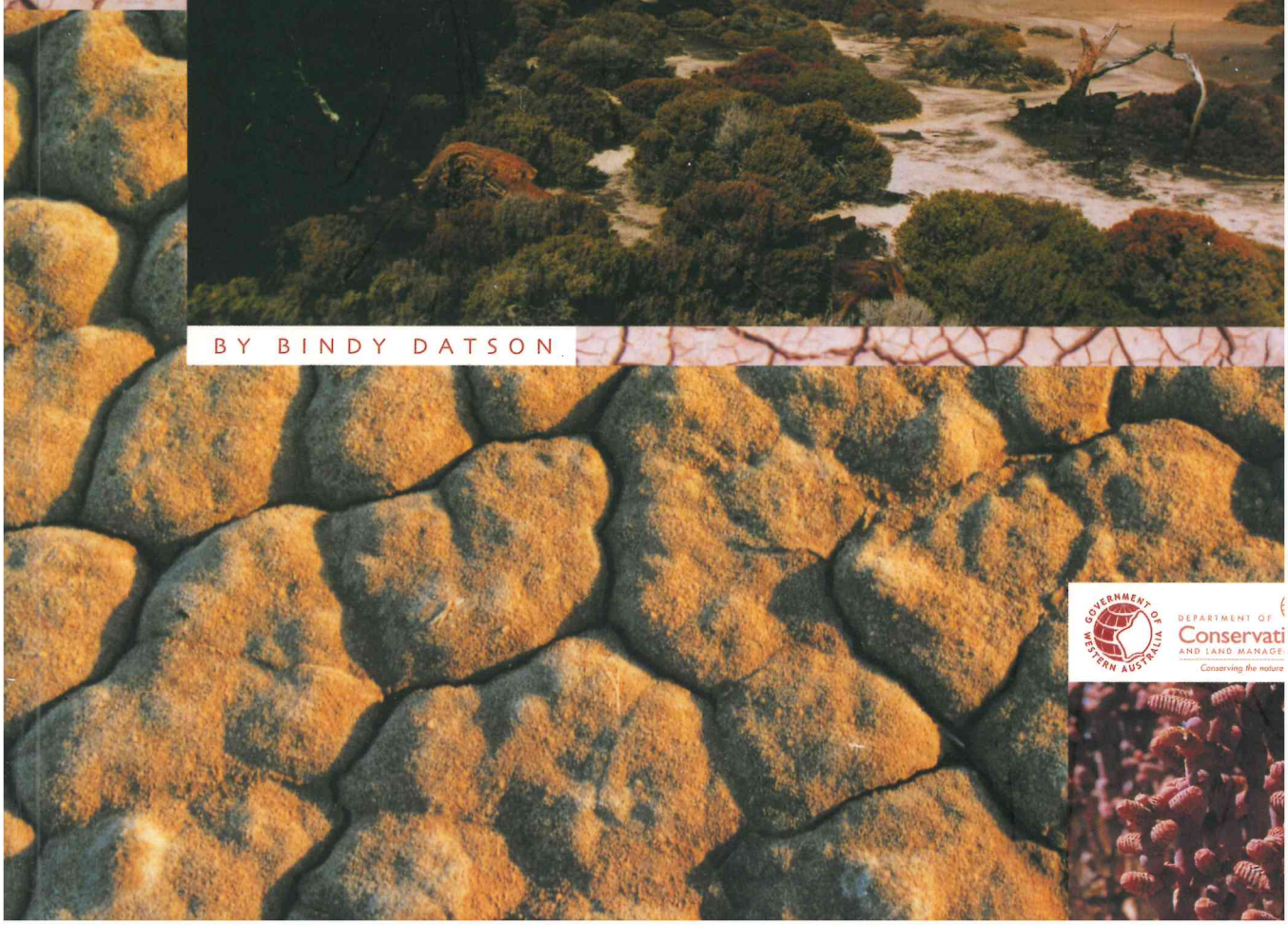
SAMPHIRES

in Western Australia

A FIELD GUIDE TO CHENOPODIACEAE TRIBE SALICORNIEAE

BY BINDY DATSON



GOVERNMENT OF WESTERN AUSTRALIA
DEPARTMENT OF Conservati AND LAND MANAGE
Conserving the nature

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Executive Editor: Ron Kawalilak
Editor: Ray Bailey
Design and Production: Sue Marais/Get Graphic
Photography: Bindy Datson
Printed in Western Australia by: Lamb Print

ISBN 0 7307 5526 6

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Acknowledgements

I would like to thank Paul Wilson for his encouragement and patience while I learned to identify the different species, Mike Lyons for his editing skills, and mining companies in the Goldfields without whom it would not have been possible to finance the studies necessary to complete this book. In particular these are Placer (Granny Smith) Pty Ltd, Sons of Gwalia Ltd, AngloGold Australasia (Sunrise Dam), Homestake Gold of Australia Ltd, Anaconda Nickel, and Aurora Gold (WA) Pty Ltd.

I would also like to thank my husband, Mark Coleman, for his support and patience while I was photographing and collecting specimens.

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Introduction

1

This book has been written to help people with a limited knowledge of botany to identify at least the more common samphire species. When the author became interested in samphire, the only book available to identify them with was Paul Wilson's taxonomic treatment (Wilson, 1980). Not being a botanist, the author found it difficult to understand the terminology well enough to key the species out. The easiest way for her to remember and be able to identify the samphires was to draw each species and keep notes on habitat, colour and obvious distinguishing features. She now uses the notes and drawings successfully to identify samphires in the field. This book is a natural progression from those notes and drawings.

Samphire is the common name for a group of succulent sub-shrubs and shrubs including *Tecticornia*, *Halosarcia*, *Sarcocornia*, *Sclerostegia*, *Tegicornia* and *Pachycornia* (the genera described in this book), belonging to the tribe Salicornieae of the family Chenopodiaceae. As well as the Salicornieae, the Chenopodiaceae family also includes five other tribes. One of these, the Chenopodieae, contains the well-known genera of *Maireana*, *Atriplex* and *Rhagodia*, to name only a few.

The environments in which these remarkable plants live must be among the most hostile to be found on earth; not only can samphires withstand searing heat of over 45 degrees Celsius, but often they are standing in hypersaline wet clays, to boot. Their growing conditions can vary from extreme heat and salinity to frost, waterlogged soils, hard-baked clays, or flash floods. Samphires are most commonly associated with saline environments of some kind.

Halosarcia and samphires in general are a little-studied group of plants. Paul Wilson of the Western Australian Herbarium undertook a revision of the Australian Chenopodiaceae, which he completed in 1980 (P. Wilson, and later 1984). There has not been any major work in Australia on this family since then.

Most of the Australian species of samphire are unique to Australia (endemic), not occurring anywhere else in the world. Exceptions to this are *Halosarcia indica*, which is found in Malaysia and in countries around the Indian Ocean, and *Sarcocornia quinqueflora*, also found in coastal New Zealand and New Caledonia. Unlike samphire species in other countries of the world, Australian samphires are nearly all perennial; only members of the genus *Tecticornia* are annual or short-lived perennial plants.

Samphires are common worldwide, and in some countries have traditionally been eaten either pickled or boiled. They have also been burned and used in the manufacture of glass (glasswort).

Because samphires are able to live in such harsh environments, it may be feasible in the future to use some of their genetic material to enable food crop plants to be bred for growing in marginal areas.

Samphire Habitats

2

Until relatively recently, salt lakes and pans, salt marshes and coastal samphire flats have been perceived as undesirable places, full of mosquitoes, unsuitable for farming and only useful as farmers' rubbish tips, or for filling in for housing sub-divisions. The relatively recent encroaching salinisation of once arable farmland has not helped to improve this negative image of salt pans and lakes.

In a shrinking world, however, with different values and perceptions, and with better understanding of natural processes, these 'salty wastes' have been renamed 'saline wetlands' and are now beginning to be seen as natural systems in their own right, to be protected and preserved.

While not as diverse in aquatic flora and fauna as freshwater wetlands, saline wetlands are nevertheless thriving ecosystems, with life cycling according to the availability of water (for instance, Lake Minigwal's crustal 'blisters' provide shelter for millions of lake spiders, which in turn are prey for fat-tailed dunnarts). Most of the macro and micro flora and fauna living in and around saline wetlands will only reproduce when the wetland water or surrounding soils reach the combination of salinity and temperature that trigger reproduction. In many species (of both flora and fauna) there is only a narrow 'window' when all factors are suitable. Samphire seeds will germinate freely when the soil is wet with relatively fresh water, in other words, after heavy rain. Samphires in general produce large amounts of seeds that are often held in spongy or woody parts of the plant, to be released when the conditions for germination are suitable. Samphire flowers produce large quantities of pollen, which can often be seen in wind drifts on inundated wetlands. Presumably this is because the flowers are wind pollinated, and are not conspicuous enough to attract insects (even though honeybees have been observed on *Halosarcia lylei* packing pollen into their 'saddle bags').

Not all samphires live in or around wetlands. There are vast tracts of samphire flats that are some way from their parent lake and not particularly saline. The conditions are still harsh, with hot dry summers, frosty winters, poor soils of high alkalinity and often very wet periods to contend with. Other samphires, such as *Sarcocornia quinqueflora*, live on tidal flats, periodically inundated by seawater.

Samphire species appear to have evolved to fill different niches in these hostile environments. The individual species grow in their preferred zones. For instance, *Halosarcia indica* subsp. *bidens* is always found in well-drained soils — at Lake Carey, in the northern Western Australian Goldfields, it is always found at about one meter above the lake playa. *Halosarcia halocnemoides* subsp. *caudata* on the other hand is rarely found growing more than a few centimeters above the lake playa and is often found out on the waterlogged saline clays. Most samphire species fall somewhere in between these two extremes, showing tendencies toward one or other end of the scale.

Samphires are closely associated with saline lakes and their surrounding clay pans, each species growing in the portion of the lake shoreline or pan that meets its needs. It is evident that many samphire species have evolved to grow in specific areas, under certain conditions, and are in reality quite fragile and susceptible to change. The species found on lake beaches are often quite different to those found on adjacent aeolian plateaux or dunes. Samphires found on a lake beach have a shallow lateral root system that extends only into the upper part of the sandy clay loam portion of the beach profile, not

Figure 1 *Halosarcia* 'Anglefish Island' at Lake Carey

further down the profile into the harder impervious clays. These roots are wiry, dark brown, often adventitious and do not extend much further than the drip line of the plant. During wet periods, small fine white adventitious root hairs grow independently of the main roots, often out of lateral branches, into the coarse sandy material portion of the beach profile.

The principal factors that affect species zonation seem to be drainage, or hydroperiod, and salt load, or salt concentration. Other factors that determine where a particular species will grow are soil composition (gypsum, sand, limestone, clay) and temperature (tropical species, sub-tropical species). pH does not seem to be a factor except in *Halosarcia lylei*, which has only been collected by the author in soils with a pH 6 to 6.5.

Figure 2 Samphire zonation on lake 'beach'

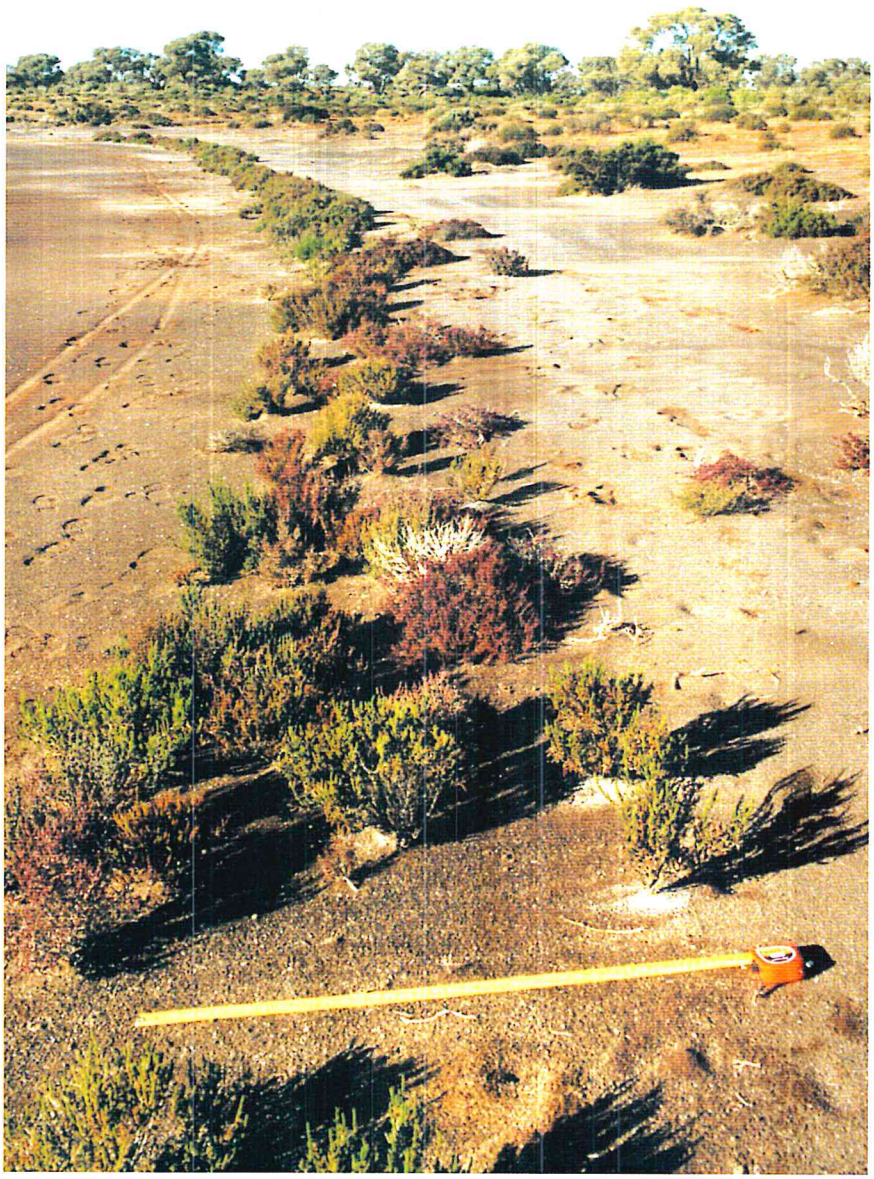


Figure 3 Samphire zonation in lake profile

Stylised lake profile showing preferred zones of Samphire species.
The elevations are not necessarily to scale but there is generally no more than a 3m rise from lake playa to hill base.

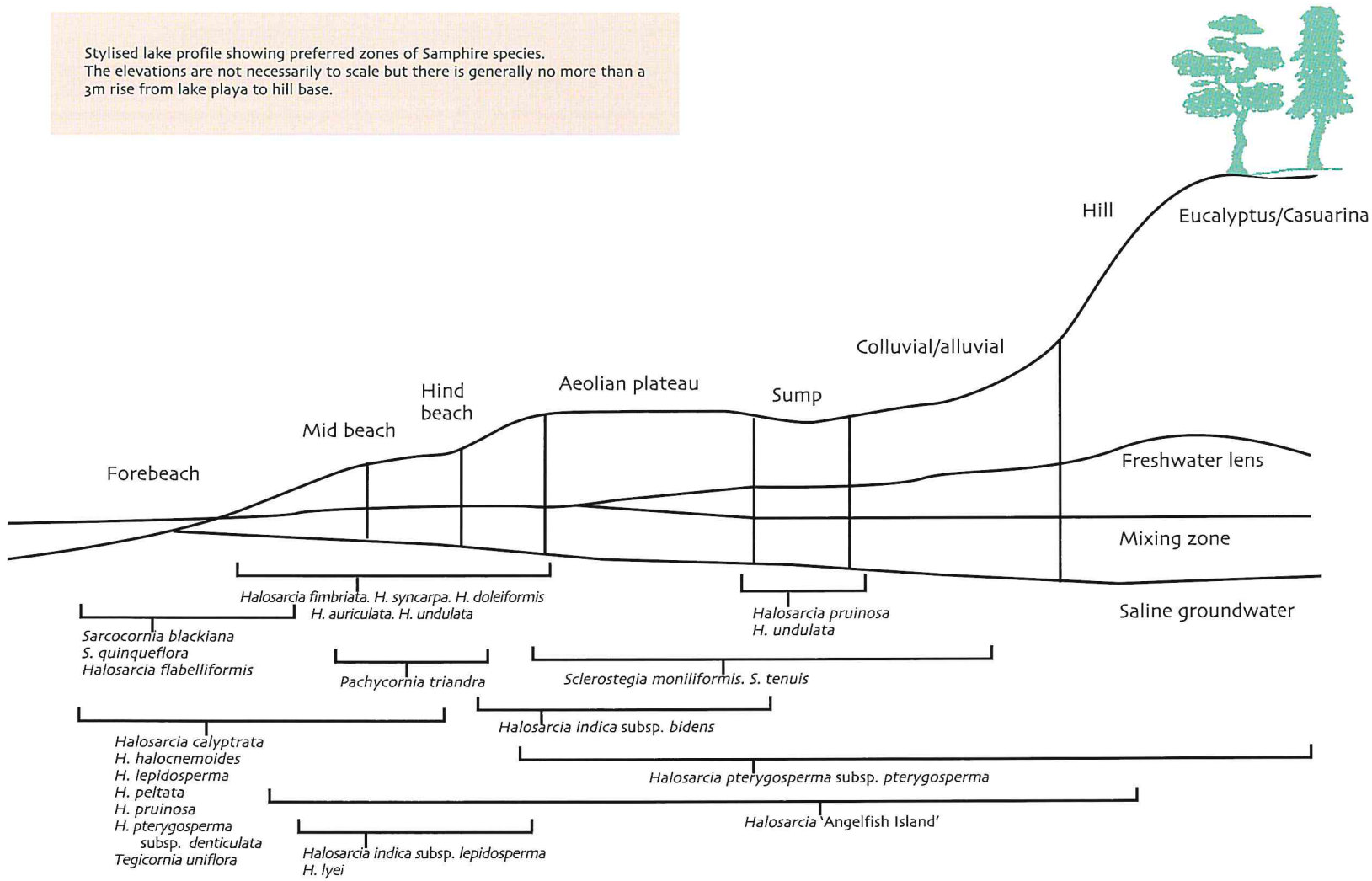
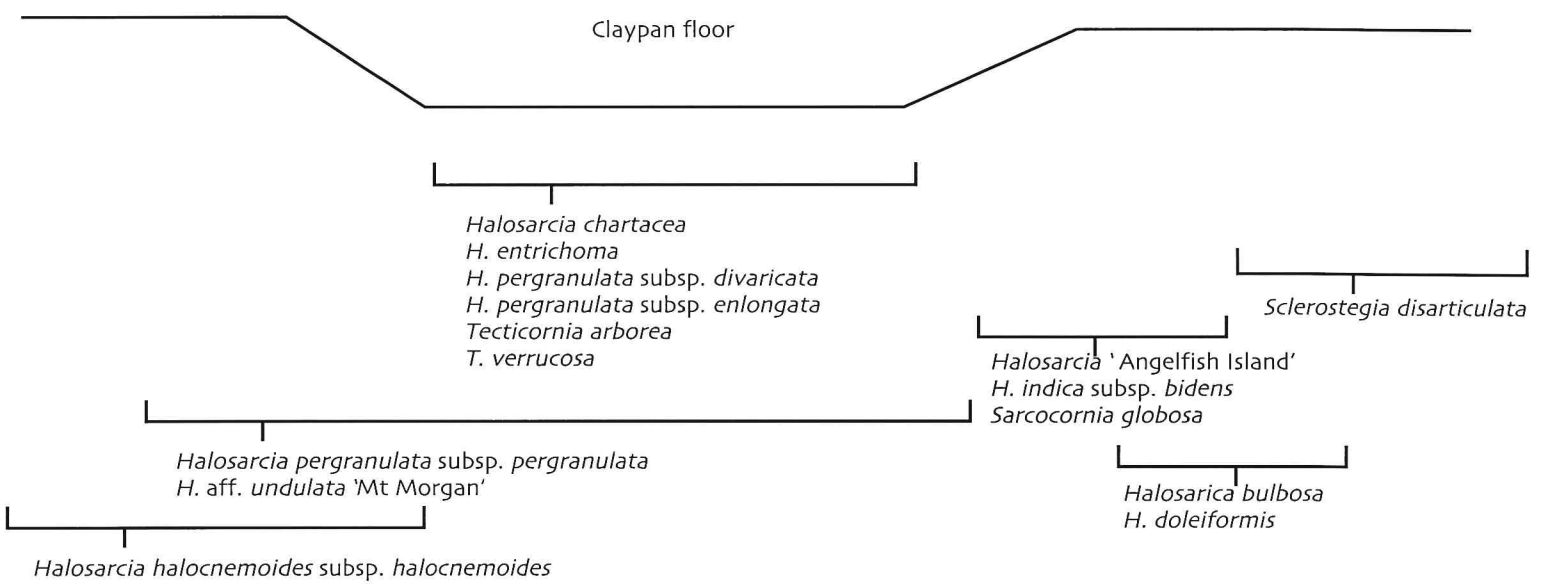


Figure 4 Samphire zonation in clay profile

Stylised clay pan — Samphire zones
Clay pans are freshwater, more often than not. They are often associated with larger lakes, usually elevated from them.



Pests and Diseases of Samphires

3

The hostile environments that samphires live in provide a natural barrier to pests that would normally decimate them — for instance, snails and slugs readily eat samphires.

Samphires are, however, often hosts to fungal parasites; this is especially the case with *Halosarcia pruinosa*, which often has orange fungal 'tubes' set into the vegetative and flowering articles. Black warty 'burls' also are seen on dried material. It is not known if these fungal parasites have any detrimental effect on their host plants, but from the author's casual observation, the fungus-free plants do not seem to be doing any better than the infested ones.

When examining samphires under the microscope, one often sees small mites, jumping spiders, looper caterpillars and other bugs that must rely on the samphire for shelter and/or food. Even with all of this wildlife, it is not usual to see any insect damage to the plants.

The greatest threats to samphires appear to be prolonged inundation, prolonged drought, physical damage by vehicles or animals and encroachment by humans (subdivisions on former wetlands).

Figure 5 Round galls on *Halosarcia indica* subsp. *bidens*

Values of Samphires

4

4.1 Aesthetic values

At first glance samphires are easily overlooked. They grow in places seen to be inhospitable to humans — muddy, hot, sand fly-ridden, barren and, to many eyes, ugly. The plants themselves seem pretty uninspiring: no leaves, no obvious pretty flowers, low growing and drab. However, once it is appreciated that these plants are like this because they have adapted to living in harsh conditions, they can be seen in another light.

The colours of samphires, while not flashy, can be subtly beautiful. Massed purple-pink on a clay pan floor, rimmed with pastel green against a backdrop of taller dark green species: the effect can be stunning. Samphire flats, which are often acres of only two or three species, are beautiful in their own way with their rusts, greens and reds: colours changing with the topography, as different species predominate in their preferred niche. Species such as *Halosarcia* 'Angelfish Island' can be appreciated for their structural beauty, with 'leaf' segments strung together like blue-green beads. Even the flowers on some samphires can have their own appeal; for instance, *Halosarcia peltata's* red globular flower spikes set against dark foliage.

Figure 6 Lake Carey, *Halosarcia pergranulata* and *Halosarcia indica* subsp. *bidens*
Figure 7 (below) Red flower spikes on *Halosarcia peltata*

4.2 Natural Values

Kangaroos and emus are often seen in samphire flats and near salt lakes. This could be because the animals are not as plagued by ticks or flies in these areas, or they might be eating the soft grasses that often grow above salt lakes and on pans. Either way, tracks of these animals and others such as camels and dingoes are often seen crisscrossing salt lakes. It is not known if any of these animals actually eat samphires, but that is unlikely because of their high salt content.

Birds, such as white-fronted chats (*Epthianura albifrons*), with their characteristic flat 'beep' (described as a 'tang' in bird identification books), are often seen in samphire flats. They are possibly eating the many seeds that are produced, or they may be eating the insects that shelter among the plants. Other birds that may be seen there are slender-billed thornbills (*Acanthiza iredalei*), Richard's pipit (*Anthus novaeseelandiae*) and rufous fieldwren (*Calamanthus campestris*). Fat-tailed dunnarts (*Sminthopsis crassicaudata*) are nocturnal predators of spiders and insects on lake playas. A dragon lizard, the salt lake dragon (*Ctenophorus salinarum*), lives in burrows beneath the samphires, presumably feeding on the many insects that live on and around samphires. As stated previously, many small insects live on samphires, but it is rare to see insect damage to the plants. They appear to be using the plants as shelter rather than a food source.

Samphires are soil stabilisers, especially on the deposition side of a salt lake. As wind-driven water deposits sand and silt onto the lake shoreline, samphire seeds germinate in the new deposits and the new plants prevent the soil from blowing away again when dry, or washing away during flooding. This is how the vast samphire flats are formed on the edges of salt lakes in the northern Goldfields.

Figure 8 Cockroach *Polyzostera mitchelli* on *Halosarcia calyptrata*

4.3 Human values

4.3.1 Agricultural

With the encroaching secondary salinisation of agricultural land, farmers are looking at alternative fodder plants. Samphires and other chenopods are being used to stabilise land laid bare by salt and waterlogging. While not as efficient as trees at pumping down the water table, samphires nevertheless can play their part in reclaiming bare scalds by providing cover to help prevent erosion by wind or water. Samphires also act as nutrient traps to collect nitrates and phosphates, which otherwise would travel on down the wetland systems. It is also more aesthetically pleasing to see vegetation growing on a river flat than to have bare salt-scalded soil.

Figure 9 Revegetation using samphires near Tammin

It has been found that sheep will eat Samphires (which contain up to 20% protein) and other chenopods readily if there is fresh water for them to drink and if there is access to supplementary dry food such as crop stubble. The samphire commonly used for animal feed is *Halosarcia pergranulata*, or black seed samphire. As samphires are brittle plants, and grow actively only during wet periods, they cannot be grazed indiscriminately, or they will die out. It is therefore advisable to fence the Samphire flat to be used as fodder and only let the sheep in to graze for a month or two when other feed is exhausted. It will take the rest of the year for the samphires and other chenopods to recover from the grazing.

As stated previously, samphires have traditionally been pickled and eaten in other countries. In Australia, the copious seeds of Samphires of the genus *Tecticornia* have long been seasonally collected and eaten by Aboriginal people in the north-eastern Goldfields of Western Australia and in the south-west of the Northern Territory. Anecdotal evidence states that the Aboriginal people sowed seeds of this Samphire (which they named Kurumi) into cracks in the chosen clay pan to ensure a good crop following the next heavy rains. Camps were set up at the clay pans at harvest time and special ceremonies were held.

Genetic breeding is a somewhat controversial subject that will receive more attention as the world's population grows, and as agricultural land is under more pressure to produce the food necessary to feed everyone.

Because samphires are able to live in such harsh environments, it may be feasible in the future to use some of their genetic material to enable food crop plants to be bred for growing in marginal areas.

Figure 10 *Tecticornia arborea* on a freshwater clay pan. The copious seeds of this plant are traditionally eaten by Aboriginal people

4.3.2 Mining Rehabilitation

Many species of samphire appear to be pioneer species; in other words they will readily colonise disturbed bare soil, if conditions for seed germination are favourable. Because of this, and the fact that they are also natural soil stabilisers, samphires can be used in the mining industry as rehabilitation plants for tailings dams and waste dumps. Some species would lend themselves more readily to this than others, depending on the composition and dimensions of the disturbed area to be revegetated. For instance, *Sclerostegia disarticulata* grows naturally on dry stony soils at some elevation from wet areas. This samphire could be used as a revegetation species on rocky waste dumps. Saline tailings should be able to support *Halosarcia pruinosa* and *H. halocnemoides* in wetter areas and *H. indica* subsp. *bidens*, *Sclerostegia disarticulata* and maybe *H. pterygosperma* on the well-drained outer face. It has been found that *Halosarcia* 'Angelfish Island' readily colonises disturbed soils around mine sites in its natural distribution areas. It would appear that this samphire could be used in the rehabilitation of mine sites around Lake Carey, and presumably other places with gypseous, well-drained soils. Another readily seeding samphire is *Halosarcia pergranulata*, suitable for rehabilitating wet but not too saline areas of disturbed soils.

Figure 11 *Halosarcia* 'Angelfish Island' colonising disturbed ground at a mine site

Collection of Seed

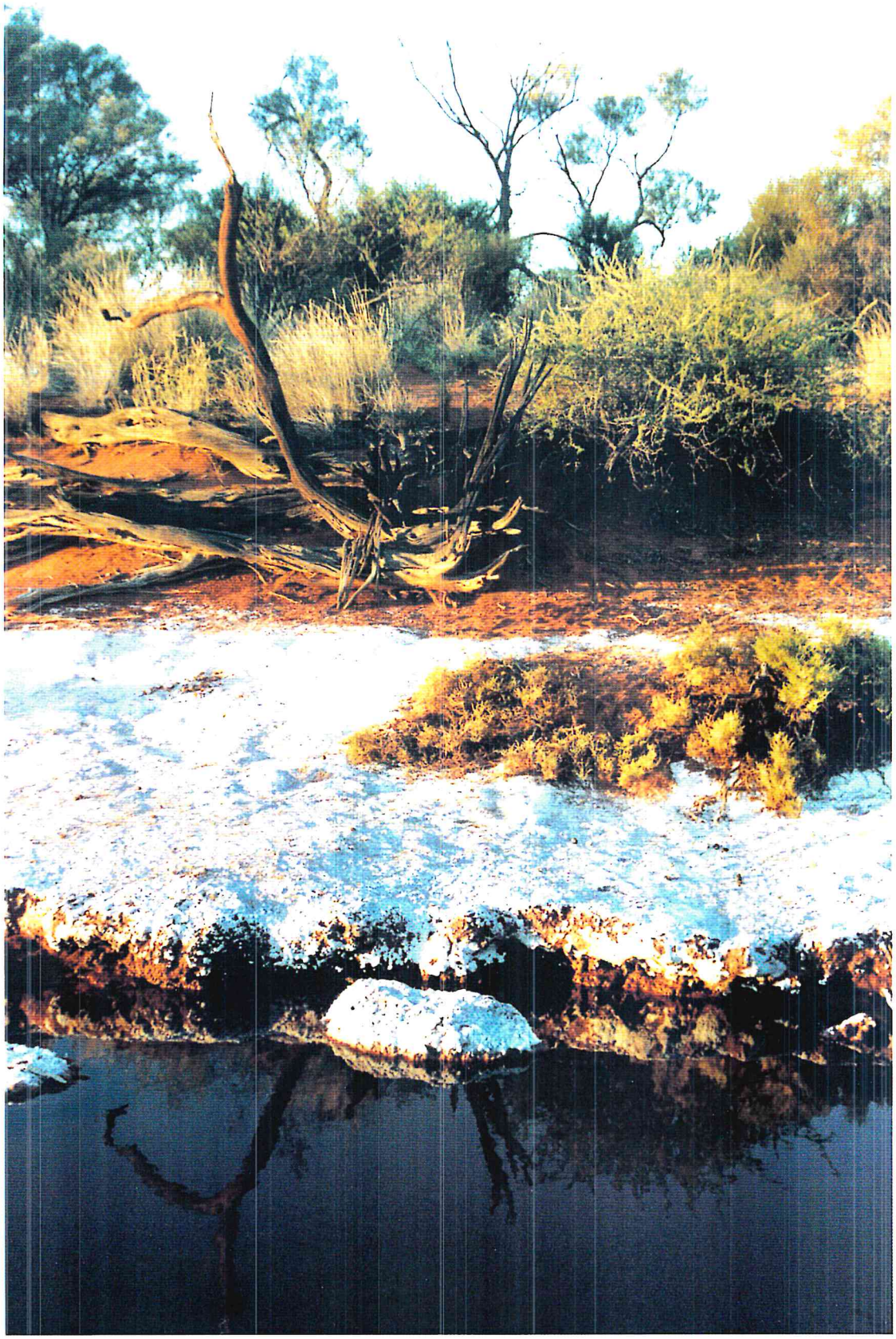
5

Most samphire species flower from early spring until summer. Quite a number will flower almost all year round, depending on conditions. Some species drop their seed heads almost as soon as they are ripe; others store the seeds in spongy or woody fruiting spikes to be released when conditions are favourable for germination. *Halosarcia peltata* is one example of a species that drops its fruiting spikes as soon as they are dry; to collect seed, one needs to know exactly when the fruit is ripe but not fallen (October to December, in this case).

