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Campynema lineare, neither lily nor iris

Phil Collier

In the "old" days of the 1980s, lilies and irises were easy to separate. Lily flowers are radially symmetrical, i.e. they have a central point and are similar all around it, whereas iris flowers are bilaterally symmetrical, i.e. you can draw a vertical line in the middle and one side is a reflection of the other. Furthermore, lilies have superior ovaries, i.e. within the flower, while irises have inferior ovaries, i.e. below the flower. At this point some readers will be anxious to point out exceptions, e.g. *Hypoxis* species, being lilies with inferior ovaries and *Isophysis tasmanica*, being an iris with radial symmetry. In more recent times, the lily family has exploded into numerous new families, which now sit within two orders, the Liliales and the Asparagales, with some of the former members of the lily family being in both orders. Meanwhile the irises still form a family of their own in the Asparagales (Wikipedia 2016).

This is a long winded way to introduce the family Campynemataceae, which can be thought of as a classic mixture of traditional lily and iris. In particular, flowers are radially symmetrical, but the ovary is inferior. Recent taxonomic work has confirmed the long-held view that this is a distinct family in the Lili-

These photos of a plant at Sisters Beach, February 2016, show many features mentioned in the article: Left: Inferior ovary on the uppermost flower; Fertile anthers in lowest flower, with minute stylodia; Uppermost flower most mature, middle flower still in bud; Upper flower with spent anthers and filaments reflexed, stylodia well developed; Shiny surface on the lower part of the petals and sepals. Right: close up of male flower. Photos: Phil Collier.

Close up of female flower. Photo: Phil Collier.

This fly was observed lapping nectar at the base of the petals. Photo: Philip Milner.

ales. It is of Gondwanan origin, and one of the oldest families in the Liliales (Wikipedia 2016). Which may help to explain why the four species in Campynemataceae are shared only by New Caledonia and Tasmania. New Caledonia has three species in Campynemanthe, with *Campynema lineare* endemic in Tasmania.

All four species have small green lily-like flowers, arranged in an umbel in *Campynemanthe* (Dahlgren 1985), and as a raceme (often 1-flowered) in *Campynema lineare*. In fact, *Campynema lineare* could easily be mistaken for an orchid when not in flower, with a single linear leaf, single flower stem, all generally less than 300 mm tall.

One of the features of all the species in Campynemataceae, is that flowers are protandrous, meaning that the male fertile parts mature before the female parts. In each individual flower, the anthers mature and release their pollen, while the three elongated stigmas (stylodia) are crowded together in the middle of the flower. Once the anthers have finished their task, the filaments twist and spread, and the spent anthers often end up outside the flower. At this point the stylodia expand forming three distinct arms in the centre of the flower (Lowry et al. 1987). All this choreography is somewhat spoiled by different flowers on the same stem being at different stages simultaneously, so that flowers can in principle self-fertilise other flowers on the same plant. This is compounded by flowers apparently opening in random order on a single stem. Meanwhile flowering within a group of plants is also poorly synchronised.

Flowers have been described as fleshy or shiny. In fact, in *Campynema lineare* shiny and matt flowers can co-exist in a single group of plants (Collier 2012). This feature is apparently investigated only for Campynemanthe (Kubitzki 1998). Without prompting about this, Ian Ferris made a remark that some flowers are coated in nectar, and further investigation suggests that this may be correct. Petals and sepals are long persistent, so it is plausible that nectar is only produced for a short period, leading to some being seen as shiny. Without a microscopic investigation of the morphology, we noted recently that the shiny part of the petals and sepals tends to be towards the base, with some stomata or glands towards the tip of the petal. We also observed flies and ants apparently feeding from the shiny base of the petals.

Most of my prior observations of *Campynema lineare* have been in the alpine and sub-alpine areas of Tasmania. There are also plenty of records at sea level in the south west. There was also a stray record in the Natural Values Atlas near Rocky Cape National Park from sometime around the aforementioned 1980s. Recently Ian and Marsha Ferris re-discovered the species near Sisters Beach in a slashed area of button grass. The resulting collection at the Tasmanian Herbarium removes any future doubt about the existence of this outlying population.

