All but the Gynodiastylidae and Ceratocumatidae are represented in the NEP. Off and on other families have been suggested, most frequently the removal of the Campylaspininae from the Nannastacidae and its elevation to family status, but these are not currently recognized. Stebbing (1913) for instance, treated many of the groups now at the subfamily level as families, recognizing 26. Băcescu introduced a ninth family, the Archaeocumatidae (see Băcescu 1988) and included it in the Crustaceorum Catalogus. It has not achieved wide acceptance and is viewed as part of the Lampropidae here.

Key to the Families of Cumacea present in the NEP (modified from Watling and McCann (1997) and Gamô (1967))

- 1a. With freely articulated telson.....2
- 1b. Without freely articulated telson.....4
- 2a. Telson with 0 or 2 terminal setae.....3
- 2b. Telson with 3 or more terminal setae.....Lampropidae
- 3a. Endopod of uropods 1 segmented; males with 5 pleopod pairs.....
.....Pseudocumatidae
- 3b. Endopod of uropods 2-3 segmented; male with 2 pairs of pleopods.....
.....Diastylidae
- 4a. Uropod endopod uniarticulate.....Nannastacidae
- 4b. Uropod endopod biarticulate.....5
- 5a. Male with 0 or 2 pairs of pleopods; female with exopods on pereopods 1-3
.....Leuconidae
- 5b. Male with 5 pairs of pleopods; females with exopods only on pereopod 1
or on pereopods 1-4.....Bodotriidae

North East Pacific Cumacean Fauna

Investigations of the fauna and its members continue on several fronts, but there are currently a relatively diverse fauna of cumaceans already known from the region. Most investigations have been focussed on the shallow shelf, so that cumacean fauna is best represented in any list of known taxa. Few cumaceans are found intertidally, although investigations there have yielded some forms. An inventory of the families represented in the region shows there are 171 species-level cumacean taxa distributed among them. Of this number 43% (73) remain to be described. The most speciose families are Diastylidae – 49 species (18 provisional), Nannastacidae – 46 species (30 provisional), Leuconidae – 30 species (6 provisional), Bodotriidae – 25 species (14 provisional), Lampropidae – 10 species (5 provisional), and the Pseudocumatidae – 2 species (1 provisional). These totals are undoubtedly not comprehensive, as many portions of the NEP have not been adequately sampled for the group. In particular, the

bathyal and abyssal fauna of diastylids, nannastacids, and leuconids, and the shallow sublittoral fauna of bodotriids are very probably underestimated by 25% or more.

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Cumacea of the NEP: equator to Aleutians and intertidal to abyss

Part 2. The Family **Bodotriidae**

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The bodotriids are primarily shallow water sand associated forms, although a few such as *Bathycuma* and *Cyclaspoides* have penetrated the deep-sea. At least 25 species in 7 genera are known from the NEP from Panama to the Arctic. It is likely that additional undetected species remain, especially from sandy sediments in the south. Three of our local provisionals are known only from the very coarse iron-stained relict red sands found off Imperial Beach south of San Diego. The family was not represented in the collection described by Watling and McCann (1997), and is consequently not discussed there. Only four species in this family are listed by McLaughlin et al (2005) as from the Pacific coast of North America. Bodotriids are more diverse in the Western North Pacific, with 21 species in 8 genera described by 1967 (Gamô 1967). Although there is considerable known NEP diversity in the genus *Cyclaspis*, most of it remains to be described. In the list provided below 6 described and 11 undescribed forms are placed in *Cyclaspis*. Materials from a light trap collected in Bahia Kino in the Gulf of California by Todd Haney have provided 3 apparently undescribed species in this genus, as well as material of several provisional forms previously collected by Donath – Hernández on the Gulf side of Baja California. Two new species described from Pacific Costa Rica (Petrescu and Heard 2004) are included, although one of them is known only from the female. Similarly large diversity in the genus is known from the western coast of South America (Pilar Haye, personal communication), and numerous additional undescribed species in the genus have been collected from the Caribbean.

Despite good diversity of *Cyclaspis*, other genera with numerous species in other areas are not represented in our fauna. These include the genera *Bodotria*, *Iphinoe*, *Symphodomma*, and *Eocuma*. The genus *Glyphocuma*, which is unrepresented in the NW Pacific, has two quite similar undescribed species in our area. The genus is otherwise only known from Australian waters, where it was erected by Hale (see Haye 2002). Bodotriids in general are well-represented in Australia, and this is probably the area of origin of the family, although this remains to be determined. The genus *Coricuma* was placed in the Bodotriidae when originally proposed, but was later transferred to the Leuconidae (Watling 1991b). The family is distributed worldwide, and has endemic genera in many areas (Băcescu 1988). It is divided into three subfamilies, the Bodotriinae, the Mancocumatinae, and the Vaunthompsoniinae, based on combinations of numbers of pereopods bearing epipods, and number of pleopods in the male.

Secondary sexual characters in this group are relatively easy to see in most cases. The male pleopods, in particular, are usually prominently displayed. In a few species, however, among them *Cyclaspis nubila*, the adult male holds the pleopods tight against the underside of the abdomen. As the abdomen is slightly concave in these species, the pleopods are effectively hidden in lateral view. Subadult male pleopods are considerably easier to see. The marsupium of the female is also relatively easy to see, if developed, even prior to the carrying of a brood. While the elongation of the male second antennae is very noticeable, the antennae themselves are often not. Under most circumstances they are carried along the underside of the carapace, thorax and abdomen, tightly appressed to the main body. They can usually be found, but it may take concerted looking to ferret them out. Only in the full adult will they sometimes be long enough to show near the last abdominal segment, even while hidden from lateral view. If the antennal flagellum is not readily evident, the males have strongly enlarged antennal peduncles, which must be

muscular and more robust than those of the females to handle these long antennae. Examination of the antennal peduncle is usually easier than finding the rest of the antenna.

Determination of sex is as important in bodotriids as in any other cumacean. The pattern of sexual dimorphism characteristic of the group as a whole holds for this family; females are smaller than males, but usually by 30% or less in total length. They also have more inflated carapaces posteriorly, which typically slope more towards the eyelobe than in the male. Where only a single sex is known, the appearance of the other can be inferred from this trend, which seems to vary little within the family. For instance, the two described species from the Gulf of California, *C. bituberculata* and *C. conceptionis* were initially believed to also occur in the Bahia Kino material. Only males of “*C. bituberculata*” were found however, which were undescribed by Donath-Hernández. The males at hand proved to be several times the length of the females they were believed to belong to. This is so contrary to the established pattern that it was concluded that this was a closely related but different species, and not the males of the described species. Similarly both males and females which bore good resemblance to *C. conceptionis* were taken in Bahia Kino. Again, they were substantially larger (3 times the size indicated in the original description) and cannot belong to the same taxon. They are now treated as another undescribed species with close affinity to *C. conceptionis*.

A key to the California bodotriids was prepared in 1996 for SCAMIT presentation. This is updated below, with the addition of the Donath-Hernández species, two Costa Rican species, three provisional forms from the Gulf of California, a record from the Gulf of the Farallones, and *Glyphocuma sp LA1* first taken in 1998. A key to all genera in the family world-wide is provided by Jones (1969, pp. 102-103). A DELTA based key, more recent and more inclusive, is provided by Haye (2002).

NEP Bodotriidae from McLaughlin et al (2005) augmented by known provisional taxa.
*= Taxa on the SCAMIT Ed 6 list. Valid taxa bolded, synonyms not.

