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An Identification Guide to the Brine Shrimps (Crustacea: Anostraca: Artemiina) of Australia

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Abstract

Identification keys are provided for the Artemiina from Australian salt lakes, allowing identification of all species found in the genera *Artemia* (family Artemiidae; 2 spp), *Parartemia* (Parartemiidae; 19 spp).

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Introduction

Most anostracans, or fairy and brine shrimps, are about 10-30 mm long (extreme range 5-150 mm worldwide; 8-50 mm Australia), and consist of a long cylindrical body divided into a head, a thorax with many pairs of foliaceous limbs and the genitalia, and an abdomen. Significantly, anostracan shrimps swim upside down. Typically they inhabit fresh to hypersaline temporary waters, and are generally found in the less well watered parts of Australia. Their occurrence is spatially and temporally erratic.

Technically shrimps of the genera *Artemia* and *Parartemia* are termed brine shrimps as they are always found in saline waters and all others which live in fresh water are called fairy shrimps. However a few fairy shrimps are tolerant of hyposaline and even mesosaline waters; they are not considered here, though allowance is made for them in the generic key.

Classification

The Anostraca is one of the orders of the Class Branchiopoda. They are so different from the other orders/suborders [Notostraca, Levicaudata, Spinicaudata, Cyclestherida (last three used to be the Conchostraca) and Cladocera] that they are placed within their own subclass, the Sarsostraca. At present, nine families are recognised worldwide, five of which occur in Australia.

Taxonomic features

Their distinguishing characteristics from other crustaceans include the lack of a carapace, foliaceous limbs (shared with other branchiopods), paired stalked eyes (though many crustaceans have stalked eyes), a body consisting of a head and a thorax of 13 segments (last two the genital segments) with foliaceous limbs and the genitalia, then six abdominal segments, and a telson bearing a pair of cercopods (Figure 1). Some slightly different arrangements of body segments occur in some genera, but they are not found in Australia.

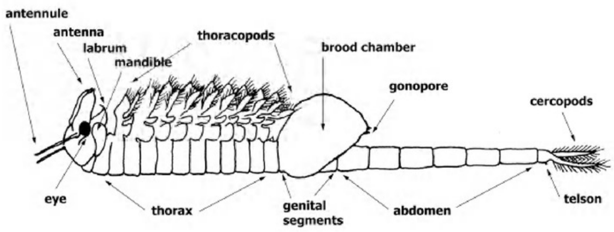


Figure 1. Lateral view of an adult fairy shrimp showing its structure

As in all crustaceans the head bears two pairs of antenna. In both sexes the first antenna are typically short and filamentous, and of little taxonomic interest, though their length relative to parts of the second antenna is sometimes useful. The second antenna of the female is also of little taxonomic interest, though again its relative length and shape can sometimes be important. However the second antenna of the male is elaborate and most important in distinguishing between species. It consists of two segments (basal and distal) and various outgrowths (Figure 2).

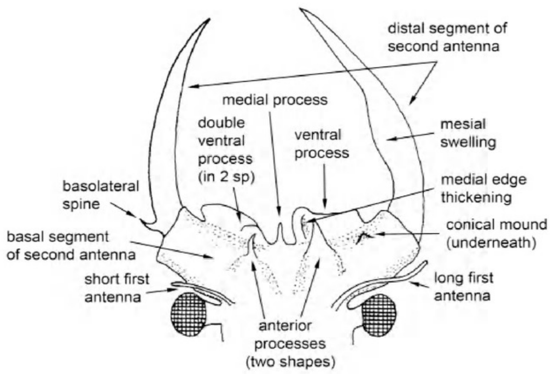


Figure 2. Dorsal view of antennae of a hypothetical male *Parartemia* showing major structures likely to be seen in Australian species.

Taxonomists focus on the form of the two segments and on the structure of the various outgrowths. In brine shrimps the outgrowths are relatively simple and consist of knob-like apophyses in *Artemia* and ventral and anterior processes in *Parartemia*. However in *Branchinella* and *Australobranchipus* (and some other non-Australian genera), during larval development, a process on each second antenna migrates to a region between the two antennae, fuse with each other and develop in to what is called a frontal appendage. Its detailed structure, almost alone, serves to separate the various species of *Branchinella*. In *Streptocephalus*, the distal joint is reduced to filament and a process from the basal joint develops into an elaborate hand-like cheliform structure. The paired stalked eyes are similar in most Australian species and are not used in species separations. Relative to other branchiopods, the labrum and mandibles are large and the maxillae and maxillules reduced. In female *Parartemia* the labrum bears a large spine, a feature easily distinguishing it from *Artemia*.

The first 11 thoracic segments each usually bear a pair of foliaceous limbs called phyllopods or better thoracopods (but not legs). These are of complex structure and consist (from medial to lateral surface) of six endites (1+2 fused and hence giving the appearance of five endites) then an endopodite, an exopodite, an epipodite and a praepipodite (Figure 3). All except the epipodite and praepipodite bear setae, often complexly structured and arranged. For any one species the thoracopods are fairly similar, though in many species there is some reduction in size and complexity in the first, and particularly, the eleventh pair, which is generally absent in female *Parartemia*. The structure of these thoracopods, particularly of the endopodite and anterior setae of the endites which are useful in detailed taxonomical studies, are hardly used in these keys.

Posterior to the thoracopods are two partly fused thoracic segments with the genitalia and called the genital segments (Figure 1). In the male these have a pair of penes on the ventral surface. The penes are composed of a proximal, usually rigid, basal part and a distal retractable part. The basal part may have spines (a pair of basal spines and distal processes *Parartemia*) and lateral swellings (but not in *Artemia* or *Parartemia*). The complex distal part is usually withdrawn and is not used in these keys. However in detailed taxonomical studies its structure gives important clues to species and generic relationships. Females have a brood chamber (not 'ovisac' as fertilized eggs mature within it) on the ventral surface. It may extend laterally or posteriorly and is useful in separating species, particularly in *Parartemia*.

The six segmented abdomen is of quite uniform structure throughout the group, as are the telson and cercopods in Australian species. In some *Parartemia* species there is not a clear distinction between the last abdominal segment and the telson.

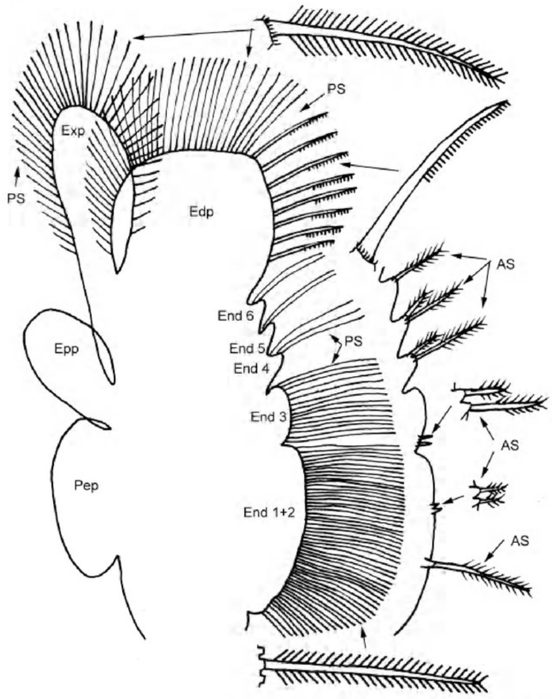


Figure 3. Thoracopod of *Parartemia acidiphila*. There are two types of setae— anterior setae (AP) of the endites shown on an extra edge on the right, and posterior setae (PS) on the main figure. After Timms and Hudson, Figure 2. Other abbreviations: End = endite, Edp = endopod, Exp = exopod, Epp = epipod and Pep = praeepipod.

All fairy and brine shrimps produce resistant eggs, which in the past were called cysts. These are carried in the brood chamber where they mature. Many species discharge these resistant eggs regularly while some retain them even in death. The eggs may have a sculptured surface (polygons and spines are common) which may be anti-predation structures, but for taxonomists provide yet another method of separating genera and often species. There is usually no surface ornamentation in brine shrimp, but eggs of *Branchinella* often have elaborate surfaces. Egg morphology will not be used in these keys, but for those interested, details of some Australian species (in *Parartemia*, *Branchinella* and *Australobranchipus*) are given in Timms et al. 2004.

Size of anostracan shrimps is not a good descriptor. This is because not only is size dependent on nutritional conditions, but brine/fairy shrimps grow throughout life, so old fairy/brine shrimps are much bigger than newly mature individuals. Nevertheless some species are characteristically big when mature and others always of medium or small size. So size is of limited use in the keys, and always as a subsidiary character, but be aware that unusual individuals may be outside the size range generally applicable to a species.

Almost no use of colour is made in the keys. *Artemia parthenogenetica* may be pink and the mature females of *Parartemia purpurea* are a deep purple, but generally brine shrimps are colourless. This compares to the pastel shades seen in some fairy shrimps, the reds and pinks of mainly *Branchinella australiensis* in clay pans and the red fringed cercopods of *Streptocephalus* and *Branchinella*. Eggs are often distinctively coloured and some *Parartemia* cover them in attractively coloured tissue. Almost all these colours are lost on preservation, though some eggs retain some colour.

Biology of Fairy Shrimps

Fairy and brine shrimps live almost exclusively in temporary standing waters, *i.e.* in clay pans, gnammas on rock outcrops, vegetated pools, newly filled freshwater lakes, salt lakes, ephemeral farm dams, roadside ditches, disconnected creek pools, in fact almost anywhere where water is ponded for more than a few days. These kinds of habitats abound in the poorly drained inland areas of Australia that receive occasional flooding rains. They do not occur in waters with fish, as anostracans are defenceless against their predation. This does not mean they are not eaten in their temporary pools. In fresh waters there are numerous invertebrate predators, but fairy shrimps prevail by developing first, fast and by fantastic fecundity. In saline waters inhabited by brine shrimps, there are few invertebrate predators, but waterbirds such as stilts and avocets can be significant consumers of shrimps. In general however, predation is less in saline waters so that brine shrimps can be present in prodigious numbers. If they are not, there may be a chemical problem or food shortage (see later).

Anostracans survive the dry period in their habitat as drought-resistant eggs. These contain an embryo in an arrested stage of development and remain viable in the surface sediments for many years. They hatch 12-48 hours after filling, but only a proportion hatches each filling, a bet hedging program in case there is insufficient water to allow the shrimps to reach maturity and reproduce. Growth is very rapid, some species maturing within four days, though 2-3 weeks is more normal. Once mature, they produce a batch of eggs every few days or so and eventually die of old age (if not eaten earlier) within month or two. Unlike fairy shrimps which are produce only resistant eggs which require drying before they hatch, brine shrimp produce two types of eggs, the resistant type and one which hatches immediately. Thus brine shrimps usually have many overlapping generations (and are multivoline), whereas fairy shrimps have just one generation (univoltine) per lake filling. Hence brine shrimp are usually present throughout the hydroperiod of a salina, unless the salinity increases beyond its tolerances as the site dries.

Almost all anostracan shrimps are filter feeders. They use their setose thoracopods (Figure 3) to filter out small particles and then pass these forward to the mouthparts for processing and then ingestion. The particles range from algae and protistians to bacteria on clay particles and organic matter. *Artemia* typically filter feed on planktonic algae, but most *Parartemia* rely on organic matter they stir up from the sediments, as well as on benthic algae. Such food sources may be not be as abundant as planktonic algae, so that populations supported may be not as dense as those of *Artemia*. Exceptions occur, thus inviting speculation as to specific limiting factors.

Sexes are separate and reproduction is usually sexual, although some *Artemia* are parthenogenetic. Males actively pursue females and commence copulation by clasping the female just anterior to the genital segments with their specially developed second antenna. Although males have two penes, only one is needed to insert into the brood pouch. Encounters are typically brief, but in most *Parartemia* and *Artemia* the two sexes remain locked together for hours or even days. The female produces a batch of ca 20-300 cysts every one to a few days and each batch needs to be separately fertilized. It is possible some Australian species retain their cysts and die with them in their brood pouch. Anyhow, cysts end up being deposited on the bottom mud, as generally they do not float like those of *Artemia*.

Collection and preservation

Fairy and brine shrimps are easily collected by sweeping a dip net through the water of a temporary pool or salina. They distort and shrink when preserved, so that placing directly into 4-5 % formalin or particularly 70 % alcohol is unsatisfactory. This is however the best way to get the males to evert their genitalia, which are sometimes important for taxonomic studies. If this has to be done then formalin gives a better result than alcohol, though of course formalin should be handled with upmost care as it is carcinogenic. In that *Parartemia* has important taxonomic structures which easily distort, it is best to use formalin rather than alcohol for these. However, alcohol generally is better than formalin, particularly if stronger at 90 – 100% as the animals can then be used for DNA and other biochemical analyses. Alcohol in saline water results in a white precipitate, so wash the shrimps first. This is easily done in a small household sieve or tea strainer. Two ways to get better preserved specimens are (a), to let them die through lack of oxygen or (b) to narcotize them with carbonated water before preservation. I prefer the later as it is more humane.

Key to families of Anostraca likely to be found in Australian salt lakes

Five families of anostracans occur in Australia, each represented by just one genus. Two of these genera, *Streptocephalus* and *Australobranchipus*, have never been found in salt lakes, and a third, *Branchinella*, has just a few representatives, but rarely are they the dominant shrimp present. More typically salt lakes have either *Artemia* (mainly in salt works and a few secondarily salinised lakes in WA) or the endemic *Parartemia,* both known as brine shrimps. The key below differentiates the saline genera, and later keys separate the species of *Artemia* and *Parartemia*, but *Branchinella* is not further teased out in these keys. If you need to identify a species of *Branchinella* go to Timms 2004. **Note**: the key is based mainly on male characteristics

1a. Distal segment of male second antenna flattened, widest halfway along its length and with an acute apex; basal segment with a prominent knob-like apophyses on baso-medial margin (Figure 4). Female with a pair of ventral spines on brood chamber. Females often pink and usually < 7 mm long .... **Artemiidae**, *Artemia*

1b. Distal segment of male second antenna tubular, usually tapering evenly to an acute apex, though sometimes slightly thickened midlength; knob-like apophyses on medial margin of basal segment typically absent (if present, then frontal appendage present). Female brood chamber without ventral spines. Females rarely pink and usually > 8 mm long. 2

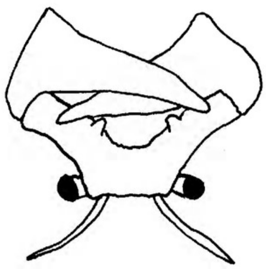


Figure 4 Head of male *Artemia*

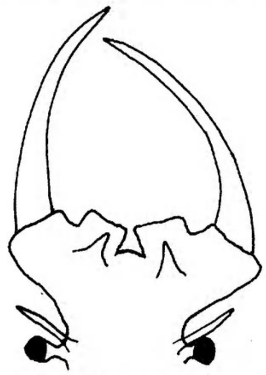


Figure 5 Head of male *Parartemia*

2a(1b). Basal segments of male second antenna fused for about half their length and with a pair of blade-like ventral process between the distal segments and pointed dorsal processes (Figure 5). No frontal appendage. Female brood chamber short and oval, often extending laterally/posteriolaterally to give a bilobed structure. Females with only 10 pairs of fully developed thoracopods (or just 9 pairs in one species) .... **Parartemiidae**, *Parartemia*

2b(1b). Basal segments of male second antenna may be fused a little, but far from half their length. No ventral processes on fused area and no dorsal processes. A central frontal appendage may be present rising dorsally from the fused area (Figures 6, 7). Female's brood chamber compact but with a tube extending posteriorly to second or third abdominal segment. Females with 11 pairs of thoracopods .... **Thamnocephalidae**, *Branchinella*

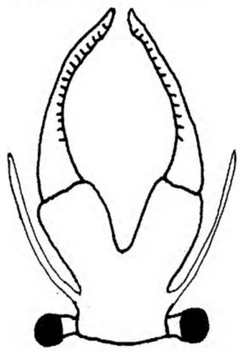


Figure 6. Head of male *Branchinella simplex*

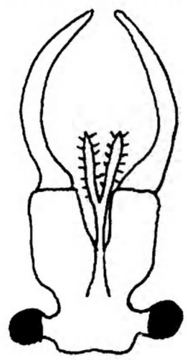


Figure 7. Head of male *B. Australiensis*

Note: Should the unidentified specimen have a male second antenna developed into a hand-like cheliform structure, then it is most likely *Streptocephalus*, and should it have a frontal appendage with the basal part sclerotised, then it could be *Australobranchipus*. In either case see Timms 2004.

Family Artemiidae Grochowski, 1895
Genus *Artemia* Leach, 1819

This is a monogeneric family, with genus *Artemia* of about eight species and innumerable genetic varieties and strains (Browne et al., 1991). Because of their importance in saltworks and aquaculture, *Artemia* spp are by far the best studied of all anostracans.