Samphire seed is mature when the flowering spikes begin to shrivel and change colour. The easiest way to collect seed is to cut or pull the ripe seed heads (spikes) from the plants, dry them thoroughly and store in a cool, dry, well-ventilated area until needed. As not all of the seeds have a hard testa (skin), it is not known how long they will remain viable in storage, and therefore it is advisable to use fresh seed every year. Dried seed and seed heads should be protected from insect damage in plastic containers with a small amount of naphthalene.

As some samphire seeds are enclosed in fruitlets that are hard to remove, breaking the spikes up into small pieces helps to release the seed. The seed will germinate within the fruitlets to some extent and grow successfully.

Figure 12 *Sarcocornia blackiana*
Figure 13 (below) Samphire pollen mixed with algae



Identification of Species

6

The author has spent more time at Lake Carey in the Northern Goldfields than at any other saline wetland, so a number of the samphire descriptions are for the species found there. While there is variability within a species in different wetlands, this is superficial, and most can be recognised throughout their range.

Colour is not always a sure guide when describing samphires, as it can vary according to habitat, the health of the plant and the time of the year. For all that, colour can give an indication of samphire species, if the other factors are kept in mind. For that reason colour has been included in the species descriptions.

Some samphires have the vestiges of leaves, which appear as slight lobing or fringing on the upper portion of the vegetative articles. This is especially noticeable in the samphire *Pachycornia triandra*, which has quite prominent lobes.

The easiest way to identify a samphire is by the seeds, which are different for most species, and by the inflorescence. To the untrained eye, most samphires look alike; it is not until a seed or a flowering portion of the plant is put under magnification that differences may be discerned.

For positive identification, a binocular dissecting microscope is needed of at least 10x magnification, as samphire seeds (at 1mm long) are difficult to see with the naked eye and in many species superficially look very similar.

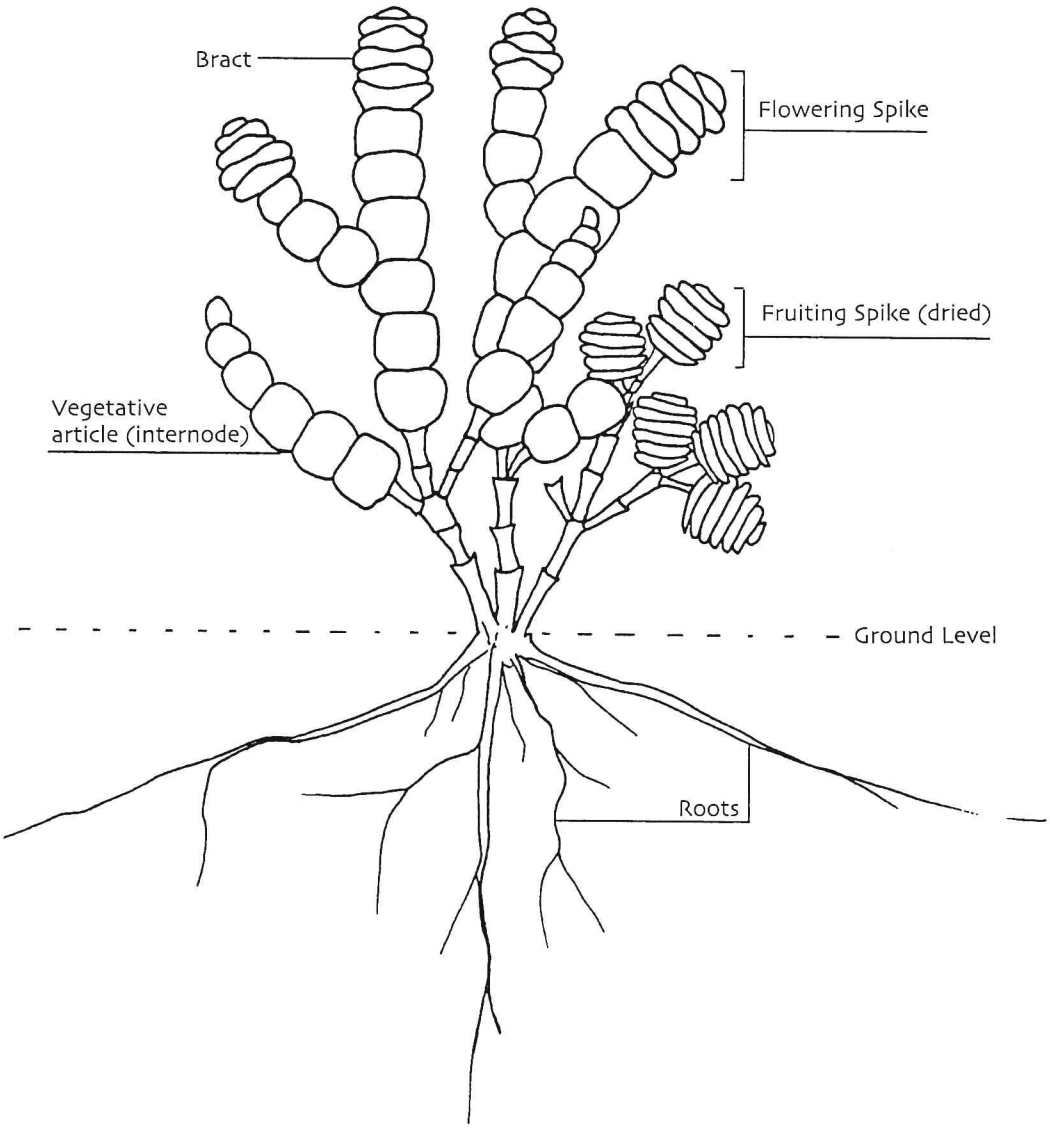
Following are descriptions of thirty samphire species and sub-species found by the author in Western Australia.

The species covered in this book do not include samphires found exclusively further north than Onslow. These tropical species include *Halosarcia indica* subsp. *julacea* and *Tecticornia australica*.

Figure 14 A freshwater seep into a saline creekbed
Figure 15 (below) Vestigial leaves on *Pachycornia triandra*

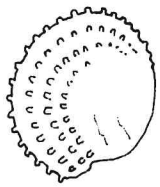
6.1 General Morphology of Samphires

Figure 16 General morphology of a samphire



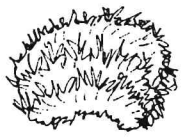
6.2 Simple Seed Key

1. Seeds with 'ropey' close-set concentric ribs. Black to dark reddish brown.



6 *Halosarcia doleiformis*
15 *Halosarcia pergranulata*
29 *Tecticornia verrucosa*

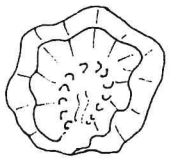
2. Seeds with concentric 'knobs' or granulations. Brown to reddish brown.



2 *Halosarcia auriculata*
4 *Halosarcia calyptrata*
8 *Halosarcia fimbriata*
9 *Halosarcia flabelliformis*
10 *Halosarcia halocnemoides*
13 *Halosarcia lylei*
18 *Halosarcia syncarpa*

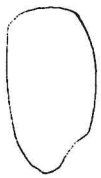
3. Seeds with prominent spiny ribs. Cream-fawn.

17 *Halosarcia pterygosperma*



4. Seeds with prominent undulate ribs, Fawn.

12 *Halosarcia lepidosperma*
30 *Tegicornia uniflora*

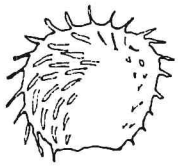


5. Seed smooth-skinned. Pale fawn, brown.

1 *Halosarcia 'Angelfish Island'*
3 *Halosarcia bulbosa*
5 *Halosarcia chartacea*
7 *Halosarcia entrichoma*
20 *Halosarcia* aff. *undulata*
25 *Sclerostegia disarticulata*
27 *Sclerostegia tenuis*

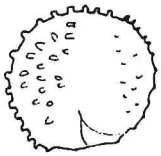
6. Seed smooth-skinned. Yellow.

11 *Halosarcia indica*
14 *Halosarcia peltata*
16 *Halosarcia pruinosa*
19 *Halosarcia undulata*
26 *Sclerostegia moniliformis*



7. Seed 'furry', straight or curved 'hairs'. Cream.

24 *Sarcocornia quinqueflora*



8. Seed tuberculate. Cream.

22 *Sarcocornia blackiana*
23 *Sarcocornia globosa*

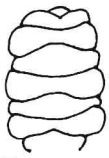
9. None of the above
Reddish brown, smooth, egg-shaped.

28 *Tecticornia arborea*

6.3 Flower spikes

These are generalised shapes. In reality there may be both globular and elongated spikes on the same bush depending on growing conditions, but overall, one type should predominate.

1. Globular to barrel-shaped.



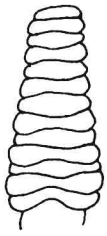
a. Bracts joined.

1 *Halosarcia* 'Angelfish Island'
5 *Halosarcia chartacea*
11 *Halosarcia indica* subsp. *bidens* (sometimes elongated)
20 *Halosarcia* aff. *undulata*

b. Bracts not joined.

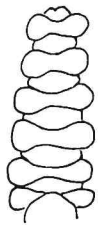
14 *Halosarcia peltata*
28 *Tecticornia arborea*

2. Elongated, bracts joined.

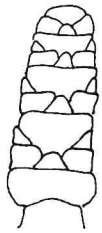


a. Smooth in outline.

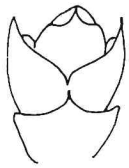
2 *Halosarcia auriculata*
3 *Halosarcia bulbosa*
6 *Halosarcia doleiformis*
7 *Halosarcia entrichoma*
11 *Halosarcia indica* subsp. *leiostachya*
12 *Halosarcia lepidosperma*
13 *Halosarcia lylei*
16 *Halosarcia pruinosa*
17 *Halosarcia pterygosperma*
22 *Sarcocornia blackiana*
24 *Sarcocornia quinqueflora*
26 *Sclerostegia moniliformis*
27 *Sclerostegia tenuis*



b. Undulate in outline



c. Bracts not joined



3. Heavily lobed

3 *Halosarcia bulbosa*
4 *Halosarcia calyptrata*
8 *Halosarcia fimbriata*
10 *Halosarcia halocnemoides*
15 *Halosarcia pergranulata*
18 *Halosarcia syncarpa*
19 *Halosarcia undulata*

9 *Halosarcia flabelliformis*
25 *Sclerostegia disarticulata*
28 *Tecticornia arborea*
29 *Tecticornia verrucosa*

21 *Pachycornia triandra*
30 *Tegicornia uniflora*

6.4 Flowers

The flowers of most samphires are grouped in threes (triads). Exceptions to this are the genus *Sarcocornia*, which has flowers in groups of three to twelve; *Tecticornia australasica*, which has three to five flowers; and *Tegicornia uniflora*, which has one flower. These flowers have no petals and generally the only conspicuous parts are the stamens (often with yellow pollen anthers) and the stigma (a feathery-looking organ).

The flowers of the genera *Halosarcia*, *Sarcocornia*, *Tecticornia* are bisexual, producing both male and female parts. The genera *Sclerostegia* and *Pachycornia* have a central bisexual flower, but the lateral flowers, which each produce one stamen, are male. *Tegicornia uniflora* is dioecious, bearing male and female flowers on different plants.

Figure 17 Pollen-bearing stamens on *Halosarcia peltata*

6.4.1 Key

These are partial keys: they do not necessarily lead to a single species at each branch. That is because not all the distinguishing features are yet known. Therefore, please use the descriptions, images and distribution information in the following pages as supplementary aids to decide which species is under examination.

1. Globular Flower Spikes
   2. Flower Bracts Joined
      - 1 *Halosarcia* 'Angelfish Island'
      - 5 *Halosarcia chartacea*
      - 14 *Halosarcia peltata*
   2. Flower Bracts Not Joined
      - 19 *Halosarcia* aff. *undulata*
      - 21 *Pachycornia triandra*

1. Elongated Flower Spikes
   3. Flower Bracts Joined
      4. Flower Spikes (Fresh/Dried) Undulate In Outline
         5. Seed
            - Ropey / Granulated
              - 4 *Halosarcia calyptrata*
              - 8 *Halosarcia fimbriata*
              - 10 *Halosarcia halocnemoides*
              - 15 *Halosarcia pergranulata*
              - 18 *Halosarcia syncarpa*
            - Smooth-skinned, yellow
              - 11 *Halosarcia indica*
              - 19 *Halosarcia undulata*
            - Undulate ribs
              - 30 *Tegicornia uniflora*
      4. Flower Spikes (Fresh/Dried) Smooth In Outline
         5. Seed
            - Ropey / Granulated
              - 2 *Halosarcia auriculata*
              - 6 *Halosarcia doleiformis*
              - 13 *Halosarcia lylei*
            - Smooth-skinned, yellow
              - 16 *Halosarcia pruinosa*
              - 26 *Sclerostegia moniliformis*
            - Smooth-skinned, pale brown
              - 3 *Halosarcia bulbosa*
              - 7 *Halosarcia entrichoma*
            - Undulate ribs
              - 12 *Halosarcia lepidosperma*
            - Spiny ribs
              - 17 *Halosarcia pterygosperma*
            - Tuberculate, cream
              - 22 *Sarcocornia blackiana*
            - Furry, cream
              - 23 *Sarcocornia globosa*
              - 24 *Sarcocornia quinqueflora*
              - 27 *Sclerostegia tenuis*

   3. Flower Bracts Not Joined
      4. Flower Spikes Smooth In Outline
         5. Seed
            - Granulated, pale brown
              - 9 *Halosarcia flabelliformis*
            - Smooth-skinned, pale brown
              - 25 *Sclerostegia disarticulata*
            - Smooth-skinned, red brown
              - 28 *Tecticornia arborea*
            - Granulated, black
              - 29 *Tecticornia verrucosa*

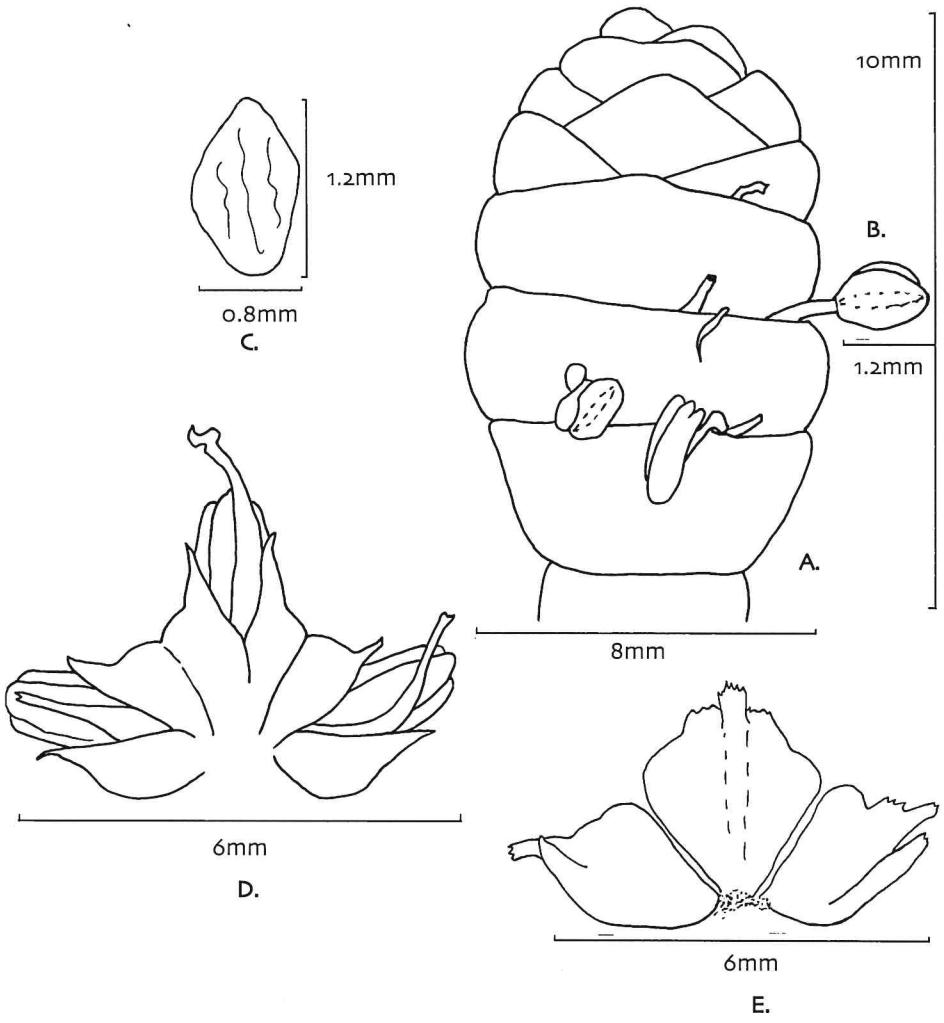
7 Descriptions of Samphires

1. *Halosarcia* 'Angelfish Island' (B. Davey) is a small, succulent sub-shrub with a stiff upright habit, growing to a height of about 40cm and sometimes reaching a width of a metre or more. It is conspicuous because of its 'fat' (up to 15mm by 15mm), succulent, grey-green articles ('leaf'/stem segments) and rounded terminal flower spikes. The seed is soft-skinned and a mid brown in colour. It measures 1.2mm by 0.8mm. The 'skin' of the articles and flower spikes is covered with a 'bloom' (glaucous), like a plum. At some times of the year, notably during extreme heat or drought, the articles will be reddish or purple (a common symptom of samphires under stress). *Halosarcia* 'Angelfish Island' has only been found at Lakes Carey and Minigwal in the Eastern Goldfields. There are similar species growing at Lakes Barlee and Ballard; these may be found to be in the same grouping as *Halosarcia* 'Angelfish Island' in the future (see *Halosarcia* aff. *undulata*).

Halosarcia 'Angelfish Island' is mostly found growing on reddish, sandy-gypseous, well-drained, saline soils. It is not often found in inlets and almost never found in wet run-off areas, preferring well-drained dunes beside the open lake. It can be found (in the right conditions) growing from the edge of the lake playa to at least 250 metres into the gypseous dunes. It has also been found around gypseous clay pans some distance from the main playa of Lake Carey. More often, though, it is not one of the common Halosarcias and only appears sporadically.

Halosarcia 'Angelfish Island' often appears with a typical suite of other Halosarcia species. These are *H. undulata*, *H. pruinosa*, *H. calyptrata* and *H. halocnemoides*. When looking for *Halosarcia* 'Angelfish Island', these others act as indicator species. The presence of any or all of these indicator species, coupled with a well-drained soil, means there is a good chance of *H.* 'Angelfish Island' being found nearby. More often than not, it is found at about a half a metre elevation above the lake playa.

Figure 18 *Halosarcia* 'Angelfish Island'

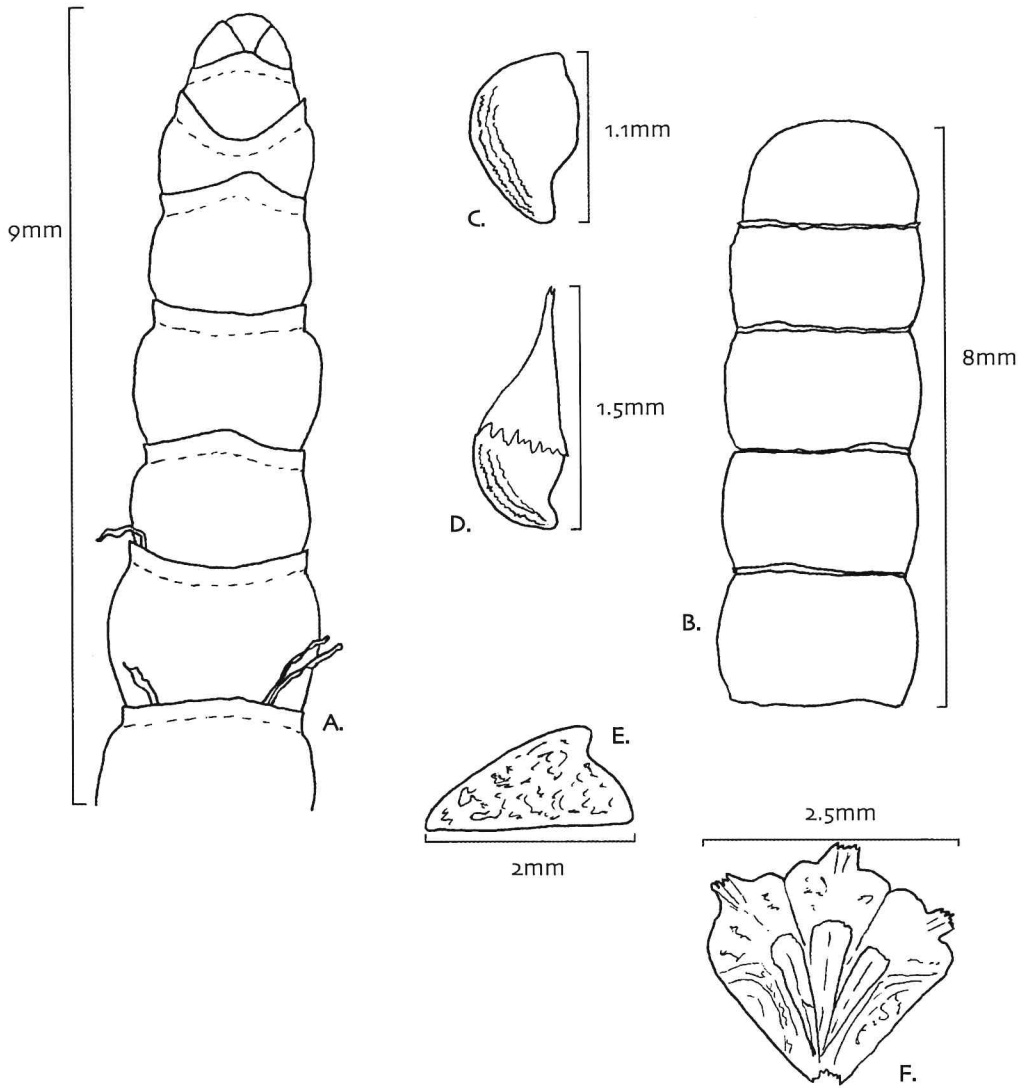


Halosarcia 'Angelfish Island'

A. Fresh flower spike
B. Anther
C. Seed: mid brown
D. Fresh triad of flowers
E. Dried triad of flowers

2. *Halosarcia auriculata* is a small shrub with a loosely upright habit, growing to a height of 50cm. This is a sub-tropical species, found in saline clay pans in the north-west of Western Australia, mainly near the coast. The articles are blue-green and glaucous. The flowering spikes are 10–40mm long and 4mm wide. The triads of flowers are hidden by the bracts. The mature and dried flower spikes are grey-brown and corky. The fruitlets are golden brown and slightly 'woolly', containing a golden brown seed, which is about 1.5mm long and has minute granulations along the longest side.

Figure 19 *Halosarcia auriculata*

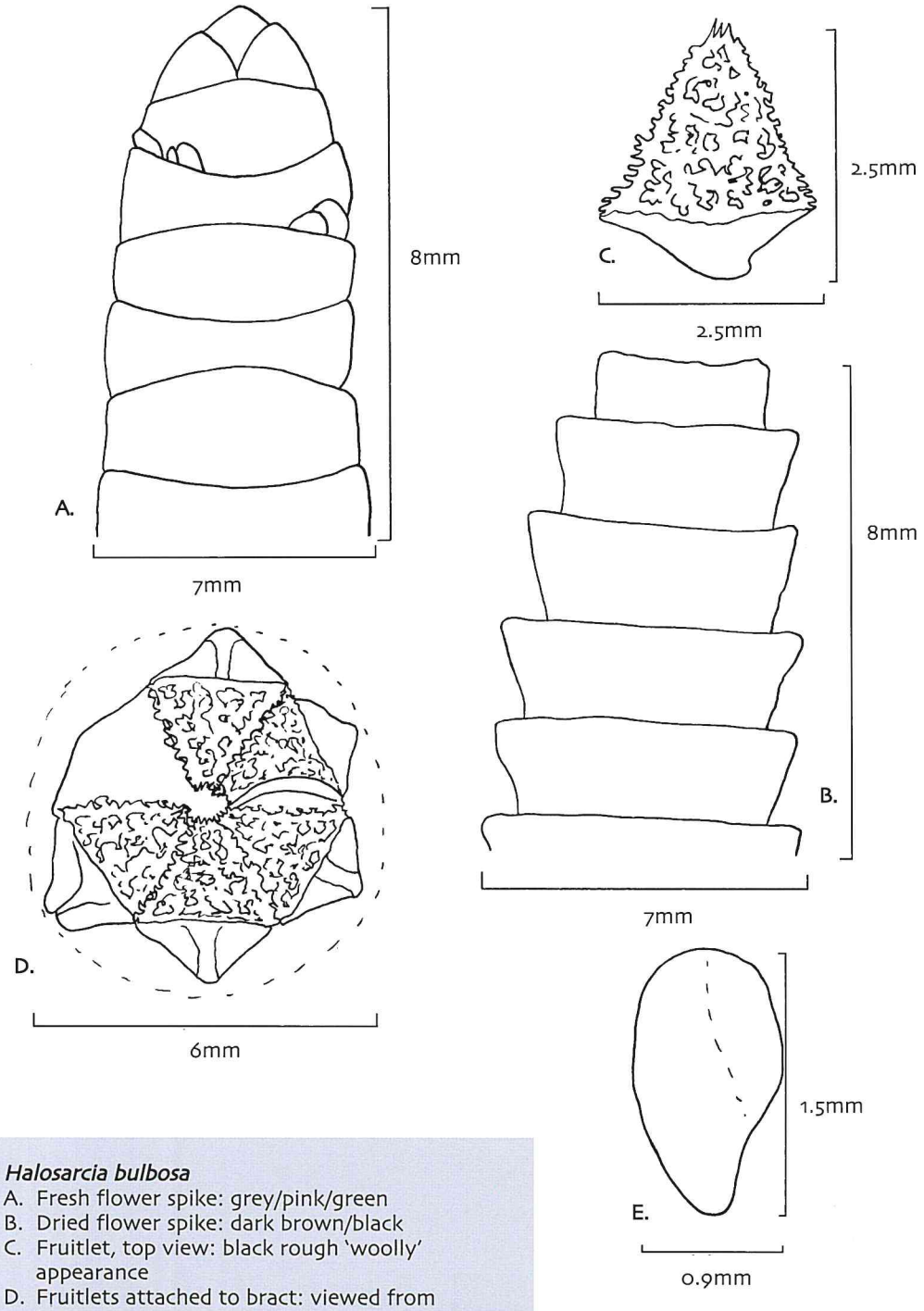


Halosarcia auriculata

A. Fresh flower spike: blue/green, glaucous
B. Dried flower spike: grey/brown, corky
C. Seed: minutely granulated, golden brown
D. Seed with covering
E. Fruitlet: golden brown, slightly 'woolly', side view
F. Triad of fruitlets, top view

3. *Halosarcia bulbosa* is known from a single location, about an acre of samphire flats near Morawa. It is Declared Rare Flora and as such is protected. It is a succulent shrub growing up to 1m high and 3m wide, though most plants seen were about 50cm high and 50cm wide. *H. bulbosa* stands out from the surrounding samphires because of its grey-green appearance and large vegetative articles. It has an upright habit and tends to grow either in groups or with *Halosarcia halocnemoides* and a small *Frankenia*. Most plants seen were grey-pink and glaucous; however, some individuals or small groups were yellow or green. The soil was a friable loam where *H. bulbosa* was growing but elsewhere on the samphire flat the soil was heavier clay. The flower spikes are about 20mm long and 7mm wide, somewhat undulate in outline, and the bracts are joined. The flower spikes are both terminal and lateral. The flower triads are hidden by the bracts. Unlike other samphires the flower spikes of *H. bulbosa* are substantially narrower than the large vegetative articles. Dried flower spikes are black. The fruitlets are black and roughly 'woolly' in appearance and somewhat pyramidal. The seed is about 1.5mm long and is pale brown and smooth-skinned.

Figure 20 *Halosarcia bulbosa*



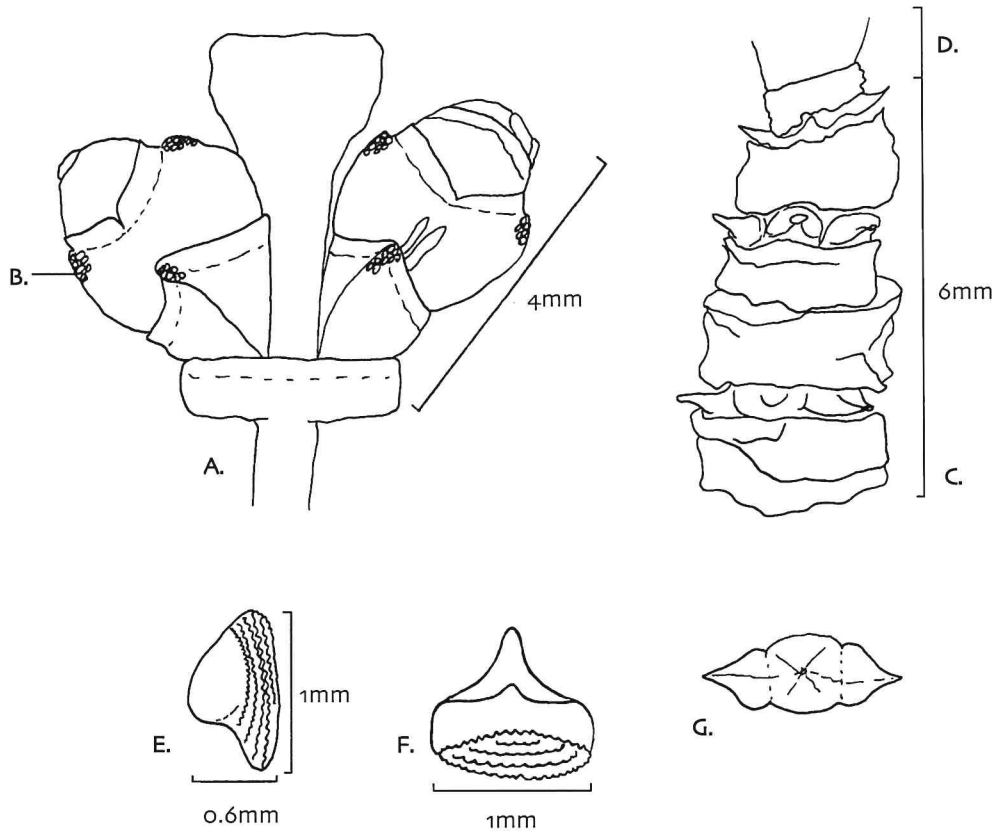
Halosarcia bulbosa

A. Fresh flower spike: grey/pink/green
B. Dried flower spike: dark brown/black
C. Fruitlet, top view: black rough 'woolly' appearance
D. Fruitlets attached to bract: viewed from below
E. Seed: pale brown, smooth skinned

4. *Halosarcia calyptrata* is quite common at Lake Carey, especially in run-off areas and wet inlets. It may grow up to 80cm high but at Lake Carey is a low-growing (up to 25cm high) sub-shrub, with a sprawling habit (often up to 60cm wide). The branches are slender and fragile; the flower spikes are from 10–20mm long, 3mm in diameter and invariably in pairs along the branches. The terminal flower spike often is intercalary, with vegetative growth continuing from the end of the spike. The bracts hide the flowers when fresh; the fruitlets are exposed when the flower spike is dry. The overall colour is either grey-green or purplish. Under magnification, the 'skin' of the plant is glaucous and slightly warty. The vegetative articles and flower bracts often have reddish granular 'keels'. A distinguishing feature is the cup-like lid (calyptra) that covers the seed. The seed itself is brown, 1–1.2mm long, with rows of minute granulations along the longest edge. *H. calyptrata* is found on slightly higher rises (better drainage) in wet, saline areas. It is often found growing with *H. pruinosa* and *H. halocnemoides* subsp. *caudata* or *H. halocnemoides* subsp. *catenulata* at Lake Carey (the last two growing at a slightly lower elevation).