Family Bodotriidae

- Atlantocuma tenue** Jones 1984 – Atlantic (587-5000m), Chile, Gulf of the Farallones; 2385-3085m
- Bathycuma longicaudatum** Calman 1912 – Mediterranean, Japan, NEP to San Diego, Chile; 1174-3950m
- Cyclaspis bituberculata** Donath-Hernández 1988 – Laguna Ojo de Liebre, outer coast of Baja California to Bahia Bocochoibampo, Sonora, Mexico; shallow
- Cyclaspis breedyae** Petrescu and Heard 2004 – Gulf of Nicoya, Costa Rica; 1-2m
- Cyclaspis conceptionis** Donath-Hernández 1988 – Bahia Concepción, Gulf of California; shallow
- Cyclaspis giveni** Donath-Hernández 2011 - Oxnard to Bahia de Todos Santos, Baja California, Mexico; 8-18m
- ***Cyclaspis nubila** Zimmer 1936 – SCB to Bahia Kino, Gulf of California; 0- 27m
- Cyclaspis vargasae** Petrescu and Heard 2004 – Los Islas Murcielagos, Costa Rica; 35m
- ***Cyclaspis sp A** SCAMIT 1995§ - Pt. Conception to Bahia Kino, Gulf of California; 0-48m
- ***Cyclaspis sp B** SCAMIT 1989§ (see *Cyclaspis giveni*)

- ***Cyclaspis sp C** SCAMIT 1986§ - Pt. Conception to La Jolla; 5-15m
 ***Cyclaspis sp D** Cadien 1996§ - Huntington Beach; 0-1m
Cyclaspis sp E Cadien 1996§ - Imperial Beach; 20m
Cyclaspis sp F Cadien 1996§ - Imperial Beach; 20m
Cyclaspis sp G Cadien 1996§ - Imperial Beach; 20m
Cyclaspis sp J Cadien 2005§ - Bahia Kino, Sonora, Mexico; 1-10m
Cyclaspis sp K Cadien 2005§ - Bahia Kino, Sonora, Mexico; 1-10m
Cyclaspis sp N Cadien 2005§ - Bahia Kino, Sonora, Mexico; 1-10m
Cyclaspis sp 3 Donath-Hernández 1985§ - Puerto Peñasco and Bahia Kino, Gulf of California; 1-10m
Cyclaspis sp 4 Donath-Hernández 1985§ - Bahia de Los Angeles and Bahia Kino, Gulf of California; 1-10m
Cyclaspoides sp BAP1 Cadien 2001§ - Baja California; 3880-3950m
 ***Glyphocuma sp A** SCAMIT 1989§ - San Miguel Id. to San Diego; 71-108m
 ***Glyphocuma sp LA1** SCAMIT 2000§ - Santa Rosa Id.; 84m
 ***Leptocuma forsmanni** Zimmer 1943 – SCB to Bahia Kino, Sonora, Mexico; 1-10m
Vaunthompsonia cristata Bate 1858 – South Africa, Mediterranean, N. Atlantic; Indonesia; Japan to Puget Sound; 0-36m
 ***Vaunthompsonia pacifica** Zimmer 1943 – NWP to Puget Sound; SCB?; 0-96m

Key to the Bodotriidae of the NEP (Modified from Cadien 1996 to include all currently recognized provisional and described species known from the equator to the Arctic Circle in the Eastern Pacific)(revised 21 November 2011)

- 1a. Exopods on only the first pair of pereopods.....2
 1b. Exopods on more than one pair of pereopods.....19
 2a. First three pedigerous segments fused with carapace.....*Cyclaspoides* sp BAP1
 2b. All five pedigerous segments free.....3
 3a. Carapace with one or more teeth on the dorsal midline.....4
 3b. Carapace lacking teeth on dorsal midline.....5
 4a. Carapace with a single pair of ridges extending from dorsal midline to join the ventral margin below the level of the antennal notch; eyes divided into 11 ommatidia.....*Cyclaspis breedyae*
 4b. Carapace with a single pair of ridges extending from the dorsal midline forward to the back of the eyelobe; eye undivided into separate lensed ommatidia.....*Cyclaspis* sp A
 5a. Antennal sinus absent; both margins of uropodal peduncle setose in female.....*Cyclaspis* sp D
 5b. Antennal sinus evident; peduncle of uropods lacking setae along both margins in female (but inner margin may be serrate).....6
 6a. Carapace smooth, without pits, tubercles, surface ornament, or anteriodorsal depressed areas in either sex.....7
 6b. Carapace strongly pitted and/or sculptured, with or without depressions anteriodorsally in both sexes.....8
 7a. Paired horn-like tubercles dorsally on last two thoracic segments....*Cyclaspis* sp 3
 7b. Thoracic tubercles lacking.....*Cyclaspis giveni*

- 8a. Carapace bearing lateral ridge(s) extending from mid-dorsal carina towards base of the carapace.....9
- 8b. Carapace lacking lateral ridge(s) extending down from the mid-dorsal carina....12
- 9a. Carapace bearing a single lateral ridge extending from the dorsal carina about 2/3 the distance to carapace base which forms the posterior boundary of a complex anterior-dorsal sinus.....*Cyclaspis sp G*♂
- 9b. Carapace bearing two or more lateral ridges.....10
- 10a. Mid-dorsal carina very strong on anterior half of carapace, weak posteriorly; two strong lateral ridges; carapace with stellate purple pigment spots..*Cyclaspis sp F*♂
- 10b. Mid-dorsal carina moderately strong on entire carapace; 3-6 delicate lateral ridges on carapace.....11
- 11a. Carapace lacking definite spots of pigment in juveniles, but both sexes increasingly pigmented with age; with 5-6 thin sloping ridges running obliquely across the carapace.....*Cyclaspis sp 4*
- 11b. Carapace with a few indistinct non-stellate pigment spots posteriodorsally; 3 delicate lateral ridges on carapace.....*Cyclaspis sp. E*♀
- 12a. Carapace with well marked anteriodorsal depression extending from dorsal carina to base of eyelobe in both male and female.....13
- 12b. Carapace lacking anteriodorsal depression in either sex.....14
- 13a. Carapace with smooth trough-like depression extending obliquely back from the antennal sinus in both sexes.....*Cyclaspis sp C*
- 13b. Carapace lacking smooth trough-like depression behind the antennal sinus in both sexes.....*Cyclaspis nubila*
- 14a. Carapace lacking either obtuse or acute anteriolateral tubercles.....15
- 14b. Carapace bearing one pair of large anteriolateral tubercles, either obtuse or edged with an acute ridge, between eyelobe and antennal sinus.....17
- 15a. Carapace strongly pitted, but lacks longitudinal strigillate sculpture.....*Cyclaspis vargasae*
- 15b. Carapace with strigillate longitudinal sculpture on sides of carapace.....16
- 16a. Uropodal exopod longer than endopod and both rami lacking long terminal spines on rami in both sexes; mature at about 7mm.....*Cyclaspis sp J*
- 16b. Uropodal rami subequal, both tipped with long (1/3 ramal length) terminal spines; mature at less than 2.5mm.....*Cyclaspis conceptionis*
- 17a. Carapace surface sculpture alveolate; anterior tubercles either obtuse or edged by an acute ridge.....18
- 17b. Carapace surface sculpture not alveolate; anterior tubercles obtuse; mature at less than 3mm.....*Cyclaspis bituberculata*
- 18a. Dorsal flanges present on thoracic somites T2 and T5; anterior tubercles edged with a sharp ridge; ventral margin strongly flared below the antennal sinus, and edged with another sharp ridge; mature at less than 2.5mm.....*Cyclaspis sp N*
- 18b. Dorsal surface of all thoracic somites lacking lobes or flanges; anterior tubercles obtuse, not edged by acute ridge; ventral margin not flared below antennal sinus; mature at 7+mm.....*Cyclaspis sp K*
- 19a. Carapace lacking teeth or denticles dorsally.....20
- 19b. Carapace bearing at least one, and usually many denticles or teeth on carina.....22
- 20a. Lateral margins of 3rd (♀) or 4th (♂) thoracic segment overlapping those of adjacent segments.....*Leptocuma forsmanni*
- 20b. Lateral margins of 3rd or 4th thoracic segments not overlapping those of adjacent segments.....21

