

# The phenologies of six native forbs (*Aphanes australiana*, *Isoetopsis graminifolia*, *Triptilodiscus pygmaeus*, *Hypericum gramineum*, *Solenogyne dominii* and *Vittadinia muelleri*) occurring in grazed grassy communities on the Northern Tablelands of New South Wales

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Trémont, R.M. (Department of Botany, University of New England, Armidale, New South Wales, Australia 2351) 1995. The phenologies of six native forbs (*Aphanes australiana*, *Isoetopsis graminifolia*, *Triptilodiscus pygmaeus*, *Hypericum gramineum*, *Solenogyne dominii* and *Vittadinia muelleri*) occurring in grazed grassy communities on the Northern Tablelands of New South Wales. *Cunninghamia* 4(1): 21–34. Information on the phenologies of native forbs occurring in grassy vegetation of the temperate Australian mainland is lacking. This has serious implications if we are to manipulate natural grassy communities to favour the continued existence of both common and uncommon native forbs, and the species richness they provide. The occurrence and duration of major life cycle events for three annual (*Aphanes australiana*, *Isoetopsis graminifolia*, *Triptilodiscus pygmaeus*) and three perennial (*Hypericum gramineum*, *Solenogyne dominii* and *Vittadinia muelleri*) forb species commonly found in grazed natural grasslands on the Northern Tablelands of New South Wales are reported in the present study. Growth took place in all seasons, across species, but reproduction was restricted to the spring–summer period. Particular life cycle events occurred over specific intervals, which varied between species. Such variation in the timing of key reproductive events can be utilised to enhance or suppress the survival of particular populations and so manipulate community composition. However, if native forbs and species-rich natural grassy communities are to be conserved or enriched, systematic data collection is required for many species. Comparative and functional group approaches may be the most effective strategies for documenting and synthesising the urgently-needed information on morphological and response characteristics of numerous native herbaceous species and their grassy communities.

## Introduction

The phenologies of many species of native forbs found in natural grassy communities of the temperate Australian mainland are unknown. However, the major contribution made by native forbs to the species richness of these communities (e.g. Patton 1936; Stuwe & Parsons 1977; Walsh et al. 1986; Lunt 1990a; McIntyre et al. 1993; Prober & Thiele 1993; Trémont 1993, 1994), the depleted status of a number of previously plentiful forb species and the probable under-representation of these plants in

Australian lists of rare and threatened plants (McIntyre 1992) suggest an urgent need for systematic studies of their biology and ecology. Furthermore, particular groups of forbs are often characterised by specific attributes, including phenological characteristics. Studies of such attributes may facilitate the differentiation and characterisation of plant communities and provide for an understanding of processes affecting population and community dynamics, structure and composition (e.g. Friedel et al. 1988; Leishman & Westoby 1992; Bell et al. 1993; McIntyre & Lavorel 1994; McIntyre et al. 1995).

Considerable attention has been given to the biology of native grasses of temperate communities as a result of their contribution to pastoral industries. The knowledge so gained has led to the development of techniques for establishing some species (e.g. McDougall 1989; Stafford 1991), as well as manipulating the compositions of grass components of pastures and rangelands (e.g. Harradine & Whalley 1980; Lodge & Whalley 1985; McDougall 1989). No such information is available for native forbs. However, if we are to help their populations survive the expansion of 'synthetic communities' (after Bridgewater 1990), this has to change. We must gain an understanding of life-history attributes of, at least, the common forb species.

The life cycles of some threatened forbs have been well documented, and particular aspects of life cycle events studied for a small collection of other notable species (see Trémont & McIntyre 1994). However, published phenological information for common native forbs of the temperate Australian mainland is generally confined to comments on flowering times in relevant floras.

