BIOLOGY OF WEST AUSTRALIAN TUBEROUS *DROSERA*

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Western Australia contains a particularly large proportion of the world's carnivorous plants. Over half of the known ninety species of *Drosera* occur in this part of Australia and a much larger proportion of the tuberous species of the genus is endemic to this region. As a typical example we will describe *D. erythrorhiza*, a conspicuous rosette species of the winter flora of the coastal sandplains of South Western Australia. It is a member of the subgenus, *Ergaleium* (De Buhr, 1977) and dies down each summer to a dormant subterranean tuber. Each season a new tuber forms into the cavity of the old expended tuber, the successive years of 'skin' or epidermis of the parent tubers building up layers of protective sheathing around the tuber (Fig. 1). By counting these epidermal sheaths it is possible to obtain a minimum estimate of the age of the plant in

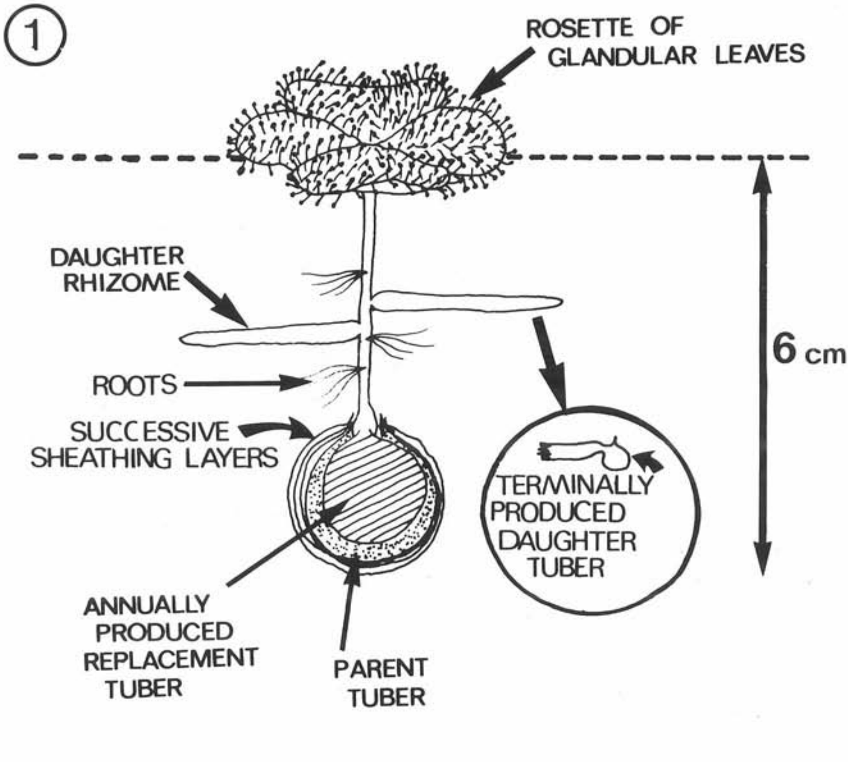


Fig. 1. Peak growth stage of *Drosera erythrorhiza* (x1). Leaf rosette fully expanded and receptive to organism capture and digestion. The underground stem has attached daughter rhizomes which swell terminally to produce daughter tubers (see inset) whilst at greater depth a replacement tuber develops within the tissues of the emptying parent tuber.

years (Dixon and Pate, 1978). Tubers can be sheathed by as many as fifty epidermal layers in plants from certain habitats, but up to twenty layers per plant is a more usual number. The protective sheaths enable the tuber to resist temperatures of 60°C for up to four hours and no doubt enhance its capacity to avoid desiccation in the long hot summers of its native habitat.

D. erythrorhiza will flower only after a summer fire, releasing the small, ornamented seeds (Fig. 2a) in late autumn. Germination is apparently a rare event, occurring in nature only in seeds older than three years. One- and two-year old seeds fail to germinate under a variety of test conditions.