- 21a. With strong ventral carapace dentition leading posteriorly from antennal sinus; sinus defined by sharp tooth.....*Atlantocuma tenue*
- 21b. Antennal sinus absent, or if present not defined by sharp tooth; anterior ventral carapace margin smooth.....*Vaunthompsonia* and *Glyphocuma* (♂♂) 26
- 22a. Abdominal somites ridged laterally.....*Bathycuma longicaudata*
- 22b. Abdominal somites not ridged laterally.....23
- 23a. Dorsal teeth or denticles in two parallel rows flanking carapace midline.....24
- 23b. Dorsal teeth in a single row along midline.....*Glyphocuma* ♀ and juvenile ♂ 25
- 24a. Eyelobe lacking denticle pair distally; carapace evenly rounded dorsally.....
.....*Vaunthompsonia pacifica*♀
- 24b. Eyelobe bearing denticle pair distally; carapace slightly excavated dorsally just before posterior margin.....*Vaunthompsonia cristata*♀
- 25a. Dorsal crest with well marked denticles; anterior ventral carapace border finely serrate.....*Glyphocuma* sp A♀
- 25b. Dorsal crest with only one or two poorly marked denticles; anterior ventral carapace border lacking serrations.....*Glyphocuma* sp LA1♀
- 26a. Anteriorly projecting lobe at the distal end of the basis of the third maxilliped.....
.....*Glyphocuma* (adult males of both local species unknown)
- 26b. Lacking lobe distally at end of third maxilliped basis.....*Vaunthompsonia* ♂ (adult males unknown for both reported species in the genus from the NEP)

Atlantocuma - A small genus of five species in two subgenera. A single NEP record of *A. tenue*, described from the deep Atlantic, exists in the grey literature. The identification is from Les Watling, so is assumed to be correct despite the very great extension of known range. Given its wide distribution at appropriate depths in both the North and South Atlantic (Jones 1984) and the record from Chile (Petrescu 1995), it's occurrence in the NEP seems not improbable.

Bathycuma – Only eight species are described in the genus (Băcescu 1988), to which a ninth must now be added (Mühlenhardt-Siegel 2005a). One additional undescribed form is known from the hadal zone of the Bougainville Trench (Wolff 1970). Only one species is from the NEP, the remainder are from the North Atlantic, South Atlantic, or Indian Oceans. Only two specimens are known from off our area; the type, from off San Diego, at 1174-1218m, and one in my possession from the Baja Abyssal Plain at 3880-3950m. It has also been taken from off Japan, and Gamô (1967) describes and illustrates it well, and the description and illustrations of Petrescu (1995) should also be consulted. Day (1975) provides a key to the genus up to that time, which includes all but the one recently described species (Mühlenhardt-Siegel 2005a) and Wolff's hadal provisional.

Cyclaspis – An extremely large genus of shallow-water (predominantly) bodotriids, with species found worldwide. Well over one hundred species are currently described, and many forms await formal description, at least in the Western Hemisphere. Over 60 years ago Hale recognized a large number of forms from around Australia, and a single species from the NEP (Hale 1944a). Since then a number of additional species have been described world-wide (Băcescu lists 93 in 1988). If the diversity evident in the Australian region is echoed elsewhere in the world, the eventual number of described *Cyclaspis* species may reach nearly 200. This sort of large genus, while not unprecedented, fairly easily lends itself to subdivision. At a minimum one would expect

that a series of subgenera would be erected, each housing a more manageable subset of the total. It is also possible that the genus will be exploded, with the description of a number of genera from this large one. There is ample morphological diversity in carapace shape (see Hale 1944a) to support such subdivision, but boundaries may prove elusive. In several faunas I have examined similar species exist in several size ranges, I suppose related to the diversity of different sized sediments the animals must burrow through. A large muscular species would be required to move large sand sized particles, while more gracile and smaller forms might occupy more uniform fine sands, or perhaps live among grains in coarse well-mixed sediments with shell debris or other biogenic components.



A small undescribed *Cyclaspis* from Caribbean Panama

Zimmer (1944) described *C. dolera* from material ostensibly taken in Salinas Bay on the Pacific coast of Costa Rica. The species was known to be distributed through the tropical Western Atlantic, but has not been seen since on the Pacific Coast. Based on the reasoning provided by Roccatagliata (1986) the species is now thought to be found only in the Atlantic, with the original labeling being an error for Salinas, Puerto Rico. It is not included here for this reason.

A small subset of the *Cyclaspis* species are deep-water animals, but the vast majority are found on sandy bottoms in the intertidal, and shallow sublittoral zones. We only take them at our shallowest stations, and then only a few individuals of two species (*C. nubila* and *C. sp A*). A broader spectrum is found in the relict red sand deposits off the coast south of San Diego, where four more provisional forms are currently known. These are all rare, however, and several are known from single specimens.

Cyclaspoides – A small deep-sea genus, with two described species listed by Băcescu (1988), and additional species described by Petrescu (1995) and Mühlenhardt-Siegel (2005a). At least two undescribed species are also known, our provisional from off Baja California, and a provisional known only from a single specimen off the Philippines (Calman 1905). The fusion of the thoracic segments with the carapace which characterize this genus makes it easy to separate from other deepwater bodotriids.

Despite having few members, the genus is widespread, ranging from the deep North Atlantic, to the South Atlantic off Angola, the Indian Ocean off South Africa, the Philippines, Ecuador, and the NEP.

Glyphocuma – Hale (1944b) erected the genus and placed four species in it, three new. All were from the southern part of Australia. Since then Greenwood & Johnson (1967) have described a fifth species from Queensland in the north. They did not provide a key to the genus including their new species, preferring to differentiate it from the type in a table. Hale (1944b) provides a key to the four species known at that time. The two forms from the NEP are both provisionals, and are the only species in the genus known from outside Australia. The pattern of differences in carapace ornamentation is one of the primary differences between the two local provisional species. Since both sexes are not known for the species, the identification of the as yet uncollected sex remains problematic.

Leptocuma – Ten species are known in the genus (Băcescu 1988) only one from the NEP. Most members are austral, although several are known from the North Atlantic. Hale (1944b) provides a key to six species from Australia, which may point out some characters of interest in the taxonomy of the species. No comprehensive key to the members of the genus exists. This genus is much more elongate than other shallow-water bodotriids found in the NEP, and the overlapping of the thoracic pleura is a distinctive feature. While there is diversity in the genus in the SW Atlantic (Roccatagliata 1993), as yet only a single species is known from the NEP, with populations from temperate and tropical waters indistinguishable.

Vaunthompsonia – A widely distributed, if not large, genus of bodotriids. Eleven described species (one with two subspecies), and two provisionals are known (Băcescu 1988). The genus is predominantly shallow, with some members deeper on the shelf. A few species are known to occur more deeply. Surprisingly broad bathymetric distributions are ascribed to some species, particularly *V. cristata*, which is normally taken at 0-36m, but has one record at 2338m (Băcescu 1988). In another case, with a species similar to *V. cristata*, he suggests that the record (from 6475-6571m in the Kurile-Kamtschatka Trench) is either a misidentified *Bathycuma*, or an animal taken from the plankton incidentally (Băcescu 1988). In tropical climes the genus can occur quite shallowly, with *V. minor* taken amongst intertidal algae in Belize (personal collection). Neither of the two reported NEP taxa occur much south of the Arctic, penetrating into the boreal region as far as Puget Sound. Reports of these animals have been made previously (a number were identified in the BLM studies in the SCB), but these have proven to be erroneously identified *Glyphocuma* specimens. Remaining records of *V. pacifica* specimens in the SCB are questionable, and should be verified.