Artemia spp are distinctive anostracans (Dumont & Negrea, 2002). Most obvious is the distal segment of the male's second antenna which is flattened and enlarged so that the widest place is almost half way along its length (Figure 8). From there it narrows unevenly to a sharp apex. The basal segment of the second antenna has a large rounded knob (apophysis) on the medial surface about ⅓ rd along the length of the basal segment from the free base. It protrudes about ⅓rd the width of the basal segment. (It should be noted that some species of *Branchinella* have superficially similar outgrowths— see Timms 2004). The non-retractable penes bases are not remarkable, except to note the individual bases are well separated and there are no lateral processes (as in many *Branchinella*) or medial recurved spines (as in *Parartemia*) (Figure 8). Females are also unremarkable, though their brood pouch is distinctive with its two ventral spines. *Artemia* superficially looks like *Parartemia*, but the two are easily distinguished as *Parartemia* has a spine on the labrum and *Artemia* does not. Most *Artemia* are small in the 6-10 mm range.

Populations occur in most saltworks in Australia and in a few other localities as well. Argument rages whether or not our brine shrimp have been introduced, with the traditional view that it has been (e.g. Williams, 1981). However Geddes (1979) opines that it is remotely possible those in coastal WA spread there naturally from Asia, a view supported and expanded by McMaster et al. (2007). At least two species are present in Australia ---a sexual species in the Rockhampton, Bowen, Dry Creek (Adelaide), Port Hedland and Dampier saltworks that is probably *A. franciscana* (M. Coleman, pers. comm..) and a parthenogenetic species in coastal Western Australia (on Rottnest Is, Three Springs, Shark Bay, Lake McLeod, Onslow) which is best called parthenogenetic *Artemia* (T. Abatzopoulos, pers. comm.). The saltworks at Adelaide also once had this form (Mitchell & Geddes, 1977), but it is now dominated by *A. franciscana* (P. Coleman & R. Eden, pers. comm.).

More worrying is the spread of *Artemia s*pp. to natural sites. Earlier this was thought to be unlikely on ecological grounds (*Artemia* prefer warm long-lived hypersaline waters which are uncommon naturally in Australia, and our salt lakes are occupied by an ecological equivalent *Parartemia*—Geddes, 1979, 1981, 1983; Williams & Geddes, 1991). By the 1980s specimens of *Artemia* had been found in a natural salt lake south of Perth, a samphire swamp at Port Adelaide, a hypersaline lake at Port Augusta and from a saline pool near Cooper Creek in central Australia (Geddes & Williams, 1987). The occurrences from old salt works at Port Augusta (P. Coleman, pers. comm.) and similarly one from Lake Koorkoodine (near Southern Cross (WA) (Pinder et al., 2002) are extant and are of *A. franciscana.* This species is spreading rapidly overseas (particularly around the mediterranean and in China) but despite predictions of Ruebhart et al. (2008), this species has not spread beyond present and past salt works in Australia, perhaps because we have a different strain. Unfortunately the same cannot be said of parthenogenetic *Artemia.* In recent years this species has been found in many natural and secondarily salinised lakes, including a lake few kms east of Quairading, similarly a lake east of Wubin, in river pools in the Fitzgerald River World Heritage Area, a lake northeast of Esperance, in Lake Boondaroo in the Nullarbor. How they got so far east from their original sites on the coast near Perth is a mystery. It is probably significant that most sites are secondarily salinised and given that more and more lakes are becoming similarly affected in south west WA, more new records are to be expected. Certainly collectors need to be aware of this possibility and we should not aid the spread of *Artemia* with dirty nets and muddy boots.

Species present in Australian saline waters:
Artemia franciscana Kellogg
parthenogenetic *Artemia*

Key to species of *Artemia* in Australia.

(this is only a rough guide; DNA profiles are needed)

1a. Both males and females present .... *A. franciscana*
1b. Only females present .... parthenogenetic *Artemia*

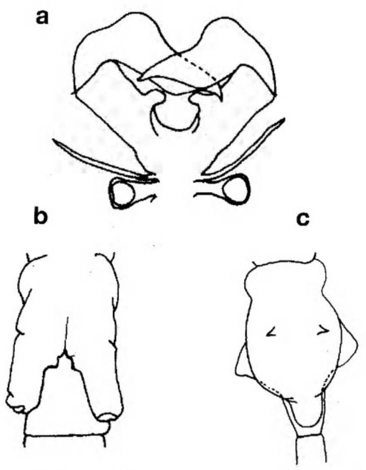


Figure 8. *Artemia,* a, dorsal view of head; b ventral view of penes base; c, ventral view of brood chamber

Figure 10. parthenogenetic *Artemia* (photo: T. Abatzopoulos)

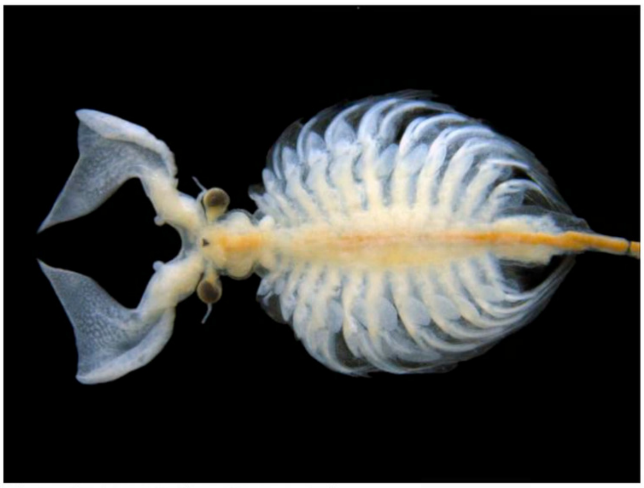


Figure 9. *Artemia franciscana* male

Family Parartemiidae Daday, 1910

Genus *Parartemia* Sayce, 1903

The genus *Parartemia* is an Australian endemic with eighteen described species and at least one undescribed species, though there could be more in remote inland WA, SA and adjacent NT. The great majority of these occur in south-western Western Australia: 13 occur in WA, 7 in SA (two of these shared with WA), 2 in Victoria and one each in NT, Queensland and Tasmania (all of latter four shared with SA or WA). All species inhabit saline lakes. The high species richness in WA is thought to be associated with the abundance and diversity of saline habitats there and their great age, while contrastingly, the low diversity in eastern Australia is in tune with the simplicity of saline environments there (Williams & Geddes, 1991). Furthermore the almost complete separation of the two faunas accords with the Cretaceous history when Australia was divided into two subcontinents by an inland sea (Heatwole, 1987). However recent evidence from DNA studies suggest the radiation in WA has been robust and rapid (Remigio et al., 2001) possibly in response to elevated osmotic stress in saline habitats (Hebert et al., 2002).

Parartemia males are distinctive in having the basal third (or slightly less) of the second antenna fused to form a clypeus-like structure. This basal antenna has a pair of dorso-ventrally flattened rectangular or short blade like ventral processes and also a pair of digitiform dorsal processes. The distal segment of the antenna is long and slender and only slightly curving inwards. There are no central frontal appendage as in most *Branchinella* and in *Australobranchipus* (see Fig, 2). Females are harder to define. Most have various adaptations of the pregenital segments of the thorax (T8-11 in most, but as forward as T5 in *P. minuta*) in order to be clasped properly by the male antenna of the appropriate species (Rogers, 2002). These adaptations take the form of various tumidities (i.e. swellings), sclerotizations and extensions of segment parts which are often distorted in preservation. Thus identification is aided by a preservative that gives the least distortion — narcotized animals in 4-5% formalin gives the best result (see earlier). Most females have brood chambers with lateral lobes though a few species have compact rounded chambers (both structures quite different from other Australian anostracans except *Artemia*).

Although Daday established this family in 1910, it has been regarded as a subfamily of the Branchipodidae for almost a century, until Weekers et al. (2002) using DNA techniques showed it to be a family it is own right which vicariates with the Artemiidae and indeed is its sister group.

Checklist and Distribution of Species of *Parartemia*

See Figures 11-13 showing present known distributions

P. acidiphila, Timms & Hudson 2009	Esperance hinterland and northeast Eyre Peninsula
P. auriciforma Timms & Hudson 2009	inland northwest SA
P. boomeranga Timms 2010	near northwestern Wheatbelt, WA
P. bicorna Timms 2010	Lake Carey in northern Goldfields, WA
P. contracta Linder 1941	northern, central and southern Wheatbelt, WA
P. cylindrifera Linder 1941	southern Wheatbelt WA, southern SA
P. extracta Linder 1941	northern and central Wheatbelt, WA
P. informis Linder 1941	northern and central Wheatbelt, WA
P. laticaudata Timms 2010	northwest and central inland WA, southwest NT
P. longicaudata Linder 1941	whole Wheatbelt, including Esperance, WA
P. minuta Geddes 1973	inland Qld, western NSW, northeast SA, nw Vic
P. mouritzi Timms 2010	eastern Wheatbelt WA
P. purpurea Timms 2010	Esperance hinterland, WA
P. serventyi Linder 1941	eastern Wheatbelt, southern Goldfields, WA
P. triquetra Timms & Hudson 2009	remote northwest SA
P. veronicae Timms 2010	Goldfields, WA
P. yarleensis Timms & Hudson 2009	central SA
P. zietziana Sayce 1903	Southern SA, north and west Vic, central Tas
P. species e	Lake Barlee, WA

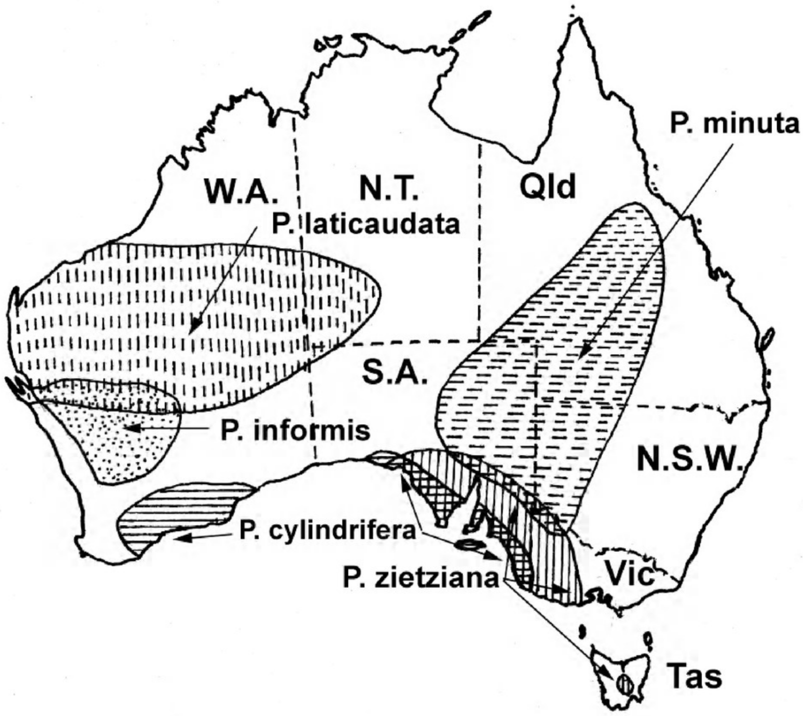


Figure 11. Distribution of five species of *Parartemia* across Australia

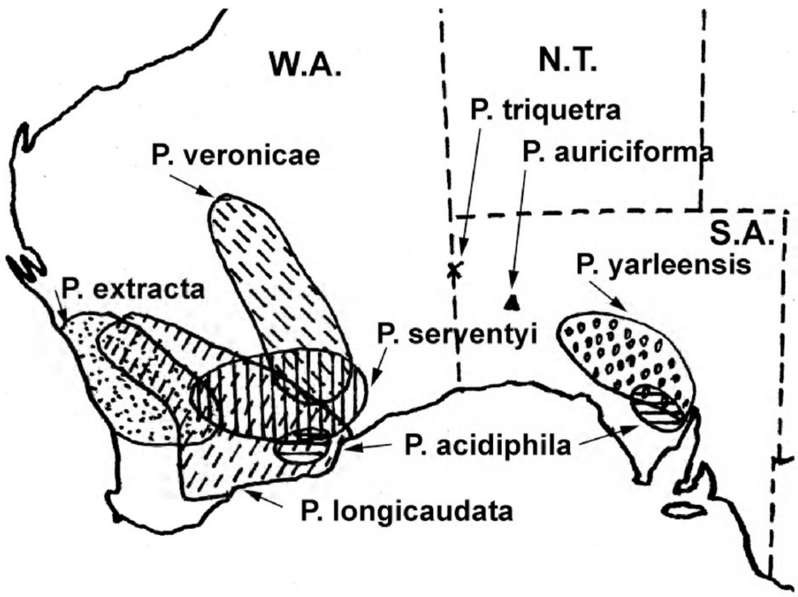


Figure 12. Distribution of eight species of *Parartemia* in central and western Australia

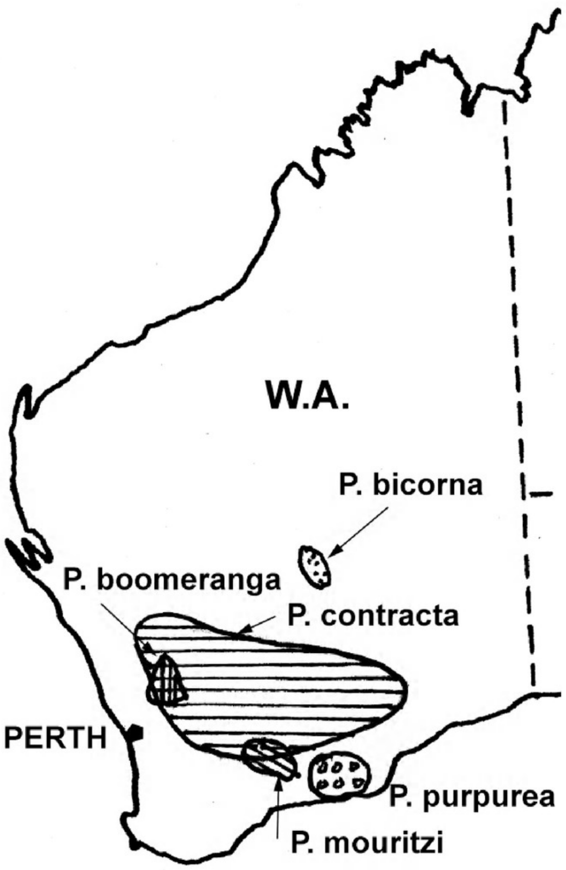


Figure 13. Distribution of five species of *Parartemia* in Western Australia.

Notes on distribution, habitat preferences and status of *Parartemia* species

Parartemia species usually are the only anostracans in a lake, unlike *Branchinella* where congeneric occurrences are common. This is probably because, in general, species of *Parartemia* eat organic matter, as well as benthic diatoms, stirred from bottom sediments and there is little opportunity for size selection to dominate in the choice of filtering setae sizes as in *Branchinella*. Where two species apparently coexist, this is usually due to one of them being washed into the lake from surrounding salinas, eg *P. laticaudata* inhabits salinas around Lake Carey and is washed into the main lake which is inhabited by *P. bicorna* (Timms et al., 2007).
Despite widespread collecting (Figures 10-13 are based on 367 collections as reported in Timms et al., 2009), distribution patterns are approximate as there are still many lakes, especially in WA, for which there are no data. Compounding the problem is the fickle nature of the presence/absence of species associated with filling regime variation, for example in a study of lakes in the Esperance area, minor and major fillings resulted in different species being present (Timms, 2009a), and also the stage in the filling/drying cycle, so that a species may be present early on, but absent as the lake dries. And the fact that salt lakes are dry most of the time does not help in live sampling, though this problem can be overcome by hatching from dried mud (V. Campagna, pers.comm.).
Nevertheless, below is a summary of what is known about each species:

Parartemia acidiphila
This species is common in acid saline lakes in the Esperance hinterland (especially in an area east and southeast Grass Patch along Ridley Rd) and also in a small area of the northeast Eyre Peninsula, including Lake Gilles and lakes at Sinclair Gap south of Iron Knob. Its known salinity range is 35-210 g/L and pH 3 to 7.4. With an average male length of 12.1 mm it is a small species. At present there is no threat to its existence, but specimens are hard to find in SA sites as they are dry most of the time, whereas most WA sites are reliably wet in winter-spring. References: Timms, 2009a; Timms & Hudson 2009.

Parartemia auriciforma
This species is known only from its type locality, Lake Wyola, in the Great Victoria Desert of northwest SA. In fact it has not been collected in the field, having been raised from

dried mud. So nothing is known of its habitat requirements, but presumedly it is safe in its remote location. It is also a small species, average male length 11.5 mm. Reference: Timms & Hudson, 2009.

Parartemia boomeranga
This rare species may already be extinct, if not, even rarer. Timms et al., 2009 recommend it be assessed as being Vulnerable as no extant populations could be found 2007-2008. Little is known of its habitat requirements, but it has been found in alkaline lakes ranging from 50 – 120 g/L in the Wubin-Kalannie area. It is a large species, male average length 21.8 mm. References: Timms, 2010; Timms, et al., 2009.

Parartemia bicorna
So far this species is known only from Lake Carey in the northern Goldfields. It is also a large species (male average length 21.6 mm) and the namesake protruding dorsal processes are only prominent in mature specimens. So far its recorded salinity range is 22-105 g/L. Despite being found in only one lake (large), it is safe enough, though its limited distribution suggests it should be assessed as a Priority One species under WA legislation. References: Timms, 2010; Timms et al., 2006, 2009.