As always, there is still plenty to discover, for those people who have their eyes out looking.

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The cover photo of a mantis fly *Campion* sp. (Family Mantispidae) was photographed at Rubicon Sanctuary by Phil Collier.

Mantis flies are in the order Neuroptera along with lacewings, owlflies and ant lions. They resemble small praying mantids (Family Mantidae) with their raptorial forelegs, extended prothoraxes and mobile heads with large compound eyes.

The larvae of mantis flies feed on the eggs or young of spiders or wasps; the adults use their raptorial front legs to capture soft-bodies insects.

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Pink Barnacles on Pumice
Hazel Britton and Julie Serafin

Whilst on Flinders Island in November 2014, Hazel Britton picked up a piece of pumice with beautiful pink barnacles attached, the shells of small crustaceans that had lived and travelled on the pumice. She had never seen these barnacles before despite many years of opportunistic beachcombing. When showing the piece of pumice to Julie Serafin, she was surprised to find that Julie had an almost identical, but slightly larger piece, also found on Flinders Island at the end of April 2014.

We were obviously curious to find out more about these barnacles, but could find no mention of pink barnacles in *Between Tasmanian Tide Lines* (2010) or on line. *Australian Marine Life* (2005) states that the Class Cirripedia (Barnacles) comprises about 1000 species, and that Acorn Barnacles like our specimens, include the great majority of *Cirripede* species.

Barnacles are known to survive where other sea life fails because their conical forms deflects waves and they adhere to a surface with a natural cement, making them ideal long distance travellers (Carson, 1998).

Sarah Lloyd suggested that we contact David Maynard, natural science curator at the Queen Victoria Museum and Art Gallery, for more information.

Two pieces of pumice with pink barnacles. Photo: Hazel Britton.

David very kindly supplied the following interesting information on the barnacles and directed us to a website regarding pumice being washed up on Tasmanian shores since 2013, related to the Havre eruption.

'I am cautious to give a definitive identification for the barnacles. This is because I am not that familiar with them but also, it likely they may have come from east of New Zealand or further afield. These large barnacles are likely to be from the genus Megabanalus, *a group of barnacles that grow to over 7 cm in length and inhabit the lower intertidal zone, where they would be exposed to the air for a short period of time each day (and you can imagine that bobbing around on a piece of pumice would be similar).*
The colour is unusual, but not uncommon. I have found links to Hawaiian specimens of similar shell form and colour. The colour may relate to the animals' diet or the colour inside the shell. I think it would normally be purple.'

After watching a media item on the local ABC that asked people on the east coast of Tasmania to be on the lookout for pumice as it washes up on our shores, we sent our photos to Dr Rebecca Carey, a Senior Lecturer in Earth Sciences at the University of Tasmania.

Dr Carey (pers. com.) said that pumice has been arriving on the north east coast of Australia since 2013 related to the Havre eruption which occurred in 2012. Havre is a submarine volcano about 1000 km north of Auckland that lies at a depth of about 700 meters. The eruption produced a gigantic pumice raft that slowly made its way around the Pacific Ocean. In March 2014, twenty months after the eruption, pieces of pumice were being found on beaches in north east Tasmanian. The two

Gooseneck barnacles and other marine life on pumice. Photo: Rebecca Carey.

photos on the ABC website were of pieces of pumice with gooseneck barnacles (above), members of the other major group of cirripede species *Lepadomorpha*. The article also mentions that up to 80 different marine species have been found on some pieces of pumice.

Dr Carey supplied two websites where we could find further information. Perusal of these sites provided a wealth of information on the formation of pumice from volcanic eruptions and expeditions and investigations by scientific institutions to the site of the Havre volcano. They also included links to other websites and other scientists working on pumice that has been washed up at other places in eastern Australia. On another website supplied by Sarah we noted that Dr Scott Bryan, Assistant Professor from the School of Earth, Environmental and Biological Sciences at the Queensland University of Technology, was heading a study investigating marine creatures found on pumice off the coast of Queensland. We decided to send him our photographs in the hope that he might be able to add to the information we had so far received.

