

Flowering of golden bamboo (*Phyllostachys aurea*) in New Zealand

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Fig. 1 An old shelter belt of *Phyllostachys aurea* in the Rotorua district. Photo: Elizabeth Miller.

Introduction – *P. aurea* in New Zealand

Phyllostachys aurea, known as fishpole, golden or walking stick bamboo, has been planted as shelterbelts in New Zealand (Fig. 1), especially in northern regions, but as far south as Canterbury. It forms dense thickets via extensive rhizomes (Edgar and Connor, 2010). It usually has light green foliage and upright, pyramidal canes. Exposed canes turn yellow in full or partial sun (hence the names “aurea” and “golden bamboo”), but they are usually more green than gold in shaded areas. It can quickly spread outwards from deliberate garden plantings or pieces of its root system (i.e., rhizomes) that are dispersed in soil or dumped garden waste. It was first recorded as naturalised in New Zealand in 1977 (NZPCN website).

It is a hardy bamboo, native to subtropical and temperate coastal provinces of China, distinguished from other species by a swollen band beneath each node and by the

short, closely crowded, sometimes asymmetric internodes at the base of the culm (Lawson, 1968; Bean, 1976; Edgar and Connor, 2010).

The New Zealand grass flora (Edgar and Connor, 2010) states that flowering of *P. aurea* is not reported for New Zealand. It is also interesting that *The Flora of China* does not describe or illustrate inflorescences or flowers of *P. aurea*, because flowering occurs so rarely that inflorescence and flower features are not reliable identification aids (Wang and Shen, 1987). Two other species of *Phyllostachys*, *P. bambusoides* (giant timber bamboo) and *P. nigra* (black bamboo), have each flowered occasionally in New Zealand, after long time intervals (Edgar and Connor, 2010).

Flowering of *P. aurea* cultivated in other countries

Bamboos of horticultural interest are grown in several countries including the UK, parts of Europe, and North America. Reports from other countries to which *Phyllostachys aurea* has

been introduced, mainly for amenity purposes, are that flowering is rare (e.g., as stated on the Lady Bird Johnson Wildflower Center and Queensland Government websites), and at variable flowering intervals, from 15 to 30 years (Dransfield and Widjaja, 1995). However, a British horticulturist, Lawson (1968) states that this species frequently produces flowering shoots, but that flowering is invariably partial and, when present, the flowers are drab and inconspicuous. Because flowering of some bamboo species is uncommon, keen gardeners have recorded these events to look for patterns. It has intrigued gardeners that after many years without flowering, the same species has flowered at different localities over the same season.

Flowering has been reported over more than one season, for example in the British Isles and other countries in 1904–1905, 1919–1921, 1935–1937 (Bean, 1976). Janzen (1976) records the last of this list as 1934–1938, over four to five years and also observed that a bamboo ‘mast crop’, or mass flowering and seed production event, is generally ‘heralded’ by scattered clumps of bamboo coming into flower in the previous year.

Reports of *P. aurea* flowering in Auckland

Mark Mortimer and Stuart Rogers work professionally with bamboo in the Auckland area, and are also members of the New Zealand Bamboo Society. In November 2016, Stuart Rogers noticed a single flowering culm of *P. aurea* in a hedge near where he lives, in North-West Auckland. The next year he noticed more flowers. “Of about 20 culms, removed from an advancing end of the hedge, some 15 culms had at least one flower bract” (Rogers, 2019). He wondered whether this could be attributed to stress on the plant. In spring 2018 there were greater

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Fig. 2 Flowers (centre of photo) on *Phyllostachys aurea*, December 2018. Photo: Stuart Rogers.

numbers of flowers in the hedge than before, and at two other sites in the vicinity flowers were present (Fig. 2). However, one small satellite clump nearby had no flowers (Rogers, 2019).

In central Auckland, on the boundary of Old Government House, significant flowers were seen on 25 October 2018. Mark Mortimer received images of significant flowering at Huia, on the north edge of the Manukau Harbour, at about the same time. Mark and Stuart have found that while there are some examples of *P. aurea* flowering across the Auckland region, there are just as many examples that are not flowering. Their observations are that in the hedge in North-West Auckland where the flowering was first noticed, it started slowly, and the amount of flowering has increased each year.

In February 2019, some members of the New Zealand Bamboo Society were taken to see the flowering at Motu Road, near Huapai, West Auckland, where the non-leafy, flowering culms were clearly visible (Fig. 3). Voucher material was collected (herbarium specimen NZFRI 31934).

Further recent reports of flowering from Stuart include two contrasting examples of flowering intensity at Waiheke Island, one of several culms on the end of a small roadside clump, and the other of near complete flowering of a large grove, most of which was dead or dying. On trips north of Auckland, Mark has not spotted any groves of *P. aurea* which have come into flower recently, and

those that were flowering previously seemed no further advanced. Both Stuart and Mark think that any flowering of *P. aurea* seems to have slowed down, possibly with the onset of shorter, cooler days. Stuart reports that where there had been flowering in his immediate area of North-West Auckland, several branches have new leaf growth (Fig. 4), although he wonders whether this is a response to heavy caterpillar browse. In recent years there has been an increase in damage by caterpillars of the bamboo moth, *Artona martini*, originally from South East Asia, and now present in northern New Zealand.