Parartemia contracta
Another acidiphile, *P. contracta* is common throughout much of the WA Wheatbelt from Morawa in the north, Kodinnin in the south and well to the east of the agricultural area to near the Balladonia Roadhouse beyond Norseman . It seems to be absent in the southern Wheatbelt, certainly in the Esperance area. It lives in acid (pH 3.5 – 6) saline waters (80 -240 g/L, but average conditions probably lower than the 4 records on which this is based) and its special osmoregulatory abilities have been studied —instead of using CO2 from lake water it must use endogenous CO2. *Parartemia contracta* is a large species (male average 20.1 mm) and it not threatened. Interestingly however in the salinisation process in WA, lakes which have become acid are not colonised by this species. References: Conte & Geddes, 1988; Timms, 2009b; Timms et al., 2009.

Parartemia cylindrifera
This species was once considered rare and endangered, but recent field work has found it is common in the southern WA Wheatbelt and also in coastal South Australia, especially in lakes along the west of Eyre Peninsula. In these two areas it lives in lakes of different types— mainly in vegetated lakes in WA, but it lakes with fine calcareous sediments usually unvegetated in SA. Overall it lives at moderate salinites (recorded field range 3 – 140 g/L) and alkalinities (pH 7.6 - 8.2). It is a large (males 22.3 mm), distinctive species (male have a large digitiform process on the 11th thoracomere; females have a single ventral brood chamber) and is now not considered threatened. However it is likely to disappear from many Eyre Peninsula lakes as they continue to increase in salinity. References: Timms, 2009a, 2009c. Timms et al., 2009.

Parartemia extracta
This species appears to be truly rare. It occurs in the central WA Wheatbelt in small lakes from near Jurien in the north to Tammin and southwards to near Lake Grace. Early records suggest it occurred also at more easterly sites near Minnivale and Koorda, but it cannot be found in these areas now. This and other evidence suggests it is worthy of a Vulnerable status. It is most common in Ruppia-dominated lakes of lower salinity (27 – 100 g/L) and moderately alkaline (pH 8.1- 9) It is a fairly large species, average male length 17 mm. References: Timms et al., 2009.

Parartemia informis
Perhaps the most common species in the northern WA Wheatbelt and also extending to the central Wheatbelt and northern Goldfields, *P. infomis* is common species occurring over a wide salinity range (30 – 186 g/L) and alkalinities (at least pH 8.5 – 9.5). It seems to prefer smaller lakes of lower salinity (< 100g/L) dominated by *Ruppia*. Some previously known sites are now salinised and lack this species, but its future is probably assured in its occurrence in small lakes are the head of drainage basins. It can be relatively large, males having an average size of 26.7 mm. References: Timms, 2009b; Timms et al., 2009.

Parartemia laticaudata
Although there are not many records of this species, it occurs over a large part of northern and central Western Australia and adjacent parts of the NT, at places as far apart as Onslow, Shark Bay, Lake Raeside and Lake Disappointment. Known salinity range is 8 – 141 g/L and most sites so far are alkaline, relatively large and unvegetated. There are no known threats to its existence. It is about average size with males at 17.5 mm, but is distinctive as males especially have wide abdomens as its name suggests. References: Timms, 2010; Timms et al., 2009.

Parartemia longicaudata
This is another common species found throughout much of the WA Wheatbelt, from near Perenjori in the north to near Cranbook in the southwest and Esperance in the east. Normally it lives in large lakes, dominated by benthic mats and often at higher salinities. Salinity range is 31 – 240 g/L and pH range ca 8 – 9. It is a comparatively large species (male average size 25.4 mm), in part due to its long abdomen. Not surprisingly it is not under threat, though of course many sites have been lost to salinisation. References: Timms 2009a, Timms et al., 2009.

Parartemia minuta
As its name suggests this is a small species (male size 14.2 mm), but its distribution is as wide as any species as it occurs from northeast Qld, southwest Qld (with few suitable lakes in between), western NSW and northeast SA, and to northwest Victoria. It is the resident shrimp in Lake Eyre (not *Artemia* as 'Australian Geographic' would have it!) and when the lake fills, it is probably the most numerous *Parartemia* in Australia. Known salinity range is wide, from 2 – 255 g/L

and it has always been found in alkaline lakes. Not surprisingly, there are no conservation issues. References: Timms, 2007; Timms et al., 2009; Williams and Kokkinn, 1988.

Parartemia mouritzi
This species could be regarded as the western equivalent to *P. minuta*, but only in size (males 10.5 mm) and morphology. Otherwise it is uncommon, has a narrow distribution from Hyden to near Norseman in the eastern Wheatbelt, a narrow salinity range of 20 - 95 g/L and moreover is an acidiphile (pH ca 5-7). All four known sites are small and unvegetated. In that two of these are weakly salinised, and given its narrow distribution it should be considered for Priority One status under WA legislation**.** References: Timms, 2010; Timms et al., 2009.

Parartemia purpurea
This is another recently described species, this time from alkaline lakes in the Esperance hinterland. It has been found over a wide salinity range (20 – 235 g/L) and also pH range (7.4 – 9.2), mainly in vegetated salinas. Of about medium size (males 18.1 mm), its most distinctive feature is the intense purple colour of its mature females, which cruise the shallows probably to lay eggs, while the colourless males swim offshore. Few lakes within its distribution are salinised, so presently it is safe. References: Timms, 2009a; 2010; Timms et al., 2009.

Parartemia serventyi
This large species (average male length 21.2 mm) is common in the Wheatbelt from Kellinberrin to Southern Cross (eg Lake Beladgie), south to Hyden/Lake King and onto Esperance's northern hinterland (Grass Patch northwards and westwards) and further east and north of the southern Goldfields (eg Lake Cowan). It prefers alkaline salinas, often hypersaline sites (salinity range 15 – 262g/L), but it is known also from acid waters (pH as low as 4). It is about the only species sometimes found in salinised waters, particularly in acid drains (G. Janicke, pers. comm.). There are no conservation concerns for *P. serventyi*. References: Timms, 2009a; Timms et al., 2009.

Parartemia triquetra
This species is known only from its type locality, one of the Serpentine lakes on the SA-WA border in the remote Victoria Desert. The extremely remote location will probably stifle data collection on it, but at least it is safe so far from civilization. Reference: Timms & Hudson, 2009.

Parartemia veronicae
This species has been known for some time, being the subject of an honours study (under various names) by Shane Chaplin on the Johnson Lakes, east of Norseman and also a doctorate study on Lake Yindarlgooda, east of Kalgoorlie, by Veronica Campagna. It has a wide salinity range 74 – 225 g/L, and generally inhabits alkaline unvegetated lakes, often of short hydroperiod. Distribution is throughout the Goldfields (eg. Lake Way, Lake Johnston) and further east (eg Lake Yindarlgooda). It is a small species (males 13.6 mm) and there are no conservation issues. References: Campagna, 2007; Chaplin, 1998; Timms, 2010.

Parartemia yarleensis
This species occurs in an arc of lakes west, south and southeast of Woomera, SA. Given these lakes rarely hold water and when they do access is difficult, nothing is known on its field tolerances. It is of average size (males ca 18.0 mm) with no known conservation issues. Reference: Timms & Hudson, 2009.

Parartemia zietziana
This was the first described species of *Parartemia*, occurring as it does in the populated southeast of Australia, from Geelong westwards past Adelaide to Ceduna, in the Riverland of SA, northwest Victoria and also central lowlands in Tasmania. It is the most studied of all species of *Parartemia* with information on its phenology and life cycle, salinity tolerance, osmotic and ionic regulation, field physiology and energetics. Salinity tolerance is very wide from 22 – 353 g/L, as are alkalinities from ca pH 7.5 -10. It is of average size (males ca 19.3 mm) with no known conservation issues. It is predicted however that as lakes on western Eyre Peninsula continue to salinise, it will replace *P. cylindrifera* in many lakes due to its superior salinity tolerance. References: Geddes, 1975a, 1975b, 1975c, 1976; Manwell, 1978; Marchant, 1978; Marchant & Williams, 1977a, 1977b, 1977c; Shepard et al, 1918; Timms, 2009c; Timms et al., 2009.

Parartemia species e
This undescribed species occurs apparently only in Lake Barlee, one of the salinaland lakes of the central inland of WA. No males are so far known and insufficient information is available on females to include it in the keys. However, if you have a female from Lake Barlee or thereabouts with no lateral lobes on its thoracomeres, dual tumidities on thoracomere 10, and a bilobed brood chamber appressed against the body (i.e. neither oval nor extended posteriolaterally), then it could be this species. Reference: Savage and Timms in Timms 2004.

Dichotomous key to males of the genus *Parartemia*

1(a). Distal segment of second antenna without a basolateral spine; basal segments of second antenna fused at an angle > 45°, usually about 75-90°; each ventral process, left and right, single (Figure 14) 2
1(b). Distal segment of second antenna with a basolateral spine; basal segments of second antenna fused at an angle < 45°, usually about 30°; each ventral process with a small duplicate medially (Figure 15) 18
Note: Depending on preservation state, some *P. acidiphila* look as though the angle of fusion is < 45°, but the other two characters are not affected by preservation.

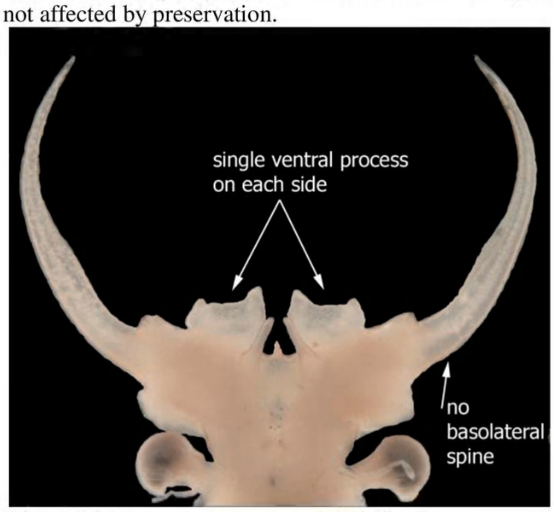


Figure 14. *Parartemia contracta* male head

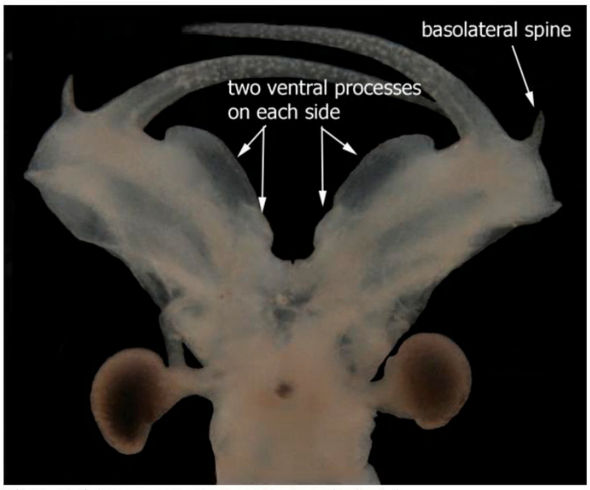


Figure15. *Parartemia mouritzi* male head

2(a) (1a) Digitiform medial process, however long or short, present (Figure 16a,b)........ .3
2(b) (1a) Medial process absent OR, if present, not digitiform or nipple-like (Figure 16c-g) 10
Note: Sometimes the triangular medial process in *P. acidiphila* looks digitiform, but it has a bifid apex, whereas no true digitiform process is bifid.

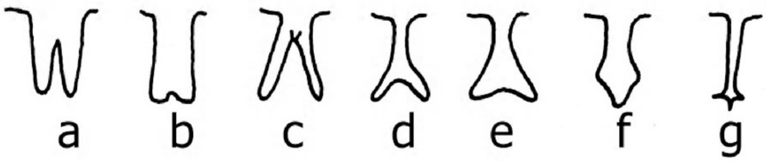


Figure 16. Various types of medial margins of the fused basal antennoemres

3(a) (2a). Medial process short, nipple-like, <1/4 length of medial space; first antenna short, about length of eye plus peduncle; ventral process >3x longer than average depth (Figure 16b, 17). 4
3(b) (2a) Medial process long, > 1/3 length of medial space; first antenna usually as long as basal antennomere, or nearly so; ventral process < 2.5 x longer than average depth (Figure 16a, 18) 7
Note: The length of the medial process in *P. contracta* is variable*,* so while it usually is accommodated in couplet 3b, it will sometimes key out in 3a, then 4a and 5b. The second character used in this couplet is variable in some populations of at least two species (mainly *P. contracta* and *P. informis*), having shorter first antenna than usual— it is rare for shrimps in the couplet 3a to have longer antenna than usual. The third character is also variable with occasional problems in *P. bicorna* and more likely in *P. laticaudata*. If there is conflict between the last two characters used, follow the first character; the variation in *P. contracta* is allowed for, as it keys out twice.

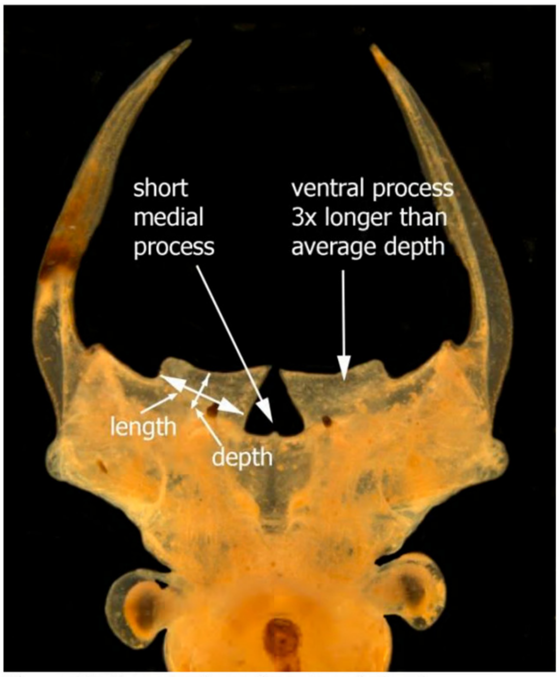


Figure 17. *Parartemia yarleensis* male head

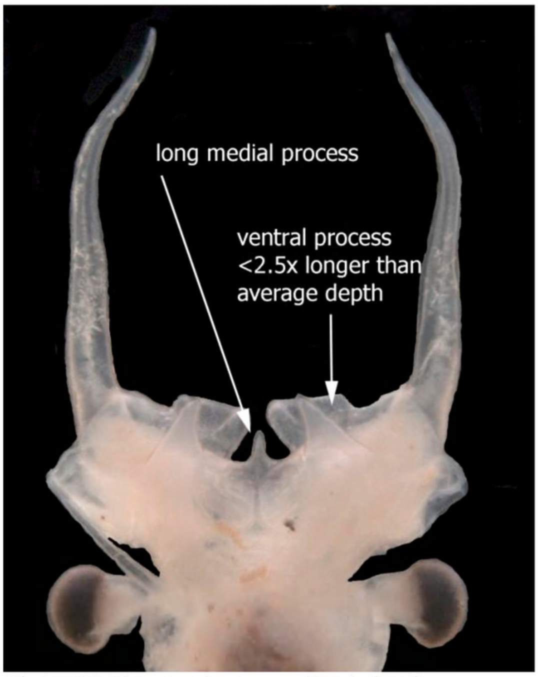


Figure 18. *Parartemia serventyi* male head

4(a) (3a). First abdominal segment narrower than previous segments; anterior processes present, digitiform and < depth of ventral process; first genital segment wider than second genital segment, but generally not wider than thoracic segments (Figure 19) 5

4(b) (3a). First abdominal segment wider than almost all others, except usually T11, G1 & G2; no anterior processes, instead a ridge at right angles to body axis; second genital segment maybe wider than first segment and wider than most thoracic segments (except T10 & T11) (Figure 20) ....*P. laticaudata* Timms

Note: In some populations of *P. laticaudata* there are small anterior processes, but the abdominal segments are always strikingly wide. In some specimens, T11&10, G1&2 are wider than A1, but the unusual width of A1 is inescapable. In *P. laticaudata* often the genital segments are wider than almost all the thoracic segments, except T11.

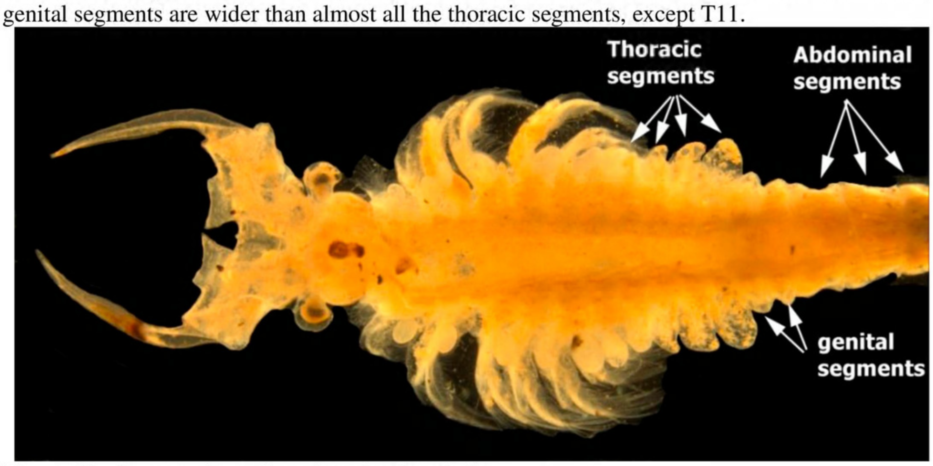


Figure 19. *Parartemia yarleensis* male, dorsal view

Figure 20. *Parartemia laticaudata* male, dorsal view

5(a) (4a). Thoracic segments, mainly their lobes, of increasing width sequentially 1 -11 and wider than genital segments; denticulate conical mound on ventral surface of basal antennomere near lateral edge of ventral process (Figs. 19, 21); occur in SA 6

5(b) (4a). Thoracic segments of fairly uniform width 1-11 and subequal in width to genital segments; no conical mound on ventral surface of basal antennomere; occurs in WA (Figure 22)... *P. contracta* Linder

Note: There may be minor sequential increase in thoracic width in *P. contracta*, but difference in width of the thoracic and genital segments is dramatic in couplet 5a and minor, if at all, in couplet 5b. Conical mounds are difficult to see, but the different distributions of species is absolute.