Dr Bryan kindly replied immediately agreeing that the pumice looked like Havre pumice sourced from the 2012 eruption. He also added the following information:

'This pumice made its way via a rather circular route down the east coast of Australia to Tasmania. We have recognised for example, some corals (mainly Pocillopora*) and also a gastropod (*Litiopia *sp.) on pumice collected in Tasmania which are species well outside their normal geographic ranges. David noted this in his correspondence to you.'*

In his email referred to above, David Maynard mentioned that the barnacle larvae could have settled on the pumice in distant waters:

'This is a great example of how new species can be naturally introduced to new environments. The dangerous thing these days is that warming waters, cause by climate change, will allow more of the natural incursions of species to survive in our region, when previously the cold winter waters would have killed them off.'

Dr Bryan added the following:

'The barnacles are definitely of the Acorn barnacle group and I am no expert, but David's suggestion of Megabanalus *seems fairly good. Based on the size of the barnacles, I would expect that they attached while in warm water (probably off Queensland, if not further afield?) and have been transported to Tasmania. Not sure if growth rates are well known for this species.* Based on the size, you could then work out how long they were on the pumice. We have certainly identified acorn barnacles on pumice we have collected here. But they were almost always very small (<0.5 cm in diameter), suggesting recent recruitment and therefore embarkation around Queensland/northern NSW would make some sense for your samples.'*

*Unfortunately we have not been able to identify the species and could find photographs of only a few of the hundreds of species

This piece of pumice has what appears to be the shells of several very small barnacles attached to the larger barnacles. There is also a small piece of coral and signs of other marine life. Photo: Julie Serafin.

The largest barnacle has a diameter of 2 cm at the widest point. Minute shells, coral and what appeared to be larval cases were found when microscopically examining the debris from inside the barnacle. Photo: Hazel Britton.

that are known to exist.

For more information about the July 2012 Havre eruption please refer to the web sites below.

Acknowledgements

We would like to thank Sarah Lloyd for showing interest in our beachcombing finds and for suggesting we contact David Maynard at the Queen Victoria Museum and Art Gallery; also for sending a link to an article on Dr Scott Bryan's work titled 'Floating Pumice Seeding Aussie Reefs'.

David Maynard, Dr Rebecca Carey and Dr Scott Bryan all replied promptly to our requests with enthusiasm and information, as well as directing our attention to various websites. Their replies stimulated us to find out as much as possible about our beachcombing finds and we thank them for encouraging us to be inquisitive. Dr Carey gave us permission to use her images of marine life on pumice.

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Hidden crab catching a ride on this piece of pumice. Photo: Rebecca Carey.

Platypus Health and Conservation Research in the Inglis River Catchment – update. *James Macgregor*

This article relates to platypus anaesthesia and is based on the second peer-reviewed publication (Macgregor et al. 2014) to come from my recent platypus health and conservation research in northwest Tasmania, which was kindly supported by the Central North Field Naturalists. While anaesthesia was not the focus of the research, it is an important method of minimising any potential stress during wildlife health examinations and the information we gathered will assist future projects. It has been previously documented that under anaesthesia platypuses may undergo sudden onset apnoea (lack of breathing) and bradycardia (slow heart rate), particularly during the periods of light anaesthesia. Platypuses are also known to show sudden onset bradycardia during diving, along with the apnoea necessary in this situation, and this is known as the dive response. The dive response has been studied in a number of diving animals and is thought to be an oxygen saving mechanism. The apnoea and bradycardia that can occur during platypus anaesthesia has been referred to as a dive response. However, there has been no explanation of why the same response should occur in two such different situations.

During the fieldwork we used the current best practice platypus anaesthetic protocol: induction and maintenance using isoflurane delivered in oxygen by face mask. We used our detailed anaesthetic monitoring records to identify sudden onset apnoeic/bradycardic events (SOABEs) and to investigate factors by which SOABEs may be triggered and maintained. We also evaluated whether the term 'dive response' is an appropriated description of these changes.