A single plant of *D. erythrorhiza* can produce up to thirteen daughter tubers a season, each tuber forming terminally on a swollen lateral rhizome which develops horizontally from the nodes of the plant's main stem (Fig. 1). These daughter tubers sprout to produce small plants the following winter, and can produce full-sized leaf rosettes in a matter of three or four seasons of growth (Front Cover). If lateral rhizomes are removed from a plant and stored in pots of moist sand, they will develop small terminal tubers. This indicates that the process of tuber formation can occur on a rhizome without further nutrients or stimuli from the parent.

D. erythrothiza exhibits a circular conformation of its colonies. Each group of plants is up to 2 metres in diameter and contains up to two hundred plants (Pl. A). Rosettes of clones may merge to comprise a continuous lawn of glistening tentacles, which, at the height of the winter, contain a veritable graveyard of insect corpses.

Preliminary studies indicate that in certain habitat situations *D. erythrorhiza* can obtain a significant portion of its annual

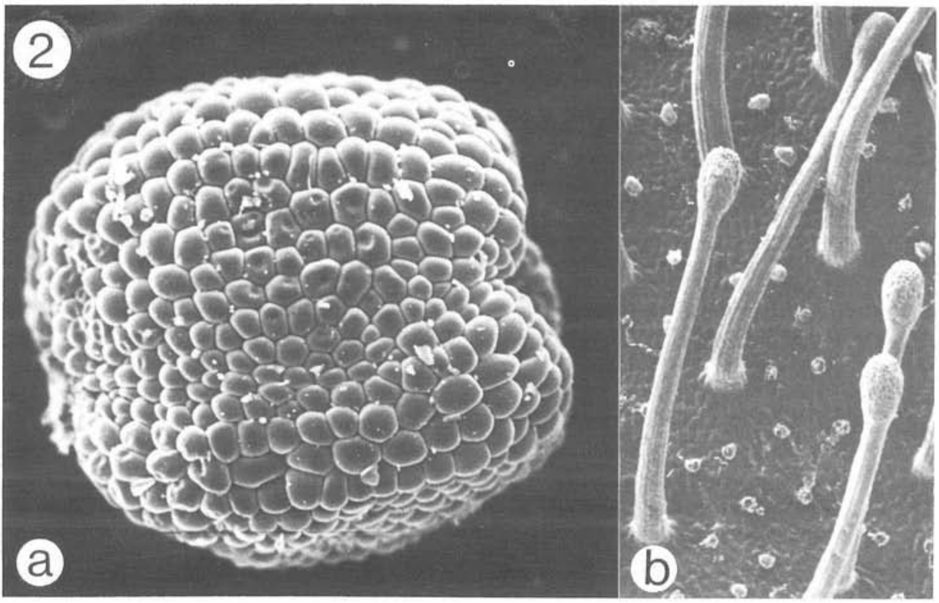
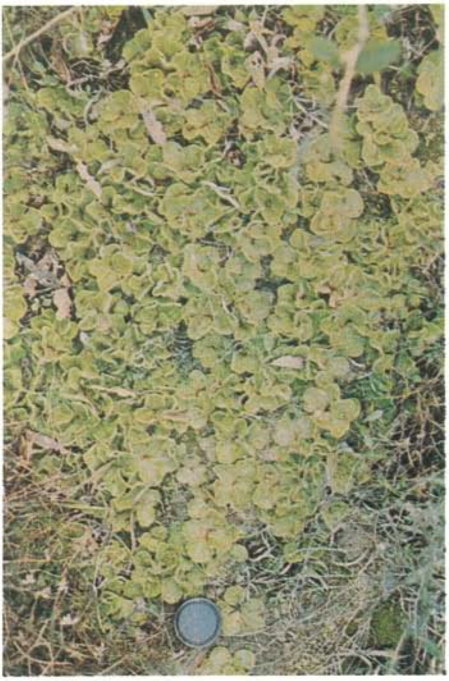