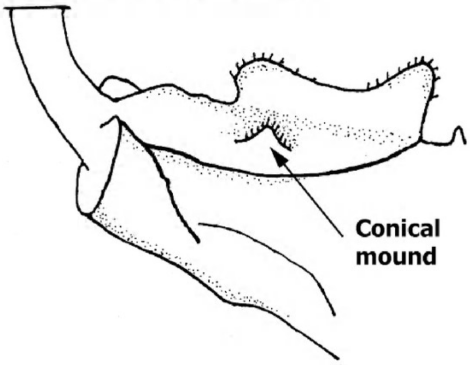


Figure 21. Ventral view of basal antennomere of *Parartemia yarleensis* male

Figure 22. *Parartemia contracta* male, dorsal view

6(a) (5a). Lateral corner of ventral process enlarged and rounded; 10th and 11th thoracic lobes similar (Figure 25); first antenna about 3/4 length of basal antennomere (Figure 23) ....*P. triquetra* Timms & Hudson

6(b) (5a). Lateral corner of ventral process not enlarged, squarish; 11th thoracic lobe much larger than 10th lobe (Figure 19); first antenna about half length, or less of basal antennomere, ie. shorter then eye plus peduncle (Figure 24) . *P. yarleensis* Timms & Hudson

Note: These two species are closely related, and the differences between their males are minor. Females are much easier to separate. A further difference in males can often be seen in the medial surface of the ventral processes – it is straight in *P. yarleensis* (Figure 24), but convex in *P. triquetra* (Figure 23).

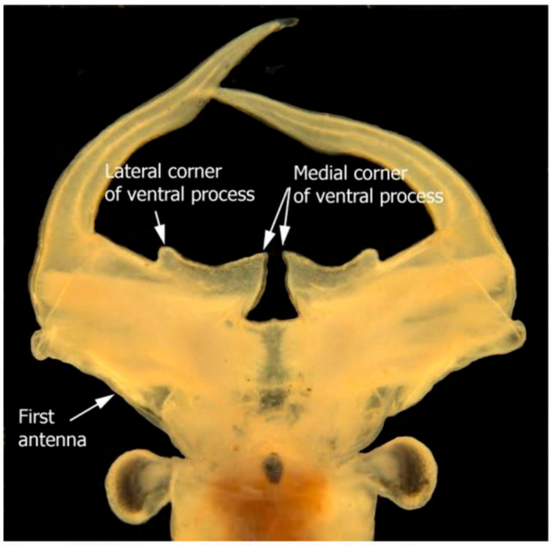


Figure 23. *Parartemia triquetra* male head

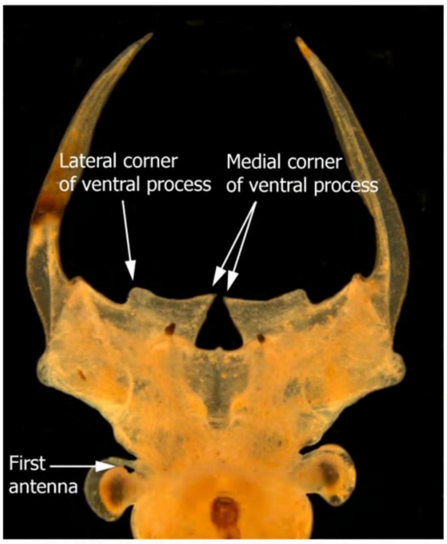


Figure 24. *Parartemia yarleensis* male head

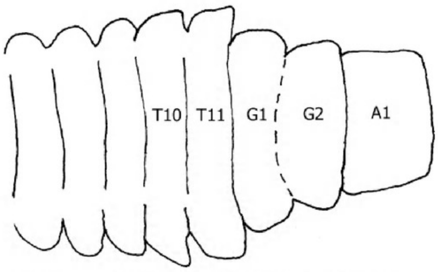


Figure 25. Thorax T7 to A1 of *Parartemia triquetra*

7(a) (3b) Medial edge of ventral process thickened; anterior process longer than or subequal to depth of ventral process; distal antennomere often unevenly curved and/or thickened mid length (Figure 26) 8

7(b) (3b) Medial edge of ventral process not thickened; anterior process shorter than depth of ventral process; distal antennomere usually evenly curved and tapering (Figure 27) 9

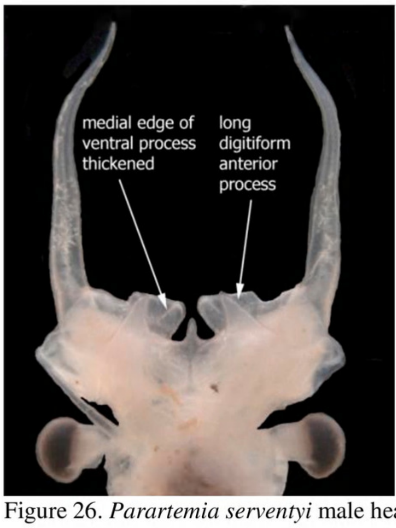


Figure 26. *Parartemia serventyi* male head

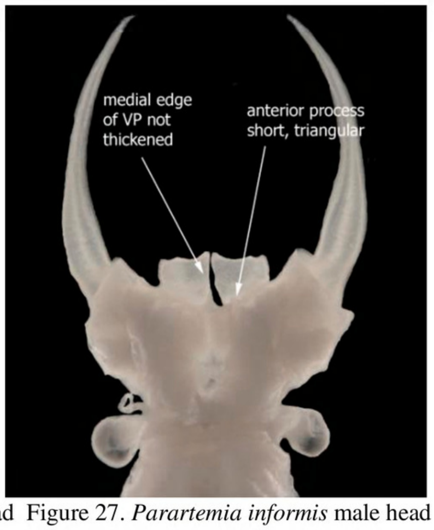


Figure 27. *Parartemia informis* male head

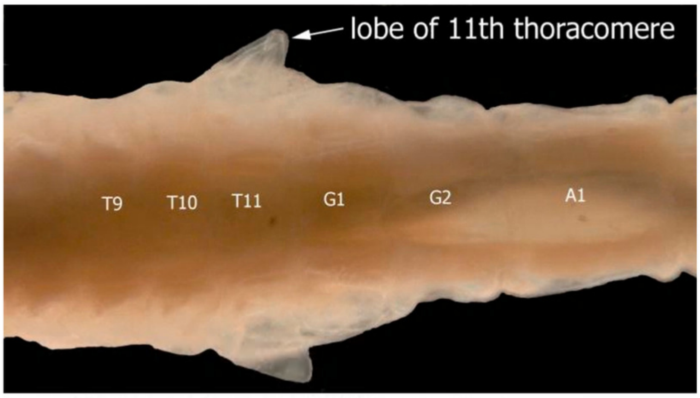


Figure 28. *Parartemia serventyi,* middle area of body

8(a) (7a) Anterior process digitiform, longer than depth of ventral process; 11th thoracomere with a prominent lateral lobe; ventral process length < 2x depth (Figure 26, 28)... *P. serventyi* Linder

8(b) (7a) Anterior process triangular, massively protruding when head prognathous; thoracomere with 11th lateral lobe not protruding and same as others; ventral process length *ca* 2.5x depth (Figures 29,30,31) .... *P. bicorna* Timms

Note: Not all *P. serventyi* have such an obvious lateral lobe of thoracomere 11. In *P. bicorna* the length of the ventral process sometimes is up to 3x the depth, which provides problems in couplet 3, but massive frontal processes are unique to this species. However these processes are not well developed in immature specimens.

Figure 29. *Parartemia bicorna* head dorsal view

Figure 30. *Parartemia bicorna* head lateral view

Figure 31. *Parartemia bicorna* male lateral view head to A3

9(a) (7b) Anterior process digitiform, length subequal to VP depth; medial edge of ventral processes distinctly undercut medially; ventral process length ca 2x mid depth (Figure 22, 32) .... *P. contracta* Linder

9(b) (7b) Anterior process small, triangular < half VP depth; medial edge of ventral process receding but not undercut; VP length = depth (Figure 33).. *P. informis* Linder

Note: The first character is only slightly variable and enough to secure a correct designation. The second and third characters are quite variable and sometimes can result in an incorrect determination. A further useful differentiating character is that the lateral and medial corners of ventral processes are usually obviously protruding in *P. contracta* while in *P. informis* the medial corner may protrude a little, but the lateral corner is almost squarish. Overall *P. contracta* is quite variable and in future may be split into two or more species.

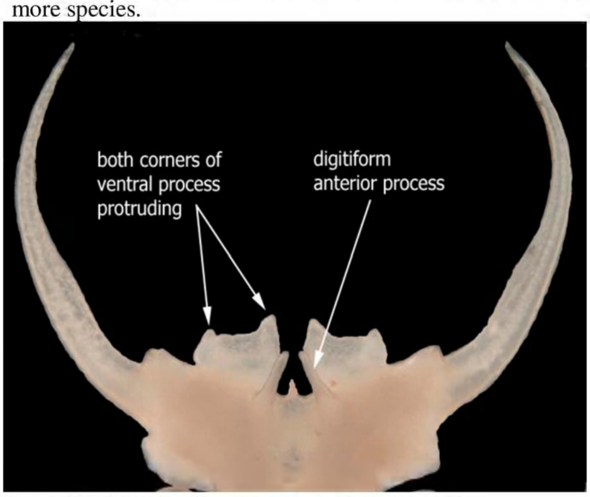


Figure 32. *Parartemia contracta* male antenna 2

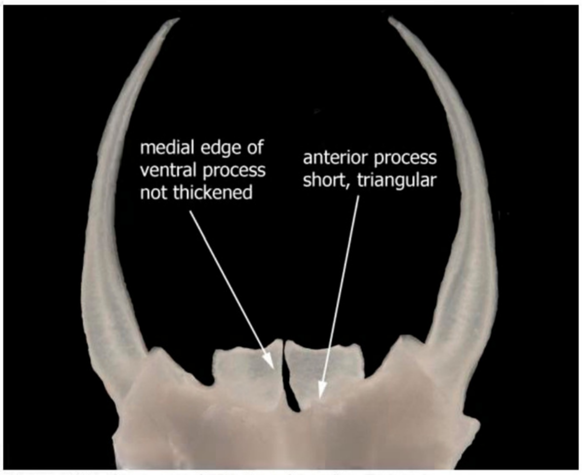


Figure 33. *Parartemia informis* male antenna

10 (a) (2b) Medial process triangular and apex bifid; ventral process 5-6 x longer than deep; distinct conical mound clothed in denticles under lateral edge of ventral process; (Figs. 16c,34,36) .... *P. acidiphila* Timms & Hudson

10 (b) (2b) No medial process; ventral process < 4x longer than deep; no conical mound with denticles under lateral edge of ventral process (Figs. 16d-g, 35) 11

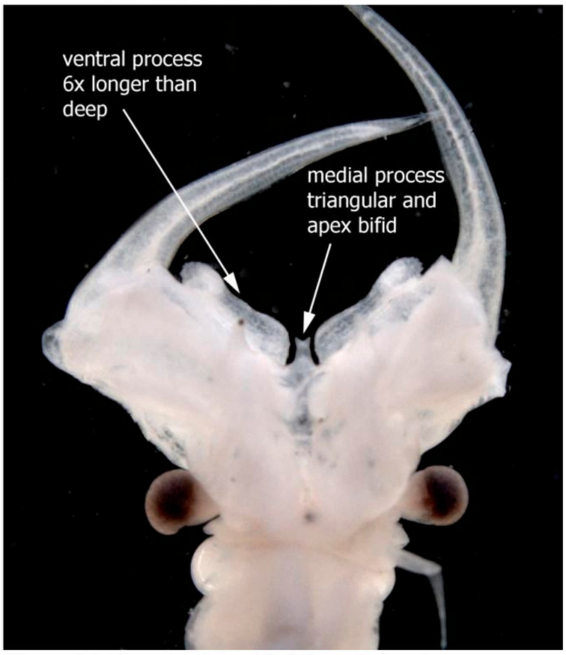


Figure 34. *Parartemia acidiphila* male head

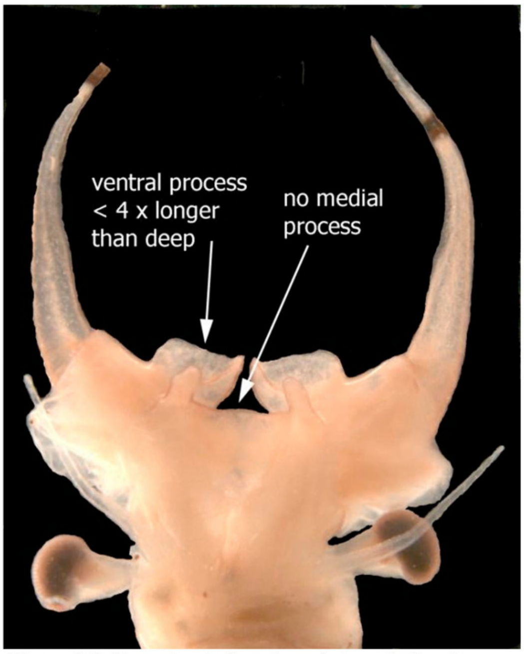


Figure 35. *Parartemia longicaudata* male head

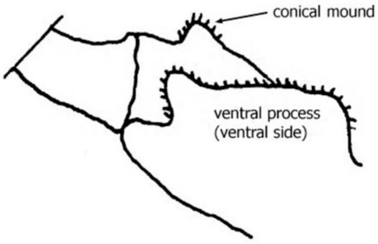


Figure 36. *Parartemia acidiphila* ventral view of right basal antennomere

11(a) (10b) Medial area between ventral processes narrow, < 1/10th width of ventral process; medial edges of ventral processes vertical or almost so, ie. parallel to body axis (Figure 37)... 12
11(b) (10b) Medial area between ventral processes wide, > 1/3rd width of ventral process; medial edges of ventral processes not vertical and usually bent (Figure 38)... 14

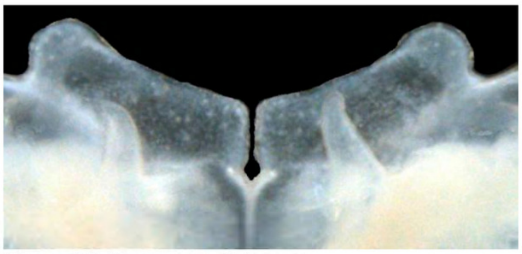


Figure 37. Narrow medial space

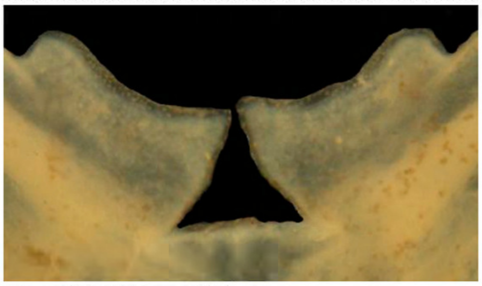


Figure 38. Wide medial space

12(a) (11a) Lateral lobe of thoracic segment l1 1arge and protruding posterodorsally to at least genital segment 1; bifid structure at base of medial space; both genital segments of similar diameter (Figure 39, 40)................................*P. cylindrifera* Linder
12(b) (11a) Lateral lobe of thoracic segment 11 small and extended horizontally and not overlapping genital segment; no bifid structure at base of medial space (Figure 37); first genital segment wider than second genital segment 13

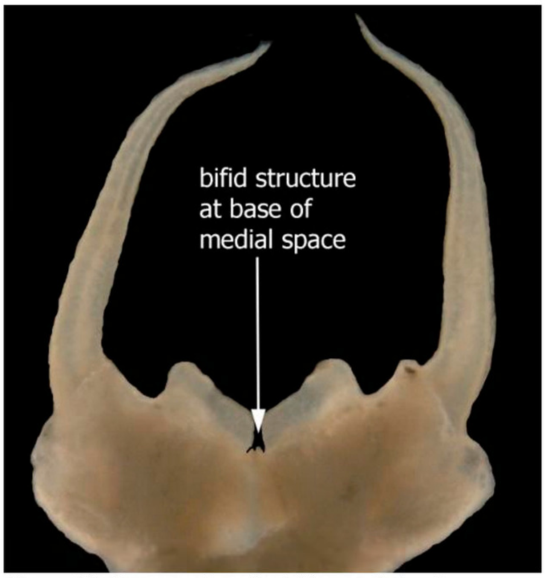


Figure 39. *Parartemia cylindrifera* male head

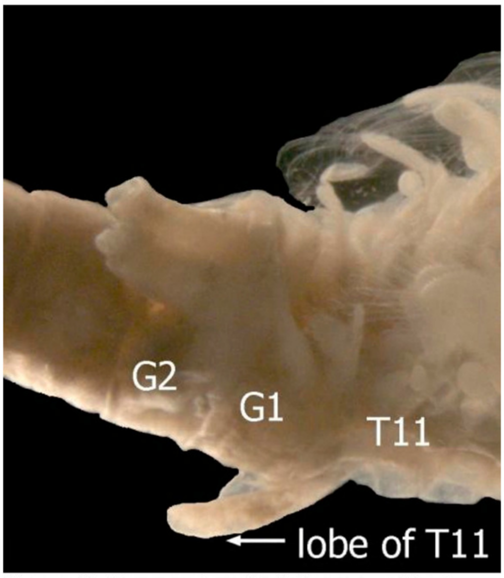


Figure 40. *Parartemia cylindrifera* part of body

13(a) 12(b) No medial space or space narrowing basially between ventral processes; anterior process short (<< depth of ventral process) and triangular; lateral corner of ventral process squarish and not protruding (Figure 41)........ *P. purpurea* Timms

13(b) (12b) Medial space between ventral processes narrow and opening to a diamond shaped space at base; anterior processes long (subequal to depth of ventral process) and digitiform; lateral corner of ventral process rounded and protruding (Figure 42) .... *P. zietziana* Sayce

Note: In both species there is some variability in all three characters, particularly the openness of the medial space, but *P. zietziana* always has a diamond shaped space at the base and *P. purpurea* does not. The ventral processes are different in the two species; besides the protruding lateral corner in *P. zietziana*, the process is longer in this species (l:d >3.5 in *P. zietziana* and l:d ca 2.5 in *P. purpurea*).