A total of 163 platypus field anaesthetic procedures (64 adult females, 3 juvenile females, 84 adult males, and 12 juvenile/subadult males) were performed in the Inglis River catchment in Tasmania between August 2011 and August 2013. A SOABE was defined as apnoea and bradycardia (< 100 beats per minute, bpm) lasting >1 min and occurring without any preceding or ongoing gradual decrease in heart rate and respiratory rate. SOABEs were never recorded during maintenance of anaesthesia, but were observed in 31 anaesthetised platypuses (19% of the 163 tested), either during induction (n = 9 individuals) or recovery (n = 17 individuals) or both (n = 5 individuals). Typical range for heart rate during maintenance of stable anaesthesia was 114-162 bpm. During a SOABE sustained minimum heart rates were usually in the range 30-72 bpm, but occasionally there was >10 s between two consecutive heart beats. Typical range for respiratory rate during maintenance of stable anaesthesia was 6 -24 breaths per minute. During a SOABE, respiration ceased for >1 min. After a period of ~1–10 min of apnoea and bradycardia, heart rate would gradually rise before regular breathing recommenced. A short period (~30–60 s) of tachycardia (increased heart rate) and tachypnoea (increased respiratory rate) would then occur, following which the apnoea and bradycardia would frequently return, usually with a slightly higher heart rate than previously. This process of apnoea and bradycardia interspersed with tachycardia and tachypnoea would continue for up to 20 min, with the periods of apnoea and bradycardia becoming steadily shorter and the bradycardia being less severe in successive periods, until eventually the platypus started breathing regularly and the bradycardia ceased. Of range of intrinsic and extrinsic factors, SOABEs at induction correlated significantly and negatively with body temperature at induction, while SOABEs at recovery correlated significantly with poor body condition and only occurred in platypuses that were anaesthetised for longer than 19 minutes.

As described above, the dive response is not limited to the platypus but has been studied in many diving mammals, birds and reptiles. In fact, the dive response is not even limited to diving animals; it has also been shown to occur in a wide range of terrestrial vertebrates including humans and may actually occur in all air-breathing vertebrates. During diving, apnoea has been shown to be partly a conscious event and partly a reflex response triggered by trigeminal nerve stimulation as a result of submersion of the face and/or nasal passages ('facial submersion') in water (particularly cold water). Apnoea and trigeminal nerve stimulation by facial submersion are synergistic on the development of bradycardia during diving. The key fact that related to our paper was the mediation of these reflexes by the trigeminal nerve, part of whose function is to carry sensory information between the face and the brain. Bradycardia and apnoea have been shown to result from a number of other reflexes mediated by the trigeminal nerve as a result of stimulation of mechanical or chemical receptors in the face, e.g. in response to upper airway irritants, mechanical stimulation of ocular and periocular structures, or direct stimulation of any part of the sensory trigeminal nerve pathway. These are considered to have, at least in part, similar physiological mechanisms.

Events very similar to the SOABEs we observed have been described in rabbits during induction of a anaesthesia with isoflurane; even with a similar cyclical nature of apnoea/bradycardia interspersed with short periods of increased heart and respiratory rates. Given that isoflurane is known to be a mild airway irritant, this response in both rabbits and platypuses is most likely to be a version of the nasopharyngeal reflex. The occurrence of the response only during light anaesthesia can be explained by the fact that a range of reflexes, such as reflex coughing or blinking in response to appropriate stimuli, are abolished by deep anaesthesia. We proposed in our paper that the SOABEs that can be observed under isoflurane

Platypus in waterway at Bell's Parade Latrobe. Photo: Sarah Lloyd.

anaesthesia in platypuses are mediated by the trigeminal nerve as is the apnoea/bradycardia of a dive response, but that use of the term 'nasopharyngeal response' would be more appropriate during anaesthesia. We also propose that the occurrence of this response might be minimised by keeping anaesthetic time under ~19 minutes, avoiding low body temperatures before and during anaesthesia, and by modification of anaesthetic protocols.