Fig. 4 Shoot of *Phyllostachys aurea* with new leaves after flowering, May 2019. Photo: Stuart Rogers.



Fig. 3 Examining the flowering culm of *Phyllostachys aurea* at Motu Road, Huapai, February 2019. Photo: Elizabeth Miller.

How widespread is the recent flowering of *P. aurea* in New Zealand?

The reports mentioned above support the view that *P. aurea* can flower partially, with some clumps flowering at the same time while others remain sterile. The clumps where partial flowering was observed in 2016 by Stuart Rogers have not all died, and flowering has increased over the years since, supporting the idea of some early 'heralding' of more widespread flowering.

It would be of interest to note and record how widespread the occurrence of flowering of this species has been and how long it may last. This current flowering may be restricted to areas around Auckland but there may be undetected or unreported flowering further afield. The degree of flowering in a particular clump, or stand, and the length of time the flowering episode lasts are useful information to increase understanding of flowering behaviour. Information is still sketchy. As flowering of this species has not previously been recorded in New Zealand, close observation of brownish, unthrifty bamboo clumps on roadsides to check for flowering, and reporting of such locations if flowers are detected, for example to the iNaturalist NZ – Mātaki Taiao website (<https://inaturalist.nz/>)² would be worthwhile. Herbarium vouchers including diagnostic features are also a useful record.

² Currently, there are relatively few observations of any *Phyllostachys* uploaded on iNaturalist NZ – Mātaki Taiao.

To identify *P. aurea* check for the crowded, asymmetric internodes at the base of the culm and the swollen band beneath each joint (Bean, 1976; Edgar and Connor, 2010; Lawson, 1968) (Fig. 5), together with other *Phyllostachys* characteristics including two or occasionally three uneven branches at each node and a groove vertically on the culm below each set of branches, alternating from side to side down the culm.



Fig. 5 Crowded, asymmetric internodes at the base of the culms of *Phyllostachys aurea*, May 2019. Photo: Stuart Rogers.

One practical point to keep in mind is that this species is often sprayed with herbicide when it encroaches on roadside infrastructure. This causes it to look similar to when it is flowering, especially when leaf growth occurs in dense short tufts (Stuart Rogers, pers. comm.).

General flowering patterns in bamboos

It was considered in the past that all bamboos that flower would then die, but this is not the case. For example, *P. aurea* is a species known to flower more than once without suffering serious harm (Lawson, 1968). Flowering in bamboos may occur in one year only or continue for many years on the same plant. "Sometimes only a few flowers are produced on one culm, while at other times a whole culm, or even every culm in a clump, may be involved. Very often the culms which produce flowers and seeds die." (Valder, 1999).

The more than 1,400 bamboo species are grouped into three different flowering patterns:

1. Those in which flowering is sporadic and partial (not the whole clump), at irregular time intervals.
2. Those in which flowering is gregarious (plants of a species all flowering at the same time, within a district) and general, at long time intervals. Flowering may appear partial, by starting at one end of a clump and looking sparse, but gradually spreading to the whole clump, followed by death of the clump, or by recovery.
3. Those that produce flowers continuously in a population, without sudden resultant mortality.

McClintock (1979) considers that flowering in bamboos can be easily overlooked if only a small part of a clump or one branch has produced a few flowers, with the rest of the plant sterile. The extent to which flowers are being produced is important, but rarely noted.

Well-established and naturally vigorous clumps may have the necessary stamina to overcome the drain on their resources caused by flowering. However, if a clump is less vigorous, or has been recently transplanted, the plant may be exhausted by flowering, and die. Heavy flowering is more likely to cause a plant to die than just a few culms flowering would. Lawson (1968) states that when flowering starts the rhizome stops making new branches, and latent buds on existing branches lose the power to break into active growth. It is generally agreed that the flowering culm, which has usually dropped its leaves, dies after flowering is over and any seed (Fig. 6) has been shed, and that clump survival depends on whether the rhizome also dies. Complete recovery of an area may take 15–20 years (Campbell, 1985). Natural stands in China are managed to prevent or minimise flowering, removing culms at first sign of flowering and providing nitrogenous fertiliser, to avoid interruption of healthy culm production (Wang and Shen, 1987).



Fig. 6 Thin-walled fruit (caryopsis) of *Phyllostachys aurea*. It is characteristic of grasses that the ovary wall is united with the seed coat. Scale bar = 2 mm. Photo: Elizabeth Miller.

Flowering synchronicity

For a long time, there has been speculation on why multiple clumps of the same species of bamboo flower synchronously. It used to be believed that the interval between successive flowerings was constant for a given species, but there are enough records to prove that this generalisation is not true (Lawson, 1968). In countries to which bamboo has been introduced, such as New Zealand, it is likely that at least some species have had only a small number of introductions and been spread by division, as shelter was required for development of horticultural and agricultural land, so that there are many plants of the same parental genetic identity or cohort (Lawson, 1968). Offsets taken from a clump before it flowers come into flower at the same time as the parent clump (Brandis, 1906). Because *P. aurea* can exhibit partial flowering, it cannot be concluded that flowering and non-flowering clumps at any particular time are from different cohorts.

