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Letters to the Editor 36

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Interaction of Giant Pandas, Bamboos and People

Revised manuscript received September 13, 1984

Introduction

This paper is the central section of a longer manuscript that provides general botanical background for the World Wildlife Fund Giant Panda Project[1]. That manuscript will eventually incorporate introductory material on the taxonomy and ecology of woody plant communities in the giant panda range, as well as further details concerning bamboos and pandas. It will complement the official WWF-PRC report on the giant panda itself. Due to difficulties of planning, travel and communication, a comprehensive scientific treatment is still not possible. We worked together only during 1982 at the Wolong Reserve, in the central giant panda range. We are waiting for further information from the region, and it may take two or three years before a complete presentation is warranted. In the meantime, a provisional summary of the manuscript has been published[2], and the following paper provides further details. It is, however, no more than a best estimate of the situation based on miscellaneous available sources as well as our limited field work. Because of the special importance of giant pandas and associated biota, and the urgency of conservation problems, a somewhat "trans-scientific" approach is now adopted. Although we strive for an objective assessment of available information, we also recognize that some of our statements have little factual backing, and are to be used to stimulate further debate on better scientific and practical approaches to the conservation problems.

To set the scene, the abstract of the summary paper itself[2] is here reproduced: "The mountains around Sichuan contain richer biological diversity than any other temperate region. But in recent centuries, human exploitation has accelerated up from subtropical lowlands, removing most temperate forest. Disturbance is generally excessive for larger mammals of subtropical-warm temperate zones, and now there are threats to those of cool temperate-subalpine zones. The cool temperate zone is wettest, favoring extensive bamboo within the forest. Bamboo is virtually the only food of giant pandas, and this species' range has been reduced by roughly half in the past century. Though much cool zone bamboo remains, patches of larger warm zone bamboos may be needed as well for seasonal use and long-term dynamics. In the past decade at least, decline of giant pandas has been precipitated by periods of bamboo flowering and mortality. Monocarpic life-cycles are a natural feature of bamboos, and flowering may be somewhat synchronous with dry climatic periods. Deforestation has reduced the diversity of alternative bamboos available for emergency use after such events. To resolve the many problems concerned with nature conservation in these mountains - taxonomic, demographic, ecosystematic and socioeconomic - much more interdisciplinary and international cooperation will be needed. There may be hope that recent centralization of planning in China can extend better land-use to the provinces, and that communication problems with western conservationists can be overcome."

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Some native people in these mountains expressed respect for natural ecosystems in their traditional culture[3], but the demand for timber export to lowlands has been overwhelming in this century[1]. Conservation of wild-animals here has only become a priority of central government since about 1976, though some protective legislation began in 1958-65, when a few reserves were set aside for "multiple-use"[4-6]. Today, the giant panda (*Ailuropoda melanoleuca*) has at last become the center of attention for conservation in these forests, and several other large mammals are given some protected status, such as the lesser (red) panda (*Ailurus fulgens*), the golden-haired monkey (*Rhinopithecus roxellanae*), the leopard (*Panthera pardus*), the takin (*Budorcas taxicolor*), some deer, and some pheasants. However, it is too late to do much for animals in the deforested subtropical zone, such as the tiger (*Panthera tigris*), which probably became extinct in this region 50-100 years ago[7-10], and the rhinoceros (*R. sondaicus*), extinct for about 2000 years[11]. Some of the endemic monotypic woody genera here have protected status, such as *Metasequoia*, *Sinowilsonia* and *Davidia*, but except for *Metasequoia* these have not been given much publicity[4,12,13].

The current range of the giant panda lies in the curved strip of land with an average altitude of 1500-3500 m from Da Liang Shan in southern Sichuan to Qin Ling in southern Shaanxi (Figure 1). Further west, towards the cold dry Tibetan plateau, the subalpine forests and alpine grasslands contain no bamboo. Further east, down to the subtropical Sichuan Basin, the human population has removed virtually all natural vegetation. The intervening geographic zone is about 800 km long and 50-100 km wide. But within this zone, most of the land is still too cold, warm or dry for the complete bamboo forest ecosystem. The five separate mountain ranges with giant pandas cover only 30,000 square km[14]. In the Sichuan region, bamboo appears to require annual precipitation of at least 900 mm, and precipitation is highest on these "rain-screen" mountains, reaching about 2000 mm. Even within these mountains, about half of the suitable natural vegetation has been excessively disturbed or destroyed[1,2]. In addition to eating bamboo, giant pandas use large trees for resting sites and scent-marking, and they may generally avoid large clear-cut areas, even if much bamboo remains[15]. Estimates of bamboo cover in a selection of giant panda reserves range from 15% to 45%[15], so that the total area in all reserves[4] is 1000 to 2000 square km, and the total area in the whole range may be roughly 10,000 square km. The total bamboo area in China including plantations is estimated at 33-34,000 square km[17,18] (though another recent estimate is 12,000 square km[18], and an early estimate was 300,000 square km[19]). The number of giant pandas in reserves is 500 to 1000, while the total number may be 1000 to 2000[15].

1. Distribution of bamboos

1.1. The Wolong Region

Most currently available information on bamboo ecology in the giant panda range comes from studies at Wolong by ourselves and others. We are particularly grateful to X.T. Zhang for most biomass data of 1981, and to our zoological colleagues J. C. Hu and G. B. Schaller for further details[15]. In 1982, we established a new series of 100 permanent bamboo plots, each covering 1-2 square m. We positioned these plots in as wide a range of environmental conditions as possible, so that various factors influencing growth could be explored. Full details of these results will be presented elsewhere.

The distribution of bamboo species in the Wolong region was as follows from high to low altitude (see also Table 1, Figure 2). In the subalpine *Abies-Rhododendron* forest at

3000-3400 m above sea level, stand of *Arundinaria fangiana* (A. Camus) A. Camus ex Y. L. Keng[35] (put in *Gelidocalamus* by P. C. Keng 1983[20]) occurred, declining in height and extent to their upper limit in this zone. Average above-ground biomass within these stands was about 0.5 kg per square m (dry-weight), but they only covered about half the ground. (Below-ground biomass amounted to about 25-35% of total biomass in all three species studied.) In the subalpine-cool temperate transition with *Abies-Tsuga-Betula* forest at 2600-3000 m, average biomass of *A. fangiana* stands was about 1 kg per square m, and these stands covered about 80-90% of the ground. In the cool temperate zone with *Picea-Tsuga-Acer* forest and disturbed scrubby vegetation at 2200-2600m, *A. fangiana* declined abruptly reaching its lower limit at about 2350 m. Instead, stands of *Fargesia* cf. *spathacea* Franchet* began abruptly, with an average biomass of 1-2 kg per square m. But, since these stands covered only about 30% of the ground within the forest, concentrated at middle slope positions, the overall biomass of bamboo was slightly less than at the *A. fangiana* maximum. In the temperate mixed broadleaf (largely deciduous) forest zone at 1800-2200 m, about two-thirds of the forest had been converted to farmland, along with the bamboo. But within the remaining forest, *Fargesia* was about as abundant as above. At all altitudes, bamboo was virtually absent from low scrub and grassland created by erosion or pastoral use, but cutting of trees without direct disturbance of the understory often appeared to have increased bamboo density. Within woody vegetation, there was no overall correlation between bamboo density and tree cover, though dense shrub cover (especially *Rhododendron*) did seem inhibitory in some areas. There was, however, a sharp decline in tree seedling density with increasing density of *A. fangiana*.

Two minor species occurred in these zones as well. In rather dry scrubby vegetation at 2400-2700 m, apparently at the western edge of the most rainy zone in this region, we saw a few clumps of *Sinarundinaria* cf. *nitida* (Mitford) Y.L. Keng. *Sinarundinaria chungii* (Y.L. Keng) P.C. Keng (put in *Yushania* by Z.P. Wang & G.H. Ye, in press?) was more frequent, with an altitudinal range slightly higher than *Fargesia*. It had a sporadic distribution concentrated near the steepest ravine walls, either on gravelly bottomland or on rocky ridges with *Quercus* and *Pinus* at its dry extreme. The average biomass within its stands was about 1-1.5 kg per square m, but the total extent of this species within its altitudinal range was probably less than 10%.

Below the general range of giant pandas, in the warm temperate zone at 1000-1800 m, mature forest was rare but man-made scrub covered roughly half the ground. *Sinarundinaria* cf. *ferax* (Y.L. Keng) P.C. Keng and *Phyllostachys* cf. *nidularia* Munro occurred here with stands probably comparable in biomass to the largest *Fargesia*, but occupying less than half the scrub. In the highly disturbed warm temperate-subtropical transition between the reserve and Guan Xian, two species of *Arundinaria* (sensu lato) have been recently described[21,22], somewhat larger than *A. fangiana* (Table 1). In the subtropical zone at 400-1200 m, there is virtually no forest and most land is used for crops. Species of *Sinocalamus*, *Bambusa*, *Sinobambusa*, *Phyllostachys* and *Chimonobambusa* are often cultivated or occur in scrub[9,13,22-24]. We saw patches of *Phyllostachys* covering a few square m in a disturbed forest remnant near the temples of Guan Xian at 800 m. Biomass of cultivated *Phyllostachys* spp. averages about 5-10 kg per square m, and most of the other cultivated species are probably similar (see references on production noted below). However, bamboos cover no more than 1% of this zone in the Sichuan Basin[13,16].

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* Differences in morphology, range, habitat and flowering date suggest some distinction from true *spathacea*; see also pages 8, 9, and 20.

