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Interactions of Water, Plants and Ground-Dwelling Fauna: Water Harvesting and Tapping by Trapdoor Spiders

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Interactions of water, plants and ground-dwelling fauna: Water harvesting and tapping by trapdoor spiders

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Background

A rich and diverse fauna of trapdoor and funnel-web spiders (Mygalomorphae) occurs in Australia. Representatives of this primitive group of spiders can generally be recognised by downward pointing fangs and two pairs of lung books (the respiratory organs which open on the underside of the abdomen). Globally (see http:research.amnh.org.entomology/spiders/catalog/) there are 15 families of Mygalomorphae with ten represented in Australia and of which eight occur in W.A.. There are over 270 named genera with over 60 found in Australia. Of these about half occur in W.A. and at least eight are endemic to the state. All but about seven of the approximately 330 Australian species are endemic and of the upwards of 71 W.A. species at least 63 are endemic. New species are being discovered progressively, partly due to targeted surveys in recent years.

Biology and life history

Most species are ground-dwelling, while a few live in or on the bark of trees (as an extension of the terrestrial habitat). Most make a burrow or tube, and many build characteristic trap-doors; some construct fans of twigs and leaves around the mouth of a burrow; others extend webs from the retreat. Mygalomorphs are generally long lived and usually take several or many years to mature. Most species are sedentary and remain in the same burrow or retreat throughout life although a few will move sites particularly web-weavers if disturbed by rain. Males mature earlier than females when they abandon their burrows and 'wander' in search of mates. After mating males die but females persist and some species may live for at least 20 years and continue to reproduce (i.e. iteroparously).

Here I shall discuss some of the specialised biology of trapdoor spiders, particularly of arid adapted species and their biological interactions with water and plants. This is prefaced with the awareness that all spiders are vulnerable to dessication because of a 'soft' abdomen.

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Mygalomorphs which inhabit arid areas appear to have adapted to aridity in situ rather than having invaded dry habitats, i.e. they are relictual from an earlier more benign geohistorical time including some genera typically occurring in present day rainforest (reference 1). Where such genera also occur in desert habitats they can be regarded as having been 'stranded' following an earlier climate change retreat of rainforest presence (reference 1) (see Figure 22 for a table listing representative taxa).

Desert or arid adapted mygalomorphs survive through a combination of avoidance and opportunism.

1. Through minimisation of water loss and dessication by

(a) Morphological modifications such as:

- large body size and/or
- sclerotisation of abdominal cuticle

(b) Behavioural tactics such as:

- Avoidance tactics particularly by having deep burrows and
- Opportunistic tactics including the following behaviours concerning phenology:

Dispersion of emergents (i.e. spiderlings as they emerge from the mothers' burrows) and male 'wanderings' and mating coincident with seasonal rain or high humidity; ambulatory dispersion rather than aerial (of emergents); aestivation of immature spiders (including penultimate instar males) and of matriarchs (ie. reproductive females) along with incubation of their eggs and broods.

2. Life history tactics including

- Longevity of matriarchs and iteroparous reproduction
- Short maturation time and annual turnover within the male population.

3. Foraging tactics

- Burrow adjuncts such as attachment of twiglines (as sensory extensions from the burrow rim) combined with enlarged eyes and longer legs increases foraging efficiency in arid habitats.

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4. Finally water harvesting and tapping

I shall proceed with reference to a selection of images demonstrating some of these attributes. My approach is through natural history observations, thus not a report of experiments and no statistics. Perhaps I am biased but *Nature has already performed the experiments, it behoves the naturalist to observe and interpret the results*.

Again from observations and simplistic interpretations *it appears that trapdoor spiders have not invaded the desert but adapted as the deserts have developed around them through geohistorical shifts and climatic changes*.

Examples of avoidance of dessication by our two most highly arid adapted trapdoor spider species.

Idiosom nigrum Main (see Figure 1) is protected from dessication partly through a deep burrow that extends into humid soil. Additionally it has an extraordinarily thickened abdominal integument. This is dorsally corrugated and posteriorly truncated with large button-like sigilla and in some parts of the geographic range has stout spines along the ridges. This morphology reduces evaporative water loss in contrast to most species in the related genus *Aganippe*. The enlarged eyes and long legs together with the attached twiglines to the burrow rim are advantageous for foraging.