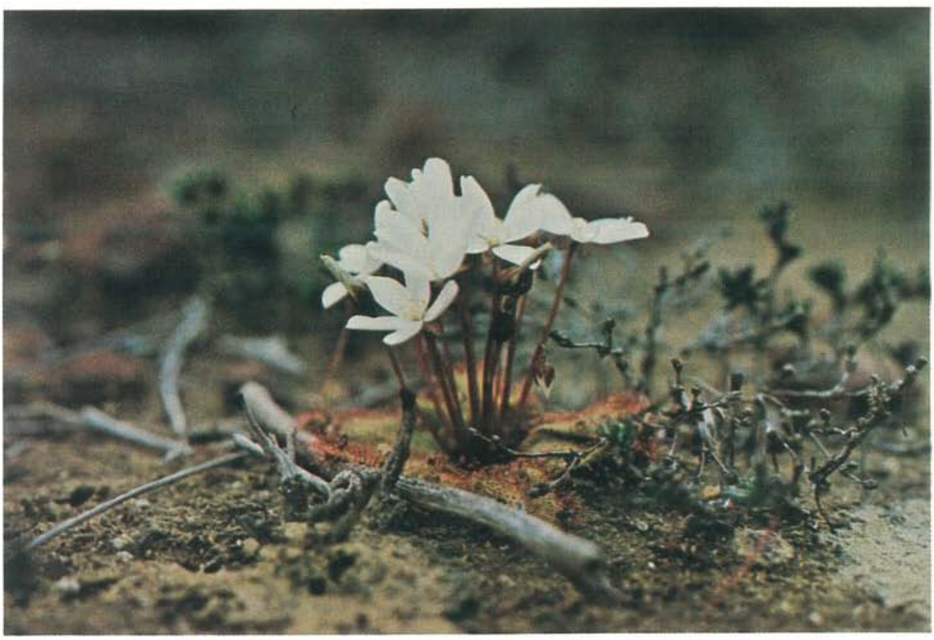
Fig. 2a. Scanning electron micrograph of a seed from *D. erythrothiza* (mag. x200) after application of a thin film of gold-palladium alloy. (Left, above)

Fig. 2b. Scanning electron micrograph of a small area of the leaf rosette of *D. erythrorhiza* (mag. x28). Leaf surface covered with small sessile glands and larger tentacles tipped with swollen glandular heads (mucilage removed). (Right, above)



Pl. A. Densely packed clone of *D. erythrorhiza*.

Pl. B. *D. erythrorhiza* can sport variants within newly emerged clones which are for the main lacking stalked glandular hairs. These plants do not have the ability to digest insects.



The many flower bearing stems of *D. macrophylla* are a familiar sight on granitic rocks throughout the S.W. of Western Australia.

requirement for nutrients by digestion of trapped insects. Isotopic labelling studies of mature plants of *Drosera erythrorhiza* show absorption of the heavy isotope ($_{15}N$) if fed vinegar flies *(Drosophila melanogaster)* labelled with this isotope. The studies show that the *Drosera* utilizes the nitrogen of the flies with 76% efficiency. Assuming that a similar efficiency of nitrogen digestion were to apply to organisms caught by wild populations of *D. erythrorhiza,* it has been estimated from studies of insect catches in nature that carnivory might account for between one-quarter to one-half of the nitrogen acquired by the *Drosera* plants during a season of growth.

Over-supply of insect prey occurs when an excesive number of organisms are captured by *D. erythrorhiza.* More than four *Drosophila melanogaster*/plant/week (ie a supply of insects equivalent to 0.1 mg N/plant/week) results in carcass decay before plant digestion is complete, and in necrotic areas developing on the leaf.

Plant variants occur which lack the mucilage secreting stalked glands (Pl. B) on the leaf rosette. These "glandless" plants fail to catch prey in habitat situations. Laboratory studies using carbon and nitrogen labelled insects also indicate an inability to digest insect carcasses (Dixon, Pate and Bailey, in press).

Although nitrogen provided from insects is important, other nutrients (eg. phosphorus, magnesium, potassium, calcium, zinc, etc) also come from insects. These nutrients, further nutrients absorbed from soil, and carbohydrates formed in photosynthesis are conserved in the aestivating tubers. Certain key nutrients (eg. phosphorus and nitrogen) are mobilized from vegetative parts to developing tubers at the end of the growing season with over 80% efficiency so that a plant can survive a poor season with virtually no additional intake of nutrients. Indeed, in pot culture there is little loss in plant vigour if tubers are grown in nutrient-deficient white sand watered with distilled water. Vigour is, however, reduced in subsequent seasons. In the wild, tubers accumulate high levels of phosphorus and other nutrients, especially after a season's growth in soil enriched with the ash of a recent fire.