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Cumacea of the NEP: equator to Aleutians and intertidal to abyss

Part 3. The Family **Diastylidae**

dbcadien 5 November 2006 (revised 21 October 2011)

The Diastylidae is a relatively large family (17 genera and over two hundred species, Băcescu 1992; now grown to 21 genera, Mühlenhardt-Siegel 2003) which is quite common in the NEP, especially in its Arctic and Boreal areas. Eight of these genera occur in the NEP, and are discussed below. A key to the genera in the family is provided by Jones (1969), but genera from couplet 16 on in that key are now considered to belong in the family Gynodiastylidae (see Day 1980). As one of three families bearing articulated telsons, its members are most often confused with members of the other two, Gynodiastylidae and Lampropidae. This confusion extends to even knowledgeable workers, with some describing lampropids as diastylids (see Gladfelter 1975). The family key provided in the first part of this series should allow appropriate allocation of specimens to families.

More of NEP diastylid species are described than was the case with the last family, the bodotriids. Of the 38 diastylids reported from the NEP, only 7 belong to provisional taxa. This is perhaps due to the relatively shallow distribution of bodotriids, into habitats frequently unsampled, while diastylids are commonly found further offshore where they can be easily taken by dredge, core, and trawl. The family also has more affinity for cold waters than does the Bodotriidae, with many of the NEP forms of only Arctic or boreal distribution. Lastly, diastylids tend to be larger than bodotriids, with some of the largest species of cumaceans in the family. At least some of the members can be brightly pigmented in life. *Anchicolurus occidentalis*, for instance, is pale pink with scarlet markings in fresh material (the color fading in preservation to bone white).

Sexual dimorphism in the diastylids is generally less pronounced than in the bodotriids, but still substantial. Again the males tend to have carapaces which are not inflated posteriorly, or are inflated less than in the female. Natural history of *Diastylis stygia* was described by Blake and Watling (1994).

NEP Diastylidae from McLaughlin et al (2005) augmented by known provisional taxa.

*= Taxa on the SCAMIT Ed 6 list. Valid taxa bolded, synonyms not.

Family Diastylidae

***Anchicolurus occidentalis** (Calman 1912) – Oregon to SCB; 10-64m

Colourostylis (?) occidentalis see *Anchicolurus occidentalis*

Diastylis abbotti Gladfelter 1975 – Dillon Beach; 2.4-13.5m

Diastylis alaskensis Calman 1912 – Japan to Puget Sound; 0-196m

Diastylis aspera Calman 1912 – Kuriles to Puget Sound; 95-1150m

Diastylis bidentata Calman 1912 – Arctic to Puget Sound; 9-1000m

Diastylis calderoni Donath-Hernández 1988 – Head of Gulf of California; 0-5m

***Diastylis californica** Zimmer 1936 – Humboldt Bay to So. Coronado Island; 19-88m

***Diastylis crenellata** Watling and McCann 1997 – Fort Bragg to Coronado Submarine Canyon; 11-606m

Diastylis dalli Calman 1912 – Arctic to Puget Sound; 24-2350m

***Diastylis newberryi** Gerken 2005 – SCB to Baja California; 15-536m

Diastylis nucella Calman 1912 – Arctic to Puget Sound; shallow

Diastylis obfuscatus see *Lamprops obfuscatus* in Lampropidae

Diastylis paraspinulosa Zimmer 1926 – Arctic to Puget Sound; 12-440m
***Diastylis pellucida** J. F. L. Hart 1930 – Vancouver to SCB; 12-829m
Diastylis quadriplicata Watling and McCann 1997 – Eureka to Gaviota; 123-366m
Diastylis rathkei (Krøyer 1841) – Arctic to Puget Sound; shallow
***Diastylis santamariensis** Watling and McCann 1997 – Puget Sound to San Diego; 6-204m
***Diastylis sentosa** Watling and McCann 1997 – Puget Sound to San Diego; 41-500m
 Diastylis triserrata see Lamprops triserrata in Lampropidae
Diastylis umatillensis Lie 1971 – SE Alaska to Puget Sound; 20-60m
Diastylis sp BAP1 – Cadien 2001 § - Baja Abyssal Plain; 3880-3950m
Diastylis sp BAP2 – Cadien 2011 § - Baja Abyssal Plain; 3880-3950m
***Diastylis sp C** Myers & Benedict 1974 § - SCB; 197-576m
Diastylis sp CS1 Cadien 2004 § - Cascadia Slope; 1372m
 Diastylis sp CS2 Cadien 2004 § see Makrokylindrus sp CS1
Diastylis sp LA1 Cadien 2008 § - off Palos Verdes; 696m
Diastylodes pacifica Gerken 2005 – Baja California; 2385m
***Diastylopsis dawsoni** S. I. Smith 1880 – Alaska to Pt. Conception; 2-35m
***Diastylopsis tenuis** Zimmer 1936 – SCB; 3-60m
***Leptostylis abditis** Watling and McCann 1997 – Central California to San Diego; 11-954m
***Leptostylis calva** Watling and McCann 1997 – Fort Bragg to San Diego; 8-198m
Leptostylis villosa G. O. Sars 1869 N. Atlantic, Puget Sound; 22-195m
 Leptostylis sp B see Diastylis newberryi
Leptostylis sp C SCAMIT 1983 § - Goleta; 30m
Leptostylis sp CS1 Cadien 2004 § - Cascadia Slope and Abyssal Plain to Tanner Basin and off Pt. Loma; 732-2800m
 Leptostylis sp D SCAMIT 1983 § see Leptostylis abditis (♀) or calva (♂)
Leptostylis sp F MBC 1985 § - Pt. Buchon to off Pt. Loma; 949-1000m
Makrokylindrus (Adiastylis) abyssi Lomakina 1955 – NWP to Arctic; 3940m
Makrokylindrus (Adiastylis) americanus Băcescu 1962 – Gulf of Panama; 1748m
Makrokylindrus (Adiastylis) menziesi Băcescu 1962 - Galapagos to Baja Abyssal Plain; 3469-3493 to 3880-3950m
Makrokylindrus (Adiastylis) sp BAP1 Cadien 2011 § - Baja Abyssal Plain; 3880-3950m
Makrokylindrus (Adiastylis) sp BAP2 Cadien 2011 § - Baja Abyssal Plain; 3880-3950m
Makrokylindrus (Adiastylis) sp BAP3 Cadien 2011 § - Baja Abyssal Plain; 3880-3950m
Makrokylindrus (Adiastylis) sp CS1 Cadien 2006 § - Cascadia Slope; 1372m
Makrokylindrus (Adiastylis) sp CS2 Cadien 2011 § - Cascadia Abyssal Plain; 2800-2816m
Makrokylindrus (Adiastylis) sp CS3 Cadien 2011 § - Cascadia Abyssal Plain; 2800-2815m
Makrokylindrus (Adiastylis) sp CS4 Cadien 2011 § - Cascadia Abyssal Plain; 2800m

- Makrokylindrus (Adiastylis) sp SD1** Velarde 2010 § - off Pt. Loma; 876m
Makrokylindrus (Adiastylis) sp TB1 Cadien 2006 § - Tanner Basin; 1335m
Makrokylindrus (Adiastylis) sp TB2 Cadien 2006 § - off Pt. Loma to Tanner Basin; 949-1335m
 ***Oxyurostylis pacifica** Zimmer 1936 – Morro Bay to SCB; 13-76m
 ***Oxyurostylis tertia** Zimmer 1943 – San Diego to Baja California; 10m
Vemakylindrus costaricanus Băcescu 1961 – Pacific Costa Rica; 3718m
Vemakylindrus hystricosa Gerken 2002 – Monterey to Baja California; 1335-1880m
 Vemakylindrus sp TB1 see Vemakylindrus hystricosa

Since so many of the members of this family in the NEP are in the genus *Diastylis*, a separate key to those species will be presented later. Other NEP diastylids are keyed below to species. The species *Diastylis newberryi* serves to intergrade the genera *Diastylis* and *Leptostylis*, and is consequently keyed below among the *Leptostylis*, and later in the *Diastylis* generic key as well. If you get to *Diastylis*, move to the key to that genus. More provisional species of *Diastylis* and/or *Makrokylindrus* may be identified in samples from the Cascadia Abyssal Plain currently under evaluation.