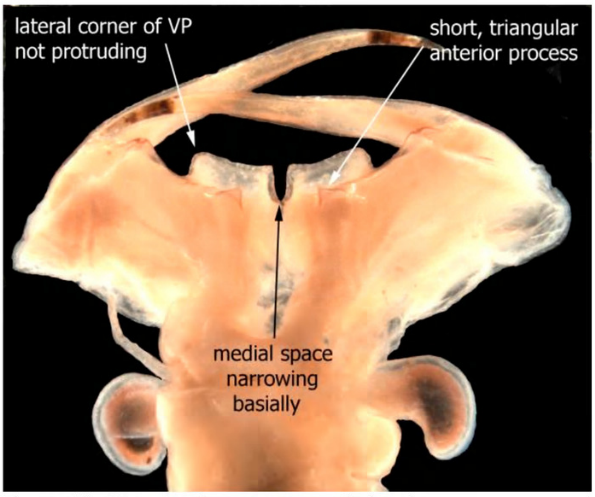


Figure 41. *Parartemia purpurea* male head

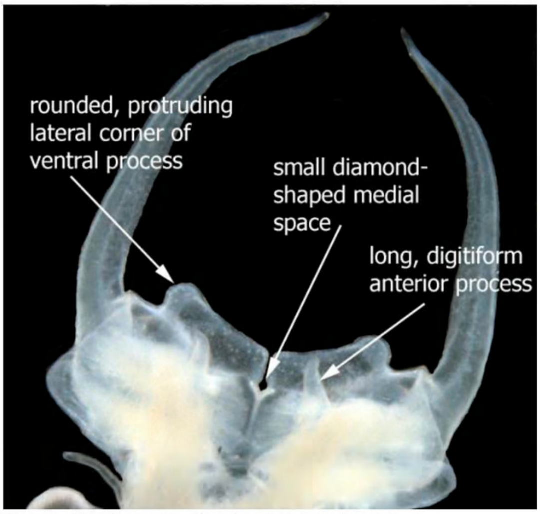


Figure 42. *Parartemia zietziana* male antenna

14(a) 12(b) Medial and lateral corners of ventral process subequal and not protruding; floor of medial space distinctly concave; ventral edge of ventral process straightish and not thickened medially (Figure 43) .... *P. extracta* Linder

14(b) (12b) Medial and lateral corners of ventral process unequal or at least one protruding or thickened; floor of medial space convex or straightish; ventral edge of ventral process concave, or if straight then medial edge thickened (Figs. 44,45)................. 15

Note: If you are still not sure you have *P. extracta* or not, then look at the first antenna— if it is about 3/4 the length of the basal antennomere then it is *P. extracta*; most other species on couplet 14b have their first antenna as long as the basal antennomere, but one has a very short antenna, ca length of eye plus its peduncle.

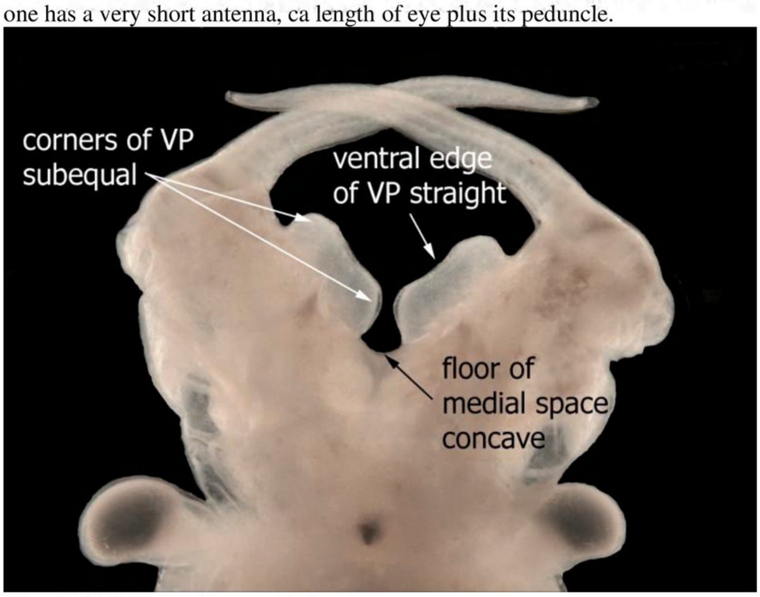


Figure 43. *Parartemia extracta* head

15(a) 14(b) Medial edge of ventral process thickened (Figure 44); basal spine of gonopod digitiform (Figure 46) 16
15(b) 14(b) Medial edge of ventral process not thickened (Figure 45); basal spine of gonopod triangular (Figure 47)...................... 17

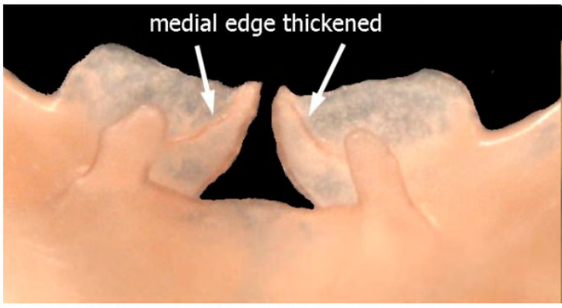


Figure 44. Ventral processes in *Parartemia longicaudata*

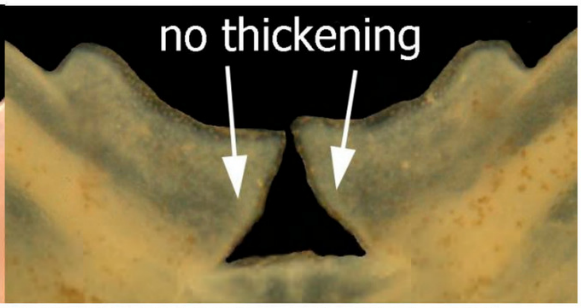


Figure 45. Ventral processes in *Parartemia auriciforma*

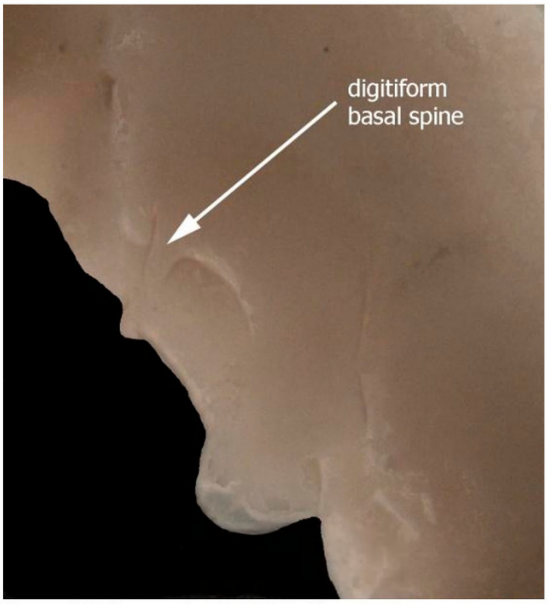


Figure 46. Gonopods: digitiform basal spine

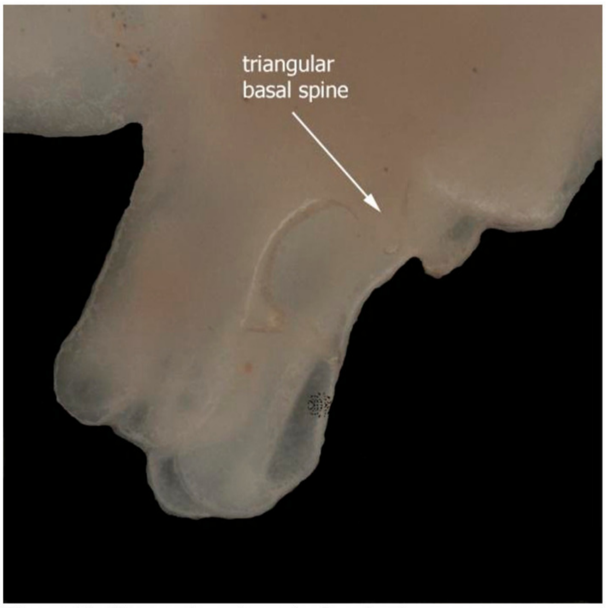


Figure 47. Gonopods: triangular basal spine

16(a) 15(a) Ratio 6th to 1st abdominal segment > 2; base of medial space usually convex; medial edge thickening of ventral process with a convex bend of < 25^{o} (Figure 48).. *P. longicaudata* Linder
16(b) 15(a) Ratio of 6th to 1st abdominal segment < 1.75; base of medial space usually concave; medial edge thickening of ventral process with a convex bend 30-45^{o} (Figure 49...*P. boomeranga* Timms

Note: These two species are very similar, and the differences between their males are minor. Remember the characters are arranged from most reliable to least. The medial edge of the ventral process is thicker in *P. boomeranga* than in *P. longicaudata*, and its apex rarely protrudes on the ventral (apparent anterior) edge of the VP. The ventral processes are about 1.75 – 2 x longer than deep in *P. longicaudata* and 2.25 – 2.5 x longer than deep in *P. boomeranga*. The anterior process is always distinctly digitiform in P. *longicaudata* but varies from triangular to almost digitiform in *P. boomeranga*. Females of the two species are more easily separated. Note that *P. longicaudata* is common and *P. boomeranga* rare, perhaps extinct.

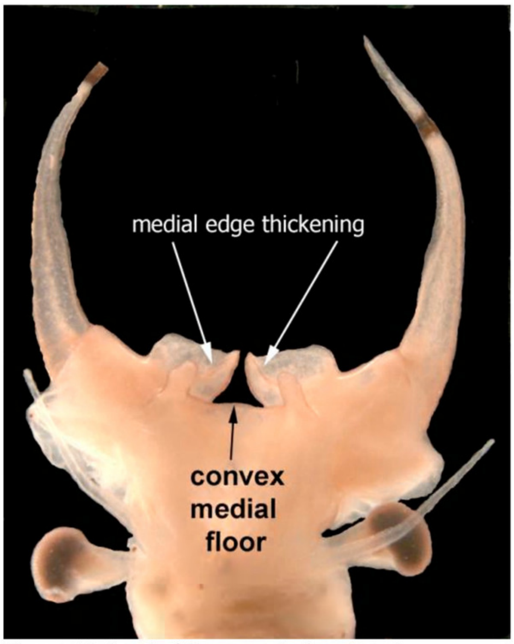


Figure 48. head of *Parartemia longicaudata*

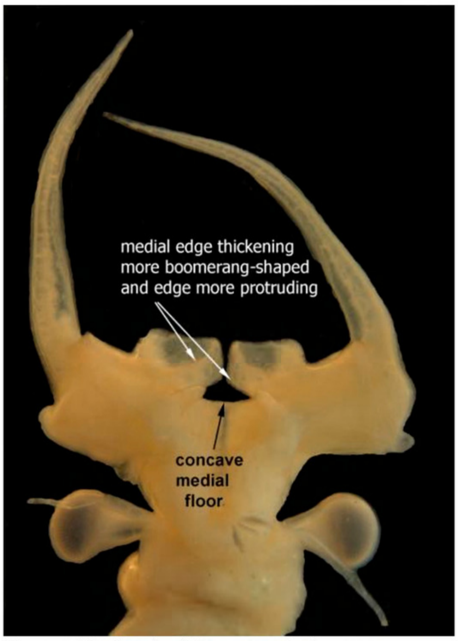


Figure 49. head of *Parartemia boomeranga*

17(a) 15(b) Floor of medial space convex and maybe enlarged to a broad-based triangular process (but apex not bifid); first antenna as long as basal segment of second antenna; both medial and lateral corners of ventral process protrude similarly; anterior process digitiform, length subequal to depth of ventral process (Figure 50).. *P.veronicae* Timms

17(b) 15(b) Floor of medial space between ventral processes concave or straightish; first antenna short, about length of eye plus peduncle; medial corner of ventral process much more protruding than lateral corner; anterior process triangular, shorter than depth of ventral process (Figure 51) ....*P. auriciforma* Timms & Hudson

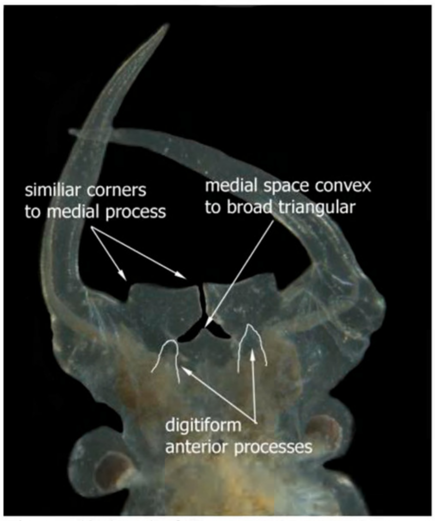


Figure 50. head of *Parartemia veronicae*

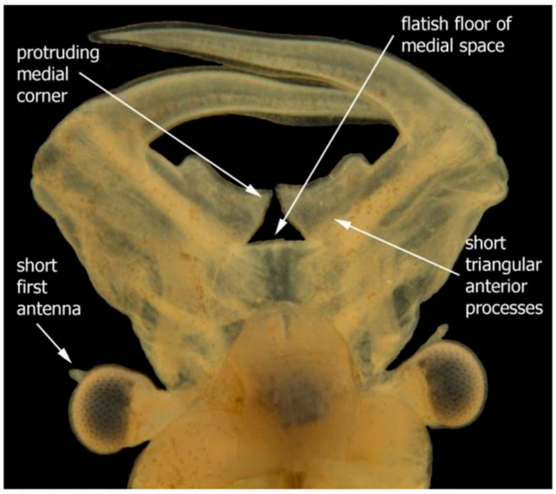


Figure 51. head of *Parartemia auriciforma*

18(a) 1(b) Medial area between ventral processes diamond-shaped if almost closed, but V-shaped if open; duplicate ventral process contained within limits of main ventral process on each side; first antenna as long as basal segment of second antenna; lives in eastern Australia .... *P. minuta* Geddes

18(b) 1(b) Medial area between ventral processes flat- floored but with a small V-shaped central notch; duplicate ventral process extending beyond medial edge of main ventral process on each side; first antenna short, usually only as long as eye plus peduncle, but sometimes longer; lives in Western Australia (Figure 53)... *P. mouritzi* Timms

Note: these two species are closely related morphologically, in fact they could be sibling species, one in the east and one in the west. The angle of fusion and the resulting medial space varies according with preservation (see first character in couplet), but the nature of the medial space remains distinctive. The most variable character in the key is the length of the first antenna, especially in *P. mouritzi.*

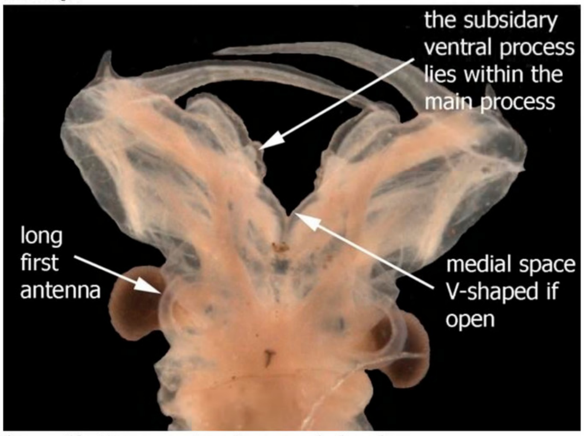


Figure 52. *Parartemia minuta* male head

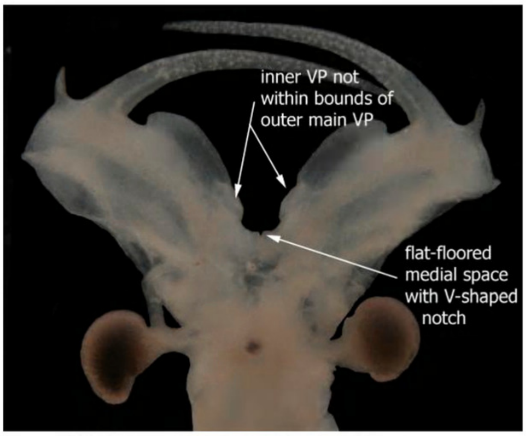


Figure 53. *Parartemia mouritzi* male head

Dichotomous key to mature *Parartemia* females

1(a) Brood chamber single, ventral; thorax maybe with a dorsal projection (not to be confused with a tumidity) on thoracomere 7 or 8 (Figure 54)... 2

1(b) Brood chamber bilobed with lobes lateral; no dorsal projection (but maybe a tumidity) on thoracomere 7 or 8 (Figure 55)......... 4

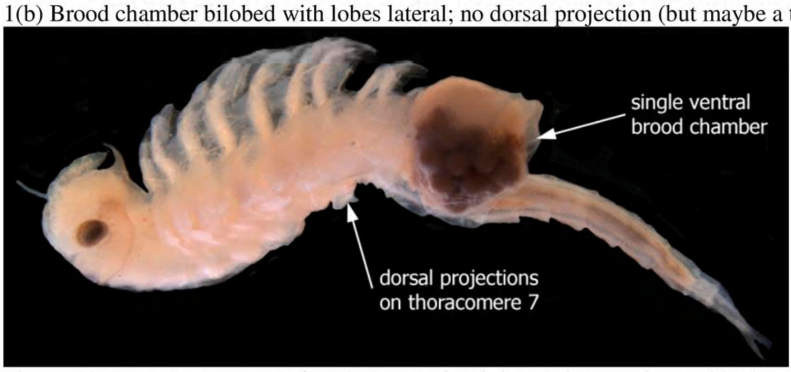


Figure 54. *Parartemia minuta* female (remember brine shrimps swim upside down!)