Idiosoma nigrum

Figure 1

Gaius villosus Rainbow (see Figures 2 and 3) has resolved the problem of water loss by virtue of its large body size (probably the largest Australian representative of the

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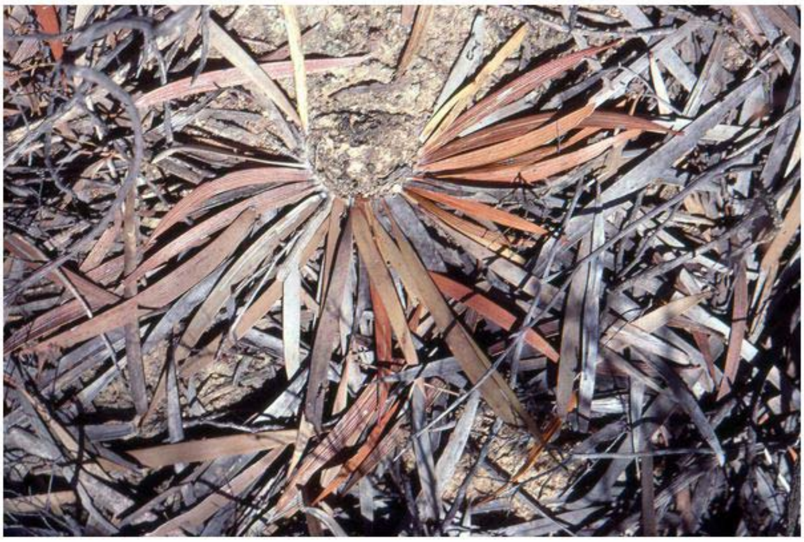
family Idiopidae), in combination with an excessively deep burrow (at least 70cm vertical depth in some instances). Like *Idiosoma nigrum*, *Gaius villosus* may, in some habitats, also attach twiglines (adjuncts to foraging) to the burrow rim (Figure 2). For both these genera and many other twiglining species (of *Aganippe*, *Blakistonia* and even desert inhabiting *Conothele*, rain drops can adhere temporarily to the twiglines rather than soaking immediately into the soil) and are thus available for the spiders to drink.



Gaius villosus

Figure 2

Gaius villosus
Female

Gaius villosus
Male

Figure 3

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Immature spiders and brooding females of *Gaius villosus* aestivate in sealed burrows. Spiders construct a mud plug (or seal) that hardens when dry and helps maintain an environment with an even temperature and humidity in the burrow during a dry summer (see Figure 4). Adult male spiders perforate this plug (Figure 4) when they emerge to mate. Such abandoned burrows assist water percolation that is particularly profitable to other spiders in such areas especially during summer thunderstorms.