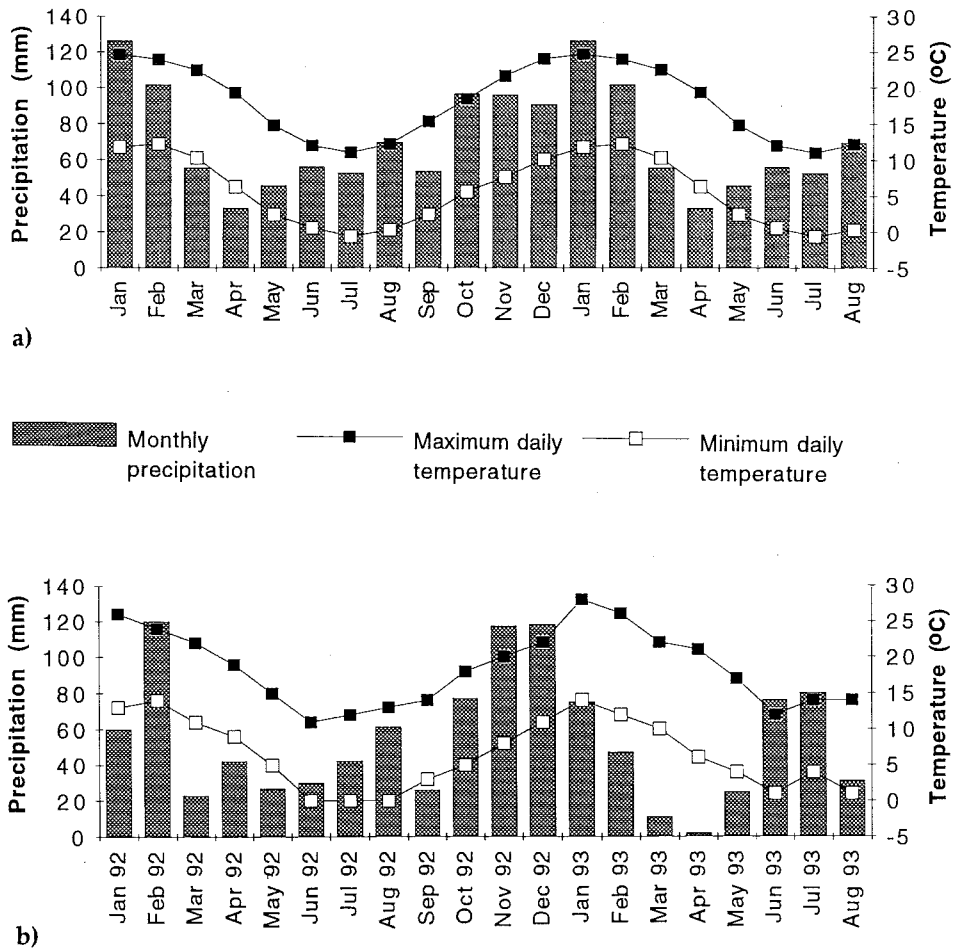
This paper describes the occurrence and duration of the main life cycle events of six native forbs commonly found in grazed natural pastures on the Northern Tablelands of New South Wales. The information reported was collected in conjunction with that for a wider study of herbaceous species and species groups occurring in grazed and ungrazed grasslands on the Northern Tablelands (Trémont 1993, 1994). The vegetation structure and the composition, diversity and life-history attributes of the flora at the study site have been described by Trémont (1993, 1994).

## Materials and methods

### Site description

The 1.2 ha study site (2 x 0.6 ha plots) was located on the Northern Tablelands of New South Wales, Australia, on the *Chiswick* CSIRO Pastoral Research Laboratory property (30°37'50"S, 151°32'42"E; 1060 m asl) near Armidale.

Meteorological data for *Chiswick* have been recorded by George et al. (1977) for the period 1949–1976 (Figure 1a). The site has a cool temperate climate, with mean maximum summer temperatures reaching about 25° C and mean winter minima of around -1° C. However, extreme maximum temperatures such as 38° C have been recorded and overnight frosts are common during autumn, winter and spring, with minima of -5 to -10° C occurring often (George et al. 1977). A mean annual precipitation



**Fig. 1.** Monthly precipitation and mean maximum and minimum daily temperatures for *Chiswick* Pastoral Research Laboratory, Armidale, NSW: a, as reported by George et al. (1977) for the period 1949–1976 (inclusive); b, as recorded during the present study from January 1992 to August 1993 (inclusive).

of 870 mm has been recorded at *Chiswick*, with approximately 60% falling during the five months from October to February (George et al. 1977). For the duration of the present study, recordings of maximum and minimum daily air temperatures and daily precipitation were obtained from the *Chiswick* weather station (Figure 1b).