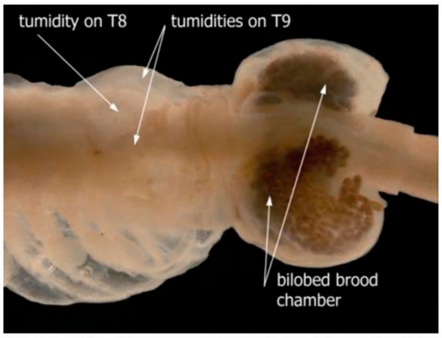


Figure 55. *Parartemia serventyi* female, T5 to A2

2(a) (1a). Integument of abdominal segments smooth, without denticles; middorsal tumidity on each of thoracic segments 5 and 6; thoracopod 10 vestigial, reduced to a stub with a few terminal setae and T11 vestigial as usual (Figure 56, 57) ....*P.cylindrifera* Linder

2(b) (1a). Integument of abdominal segments covered in denticles; middorsal projections on thoracic segment 7 or 8 (Figure 54); thoracopod 10 reduced as normal for the genus (i.e. about 2/3rds size of thoracopods 3-9 and with setae reduced) and T11 vestigial (Figure 58) 3

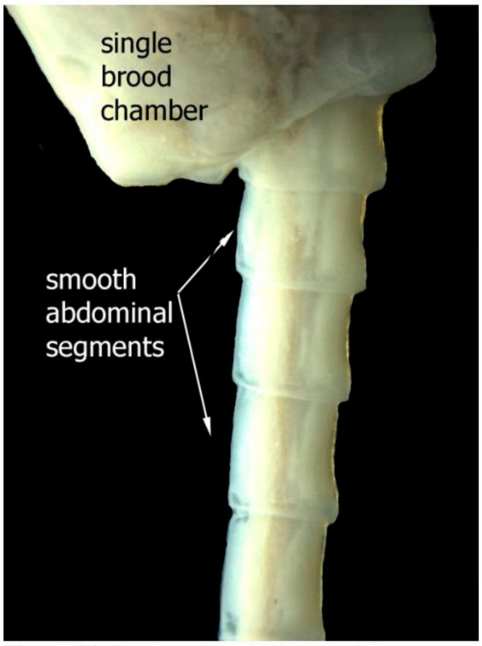


Figure 56. *Parartemia cylindrifera* abdomen

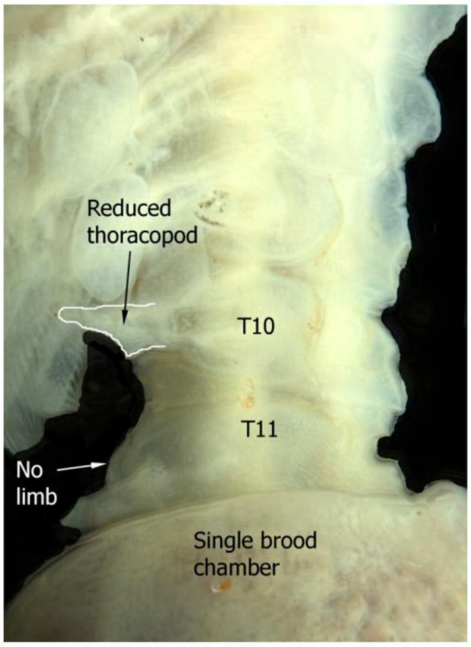


Figure 57. *Parartemia cylindrifera* T10 & T11

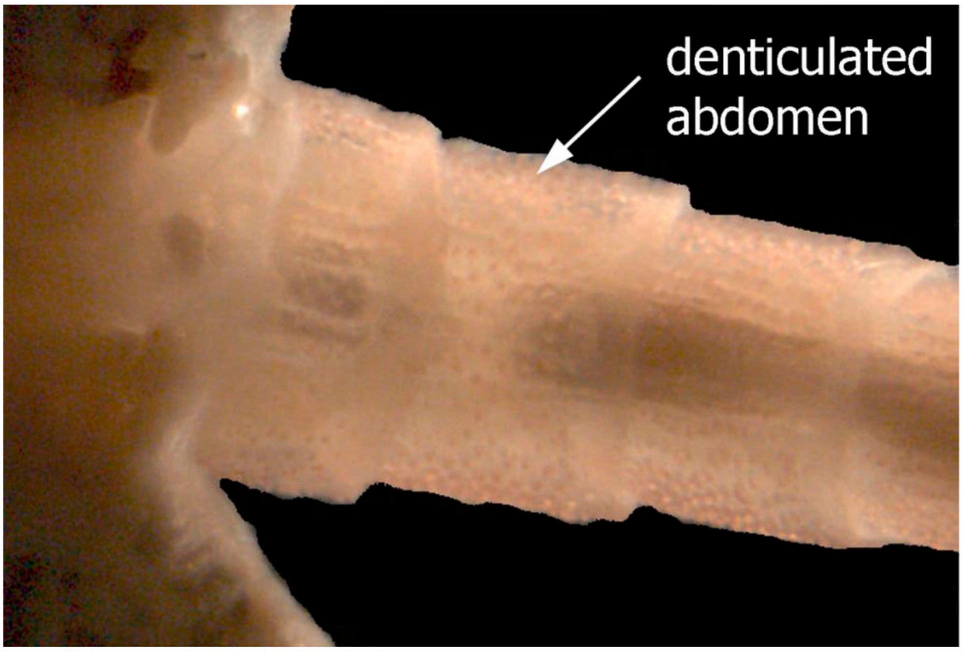


Figure 58. denticles on abdominal integument

3(a) (2b) Thoracomere 8-11 concertined and without lateral lobes; 3 middorsal projections on segment 7; no denticles on thoracic segments 9-11(Figures 54, 59, 60) ....*P. minuta* Geddes

3(b) (2b) Thoracomere 8-11 about same size as previous segments, and with distinct lateral lobes; 1 middorsal projection on segment 8; segments 9-11 with denticles laterally (Figures 61, 62) .... *P. mouritzi* Timms

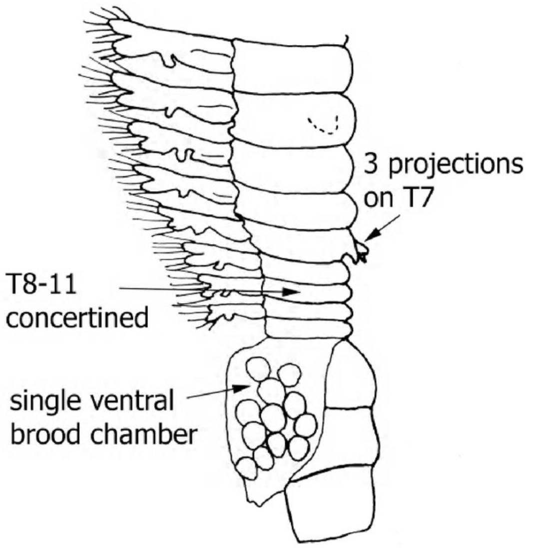


Figure 59. *Parartemia minuta* female T3 to A1

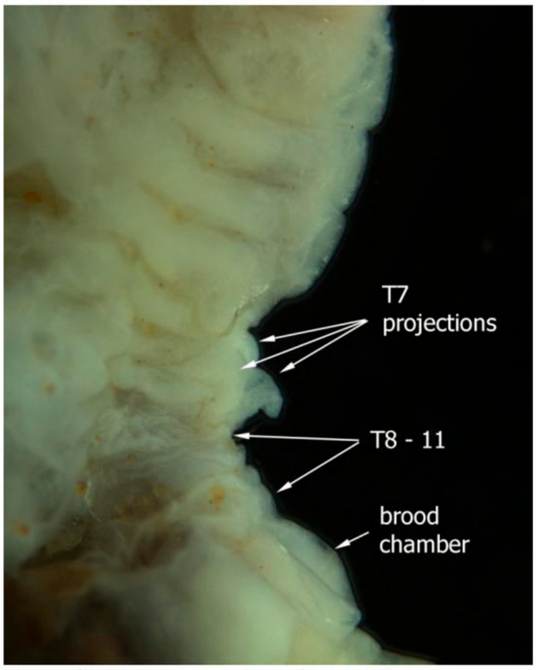


Figure 60. *Parartemia minuta* female T7-11

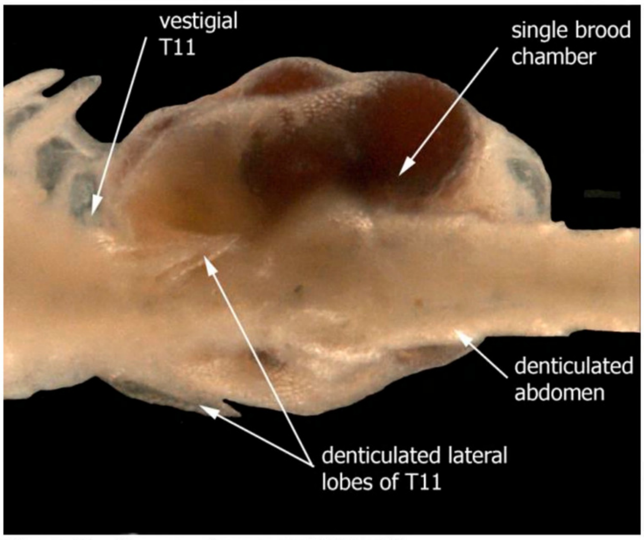


Figure 61. *Parartemia mouritzi* T9 to A3

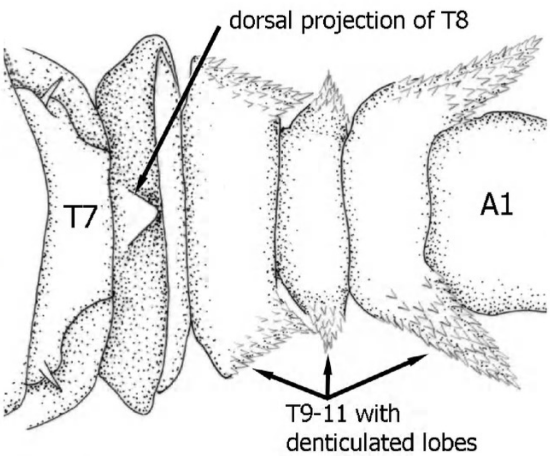


Figure 62. *Parartemia mouritzi* T7 to A1

4(a) (1b) Brood chamber bilobed, each lobe extending to at least the posterior boundary of abdominal segment 2 (Figure 63)............ 5

4(b) (1b) Brood chamber bilobed, each lobe not reaching posterior boundary of abdominal segment 1, or rarely reaching just beyond the 1st abdominal segment (Figure 64) 11

Figure 63. *Parartemia longicaudata* female BC

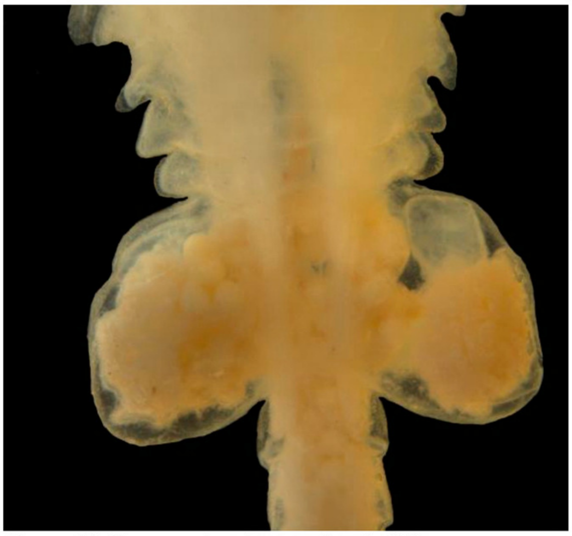


Figure 64. *Parartemia triquetra* female BC

5(a) (4a) Brood chambers asymmetrical and markedly protruding laterally at >45^{o} (sometimes to 90^{o}) with posterior edge straightish, all in the same plane as the body axis (Figure 63) ....*P. longicaudata* Linder

5(b) (4a) Brood chambers more or less symmetrical and roundish with posterior edge convex, but all in the same plane as the body axis (Figure 64), or extended and protruding posteriodorsally away from the body axis (Figure 5) 6

Note: In young ovigerous female *P. longicaudata*, the brood chambers may be symmetrical and may protrude at an angle of <45^{o}. Moreover the chambers may not reach the posterior margin of the second abdominal segment. A characteristic feature displayed in almost *P. longicaudata* is a large central tumidity (not 3 as in *P. laticaudata*) on the mid dorsal side of thoracomere 9 (not on T8 as in *P. serventyi*). This feature is shared only by *P. boomeranga*, but it is easily distinguished from this species by the latter's brood chamber being squarish and itsT11 being large with a triangular lateral lobe (T11 is reduced, lobeless and denticulate in *P. longicaudata*) . *P. boomeranga* should not be in the 4(a) half of the couplet so confusion should not arise with this species. But see couplet 16.

A further complication may arise in the shape of the brood chamber in *P. bicorna* and *P. contracta*. Their brood pouches are sometimes asymmetrical (see Figure 78), but the angle of protrusion is always <30^{o}, and the pouches fall far short of the posterior edge of A2 --- so they should not be in couplet 5(a).