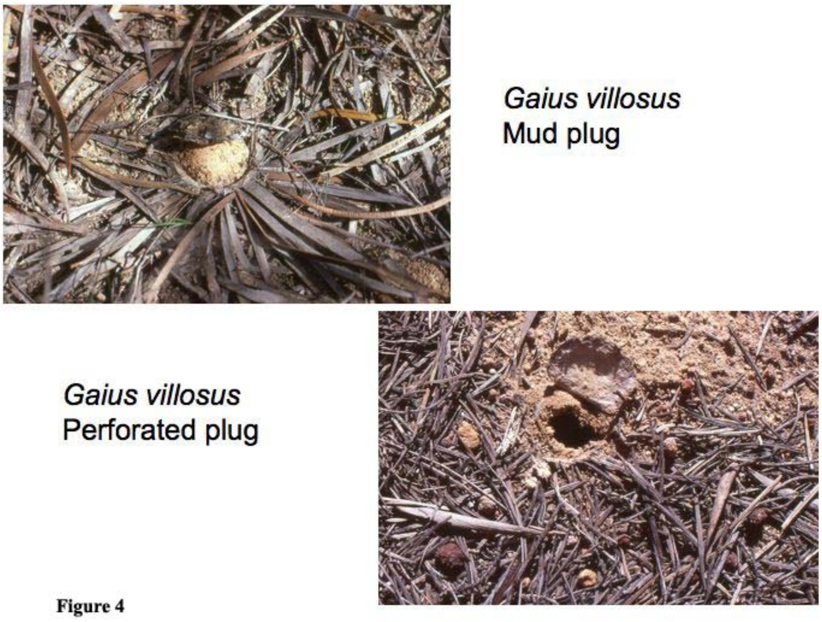

Figure 4

Mobility response to extremes of flooding and drought

Tropical species of the ctenizid *Conothele* (see Figure 5) that make their burrows in the banks of creeks (or in inland desert areas subject to periodic sheet flooding) are subjected alternatively to wet and dry conditions. Burrows are frequently washed out of the banks or clay pans. However the stocking-like lining of sealed tubes, which maintains an even environment during dry seasons also prevents destruction and drowning in times of flood. If dislodged during a flood they may be deposited elsewhere and the spiders resettle, a rare phenomenon among trapdoor spiders.

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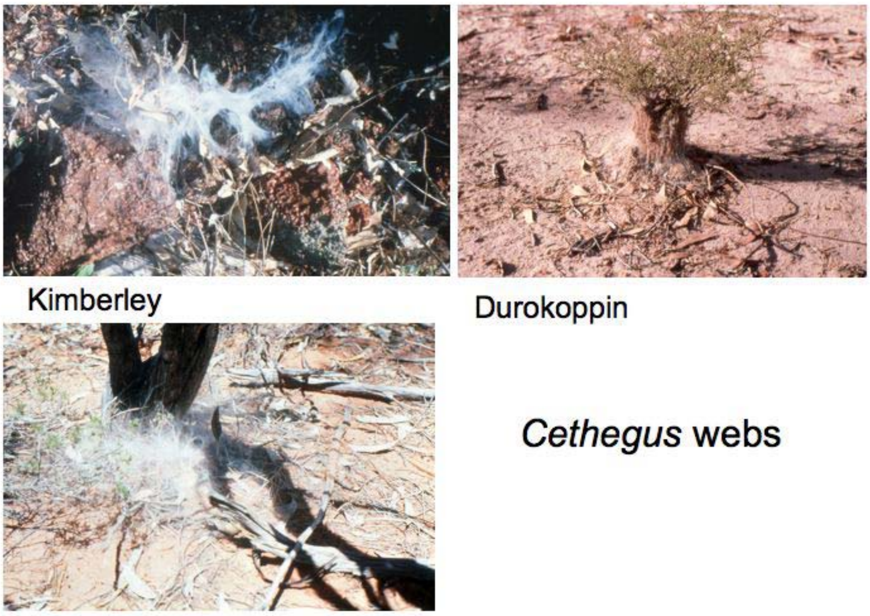
Conothele/Kimberley

Figure 5

However, the web weaving diplurid *Cethegus* (see figure 6) is also able to 'move camp' following heavy rain which may destroy the prey catching sheet web. In the Kimberley, webs are constructed over shallow burrows in creek beds which although dry on the surface maintain humid sub-surface conditions (preventing dessication). Then, in times of inundation of a river bed, webs are swept away with the web-swaddled spiders that again like *Conothele* may settle elsewhere. In dry desert areas if webs are destroyed and burrows flooded the spiders similarly 'move camp' and reconstruct burrows and web elsewhere.



Widgiemooltha

Figure 6

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Seasonality response

Although granite rocks in the arid interior appear (generally) dry and inhospitable during the summer they are also water catchments. During seasonal rain (both in winter and after summer thunderstorms) they frequently provide tiny seasonal oases in the form of shallow meadows (see Figure 7) in the scoops formed through the infilling of former rock pools. These provide habitat for relictual populations of the nemesiid genus Teyl (see Figure 8) which construct 'open-holed' burrows (that is no trapdoor but a retractable collar-like entrance in the moss and gritty soil that remarkably retains a humid substrate. However the spiders seal their tubes during dry periods and shut down their metabolism until the meadow is watered again when the spiders resume activity, release spiderlings, feed and mate.

Meadow on granite rock, Payne's Find, habitat of *Teyl*

Figure 7

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Teyl luculentus male

and female

Figure 8

Water harvesting by canopy of rain, dew and fog

Many desert sites actually provide remarkably favourable microhabitats for invertebrates such as terrestrial snails, isopods (native slaters), insects, myriapods and trapdoor spiders. As an example, at Wigunda (see Figure 9) on the unpropitious limestone soil the hummocky, low vegetation of mallee, titree shrubs and saltbush shelters populations of a species of the genus Anidiops (see Figure 10 of a cluster of trapdoor spider burrow entrances). The vegetation catches dew, mist and rain and directs the moisture to the ground under the umbrella-like canopy where the litter and soil retains a humid microhabitat.