Key to the known NEP Diastylidae (modified from Jones 1969) – dbcadien 31
 October 2006 (revised 14 November 2011)

- 1a. Mandibles broad at base, truncate basally.....*Diastylodes pacifica*
- 1b. Mandibles tapering to base, subacute basally.....2
- 2a. Telson lacking both lateral and terminal spines and/or setae (although ♂ has a pair of ventral setae at the end of the telson)*Anchicolurus occidentalis*
- 2b. Telson bearing either lateral or terminal (or both) spines and/or setae3
- 3a. Pseudorostrum as long as or longer than carapace.....*Vemakylindrus* 4
- 3b. Pseudorostrum much shorter than carapace.....5
- 4a. Pseudorostrum as long as remainder of carapace, horizontal; carapace covered with several sizes of large spines.....*Vemakylindrus hystricosa*
- 4b. Pseudorostrum longer than rest of carapace, upturned; carapace with a few small spines and many spinules.....*Vemakylindrus costaricanus*
- 5a. Thoracic somites 3 and 4 much wider basally than dorsally in both sexes (5-10X)*Diastylopsis* 6
- 5b. Thoracic somites 3 and 4 only 1-3x as broad basally as dorsally in both sexes.....7
- 6a. Thoracic sternite 5 with a pair of denticles or teeth.....*Diastylopsis dawsoni*
- 6b. Thoracic sternite 5 with a single denticle or tooth.....*Diastylopsis tenuis*
- 7a. Telson shorter than or equal to last abdominal somite in length8
- 7b. Telson at least 1.25 length of last abdominal somite.....11 (note triplet)
- 8a. Outer ramus of uropod only about ½ length of inner.....*Leptostylis abditis*
- 8b. Outer and inner rami of uropod subequal.....9
- 9a. Female with rudimentary epipods on 3rd and 4th pereopod bases; males with well developed and evident pleopods for several molts; carapace smooth or variously setose, gray or tan, matte, not shiny.....10 (note triplet)
- 9b. Female completely lacking rudimentary epipods on 3rd and 4th pereopod bases; pleopods poorly developed in all but final male molt (2 reduced articles), carapace globular, smooth, translucent or white, shiny.....*Leptostylis sp F*

- 10a. Carapace with a few scattered setae.....*Leptostylis calva*
- 10b. Carapace quite hirsute.....*Leptostylis villosa*
- 10c. Carapace lacking setae.....*Diastylis newberryi* (see also in *Diastylis* key)
- 11a. Terminal spines lacking on telson, which tapers to sharp point*Oxyurostylis* 12
- 11b. Terminal spines lacking on telson, telson with a long tubular preanal portion; post-anal portion tapers to a narrow truncation.....*Makrokylindrus* sp CS2
- 11c. Terminal spines present on telson.....13
- 12a. Carapace with row of small spinules along dorsal midline, along anterior dorsal border, and on ocular lobe.....*Oxyurostylis tertia*
- 12b. Carapace minutely villose(♀) or smooth (♂), but lacking spinules along dorsal midline, with serrations on anterior ventral border in ♂*Oxyurostylis pacifica*
- 13a. Pre-anal telson elongate, tubular, generally much longer than post-anal portion; lateral setal pairs few or lacking, restricted to post-anal telson (pre-anal telson may bear lateral teeth or denticles however).....*Makrokylindrus* 14 (note triplet)
- 13b. Pre-anal telson not tubular; quadrate, subquadrate, or tapering; length generally shorter than post-anal portion, but occasionally equal to or longer; lateral telsonic setal pairs usually four or more, occasionally one or two; may extent to pre-anal telson, but generally on post-anal only.....*Diastylis*
- 13c. Pre- and post-anal telson subequal, pre-anal tubular, post-anal with four pairs of spines extending over 60% of post-anal length.....*Diastylis* sp CS1 (see also key to the genus *Diastylis*)
- 14a. Post-anal portion of telson close to 50% the length of pre-anal portion.....15
- 14b. Post-anal portion much less than ½ length of pre-anal portion.....17
- 14c. Urosome unknown, carapace ventrally serrate on anterior 1/3 and bearing two dorsal horn-like spines flanking ocular lobe.....*Makrokylindrus* sp CS4
- 15a. Post-anal telson distally patulous, bluntly rounded.....*Makrokylindrus abyssi*
- 15b. Post-anal telson distally tapering, pointed.....16 (note triplet)
- 16a. Carapace with a curved serrate ridge extending from pseudorostrum to anterior ventral margin of carapace; last thoracic and first abdominal somites lacking spines; telson with two pair of lateral spines.....*Makrokylindrus* sp CS1
- 16b. Carapace with muddy accretion similar to that seen in *Procampylaspis* which must be removed to reveal a spinose lateral ridge which bifurcates just before the midpoint of the carapace sending limbs toward the dorsal and ventral margins; thoracic segments with small dorsal spinules; abdominal segments 1-3 bearing a pair of small dorsal spines; telson with 5-7 pairs of lateral spines, but lacking a terminal pair.....*Makrokylindrus* sp CS2
- 16c. Carapace lacking ridges; last thoracic and first abdominal somites bearing a pair of posterior (T5) or posteriodorsal (A1) spines..... *Makrokylindrus* sp TB2
- 17a. Basal 2/3 of pre-anal telson laterally dentate.....18
- 17b. Pre-anal telson lacking lateral teeth.....19
- 18a. Telsonic lateral teeth separated by less than half their length, nearly contiguous; P1 no more than 2/3 carapace length, basis lacking ventral spines.....*Makrokylindrus menziesi*
- 18b. Distance between telsonic lateral teeth at least 1.5x their length, widely separated; P1 circa 1.3X carapace length, basis bearing ventral spines on it's distal half.....*Makrokylindrus* sp SD1

- 19a. Pre-anal telson acanthose and very long.....*Makrokyllindrus* sp BAP1
 19b. Pre-anal telson smooth.....20
 20a. Post-anal telson lacking lateral spine pairs.....21
 20b. Post-anal telson bearing at least one pair of spines.....23
 21a. Uropodal peduncle subequal to pleotelson length, carapace obliquely truncate anteriorly, with a dorsal spine at the junction of anterior and lateral margins; ventral carapace margin lacking teeth; thoracic segment 5 not spined; pseudo-rostrum with two long, thin, anteriorly recurved teeth distally.....
*Makrokyllindrus* sp BAP3
 21b. Uropodal peduncle shorter than pleotelson; carapace not obliquely truncate anteriorly, oval to globose; ventral carapace margin toothed or serrate anteriorly; with dorsal teeth on pseudorostrum not elongate.....22
 22a. Thoracic segment 5 with a pair of spines directed posteriorly from its distal margin; abdominal segment 1 with a pair of spines directed vertically on its distal margin; ocular lobe with an anterior denticle; carapace ventral margin spined to posterior of carapace.....*Makrokyllindrus* sp TB1
 22b. Thoracic segment 5 with a pair of spines directed vertically from its distal surface, other thoracic and abdominal somites dorsally spined, with number of spined segments increasing with growth; carapace ventral spination only on anterior ½*Makrokyllindrus* sp BAP2
 23a. With strong denticles on ventral carapace margin from antennal sinus to postero-ventral corner of carapace, not extending onto posterior margin; only scattered small spinules elsewhere on carapace; no tubercles on pseudorostrum
*Makrokyllindrus americanus*
 23b.. Lacking denticles on ventral carapace margin; pseudorostrum with a row of small spinules flanking its central split, but lacking large recurved spines; with scattered small spinules dorsally on carapace; sternite of first abdominal segment with 2-4 strong spines in male (absent in female).....*Makrokyllindrus* sp CS3

Anchicolurus – monotypic, containing only the local *A. occidentalis*. This is a large robust animal with heavily calcified carapace. It is readily recognized among other shallow water diastylids in the SCB by its prominent antero-ventral carapace corners, which give a quadricuspedate frontal margin; and the enlarged pleura of the thoracic segments. No other diastylid occurring in the NEP has such a short telson, or one lacking any lateral spines or setae.