There have been "some striking coincidences of flowering dates" between native plants of a country and the same species introduced and cultivated in different continents (Campbell, 1985). However, if plants are raised from seed, rather than vegetatively, as is usual in cultivated situations, the botanical make-up varies within narrow limits and there is a chance of evolving to suit different conditions (Lawson, 1968). At one site, examples of one species of bamboo (*Semiarundinaria fastuosa*) introduced from several different sources have not all flowered synchronously (Lawson, 1968).

Seed production

Seeding is not often observed in cultivation (McClintock, 1967; Janzen, 1976). Brandis (1906) mentions that after “the fires of the hot season have swept away the tangled mass of dry stems, the next rainy season produces millions of seedling bamboos...”, an indication that seed production may at least sometimes be more successful in natural bamboo forest areas than in cultivated situations. In native bamboo habitats, widespread synchronous flowering is likely to benefit seed production, through better cross-pollination.

Theories on benefits of flowering patterns

Studies and reviews have analysed the hypotheses for advantages of synchronous flowering, production of flowers and seed at long time intervals, and of individual clumps flowering only once, and then dying (monocarpy) (Campbell, 1985; Kelly, 1994; Keeley and Bond, 1999). Species that flower and produce heavy seed crops at long time intervals (mast species) are considered to respond to ‘internal calendars’ at a cell level that cause cessation of vegetative growth and production of flowering culms instead (Kelly, 1994).

‘Predator satiation’, proposed by Janzen (1976) suggests that even though high volumes of seed will attract large numbers of rodents and other seed eaters, there will be surplus for germination, but the predator population will not be sustained during a long gap between flowering episodes. However, the long interval between mass flowerings greatly exceeds the lifespan of predators, much longer than needed to interrupt the pest cycle. If adjacent clones or other potential food sources are not synchronised, predators could migrate to alternative nearby areas (Campbell, 1985). Mass seeding events of bamboo do cause population explosions of rodents that then disperse to eat crops and grain, sometimes causing human famine, so their population is not limited by the consumption of all available bamboo seed (Bedi, 2006). Also, a mast event often carries on for more than one season, allowing predator populations to continue to build (Keeley and Bond, 1999). From these detracting

factors it is concluded that, although predator satiation may be a weak selective force, it is unlikely to be the only influence and there are probably multiple causes, including climate factors, which help set the baseline in any particular case (Kelly, 1994). Proposals in which plants match time of flowering and seeding to their own build-up of resources, or to particular climatic conditions, are not considered likely to be major selection factors on their own, but matching such conditions will contribute to success of individual particular events (Kelly, 1994).

Keeley and Bond’s ‘fire cycle hypothesis’ (1999) links mast flowering with flowering and seeding only once, delayed reproduction, and typical gregarious distribution. It proposes that destruction of the large fuel accumulation removes competition, to allow bamboo seedlings to establish. The long vegetative phase before flowering would allow build-up of resources in the plant to support the heavy flowering that will, from synchronised flowering over a wide area, encourage cross-pollination and hence seed production. The large amount of accumulated fuel from a long growth phase and accumulation of many culms followed by death would support efficient burning to clear the ground for succession and discourage competition from invading trees or weeds. This generalised situation seems plausible for at least some regions.

Bamboo reaches full culm height in one season, which leads to the production of continuous stands with no temporary gaps, as in tree populations (Campbell, 1985). Large clonal patches densely occupy space, forming a closed canopy that inhibits seedling recruitment. Seed dispersal is passive around the parent. Death of the parent plant allows space for seedling development (Keeley and Bond, 1999). Parental competition is seen as a major factor affecting succession, with seedling survival occurring if parent plants die after shedding seed (Campbell, 1985). Disturbance, such as by fire, would clear away the fuelwood resulting from the death of the mature bamboo, and Keeley and Bond (1999) argue that wildfire initiated by lightning

strikes would clear the ground for seedling recruitment. There are areas in Asia with dry season climate cycles where wildfires are either a common or occasional occurrence.

On a large scale, in native habitat, long time intervals between flowering episodes tend to be correlated with rapid canopy invasion from forest trees, and slower bamboo maturation (Keeley and Bond, 1999). *Phyllostachys aurea*, reported as flowering partially in clumps at long time intervals without complete mortality, may be adapted to maintaining rhizomatous growth, possibly in a less fire-prone temperate forest region. This is also the type of situation which occurs in New Zealand.

Recent research has examined how the transition from producing vegetative shoots to reproductive shoots is regulated (Hisamoto and Kobayashi, 2007) and concludes that mechanisms that alter gene expression, such as foliage variegation, are probably responsible. It is possible that a single amino acid residual change could control flowering behaviour. Reasons for the gene expression change seem to be still elusive.

There is still much to learn about flowering behaviour of bamboos such as *Phyllostachys aurea*, especially in cultivated situations.

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