Parent material at the study site consists of laterized basalt colluvium and sediments. Soils are grey-brown podzolics which are mildly to strongly leached and highly differentiated (King 1989). The site is gently undulating and has a convex mid-slope. Aspect is north to north-north-westerly and drainage is generally good.

At the time of European settlement, the study site was probably part of a *Eucalyptus melliodora*-*E. blakelyi* woodland community, with a graminaceous understorey dominated by *Poa sieberiana*, *Themeda australis* and *Sorghum leiocladum* (Whalley et al. 1978; Lodge & Whalley 1989). Native herbaceous legumes, such as the warm-season *Desmodium varians*, *Glycine tabacina* and *Psoralea tenax*, may have also been common (Whalley et al. 1978). However, little is known about other forbs in the pre-European grassy communities. These communities were replaced by a temperate tallgrass grassland community (King 1989) following the introduction of domestic stock and tree clearing in the mid-nineteenth century (Lodge & Whalley 1989). Until 1976, the site was unfenced and supported unfertilised pasture grassland grazed intermittently by sheep. From 1976, the 1.2 ha (2 x 0.6 ha plots) used for the present study were grazed continuously by mature fine-woolled non-Peppin Merino wethers at a stocking rate of 6.6 sheep per hectare. The natural pasture has remained unfertilised and unseeded (King 1989, pers. comm.).

During the present study (April 1992–August 1993, inclusive) the grass matrix of the grazed natural pasture generally consisted of small-statured grass species; bare ground was readily observable; sheep dung, lichen and moss were common; and there was relatively little plant litter. However, there were also areas which contained relatively more litter, less bare ground and sheep dung, and which were dominated by grass tussocks to about 25 cm diameter. This heterogeneity within the grassy vegetation was probably due to the effects of the camping behaviour of the sheep (Trémont 1993). Heavily utilised camp areas were dominated by small-statured grasses including the exotics *Vulpia* spp., *Poa annua* L. and *Bromus brevis* Steud., as well as native *Danthonia* spp.. Forb species such as *Paronychia brasiliensis* DC., *Oxalis* spp. and *Capsella bursa-pastoralis* (L.) Medikus were also common. Moderately utilised areas had a more diverse flora (of mixed origin), generally dominated by *Bothriochloa macra* (Steud.) S. T. Blake, *Danthonia* spp. and *Vulpia* spp., as well as the forbs *Hypochoeris radicata* L., *Triptilodiscus pygmaeus* Turcz., *Gnaphalium* spp., *Trifolium campestre* Schreber and *T. cernuum* Brot.. Areas which were least utilised by the sheep were characterised by the native grasses *Themeda australis* (R. Br.) Stapf and *Poa labillardieri* Steud./*P. sieberiana* Spreng. and native forbs such as *Hypericum gramineum* Forster f., *Haloragis heterophylla* Brongn., *Desmodium varians* (Labill.) Endl. and *Leptorhynchos squamatus* (Labill.) Less. (Trémont 1993).

### Species studied

Six native forb species were selected for phenological studies. The species chosen included three annuals — *Aphanes australiana* (Rothm.) Rothm. (Rosaceae), *Isoetopsis graminifolia* Turcz. (Asteraceae) and *Triptilodiscus pygmaeus* Turcz. (Asteraceae); and three perennials — *Hypericum gramineum* Forster f. (Clusiaceae), *Solenogyne dominii* L. Adams (Asteraceae) and *Vittadinia muelleri* N. Burb. (Asteraceae). *Aphanes australiana*, *I. graminifolia* and *T. pygmaeus* typically occurred in the moderately utilised areas of the plots, while *S. dominii* was found in places between the heavily and moderately utilised areas. *Vittadinia muelleri* and *H. gramineum* occurred in places used moderately or least by the sheep. The three annuals were selected as they appeared to be the

most abundant non-leguminous native forbs which germinated on the study site during autumn 1992. Among the perennials, *S. dominii* was chosen because it was the most common native species with a rosette life form. *Vittadinia muelleri* and *H. gramineum* were selected as they were two of the three most abundant of the taller native forbs in little-utilised areas (see Trémont 1993). Voucher specimens of each species have been deposited with the New England Herbarium (Botany Department, University of New England, Armidale, NSW).