Halosarcia calyptrata is found on the margins of gypseous saline wetlands and slightly saline clay pans in the Northern Territory and north-central Western Australia.

Figure 21 *Halosarcia calyptrata*



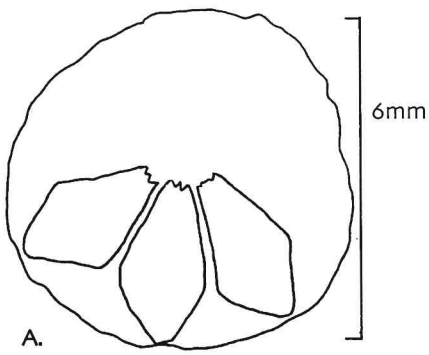
Halosarcia calyptrata

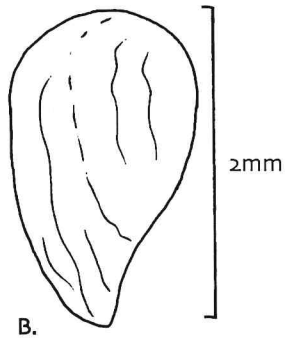
A. Fresh flower spikes
B. Apices of bracts 'granular', red
C. Dried flower spike, vegetative growth continuing
D. Vegetative growth continuing from dried flower spike
E. Seed: pale brown
F. Seed with cup-like covering
G. Dried triad of fruitlets

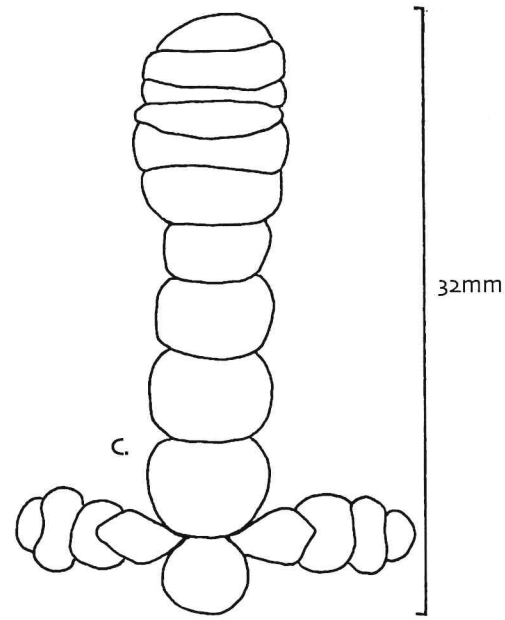
5. *Halosarcia chartacea* is a brittle shrub growing to a height of 1m, with a stiff upright habit. The specimen drawn was found growing in the hard clay floor of a 200m by 200m clay pan to the north-west of Lake Rebecca. When a soil sample was taken from under the plants for analysis, the baked clay was very hard and had cracked on the surface into hexagonal patterns. The soil sample analysis of the baked red clay showed a pH9.5, moisture of 15% and a salt level of 22.84g/kg. The colour of this plant appears to be blue green; however, this is caused by a light blue-green 'bloom' (glaucous). This rubs off readily to reveal the darker green colour underneath. The flower spikes are about 3.5cm long by about 1cm wide; they are succulent and brittle, and they and the leaf articles become damaged easily. The seed is smooth-skinned with a thin testa and is 2mm long, quite large for a samphire seed. At the time of collection of the specimen there were many *H. chartacea* juveniles also growing in the hard, cracked red clay. Growing at the edge of the clay pan, on red coarse sand, were *H. pergranulata* and *H. indica* subsp. *bidens*. A soil sample taken from under these two latter species showed that the moisture level (4.25%), pH level (pH9) and salt level (4.72g/kg) were less than at the centre of the pan.

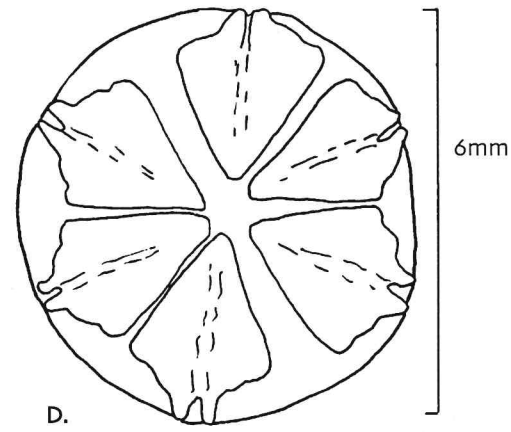
Halosarcia chartacea is found on low-salinity clay pans in central Western Australia but is not common.

Figure 22 *Halosarcia chartacea*







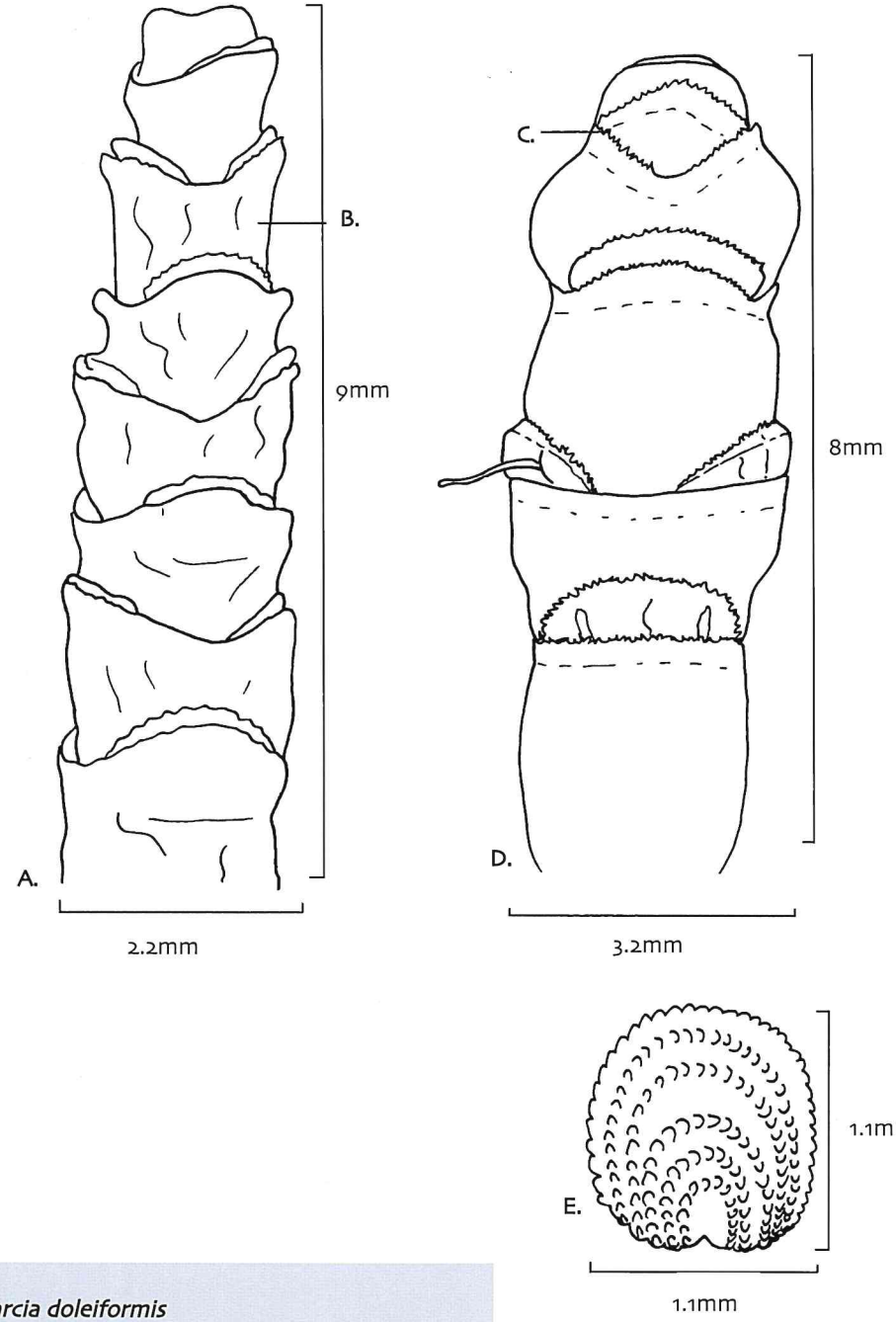


Halosarcia chartacea
A. Dried triad of fruitlets on disk
B. Seed: pale fawn
C. Fruiting spike and articles
D. Fresh fruitlet triads on disk

6. *Halosarcia doleiformis* is a sub-shrub growing to a height of 50cm, with a spreading but upright habit. It has a 'dusty' green appearance, often with pinkish tips. A distinguishing feature is that the old stems and vegetative articles become grey and often spongy with age. The flower spikes are slightly undulate in outline; the fruiting spikes and vegetative articles are smooth in outline. The articles, bracts and perianths have a marginal fringe of fine hairs (ciliolate). The seeds are the same as *H. pergranulata*, having concentric 'ropey' ribbing over most of the surface. The colour of the seed is dark reddish brown. *H. doleiformis* is often found on gypseous soils.

Halosarcia doleiformis is found in south-western Western Australia from Onslow south to Northam and Norseman.

Figure 23 *Halosarcia doleiformis*

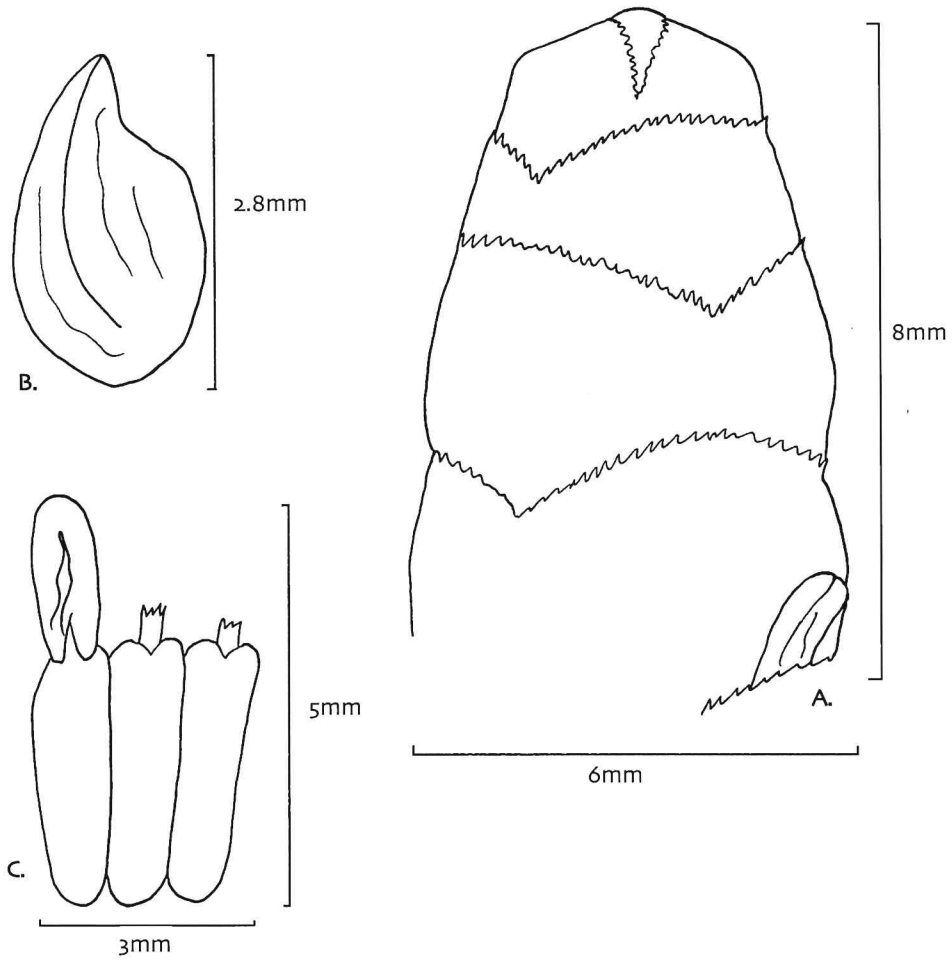


Halosarcia doleiformis

A. Dried spike
B. Grey 'webby' appearance
C. Hairs on edges of flower perianths and bracts
D. Fresh flower spike, reddish flower perianths
E. Seed: dark reddish black

7. *Halosarcia entrichoma* is a dwarf shrub growing to a height of about 10cm. It is only known from one location, a small clay pan in the Frank Hann National Park, near Lake King (town). It has a Priority Four listing. This species is the only samphire on the pan floor, though associated species at the edge of the pan are *Halosarcia indica* subsp. *bidens* and *Sarcocornia sp. Halosarcia entrichoma* grows in small raised clumps, often with a species of grass growing up through it. The flowering spikes of this species are up to 20mm long and up to 8mm wide. The colour of both vegetative articles and flower spikes is a glaucous mid grey-green, and the margins of both are ciliolate (entrichoma means eyelash-like). At the time of collection (August), the plants consisted mainly of flowering and fruiting spikes, with little vegetative growth. The seed of *H. entrichoma* is quite large for a samphire, being 2.8mm long, smooth-skinned and mid to dark brown. The floor of the clay pan (in August) was grey silty clay with a 'polished' shiny surface when dry. Because of the presence of shield shrimp (a freshwater species) carapaces on the pan, it is assumed that the pan is not very saline. The results of the analysis of a soil sample taken from the pan were — pH8.5, grey clay, 3.8g/kg salt, and 32% moisture.

Figure 24 *Halosarcia entrichoma*

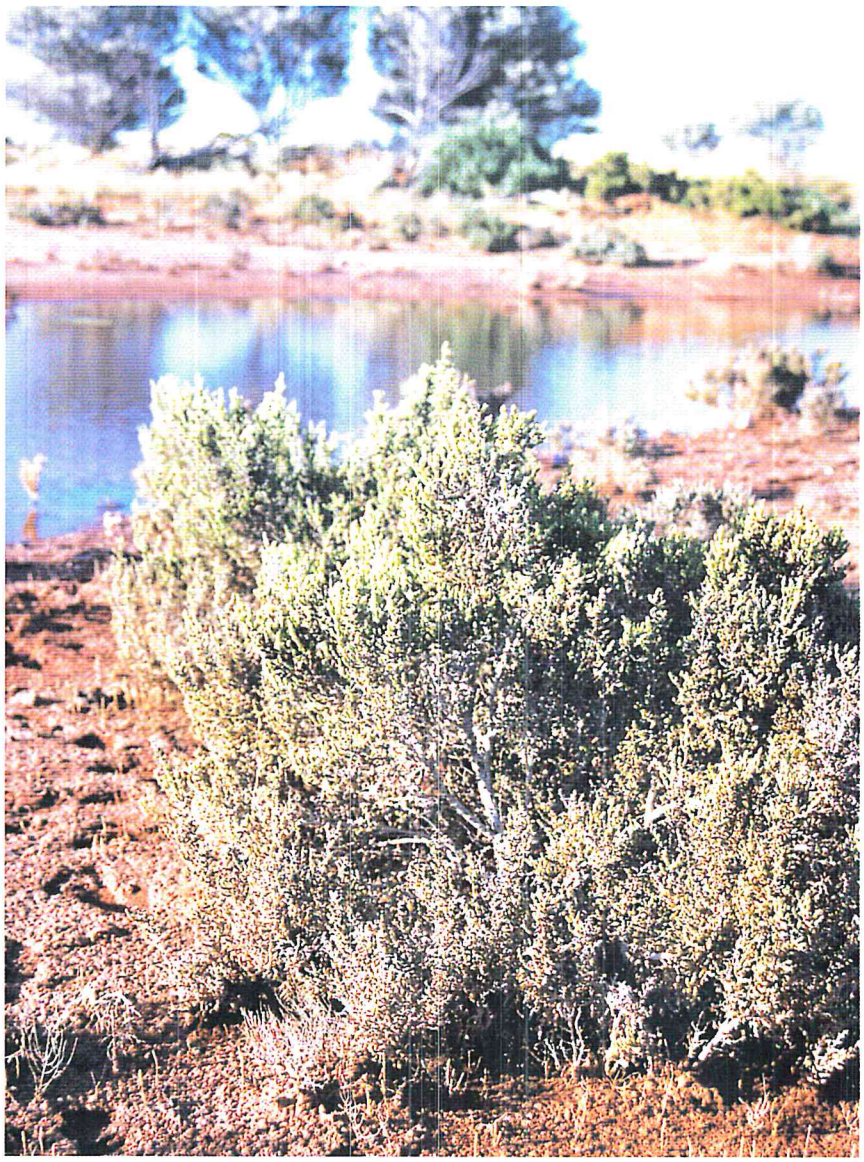


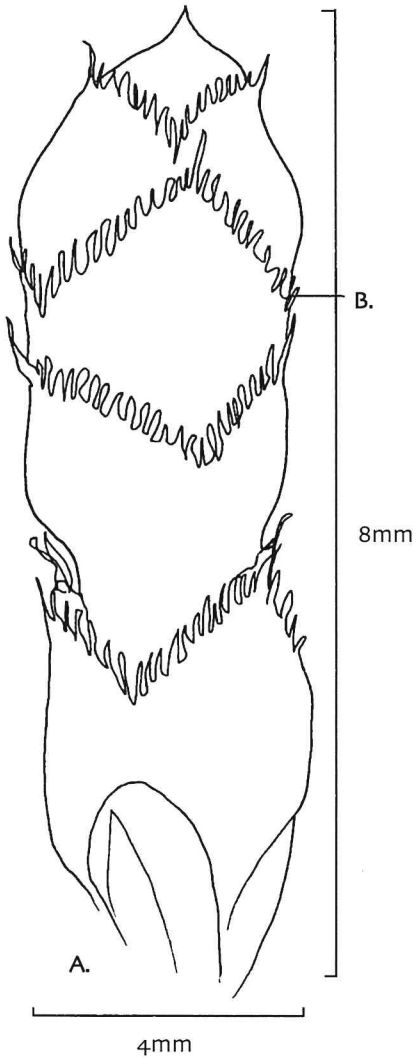
Halosarcia entrichoma
A. Fresh flower spike: grey/green
B. Seed: mid to dark brown
C. Fresh flower triad

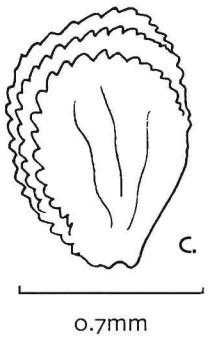
8. *Halosarcia fimbriata* is a sub-shrub growing to a height of 1m (the specimen drawn was 50cm high), with a narrow upright habit. The specimen drawn was collected at Lake Darlot, in the northern Goldfields, further east than previously known. At Lake Darlot *Halosarcia fimbriata* was found growing from the edge of the lake playa to about 1m above it. The colour is light to mid dull green. Flower spikes are up to 10mm long and 4mm wide, and are undulate in outline. *Halosarcia fimbriata* is readily recognised under magnification by the fimbriate (hair-like fringe) margins to the vegetative articles (leaf segments) and flower spikes. The seed of *H. fimbriata* is reddish brown, 1mm long, with rows of knobs on the outer edge, the rest of the seed being smooth. The fruitlets are soft and fringed, the seed being easy to remove.

Halosarcia fimbriata is found on the margin of saline, often gypseous wetlands in the central south-west of Western Australia.

Figure 25 *Halosarcia fimbriata*



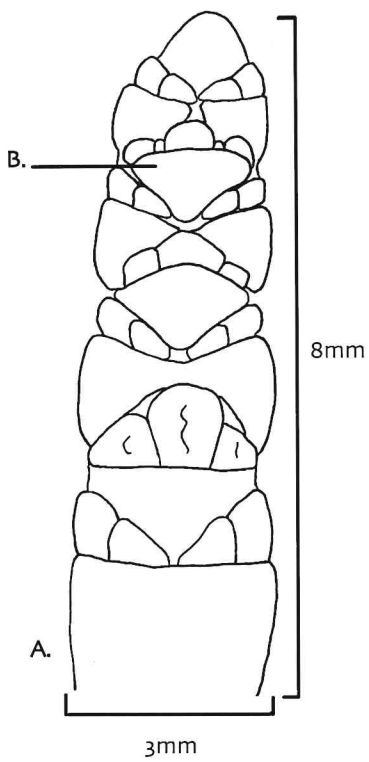


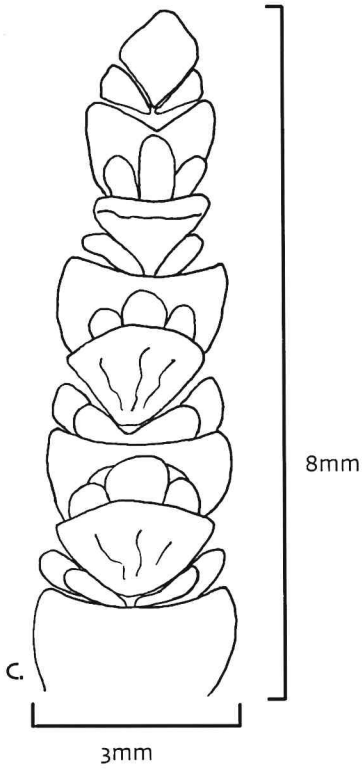


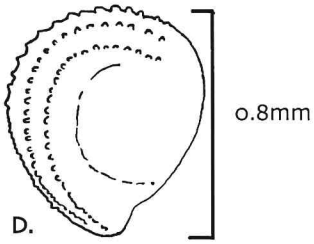
Halosarcia fimbriata
A. Fresh flower spike
B. Hairs on edges of bracts
C. Seed: reddish brown

9. *Halosarcia flabelliformis* is a dwarf shrub growing to a height of about 10cm. It is not common but is found in central south-west Western Australia and South Australia in the lowest part of the beach or lake profile. It is unusual for a halosarcia in that the bracts on the flower spike are not joined — *H. peltata* is another halosarcia with unjoined bracts. The vegetative articles are slender, measuring up to 5mm by 2.5mm. They and the flower spikes are a bright yellowish green and slightly glossy. The flower spikes measure up to 5mm wide by up to 40mm long. The seed is about 1.8mm long and is translucent and reddish with rows of tubercules along the longest side. This plant has a Priority One listing.

Figure 26 *Halosarcia flabelliformis*





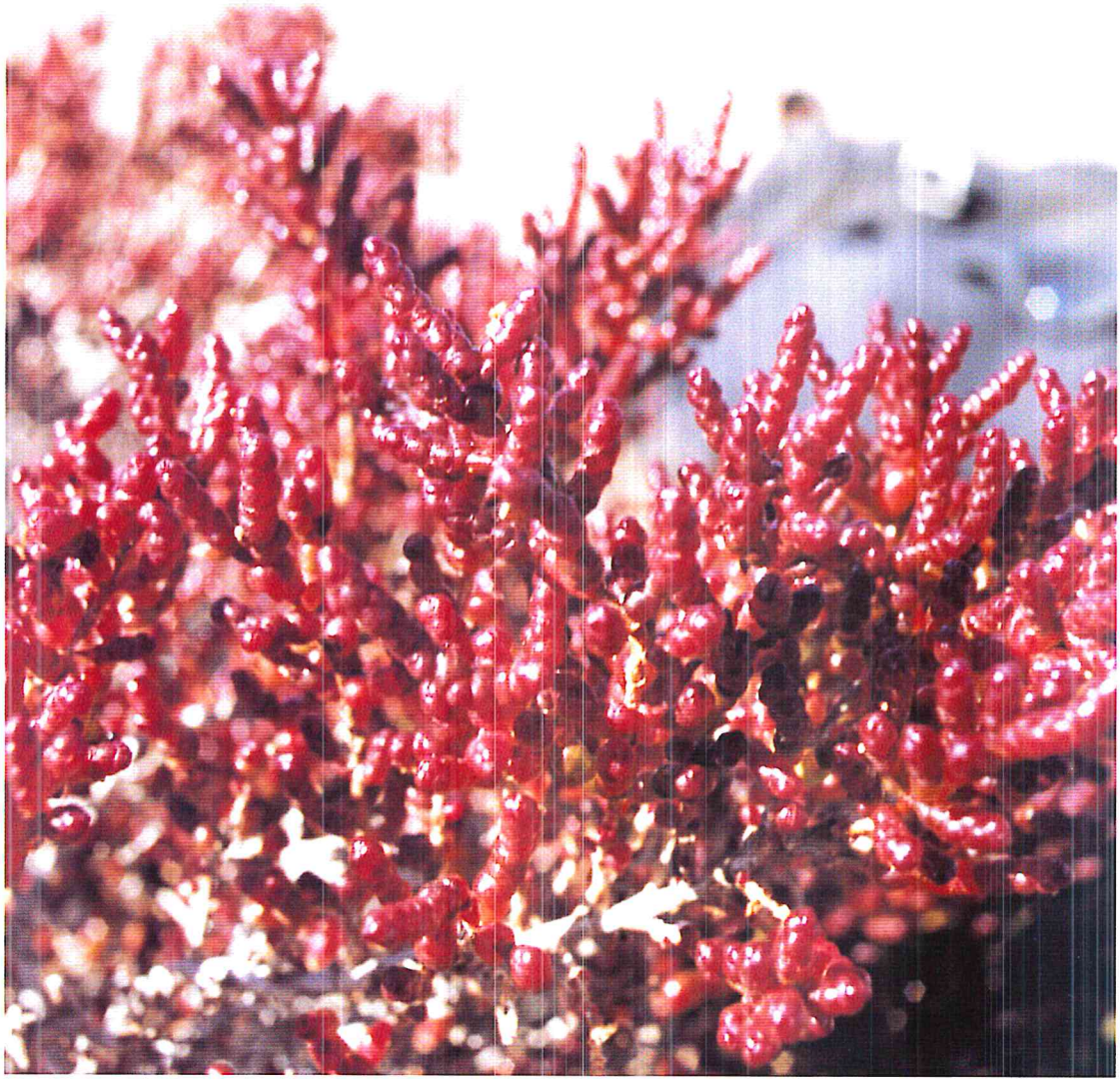


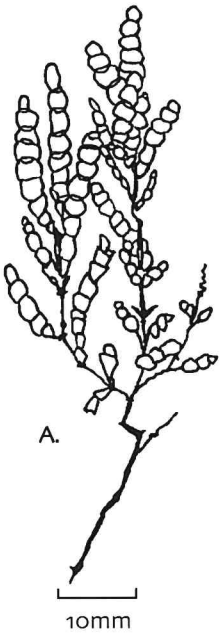
Halosarcia flabelliformis
A. Fresh flower spike: bright green
B. Fresh flower spike: unjoined bracts
C. Dried flower spike: straw-coloured
D. Seed: minutely granulated, reddish

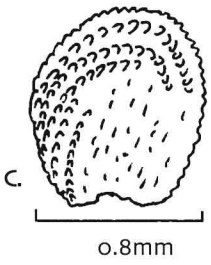
10. *Halosarcia halocnemoides* is a species that needs to be studied further. There are sub-species in the northern Goldfields (which the author has studied) that don't quite fit any category, and probably there are others elsewhere. The identification of *H. halocnemoides* subsp. *catenulata* and *H. halocnemoides* subsp. *caudata* below is as described by Paul Wilson (1980); however, the other two sub-species have been placed in categories that fit them most closely. All *H. halocnemoides* sub-species have small articles and a seed that has small concentric bumps or granulations on the outer edge, and generally is mostly smooth on the sides. The seed colours range from orange-brown to dark brown.

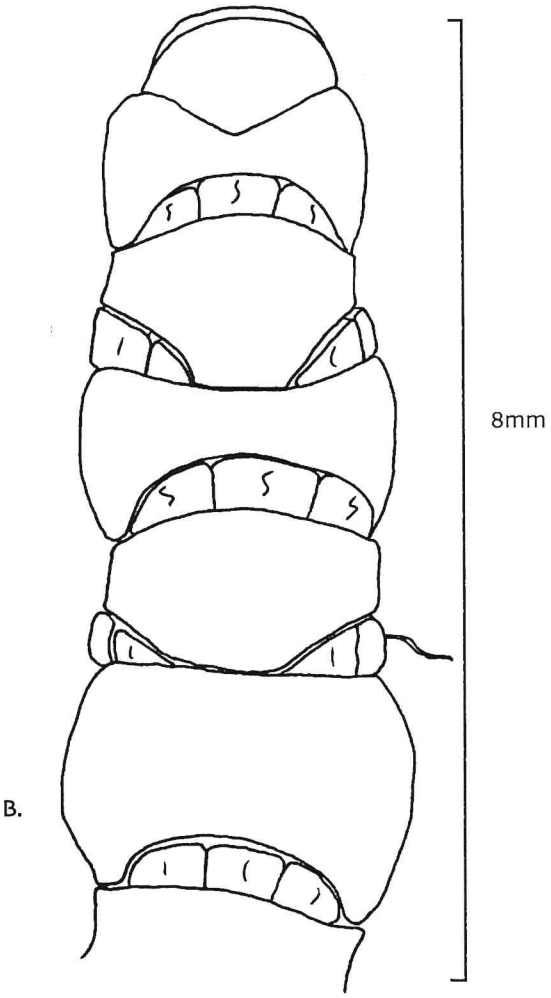
H. halocnemoides subsp. *catenulata* is a sub-shrub with a compact habit, growing to a height of up to 50cm, though usually less. It is easily distinguished from the other *Halosarcia halocnemoides* sub-species by its glossy articles. The colour is variable, from bright green to purple-red. The seed colour is dark reddish brown. It is found in the wettest and most saline parts of the wetland profile. This sub-species has been seen growing in salt crystals that almost covered it.