6(a) (5b) Thoracomeres 10 and 11 sclerotized; brood chamber extended dorsolaterally to reach (when aligned) to at least the posterior boundary of abdominal segment 3; thoracomeres 9-11 without lateral lobes (Figure 65)... 7

6(b) (5b) Thoracomeres 10 and 11 not sclerotized; brood chamber extending posteriorly to reach only the posterior boundary of abdominal segment 2; thoracomere 9 with lateral lobes (though these are small in one species) and maybe 6-11 with lobes as well (Figure 66) 8

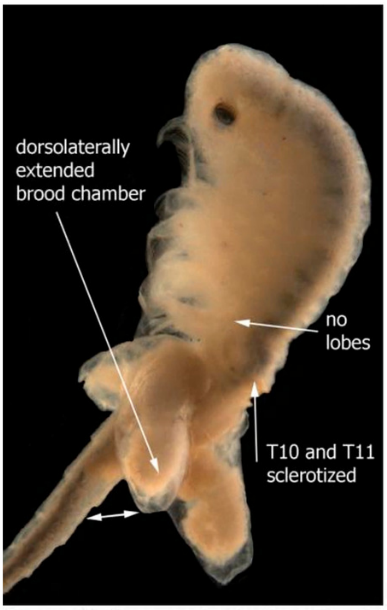


Figure 65. *Parartemia zietziana* female

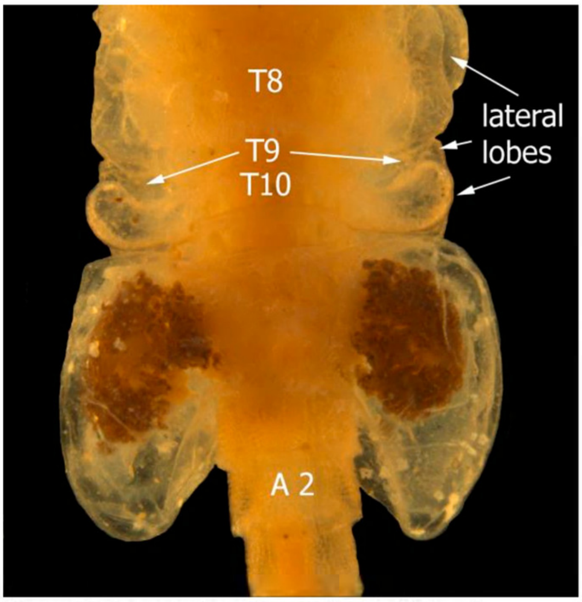


Figure 66. *Parartemia yarleensis* female T7 to A3

7(a) (6a) Thoracomeres 10 and 11 concertined, sclerotization of these thoracomeres banded at right angles to body axis; brood chamber lobe reaching to posterior end of about the 3rd abdominal segment (Figures 65, 67).................... *P. zietziana* Sayce

7(b) (6a) Thoracomeres 10 and 11 expanded compared to other thoracomeres; sclerotization of these thoracomeres largely lateral; brood chamber lobes reaching to about posterior end of 4th to 5th abdominal segment (Figure 8) .... *P. extracta* Linder

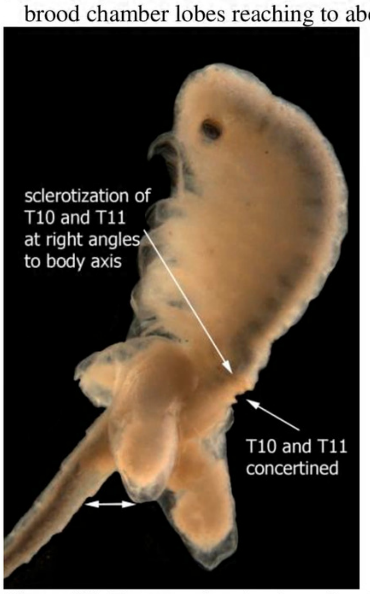


Figure 67. *Parartemia. zietziana* female

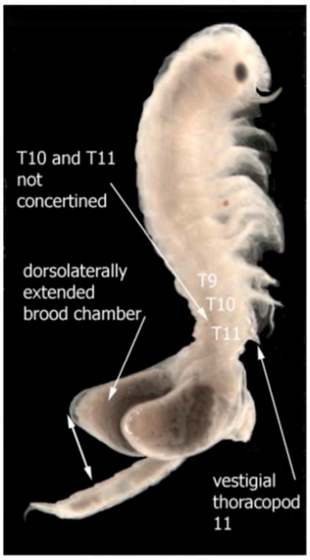


Figure 68. *Parartemia extracta* female

8(a) (6b) Thoracomere 9 larger than others and with a triangular posteriolateral projection; thoracomere 10 markedly reduced with two small tumidities (pimples) laterally; thoracomere 10 without a superior lateral lobe (Figure 69) 9

8(b) (6b) Thoracomere 9 about same size as others and with a rounded lateral lobe as in previous thoracomeres or sometimes enlarged; thoracomere 10 slightly reduced in size and perhaps with a single tumidity centrally; thoracomere 10 without a lobe of any kind or with a lateral lobe dorsal (i.e. superior) to other lobes (Figure 70)... 10

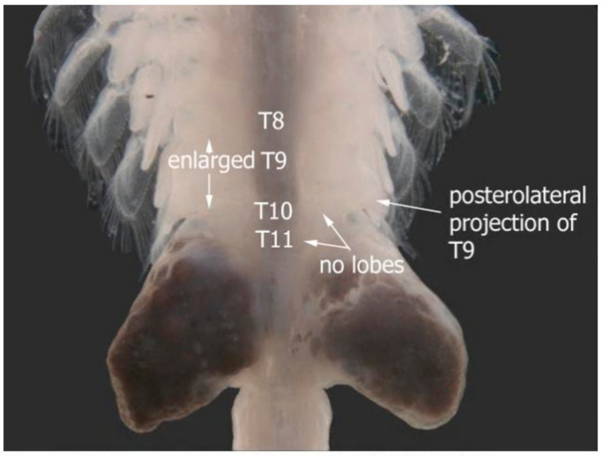


Figure 69. *Parartemia contracta* female T6 to A1

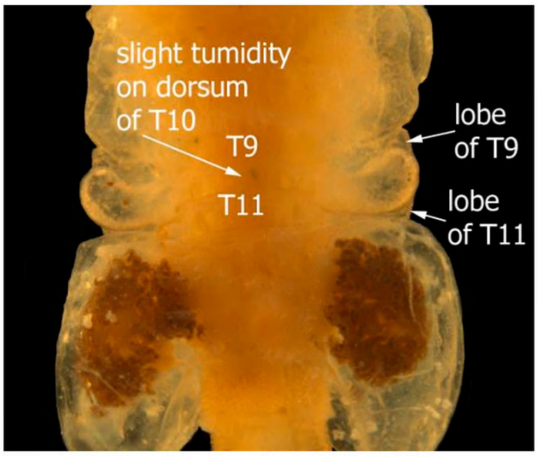


Figure 70. *Parartemia yarleensis* T7 to A2

9(a) (8a) Thoracomeres 7-9 with lateral lobes increasing in size posteriorly; thoracomere 9 usually with middorsal tumidity; 11th thoracopod completely lacking (Figs. 71, 72, 81e)... .*P. informis* Linder

9(b) (8a) Thoracomeres 7-9 without lateral lobes; thoracomere 9 never with a middorsal tumidity; 11th thoracopod present as a rounded stump (Figs. 69,73, 81d) .... *P. contracta* Linder

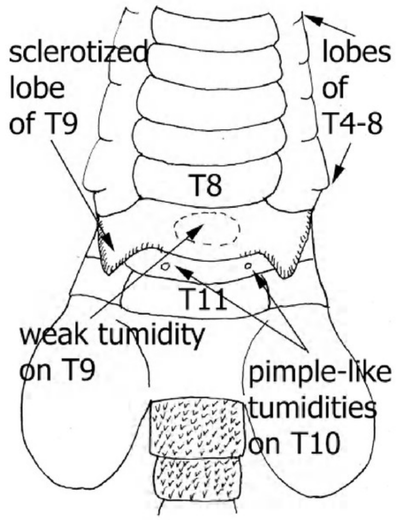


Figure 71. *Parartemia informis* T4 to A2

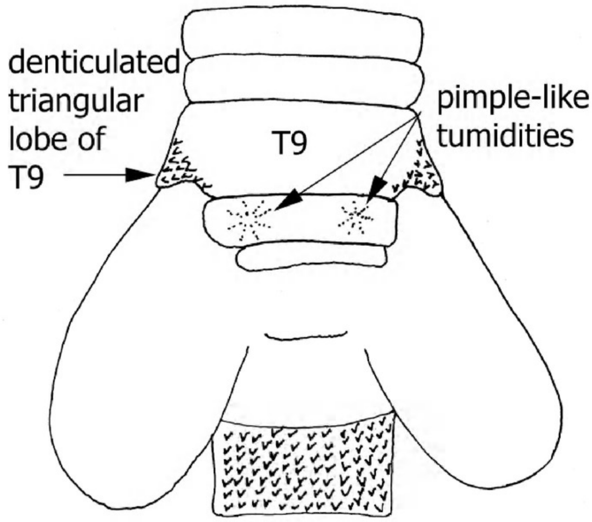


Figure 73. *Parartemia contracta* T7 to A2

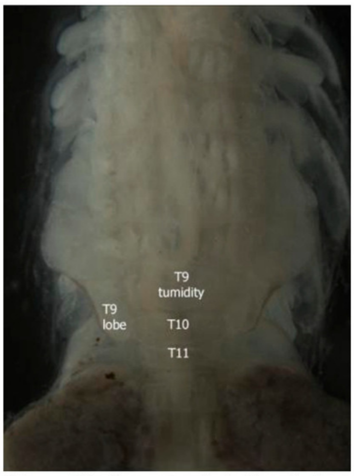


Figure 72. *Parartemia informis* female

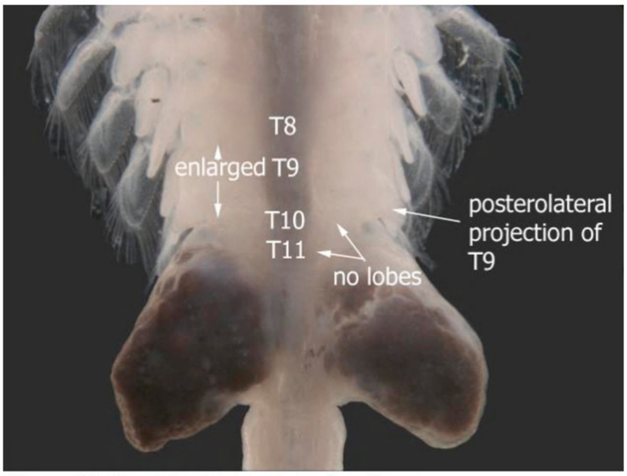


Figure 69. *Parartemia contracta* female

10(a) (8b) Thoracomere 10 reduced and without any lobes; thoracomere 9 with a rounded lobe extending posteriorly, unlike those of segments 7 & 8; occurs in WA (Figs. 74,77,78) .... *P. bicorna* Timms

10(b) (8b) Thoracomere 10 of average size compared with others and with lateral lobe dorsal (ie superior) to other lobes; thoracomere 9 with evenly rounded lobe similar to those of segments 8 and 11; occurs in SA (Figure 70) .... *P. yarleensis* Timms & Hudson

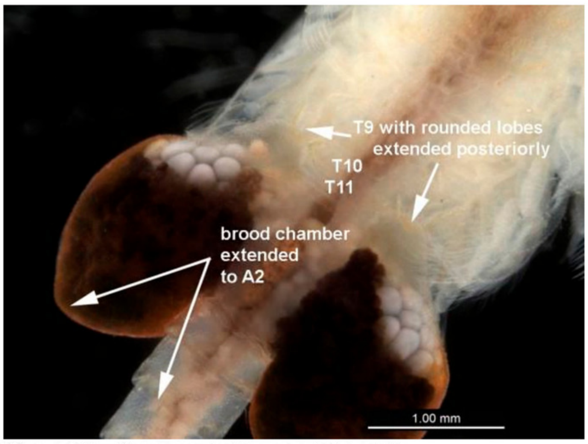


Figure 74. *Parartemia bicorna* T6 to A3
(photo: Erin Thomas)

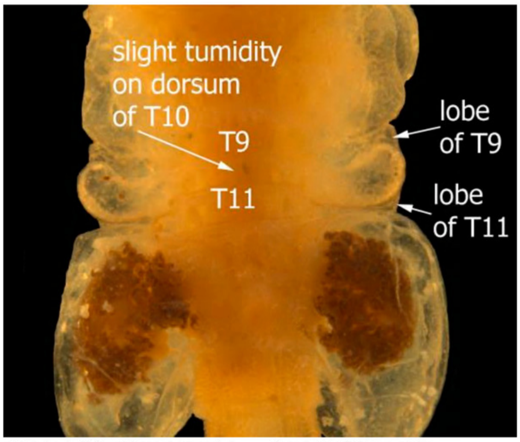


Figure 70. *Parartemia yarleensis* T7 to A2

Note: *P. bicorna* is brought out twice in the key because of variability in the size of its brood chamber, *i.e.* often it reaches the posterior edge of A2, but just as often it reaches a little beyond A1. So it will not matter if the 4a or 4b path is chosen.

11(a) (4b) No tumidities on any thoracomere (Figure 75) 12
11(b) (4b) At least one tumidity on a thoracomere (Figure 76).. 14

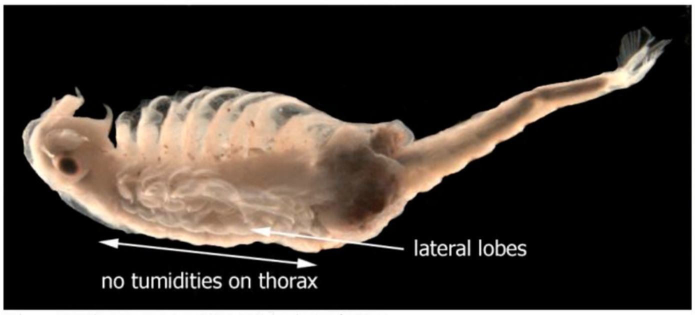


Figure 75. *Parartemia acidiphila* female

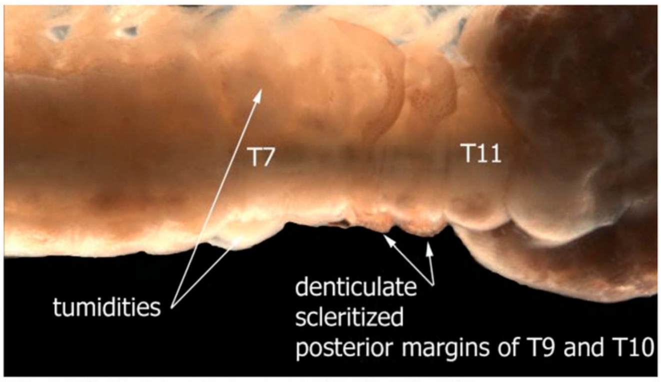


Figure 76. *Parartemia purpurea* female T4 to G1

12(a) (11a) Thoracomeres 7-9 with similar lateral lobes; thoracomeres 10 and 11 with denticles (Figure 76); thoracomere 11 with two small mounds or projections laterally; (Figs. 79, 80) 13
12(b) (11a) Thoracomere 9 with a lateral lobe posteriorly extended, unlike those on thoracomeres 7 and 8; thoracomeres 10 and 11 smooth surfaced; thoracomere 11 with a one very small projection laterally, usually hidden (Figs.74, 77, 78) .... *P. bicorna* Timms

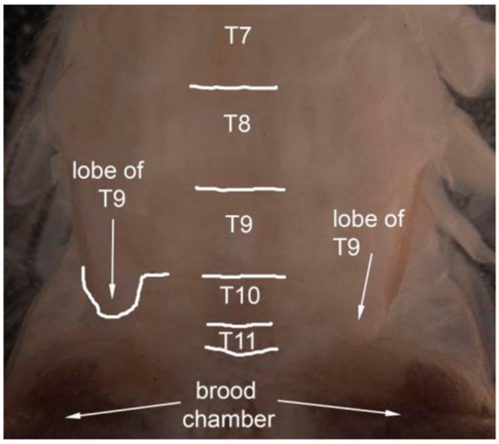


Figure 77. *Parartemia bicorna* female T7 to G1

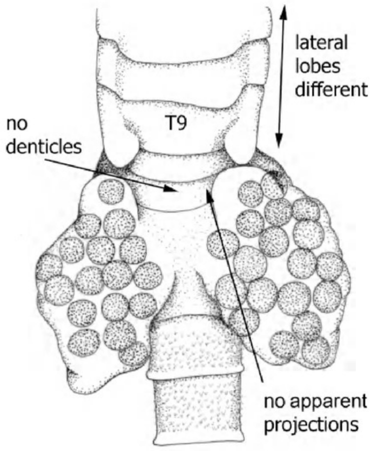
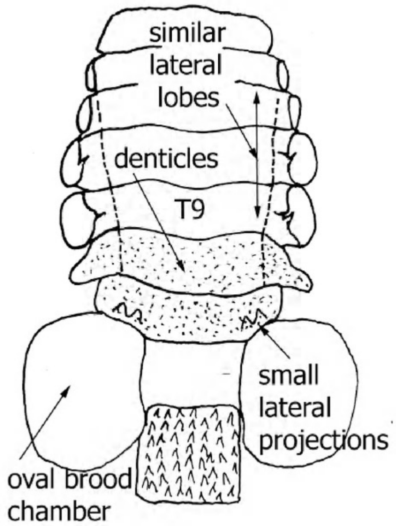


Figure 78. *Parartemia bicorna* female T7 to A2

13(a) (12a) Thoracomeres 6-9, particularly 8 and 9 with auriform lateral lobes; 11th thoracopod completely absent; each lobe of brood chamber distinctly oval (Figure 79) ....*P. auriciforma* Timms & Hudson

13(b) (12a) Thoracomeres 6-9 with normal squarish flat lateral lobes; 11th thoracopod reduced to a digitform stump bearing few setae apically; bilobed brood chamber rectangular in dorsal view (Figure 75, 80) .... *P. acidiphila* Timms & Hudson



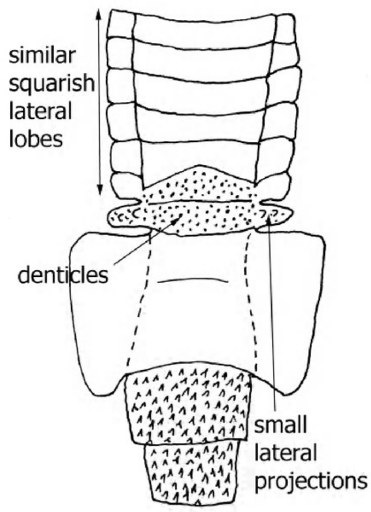


Figure 79. *Parartemia auriciforma* female T5 to A1 Figure 80. *Parartemia acidiphila* female T5 to A2