The life cycle continuum of the annual species was divided into the following phases:

- germination — from the time both cotyledons appeared until two true leaves were present
- vegetative growth — increased leaf number or size, or plant height
- flower buds — flower buds present but unopened
- flowering
- fruiting — development of fruits and shedding of fruits or seeds
- senescing — yellowing and drying of the plant.

The life cycles of the perennial species were divided slightly differently:

- vegetative only, growing — leaf number or size, or plant height, increased but no reproductive organs visible
- vegetative only, not growing — leaf number or size, or plant height, unchanged, no reproductive organs visible
- flower buds — as for annuals
- flowering
- fruiting — as for annuals
- senescing — as for annuals.

Each phase of the life cycle for each species began or ended when at least one plant was observed to be the first or last, respectively, to bear the relevant structures.

Observations on the annual species began around the time of germination (April–May 1992). On 9 May 1992 ten individuals of each of *A. australiana* and *I. graminifolia*, and 14 for *T. pygmaeus*, were randomly selected from the populations present on the study site. These plants were then marked using wooden kebab sticks, driven into the ground approximately 2–4 cm from each plant, and were protected from grazing by the placement of wire mesh exclosures (100 cm high x 55 cm x 153 cm). Records of life cycle events (see above) from marked plants were supplemented with general observations of non-marked plants from the same cohort. Between 9 May 1992 and 31 October 1992 observations were made at 6 to 31-day intervals, becoming more frequent in late winter–early spring, as growth rates increased. From 31 October 1992 observations were made every 14 days until all plants had senesced, at the end of January 1993.

For *S. dominii* (a perennial), 13 randomly chosen plants were marked (eight on 9 May 1992, five on 23 May 1992) in the same way as for the annuals. The ages of *S. dominii* plants were unknown. Each had at least three and up to six leaves at the time of marking but excavation of plants would have been necessary to determine if the leaves were from seedlings or resprouting mature plants. Observations were made at the same time as those for the annuals but the fortnightly records begun on 31 October 1992 were continued until 29 May 1993. Two further censuses were then made, on 24 July 1993 and 28 August 1993.

Casual observations of the sprouting behaviour of established *H. gramineum* and *V. muelleri* plants were made during May, June and July 1992. Then, on 25 August 1992, 16 mature plants for each species were marked using alloy tent pegs, one driven into the ground about 4–5 cm from each plant. Observations of marked plants were made on 19 September, 10 October and 31 October 1992. Then, from the end of October, until the study concluded (28 August 1993), observations were as for *S. dominii*.

On each observation day each plant was recorded as having grown or not grown — on the basis of the number or size of leaves, or plant height; and the presence of buds, flowers, seeds or fruits and some degree of senescence were determined. For *H. gramineum* and *V. muelleri* the presence and height of newly sprouted leaves and stems were also recorded during the autumn and winter of 1993, following senescence of the previous season's foliage. These sproutings originated at, or within, 0.5 cm of ground level and were hence designated 'basal sprouts'.

## Results

### Seasonal weather

Overall, mean maximum and minimum daily temperatures for all months of the present study were similar to those reported by George et al. (1977) for *Chiswick* (Figure 1). However, mean temperatures for January and February 1993 were two to three degrees higher than those reported previously. The total precipitation recorded for January 1992 to August 1993 (inclusive) was 1090 mm, approximately 77% of the total mean precipitation reported by George et al. (1977) for the same sequence of months. This occurred because the total monthly rainfall for each of January and March 1992, January, February, March, April and May 1993 was no more than half that recorded for each month, respectively, over 27 years by George et al. (1977) (Figure 1).

## Plant responses

### a) Annuals

Germination of *Aphanes australiana*, *Isoetopsis graminifolia* and *Triptilodiscus pygmaeus* had begun by May 1992 (Figure 2). This coincided with declining maximum and minimum daily temperatures during autumn and was probably aided by the higher rainfall in April, compared with that of a relatively dry March (Figure 1). Vegetative growth continued through winter until late August-early September 1992. At this time maximum and especially minimum daily temperatures had started to rise (Figure 1b), and reproductive structures were observed for all species (Figure 2).