Figure 27 *Halosarcia halocnemoides* subsp. *catenulata*







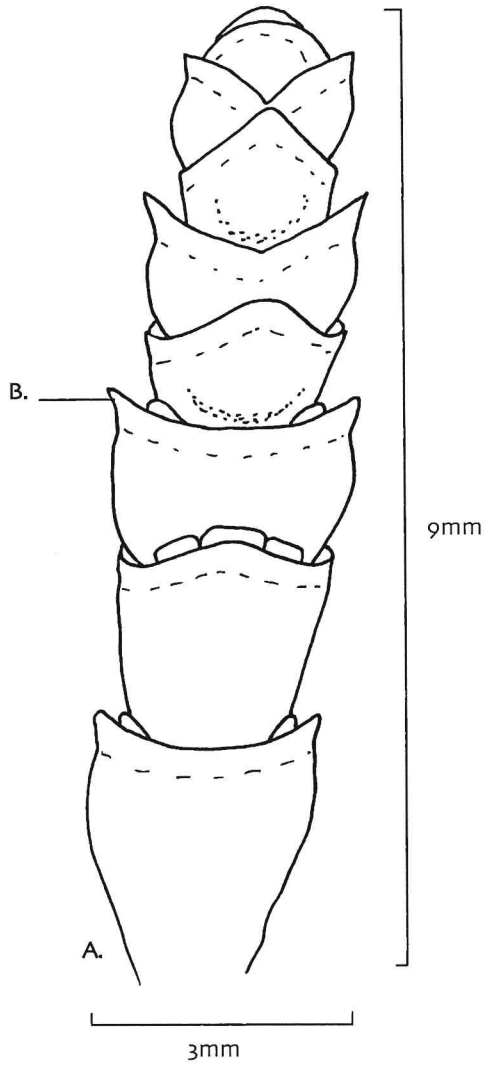


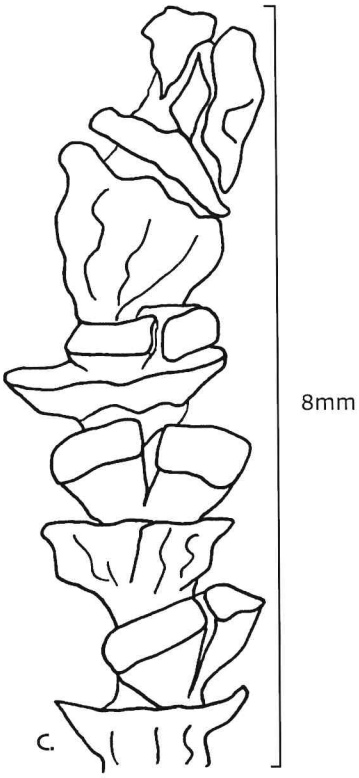
Halosarcia halocnemoides* subsp. *catenulata

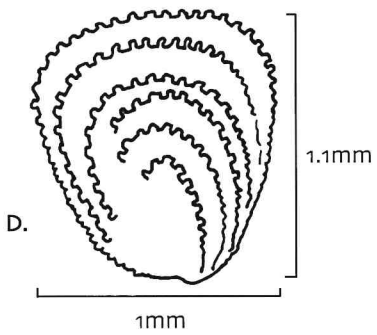
A. Vegetative articles and flower spikes
B. Fresh flower spike: green with reddish perianths
C. Seed: dark brown

Halosarcia halocnemoides subsp. *caudata* is very common at Lake Carey — it is one of the most common species growing on or near the lake playa. It is an upright, bright yellow-green shrub or sub-shrub, up to 60cm high, though more often about 30cm high. Under magnification, *H. halocnemoides* subsp. *caudata* can be easily distinguished from *H. halocnemoides* subsp. *tenuis* by the 'boat-like' upper margins of the flower bracts; other than that, the two sub-species are similar. The bracts of the flower spike obscure the flowers more than in any other *H. halocnemoides* sub-species. The 1mm long reddish brown seed is nearly circular and has concentric granulations or crenulations on the outer edge, and some on the sides. It is found in the wettest and most saline part of the beach profile, often growing out on the lake playa.

Figure 28 *Halosarcia halocnemoides* subsp. *caudata*







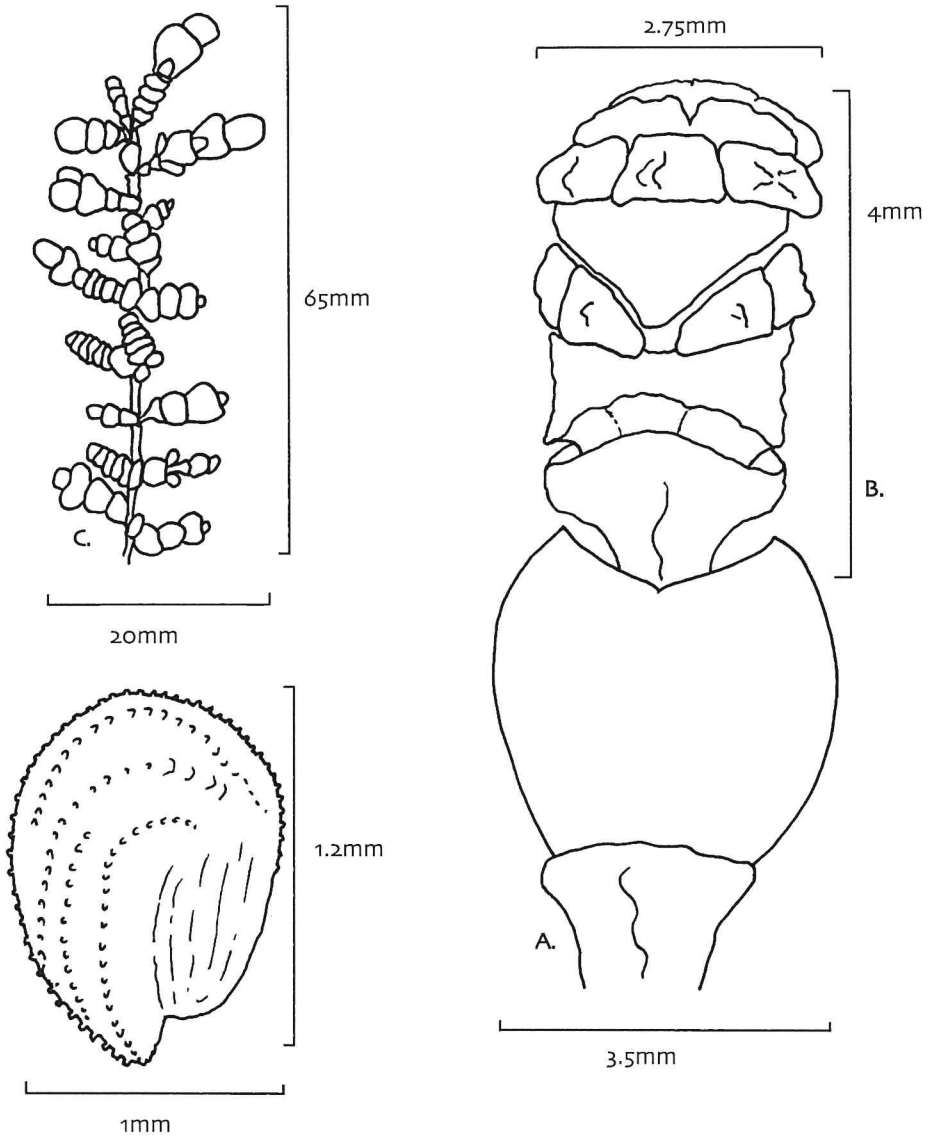
Halosarcia halocnemoides* subsp. *caudata

A. Fresh flower spike: bright yellow-green
B. Stepped bract
C. Dried flower spike
D. Seed

Halosarcia halocnemoides aff. subsp. *halocnemoides* is another common species at Lake Carey. There is a question mark over the sub-species name as it is similar to *H. halocnemoides* subsp. *halocnemoides* but should be a separate sub-species (hence 'aff.' — 'affinity to'). It is easily recognised by its tiny vegetative articles (leaves) and its old-looking, gnarled, woody trunk. The 'dusty' vegetative articles are either a yellowish green or a reddish green. There are often only 3 or 4 vegetative articles at the end of each branchlet. It grows to about a metre high and is a shrub with a bushy habit. The seeds (of the specimen collected at Lake Carey) were 0.8mm long by 0.6mm wide of a reddish brown colour and were shaped like commas. This species grows in the wettest part of the wetland profile and right up into the dunes. It is also found further away from lakes on extensive samphire flats.

True *Halosarcia halocnemoides* subsp. *halocnemoides* is found over most of Western Australia, South Australia and some of Victoria. It can be found in a wide range of habitats — tidal salt marshes, brackish seeps and saline and/or gypseous wetlands.

Figure 29 (left) *Halosarcia halocnemoides* subsp. *halocnemoides* — Creery Wetlands
Figure 30 (right) *Halosarcia halocnemoides* aff. subsp. *halocnemoides* — Shark Bay

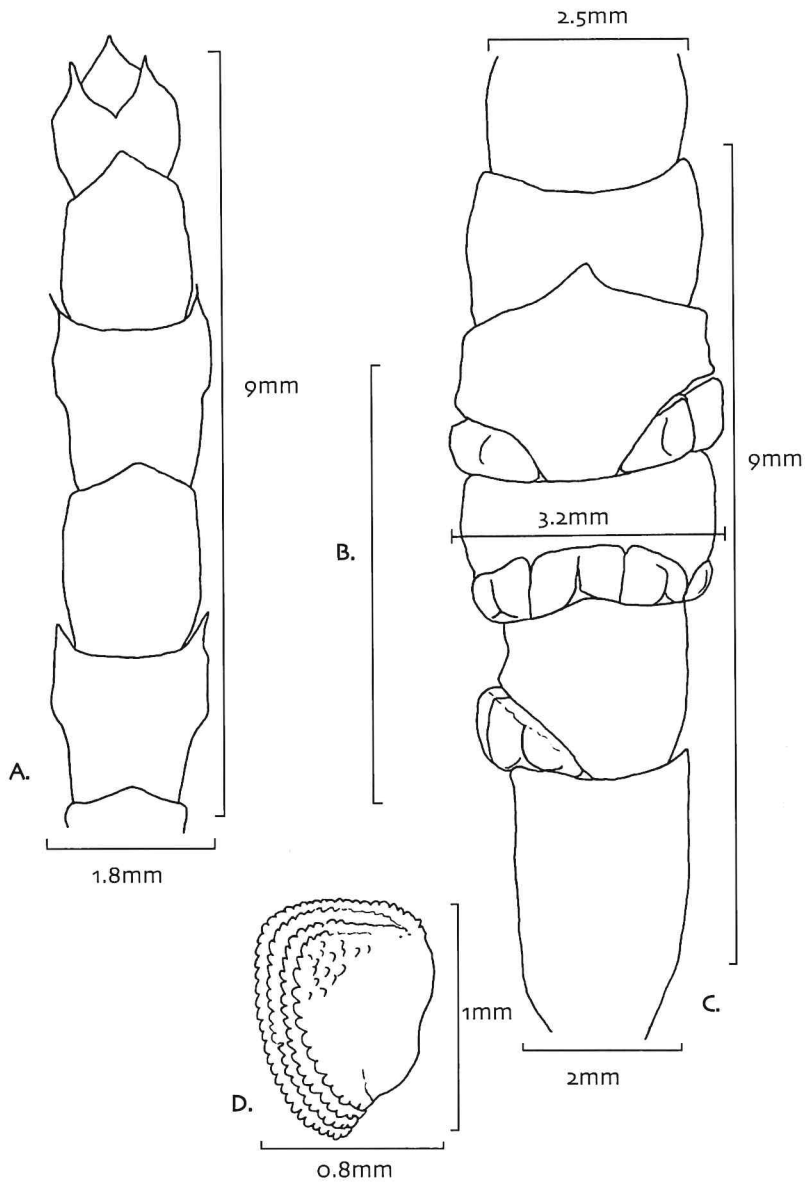


Halosarcia halocnemoides* subsp. *halocnemoides

A. Fresh flower spike: green vegetative article
B. Fresh flower spike: two tiers of dried flower triads
C. Fresh vegetative articles and flower spikes
D. Seed: black with tiny protrusions

Halosarcia halocnemoides subsp. *tenuis* is a sub-shrub growing to 30cm (though at Lake Carey it grows to 60cm), with an upright bushy habit. It grows in the wettest part of the wetland profile and out onto the lake playa. It has a dull green colour and is conspicuous in the field because of its yellow dried terminal fruiting spikes, which persist even after the seeds have been shed. The 0.8mm to 1mm seed is a pale orange-brown with darker brown concentric ridging or granulations on the outer edge.

Figure 31 *Halosarcia halocnemoides* subsp. *tenuis*



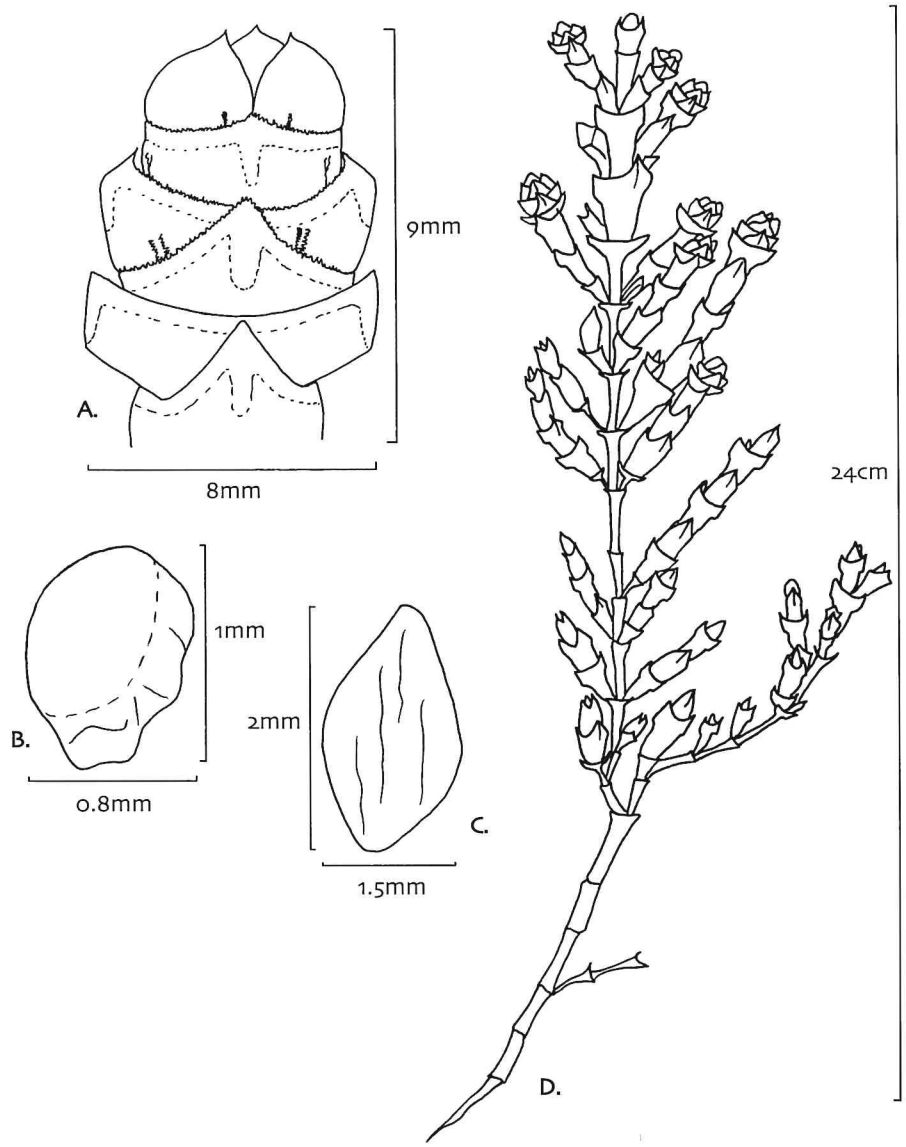
Halosarcia halocnemoides* subsp. *tenuis

A. Vegetative articles: reddish tips to bracts
B. Fresh flower spike: intercalary, red granular
C. Fresh flower spike: vegetative articles above and below
D. Seed: orange and dark brown

11. *Halosarcia indica* subsp. *bidens* is a shrub with a strongly upright habit growing up to 2m high. This sub-tropical to temperate species is found growing in well-drained saline soils. It is recognised by its persistent old flower spikes, which become grey and corky with age, and also by the 'keels' on the vegetative articles and flower spikes. The specimens of *Halosarcia indica* subsp. *bidens* from southern Western Australia are more robust than the specimens from the northern Western Australian Goldfields, which do not grow as tall. There is another variant of *Halosarcia indica* subsp. *bidens* that grows at the upper margins of slightly saline clay pans, seen near Lake Carey and Lake Rebecca. This type does not have the strong upright growth of the southern type, or even the northern Goldfields type, but is open and sprawling. It may be found to be a separate sub-species in the future. The colour of *Halosarcia indica* subsp. *bidens* varies from mid blue-green, to bright green, to yellowish green (all glaucous in varying degrees), depending on location. The edges of the bracts and keels are often red or reddish. *Halosarcia indica* subsp. *bidens* can be differentiated from other *Halosarcia indica* sub-species by the lowest bract on the flower spike, which is larger and more deeply 'keeled' (lobed) than the bracts above. The flowers are joined together and to the upper bract, and are mostly hidden behind the bracts. The seed is 1mm to 1.2mm long and is yellow, smooth skinned and difficult to extract from the fruitlet, which is very hard.

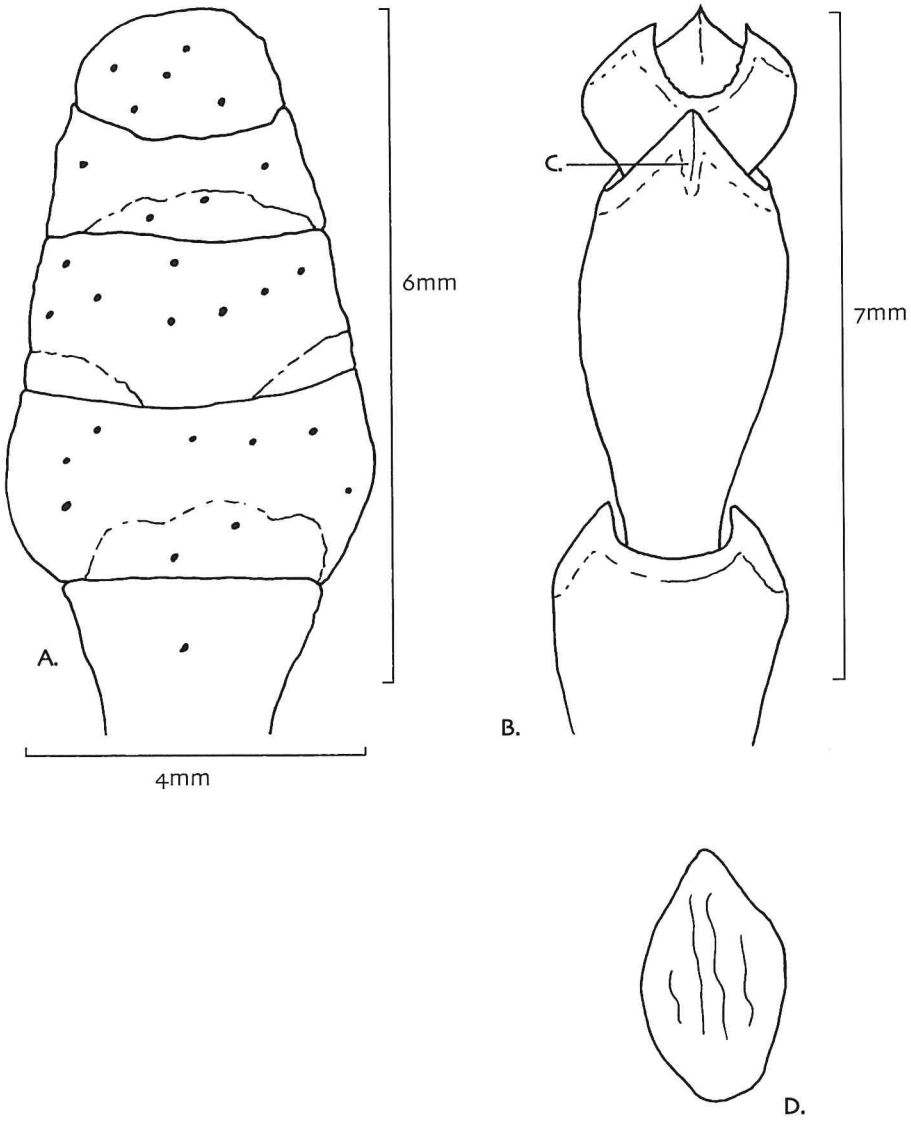
Halosarcia indica subsp. *bidens* is found throughout the south-west of Western Australia from Shark Bay south. It is also found in South Australia and Victoria.

Figure 32 *Halosarcia indica* subsp. *bidens*



Halosarcia indica* subsp. *bidens
A. Fresh flower spike: heavily 'keeled'
B. Seed: gold
C. Fruitlet
D. Branch indicating upright habit

Figure 33 *Halosarcia indica* subsp. *bidens* (slim form)



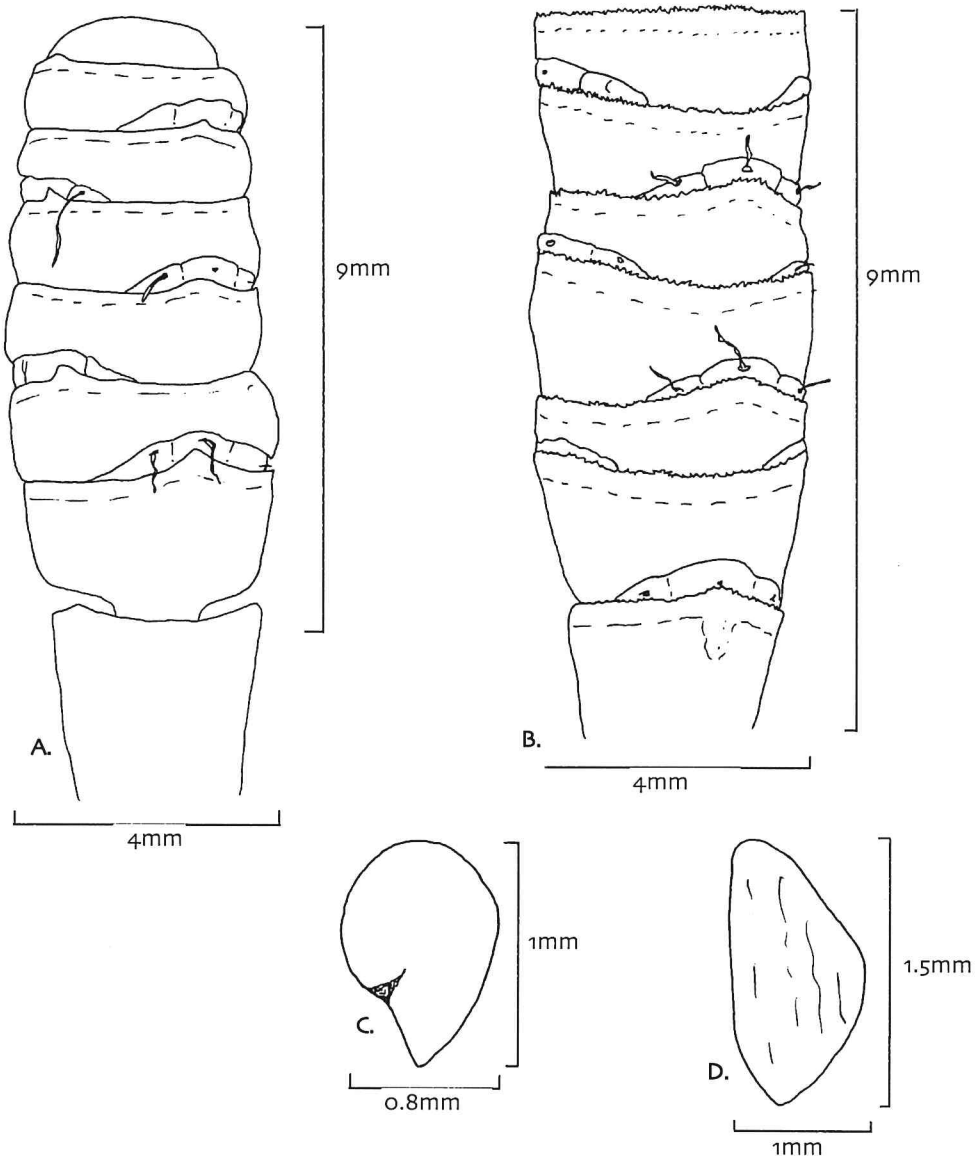
***Halosarcia indica* subsp. *bidens* (slim form)**

A. Dried flower spike: greyish, 'webby', small black nodules
B. Vegetative growth: articles 'keeled'
C. Reddish edges to keel
D. Dried fruitlet

11.1 *Halosarcia indica* subsp. *leiostachya* is a loosely upright sub-shrub growing to a height of about 40cm. It is a tropical species, unlike *Halosarcia indica* subsp. *bidens*, which is a sub-tropical species. The colour is grey-green and glaucous, with pinkish flower spikes. The flower spikes are relatively long, between 5mm and 40mm long (the specimen drawn was 20mm), and about 4mm wide. The lowest bracts of the flower spikes are smaller than or equal to the bracts above. The flowers are joined to each other and to the upper bract, and the fruitlets are not totally obscured by the bracts. Vegetative articles and flower spike bracts have ciliolate margins, though not the dried fruiting spikes. The dried fruiting spikes are pale fawn and are corky or leathery. Dried fruitlets are pale gold-brown; the seeds are 1mm long, smooth-skinned, gold-brown with a soft testa (skin).

Halosarcia indica subsp. *leiostachya* is found in tropical and sub-tropical Western Australia and the other states of Australia except Tasmania.

Figure 34 *Halosarcia indica* subsp. *leiostachya*

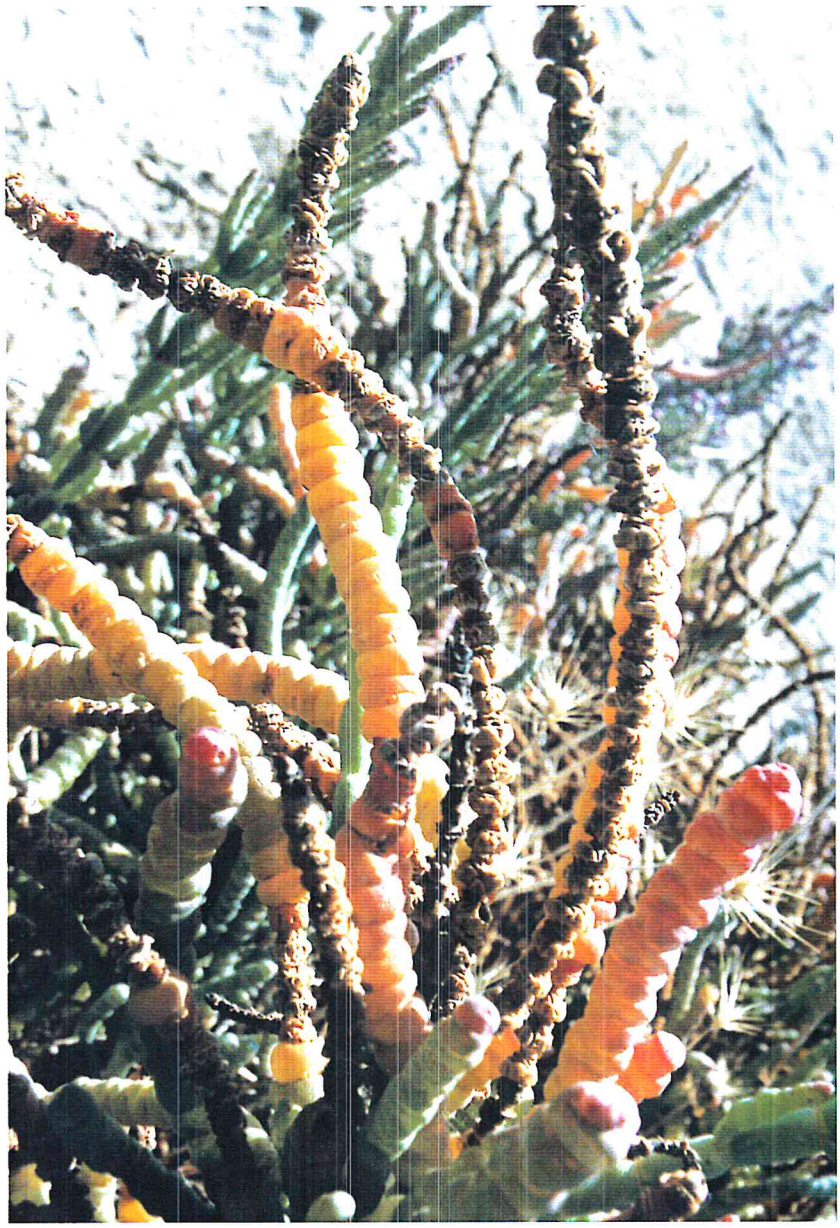


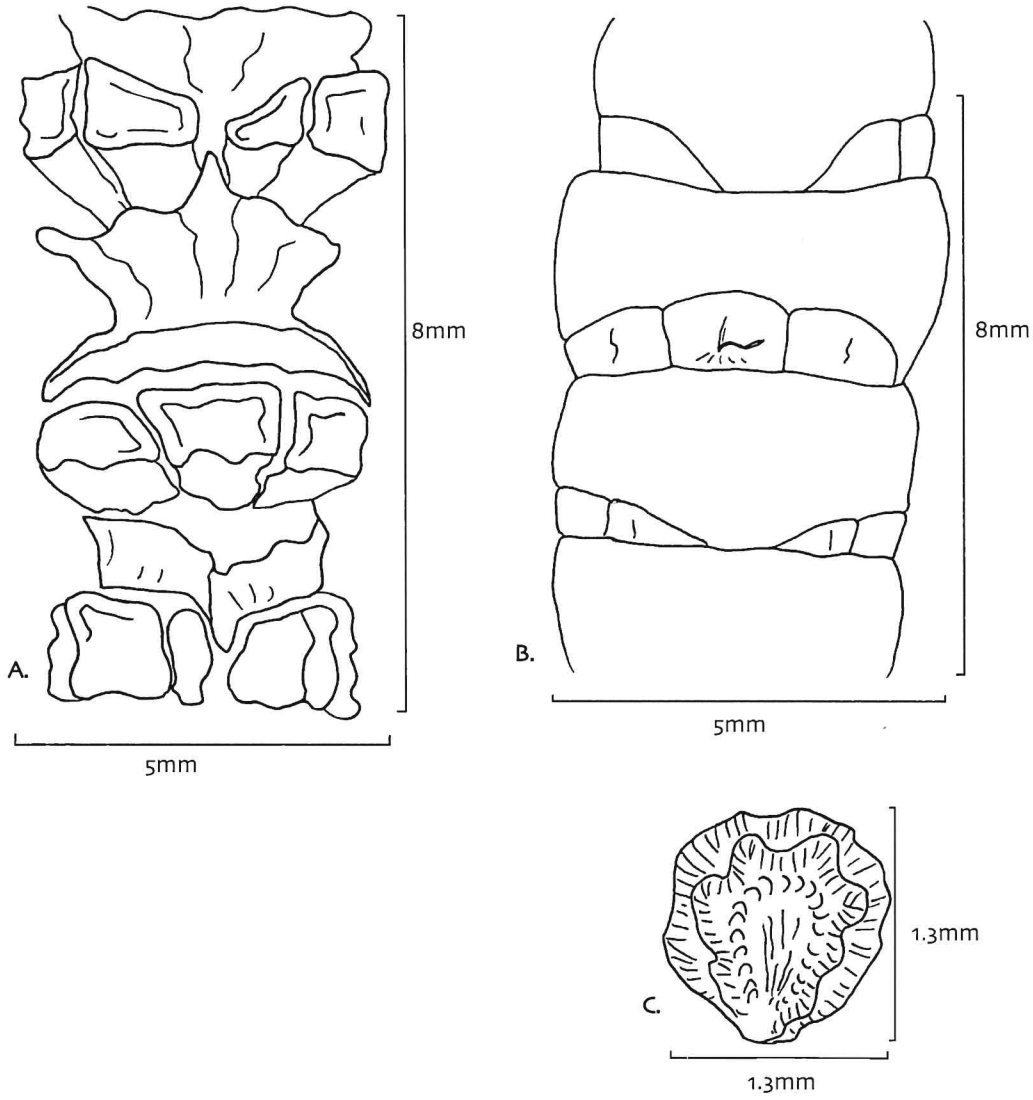
Halosarcia indica* subsp. *leiostachya
A. Dried flower spike: corky, fawn
B. Fresh flower spike: grey/green, glaucous
C. Seed: smooth soft testa, golden brown
D. Fruitlet: pale gold/brown

12. *Halosarcia lepidosperma* is a sub-shrub growing to about a metre with an upright growth habit. The flower spikes are up to 50mm long and 3mm to 5mm wide, smooth in outline and tapering at the ends. *Halosarcia lepidosperma* is mid to yellowish green, somewhat glaucous; the vegetative articles are up to 5mm wide and 10mm long. The ends of the immature flower spikes taper, the mature spikes are rounded, bract tips and the ends of the flower spikes are pinkish. The specimens drawn were found near Wagin at the Ballalying Road river flats, and at Lake Toolibin. The seed of this species is easily recognisable — it is fawn in colour and has concentric undulating ribs on the outer margins.