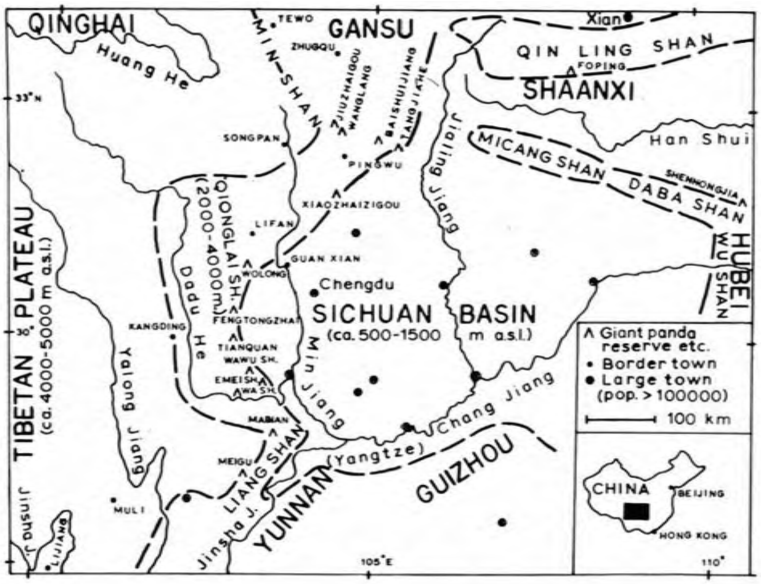


Figure 1a. The Sichuan region referred to in the text; general topography and place names (based on various sources[1]).

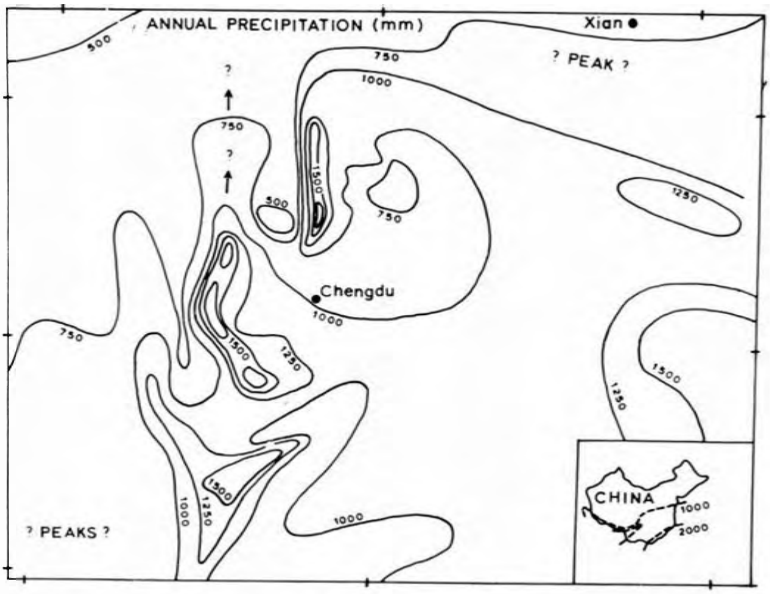


Figure 1b. Annual precipitation, largely based on the most detailed available source[127]. Considerable differences exist on other maps (cited elsewhere[1]). Peaks may be underestimated due to absence of stations at high altitude in the most rainy zones.

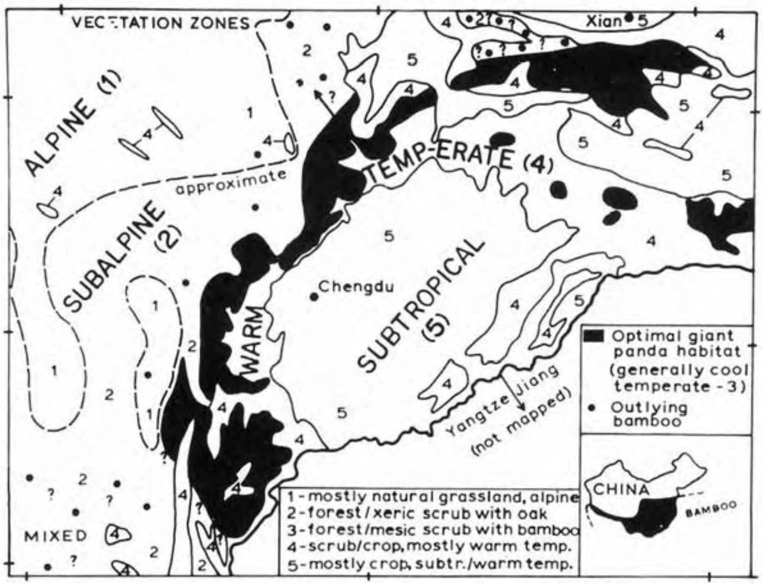


Figure 1c. Major vegetation zones based on recent maps and miscellaneous bamboo reports[1,13]. The mixed scrub-crop zone is largely the difference in limit of cropland between recent sources (detailed for Wolong elsewhere[1]).

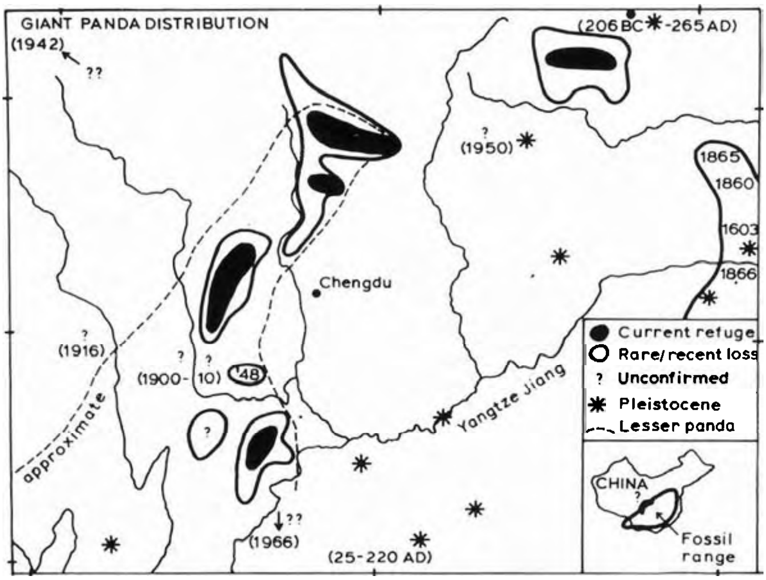


Figure 1d. Panda distribution[5,119,123] (and other miscellaneous sources[1]).

Table 1. Bamboos of the Wolong Region, with Major Vegetative Features.

Species [a]	Altitude meters	Culm Length[b] meters	Rhizome Form[c]	Shooting Season[d]	Abundance
*Gelidocalamus fangiana** (A. Camus) P.C. Keng	2300-3400	0.25-2.5	leptomorph-metamorph I/II	(4)5-7(8)	zonal dominant
Yushania chungii# (Y.L. Keng) Z.P. Wang & G.H. Ye	1800-2900	0.5-3.5	pachymorph (long neck)	4-6 ?	rare/local dominant
Fargesia cf. *spathacea*# Franchet	1600-2800	1-6	pachymorph (medium neck)	4-5(6)	zonal dominant
Sinarundinaria cf. *nitida*# (Mitford) Y.L. Keng	2400-2700	1-6 ?	pachymorph (short-med. neck)	5 ?	rare
Sinarundinaria cf. *ferax*# (Y.L. Keng) P.C. Keng	1200-1700	2-7 ?	pachymorph (short-med. neck)	4-5 ?	local dominant
Phyllostachys cf. *nidularia* Munro	900-1600 ?	3-10 ?	leptomorph	5-6 ?	local dominant

*Pseudosasa guanxianensis** T.P. Yi	1000-1200	2-3.5	leptomorph	4	rare, east of reserve?
*Bashania qingchenshanensis** P.C. Keng & T.P. Yi	800-1200	2-4	leptomorph-metamorph I?	4	rare, east of reserve?
Chimonobambusa purpurea C.J. Hsueh & T.P. Yi	500-1500	3-7	leptomorph	9-10	rare, east of reserve?
Sinobambusa sichuanensis T.P. Yi	400-1200	2-4.5	leptomorph-metamorph I?	8-12	rare, east of reserve?
Phyllostachys cf. *congesta* Rendle (and other spp?)	400-1200	5-13	leptomorph	5 ?	cultivated local dominant?
Bambusa rigida Y.L. Keng & P.C. Keng (etc.?)	400-1200	5-20	pachymorph (short neck)	8-10	commonly cultivated
Sinocalamus affinis (Rendle) Y.L. Keng (etc.?)	400-1200	10-25	pachymorph (short neck)	8-10	commonly cultivated

a: Still tentative. b: Basal diameter = 0.3-0.7 % of the length. c: Terms from McClure (1966)[105].
d: 1-12 = Jan. to Dec. *: *Arundinaria* sensu lato. #: *Fargesia* sensu lato

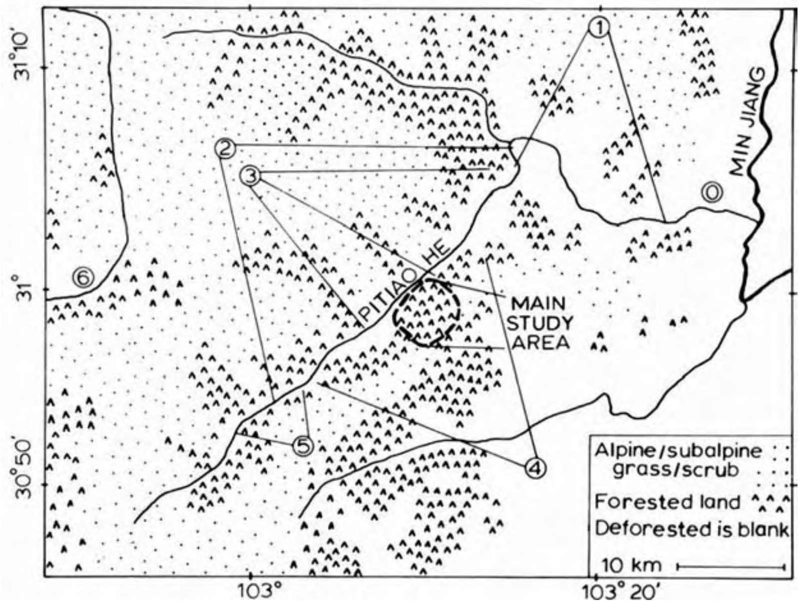


Figure 2. The study area at Wolong (see also Figure 1a). Numbers indicate the following features of bamboo distribution.