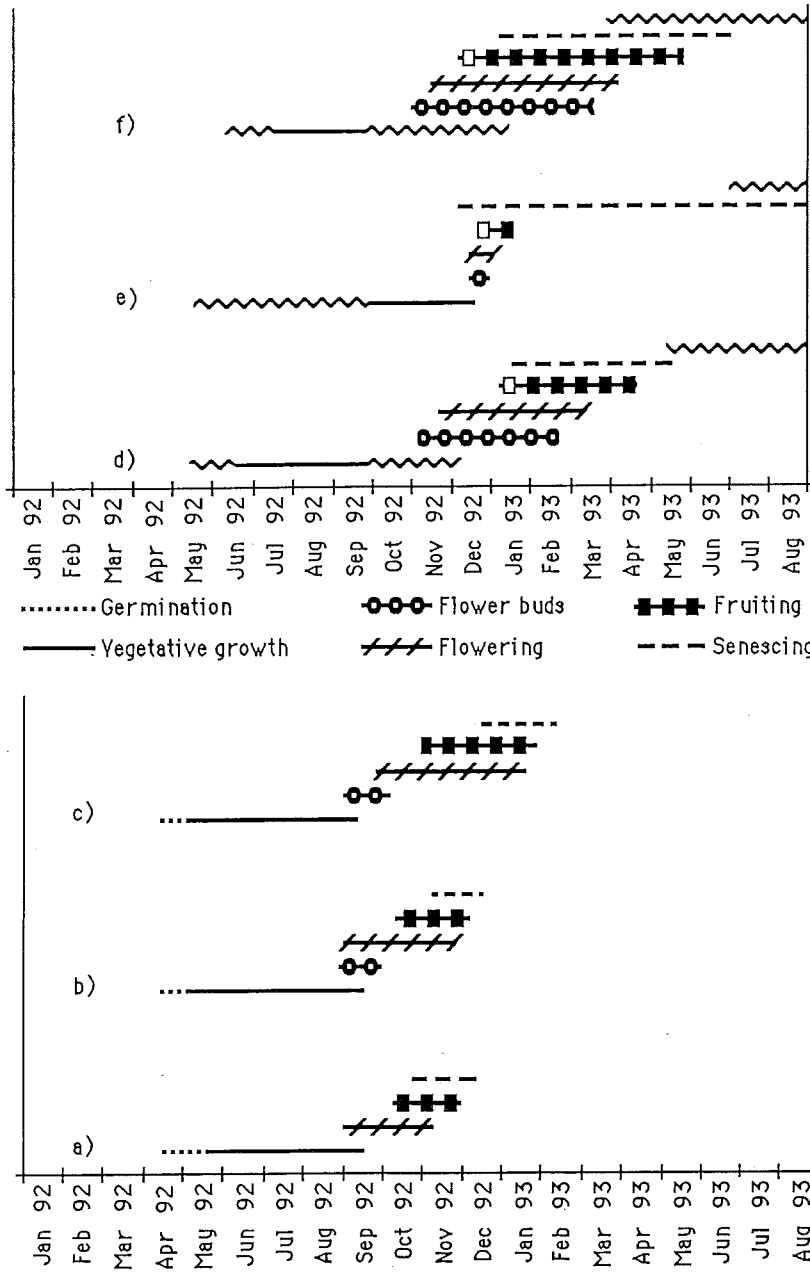
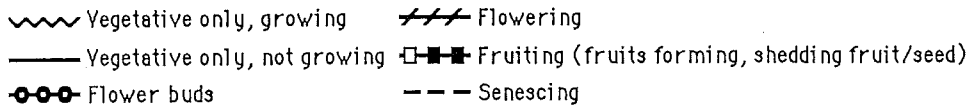
Flowering of *A. australiana* and *I. graminifolia* occurred from September until mid-November 1992 (Figure 2), despite August, September and October rainfalls which were 10 to 30 mm lower than average (Figure 1). Fruiting was then observed for these species from mid/late-October until late-November/early-December, during which time maximum and minimum daily temperatures continued to increase and total rainfall was about 20 mm above average (Figures 1 & 2). Fruiting was of a slightly longer duration for *I. graminifolia* (Figure 2). All *A. australiana* and *I. graminifolia* plants had senesced by mid-to-late December 1992 (Figure 2), in the face of increasing daily temperatures and despite average rainfall (Figures 1 & 2).