Halosarcia lepidosperma is found in south-west Western Australia and South Australia on moderately or slightly saline soil.

Figure 35 *Halosarcia lepidosperma*





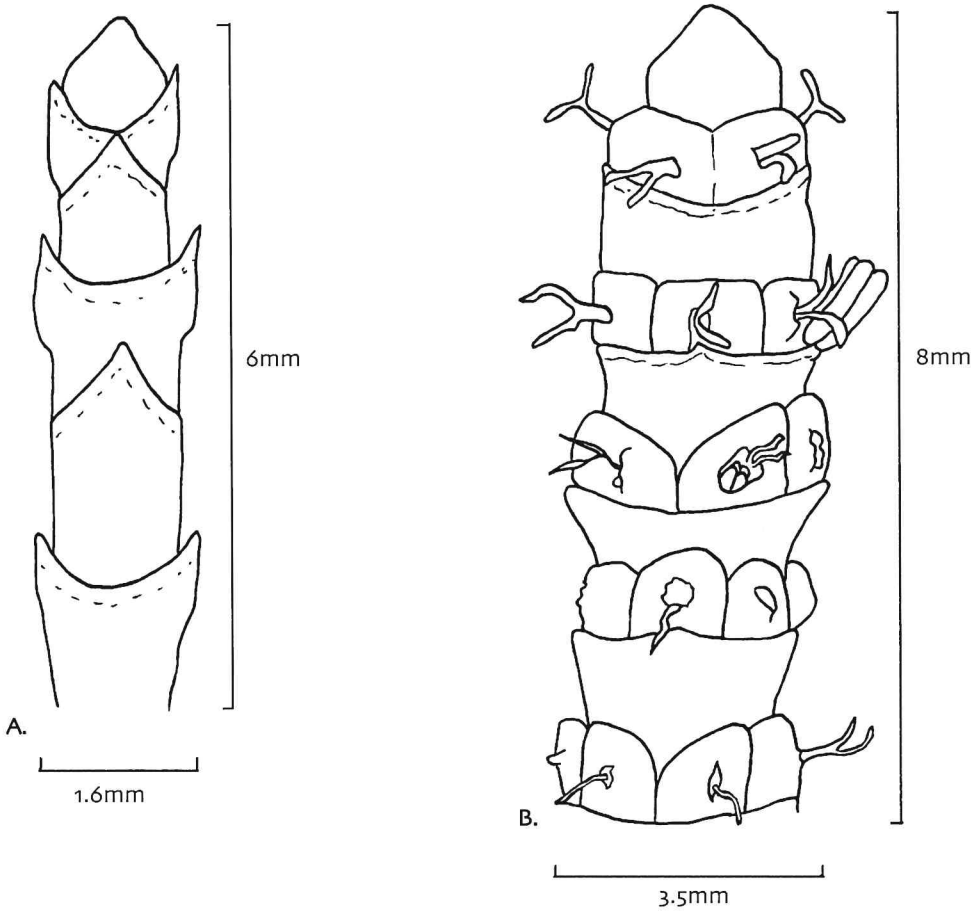
Halosarcia lepidosperma

A. Dried flower spike
B. Fresh flower spike: yellow/green with pinkish tips
C. Seed: fawn, undulating ribs

13. *Halosarcia lylei* is a woody perennial, growing to a height of 1m, with an erect, bushy habit. From a distance it is easily mistaken for a casuarina. Unlike other samphires, *Halosarcia lylei* does not have swollen vegetative articles; these are about 3mm long and 2mm wide and have pointed (apiculate) leaf-lobes. The colour is a dull mid green. The flower spikes are terminal, 20mm long by 3.5mm or 4.5mm wide, and are also dull mid green. The bracts do not hide the flowers. The fruitlets shed readily when ripe; the 1mm seeds are reddish/orange brown with rows of minute concentric granulations along the outer edge. The specimen drawn (from Lake Gilmore) had a soil sample taken from beneath it — pH6 (the lowest pH reading the author has measured at a saline wetland), 22.8% moisture and 91.72g/kg salinity.

This is a southern Australian species, from temperate to sub-tropical regions, found in Western Australia, South Australia and Victoria. All samples of this plant seen by the author were growing in soil with a pH6 to 6.5.

Figure 36 *Halosarcia lylei*

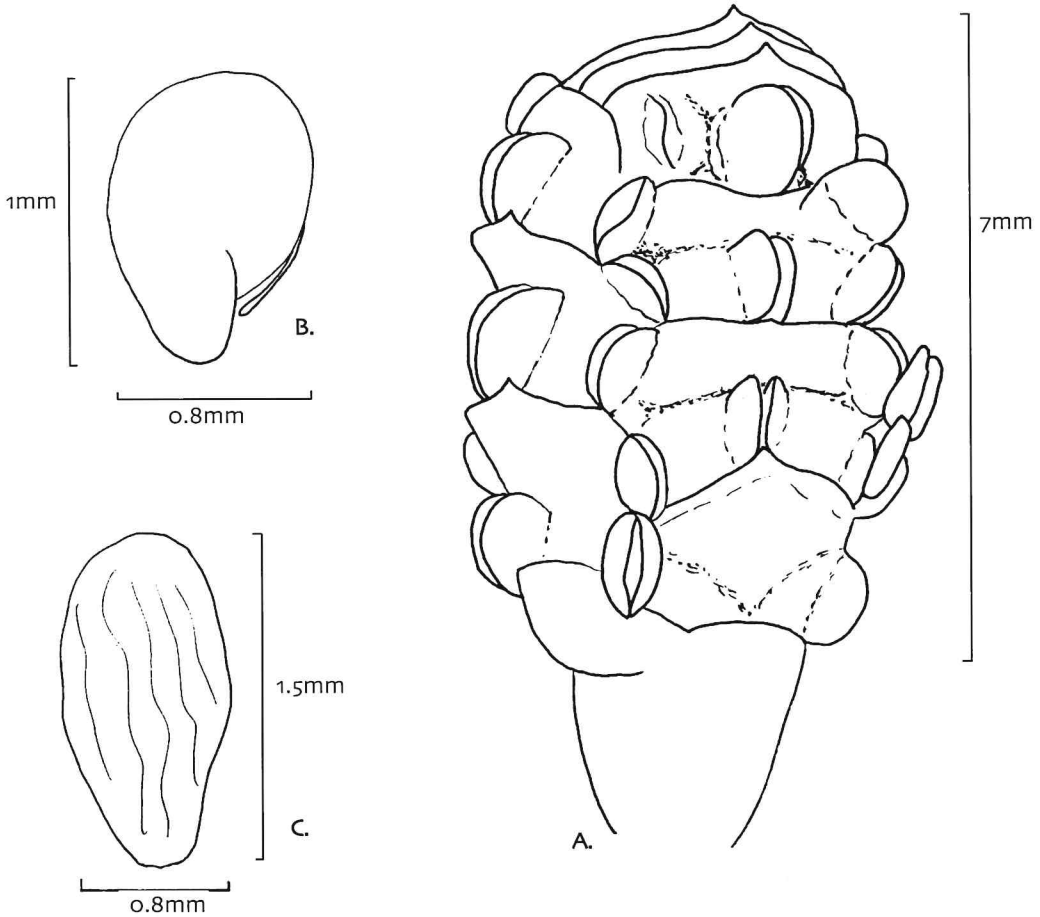


Halosarcia lylei
A. Vegetative articles: non-succulent
B. Fresh flower spike

14. *Halosarcia peltata* is a sub-shrub growing to about 1m, with an upright bushy habit. It is readily recognised while it is flowering by the round to cylindrical terminal flower spikes. These flower spikes are green with red edges to the bracts. Some samples featured prominent lobes on the bracts; in others the lobes were almost non-existent (see drawings). The bracts of the flowering spike are not joined. When the plant has finished flowering the flower spikes turn a cream colour, dry and drop off, making the plant difficult to identify. The vegetative articles are 'dusty' reddish green. The 1mm long seed has a smooth testa and is a golden yellow. This species is often found in the lowest part of the wetland profile, or in wet areas. It seems to be able to tolerate high salinity and is quite common, particularly in run-off areas and gutters. The highest salinity reading for a soil sample taken from under a *H. peltata* was 108g/kg, pH9, and 17.5% moisture.

Halosarcia peltata is found from Lake McLeod down to Northam in Western Australia.

Figure 37 *Halosarcia peltata*



Halosarcia peltata

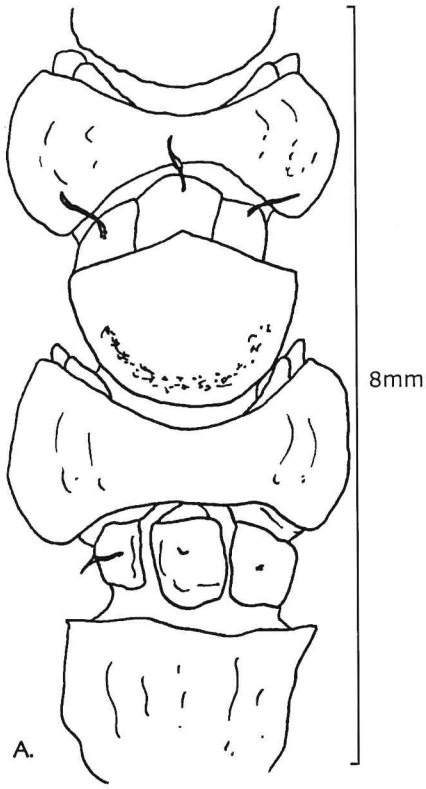
A. Fresh flower spike — reddish lobes
B. Seed: smooth, yellow/gold
C. Fruitlet: cream/brown

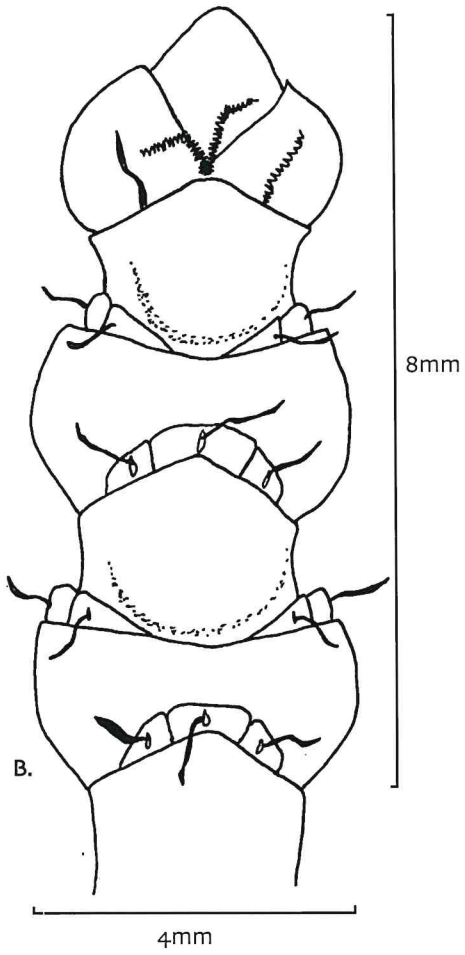
15. *Halosarcia pergranulata* can be easily recognised by taking an old dried flower spike and rubbing it between the fingers. This species has large quantities of small black seeds that are readily released by rubbing and are just visible. No other species will do this. The common name for *Halosarcia pergranulata* is black seed samphire. *H. pergranulata* is a sub-shrub growing up to 50cm with an upright but sprawling habit. This species is a good example of why one should not identify samphires by colour; some are bright purple-pink, others are mid green, and others still are a pale blue-grey green. The 'skin' of the articles (leaves) and flower spikes is glaucous (having a 'bloom' like a plum). The flowering spikes can be up to 10cm long on some sub-species of *H. pergranulata*, or only 1cm on others. The distinctive black to red-brown seed that they all have in common is covered with concentric 'ropey' ribbing over most of the surface.

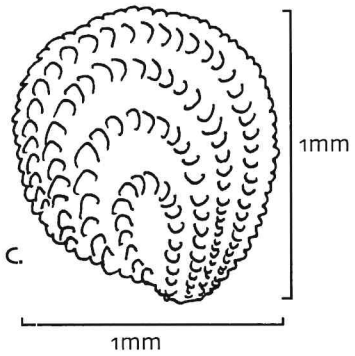
This is a species that needs to be studied further, as there appears to be much variation. From observation, the species appears to be divided into clay pan varieties, which are generally quite small and upright (to 30cm high), and varieties colonising wet disturbed areas and the margins of larger saline wetlands, which are larger and more sprawling (to 50cm high and 60cm wide). These two varieties may be eventually placed in different species; the smaller clay pan varieties are very variable in their flowering, while some have the flowers enclosed within the bracts, and one specimen was found to have the two side flowers enclosed by the bracts but the central flower free. 'Typical' *H. pergranulata* has flowers that are not joined to each other or to the bracts.

This plant is found growing in the lower parts of the wetland profile, in wet areas that are not necessarily particularly saline. It is a very common species, especially on clay pans, throughout southern Western Australia.

Figure 38 *Halosarcia pergranulata* subsp. *pergranulata*

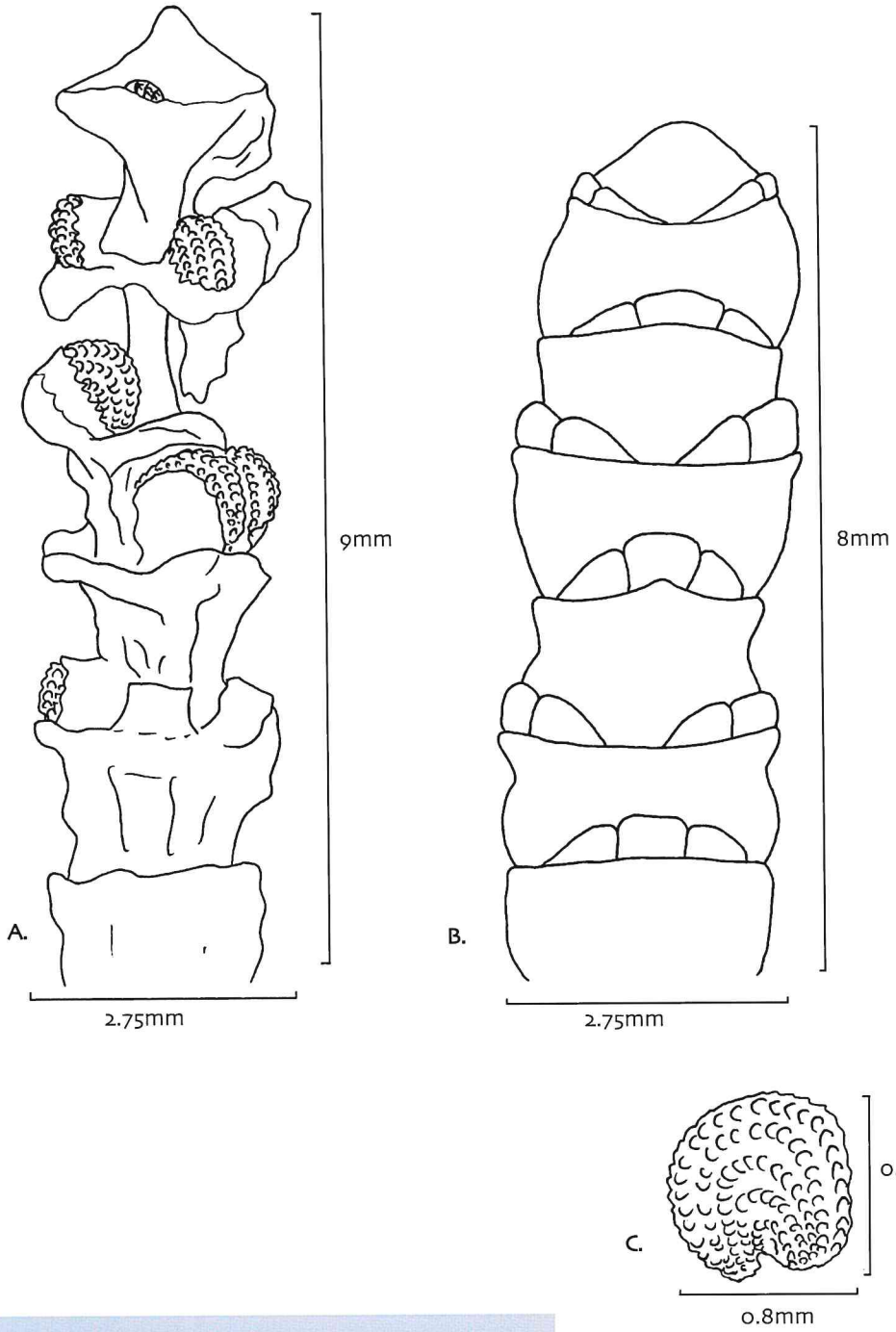






Halosarcia pergranulata* subsp. *pergranulata
A. Semi-dried flower spike
B. Fresh flower spike
C. Seed: black

Figure 39 *Halosarcia pergranulata* at a Lake Carey clay pan

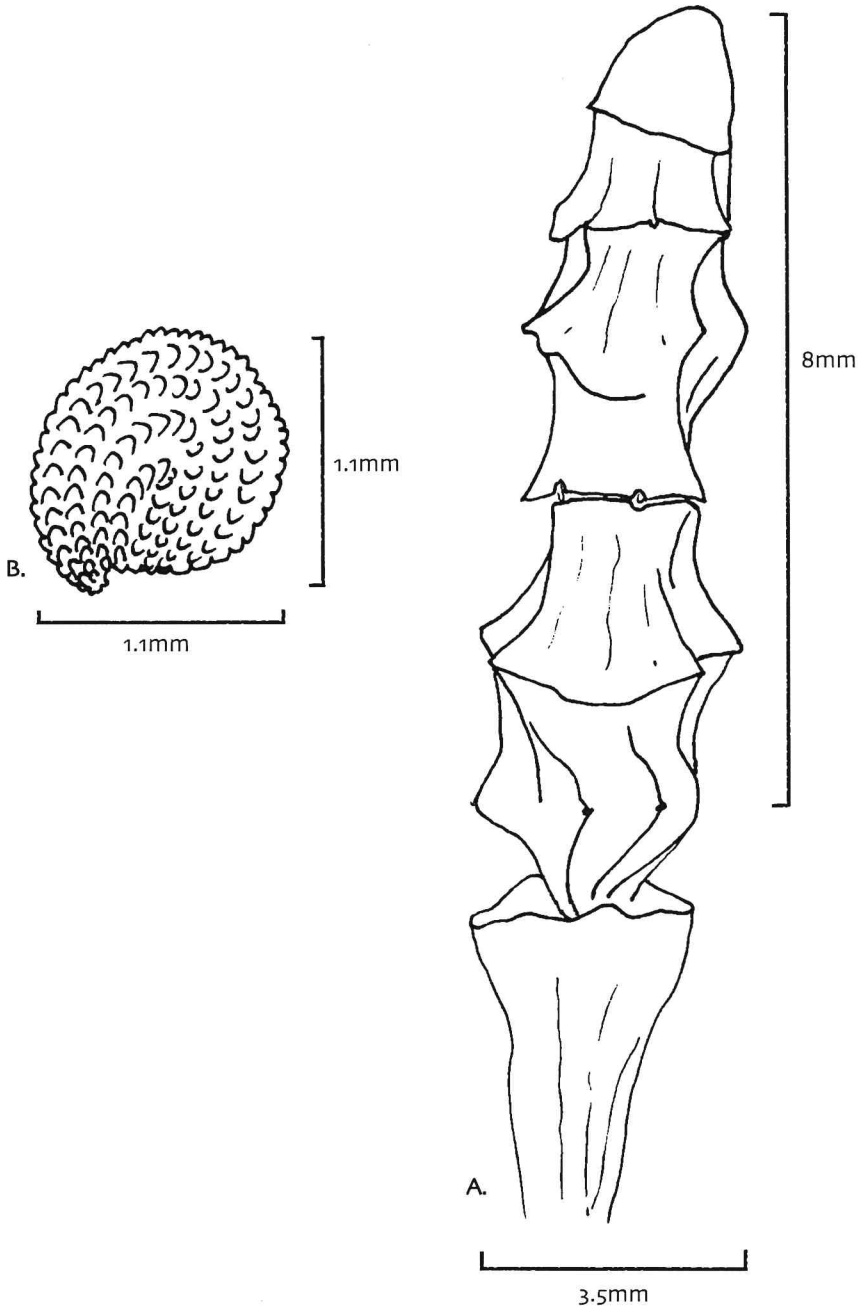


Halosarcia pergranulata* subsp. *pergranulata
A. Dried flower spike
B. Fresh flower spike
C. Seed: dark red/brown

15.1 *Halosarcia pergranulata* subsp. *divaricata* is an erect shrub, which reaches a height of 1m. The specimen drawn, however, was a young plant of 20cm. The barrel-shaped articles are pale green and slightly glaucous, measuring 7mm by 3.5mm. The articles become spongy and chartaceous with age. The lateral growth is nearly at right angles from the main stem, giving the plant an angular appearance. The flowering spikes measure about 10mm by 3.5mm. The triads of flowers are joined to each other and the upper bract but not joined to the lower bract. The dark reddish brown seed has the distinctive pergranulata concentric ropey ribbing over most of the surface, but the seed has a 'chubby' appearance and is large for a *pergranulata* (1.1mm by 1.1mm).

The plant drawn was taken from a fresh-to-brackish pan adjacent to Lake Darlot WA, where a mass germination had taken place in 1998. The plants were now adult. Two sub-species of *Halosarcia pergranulata* were growing on this pan but at slightly different elevations — the other sub-species was *Halosarcia pergranulata* subsp. *elongata*, mentioned next.

Figure 40 *Halosarcia pergranulata* subsp. *divaricata*

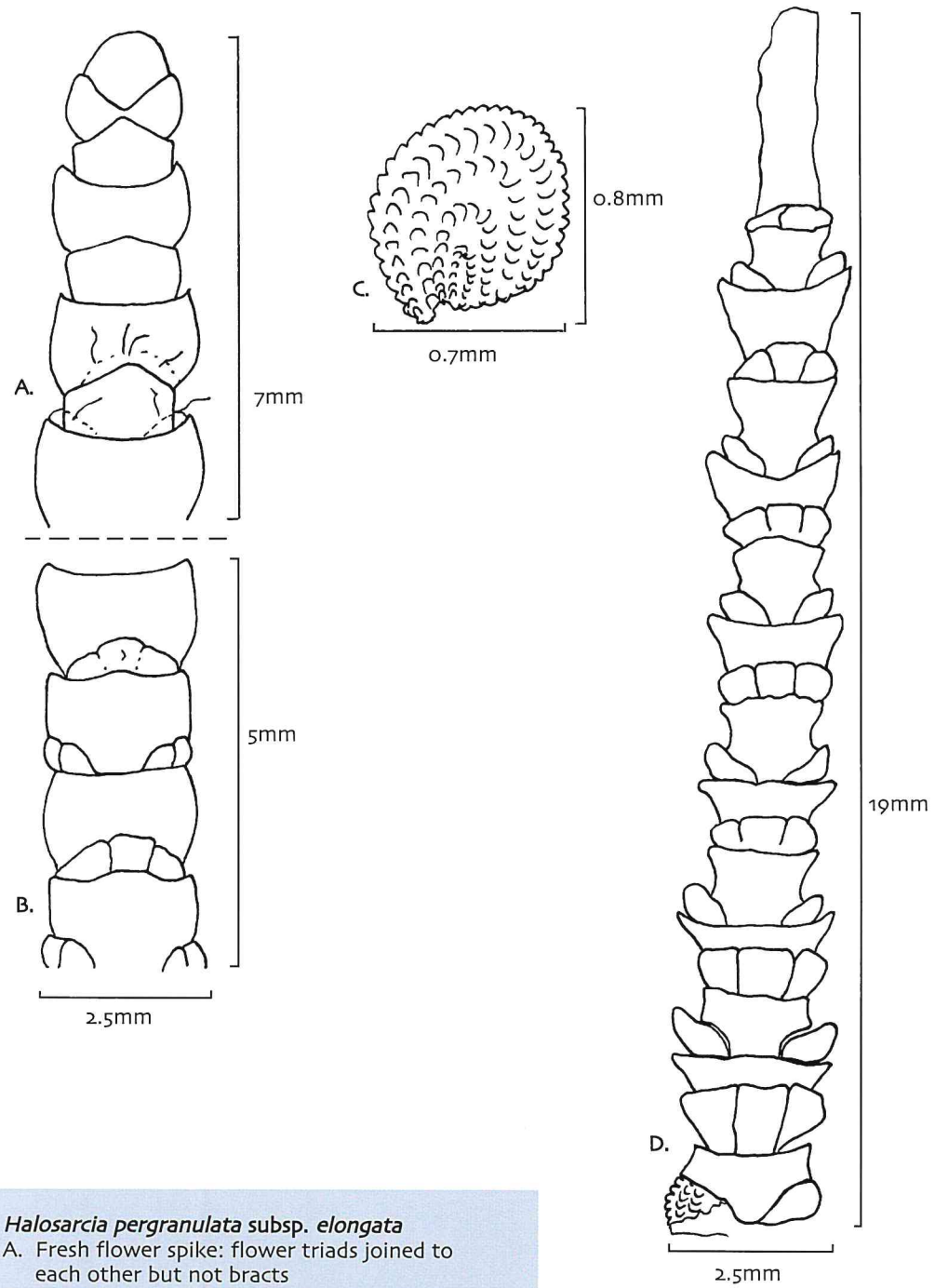


Halosarcia pergranulata* subsp. *divaricata
A. Dried flower spike: cream, chartaceous
B. Seed: dark red/brown

15.2 *Halosarcia pergranulata* subsp. *elongata* is a herbaceous short-lived perennial sub-shrub growing to about 20cm in height. It is pale green and pink and often is growing on its own en masse in freshwater clay pans. The flower spikes are long and slender — up to 60mm long by 2.5mm wide. They are slightly glaucous and are pale green with pink triads and bract margins. The flowers are in triads and when immature are joined to each other but not to the bracts. As the spike ages (oldest at the base of the spike), the flowers in the triads separate from each other and the bracts. The vegetative articles are also slender — 3mm long by 2mm wide. The seed is a dark red-brown with the distinctive pergranulata concentric ropey ribbing over most of the surface; however, the seed of *Halosarcia pergranulata* subsp. *elongata* is smaller (0.7mm by 0.8mm) than that of the more commonly seen *Halosarcia pergranulata* subsp. *pergranulata* (1mm by 1mm).

The plant drawn was taken from a fresh-to-brackish pan adjacent to Lake Darlot WA, where a mass germination had taken place in 1998. The plants were now adult. Two sub-species of *Halosarcia pergranulata* were growing on this pan but at slightly different elevations — the other sub-species was *Halosarcia pergranulata* subsp. *divaricata*.