Macgregor JW, Holyoake C, Fleming PA, Robertson ID, Connolly JH, Warren KS (2014) Investigation into the characteristics, triggers and mechanism of apnoea and bradycardia in the anaesthetized platypus (*Ornithorhynchus anatinus*) *Conservation Physiology* 2: cou053

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Murdoch University Platypus Research Project background

James Macgregor

15.3.16 To: CNFN

Firstly I would like to thank you very much for your support in recent years for my platypus health and conservation research project. This project has achieved a great deal, and would not have been possible without the help of so many individuals and organisations.

The main aim of the project was to investigate platypus health and a range of other factors in order to get a picture of how the platypus populations around Wynyard are faring. As part of this project we captured, examined and released 154 platypuses. Both this field study and our survey of public sightings indicated that platypuses are widely distributed throughout the Inglis River and Seabrook Creek Catchments. Essentially, platypuses can be found in nearly all of the water bodies that are accessible to people. It would be reasonable to assume that the same can be said for the more remote water bodies.

We used microchips about the size of a grain of rice to individually identify the platypuses that we captured. We developed the use of instream antennas to monitor platypus movements. Using these antennas we showed that, over the 2011–2013 time period, 80% of the platypuses captured between 2011 and 2013, and 42% of platypuses that were captured 3–5 years previously, continued to use the site of their capture. We were also able to gather information about the time of day that platypuses are active in this area. Unexpectedly, movement patterns even gave clues about breeding success at one location that has been continuously monitored for 3.5 years. We hope to continue to use this technique to monitor platypus longevity, migration and behaviour in the coming years.

By sequencing the gene for one part of the immune system in all 24 platypuses captured in the Seabrook Creek Catchment, we found that the genetic diversity for this gene in this catchment is intermediate to those in previously studied catchments. This could indicate the likely ability of this population to respond to a new infectious challenge. Genetic diversity is generally smaller for smaller populations, and a higher genetic diversity would be expected in the larger Inglis River Catchment.

Mainland platypuses have been shown to breed between August and October. It has long been suspected that Tasmanian platypuses breed at some time later in the year. By measuring reproductive hormone levels, capturing ultrasound images of the internal reproductive organs, and by using data from the in-stream antennas, we were able to show that the breeding season occurs from early November to mid-December. **This suggests that it would be preferable to avoid earth works around creeks and dams in this time period and from the beginning of November to the end of April.** These months include the breeding season, incubation of eggs by the female and the first four months of the young platypuses' lives when they remain in the natal burrow and are particularly vulnerable to human activities.

The health of the platypuses that we captured was generally good. Most importantly, we didn't detect the serious fungal disease mucormycosis that has, at times, affected up to a third of the platypuses at certain locations in northern Tasmania. As in other studies, ticks and blood parasites were common, but these rarely affect the platypuses. Other internal and external parasites were rare. Evidence of exposure to *Leptospira* spp (10%) was lower than those in previous mainland studies (33-50%). Six (3.9%) of platypuses were found to be infected with *Salmonella mississippi* which is very common in wildlife and aquatic environments in Tasmania, and one (0.7%) was positive for *Salmonella bovismorbificans* which is likely to have originated from livestock.

Overall, the populations of platypus in the Inglis River Catchment and Seabrook Creek Catchment appeared to be in a reasonable state. However, the pattern of our capture rates suggests that, in general, land has been selected for agriculture in the same areas of high productivity that naturally support the largest numbers of platypuses. Maintaining river health (to provide food for platypuses) and riparian vegetation cover (to provide suitable burrow sites and a healthy river) are therefore of great importance to support platypus numbers in these areas.

The broad nature of this research project has allowed us to make contributions to the understanding of platypuses in a number of more academic areas including: anaesthesia, assessment of platypus body condition, skin lesions that look similar to mucormycosis but had different causes, and seasonal variation in red blood cell counts.