*Triptilodiscus pygmaeus* developed buds from early-September 1992 and flowering took place from late-September 1992 until mid/late-January 1993 (Figure 2). Consequently, flowering was slightly later and continued for almost twice the length of time compared with *A. australiana* and *I. graminifolia*. It also continued into the period of highest daily temperatures. Fruits of *T. pygmaeus* were present from late-October/early-November 1992 until late-January/early-February 1993 and all plants had senesced by mid-February 1993 (Figure 2). Thus the life cycle of *T. pygmaeus* continued for longer than that of *A. australiana* or *I. graminifolia* - starting at a similar time in the autumn but continuing well into mid-summer (Figure 2). The senescence of *T. pygmaeus* occurred during the first two months of a period (January to May 1993) during which rainfall was 20 to 50 mm below average for each of five months (Figures 1 & 2).

### b) Perennials

*Hypericum gramineum* and *Vittadinia muelleri* had life cycles for which the various phases occurred at comparable times (Figure 2). In contrast, *Solenogyne dominii* had a notably restricted reproductive period and a relatively long time of senescence/dormancy (Figure 2).

*Hypericum gramineum* and *S. dominii* showed growth of basal sprouts or new leaf production, respectively, from at least mid-May 1992, while *V. muelleri* produced basal sprouts from mid-June, despite this being a time of lowest daily temperatures (Figures 1b & 2). For *H. gramineum*, vegetative growth ceased between mid-June and mid/late-September 1992 (when mean daily temperatures were at their lowest), but basal sprouts again increased in length from the latter time, when temperatures began to rise (Figures 1b & 2). For *V. muelleri*, growth of basal sprouts ceased from



**Fig. 2.** Occurrence and duration of life cycle phases for the three annual species: a, *Aphanes australiana*; b, *Isoetopsis graminifolia*; c, *Triptilodiscus pygmaeus*; and the three perennials: d, *Hypericum gramineum*; e, *Solenogyne dominii*; and f, *Vittadinia muelleri* at Chiswick Pastoral Research Laboratory, Armidale, NSW.



late-July/early-August 1992 but also recommenced in mid-late September (Figure 2). New leaves were produced by *S. dominii* plants throughout the winter, from May until late-September/early-October 1992. From then, until late-November/early December 1992 no growth occurred for *S. dominii* but a small proportion (4.3%) of plants produced flowers and fruits during December (early summer), a comparatively warm, moist period (Figures 1b & 2).

*Vittadinia muelleri* began to produce flower buds in late-October 1992, as mean maximum daily temperatures increased, and flowers first opened in early-November (Figures 1b & 2). New buds continued to be produced until early March 1993 and flowering finished in late-April/early-May 1993 (Figure 2). Flowering continued despite spanning the hottest period of the year and a summer-autumn season that was notably dry, especially during January, February, March and April 1993, when monthly rainfalls were 30 to 50 mm below average (Figures 1 & 2). Fruits of *V. muelleri* began forming in early-December 1992 and mature fruits were released until the end of May/early-June 1993 (Figure 2). Signs of senescence began in January 1993 but it was not until the end of June 1993 that the growth for the 1992-93 season, for all 16 plants, had died (Figure 2). However, basal sprouts were first observed (for at least one plant) in late-March 1993 (despite three consecutive months of below-average rainfall) and by late-August 1993 (following some rain, but cool mean daily temperatures) all but two plants had new growth (Figures 1 & 2). As these two plants were seen to senesce during the hot, dry months of January and February 1993 and had not shown new growth by the end of the study, they were possibly dead. Basal sprouts of *V. muelleri* plants grew at least slowly from the time they appeared during autumn 1993 until the end of the study in late winter (28 August 1993).