Figure 41 *Halosarcia pergranulata* subsp. *elongata*

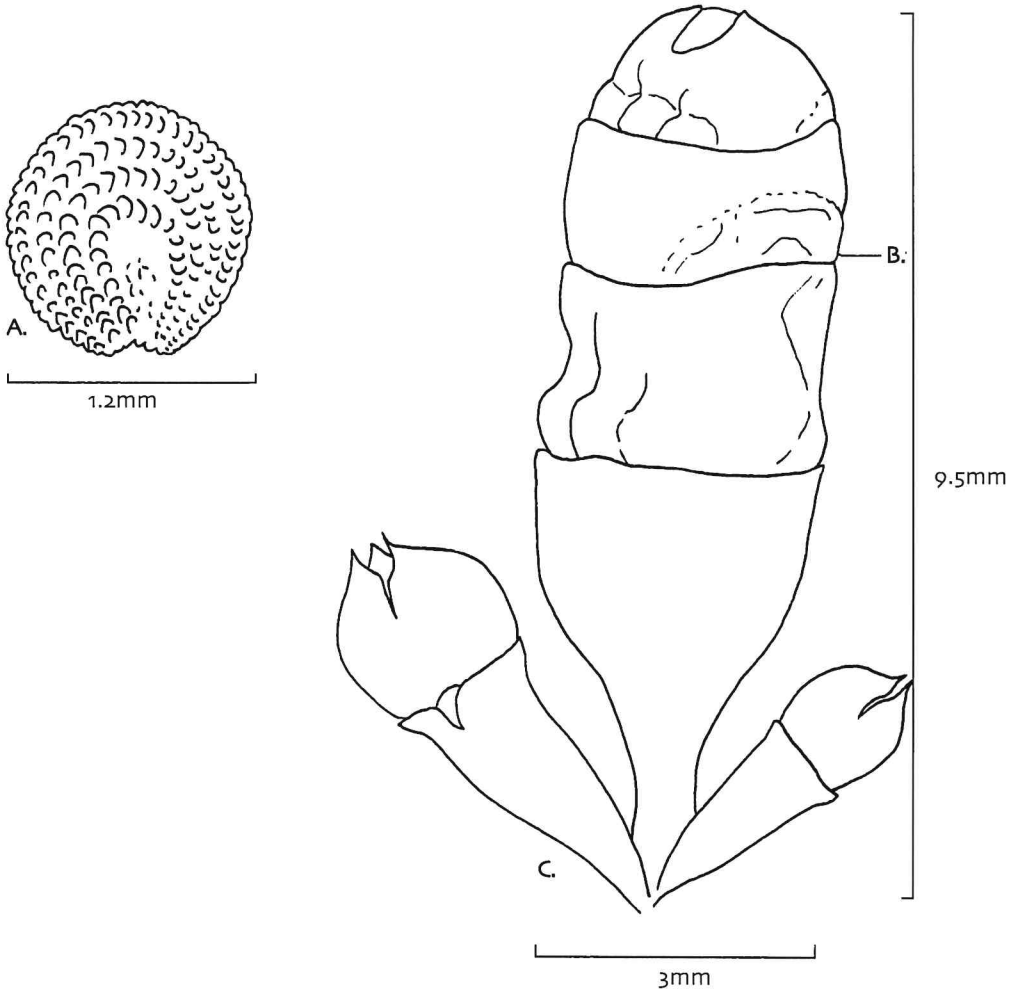


Halosarcia pergranulata* subsp. *elongata

A. Fresh flower spike: flower triads joined to each other but not bracts
B. Same flower spike: flower triads separate from each other and bracts
C. Seed: dark brown
D. Dried flower spike

Halosarcia aff. *pergranulata* 'Toolibin' is a sub-shrub growing to about 15cm in height with an upright sparse habit. It is found in a fringe at the lowest point of a slightly saline clay pan near Lake Toolibin. It differs from *Halosarcia pergranulata* in that the fruitlets are joined to each other and to the bract. It has the characteristic ropey concentric ribbing of *H. pergranulata* but the seed is quite large at 1.2mm. The plant is purple-pink and the articles and flower spikes are glaucous.

Figure 42 *Halosarcia* aff. *pergranulata* 'Toolibin'

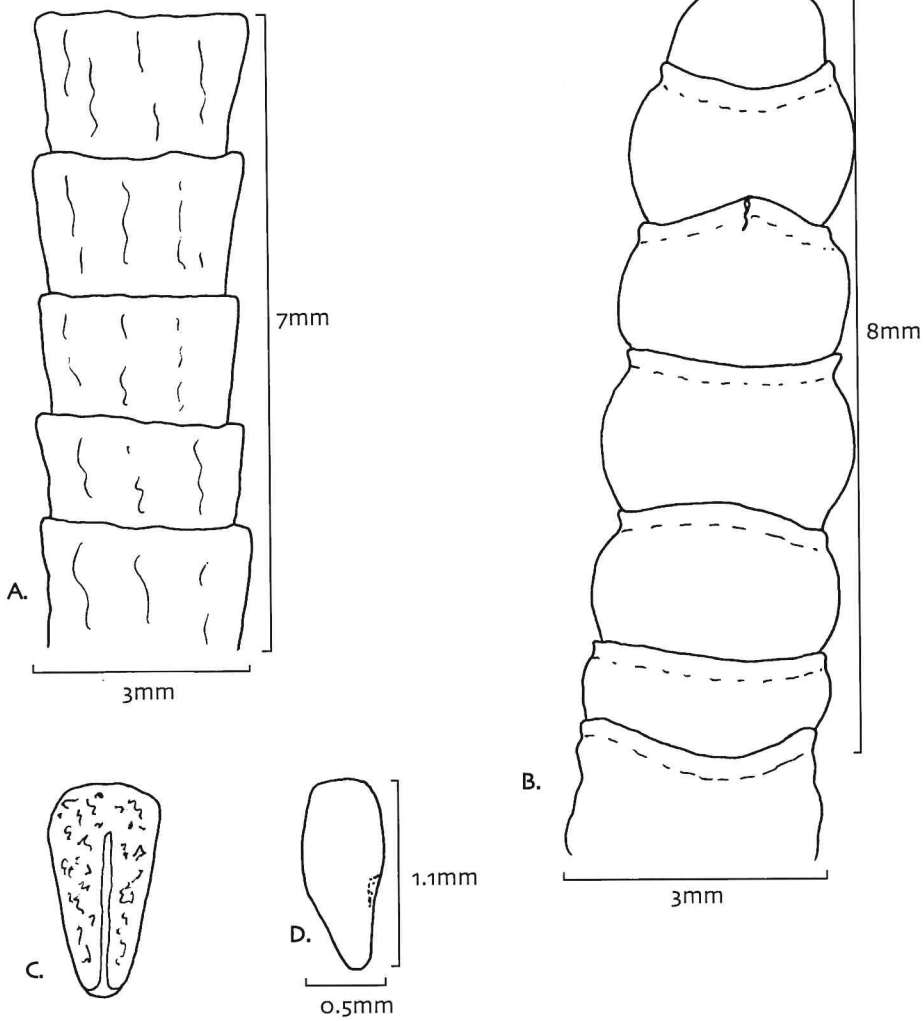


***Halosarcia* aff. *pergranulata* 'Toolibin'**
A. Seed: red/brown
B. Fruitlets joined to each other and bract
C. Semi-dried flower spike: purple-pink, glaucous

16. *Halosarcia pruinosa* is a sub-shrub growing to about 1m in height (though more often it is about 40cm high), with a bushy upright habit. It has a dusty grey-green appearance, with a hint of pink or purple, especially on the tips. The old flower spikes sometimes become intercalary. It can be recognised by the persistent old flower spikes that are mostly even in outline, unlike those of *H. undulata* (a similar species), which are 'undulate'. The flowers/fruitlets are totally covered by the bracts. The fruitlets are roughly pyramidal in shape and are covered in rough woolly-looking fibres. The 1mm seeds within are a pale yellow brown with a smooth testa. *H. pruinosa* is the most versatile of the samphires at Lake Carey, being found from the lake playa, up through the beach profile and into the wetter depressions in the dunes. It tolerates high salinity, waterlogging, and dry conditions. The results of a soil sample taken from under one of the specimens drawn, were pH9, 38% moisture and 102g/kg salinity.

Halosarcia pruinosa is widespread over central Australia.

Figure 43 *Halosarcia pruinosa*



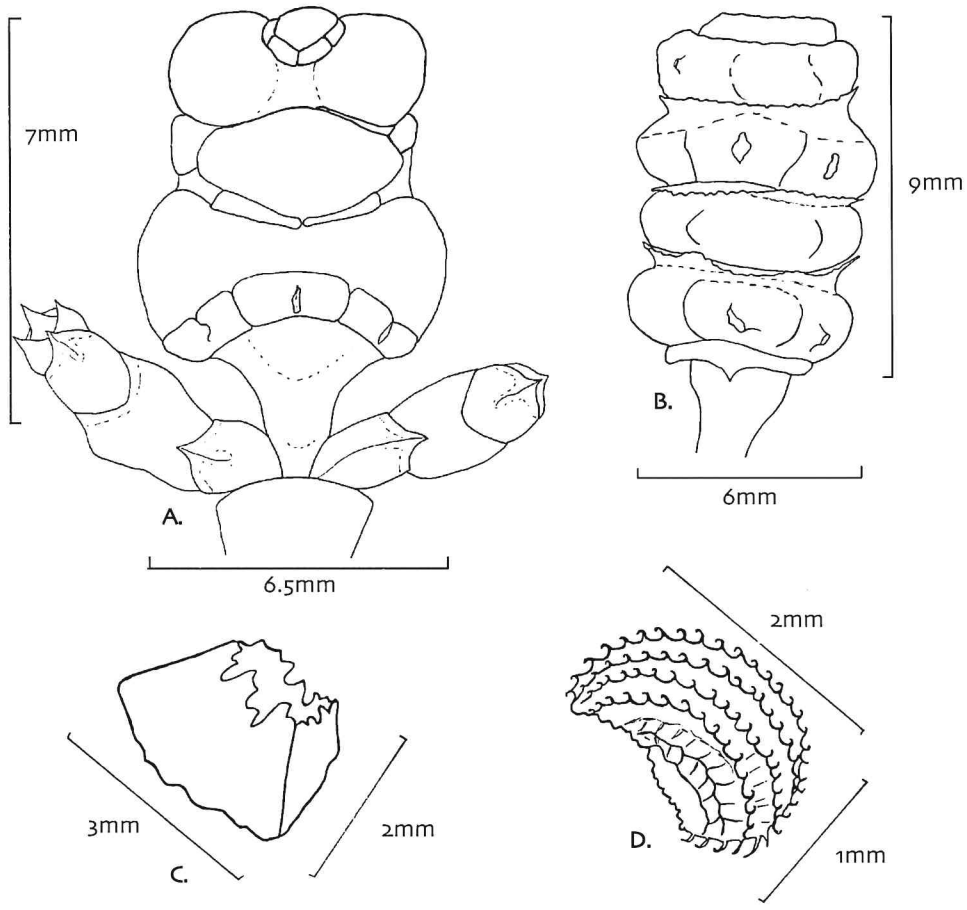
Halosarcia pruinosa

A. Dried flower spike
B. Fresh flower spike: light to mid green
C. Dried fruitlet: 'woolly', light yellow brown, top view
D. Seed: yellow/brown, thin testa

17. *Halosarcia pterygosperma* subsp. *denticulata* is a sub-shrub growing to a height of 20cm, though often prostrate, with a sprawling habit. The specimen drawn was found on tidal gypsum flats near Useless Loop in Shark Bay, WA. The flowering spike is reddish and is 7mm long by 6.5mm wide. All spikes on the plants seen contained only 3 or 4 segments. The dried spike is a yellow-cream colour and is 'spongy' like the spike of *Halosarcia peltata*. There is a hard 'stalk' in the centre of the spike — the dried bracts and fruitlets slide off, leaving the stalk. The fruitlets when dry resemble papery bags. The seed is quite large for a samphire, being 2mm by 1mm, and is covered in concentric spiny ribbing, which is similar to *Halosarcia pterygosperma* subsp. *pterygosperma*, but the ribbing tends to be united at the base and the ribbing in the specimens seen tended to be hooked.

Halosarcia pterygosperma subsp. *denticulata* is found on the coast between Port Hedland and Shark Bay in Western Australia.

Figure 44 *Halosarcia pterygosperma* subsp. *denticulata*



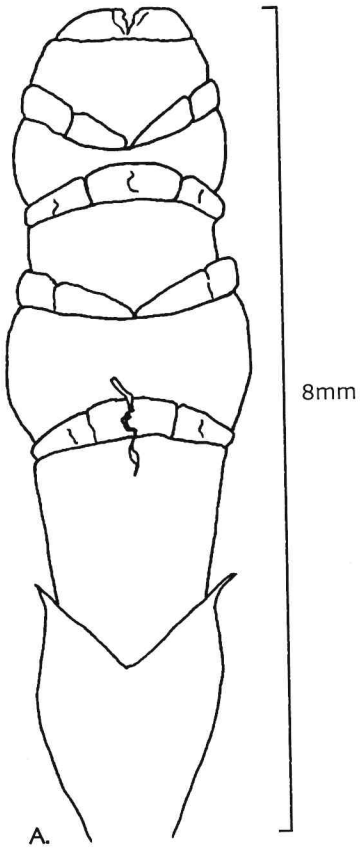
Halosarcia pterygosperma subsp. *denticulata*

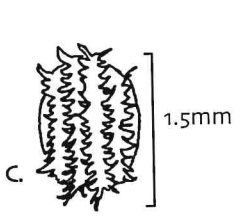
A. Fresh flower spike: red
B. Dried flower spike: yellow/cream, chartaceous
C. Fruitlet: dry papery 'bag'
D. Seed: ribbed and hooked

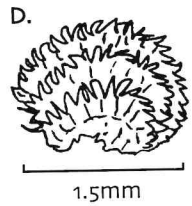
17.1 *Halosarcia pterygosperma* subsp. *pterygosperma* is a sub-shrub growing to a height of 50cm, with a somewhat sprawling habit. It is normally found on the upper margins of salt lakes, though interestingly it has been found growing high (up to 10m up) on gypseous islands on lakes in the Goldfields, almost exclusively underneath casuarina trees. It is mid green, sometimes glaucous, sometimes with a yellowish or reddish tinge to the flower spikes. There is no mistaking this species when the seed is seen under magnification — it is 1.5mm long, fawn like that of *H. lepidosperma*, but is covered in concentric spiny ribbing (like a hedgehog) instead of *H. lepidosperma's* rows of undulating ribbing. The fruitlets when dry resemble papery bags and drop from the spike readily.

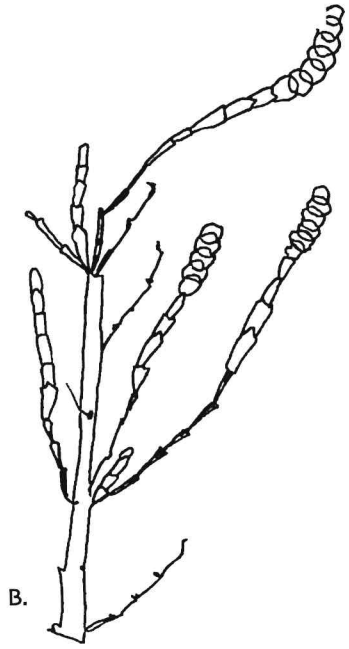
Halosarcia pterygosperma subsp. *pterygosperma* is found in the south-west of Western Australia, South Australia, New South Wales and Victoria.

Figure 45 *Halosarcia pterygosperma* subsp. *pterygosperma*







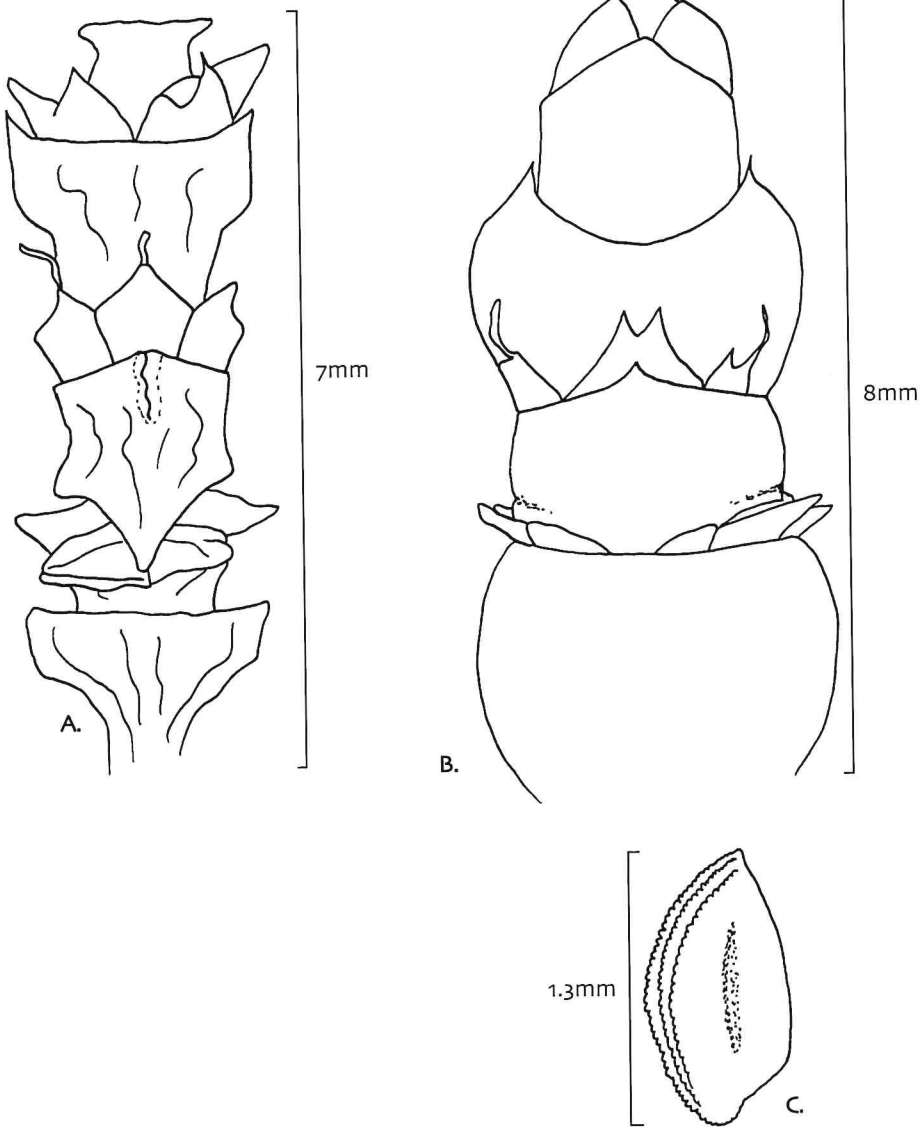


Halosarcia pterygosperma* subsp. *pterygosperma
A. Fresh flower spike: mid green, yellowish perianth
B. Fresh branch with flower spikes
C. Seed: top view, pale brown
D. Seed: side view

18. *Halosarcia syncarpa* is a sub-shrub growing to a height of 1m (though most specimens drawn were between 20cm and 40cm), with an upright habit. The mid to bright green vegetative articles are somewhat heart-shaped, often with a reddish tinge to the bases. The vegetative articles are usually glossy, and can have a reddish tinge. *H. syncarpa* is often found growing on the margins of highly saline lakes (up to 128.4g/kg salinity), but is not usually found in the lowest part of the playas or pans. The flower spikes and articles usually only consist of 1 to 3 segments, but can contain up to 7. The intercalary flower spikes are either terminal or lateral with vegetative growth developing from the end of the spikes. The ends of the flowers/fruitlets protrude strongly above the edge of the bracts and the flower triads or fruitlets are joined together. The seeds are difficult to remove from the fruitlets and are a golden brown with rows of 'bumps' or tiny nodes on the longest edge. The seeds are about 1.2mm to 1.6mm long.

Halosarcia syncarpa is found in the south-west of Western Australia.

Figure 46 *Halosarcia syncarpa*

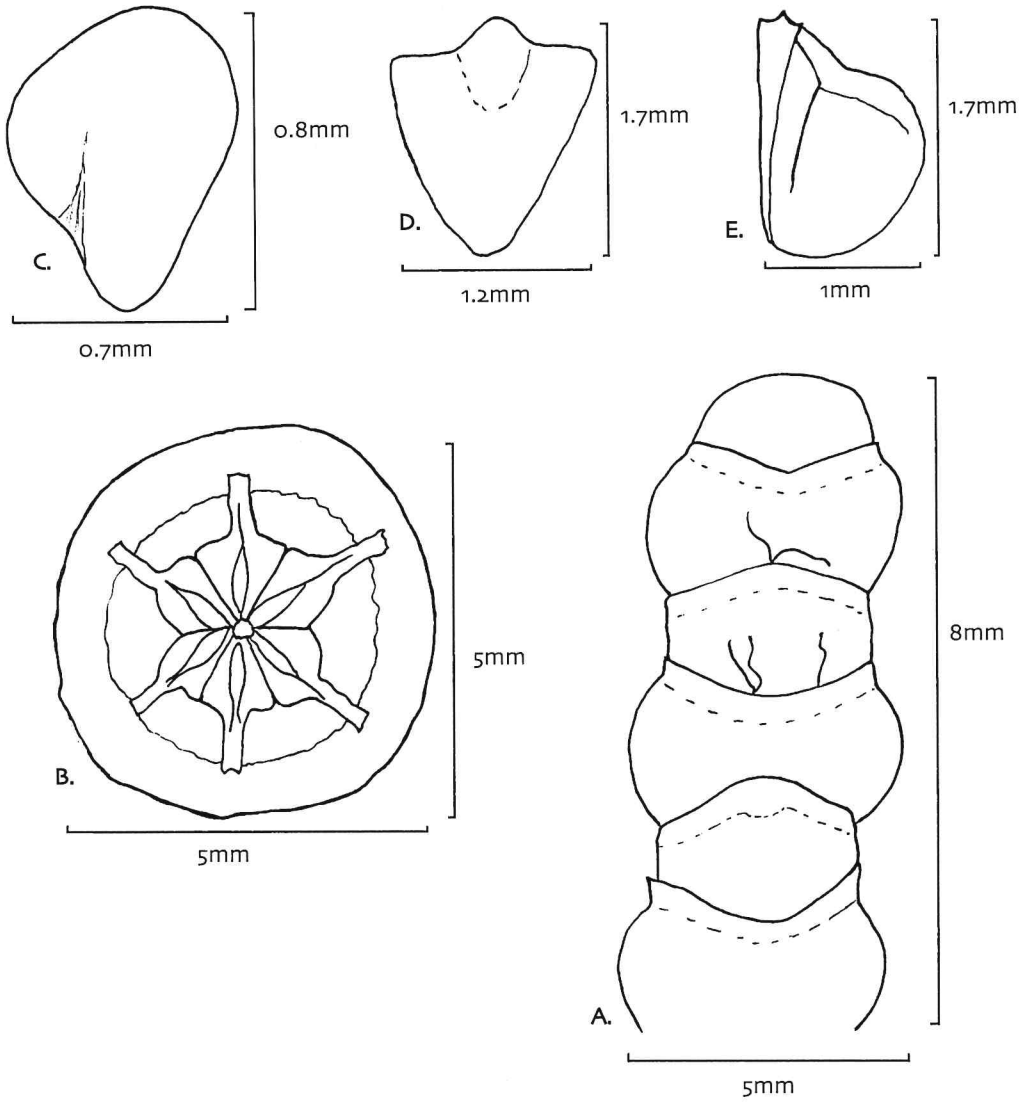


Halosarcia syncarpa
A. Dried flower spike
B. Fresh flower spike
C. Seed: gold/brown, minute granulations

19. *Halosarcia undulata* is a species that is very variable in morphology; even at Lake Carey there are several types. It is recognised by the flower spikes, which are up to 30mm long, tapering, and undulate in outline. The flower spikes can be either terminal or lateral. *H. undulata* is a sub-shrub of sprawling habit, growing to about 40cm, depending on the sub-species. *H. undulata* is found mainly in the lower part of the wetland profile and is one of the more common species at Lake Carey. The flowers of *H. undulata* are joined to each other and to the upper bract. The soft-skinned seed is about 1mm long and pale yellow to yellow-brown in colour.

Halosarcia undulata is found over most of southern Western Australia and in southern Northern Territory and northern South Australia.

Figure 47 *Halosarcia undulata*



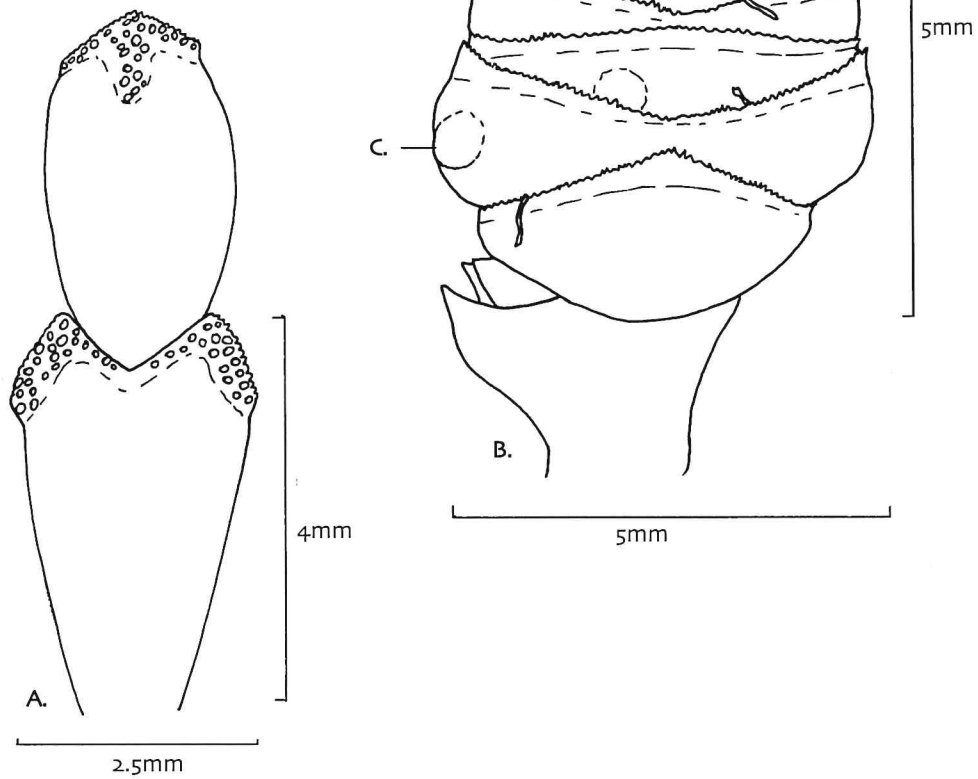
Halosarcia undulata

A. Fresh flower spike: reddish green
B. Underneath of bract: fruitlets *in situ*
C. Seed: golden brown
D. Fruitlet: 'goosefoot', top view
E. Fruitlet: side view

20. *Halosarcia* aff. *undulata*. There are a number of *H. undulata*-like variants that show enough differences to be recognised as distinct species. They are known loosely as *Halosarcia* aff. *undulata*, until they are studied further and placed in their own taxonomic grouping.

Halosarcia aff. *undulata* 'Mt Morgan' has been previously thought of as a hybrid of *H. undulata*, but it now appears to be a distinct species, possibly in the same group as *H.* 'Angelfish Island'. On Lake Carey itself, it appears as a solitary, compact sub-shrub and is often found dead. This is presumably because its preferred habitat is not the open lake but large clay pans beside the lake, where it is found growing almost exclusively. It is an open 'scrappy' sub-shrub with small 2mm by 4mm purple-green glaucous vegetative articles. The flower spikes are terminal, about 10mm by 0.6mm, and are round to barrel-shaped. The seed is similar to that of *Halosarcia undulata*. This species is not common on Lake Carey itself, but very common on some clay pans adjacent to Lake Carey. It is found on other lakes in the northern Goldfields.

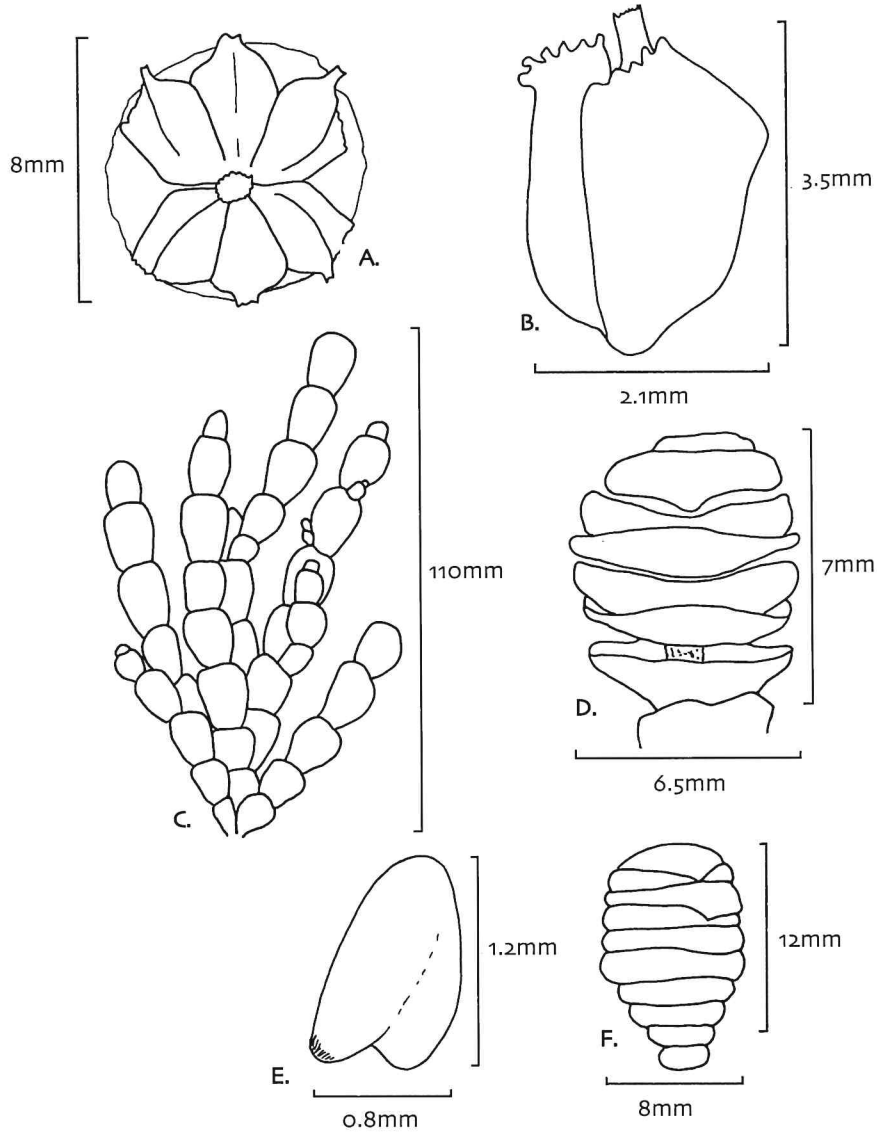
Figure 48 *Halosarcia* aff. *undulata* 'Mt Morgan'



***Halosarcia* aff. *undulata* (Mt Morgan)**
A. Vegetative articles: 'keeled', reddish
B. Fresh flower spike: reddish
C. Fungal wart

20.1 *Halosarcia* aff. *undulata* 'Barlee' is another *undulata* species that will probably end up in the same grouping as *Halosarcia* 'Angelfish Island'. The vegetative articles are mid green with a grey-blue 'bloom'. The seed is 1.2mm long by 0.8mm wide and is a greyish brown. It is very common at Lakes Barlee and Ballard. The flower spikes are both terminal and lateral and are barrel-shaped to elongate.