Repeated severe drought can result in complete death of clones, as occurred recently in Western Australia in the dry seasons of 1976 and 1977.

Plants developing from daughter tubers relocate their subsequent replacement tubers at progressively greater depths by production of a vertical stem or dropper which grows through the base of the parent tuber. Eventually, after a depth of 5 - 8 cm is reached, the plant replaces its tubers *in situ,* to give the sheath-enveloped tubers typical of mature plants (Fig. 1).

On the few occasions when we have discovered seedlings we find that these also engage in a depth-seeking system of tuber replacement. However, because of the high temperature and dryness of the upper soil layers and the small amount of nutrient capital in the original seed, there is a high mortality of seedling plants over the first few summers. Mortality is highest when tubers are still relatively high in the soil profile.

Although the studies to date have concentrated on *D. erythrothiza,* many other members of the subgenus *Ergaleium* show similar strategies, although habitat differences are vast. For example *D. bulbosa* and *D. gigantea* are often completely submerged in water in seasonally swampy areas, whilst *D. stolonifera* and *D. macrantha* are typical of very dry habitats. Many of the tuberous Droseras can be grown from seed or daughter propagules and some produce showy flowers in pot culture (eg.*D. bulbosa, D. macrophylla (Pl. C),* and *D. stolonifera. Drosera zonaria (Rear Cover),* grows well in pot culture, but like *Drosera erythrorhiza,* requires fire before flowering. Our experience with the Western Australian sand plain Droseras is that their tubers should be stored dry at 25 - 30°C in pots of sand through summer. Gradual addition of water to pots in early

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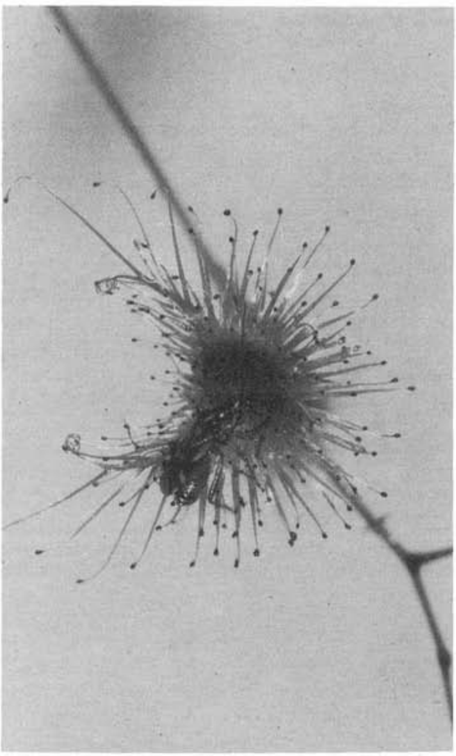
autumn (Southern Hemisphere) will promote early rosette growth and, in certain species, flower production.

Although natural flowering of *D. erythrothiza* is usually stimulated by a habitat bushfire over summer or early autumn, removal of tubers from soil and storage in closed paper bags for a week or so, followed by replanting, can result in up to 20% of the tubers producing inflorescences. Burning plant litter on the soil surface of pot grown plants will also induce flowering, but the addition of cold ash to non-stimulated tubers has no effect. Studies have yet to confirm the nature of the stimulus caused by fire. High concentrations of ethylene gas in soil during and after fires may well be a key factor in initiating floral primordia (Smith, 1977).



A bug (*Cyrtopeltis* sp.) cohabiting and gaining nutrients from the captured prey of *D. gigantea*. Photo by Dixon and Pate.

Not all tuberous Droseras are amenable to cultivation. *D. gigantea,* a branched erect species up to 1½ metres tall, inhabits swampy ground and its large tubers (up to 2 cm in diameter) are often buried up to 70 cm deep, usually at the base of a layer of silt or sand overlapping a clay pan. These conditions would be difficult to simulate in culture.