0. Zone with *Phyllostachys*, *Bambusa*, and related genera (subtropical).

1. Limits of zone with *Sinarundinaria* cf. *ferax* and *Phyllostachys* cf. *nidularia* along the river valley (warm temperate).

2. Limits of *Fargesia* cf. *spathacea* along the river valley (cool temperate).

3. Localities with *Sinarundinaria* (*Yushania*) *chungii*.

4. Limits of forest with abundant *Arundinaria fangiana* on this northwest facing slope (subalpine-cool temperate). Patches of this species also occur up to 10 km beyond these limits.

5. Clumps of *Sinarundinaria* cf. *nitida*.

6. No bamboo is reported in this valley.

Note: "forested land" refers to forest that may have been cut over, but which has had at least 20-30 years for regeneration. This map is provisional since our work was restricted to the Pitiao valley.

1.2. Other Areas Around Sichuan

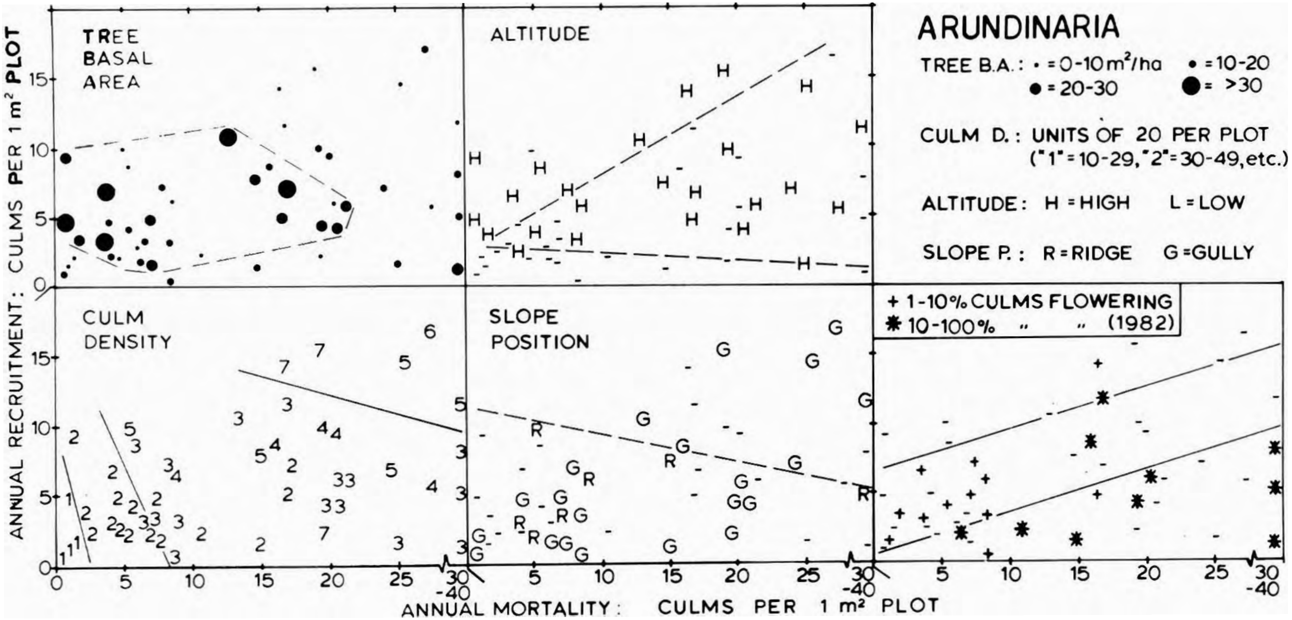
In some other sections of the giant panda range, there are considerable differences in bamboo species and their topographic distributions. In the northern sections adjacent to the subhumid or arid plains of north-central China, *Arundinaria* is rare or absent in the cool temperate and subalpine zones. Instead *Fargesia* replaces it partially up to about 3300 m, perhaps with a different species than in warmer zones[13,25,26] (M. Riedelsheimer and T.P. Yi first drew our attention to possible confusion with the Wolong *Fargesia*). This higher limit has been attributed to release from competition with *A. fangiana*[15]. Another major difference in the northern Min Shan of southwest Gansu and disjunct outlying mountains is that *Sinarundinaria nitida* becomes relatively abundant, extending further north than other species, and as high as 4400 m (sterile collection in 1923 by R.C. Ching-974 in U.S. National Herbarium; we are currently compiling all distribution records from herbaria). Considering the preliminary evidence for changes in forest distribution since the Tertiary era within China[27-29], it is possible that periods of warm or dry climate eliminated *Arundinaria* from the mountain tops along this northern limit of bamboos, allowing the other species to replace it partially when cooler or moister conditions returned. However, even today, the bamboo forests in these regions are relatively fragmented by dry microclimate and disturbance. Moreover, *S. nitida* introduced from here to European gardens is known to be relatively tolerant of cold dry conditions[30,31]. In the Qin Ling, bamboo may be abundant only up to 2000 m, with even *Fargesia* being rare or absent[19,32]. In the southern Min Shan, subalpine *Fargesia* still does not form as continuous an understory as *A. fangiana* further south[15]. Even in the Wolong Reserve, we saw some peripheral areas where *A. fangiana* was absent from its typical altitudinal range, but where patches of the other species occurred as much as 1000 m above their normal limits (localities indicated on Figure 2). As in the north, these localities appeared to be in relatively dry, disturbed or isolated parts of the subalpine zone.

In the southern sections of the giant panda range (Dadu He and Da Liang Shan regions), *Arundinaria fangiana* does still occur in the subalpine zone, but the *Fargesia-Sinarundinaria-Yushania* complex is partially replaced by the more southern *Chimonobambusa-Oreocalamus-Qiongzhuea* complex in temperate zones[13,15,33-36]. The latter genus-complex, together with *Phyllostachys*, is assigned by P.C. Keng (1982)[20] to the largely tropical or subtropical "Bambusatae" division of Asian bamboos, as opposed to the largely temperate or subalpine "Arundinariatae" (see also[18]). Its increase here is associated with the increased importance of evergreen broadleaf trees in the temperate zone, presumably reflecting reduced seasonality.

Species of the *Indocalamus* or *Sasa* subgroups of Arundinariatae have been reported in the giant panda range, especially to the east[13,15,25]. But since almost all material referred to is sterile or incompletely described, the extent of these East Chinese and Japanese types in the Sichuan region remains uncertain (based on ongoing herbarium studies).

2. Growth of Bamboo

In non-flowering stands at Wolong in 1980-82, annual above-ground production amounted to 15-25% of above-ground biomass on average. This percentage differed little between species, altitudes, or various stand densities. The production of new culms was similar to the production of new branches plus leaves, which occurred most vigorously on 2-4 year-old culms. In terms of recruitment and mortality of full-grown culms (past the sensitive shoot stage lasting 1-3 months), the annual turnover rates were also about 15-25% of stand density. The turnover of *Arundinaria fangiana* was slightly higher than *Fargesia*, with maximum culm longevity of 5-6 years as opposed to 6-7 years. Mortality of culms appeared to increase with their age. In non-flowering plots, there was no significant difference between overall recruitment and mortality during 1978-82, based on age-distributions as well as direct observation during 1982. If anything, there was a deficit of recruitment in *A. fangiana*, but most of this species eventually flowered in 1983, as described below. Similar average production and turnover percentages have been indicated in bamboos elsewhere, from tropical to alpine zones[37-52]. But there is considerable variation: young stands may have higher production; some stands may decline without flowering; and exceptionally old stands may have only 5-10% turnover each year[53].