Wigunda, *Anidiops* site

Figure 9

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Anidiops burrows

Figure 10

In contrast to this stark, arid habitat the tingle trees (Figure 11) of the southwest forest exercise the same principle of canopy catchment. These enormous eucalypt trees take advantage also of mist, dew, fog and rain but then frequently channel the moisture simply through 'drip' down onto their trunks where it runnels to the ground. Several species of mygalomorphs actually construct burrows in the bark of the trunks that are moist throughout the year.

Tingle trees, canopy catchment and water harvesting on butt

Figure 11

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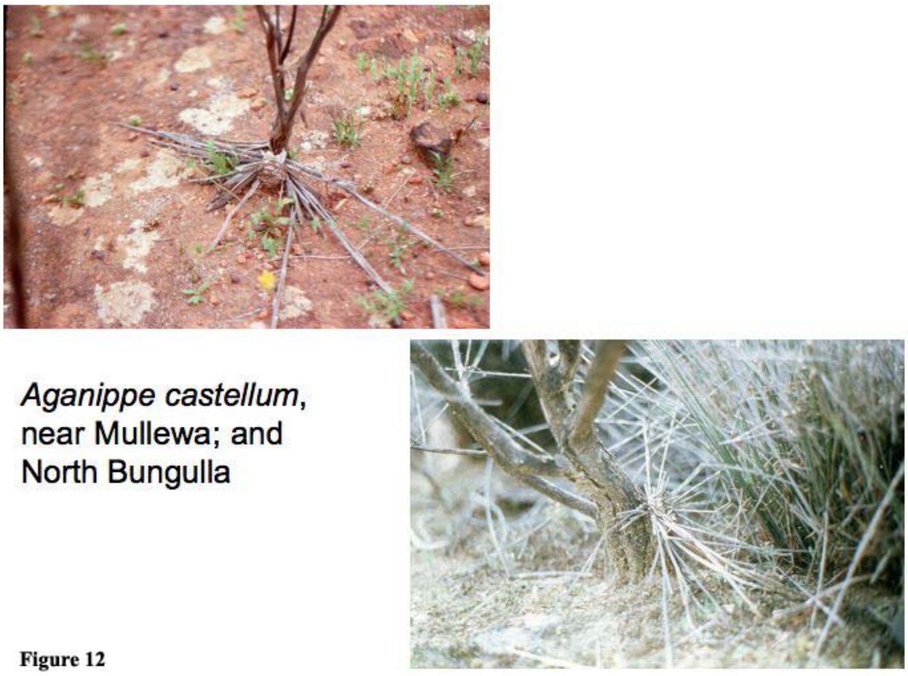
Water harvesting by canopy and tree and shrub stems

Many desert and arid-habitat species of trapdoor spiders take advantage of vegetation which harvests water from rain in the canopy and directs it down stems and/or trunks (see Figure 13) into the litter and soil where it is stored and ultimately available to ground-dwelling invertebrates including trapdoor spiders. Many species form aggregations or clusters around the bases of individual trees and tap the water source. This could occur in two ways; firstly as the water drains from the plant stems into the soil and secondly (later), following drying of the soil surface when through hydraulic lift (see reference 2) the roots take up deep water and discharge it through root hairs on sub-surface roots into the soil again (references 2 & 3) (see Figure 23 illustrating the process of water uptake, hydraulic lift and water release by plant roots). It is worth noting that as well as such 'tapped' water helping to maintain humidity in burrows, the spiders also probably drink such water by 'sucking' the moist soil. 'Sucking' of soil moisture by spiders has been recorded elsewhere (reference 4).

Examples of species which take advantage of such water harvesting by plants include *Aganippe castellum* Main (see Figure 12) and *Aname turrigera* Main (see Figure 14).



Aganippe castellum, near Mullewa; and North Bungulla

Figure 12

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Water harvesting, "run-down" on mulga trunk

Figure 13

Aganippe castellum Main, a widespread idiopid species through the eastern wheatbelt and into the goldfields, although with a rather conspicuous burrow top, is not often observed due to its patchy distribution in favourable habitats. The burrow of the spider is sited against the butt of a shrub or tree and the silk tube extends vertically against the stem, with the opening facing the stem and the door falling away backwards from the hinge (see Figure 12). Thus the spider is able to take advantage of water running down the stem and secondarily of the added moisture below the surface.