Diastylis – A large genus, largest in the family. Băcescu (1992) lists 84 species, to which the four species of Watling and McCann must be added along with additional more recent species (i.e. Gerken and Watling 1998). The description of *Diastylis newberryi* (Gerken 2005) complicated separation of *Diastylis* from *Leptostylis*. The species intergrades with *Leptostylis* in the structure of the telson, but is differentiated by the length of the antenna in the male, and by the lack of inflation in the peduncle of the male antennule which characterizes *Leptostylis*. In consequence, this animal is included in the above key to non-*Diastylis* members of the family, where it keys with members of the genus *Leptostylis*. It has also been included below in the key to the NEP *Diastylis*. A number of the forms reported from the NEP are only known from Arctic or boreal waters. None-the-less I provide below a key to the species known from the NEP, since no comprehensive key currently exists. Watling and McCann (1997) provide a key to some of the more common species of the genus from our area, but it is not comprehensive.

Key to known NEP species of *Diastylis* – drcadren, 5 November 2006 (revised 17 Nov 2011)

- 1a. Carapace lacking ornamentation of either ridges or spines; smooth.....2
- 1b. Carapace ornamented with either ridges, spines, or a combination.....5
- 2a. Carapace with numerous setae, hirsute; eyelobes poorly defined.....3
- 2b. Carapace with few or no setae; eyelobes well defined.....4
- 3a. Eyelobe bear a pair of minute spinules; carapace minutely villose; ventral margin serrate, with large recurved pointed teeth; telson with 4 lateral setal pairs
.....*Diastylis sp CSI*
- 3b. Eyelobe lacking spinules; carapace smooth, not minutely villose; ventral margin smooth, lacking large teeth; telson with 8-9 setal pairs.....*Diastylis umatillensis*
- 4a. Carapace lacking hump in behind eyelobe and without sulcus around ocular lobe; post-anal telson shorter than pre-anal; one pair of lateral setae on telson.....
.....*Diastylis newberryi*
- 4b. Carapace with eyelobe followed by a large hump, both set off by a sulcus similar to that of *Hemilamprops californicus*; post-anal telson longer than pre-anal; four pairs of lateral setae on telson.....*Diastylis sp C*
- 5a. Carapace ridges ending in large spurs.....*Diastylis calderoni*
- 5b. Carapace with either spines or ridges, but not both.....6
- 6a. Carapace with spines, but no ridges.....7
- 6b. Carapace with ridges, but no spines.....10
- 7a. Spinules or small spines, but no large spines, present on carapace.....8
- 7b. Large spines present on carapace.....9
- 8a. Spinules present only anteriolaterally on carapace, absent from dorsal midline; pre- and post-anal segments of telson subequal; 7-11 lateral setal pairs on telson, with more in larger animals.....*Diastylis sp BAP2*
- 8b. Spinules or small spines along dorsal midline; post-anal telson much longer than pre-anal; lateral setal pairs numerous.....*Diastylis rathkei*
- 9a. Large spines present on carapace in one horizontal row; post anal telson much longer than pre-anal; lateral setal pairs numerous.....*Diastylis paraspinulosa*
- 9b. Large spines present on carapace in four horizontal rows; post anal telson equal to pre-anal; with four lateral setal pairs.....*Diastylis sentosa*
- 10a. Carapace with serrate, crenulate or castellate ridges.....11
- 10b. Carapace ridges smooth, lacking serrations, crenulations, or castellations.....15
- 11a. Pre-anal telson about ½ length of post anal.....*Diastylis nucella*
- 11b. Pre and post anal telson sections subequal in length.....12
- 12a. Carapace with a single ridge which is castellate anteriorly, but smooth posteriorly; telson very short, only about 1/3 of uropodal peduncle length; one lateral setal pair, or lateral setae lacking.....*Diastylis sp BAP1*
- 12b. Carapace with multiple ridges; telson ½ or more uropodal peduncle length; two or more pairs of lateral telsonic setae.....13
- 13a. Telson only about ½ length of uropodal peduncles in both sexes; bearing 2-6 pair of lateral setae.....14
- 13b. Telson subequal to uropodal peduncle in length; bearing about 9 pairs of lateral setae.....*Diastylis aspera*

- 14a. Three transverse ridges across carapace; ridges not separated by smooth sulci, all three ridges parallel, not anastomosing; telson with 5-6 pairs of lateral setae
.....*Diastylis pellucida*
- 14b. Carapace with two ridges which join behind and below the anterior lobe of the carapace; the anterior ridge runs transversely across the carapace; the posterior ridge is separated into curving sections on either side of the dorsal midline which extend posteriorly at the start then downward and back forward to join the anterior ridge; where they join, the posterior ridge bifurcates and its ventral branch meets the ventral margin; between the two ridges dorsally are crescentic sulci on both sides of the carapace midline; telson with 2-4 lateral setal pairs
.....*Diastylis crenellata*
- 15a. At least one ridge bearing a tooth on each side of the carapace.....16
- 15b. No teeth on carapace ridges.....17
- 16a. One tooth on the second carapace ridge; post-anal telson nearly three times length of pre-anal part; 10 lateral telsonic setal pairs.....*Diastylis bidentata*
- 16b. Two teeth on the first carapace ridge, one lateral to the frontal lobe, and a second above the frontal lobe; pre-anal telson longer than post-anal; 4-5 lateral telsonic setal pairs.....*Diastylis californica*
- 17a. Pre and post-anal portions of telson subequal.....18
- 17b. Post-anal portion of telson longer than pre-anal.....20
- 18a. Telson and uropodal peduncle subequal in length.....19
- 18b. Uropodal peduncle 1/3 longer than telson.....*Diastylis alaskensis*
- 19a. Oblique carapace ridges reaching the ventral margin; telson with 2-3 setal pairs laterally.....*Diastylis abbotti*
- 19b. Oblique carapace ridges extend forward at the base, not reaching ventral margin; telson with 6 setal pairs laterally.....*Diastylis quadriplicata*
- 20a. Post-anal telson twice the length of pre-anal; 8-9 lateral setal pairs on telson; the carapace ridges not anastomosing into polygons mid-dorsally.....*Diastylis dalli*
- 20b. Post-anal telson 1 1/2 times the length of pre-anal; 5 lateral setal pairs on telson; carapace ridges forming polygons mid-dorsally.....*Diastylis santamariensis*

Diastylloides – A small genus of seven described species worldwide (Băcescu 1992) to which an eighth must now be added (Gerken 2005). The only species known from the NEP is the newly described *D. pacificus*, from deep-water off Baja California. Reyss (1974) provides a key to the genus except for *D. pacificus*. *Diastylloides pacificus* is most similar to *D. atlanticus* (Gerken 2005) and should key with that species in Reyss' key.

Diastylopsis – The genus is easy to recognize because of its long cylindrical carapace. It occurs in relatively shallow sands, but in some areas has been reported as deep as 60m. This seems rather atypical, but the members of the genus cannot be confused with any other present in the NEP, and so these deep records are regretfully and suspiciously accepted. There seems to be a good separation between the two taxa which occur in the area, with *D. dawsoni* occurring north of Pt. Conception, and *D. tenuis* occurring south of that biogeographic divider in the SCB. There is some overlap, however, and specimens taken in the area bounded by Pt. Conception and Morro Bay should be carefully examined; *D. tenuis* does occasionally occur there. I know of no

substantiated reports of *D. dawsoni* within the SCB, however. Barnard and Given (1962) state that they had been unable to find intergradation (I assume this to mean hybridization) between the two taxa, despite examination of a great deal of material. They illustrate the male of *D. tenuis*, which was not known to Zimmer when he described the species (Zimmer 1936). The two species can be distinguished by their sternal tooth formulae (ventral teeth on thoracic and abdominal somites). In males it is T2 (1), T3 (1), T4 (0), T5 (1), A1 (1), A2 (1), A3 (0) for *D. tenuis* and T2 (0), T3 (0), T4 (0), T5 (2), A1 (1), A2 (1), A3 (1) in *D. dawsoni*. For females the formulae are T5(1), A1(0) in *D. tenuis* vs. T5(2), A1 (1) in *D. dawsoni*.