ARUNDINARIA
TREE B.A.: • = 0-10 m²/ha • = 10-20 ● = 20-30 ● = >30
CULM D.: UNITS OF 20 PER PLOT ("1" = 10-29, "2" = 30-49, etc.)
ALTITUDE: H = HIGH L = LOW
SLOPE P.: R = RIDGE G = GULLY
+ 1-10% CULMS FLOWERING
✱ 10-100% " " (1982)
TREE BASAL AREA
ALTITUDE
CULM DENSITY
SLOPE POSITION
ANNUAL RECRUITMENT: CULMS PER 1 m² PLOT
ANNUAL MORTALITY: CULMS PER 1 m² PLOT
0
5
10
15
20
25
30
-40

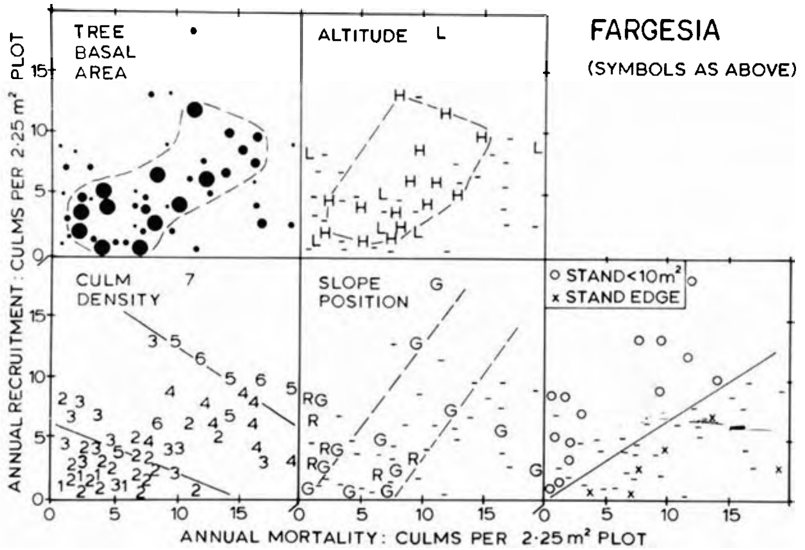


Figure 3. Culm turnover and environment of bamboo plots at Wolong. Culms counted are those that have passed the stage of high mortality and grown to full height. This "recruitment" and subsequent mortality were estimated for 1981 and 1982, and means of these two years used here. The topographic classification is based on analysis of forest composition detailed elsewhere[1]. (The central, generally cool temperate, altitudinal zone is defined from 1st "DECORANA" axis scores: < 7 for *Arundinaria*; 4-5 for *Fargesia*. The mid-slope position zone is defined from 2nd axis scores: 3.5-4 for *Arundinaria*; 3-4.5 for *Fargesia*.) The only significant relationships shown (solid trend lines) are as follows ($P < 0.05$ with χ^2 tests above and below medians):

1. increase in recruitment and mortality with increasing density;
2. low recruitment-mortality ratio in flowering *Arundinaria*;
3. high ratio in *Fargesia* stands under 10 square m in area.

Marginal significance ($0.1 > P \geq 0.05$) occurs as follows:

1. high ratio in high altitude *Arundinaria*;
2. high ratio in ridge plus gully *Fargesia*.

Despite the overall demographic balance of culms in non-flowering stands at Wolong, there was, indeed, much small-scale variation. This variation had little clear relation to such obvious environmental factors as altitudinal and topographic gradients, forest cover and bamboo density (Figure 3). In *Arundinaria fangiana*, there was a weak association between low recruitment-to-mortality ratio and location in the cool temperate versus subalpine zone. However, that trend may be largely attributed to declining recruitment at lower altitudes leading up to mass-flowering. Flowering began to increase in 1981-82 at lower altitudes, compared to a negligible incidence before, then it spread to most of the higher area in 1983. In *Fargesia*, there was a weak association between high recruitment-to-mortality ratio and extreme location on the intrazonal topogaphic gradient, i.e., typically ridges and gullies. However, stands on such sites were less continuous, and there was a much more significant association between high ratio and stand size under 10 square m (Figure 3). As with total culm density, there was no overall correlation between this dynamic ratio and the basal area of trees surrounding each bamboo plot. But there did appear to be more variation in turnover rates at lower basal areas (Figure 3), in accord with the variable response of bamboo to different kinds of forest opening suggested above. Most of the variation on the scale of these 1-2 square m plots may be related to internal processes of clump formation and decay, which will require more thorough demographic analysis before environmental relations can be clarified. There may also be frequent variation in recruitment from year to year of at least 50%, perhaps related to variation in precipitation, as suggested by a few data here and elsewhere[39,45,49,51-53].

3. Consumption by Giant Pandas

3.1. General Patterns at Wolong (1981-82)

Giant pandas at least two years old each consumed about 2-4 metric tons of bamboo (dry weight) per year at Wolong[15]. This rate was equivalent to the total above-ground production of about 1-2 hectares of *Arundinaria fangiana* at its optimal altitude (see above). However, since the internal use of production for physiological maintenance of the bamboo has not been studied yet, nor the flexibility of production under consumer pressure, no direct measure of carrying capacity can be made at present. With giant panda densities on the order of 0.1-1 per square km of bamboo, their consumption amounted to only 0.1-2.0% of the production at optimal altitude. But a large number of other animals at Wolong also consumed bamboo in various ways[15]: monkeys, bears, pigs, takin, deer, badgers, rodents, pika, pheasants, insects, etc., as well as domestic livestock along the edge of farmland. The damage to fresh culm shoots in the spring was especially high, with about 30-40% killed on average. Most shoot mortality was due to insect larvae boring in the lumen (diptera and lepidoptera, etc.), as also observed in Japan[39].

Giant pandas are known to select certain parts of bamboo for food, and change their selection with the seasons[15,54-56]. At Wolong, after the flush of leafy production during June-July, they mainly eat leaves of *Arundinaria fangiana* until October. In this period, culms were somewhat depleted of nutrients after producing leaves; protein contents of leaves were relatively high (16-18% dry weight) and silica contents low[15] (as also observed in Japan[57]). From November to March, they mainly eat a mixture of *A. fangiana* leaves and culms produced in the preceding summer; leaf protein was lower and silica variable[15]. A little *Fargesia* was also eaten; its leaf protein did not decrease in the winter, in accord with its greater leaf longevity. Our observations of tagged *Fargesia* culms indicated that 60-95% of new leaves survive their first winter (to April) and 20-50% survive their second summer (to September); respective percentages for *A. fangiana* were 50-60% and 5-20%. In warm temperate *Phyllostachys*, leaf protein may even increase in winter[58].

From April to June, when the thicker culm shoots of *Fargesia* emerged and accelerated in height, some giant pandas descended to feed preferentially on these shoots and also on a few older culms. In 1981-83, about 10-20% of all shoots that emerged at 2200-2600 m were eaten or fatally damaged by giant pandas. They selected shoots over 10 mm in basal diameter (the maximum being about 25 mm), while small mammals and insects selected narrower shoots. However, other giant pandas, apparently younger ones, did not descend for these shoots[15]. They did not even select shoots of *Arundinaria fangiana*, which are only 1-7 mm in diameter, but they mainly eat older culms. Almost no leaves were eaten in this season, which may be related to leaf age and high silica levels at this time: 4-5% of dry weight in leaves compared to about 1% in culms of *A. fangiana*[15]. Silica generally reduces digestibility in herbivorous mammals (as reviewed elsewhere[15,54,59]). Also, protein contents in young culm shoots (15-20% dry weight) equaled or exceeded contents in leaves during this season (11-16%)[15]. Differences in protein may not have much direct importance, since in any season the basic requirement is exceeded by a factor of 2 to 7, but there is probably a general association between protein and other nutrients such as hemicellulose, the major energy source[15].

Few comparable data on feeding are available from other areas, aside from the general observation that bamboo is almost the only food, as at Wolong. Some herbaceous species (e.g., Umbelliferae), fruits (e.g., *Rubus*), tree barks and small mammals have occasionally been reported in the diet, but under normal conditions of bamboo growth such items probably make up less than 1%[5,10,14,15,60,61]. The suggestion of a more omnivorous diet by Nowak and Paradiso (1983)[62] is based partly on doubtful reports. The species composition and topographic distribution of bamboos varies considerably within the range (see above), and this must influence feeding behavior, but quantitative comparisons have not yet been made.

3.2. Importance of Culm Shoots

Despite the variable conditions, the descent to feed on thick shoots at certain seasons, especially in the spring, does seem to be a consistent feature from the northeastern Foping Reserve[32] to the southwestern Mabian Reserve[15]. At Foping, a record consumption rate of 57 kg (fresh weight) per day was reported for an animal feeding on *Phyllostachys* (?) sp. in the warm temperate zone. At Mabian, where extensive forests occur as low as 1300 m in the transition to subtropical conditions, there is a greater variety of bamboo species available, with shooting seasons ranging from March to October. Some descent in winter has been reported further north, though without observations of feeding[6,15,60].

Below Wolong, as well, a greater range of shooting seasons exists in bamboos of warmer zones (Table 1), but these are not accessible to giant pandas due to the dense human population. The lowest feeding site observed at Wolong was during late April 1982 on a 2150 m ravine bottom, where a narrow gorge and waterfall prevented direct contact with farmland of the main river valley at the same altitude. Giant pandas returned by June to the upper limit of *Fargesia*, where shoots tended to emerge later. The absence of feeding in lower areas of *Fargesia*, which occurred down to about 1650 m, was most likely due to past and present human disturbances: hunting, logging, pasture, agriculture and roads, etc.

From recent reports, giant pandas have descended as low as 1200 m in the southern Mabian Reserve[15] and 800 m in the northern Wanglang Reserve[60]. These reserves may have the best protection. Moreover, *Bambusa* and *Sinocalamus* of the subtropical zone below 1000-1500 m were included in the food lists of Zhu and Long (1983)[14] for most sections of the range, though no more than the upper edge of this zone is accessible. In contrast, when giant pandas had greater range and morphological diversity in the Pleistocene[5,109], the large shoots of subtropical bamboos could have been seasonal staples. This food-source may have declined progressively in post-glacial time since these bamboos were probably concentrated along forest edges on floodplains[1], sites that were also favored for early human settlements, and, during the past 4000-6000 years, for agriculture.