I hope to be able to continue this research in some form over the coming years. If you would like to know more about my research, contact me at platypusproject@hotmail.com or on 0487 979 213. If you want to see all of the details I could send a link for you to download all 406 pages of my thesis.

Thank you again for your support of this project. James

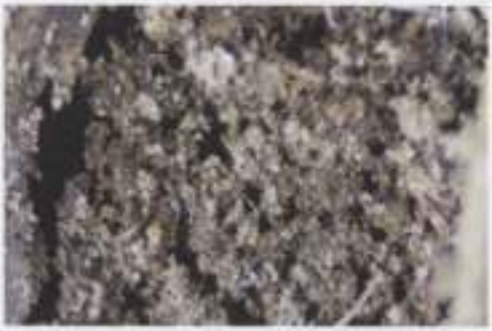
Soil Biology (Part 1)

Sue Gebicki

2015 was the International Year of Soils designed to create awareness of the importance of healthy soil, the damage we have inflicted on soils around the world, and to teach how to maintain soils in good condition and prevent further loss.

Soil is one of nature's most complex ecosystems and one of the most diverse habitats on Earth. It contains an amazing number of different organisms, all interacting, contributing to global cycles and making a large proportion of life possible.

Soils are a product of physical, chemical and biological processes, and while there has been much research into the physical and chemical aspects of soils, there has been comparatively little research into soil biology and ecosystems. Although soils are home to over a quarter of all living species, it is estimated that only 1% of soil bacteria and fungi species, 4% of mites, 15% of collembola, 1.3% of nematodes, and 7.5 % of protozoa have been identified. To add to the difficulty of research, soil microbes can readily exchange genetic information leading to a very fast and ongoing diversification of microbes in natural environments (Monier et al. 2011). Furthermore processes within the soil are not the result of a single organism but of microbial communities which closely interact with each other (Aneja et al. 2006). Even the development of symbiotic interactions between plants and microbes are much more complex than described in textbooks as they include the involvement of a diverse number of 'helper organisms' which contribute to the process.



Top left: Sandy soil from eucalypt plantation; right: soil from cow paddock. Bottom: forest soil from Birralee. Photos taken with DSLR Camera on stereo microscope by Sarah Lloyd

Actions of soil organisms and organic matter

Organisms in soil act together in complicated relationships of predators, prey, parasites, decomposers and soil reorganisers, maintaining a healthy equilibrium which sustains soil fertility. These organisms:

Organise soil structure to bind soil particles together in stable aggregates. This is necessary for the presence of air spaces (macropores) which determine how readily a soil can transmit water, allow root growth and provide air for soil organisms.

Break down inorganic matter into constituent minerals. The weathering of rocks is enhanced by organic acids, siderophores (iron-chelating compounds) and protons produced by fungal, microbial and plant root action.

Decompose organic waste and pollutants, and bind heavy metals and pesticides. Soil from waste sites have been found to have higher concentrations of gene sequences from certain bacterial groups known to degrade common pesticides like hexachlorocyclohexane. Some microorganisms have developed different detoxifying mechanisms—biosorption, bioaccumulation, biotransformation and biomineralization—and can be used for bioremediation.

Provide carbon storage. Soils in combination with plant biomass hold approximately 2.5 times more carbon than the atmosphere (Singh et al. 2010).

Process organic matter. Microorganisms decompose organic matter, using the carbon and nutrients for their own growth and releasing excess nutrients into the soil for use by plants.

Change soil to allow water purification and buffer water flows. The rate of erosion increases with faster water flow. A healthy soil will act like a sponge, reduce evaporation and filter the water before releasing it slowly in dry periods. This helps to maintain environmental flows in creeks and rivers.

Fix nitrogen. Some organisms in soil and plant roots convert atmospheric nitrogen to ammonia compounds, which are available for plants. The process is not yet completely understood, but biological nitrogen fixation contributes approximately 60% of nitrogen fixed on earth.

Control pests. For example, some protozoa consume pathogenic fungi.