Leptostylis – As discussed by several authors (i.e. Day 1980, Gerken 2005, Gerken and Watling 1998, Watling and McCann 1997) the genus tends to intergrade with *Diastylis* and *Makrokyllindrus*. Previous seemingly clear distinctions in telson structure are now blurred, so that determination of *Leptostylis* is no longer straightforward. Problems continue to make themselves apparent. With the provisional *Leptostylis* sp F for instance, the males do not bear pleopod primordia until they are in the pre-reproductive molt, and then they are rudimentary (only two small articles). No males with fully developed pleopods have yet been found, but one which shows the rudiments of two pleopods is known from the Tanner Basin. As is often the case, the problem did not appear until sufficient material was available for full characterization of the taxon. Since the pleopods are so little developed, sexing the animals depends on the count of epipods on the pereopods: 1-4 in the male, and 1-2 in the female. It is possible that this species never fully develops setose pleopods in the male; we will keep looking for additional material to answer that question. Day (1980) used male pleopod number as a distinguishing factor in the separation of the Diastylidae and Gynodiastylidae. She defined the Gynodiastylidae as lacking pleopods in the male, and the Diastylidae as bearing two pleopods in the male. Difficulty with male pleopods was already apparent in the description of *Atlantistylis* by Reyss (1975), a genus lacking pleopods in the male, but retained in the Diastylidae by Day (1980) without comment on the disparity. It has recently led to erection of new genera of diastylids similar to *Leptostylis*, but with a single pleopod in the adult male (*Ekonodiastylis*, Gerken et al 2000; *Divastylis*, Mühlenhardt-Siegel 2003).

Makrokyllindrus – Thirteen representatives of this genus are found in the NEP, two provisionals from the Tanner Basin, one from the Cascadia Slope, three from the Cascadia Abyssal Plain, three from the Baja Abyssal Plain, and one from off Pt. Loma; two described species from considerably to the south, in deep-water of the Gulf of Panama and off the Galapagos (Băcescu 1962), and one in Bering Sea waters (see Lomakina 1958), all in the sub-genus *Adiastylis*. The subgenus *Makrokyllindrus* ss occurs sparingly (3 spp.) in the NW Pacific, but is absent in the Eastern Pacific. *Adiastylis* is also present, and diverse, in the NW Pacific (6 species). The genus, including both subgenera, is distributed world-wide, with many representatives in the Atlantic, Indian, and Pacific Oceans, and a few in the polar seas. Băcescu (1992) lists 15 species in *Makrokyllindrus* ss., and 40 in *Adiastylis*, but this number has certainly increased in recent years (i.e. Mühlenhardt-Siegel 1997). It is best separated from *Diastylis* by the relative lengths of the pre and post anal sections of the telson, but there is a tendency for this to intergrade in some forms including one provisional from the NEP currently placed in *Diastylis*. No members of this genus were reported from collections at 2385-3085m south of the entrance to San Francisco Bay by Watling (in Blake et al 1992). It is likely that more undescribed forms will be located in the collections from Station M, in 4000m water depth off Central California, once those only partially sorted materials are

examined in the Scripps Invertebrate Collection. It is also possible that additional specimens will be located among the materials of MBARI from their seamount and other deep water collections. Although no members of the genus are currently described from the zone between 10°N and arctic Alaska, a surprising variety of new species have been uncovered in available deep water samples.

Oxyurostylis – Băcescu (1992) lists only five species in the genus, and no additional ones have been described since. Two of these species occur in the NEP. The record of *Oxyurostylis* sp. (J. L. Barnard (1970) represent undeterminable specimens, since both *O. pacifica* and *O. tertia* were reported from the collections. Specimens of *O. tertia* are unlikely to occur much to the north of San Diego, although that remains a possibility during ENSO events with strong northward warm current flow. All *Oxyurostylis* are shallow water animals, and the 76m record for *O. pacifica* is unusual, most specimens being taken shallower. They frequent bays and estuaries, and were common components of several associations the benthos in Bahia San Quintin (J. L. Barnard 1970).

Vemakylindrus – Ten species in this genus were listed by Băcescu (1992), to which *V. hystricosa* Gerken 2002 must be added. A juvenile specimen of this species was taken in the Tanner Basin at 1335m. While this initially appeared separable, the differences were, on further reflection, ascribed to ontogenetic change, and the erected provisional was synonymized with *V. hystricosa*. Members of this genus seem to be very uncommon locally, with only five specimens known from California, three of them manca. No material identifiable as *Vemakylindrus* was recorded from the bathyal-abyssal collections made in the Gulf of the Farallones near San Francisco, and none has yet been located in materials from bathyal and abyssal depths off Oregon. Similarly the two species described from deep tropical waters in the Eastern Pacific (Băcescu, 1961) are known from a total of three specimens.

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Cumacea of the NEP: equator to Aleutians and intertidal to abyss

Part 4. The Family Lampropidae

dbcadien 6 November 2006 (revised 31 October 2011)

The cumacean family Lampropidae is the second of three families belonging to the clade of forms with articulated telsons. It, along with the families Diastylidae, and Gynodiastylidae form this clade. The Pseudocumatidae, the sister taxon to all other cumaceans, also has an articulated telson. The Lampropidae is smaller than the Diastylidae, which was previously covered, having only 58 species distributed among 13 genera in the Crustaceorum Catalogus treatment (Băcescu 1988). Additional forms have been described since. In the NEP only four genera of lampropids are known to occur. with 20 species; nearly a third of which are provisionals. Like the diastylids, the lampropids are primarily a cool water and/or deep water group (Day 1978). Most of the local lampropids are in the genus *Lamprops*, which is a generally shallow-water genus of the northern Hemisphere (Day 1978). The genus *Mesolamprops* is also primarily shallow-water, while *Hemilamprops* and *Paralamprops* are deeper dwelling. The family is sexually dimorphic along the lines of most cumacean families. Unfortunately, the taxonomy at the generic level is dominated by separations based on adult male morphology. This makes it impossible to accurately place females and juveniles of a species in the appropriate genus, although specific identity may be clear.

It should be noted that under ICZN Article 30.1.4.3. all generic group names ending in -ops are to be treated as masculine. In consequence, to retain agreement in gender, all species level names originally proposed as feminine or neuter must be recast in masculine. For species in this family, where most generic names end in -ops, the appropriate masculine ending for species level names is -us rather than -a. All names have been emended below to conform to this article.

NEP Lampropidae from McLaughlin et al (2005) augmented by known provisional taxa.
*= Taxa on the SCAMIT Ed 6 list. Valid taxa bolded, synonyms not.