Aname turrigera Main, a nemesiid, builds turret-like extensions, or 'towers' (which resemble the flight towers of termites) from its burrow, frequently close to the butts of trees (see Figure 14, clump of towers near Mallura and single turret near Yardea). These towers probably, firstly deflect flood water from the burrow openings and secondarily the spiders are able to tap into the water released by the plant roots.

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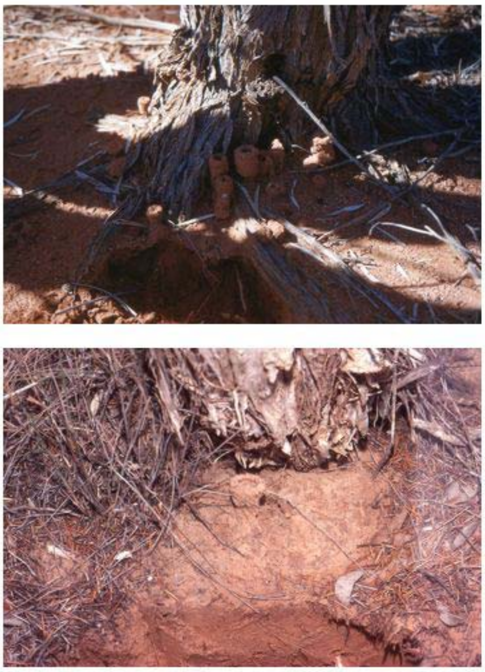

Aname turrigera

Cluster of turrets of burrow entrances at base of mulga and single turret at base of paperbark.
Tree stems harvest water after rain, creating moist habitat.

Figure 14

Significance of summer fog

The significance of summer fog for ground-dwelling (and tree trunk living trapdoor spiders) from desert to forest cannot be over emphasised. The southern slopes of the Stirling Ranges in southern W.A. capture fog from coastal south east winds in the summer (see Figure 15) while the northern slopes are still exposed to dry conditions. The fog hits the southern slopes, rolls up to the crest then slides down the valleys again, maintaining moist soil conditions favourable to various insects and other invertebrates including trapdoor spiders (such as *Eucyrtops* see Figure 16, burrows sited in a bank adjacent to a walking path).

Another montane area close to the coast, farther east is Mt Ragged, surrounded by dry scrubby vegetation. Nevertheless, during the summer and associated with high pressure weather systems, moisture-laden southeast winds form orographic cloud and lingering fog on the summit of this otherwise inhospitable ridge (see Figure 17). The outcome for the terrestrial invertebrates means a sustained damp environment while the surrounding terrain of lower elevation basks in the dry heat of summer. Figure 18 shows a sheet web of the platform spider, drenched with fog.

Again on the coastal plain south of the Nullarbor, during the summer onshore moisture laden winds produce light or dense fog (see Figure 19, February fog between Mundrabilla and Madura). This is beneficial to vegetation and generally keeps the soil and litter moist. Such fog can also be of immediate advantage to trapdoor spiders especially those with open entrances which are frequently screened with a silk hymen that gathers the moisture which then coagulates into water

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droplets (see Figure 20, *Aname* species). Such droplets are directly available to spiders which can drink the water from below the hymen.

Bluff Knoll, fog from south coast high pressure system
Exposed landscape following fire. Fog helped retain moisture in deep gullies. Some spiders survived.

Figure 15

Wet bank
Bluff Knoll, Stirling Range, habitat of spider burrows

Eucyrtops, trapdoor spider, from above bank

Figure 16

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Mt Ragged ne Israelite Bay, fog, orographic cloud

Figure 17

Corasoides platform web, fog catchment

Figure 18

As an aside, early settlers demonstrated many ingenious ways of harvesting water from ditches draining into dams, rock wall catchments on granite rocks, diversion of rainwater from iron roofs into tanks to wells with elaborate bulwarks of stones or logs (see Figure 21 of one such well along Holland's Track).