This seasonal migration may be an important requirement that has been disturbed to a critical degree in most areas. Despite the continued abundance of *Arundinaria fangiana* at higher altitudes, and despite the need to consume two to four times more fresh weight when feeding on shoots with 80-90% water (as opposed to 30-70% in older material), some adults have shown a distinct change of behavior in making the descent. It is likely that the superior nutritional content of shoots compensates for the increasingly poor diet from winter to early spring, at least in energy value[15]. Hypothetically, there might also be some relationship with the reproductive cycle. Mating is restricted to April or May (rarely March or June in captivity)[83], when shoots of temperate bamboos generally emerge. Also, weaning of young, which are born in autumn, does not begin until the next growing season, when shoots might make a suitable introduction to solid food.

The effort and risk involved in such descent may have been rewarded more in the past. Average culm sizes (length and diameter) tend to increase in bamboos of warmer zones (Table 1), and protein contents of *Phyllostachys* and *Bambusa* shoots are as high as 25-30% (dry weight)[39,54]. Leaf protein may also average higher in more evergreen species here[58], though leaf silica is reportedly higher as well, at 6-12% (dry weight)[39,54,57]. The greater seasonal range of shoot production in warmer zones could be a critical factor. Autumn oestrus behavior has been observed in captive animals, perhaps relictual from the time when giant pandas had greater geographic and ecological range (reviewed in [63]). If there is some relation between eating large shoots and the reproductive cycle, then this behavior might specifically reflect the former consumption of such shoots in autumn. The overall seasonal pattern of shoot production in some warmer zones is bimodal (e.g., Table 1), which might result from bimodal rainfall patterns. In general, rainfall is concentrated in summer, with little in winter, but secondary minima have often been recorded about July[1].

4. Mass-flowering of Bamboo

4.1. Historical Patterns

The recent alarm about giant panda survival did not develop from concern for critical habitat destruction. It was precipitated by the sudden flowering of most *Fargesia* in the Wanglang and Baishui Jiang regions of the southern Min Shan during 1974-76. Flowering was followed within a year or so by the complete death of bamboo stands, leading to starvation of at least 138 giant pandas[5,15,64,65]. Although similar mass-flowering and mortality of bamboo had been reported previously in the Sichuan region (Table 2), there was no previous record of associated giant panda starvation. So questions of interaction between giant pandas, bamboo growth, habitat destruction and other environmental factors, have become further complicated.

In attempting to understand and predict such flowering, we can ask initially whether it shows any pattern or relationship to environmental factors such as climatic fluctuations. Indeed, some association with dry periods has been often suggested in China[15], Japan[46], India[47,66-69] and elsewhere. However, there is still much taxonomic confusion between species and genera, while complete temporal records of one species' flowering at a particular site, together with climatic data, are rarely available, if at all. Thus, no definite conclusions have been reached. Nevertheless, we can pool records from more than one species and from larger areas, providing data sets which are larger though susceptible to additional natural variations and sampling biases. With this approach, we have reached tentative conclusions for Sino-Himalayan bamboos.

Available flowering records from the Sichuan region have several clusters in time (Table 2): about 1886-92 (-1908?) in northern areas; 1914-22 in southern areas; 1930-43 in widespread areas; 1949-52 in west-central areas; 1955-65 in central lowland areas;

Table 2. Flowering Dates Recorded for Bamboos in the Sichuan Region*

Area	**Species**	**Flowering Dates (years)**											
		187-	188-	189-	190-	191-	192-	193-	194-	195-	196-	197-	198-
North east	*I. wilsonii*				1								
	I. rigidula			?									
	S. confusus		9		0?			9					
	F. spathacea		?	**2**									
North	*A. fargesii*			?	7			3					**1-2**
North west	*S. nitida*	(9-?)	**6**										
	S. pandarum							3				6	1-3
	F. spathacea										9	**4-6**	3
North central	*A. fangiana*							?				8	**2-3**
	F. spathacea?								9	**0-2**		(7)	(1-2)
	A. quingchensis.												1
South central	*A. fangiana*						8		0-2	2		4,9	
	S. chungii							3-8	2	2		8	
	F. spathacea?								2				
	S. ferax							0	4			8	
	C. szechuanensis				8							6-7	
South west	*A. pauciflora*					4							
	S. brevipaniculata					**4-5**						3	1
	S. violascens etc.					6-9	2						
	I. spp.					6							3
	C. spp.							0				3-7	
	Q. spp.										5	6	0-1
South east	*A. faberi*		7										
	I. victorialis												
	C. utilis							?					
	Q. communis											7	
Central lowland	*Sb. sichuanensis*										8	0,3	
	P. nidularia etc.		?		7			0,9		5-8		3	
	P. congesta etc.		5-8		0			9		6-8	1,4		
	P. bambusoides etc.						2		1-2	5,8-9	1,5 -?	3	
	B. rigida							9	2-3				
	Sc. affinis etc.								0-3	7			

*Table 2. Explanation.

Many species identifications remain tentative, and flowering data are incomplete, generally with no record of how widespread flowering was. Each column entry number is the year in the decade of that column. The cases believed to have covered more than a hectare or so are in bold. A "?" is used where only the decade is known. Full references and taxonomic details will be given elsewhere[1].

A. Arundinaria	*I. Indocalamus*	*S. Sinarundinaria/Yushania*	*P. Phyllostachys*
B. Bambusa	*F. Fargesia*	*Sb. Sinobambusa*	
C. Chimonobambusa	*Q. Qiongzhuea*	*Sc. Sinocalamus*	

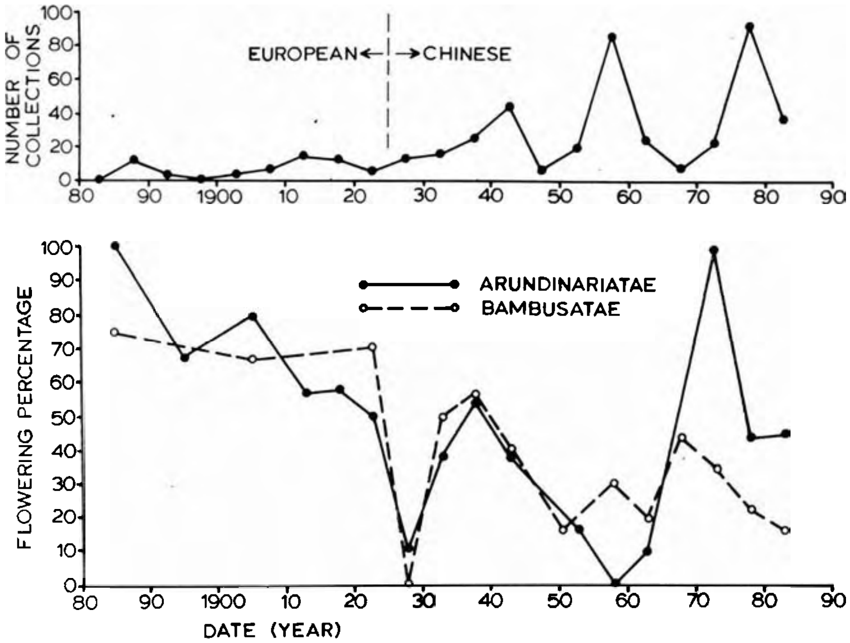


Figure 4. Historical trends in bamboo collections from Sichuan and adjacent provinces, based on all available literature and herbarium data[1]. Note: only about five collections are exceptions to the indicated division between European and Chinese. The taxonomic division into Arundinariatae and Bambusatae is based on P. C. Keng (1982-84)[20]. Five-year classes are used, except where the resulting number of collections is less than five, in which case classes are combined to obtain flowering percentages.

1973-83 in widespread areas. About 95% of flowering records, counting individual herbarium collections, fall in these periods that cover only 55% of the last 100 years. Fluctuation in botanical work (Figure 4)[1] must have influenced this clustering, but it is probably not the major cause. Aside from A. David and other early missionaries, the first period of exploration was in 1880-92, with concentration in peripheral northeastern areas[91]. This period contributed to the initial clustering of flowering records. There was then a decline in the number of botanical collectors, but in 1900-1910, E.H. Wilson did more work here than all previous collectors combined[9,70-72]. His work produced no evidence of mass-flowering and only about eight flowering collections in all. (Most bamboo species flower rarely on individual culms or small clumps, between periods of mass-flowering by the whole stand or species.) Wilson was a diligent observer of the natural scene, and he surely would have noted mass-flowering had he seen it. The southwestern cluster of records during 1914-22 might initially reflect the virtual absence of exploration in that region before then. However, there was a complete absence of records from other areas at the same time, when northern areas were being covered just as intensively by botanists. That the south was really out of phase is indicated further by results of the subsequent 1935-36 Sino-American expedition to southern Sichuan and Yunnan. Only about ten bamboo collections were made, all sterile (Harvard University Herbaria). There were dramatic declines in collection rates within Sichuan during 1945-50 and 1966-76 (Figure 4), which may have enhanced the minor clusters of records between these periods. But the 1949-52 flowering of *Fargesia* (in the Wenchuan region, perhaps including Wolong) was gregarious according to local records[15], while the 1955-65 cluster of *Phyllostachys* records was followed 5-10 years later by much flowering of this genus throughout the world.[73-78] Finally, the historical trend in the ratio of flowering to sterile collections (pooled from herbaria and literature) indicates major peaks in 1880-1910, 1930-40 and 1970-80 for both Arundinariatae and Bambusatae (Figure 4). It is also worth noting that some observations within recent flowering periods have suggested spread of flowering from northwest to southeast[6,78] (see also Table 2), but the extent and significance of this cannot be defined at present.