*Hypericum gramineum* grew vegetatively from late-September until early-December 1992 and buds, then flowers, were observed in early and late-November 1992, respectively (Figure 2), as mean daily temperatures and monthly rainfall increased (Figure 1b). New buds continued to be produced until late-February 1993, while flowering continued until early/mid-March. This was despite the occurrence of highest daily temperatures and below-average rainfall during this time (see above and Figure 1). Fruits began to form in early-January 1993 (a time of highest temperatures and decreasing rainfall) and seeds were released until mid/late-April 1993 (Figure 2). Signs of senescence were first observed concurrently with fruit formation and continued so that all plants appeared to be 'dead' by late-April/early May 1993 (Figure 2), as temperatures fell towards winter minima (Figure 1b). During mid-May 1993 one plant produced basal sprouts. By the end of May four individuals had resprouted and at the late-July and late-August 1993 winter censuses all but four plants had resprouted (Figure 2). As these four had appeared 'dead' since the hot, dry period of late-January/early-February 1993, it is possible that they, too, had completed their life cycles.

Following the brief reproductive period of a small proportion of the *S. dominii* plants, in December 1992 a protracted period of senescence and dormancy began. It continued through the hot, dry summer and dry autumn, and for some plants extended at least

until the end of the study (Figure 2), despite a mild winter and some rain (Figure 1). However, between late-May and late-July 1993, during a cool, relatively moist period, over 50% (7/13) of marked plants produced new leaves (Figures 1 & 2), some individuals reappearing following a period of absence. From late-December 1992/early-January 1993 to late-May 1993 all marked *S. dominii* plants had decreasing numbers of leaves and all but two plants were completely absent for at least one census. Of those plants that became absent and had not resprouted by the end of the study, one disappeared in early-December, one in early-January, one in early-February, two in late-March and one in early-April. Of the plants that became dormant and subsequently reappeared, small numbers disappeared gradually over several months (January to March 1993) and resprouted after a dormant period of two to three months. *Solenogyne dominii* plants then showed leaf growth under the cool, moist conditions of winter 1993. This growth was similar to that of May to September 1992, but began slightly later in 1993 — probably because substantial rains did not fall until June (Figures 1 & 2).

### Discussion

In the present study, *Hypericum gramineum*, *Vittadinia muelleri* and *Triptilodiscus pygmaeus* had flowering times which were up to two or three months longer than those indicated in the relevant floras (Harden 1990, 1992; Beadle 1976, 1980; Stanley & Ross 1983, 1986). *Hypericum gramineum* and *V. muelleri* continued to flower into late-summer and autumn (particularly *V. muelleri*) and *T. pygmaeus* flowered until mid-summer. Although this was possibly due to the mild climate of the Northern Tablelands, these extended flowerings were despite a dry mid-to-late summer and autumn. A study over numerous growing seasons would be required to establish whether the reproductive period of the annual *T. pygmaeus* might be longer under more favourable conditions, or whether it is strongly determinate and hence dependent on the time of germination and the initiation of reproductive events.

Hosking (1990, 1991) recorded the flowering times of plants found in Oxley Park, Tamworth. Tamworth is located approximately 110 km south-west of Armidale and although the altitude of Oxley Park is 200–600 m lower than that of *Chiswick*, and despite the two sites being in separate botanical divisions of NSW, they have many herbaceous species in common. Hosking (1990, 1991) recorded the presence of and flowering times for all species of the present study, except *Solenogyne dominii*. In general, the findings of Hosking concur with those of this study. However, flowering times of *H. gramineum* and *V. muelleri* near Tamworth were less restricted, presumably as the frost-free period is longer. Flowering periods for *Aphanes australiana*, *Isoetopsis graminifolia* and *T. pygmaeus* were shorter near Tamworth than on the tablelands, probably due to the longer and hotter summers typical of the north-western slopes. However, *A. australiana*, *I. graminifolia* and *T. pygmaeus* are all small, inconspicuous annuals which may be easily overlooked, perhaps resulting in artificially few records of flowering times (Hosking 1990, 1991).