Create humus (decomposed organic matter). Humus retains moisture and forms the structure of the soil. It is covered in negatively charged sites that bind to positively charged ions (cations) of plant nutrients. This is important for the supply of nutrients to plants, reduces the potential toxicity of plant nutrients and prevents the leaching of trace elements into the subsoil. Humus suppresses plant disease by stabilizing soil enzymes, thus restricting the action of potential plant pathogens which rely on enzymes to break down plant defences. It also liberates carbon dioxide from calcium carbonates present on the soil. The carbon dioxide can be taken up by plants or form carbonic acids, which act on soil minerals to release plant nutrients.

Buffer pH. Humus produced by soil biota neutralises the soil which frees any trace elements that are unavailable to plants in very acid or alkaline soils.

Maintain soil temperature. The actions of soil organisms affect the colour of soil which in turn affects its ability to absorb infra red radiation. Air pores and humus in the soil provide insulation.

Provide a reservoir of plant nutrients.

Promote plant growth by producing auxins, gibberellins and antibiotics.

Return nutrients to their mineral forms which plants can then access.

Regulate and influence the composition of the atmosphere.

Affect flowering time. Experiments have shown that plants in pots inoculated with microbes from different sites, when sown at the same time and given the same conditions, flower at different times.

Enhance drought tolerance of plants through active water absorption by the greater root mass provided by mycorrhizal fungi and growth promoting rhizobacteria.

Reduce the concentration of sodium salts and increase the concentration of other elements through the application of humins, humic acids, fulvic acids and specific soil organisms. This could be essential for the recovery of vast areas of excessively saline land which are unproductive because of land clearing and irrigation.

Positively influence seed germination and seedling development.

Enhance root initiation and increase root growth with the application of humic acids and/or fulvic acids, present in humus.

Maintain strong genetic plant pools. Weak plants are further weakened and killed by pathogens in the soil, preventing them from cross pollinating and passing their genes on to other plants.

Soil organisms

Soil contains organisms from every kingdom of classification. A typical healthy soil may contain several species of earthworms, 20–30 species of mites, 50–100 species of insects, tens of species of nematodes, hundreds of species of fungi and perhaps thousands of species of bacteria and actinomycetes.

Bacteria

Bacteria are the most numerous of soil organisms, with up to one billion per gram. They are generally about 1 micron in length or diameter and usually occur as single cells. They contribute to soil health by decomposing organic compounds, nutrient cycling, humus production, soil aggregation, nitrogen fixation and control of plant pathogens. Denitrifying bacteria are anaerobic (active where oxygen is absent) and convert nitrate to nitrogen or nitrous oxide in saturated soils.

Bacteria are concentrated in the rhizosphere, i.e. the area around the root zone. Plants exude carbon-rich materials to stimulate bacteria and in return benefit from their presence. Different bacteria have different functions:

Decomposers break down a wide range of compounds into simpler forms that become available to plants and animals. They are especially important for retaining nutrients in their cells, thus preventing their loss from the soil.

Mutualists form associations with plants. E.g. the Rhizobia form nodules on legume roots and fix nitrogen from the air.

Pathogens select weak plants and organisms and hasten their breakdown and recycling.

Chemoautotrophs obtain energy from non-carbon sources such as sulphur, nitrogen, methane or sodium. Some are important to nitrogen cycling and degrading pollutants.

Fungi

Fungi grow long threads called hyphae (usually a few thousandths of a millimeter wide) that bring soil particles together into stable aggregates. Hyphae mass to form mycelium which absorb nutrients from organic material and the plant roots they colonise.

Mycena austrorida is a saprotrophic fungus found on small branches in wet forests. Photo: S. Lloyd.

Cortinarius metallicus is a mycorrhizal species found in association with myrtle-beech. Photo: S. Lloyd.

Fungi are important for nutrient cycling, disease suppression and water dynamics and can be grouped into broad categories:

Mycorrhizal fungi live in close association with plant roots, either inside or outside the roots depending on the type. They effectively increase the root zone and thus the accessibility of soil nutrients, particularly nitrogen and phosphorus. Arbuscular mycorrhiza are the most common and widespread involving 80% of plant species.