Statistical analysis of Chinese climatic history, with 500 years of records, has shown periodicities in precipitation of about 2-3, 5-6, 10-11, 20-22, 30-40 and 80-90 years, depending on region[79-82]. At the latitude of giant pandas, minima of the two longer cycles occurred about 1730-40 (major minimum), 1770-80, 1810-20 (major), 1850-60, 1890-1900 (major), 1930-40 and 1970-80 (major). These cycles are reported to be more pronounced in cooler regions, with the minima moving from northwest to southeast in 30-40 years. The cycles of about 10-11 and 20-22 years are relatively pronounced in the Hwang He and Yangtze Jiang valleys, respectively. Droughts of the central Yangtze valley have been concentrated in 1733-40, 1750-52, 1770-75, 1796-97, 1818-21, 1835-36 (?), 1854-64, 1871-74, 1888-92, 1913-23, 1932-37 (?), 1944-53 and 1972-78. In general, shorter cycles are reported to predominate in warmer regions, as also found in India.[83]

In the Sino-Himalayan region itself, annual precipitation commonly varies by ±20-40% over periods of 2-6 years, and the mean for such short periods varies by about as much over periods of some decades.[84] However, details of climatic history are not available for most of the Chinese side in this whole region. Even central Sichuan is marginal to the area analyzed in the studies cited above. The few records that have come out suggest a general decrease to a minimum during the 1930's, and perhaps a cycle of about 20 years since 1880 (we are continuing to request data from official sources). On the Himalayan side as far as Kashmir, there are more raw data available[84] which also suggest cycles of about 20 or 40 years, roughly in phase with the Chinese data (the data from Simla are particularly useful).

Comparison of these dry climatic periods and flowering records from around Sichuan does provide striking coincidences. Similar coincidences exist with the more complete Himalayan data (to be presented elsewhere[1]). In the Sichuan region, only the cluster of records during 1955-65 in warmer zones, mainly from *Phyllostachys* spp., does not coincide with a dry period. Species of this genus are known to flower at particularly regular intervals without clear relationship to climate[74].

4.2. Causal Hypotheses

Though still controversial, some climatic and biological cycles elsewhere appear related to regular astronomical cycles of about 11 and 22 years[85-89] (and further papers in the journal *Climatic Change*, etc.). In Gansu (north of Sichuan), Teng (1948)[90] suggested that drought cycles are related to sunspots, from a pilot study of annual growth in trees (though major reductions in growth were only indicated about 1872, 1894 and 1928). Further dendroclimatic studies have been made in China, but details are not yet available[82]. At least it is known that climatic cycles with mean periods of about 11 and 22 years have existed for 680 million years in various parts of the world, as indicated by sedimentary rocks[87,89]. Thus, if bamboo life-cycles are related to such predictable astronomical cycles, we can suggest how genetic programming of flowering time might have evolved, in addition to any direct stimulus by the environment. Moreover, genetic programming for a regular flowering cycle, matching predictable climatic events, might reduce direct effects of 'noisy' variation in a climatic cycle.

Our evolutionary hypothesis to explain the coincidence between flowering and dry periods is as follows. First, it is important to note that bamboos, in general, occur in regions with particularly high precipitation and humidity during the growing season, which is probably especially important for shoot production[1]. Annual precipitation of at least 1500 mm is considered optimal in East Asia[46]. Thus, fully grown bamboo plants would suffer anyway during relatively dry periods. Instead, short stands composed of juvenile plants produced from seeds might require less moisture for maintenance, due to smaller amounts of transpiring foliage and less exposure to winds. Also, dispersal of seeds to moister microsites might be advantageous. It is even possible that seeds can remain dormant for up to three years (e.g., in the case of *Sinarundinaria nitida* transported to Europe[91]). But, whatever the immediate fate of juvenile plants, it is likely that, with a good chance of precipitation increasing after a dry period, they would then experience favorable conditions during growth to full size. On average, it may take about 10-15 years after germination for Sino-Himalayan bamboos to recover full size and biomass (based on our observations of excavated *Fargesia* rhizomes at Wolong, reports after the recent *Fargesia* flowering in the Min Shan[6,15] and other general observations[39,40,44,66,67,74,76]). Even if there is no direct advantage to vegetative growth of juvenile plants at such times, it may be that their growth relative to mature plants damaged by dry years is the critical factor. Furthermore, if sexual reproduction must occur at some time due to the fundamental need for promoting genetic variation and seed-dispersal, then gearing this to dry periods may simply be the best option for plants which otherwise do well just with vegetative growth.

There are some other environmental factors of potential importance for bamboo that might be associated with dry periods. Cold windy winters with little snow accumulation, from dry air-masses of central Asia, might favor shorter stands with less exposure (snow is known to be protective at high altitude in Japan[92]). Fires, sometimes promoted by the fuel of dead bamboo after flowering[67,93,94], might reduce competition from more fire-sensitive woody plants during regeneration. Other general damage to competing woody plants is possible due to climatic fluctuations. However, there are no detailed records of such factors available for analysis.

A more far-fetched association of bamboo flowering, suggested by some Chinese workers, is with earthquakes[6,15,65,95]. This idea may be supported by the historical occurrence of earthquakes with at least 5-6 Richter Magnitude in Sichuan during **1725-38**, 1748, **1785-93**, 1811, **1846-56**, 1870-79, **1892-96** (-1904), 1913-23, **1932-41**, 1948-60, **1967-76** (major concentrations are in bold)[96,97]. Cycles of 100 years or more are also suggested by such data. Earthquakes have been concentrated in the outlying mountain ranges of the Tibetan Plateau, where bamboo is densest, and their historical pattern bears considerable resemblance to the patterns of climate and flowering just described. It is even possible that earthquakes cause some forest openings suitable for bamboo regeneration[49], providing fuel for evolutionary speculation. However, the study of seismic-climatic relationships is in a preliminary stage[98-101] (and other papers in Acta Geophysica Sinica), and a respectable mechanistic hypothesis cannot be developed in this case. The evidence for long-term correlation between earthquakes and flowering presented by R. L. Yang et al. (1981)[65] was highly selective. Abnormal late summer flowering of fruit trees and other unusual biological events, as reported shortly before the southern Min Shan earthquakes in August 1976 (three of Magnitude 7), also need to be examined with more rigor[95]. There was some suggestion than the massive *Fargesia* mortality of 1976 was promoted by ground water changes linked with the earthquakes, but there has been no quantitative examination of this interesting idea.

Apart from moisture-stress, the other major type of environmental correlation with flowering that has been proposed in the literature involves populations of seed-consuming animals. Reports of large increases in rodents and birds, etc., after widespread seed-production, then starvation or migration, led Janzen (1976)[74] to hypothesize that monocarpic bamboos satiate these animals before their population increases have time to threaten regeneration from seed. He suggested that genetic control through a physiological "clock" allows synchrony between neighboring clones. Many of these reported animal responses are persuasive, and one may add the case of birds flocking to eat ground-covering seed of *Sinarundinaria nitida* at the northern edge of the giant panda range in 1886[91]. However, the significance of other reports can be questioned. Since some of the animals that eat seeds also eat vegetative parts of bamboo, their apparent increases in agricultural areas near dying bamboo stands might be caused by concentrated migrations rather than overall increases. For example, the vole *Clethrionomys rufocans* that reportedly increased after flowering of *Sasa* in Japan during the 1950's[73] was later shown to have a diet exceeding 73% bamboo in non-flowering stands[102]. Also, in the giant panda range, the bamboo rat *Rhizomys sinensis* specializes on bamboo stems, and was reported to migrate in large numbers down to agricultural areas after flowering of *Fargesia* about 1950[15]. Another potential flaw in this hypothesis concerns the time required for bamboos to accumulate reserve nutrients for monocarpic seed-production. Reproductive allocations of resources in bamboos have not been satisfactorily measured in any case, but existiong data indicate that inflorescences plus seed crops amount to only 1-3 years worth of typical vegetative production above-ground (dry weight), or perhaps double this in terms of crude protein[103,104] (also references cited by Janzen[74], the general impression of McClure[105], and our data from Wolong). Moreover, in each year, most carbohydrate reserves in bamboos appear to be shifted from old stems to new production[38,39,106]. It may be relevant that abrupt reduction in above-ground production has been reported during the year or two preceding flowering in several cases[39,74,76,104]. The resultant saving of reserves might contribute substantially to flowers and seed. To the time required for accumulating reserve nutrients, one must add the 10-15 years or so required for bamboo stands to reach their maximum biomass after regeneration (see above), making a total of roughly 15-20 years. But many bamboos have much longer interfloral periods, 30-120 years or more in the giant panda range and elsewhere in temperate East Asia (Table 2 and other data compiled from various sources[74,77]). It seems unlikely that such long times are required merely to accumulate nutrients for seed, as Janzen maintains. One further general problem is that several bamboos flower at irregular intervals, and synchrony is not always apparent when some species are transplanted to different continents[105,106]. The extent of regularity and synchrony in bamboo flowering needs thorough reassessment.