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Fog coastal plain Mundrabilla

Figure19

Droplet formed from fog precipitation on silk hymen of *Aname* burrow entrance, Mundrabilla

Figure 20

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Old well, Holland's Track

Figure 21

Table 1. Families and genera of mygalomorphs which occur in semiarid/arid regions. * Genera which range from tropical rainforest to semiarid/arid region (Main 1997).
+ Occur only in semiarid/arid zone.

ACTINOPODIDAE	* ***MISSULENA***
CTENIZIDAE	* ***CONOTHELE***
DIPLURIDAE	* ***CETHEGUS***
HEXATHELIDAE	* ***HADRONYCHE***
IDIOPIDAE	***AGANIPPE***
	+ ***ANIDIOPS***
	* ***ARBANITIS***
	BLAKISTONIA
	EUCYRTOPS
	+ ***GAIUS***
	+ ***IDIOSOMA***
NEMESIIDAE	* ***ANAME***
	* ***CHENISTONIA***
	* ***KWONKAN***
	+ ***MERREDINIA***
	? * ***YILGARNIA***
BARYCHELIDAE	* ***IDIOMMATA***
	* ***SYNOTHELE***
	* ***MANDJELIA***
	* ***OZYCRYPTA***
THERAPHOSIDAE	* ***SELENOCOSMIA***

Figure 22

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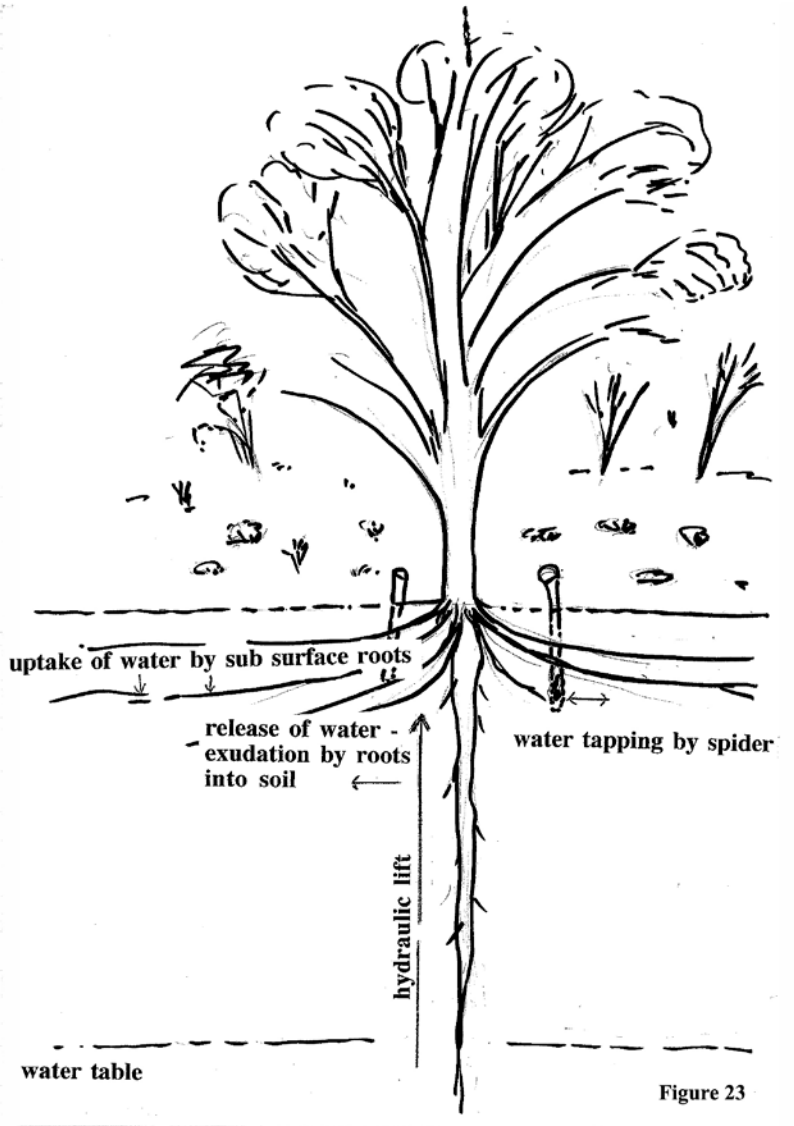

Figure 23

ACKNOWLEDGMENTS

Photo credits: Figure 1, Densey Clyne; Figures 5, 14, A.R. Main.

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