Flowering times for *I. graminifolia* and *T. pygmaeus* (*Helipterum australe*) in grazed *Danthonia caespitosa* grasslands of southern NSW have been reported by Williams (1961, 1971). For *I. graminifolia*, flowering occurred between late-August and mid-to-late-October, while for *H. australe* it was from late-August to late-September, with isolated flowering in October. Groves (1965) also recorded flowering times for these two species, but from a *Themeda* grassland in southern Victoria. Groves (1965) reported *I. graminifolia* as flowering in October and November and *H. australe* in October.

The flowering times for *I. graminifolia* and *T. pygmaeus* (*H. australe*) in both southern NSW and Victoria are little different from that reported in this study. It is likely that changes in day length determine the season of flowering (Williams 1961, 1971) but latitudinal, seasonal and yearly differences in temperature and rainfall between northern NSW, southern NSW and southern Victoria are possibly responsible for the within-season variation in flowering times of these species between studies. Similarly, variations in flowering times are likely to occur at *Chiswick* given the variability of seasonal weather from year to year.

The germination ecology of *V. muelleri* (and several other native forbs) has been studied by Willis and Groves (1991), using seed collected in Canberra. These authors found that *V. muelleri* germinated best under an alternating temperature regime of 25° C for 8 hours/15° C for 16 hours. However, germination rates greater than 80% were also achieved under other temperature regimes. In addition, light, storage of seed at high temperatures and cold stratification of seed promoted germination of *V. muelleri*. There was little effect of an after-ripening treatment and the application of gibberellic acid was inhibitory. These findings confirm that at least some of the physical conditions occurring within grazed grassy communities on the Northern Tablelands of NSW are suitable for the germination of *V. muelleri*. However, the present study did not consider the germination of any of the perennial species observed. Thus no comparison can be made for this aspect of the life cycle of *V. muelleri* on the Northern Tablelands.

Flowering and germination are two key events in any life cycle, determining potential seed production and plant establishment. Seed production, germination rates and seedling survival can be enhanced or suppressed by the timely application of agents such as burning, slashing or grazing, or by the application of herbicides or soil disturbance. These agents can be used in grassy communities of temperate Australia to minimise seed production and seedling (or sprout) survival, if applied with sufficient intensity or frequency at times when reproductive growth or seedling establishment are occurring. Conversely, the exclusion of destructive agents at these critical times may enhance reproductive potential of plant populations, provided seasonal conditions are those required by the target species (e.g. see Lodge & Whalley 1985).

A further consideration in the manipulation of native forb populations is the status of the grassy matrix (Hitchmough et al. 1989). Where grass plants are large and abundant and litter has accumulated, forb populations are frequently small in number and communities are of limited species richness (e.g. Carr & Turner 1959; Stuwe &

Parsons 1977; Wimbush & Costin 1979; Trémont 1993, 1994). In these situations the vigour and cover of grasses need to be reduced, using a strategy involving one or more of the agents listed above which does not favour undesirable (e.g. exotic or highly competitive) species. Such strategies may need to utilise agents which reduce grass biomass without causing soil disturbance or providing significant nutrient or water enrichment (McIntyre & Lavorel 1994a, 1994b; McIntyre et al. 1995). In some communities, however, a potentially useful agent such as fire may also be unsuitable, stimulating unwanted germination of exotics when they are present in the soil seed bank (e.g. Lunt 1990b). Where the grass matrix can be reduced and the invasion of unwanted species minimised, resources can be made available for the introduction or expansion of native forb populations, the relative abundances of which can then be manipulated, in turn, by the application of suitable agents at certain life cycle phases of target species.

The phenological data obtained during the present study provides the type of information upon which species manipulations and the conservation of endangered species and remnant grassy communities should be based. However, similar information for the dominant grasses and other forbs (desirable and undesirable) in the community should be gathered before large-scale strategies or particular manipulative agents are applied. The collection of this additional data might be conducted utilising a comparative (e.g. Jurado & Westoby 1992; Leishman & Westoby 1992) or functional group (e.g. Friedel et al. 1988) approach, over a number of seasons. In this way, information could be recorded for a variety of characteristics and responses of many more species (using consistent definitions and methods), and correlations among species characteristics and between these and environmental factors determined. This information would then be available for the development of strategies for manipulating the composition, structure and dynamics of native forb populations and grassy communities. In this way it should be possible to conserve many species of native forbs, as well as the grassy communities of which they are an essential part.

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