4.3. Observations at Wolong

Some details of growth measurements preceding flowering of *Arundinaria fangiana* at Wolong are relevant here. Culm production of all three species studied appeared to have been unusually low in 1981, as compared to 1978-80, with overall declines of 20-70%. There was partial recovery in 1982, but then further declines in 1983[15]. The average diameter of culms produced in each year also appeared to have declined during this time in *A. fangiana*, whereas it increased in *Fargesia*. Plots with some flowering of *A. fangiana* by late 1982 had experienced more decline in culm recruitment from 1981 to 1982 than plots without flowering (t-test, $P = 0.04$). Vegetative production of flowering plots declined by about half since 1980, and this accumulated loss was comparable with the weight of inflorescences and seeds produced in 1982, though we did not have an opportunity to make a thorough analysis. This reduction in recruitment for two years may have had little effect on overall stand density, since age-distributions indicated that recruitment in 1979-80 had been relatively high and that culms less than 5-6 years old experienced little mortality before flowering. At least, there was no significant difference in recruitment-mortality ratios of 1981-82 between plots with incipient (1-10%) flowering in 1982 and those with no flowering (Figure 3).

Our few records of climate in the study area suggest that precipitation decreased by roughly 20-50% from 1975-80 to 1981-83. We estimated an annual total of about 900 mm in 1982, which is probably suboptimal for bamboo[1]. In 1978-80, the proportion of *Arundinaria fangiana* flowering in our main 25 square km study area was much less than 1%. In 1981, there was some increase, though the proportion was still less than 1%. By the end of the 1982 growing season, roughly 10% was in flower. By the middle of the 1983 season, over 90% was in flower[15]. Before late 1982, most flowering was concentrated at relatively low altitudes of 2450-2650 m, whereas the total range of the species was 2350-3350 m. In the growing season of 1982, soil water contents averaged 30-50% of dry soil weight in this narrow zone, as opposed to 50-100% in zones above and below, perhaps due to some anomaly in precipitation pattern or other factors.

Based on these observations, our working hypothesis is that dry climate after 1980 triggered a sequence from the drop in culm production to the mass-flowering two years later. The spread of flowering to higher altitudes might be explained by various environmental, physiological or genetic factors. (One cannot even rule out pheromones.) Clearly, genetic difference was involved at the species level, since *Fargesia* adjacent to *A. fangiana* did experience a similar drop in culm production during 1981, but then recovered more in 1982 with virtually no flowering. Only three flowering clumps of *Fargesia* were discovered in 1981-82, with a total area no more than 50 square m, though it is interesting that all three clumps occurred in the same zone as the initial flowering concentration of *A. fangiana*. Flowering of *Fargesia* during 1969-83 in the southern Min Shan, closer to the dry northwestern plains than Wolong, appears to have been preceded by more striking decreases in production for a year or more[15]. Perhaps a more serious dry climatic period is required to trigger flowering in this bamboo, or an internal "alarm clock" differs in its setting.

4.4. Retention of Multiple Hypotheses

In developing these various ideas and observations, it may be useful to look for some differences between warm and cool zones. The satiation hypothesis of Janzen might best apply to some subtropical or tropical bamboos with regular interfloral periods of only

3-30 years[74]. As indicated above, the longer periods of subalpine or temperate species probably exceed the time required to accumulate reserves for seed-production, and they may be related instead to long climatic cycles in cool zones. Also, small seeds and lower seed production per square m in cool zone bamboos might result in less attraction for some types of animal. Most subalpine or temperate bamboos have seed weights in the range of 0.01-0.1 grams (based on material in U.S. National Herbarium). Among the 10-15 species available to giant pandas, only two or three warm temperate-subtropical species appear to have seed-weights of 1-10 grams (in *Oreocalamus* and *Indocalamus*?)[15,34]. Many tropical species also have small seeds, but some are as large as 10-100 grams (*Melocanna* and relatives)[39,74].

Finally, perhaps the most fundamental difference in cool humid zones is simply the greater extent of bamboo stands in natural vegetation, together with the prevalence of monopodial or long-necked sympodial rhizomes that make stands less clumped. The combination of somewhat open forest cover on unstable mountain slopes, plus the high humidity suitable for such rhizome growth[39,41], may be the major factors promoting such stands. This bamboo understory can suppress woody regeneration to a considerable degree[1,6,19,49,92-94], and it is likely that mortality after flowering greatly increases the survival of bamboo seedlings. Such a response would provide a purely internal demographic function for the monocarpic trait[68]. Even in areas where bamboo does not fully occupy its potential niche in the forest, the lack of efficient dispersal agents for bamboo seeds[108] would limit escape from parental competition. In contrast, primary tropical rain forest contains little bamboo, which is largely restricted to disturbed areas[46]. It is possible that the greater flowering frequency of most tropical bamboos, some of them annual without dying, reflects the need for more frequent dispersal of seeds into shifting zones of disturbance.

In conclusion, the current scarcity of relevant data prevents firm support of any particular hypothesis to explain flowering patterns. It may be best to retain a multiple-hypothesis approach, especially when considering the great natural and economic role of bamboo, and the many uses to which understanding of these patterns could be put.

5. Large-scale Dynamics of Pandas, Bamboos and People

5.1. Historical Summary

After originating in the late Tertiary or early Quaternary era, giant pandas came to range over most of southern China and adjacent Burma, at 23-38 degrees North (Figure 1). Fossil records are concentrated in the somewhat disjunct low eastern mountains from Guangxi to Zhejiang, as well as the Sichuan region itself[5,14]. The estimated dates of these fossils suggest that decline began 10-20,000 years ago, and, even this early, human activity may have been a major cause of decline[109]. However, large climatic changes have occurred in the Quaternary due to glacial cycles and uplift of the Tibetan Plateau[11,27-29,110]. In the current post-glacial period, temperature and perhaps precipitation (W. Kellogg[78]) were maximal about 4000-6000 years ago. Bamboos (and bamboo rats) were abundant as for north as Hopei then[11] (and even later?[19]). Perhaps giant pandas in warmer zones tolerated the higher temperatures of interglacial maxima, aided by the smaller body size of some fossil forms[109]. But the relative scarcity of bamboo in undisturbed subtropical forest could have pushed them to higher altitude and latitude. Thus, the recent concentration of giant pandas at 28-34 degrees North around Sichuan might be largely caused by the concentration here of a cool, humid climate suitable for bamboo forest[1].

Only further palaeo-ecological research can resolve the questions of prehistory and the importance of early human disturbance. But there is one fossil record from Guangxi at 24 degrees North dated as post-glacial, when temperatures are unlikely to have been lower than in the current range[5,14]. Also, Zhu and Long (1983)[14] cited a historical (or mythical?) record of about 6000 years ago from western Honan, northeast of the current range. They also cited records of 206 B.C. to 265 A.D. to the northeast, and to the south at 26-27 degrees North, in the Yunnan-Guizhou borderland and the maritime Jiangxi-Fujian region (some shown on Figure 1). Agriculture began to dominate subtropical lowlands after this 'First Unification' period of Imperial China about 2000 years ago[1]. There are still minor outlying eastern hills with cool humid climate and bamboo that might support giant pandas, were it not for human disturbance[1]. In addition to disturbance of montane bamboo forest, lowland bamboo important for any seasonal or long-term migration has been removed or monopolized by human use. Migration of giant pandas across lowlands has been prevented, which must have caused populations to become dangerously small and inbred[15].

Historical records of the past 2000 years suggest that giant pandas have only occurred in the Sichuan region, including parts of surrounding provinces[15,61], within which there have been further declines. Zhu and Long (1983)[14] mapped six records of 1603-1866 A.D. from the Wu Shan region of western Hubei and northern Hunan, which is adjacent to eastern Sichuan (Figure 1). Agricultural expansion was accelerating in that period[1]. By Wilson's (1913)[9] time there had been much deforestation in mountains east of the central Min Jiang valley, and he found no sign of giant pandas here. But within this north-central region, there was a record from the Micang Shan in 1950, and a small population may still exist in the 100 square km Xiaozhaizigou Reserve (Figure 1). During the 19th century, logging for timber export to lowlands increased but was largely restricted to the south-central section of the current giant panda range, in the lower Dadu He and lower Min Jiang watersheds[1]. Giant pandas have disappeared from most of this section since then[9,15,111] (Figure 1), though there was a record from Emei Shan in 1948[5]. Today, there are virtually no reports from Emei Shan to Tianquan (though the latter still has takin, an endangered ungulate of the subalpine zone[4]). About 1885-1900 in northern regions and then 1913-23 in southern, there appear to have been periods of dryness and bamboo flowering (see above), but effects on giant pandas are unknown.

In 1920-50, logging accelerated greatly in the upper Min Jiang watershed and adjacent Gansu Province[1]. Also, there was a period of widespread dryness and flowering about 1930-40, and more flowering restricted to west-central areas about 1950 (see above). Before this period there had only been about four sightings of collections of giant pandas by foreigners (in 1869, 1893, 1916), though Wilson (1913), Limpricht (1922)[112] and others saw droppings on several occasions. Then, in 1929-41, interest increased and about 25 animals were killed or captured for foreign trophies, museums and zoos[5,61]. In 1937-39 alone, about 12 were taken. Except for the one killed by the Roosevelt expedition near Da Liang Shan in 1929, all these giant pandas were taken in the valleys around Tsaopo in the Wassu tribal region. This region was centered to the west of the upper Min Jiang valley between Wolong and Lifan (Figure 1), just south of the concentrated logging[1]. It had relatively high giant panda density in the early 1930's with at least 0.3-0.6 per square km in the central valleys, as estimated by Sheldon (1974)[10]. But as much as half the population may have been taken, based on these estimates. Later, in 1942, S. Y. Hu (1956)[113] saw no sign of giant pandas (or flowering bamboo) during her journey through the region. In 1942-52, only about three giant pandas were reportedly taken in the whole range[5]. It is possible that heavy logging and bamboo flowering made them more accessible to collectors in the 1930's. Today, there are no reports of giant pandas or extensive bamboo stands in the old Wassu region, except adjacent to the Wolong Reserve (Figure 1). But at least in 1951, *Fargesia* extended as far as Hei-shui He, 40 km north of Lifan (flowering collection of R. C. Lee in Sichuan University Herbarium).