Figure 49 *Halosarcia* aff. *undulata* 'Barlee'



***Halosarcia* aff. *undulata* (Barlee)**

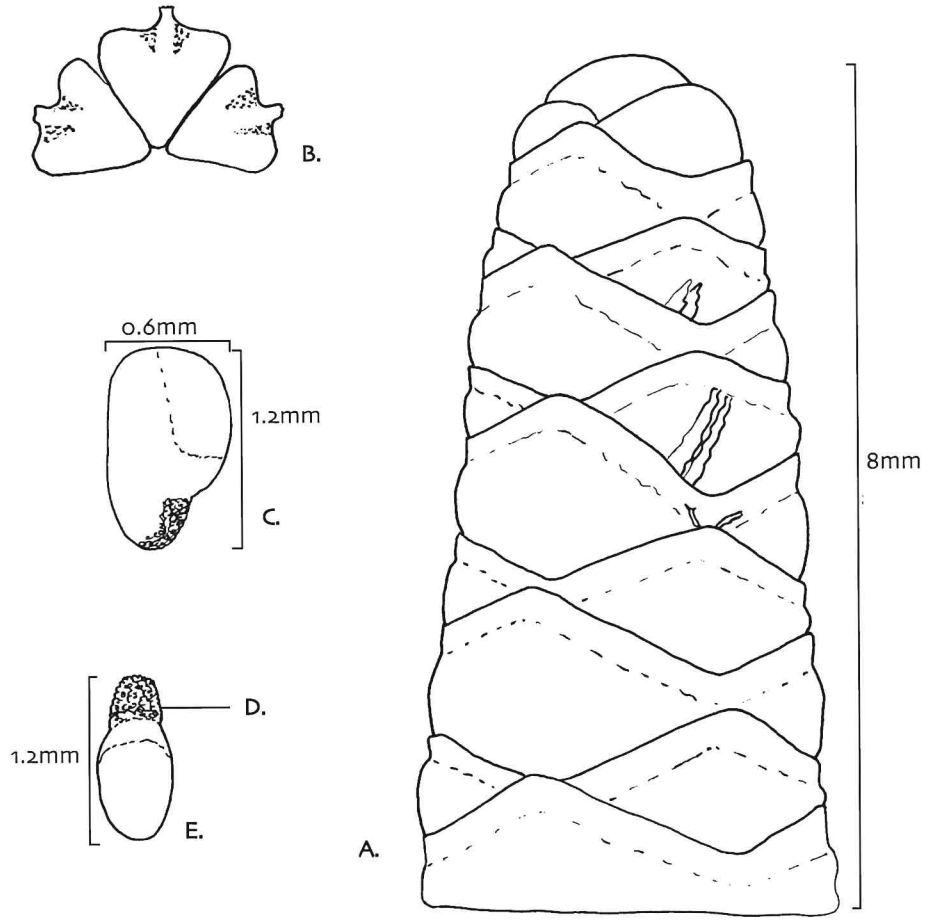
A. Flower bract with two fruitlet triads
B. Fresh fruitlet
C. Vegetative articles: mid green, grey/blue 'bloom'
D. Flower spike: semi-dried
E. Seed: greyish/fawn
F. Flower spike: fresh

20.2 *Halosarcia* aff. *undulata* 'Nigracauda'

'Nigracauda' is yet another *undulata*-like halosarcia that could end up in the same grouping as *Halosarcia* 'Angelfish Island'. Superficially it resembles *Halosarcia* 'Angelfish Island' except that the flower spikes are elongated and pointed, and are as often lateral as they are terminal. The reason for the working name is the distinctive brown-black 'tail' on the seed, not seen in other *undulata*-like plants.

Halosarcia aff. *undulata* 'Nigracauda' has only been found at Lake Carey in the Goldfields of Western Australia.

Figure 50 *Halosarcia* aff. *undulata* 'Nigracauda'

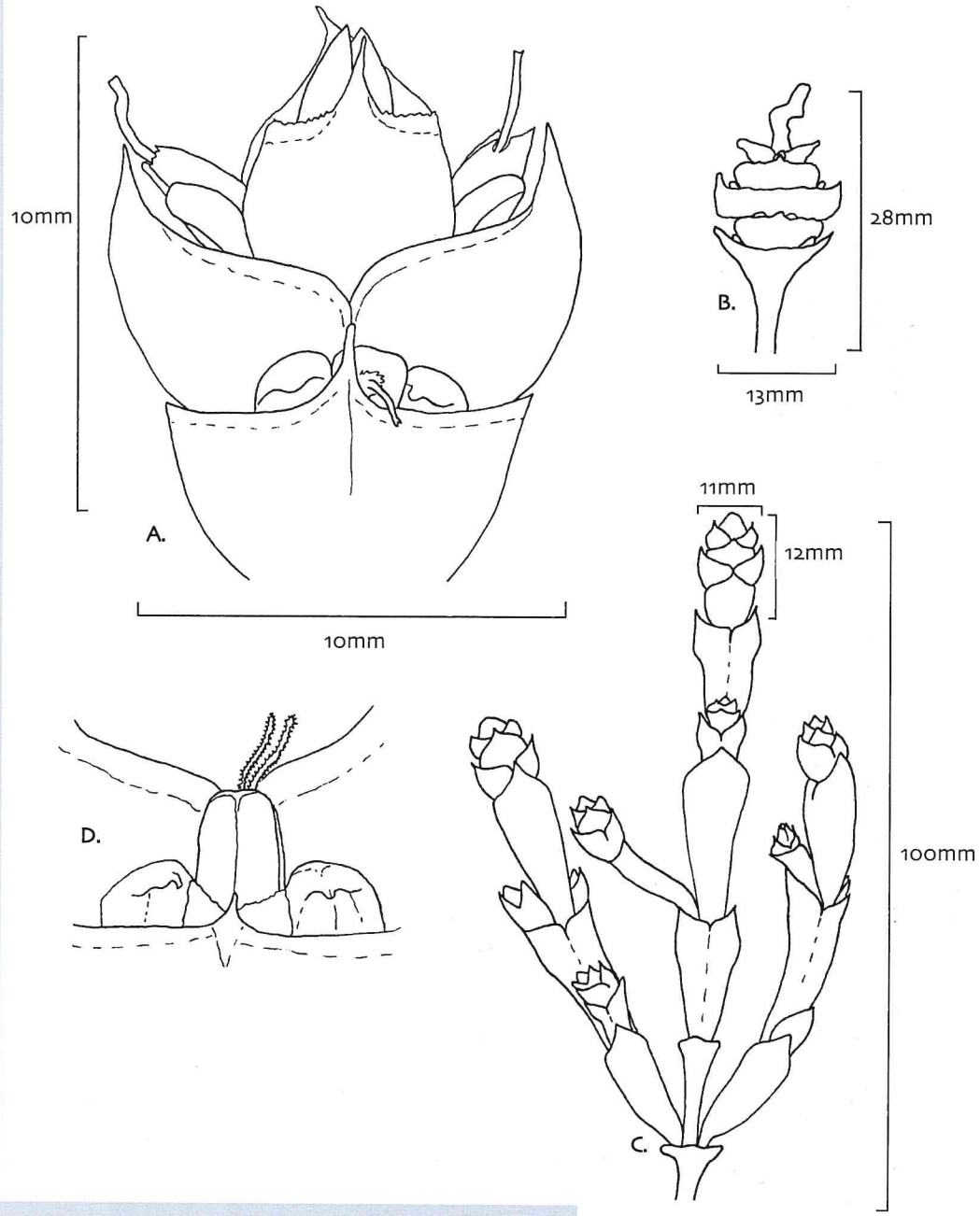


***Halosarcia* aff. *undulata* 'Nigracauda'**
A. Fresh flower spike: reddish
B. Dried triad of fruitlets
C. Seed: side view, yellow, black 'tail'
D. Seed: black/brown 'tail'
E. Seed: top view

21. *Pachycornia triandra* is a sub-shrub growing to about 50cm high. It is bright green with fleshy, lobed vegetative articles. These articles are nearly divided by a groove running down the length. The seed spike is persistent, black, woody and about 15mm by 10mm. Because the seed spike was so hard it was not possible to extract the seed to draw.

This species is not common at Lake Carey. It is found in other states of Australia and near Kalgoorlie, Western Australia, but it is not common anywhere. It has only been found at Lake Carey in the area known as 'Salinaland', a large natural inflow area, heavily invaginated and away from the lake proper. It grows at Lake Carey in well-drained, gypseous red loam about a metre up from the lake playa.

Figure 51 *Pachycornia triandra*



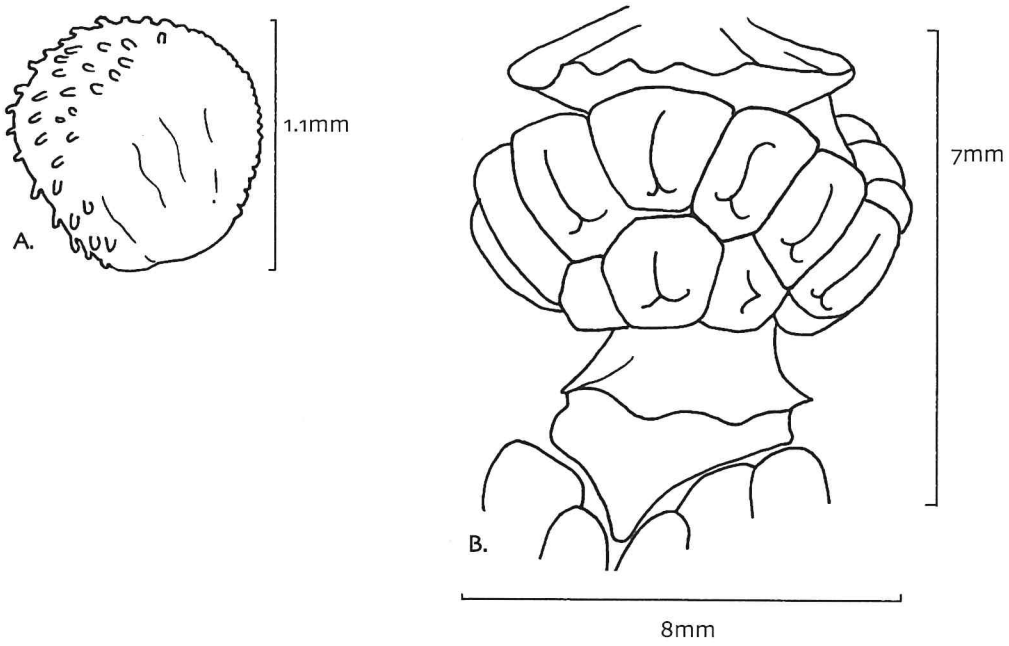
Pachycornia triandra

A. Fresh flower spike: bright green
B. Dried flower spike: hard and woody
C. Vegetative articles and flower spikes
D. Triad of flowers: hermaphrodite central flower, male side flowers

22. *Sarcocornia blackiana* is a perennial herb or low-growing sub-shrub. It has a sprawling, erect habit and often roots at the nodes, growing to a height of 80cm, though specimens seen by the author were only up to 30cm high. The vegetative articles were up to 10mm by 7mm, mid green with reddish tinges. It can be differentiated from *S. quinqueflora* by the flowering spike — there is often an extra flower beneath the central flower — giving it a two-tiered appearance. The flower spike can be from 20mm to 50mm long by about 8mm wide. The seeds are cream-coloured, covered with nodules or hairs, and measure 1.2mm long. *S. blackiana* is found growing in periodically waterlogged saline soils.

Sarcocornia blackiana is found on the coast from Geraldton down to Esperance and the wheatbelt in between, and coastal South Australia, Victoria and Tasmania.

Figure 52 *Sarcocornia blackiana*

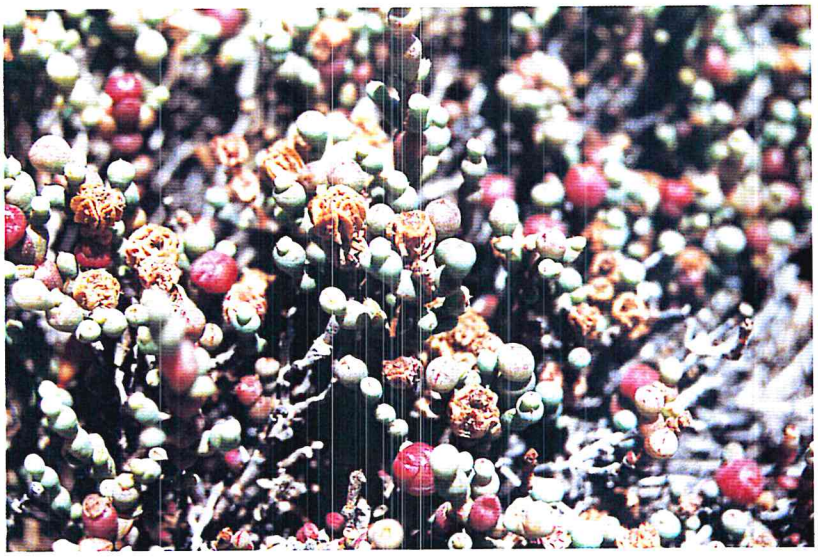


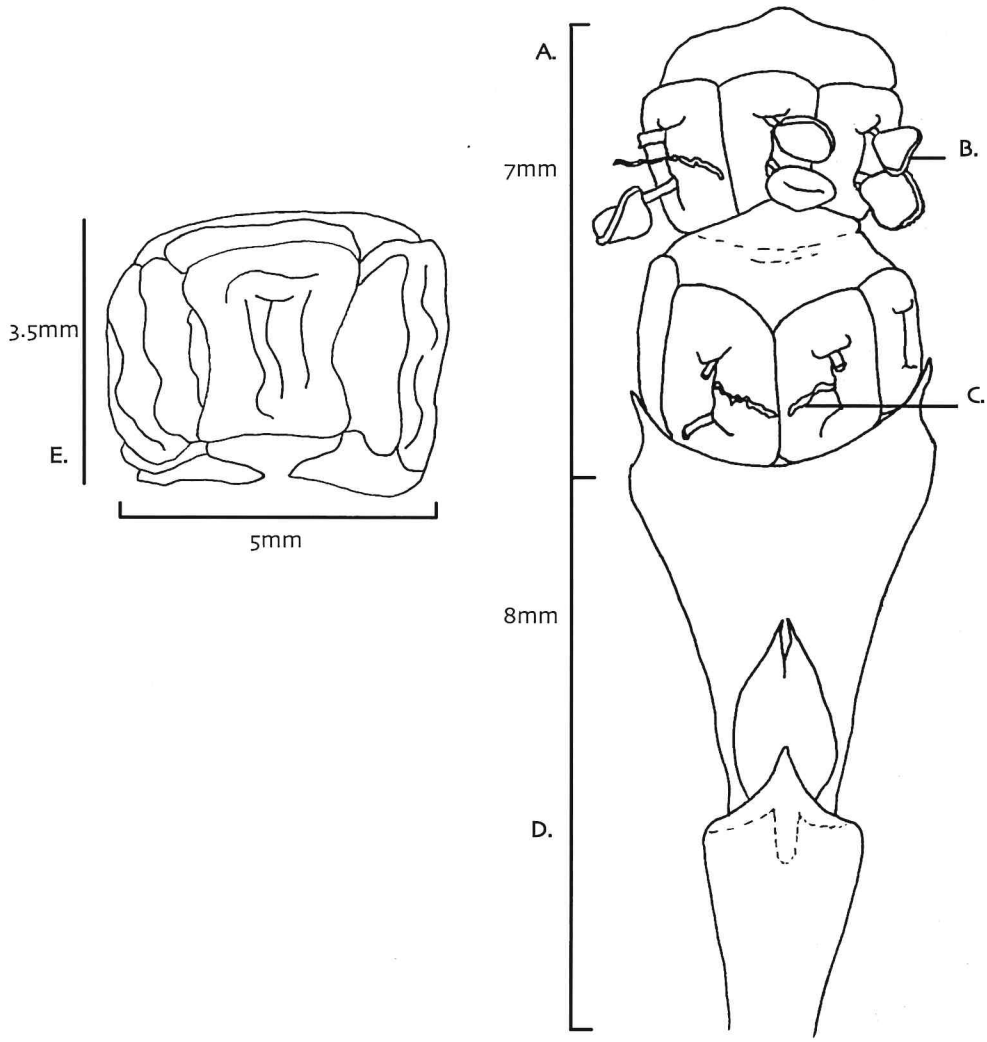
Sarcocornia blackiana
A. Seed: tubules on perimeter
B. Dried flower spike

23. *Sarcocornia globosa* is a small woody perennial growing to about 20cm high and with an erect habit. The articles are a mid to light green, slightly glaucous and are up to 7mm long by 3mm wide. The articles have strongly ridged 'keels' on the apices. There was not much vegetative growth on the specimens observed — mostly grey woody twigs. The flower spikes are terminal and are conspicuous by being globular with one, two or (rarely) three articles. The flowers are in threes on opposite sides of the bracts, but joining each other.

This plant is found in inland south-western Western Australia from Meckering to Lake King. Unlike *S. blackiana* and *S. quinqueflora*, which grow in waterlogged (even tidal) places, *S. globosa* grows in drier, better-drained conditions.

Figure 53 *Sarcocornia globosa* — dried seed heads (above) and fresh flower spikes (below)



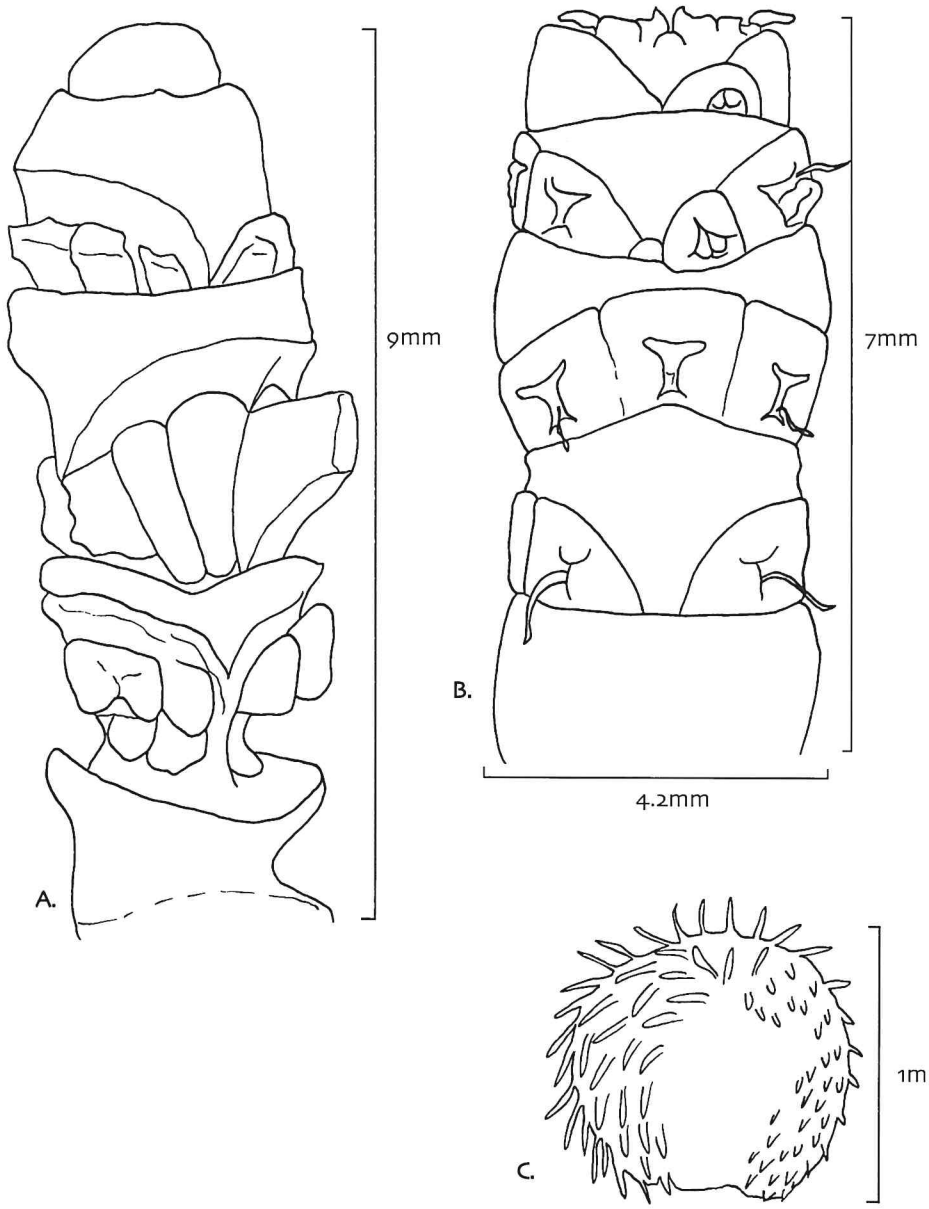


Sarcocornia globosa
A. Fresh flower spike
B. Fresh flower spike: anther
C. Fresh flower spike: stigma
D. Vegetative portion of flower spike
E. Dried flower head

24. *Sarcocornia quinqueflora* is a perennial herb, growing to a height of 50cm. It has a sprawling habit, rooting at the nodes and often growing in thick clumps. It is often seen in estuaries and tidal flats, where it is periodically inundated with water, but grows on inland saline wetlands as well. *Sarcocornia quinqueflora* is also found in coastal New Zealand and New Caledonia. It is very similar to *S. blackiana* in appearance. The seeds are cream-coloured and covered with hair-like appendages, which are often hooked, unlike the seeds of *S. blackiana*, which are covered in smaller nodules.

Sarcocornia quinqueflora is a common coastal plant, found in all states except the Northern Territory.

Figure 54 *Sarcocornia quinqueflora*

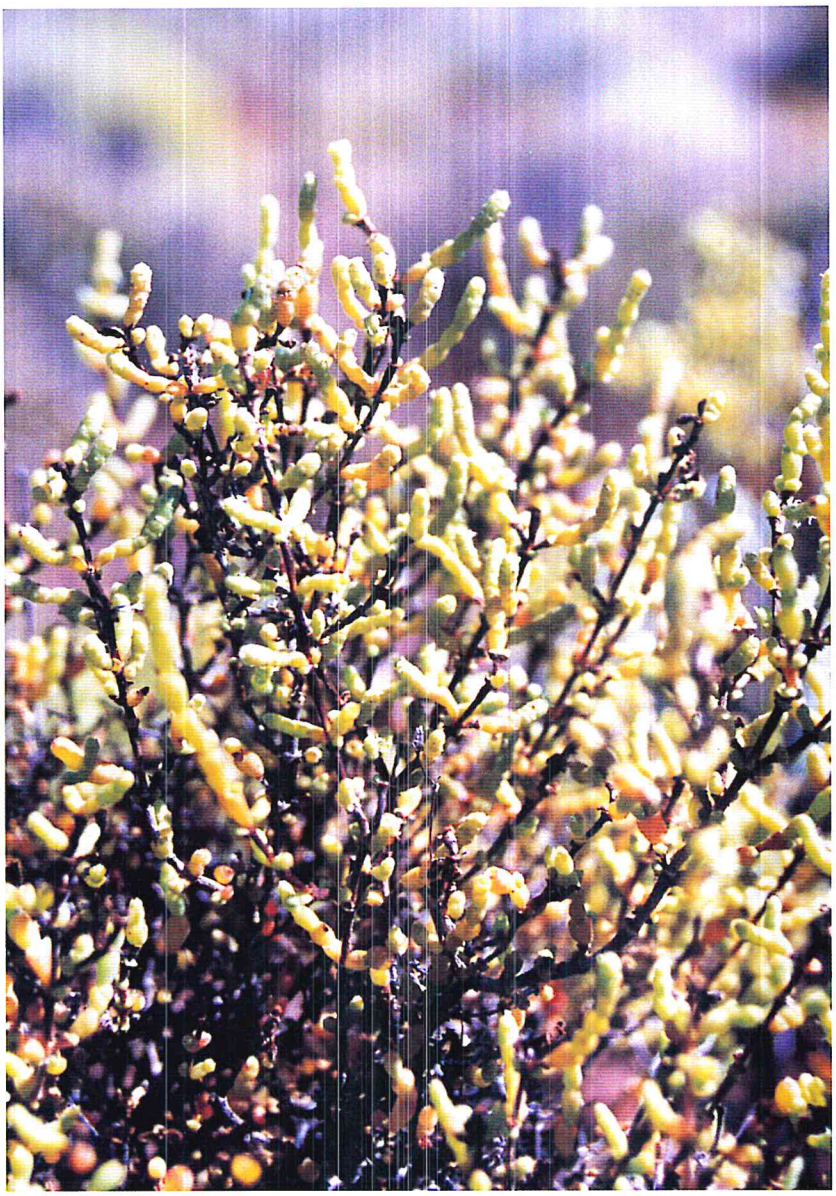


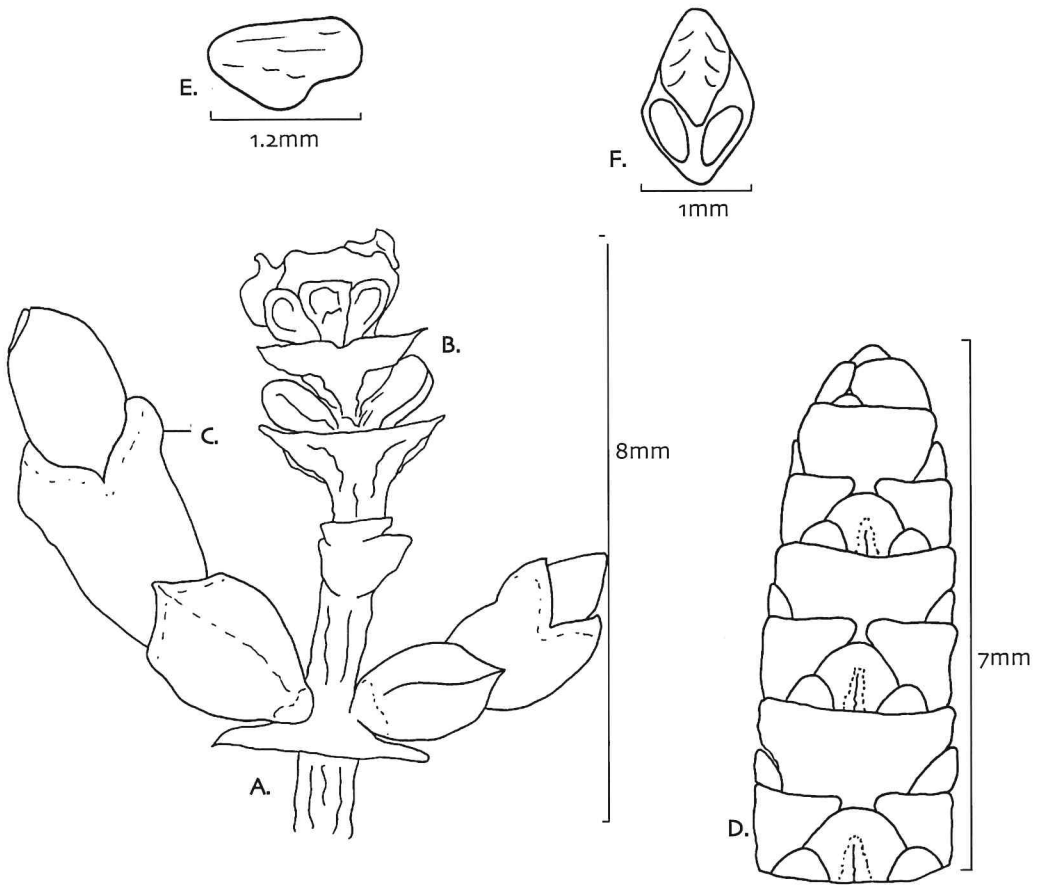
Sarcocornia quinqueflora
A. Dried flower spike
B. Fresh flower spike: reddish bracts
C. Seed: pale fawn, long hairs, sometimes hooked

25. *Sclerostegia disarticulata* is a sub-shrub growing from 30cm to 1.5m in height, with an upright bushy habit. It has brittle woody stems, which are often dark brown or blackish. Under magnification it can be seen that the flower bracts do not join and the triad of flowers can be seen in front of the bract ends. The vegetative articles are bright green, as are the flower spikes. The seed, measuring 1.5mm long, has a thin pale brown testa and is hard to remove from the pericarp. *S. disarticulata* is found growing in stony, alkaline or slightly saline soils, not necessarily near any saline water feature. *S. disarticulata* does not seem to change in appearance with regional variation, as other samphires do.

Sclerostegia disarticulata is a common plant from mostly inland regions, found from Carnarvon to the Nullarbor and throughout southern Northern Territory, South Australia, western New South Wales and northern Victoria.

Figure 55 *Sclerostegia disarticulata*





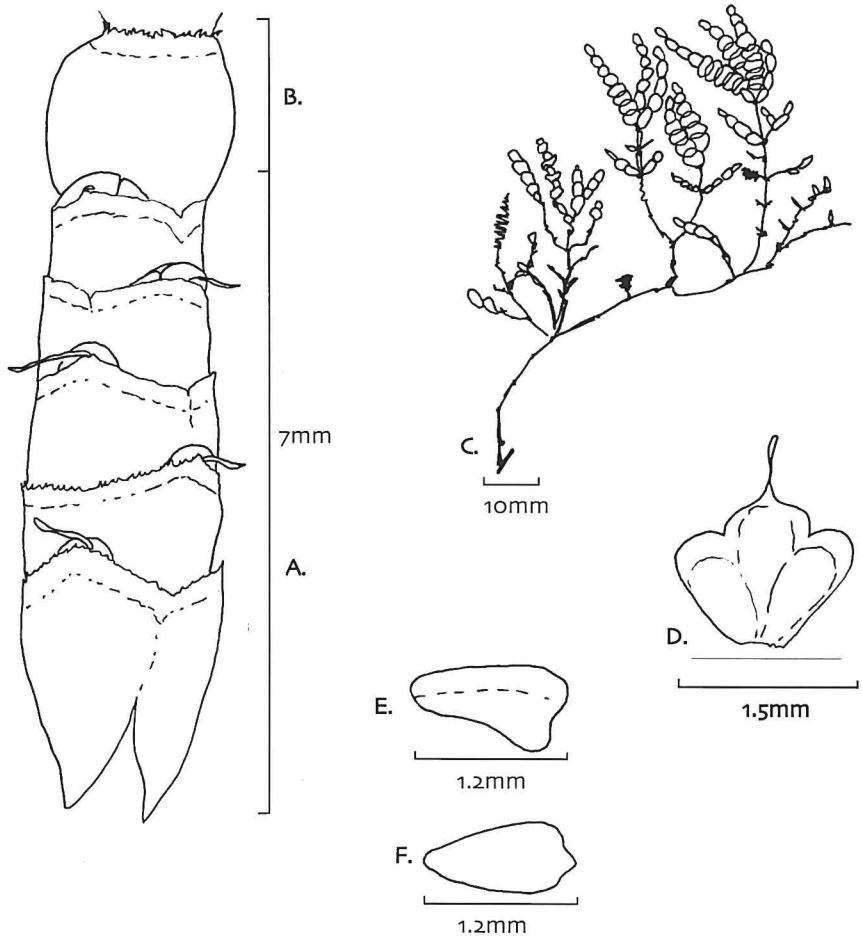
Sclerostegia disarticulata

A. Vegetative growth and dried flower spike
B. Dried flower spike
C. Vegetative article: prominent 'keel'
D. Fresh flower spike: bracts do not join
E. Seed: side view
F. Seed: top view

26. *Sclerostegia moniliformis* is a somewhat brittle shrub growing up to 1m high, with an upright bushy habit. It is a 'velvety' green and the flower spikes are terminal, becoming intercalary with age. The margins of the articles and bracts, while not quite hairy, are 'untidy' and membranous (seen under magnification). The flowers are joined together and to the upper bract, the styles of the central flower protruding above the bract. The dried spikes break up readily and the seed is easy to remove from the fruitlets. The 1mm to 1.5mm seed is ovoid, with a thin, wrinkled, yellow to pale brown testa.