The reader is referred to the articles listed below for further information on the biology of Australian tuberous Droseras.

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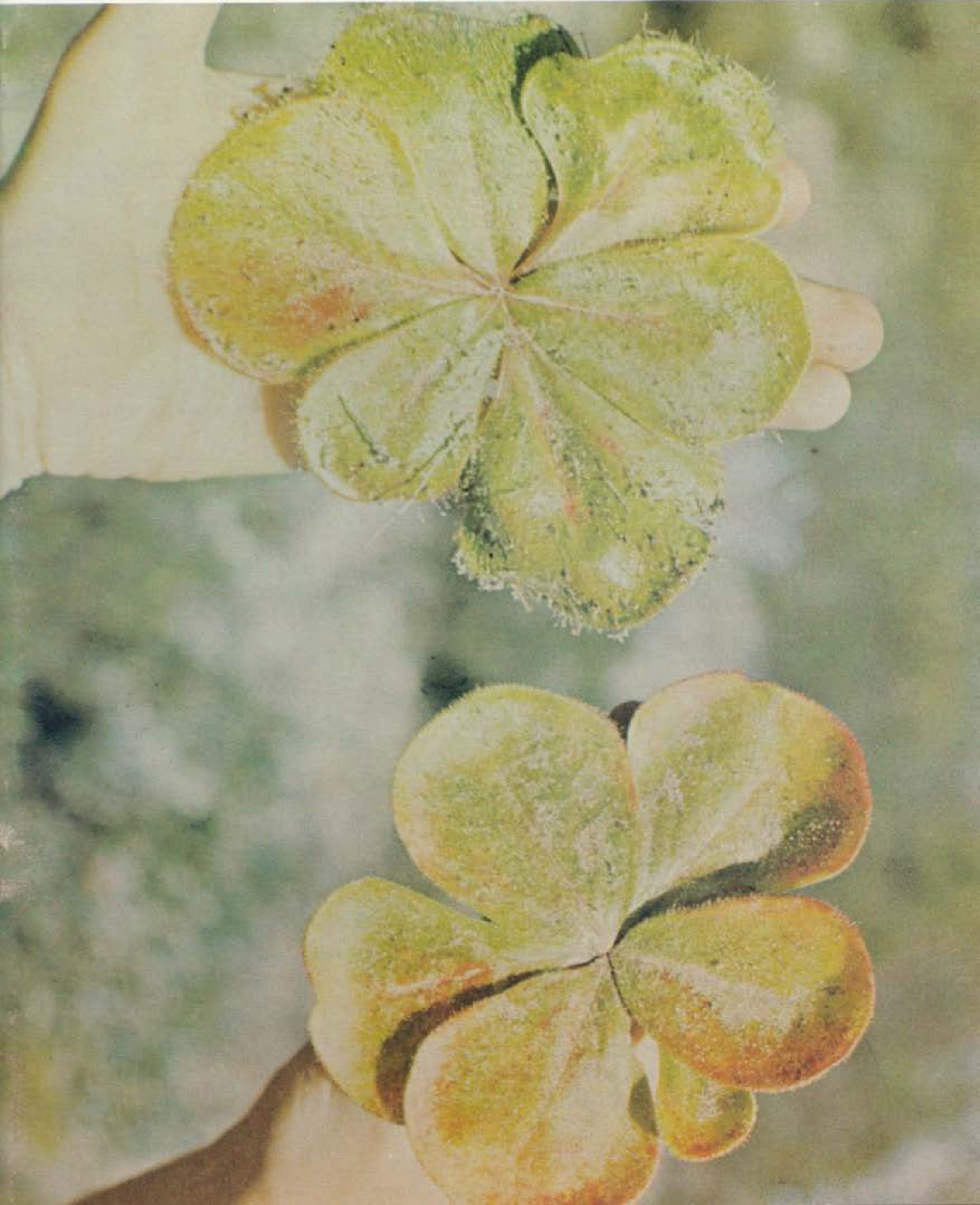

D. zonaria, showing the concentric arrangement of rosette leaves.

Photos by K.W. Dixon and J.S. Pate