Lampropidae

***Hemilamprops californicus** Zimmer 1936 – Japan, Puget Sound to San Diego;
13-177m

Hemilamprops gracilis J. F. L. Hart 1930 - Alaska to Puget Sound; 120-200m

***Hemilamprops sp A** MBC 1985§ - Oregon to Pt. Loma; 305-798m

***Hemilamprops sp B** Paquette 1985§ - Oregon to Pt. Loma; 185-732m

Lamprops augustinensis Gerken 2005 – Cook Inlet, Alaska; 0-1m

Lamprops beringi Calman 1912 – Arctic Alaska to Puget Sound; 0-129m

***Lamprops carinatus** J. F. L. Hart 1930 – Arctic Alaska to SCB; 18-120m

Lamprops fuscatus G. O. Sars 1865 – No. Atlantic; SE Alaska to Puget Sound;
2-121

Lamprops krasheninnikovi Derzhavin 1926 – NW Pacific to Puget Sound;
0-12 m

Lamprops obfuscatus (Gladfelter 1975) – Tomales Bay; 18m

***Lamprops quadriplicatus** S. I. Smith 1879 – NW Pacific; Alaska to Oxnard; 0-
104m

- Lamprops serratus** J. F. L. Hart 1930 – Puget Sound; 20-95m
 ***Lamprops tomalesi** Gladfelter 1975 – Tomales Bay to the Santa Barbara Channel; 6-10m
Lamprops triserratus (Gladfelter 1975) – Tomales Bay to Oxnard; 7-16m
 ***Lamprops** sp D MBC 1985§ - SCB; 69-197m [may = *M. bispinosus*]
Lamprops sp E MBC 1985§ - off Pt. Arguello; 951m
Lamprops sp F MBC 1985§ - off Pt. Arguello to Tanner Basin; 954-1150+m
 ***Mesolamprops bispinosus** Given 1964 – Pt. Conception to San Diego; 30-100m
Mesolamprops dillonensis Gladfelter 1975 – Tomales Bay; 13-21m
Paralamprops sp BAP1 Cadien 2001§ - Baja Abyssal Plain; 3880-3950m

Key to the NEP Lampropidae (modified from Jones 1969) – dbcadien 6 November 2006

- 1a. Males with pleopods.....2
 1b. Males lacking pleopods.....*Lamprops* (see key to genus)
 2a. Male with two pleopods.....*Mesolamprops* 3
 2b. Male with three pleopods.....4
 3a. Uropodal exopod shorter than endopod; telson with two pairs of lateral setae or spines; carapace lacking incised sulcus around ocular lobe and pseudorostrum, smooth.....*Mesolamprops bispinosus*
 3b. Uropodal exopod as long as endopod; telson with 3-6 (usually 4-5) pairs of setae or spines laterally; carapace with incised sulcus around ocular lobe and pseudo-rostrum as in *Hemilamprops californicus*.....*Mesolamprops dillonensis*
 4a. Basal article of uropodal exopod subequal to or longer than distal article; basis of third maxilliped distally widened*Hemilamprops* 5
 4b. Basal article of uropodal exopod much shorter than distal article; basis of third maxilliped not distally widened.....*Paralamprops* sp. BAP1
 5a. Carapace with incised sinus enclosing pseudorostrum and eyelobe extending ½ carapace length then curving to dorsal midline.....*Hemilamprops californicus*
 5b. Carapace lacking incised sinus, but with other carapace sculpture.....6
 6a. Carapace with serrate mid-dorsal crest on anterior ½.....*Hemilamprops* sp A
 6b. Carapace lacking mid-dorsal crest.....7
 7a. Carapace with a single horizontal carina extending from position of antennal sinus posteriorly which sweeps up to the dorsal midline at the posterior carapace margin telson with three subequal terminal spines, and 4 pairs of lateral telsonic spines or setae.....*Hemilamprops gracilis*
 7b. Carapace with series of anastomosing ridges which divide it into several irregular polygons of various sizes on each side of carapace; telson with three subequal terminal spines, and 2 pairs (♂) or 8-9 pairs (♀) of lateral setae or spines.....*Hemilamprops* sp B

Separating *Lamprops*, *Hemilamprops*, and *Mesolamprops* -If males are present the separation is fairly trivial, with differing numbers of pleopods in the three genera: *Lamprops* with 0, *Hemilamprops* with 3, and *Mesolamprops* with 2. Juvenile males, prior to full development of pleopods, may also prove difficult, but pleopod rudiments should be visible in all but the smallest specimens.

Females are much more difficult. Several recent papers have mentioned additional information separating *Lamprops* from the other two in females as well (Haye

and Gerken 2005, Shalla and Bishop 2007). They both suggest females of *Lamprops* species have the basis of P1 longer than the remaining articles; that is, the basis comprises more than 50% of the entire limb.

Our current difficulty in separating *Lamprops* sp D from *Mesolamprops bispinosus* can perhaps be solved using this tool. Since we have not found males of *Lamprops* sp D to date, placement in *Lamprops* remains tentative. Since sex ratio is not particularly skewed in other *Lamprops* and in either *Hemilamprops* or *Mesolamprops*, the absence of males in *Lamprops* sp D is troubling. Comparison of the voucher sheet with females of *Mesolamprops bispinosus* yielded few differences other than the fine denticulations on the anterior carapace margin pointed out by Jim Roney. If the females attributed to *Lamprops* sp D do not have the elongate P1 basis characteristic of the genus, I suggest they are the same as *M. bispinosus*.

Comparisons of the type species of the three genera are required to validate the existence of the female character of P1. These are:

Hemilamprops – *H. roseus* (Norman 1864) by subsequent designation

Lamprops – *L. fasciatus* Sars 1863 by monotypy

Mesolamprops – *M. bispinosus* Given 1964 by monotypy and OD

This comparison suggests that the basis/limb ratio of P1 is a useful criterion for separation of females of *Lamprops* from females of the other two genera in the types. But variability in this measure in other members of the genera remained to be explored. This exploration is reported in the accompanying table. Fourteen species of *Lamprops*, 16 of *Hemilamprops*, and 6 of *Mesolamprops* were evaluated for the length ratios of the articles of their first pereopods. This was done by measurement of published illustrations of the taxa by the original authors and subsequent reporters. Measurement of specimens would have been preferable, eliminating one source of potential error, but would have required unacceptable delay in comparison. The values reported in the table are dimensionless, being based on reproduced illustrations of varying size with no attempt to standardize by manipulation of measurements. Consequently ratios can only be determined within individual species. Absolute values cannot be compared for a single article between species, or even sexes of the same species. As can be seen from the table, it is not just the length of the basis that is important, but also the relative lengths of the propod and dactylus. These two articles are generally more elongate (sometimes by 3 or 4 times) when the basis/limb ratio is low.

In a number of cases data could be obtained for both males and females of a species. Since Sars (1900) did not specify the sex of the illustrated pereopods, it was useful to compare the degree of intraspecific variability in basis/limb ratio with that between species. In all three genera males and females of a species were usually within 10% of each other with regard to basis/limb ratio. Since we will be applying this measure only to females, it should not particularly matter, except in interpreting early reports with sex not reported. Since these appear to conform to the general trend, we can disregard sex in subsequent discussion.

The only *Lamprops* for which females had a basis/limb ratio less than 50% was *Lamprops tenuis*, a species from the northwest Pacific Arctic. The type species, *Lamprops fasciatus* had a ratio of 53%. All *Hemilamprops* species exhibited ratios well below 50%, some as low as 35%. The type had a ratio of 37%. *Mesolamprops* was a bit more varied, with *M. dillonensis* a clear outlier at a ratio of 71%. The rudimentary nature of the illustrated articles beyond the basis suggests that perhaps this was a regenerated individual. The distal portion of the first pereopod is not infrequently lost, and the post basal portion of the *M. dillonensis* type may have suffered such damage. Alternatively,

the drawing could be inaccurate. Other drawings in the same paper seem to conform to existing trends and look more appropriately proportional, so inaccuracy does not seem likely. Females of *M. japonicus* were also reported to have a basis/limb ratio of 50% by Harada (1959). This same species illustrated by Tzareva (1999) had a ratio of basis/limb length of only 43%, well within expectation. She also reported a male of the species with a ratio of 51%, however, so the ratio for the species is not yet confirmed. In general, however, the rule separating *Lamprops* from the other two genera seems to hold; *Lamprops* females show a ratio of more than 50%, while those of *Hemilamprops* and *Mesolamprops* have ratios of measurably less. That the type of *M. dillonensis* is aberrant (as suggested above) in this regard needs to be further investigated by measurements of more specimens of *M. dillonensis*.