S. moniliformis has only been found in southern Western Australia.

Figure 56 *Sclerostegia moniliformis*

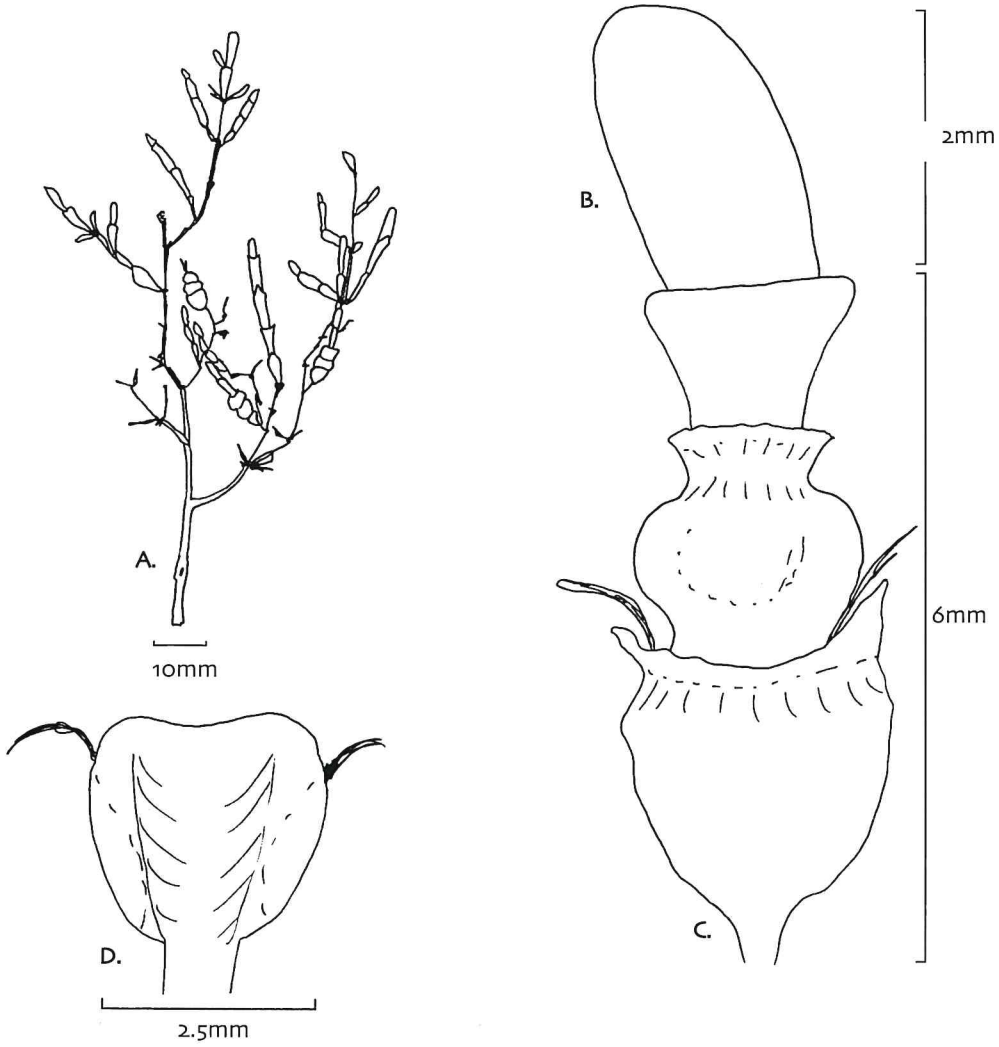


Sclerostegia moniliformis

A. Fresh flower spike: mid green
B. Vegetative articles continuing from flower spike
C. Branch showing both vegetative articles and flower spikes
D. Fresh flower triad
E. Seed: side view, mid brown, raisin-like
F. Seed: top view

27. *Sclerostegia tenuis* is a somewhat brittle sub-shrub growing to about 60cm high and up to 2m by 2m wide. It is a rounded bush of sprawling habit, mid to yellow green. The articles are long and thin, up to 10mm long, with short lobes on the apices (terminal ends). It is not readily identified by eye; under magnification, however, the old flower/fruiting spikes can be seen to have become woody and integrated with the stems. The style (female pollen receptor) can be seen to be still protruding from the woody spike. As the author was not able to break open the woody capsule, it was not possible to draw the seed, but Paul Wilson states that it is smooth-skinned, pale brown and 2.5 to 3mm long. At Lake Carey, *S. tenuis* is not often seen; however, in the calcrete area north of 'Horses Head' it grows exclusively on an area of crumbly, friable red loam. It is a common species elsewhere and is found in all states except Tasmania.

Figure 57 *Sclerostegia tenuis*



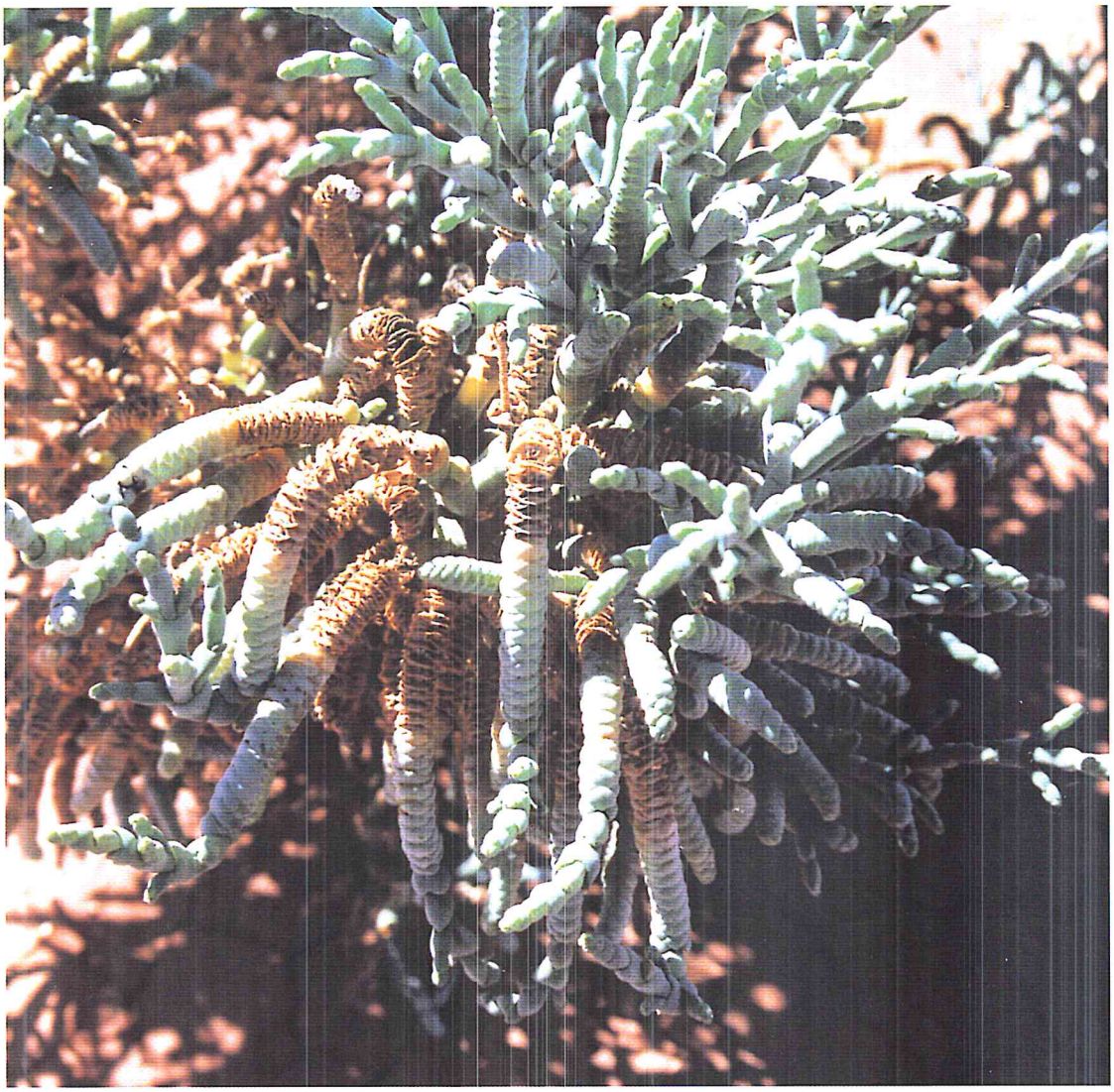
Sclerostegia tenuis

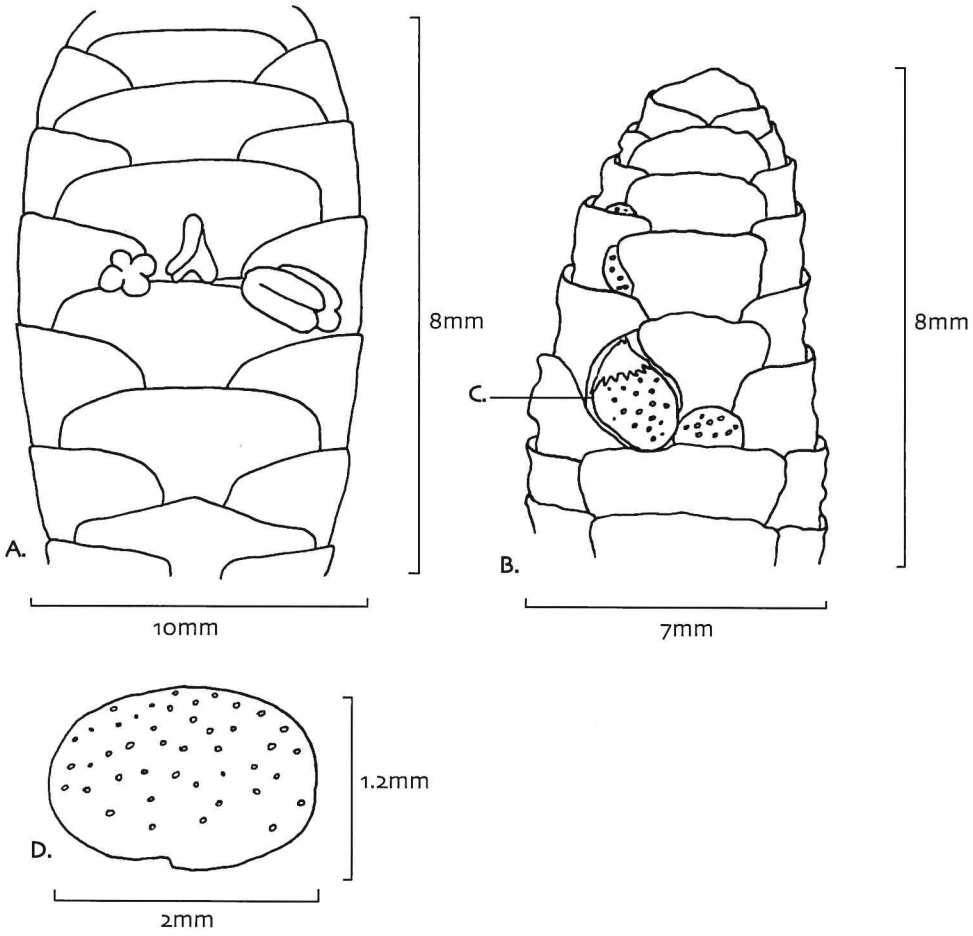
A. Branch from plant: slender articles
B. Vegetative growth continuing from flower spike
C. Dried flower spike
D. Woody capsule (stem modification) containing seeds

28. *Tecticornia arborea* is a strongly upright shrub, growing to a height of 1.5m. The stem internodes are up to 3cm long by 1cm wide. The vegetative articles are mid green and glaucous. The plant is a short-lived perennial — most plants seen were succulent, some had woody stems. The flower spikes are up to 40mm long by 7mm wide. The flowers are in triads and the bracts do not join. The sample examined had only male flowers, which produced copious amounts of yellow pollen. The seed of *Tecticornia arborea* is large (2mm) compared with other samphires, and large quantities are produced. The seeds are reddish and mostly smooth-skinned (slightly warty). *Tecticornia arborea* is not common — it is only known from a few sites in sub-tropical Western Australia. The plant drawn was found at Bulli-Bulli Claypans, which are freshwater pans north-west of Leinster.

The furthest south it is known from is near Lake Goongarrie in the Goldfields. This samphire was (and probably still is) eaten by the Aboriginal people, who harvested the copious seeds seasonally with accompanying ceremonies. They planted seeds in the cracks of the clay pan to ensure a good harvest the following year.

Figure 58 *Tecticornia arborea*



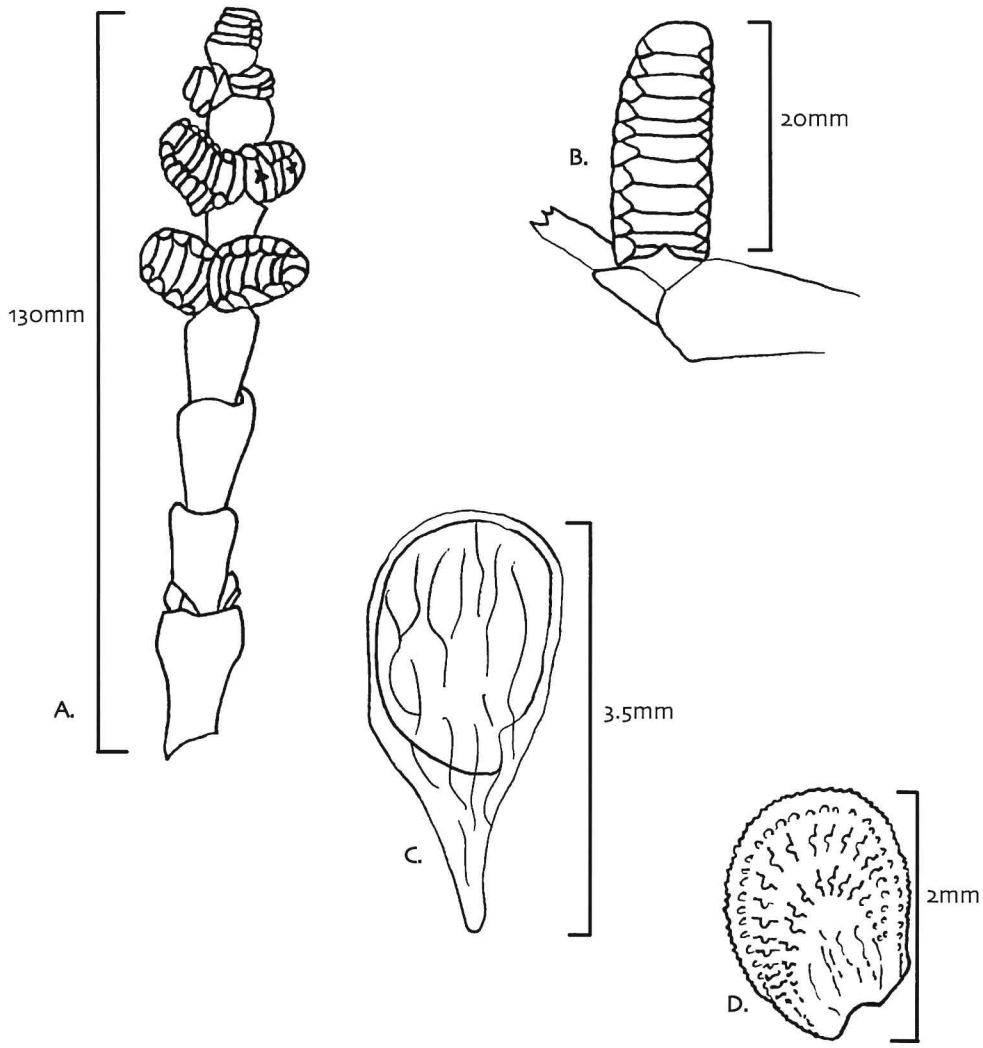


Tecticornia arborea
A. Fresh flower spike
B. Semi-dried flower spike
C. Seed in semi-dried spike
D. Seed: orange/brown, tiny warts on surface

29. *Tecticornia verrucosa* is a shrub with a strongly upright growth habit, reaching a height of 65cm. It is a short-lived species. The articles are 15 to 25mm long and up to 15mm wide and are a pale glaucous blue-green, sometimes pink. The terminal flower spikes are 10 to 20mm long and are pink and glaucous. The bracts do not join and completely hide the triads of flowers. The large seeds (2mm) are black and have concentric rows of granulations over most of their surface. The copious seeds of this plant were collected and eaten by the Aboriginal people, who ensured a future crop by placing some seeds in cracks in the clay pan where the plants were growing.

Tecticornia verrucosa is found in western Northern Territory and sub-tropical Western Australia and from a few localities in south-western Western Australia. It is found on coastal mud flats and inland slightly saline clay pans.

Figure 59 *Tecticornia verrucosa*



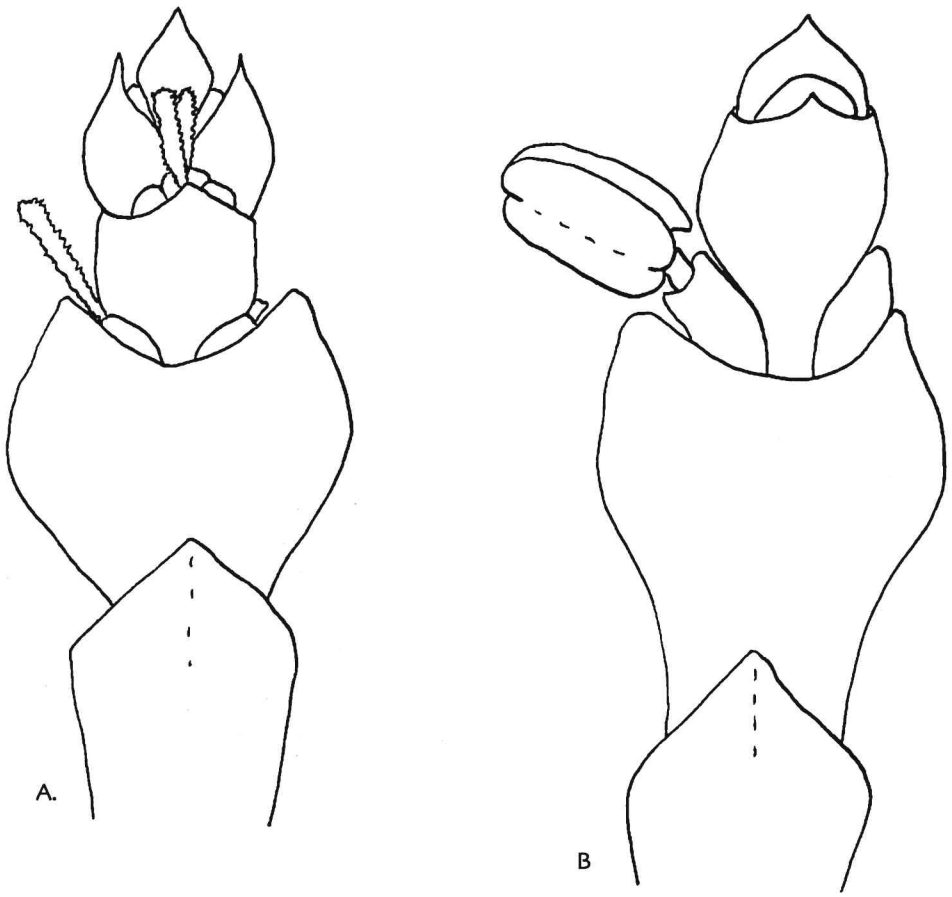
Tecticornia verrucosa

A. Portion of plant with flower spikes: pale green, glaucous
B. Flower spike: pink, glaucous
C. Seed with cellophane-like pericarp
D. Seed, black with tiny 'knobs'

30. *Tegicornia uniflora* is a small prostrate perennial herb. The new growth is red, as are the edges of the flower bracts. The plants are dioecious — single-sex plants. There is a single flower per bract. The flower perianths are red, the stigmas and anthers are yellow. The articles are green to red, glossy, keeled, elongated and measure up to 15mm long by 6mm wide. The plant mats seen measured from 10cm across to 40cm across and 2cm high.

Tegicornia uniflora is found at a small lake near the Stirling Ranges in the south-west of Western Australia. It has a Priority Four status and should be protected.

Figure 60 *Tegicornia uniflora*



Tegicornia uniflora
A. Flower spike: female flowers
B. Flower spike: male flowers

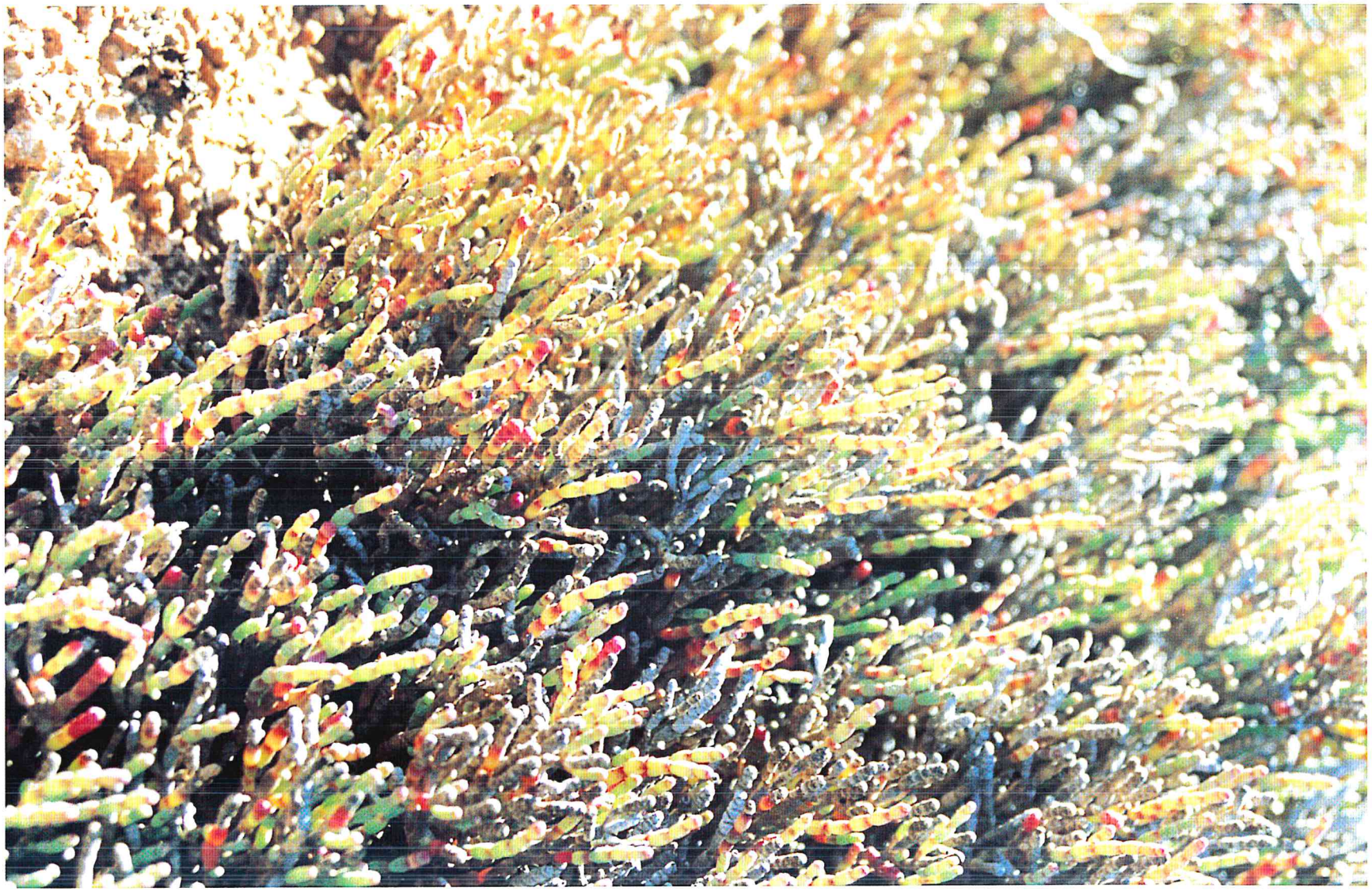


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Figure 61 *Halosarcia doleiformis*

Glossary and References

9

9.1 Botanical Terms

Apiculate — Ending in a small slender point.

Article — A vegetative segment or 'leaf' of a samphire.

Bract — A reduced leaf or leaf-like structure at the base of a flower; in the case of a samphire it is a fleshy 'segment' of a flower spike with the often-hidden flowers behind it. The bracts of samphires are all opposite each other, some joining, some not.

Ciliolate — A marginal fringing of fine hairs.

Chartaceous — With a papery texture, usually not green.

Dioecious — Single sex flowers borne on different plants.

Fimbriate — A marginal fringing of hairs.

Fruitlet — A ripened ovary and connected structures. Each fruitlet contains a seed.

Glaucous — Covered with a whitish or bluish waxy coating (as on a plum)

Inflorescence — The flowering part of a plant; in the case of a samphire it is a flower spike.

Intercalary — A flower spike is termed intercalary when vegetative growth develops from the top of the spike.

Lateral — Borne on the side.

Perianth — Normally the calyx and corolla of a flower, in samphires it is the portion of the flower, other than stamens or stigma, sometimes showing above the bract.

Samphire — The common name for members of the Salicornia tribe of the Chenopodaceae family, comprising *Halosarcia*, *Sclerostegia*, *Sarcocornia*, *Tecticornia*, *Tegicornia*, and *Pachycornia*.

Sessile — Without a stalk.

Spike — An unbranched, elongated inflorescence with sessile flowers maturing from the bottom upwards.

Stamen — Male part of a flower consisting of anther and filament, distributing pollen.

Stigma — Part of the female portion of a flower, receives pollen from the male stamen.

Terminal — At the end or tip of a plant (apex).

Testa — The seed coat or skin.

Triad of Flowers — Samphire flowers are nearly always in groups of three, sometimes joined to each other, or to either the upper or lower bracts, or both. Exceptions to this are *Sarcocornia quinqueflora* and *Sarcocornia blackiana*, with 5 to 9 flowers in a group, and *Tegicornia uniflora*, with single-sex flowers borne on separate plants (dioecious).

Figure 62 Lake Carey

9.2 Terminology Relating to Saline Wetlands in the Northern Goldfields

Aeolian — Relating to, or caused by, the wind. **Aeolian** deposits are materials that have been transported and laid down by the wind.

Aeolian Plateau — The portion of the **lake shoreline** above the **beach**, usually comprising aeolian material from the lake and erosion from nearby land. It can be differentiated from the beach by the different suite of **samphires** and other flora growing there. This is the area where one would expect to find **dunes**, though they are not always present.

Alluvial — Relating to **Alluvium**, which is a fine-grained fertile soil consisting of mud, silt and sand deposited by flowing water on flood plains, in river beds and in estuaries.

Beach — The portion of a **lake shoreline** between the **lake edge** and the **aeolian plateau**, usually topped by coarse, sandy, well-drained material. Underneath the coarse material is a broad band of sandy clay loam, over a hard compacted clay layer. Timms (1992) describes this area as the 'Zone of Efflorescence', influenced by the **capillary fringe**.

Capillary Fringe — It is assumed, though it has not been studied, that sandy, coarse material on the beach acts as a wick, drawing moisture up from the water table by capillary action. The presence of this moisture dictates the species of **samphire** growing on the **beach**.

Clay Pan — See **pan**.

Colluvium — A mixture of rock fragments from/at the base of a cliff.

Deflation Basin — A basin formed once wind speeds exceed 10m/sec, reflecting a combination of sparse vegetation cover, competent winds, sandy clayey soils and episodic rainfall. These basins originally formed over palaeodrainage systems (as in the case of Lake Carey) and are inching westwards, against the prevailing wind. On the western side, most of these **deflation basins** are weathered, eroded and steeper sided with little **alluvial** build up. On the eastern side these **deflation basins** are flatter, comprising **alluvial** and **aeolian** deposits and **aeolian dunes**.

Dune — A mound or ridge of sand formed either in a desert, along the seacoast, or (in the case of Lake Carey) along a **lake shoreline**, through transportation by the wind.

Endorheic (Endoreic) Basin — A closed drainage basin (for example Lake Carey), which does not drain directly to the sea.

Fluvial — Of, relating to or occurring in a river.

Halophyte — A plant that has adapted to living in saline conditions. Some of these plants survive by excreting salt through the leaves (*Frankenia*, mangrove); others rely on storage capacity and high salt content (samphires).

Island —The Northern Goldfields lakes have a multitude of islands of differing sizes and shapes. These appear to be either eroded rocky outcrops or dykes, eroded ancient lake deposits, islands built up from material eroded from other islands or from the lake shore, or a combination of these. The deposits often contain large amounts of gypsum. The islands typically have shield shaped **aeolian/alluvial** deposits as viewed from the air on the north-western shores. This indicates strong winds from the north-west at the time of deposition.

Lake Edge — The **playa** edge where the first terrestrial flora grows (usually samphires).

Lake Shoreline — The vegetated portion of the lake between the lake **playa** and the appearance of the non-saline terrestrial flora. The lake shoreline is the samphire habitat.

Palaeochannel, Palaeoriver or **Palaeodrainage System** are the words used to describe ancient river systems or drainage basins. The systems in the Goldfields were formed before life appeared on Earth in the Tertiary period, approximately 65 million years ago. The five parallel palaeodrainage systems that drain eventually into the Eucla Basin are the Carey, Raeside, Lefroy, Lake Roe and Yindarlgooda Palaeodrainage Systems. The Carey **Palaeodrainage System** terminates at Plumridge Lakes, then beneath the sands of the Eucla Basin. The Raeside, Lake Roe and Lefroy **Palaeodrainage Systems** have a surface expression at their termination: Ponton Creek some 200km east of Kalgoorlie, which itself disappears beneath the sands of the Eucla Basin. The area in the Goldfields containing these systems is known as Salinaland and stretches roughly between Wiluna and Kalgoorlie.

There are several other **palaeodrainage systems** in Western Australia — the south-west examples do not appear to drain externally. The examples north of Perth, Lakes Moore and Austin, drain towards the west coast and disappear beneath the sands to the north of Mullewa and south of Three Springs.

The lakes above these ancient drainage systems are thought to be slowly moving westward, with the westward ends being deflated by wind erosion, and the resulting sand accumulating at the eastern ends. The lakes may not be directly over the **palaeodrainage systems** due to their wind-generated migration and/or intersection by outcrops. However, as the lakes have not moved far away from the **palaeodrainage system** over millions of years, it would appear that this lake 'migration' fluctuates. The lakes appear to be surface expressions of the ancient (but still functioning) drainage systems. The water in these systems moves very slowly.

Pan — A small **deflation basin** found in arid areas, often bare of vegetation and underlain with clays, where water remains for a longer period than the surrounding land. **Clay Pans** sometimes reflect the vegetation of the larger lakes with which they are in close proximity, though just as often they are separate entities with their own unique suite of flora and fauna. **Clay pans** are commonly elevated from nearby lakes, and therefore usually have lower salinity and a shorter wetting period than those lakes.

Playa — The portion of an arid area saline lakebed, or large **deflation basin**, usually bare of vegetation and underlain with clays, where water remains for the greatest length of time.

Temporary-Episodic — Describes a lake that frequently dries out, contains water more or less unpredictably and is usually dry. Lake Carey is a **temporary-episodic** lake type.

Temporary-Intermittent — Describes a lake that frequently dries out, contains water more or less predictably and is often dry.

Wetland — An area that is seasonally or permanently inundated with water (either fresh, brackish or saline), usually with an accompanying suite of plants that have adapted to surviving wetter conditions.

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