14(a) (10b) Lateral tumidity on thoracomere 7 (Figure 76); 11th thoracopods present as digitiform processes with lateral and 5 terminal setae (Figure 81a); purple in colour when alive and mature..*P. purpurea* Timms
14(b) (10b) No lateral tumidities on thoracomere 7, 11th thoracopods, if present as digitiform processes, lack lateral setae and with <4 terminal setae each (Figure 81b-e); colourless when alive................................... 15

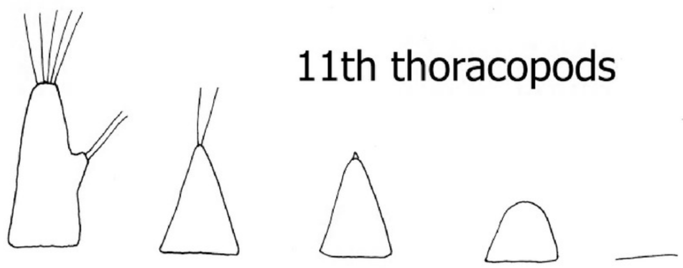


Figure 81. (a) (b) (c) (d) (e)

15(a) (14b) Single middorsal tumidity on thoracomere 9; lobes of brood chamber extended posteriolaterally; thorax widens markedly after thoracomere 8 to genital segments (Figure 82) 16
15(b) (14b) Thoracomere 9 lacks tumidities or has 3 of subequal size; lobes of brood chamber approximately oval in shape and if enlarged posteriorly then this is symmetrical; thorax does not widen markedly, and may narrow after thoracomere 8 (Figure 83) 17

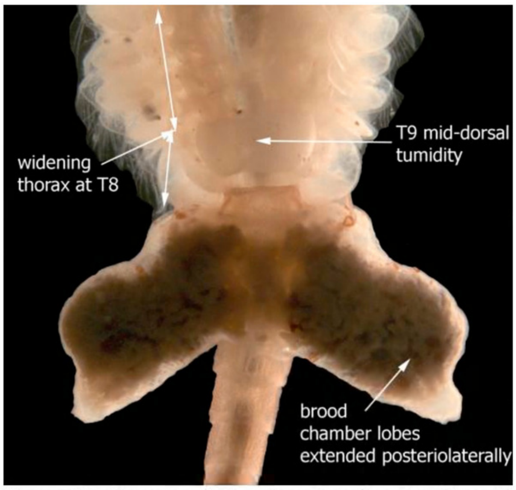


Figure 82. *Parartemia longicaudata* female T5 to A3

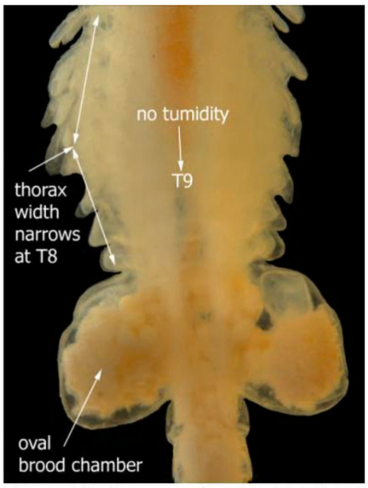


Figure 83. *Parartemia triquetra* female T4 to A2

Note: Couplet 15a allows for *P. longicaudata* to be keyed out in the next couplet 16a, just in case the brood chamber did not reach the posterior edge of A2, and hence it was not removed into couplet 4a then 5a.

16(a) (15a) Thoracomere 11 markedly reduced and almost enveloped by thoracomere 10; and without a lateral lobe; thoracomeres 10 and 11 denticulate (Figure 84); 11th thoracopods reduced to digitiform processes (Figure 82c).......... *P. longicaudata* Linder

16(b) (15a) Thoracomere 11 markedly expanded and with a lateral lobe with a triangular posteriolateral projection; thoracomeres 10 and 11 with a smooth surface (Figure 85); 11th thoracopods absent (Figure 82e)............................... *P. boomeranga* Timms

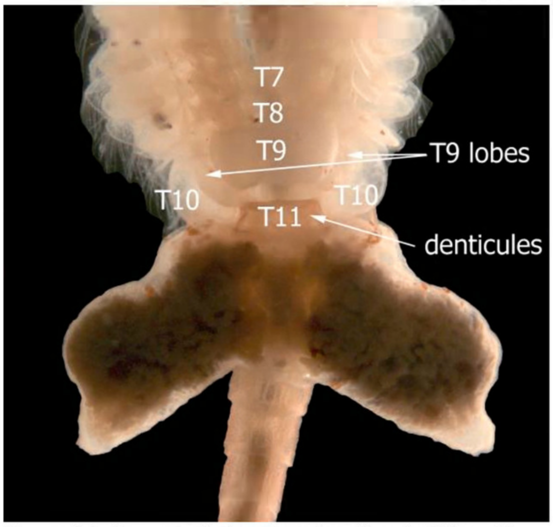


Figure 84. *Parartemia longicaudata* female T5 to A3

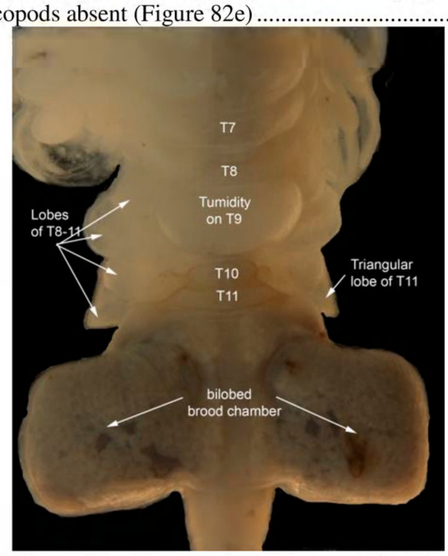


Figure 85. *Parartemia boomeranga* female T6 to A1

17(a) (15b) Up to 3 tumidities on thoracomeres 8 and 9; at least one tumidity medial; part of thoracomere 10 sclerotized (Figure 86) 16

17(b) (15b) Total of 4-6 tumidities, but on thoracomeres 10 and 11; all tumidities lateral; thoracomere 10 unsclerotized, but may be denticulate (Figure 87) 17

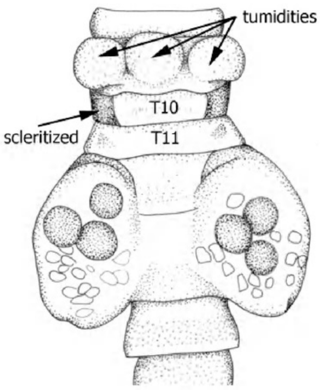


Figure 86. *Parartemia laticaudata* female T8 to A2

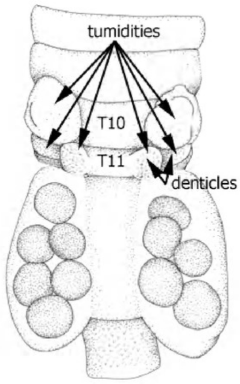
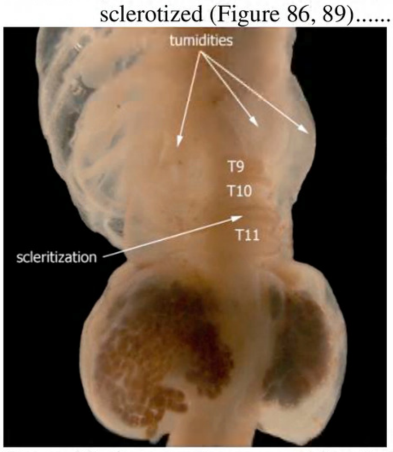


Figure 87. *Parartemia veronicae* female T8 to A1

18(a) (17a) Major tumidity middorsal on thoracomere 8 and two small lateral tumidities usually present on thoracomere 9; posterior margin of thoracomere 10 sclerotized (Figure 88).. *P. serventyi* Linder

18(b) (17a) Thoracomere 9 with three subequal tumidities, one middorsal and two lateral; lateral surfaces of thoracomere 10 sclerotized (Figure 86, 89).. *P. laticaudata* Timms



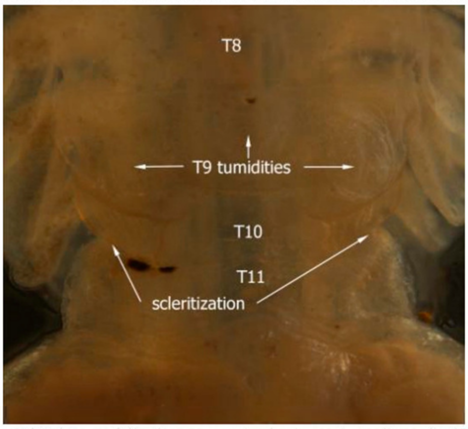
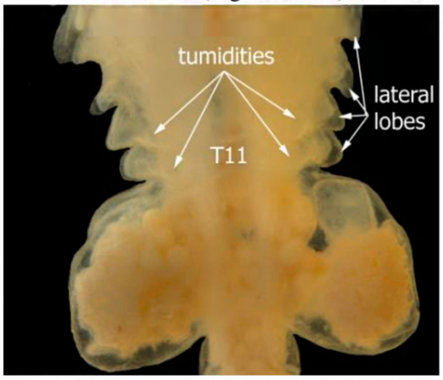


Figure 88. *Parartemia serventyi* female T5 to A1 Figure 89. *Parartemia laticaudata* female T8-G2

19(a) (17b) Thoracomeres 5-11 with lateral lobes; single small lateral tumidities on thoracomeres 10 and 11(Figures 83, 90); 11th thoracopods reduced to small triangular stumps (Figure 81c) .... *P. triquetra* Timms & Hudson

19(b) (17b) Thoracomere 5-11 without lateral lobes; thoracomere 10 with a lateral tumidity and thoracomere 11 with two lateral tumidities (Figure 87, 91); 11th thoracopods absent (Figure 81)...*P. veronicae* Timms



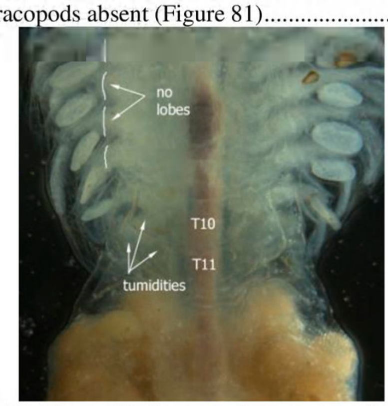


Figure 90. *Parartemia triquetra* female T8 to A1 Figure 91. *Parartemia veronicae* female

Easy Identifications?

Some species are distinctive because of obvious features. These are listed here, for quick approximate identification, but to be sure the key really needs be followed in detail.

Males
If the frontal processes are huge (triangular and protruding) then it could be *P. bicorna.*

If there is a large digitiform process on T11 then it could be *P. cylindrifera.*

If the abdomen is unusually wide, then it could be *P. laticaudata.*

If the abdomen is unusually long, it could be *P. longicaudata*

If the whole shrimp is adult and rather small (< 12 mm) it could be either *P. acidiphila, P. auriciforma, P. veronicae* or parthenogenetic *Artemia.* Note *P. minuta* is not the smallest *Parartemia*!

If the whole shrimp is comparative large (> 25 mm) if could be either *P. informis* or *P. longicaudata* or a extremely well fed/old individuals *of P. cylindrifera, P. serventyi, P. boomeranga* or *P. bicorna*.

Females
If the brood chamber is single it could be either *P. cylindrifera, P. minuta* or *P. mouritzi*

If the brood chamber is large and prominent (i.e. sausage-shaped on each side) it could be *P. zietziana* or *P. extracta.*

If the shrimp is a deep purple colour it could be *P. purpurea.*

If the shrimp is very small (<9 mm), it could be either *P. acidiphila, P. auriciforma, P. mouritzi* or *P. veronicae* or an immature of any of 18 species.

Glossary

A	Abbreviation for abdomen
abdomen	third division of the body, with 6 segments and a telson bearing two cercopods. Segments without appendages.
antenna	sensory appendages of head. First antenna (= antennule) small, thin and one segment. Second antenna (=antenna) larger, particularly in males, one or two segments, known as antennomeres Plural antennae.
antennule	first antenna
antennal process	a comparatively large outgrowth from apex of basal segment of antenna; most obvious in male *Streptocephalus*. Also in many *Branchinella,* but not in brine shrimps.
anterior process	protuberance on the upper surface of the fused basal antennomeres (usually referring to male *Parartemia*). It used to be termed the frontal process
apex	tip
apical	refers to the tip
apophyses	a bulbous swelling or protruding process, usually from the basal segment of the antenna. Present in *Artemia franciscana*.
appendage	in crustaceans, any of the paired, articulated structures attached to each segment, e.g. antennae, thoracopods.
basal segment	proximal part of antenna that is attached to the head.
bifurcated	divided into two
bilobed	with two lobes
biramous	having two branches
brood chamber	external pouch carried on the lower and perhaps lateral surfaces of the genital segments of females to store fertilized eggs until deposition or death. The term 'ovisac' should not be used as the eggs are fertilized. Brood pouch is an alternative word.
bulbous	swollen or bulb-like
carapace	hard cuticular covering of the segments. Some *Parartemia* females have parts of the carapace very thick and particularly hard (=scleritized).
cercopods	a pair of terminal appendages that articulate with the telson.
clypeus	anterior head plate formed by the fusion of the basal segments of the second antenna. Not used now as it is not homologous with the clypeus of insects.
conical mound	A more or less symmetrical mound, usually clothed with denticles, on the ventral posterior surface of the basal antennomere near base of the lateral edge of the ventral process.
cyst	shell-covered dormant embryo. The wall is often thick and perhaps patterned. Better termed the 'resting egg'
denticulate	bearing small teeth-like structures
dichotomous	division in two more or less equal parts
digitiform	shaped like a finger, i.e. elongated, tubular.
distal	the part of the structure furthest from the point of attachment (opposite = proximal or basal)

endites — Medially directed expansion of the basal part of the thoracopod (= phyllopodous limb). Usually 6 in number with the distal one the endopod.
endopod — distal medially directed expansion of thoracopod.
epipodite — a laterally directed expansion of the thoracopod between the preepipodite and exopodite. Normally sausage-shaped.
exopodite — flattened laterally directed most distal expansion of the thoracopod. Also called an exopod.
fecundity — fertility, usually expressed as numbers of eggs produced during the life of a female.
filamentous — thread-like
foliaceous — leaf-like
frontal appendage — Median outgrowth from the front of the head in some male anostracans (mainly in *Branchinella*). Rarely called a frontal process and should not be termed a frontal organ.
frontal process — This is the old name for the anterior process of *Parartemia* males.
genital segments — The two fused segments between the thoracopod-bearing segments of the thorax and the abdomen. They are part of the thorax, not the abdomen. In males these segments bear the penes and in females the brood chamber.
G — Abbreviation for genital segments
genitalia — external structures involved in reproduction.
gonopore — hole at the distal end of the brood pouch for insertion of the penis and for expulsion of eggs.
hand — this refers to the hand-like structure of the second antenna of male *Streptocephalus*.
head — anterior most region of the body. It is formed by the coalescence of 5 segments and bears the stalked compound eyes and 5 pairs of appendages ☐ antennules, antennae, mandibles, maxillules and maxillae
integument — outer layer of body (=carapace)
lamellar — flat and thin; sheet-like
lanceolate — shaped like a spear head, tapering at each end.
lateral — outer edge
limb (leg) — an appendage, usually one used in locomotion. Better termed thoracopod.
mandible — first pair of mouthparts; hardened jaws used for crushing or biting food.
maxilla — third pair of mouthparts. Plural maxillae
maxillule — second pair of mouthparts. Plural maxillules
medial process — refers to the protuberance (usually finger-like) in the middle of the anterior surface of the clypeus.
medial space — this is the area between the two ventral processes in the anterior middle of the fised basal antennomere. In some species it is occupied by the medial process.
mesial/medial — towards the mid-line.
ovisac — incorrect term for the brood pouch. See brood pouch for explanation.
outgrowth — a small definitive protrusion
papillae — a small single lobe or nipple
parthenogenesis — asexual reproduction in which the egg develops without fertilization
penes — plural of penis
penis — male copulatory organ
phyllopod — one of a pair of flattened or leaf-like swimming appendages on the ventral surface of the thoracic segments. Synonym thoracopod.
preepipodite — basal lateral lobe of the thoracopod (or phyllopod)
prognathous — head and mouthparts pointing downwards
projections — in *Parartemia*, these refer to small uneven protuberances from the dorsal surface of thoracic segments, sort of like a large denticle (see also 'tumidity' below).
proximal — towards the point of attachment (opposite of distal)
sclerotized — chitinous integument hardened by the deposition of proteins
seta — a chitinous hair or bristle. Plural setae
setose — bearing many setae
segment — a single element or article in a jointed appendage, or one of the units making up the body
somite — the more correct term for a body segment
sympatric — occurring toegether
subequal — The two parts are almost equal
T — Abbreviation for thorax
telson — the terminal part of the body behind the last abdominal segment
thorax — the middle grouping of segments of an anostracan body. Typically consists of 11 segments bearing thoracopods followed by two fused genital segments
thoracopod — any of the paired appendages of the thorax. Syn: thoracic leg, phyllopod.
truncate — top cut off any object
tumidity — a more or less even swelling, like a blister
vestigal — much reduced
VP — abbreviation for ventral process

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