Parasitic fungi invade weak plant and animal tissue. They ensure plant health by removing the diseased and weak. Some, such as the nematode-trapping fungi, parasitise disease-causing nematodes.

Saprotrophic fungi (decomposers) get energy from organic matter. Nutrients are recycle from organic matter to the fungal biomass, and eventually back to the rhizosphere when the hyphae are consumed or die.

As an interesting aside, scientists studying the evolution of fungi have found evidence that the end of the carboniferous age may have been brought about by the evolution of fungi able to digest lignin. Prior to that, much dead vegetation was decomposed at such a slow rate that it was possible for it to be buried by natural processes, and eventually physically and chemically acted on to produce the vast coal reserves that we dig up and burn today.

Protists

Protists and other similar single-celled organisms are several times larger than bacteria and live in wet environments. About 1 500 of approximately 50 000 known species live in soils, and more than a billion amoeba and up to several million ciliates have been found per square metre in the top 50 mm of some soils. They are able to form dormant cysts when the soil dries out.

The two main groups of soil protists are the ciliates and the flagellates. Along with the amoebae they play an important role in boosting nitrogen available to plants. Protists feed primarily on soil bacteria, which are rich in nitrogen. However, they cannot absorb all the nitrogen, so they excrete the excess as ammonium, which is readily used by plants. They also regulate populations of bacteria because their grazing stimulates bacterial growth. Bacteria are an important food source for other soil organisms and help suppress disease by competing with or feeding on pathogens. One group of amoebae, the vampyrellids, include root pathogens in their diet. They are called vampyrellids because they attach to the surface of hyphae, generate enzymes that eat through the fungal cell wall then suck dry or engulf the cytoplasm inside the fungal cell.

This article with full references is on the disjunctnaturalist website.

Walks and other events

Walks start at 10.00 unless otherwise stated. Bring lunch, water and clothes for all weather.

May 1st: Panatana, on the eastern side of the Rubicon Estuary, has recently been purchased by the Tasmanian Land Conservancy and the Indigenous Land Council. Entrance to Panatana is approx. 10 km along Bakers Beach Rd but please meet and car pool at the junction of Bakers Beach Rd and the Frankford Highway. (Attendance: Sarah)

June 5th: Sisters Beach East looking at birds, plants, geology and its relation to the geography and vegetation, and interesting archaeology.

A car shuffle is required so the fewer cars the better. Meet at the start of Postmans Track on Sisters Beach Rd at 10:00. (Be punctual or we may have difficulty getting you back from the end of the walk.) There is a blue NP sign on the right, but parking is limited. Passengers and gear will be dropped off, and drivers will be directed on to Sisters Beach. One or two cars will return the drivers to the walk start. Please do not wander off, wait approx 20 mins until drivers return.

The walk is quite easy, with a few physical challenges, but nothing too dramatic. Sisters Beach Rd (C233) is off Port Road (C232) off the Bass H'Way. (Attendance: Ian) For more details phone Ian on 0401 434 080 or 6411 4900.

July 3rd Don Reserve, Devonport: remnant bush bordering the Don Estuary. Meet at 10.00 at Devonport Aquatic Centre car park at the western end of Steele Street. (Attendance: Patricia)

August 7th AGM and winter social at Jim Nelson's, 68 Dynan's Bridge Rd, Weegena.
As in previous years, we will be asking for an audit exemption. AGM will start at 10.30. This will be followed by lunch – bring food to share. **NB change of date and time for the AGM.**

September 4 Lobster Falls. The start of the walk is signposted on road B12 near the top of the rise at the end of the long, straight section of road east of Chudleigh; about 10 minutes from Deloraine or Mole Creek. Parking on grassed area off B12.

September There will be an extra walk later in the month to monitor *S. obcordatum* at Hawley - date dependent on flowering time. To participate contact Phil Collier. phil@rubicon.org.au

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