After 1950, logging continued at about the same high rate as in the 1930's, spreading to most sections of the giant panda range except the far south[1]. Flowering of bamboos appears to have increased during 1955-65 at lower altitude, and since 1973 in widespread montane localities, perhaps associated with reduced precipitation (see above). In 1953-59 about 18 animals were reportedly captured for zoos, in 1960-69 only about 2, and then in 1970-76 about 25[5,64]. Together with earlier events, the approximate coincidence between major periods of capture and those of bamboo flowering may be significant. These periods also tended to supply larger animals for foreign zoos[5]. At least during the mass-flowering of 1974-76 in the southern Min Shan, starving giant pandas came down to agricultural land and 13 were caught by rescue workers[64]. It would be interesting in this context to compile records of trapping and trade within China, such as the illegal acts reported from Wolong and Taiwan in 1983 (WWF press files).

An unanswered question of great practical importance is whether the disastrous deforestation of the past 50 years has influenced climate to the extent that bamboo forest is affected. Serious general ecological concern about "desertification" trends has recently been raised in Sichuan, with forest cover estimates declining from 26% in the 1930's to 19% in the early 1950's to 13.3% in 1981[1,12]. We might expect vegetative growth of bamboo to decrease, and flowering to increase, following from the discussion above.

5.2. Range Margin Conditions

At the northern, western and southern limits of the giant panda range, additional climatic factors may have worsened the crisis. To the northwest of existing reserves, there is a large area with scattered bamboo where giant pandas are rare or absent (Figure 1). *Sinarundinaria nitida* occurs as far as the northern Min Shan (between Towe and Jone; R.C. Ching-974 in U.S. Nat. Herb.) and, 150 km further north, in the isolated Xinglong Shan of central Gansu[114] and Liupan Shan of southern Ningxia[18,115]. In this region, humid forest with bamboo is restricted to high altitude by dry lowland climate[1,116], and these marginal conditions for bamboo probably have enhanced the problems of flowering. Unconfirmed reports of giant pandas in eastern Qinghai are tantalizing[5,117,118] but doubtful[15,119].

To the southwest of the giant panda range, there is also a large area with bamboo but without definite records of giant pandas (Figure 1). Tentative sightings of the species have been made in the Yalong Jiang watershed, 200 km west of the currently known range (by J. H. Edgar in 1916), and in northern Yunnan (1966 Chinese report)[10,118]. Although well-preserved bamboo forest does occur here from 1500-2500 m to 3500-4000 m in altitude, it appears to be more fragmented by dry and disturbed areas than in central Sichuan[33,116,120,121]. The Yangtze-Mekong (Jinsha-Lancang) divide is especially dry, with little bamboo (or deciduous forest). Lower altitudes in the deep river gorges here are generally too dry or disturbed for any type of forest, and giant pandas must have had severe difficulties in migrating. Uplift of these mountains during the Quaternary probably contributed to the dry valley phenomenon[110,122], cutting off the former giant panda range in northern Burma. Another special factor in Yunnan and southeast Tibet might be the quality of bamboo. The genus *Chimonocalamus* is endemic here and in adjacent Indo-Burmese hills[36]. These caespitose bamboos have the unusual characters (for temperate taxa) of thorniness and apparent chemical defense of shoots (a yellow aromatic fluid that repels insects). Perhaps such characters evolved in response to a long history of consumer pressure (see also Ueda[39], p.54). In contrast to this endemic genus, some other types of bamboo that are staples in the central giant panda range may have gaps in their Sino-Himalayan distributions across this Yunnan-Tibet borderland (*Arundinaria racemosa-fangiana*, *Thamnocalamus-Fargesia*)[1].

The lesser (red) panda, which also largely feeds on bamboo, extends from Sichuan to Nepal, though not as far as the northwestern bamboo limit in the Himalayas[123] (Figure 1). It is more opportunistic in diet and habitat. Also, its altitudinal range is reported to be about (1800) 2000-4000 (4800) m, which is centered higher than the giant panda's of about (800) 1500-3500 (4000) m (see also[62]). Thus, this species may be less sensitive to the dryness and disturbance of deep valleys between China and the Himalayas. However, its range too has become dangerously fragmented in many areas.

5.3. Current Events

While the tragic effects of bamboo flowering currently work themselves out, we can at least organize available observations into preliminary predictions of how serious these effects will be, and what research and conservation action must be initiated to reduce such effects in the future.

Although intensive work began too late during the flowering of *Fargesia spathacea* in the southern Min Shan during the 1970's, there are now some useful observations on the aftermath of the event[6,15,64,65,124]. The flowering mostly occurred in 1974-76, but a little began in 1969 and some may be continuing. A *Sinarundinaria* (or *Yushania*) species also flowered in some areas. The total area involved was about 5000 square km, though only 1000-2000 square km of this was covered by bamboo. In the Wanglang Reserve, at least 80% of the *Fargesia* died, and the giant panda density declined from at least 0.7 to only 0.1-0.2 per square km of bamboo. Heavy mortality of bamboos and giant pandas was also reported in the Baishui Jiang Reserve. However, in the Jiuzhai Gou and Tangjia He Reserves, which may be better protected by topography from dry northwestern winds, the flowering of *Fargesia* in 1974-76 was largely restricted to altitudes above 2400-2600 m (up to 3000-3300m), with a delay until 1983 below (down to 2000-2300 m). This spread of flowering may have saved many giant pandas in these two areas, which still had densities of 0.3-0.6 per square km of bamboo in 1983[15].

It is clear that survival during such events depends greatly on migration to areas of non-flowering bamboo. In the southern Min Shan and Wolong regions, such areas are currently concentrated at lower altitudes and other marginal sites. Even during periods between flowering, seasonal descent to feed on thick shoots is probably normal behavior for adults (see above). Concentration of feeding in temperate zone bamboo stands before deforestation would have taken no more than 1-10% of annual above-ground production, based on rates estimated above. Such concentration might not have been serious if limited to the decade or so needed for higher bamboos to regenerate sufficiently. But the problem today is that most temperate bamboo forest has been removed or excessively disturbed up to an average altitude of about 2000 m, or as high as 2400-2600 m in the southern Min Shan[1]. Also, relatively large areas at lower altitude in that northwestern region may be too dry for bamboo.

The typical bamboos below *Fargesia* in central and northern sections of the range are *Sinarundinaria nitida* or related species[25] (see above) and, more locally on moister sites, *Phyllostachys* spp. *S. nitida* appears to have an interfloral period exceeding 90 years. The only definite record was in 1886 near Zhughu ("Siku") and Dangyang ("T'an Ch'ang"?) in southern Gansu, when villagers recalled their grandparents talking about the previous flowering[91] (there may also be records for 1879-85)[65]. Even plants cultivated in the West and observed continually since their establishment in 1889 have not flowered at all[107,124]. Some *Phyllostachys* species may also have relatively long interfloral periods of about 60 or 120 years[73-78], sometimes out of phase with bamboos of cooler zones (e.g., Table 2). Thus, these warm zone bamboos could have been highly important to the long-term dynamics of giant pandas, which are said to feed heavily on these species in some cases[25,32,125], though preferring species of higher altitude when available (especially *Yushania*)[15]. However, the only reserve today where *Sinarundinaria* and *Phyllostachys* dominate the diet is Foping, in southern Shaanxi[32], and there may be no other reserves where these species alone are sufficient.

In 1982-84, most *Arundinaria fangiana* has now flowered. This species was the staple food for giant pandas in subalpine to cool temperate zones in central and southern sections of their range (see above). There are also reports that other species have flowered to various extents (more *Fargesia* - and others? - in the Min Shan; *A. fargesii* in the Qin Ling; others in the Da Liang Shan). In central regions, there may still be enough *Fargesia* (and locally *Yushania*) for concentrated feeding instead of *A. fangiana*. However, giant pandas have avoided moving closer to human settlements for these alternative species, and at least 20 have been found dead or dying in 1983-84. It is possible that the last healthy populations, best represented at Wolong, are now being lost.

While zoologists attempt to guide massive feeding and rescuing of starving animals, what can botanists do?

1. There should be much more taxonomic work on these bamboos, especially with the new flowering collections. Ideally, there should be more exchange with western herbaria and gardens, where some early type collections exist. Clarification of genetic relationships between bamboos, beginning with traditional taxonomy, would of course be essential to any prediction of flowering in the future.
2. There should be no further delay in starting intensive study of bamboo life-cycles. More plot work and excavation of rhizomes is needed for better estimates of vegetative production and nutrient flow. Flowering, seed production and consumption, and seedling establishment need much more attention, with quantitative measurements initiated. A broad-minded, interdisciplinary, multiple-hypothesis approach is needed to the whole study of environmental relationships. It is pitiful that climatic data are not yet available for proper examination of relationships to flowering and other processes.
3. Botanists must enter the general ecosystematic and socioeconomic arena to address the fundamental problem of deforestation. The extent of deforestation needs to be more accurately surveyed, using LANDSAT for example. Effects of disturbance on bamboo species need to be studied, as well as general degradation of forests due to erosion and climatic change. Politically acceptable compromises need to be worked out between conservationists, native mountain people, and lowland users of timber exports. Realistic plans for reestablishing bamboo forest in the warmer temperate zones need to be made and implemented. A general compromising concept that may prove valuable would be to delimit buffer zones between montane reserves and lowland settlements. Bamboos in these zones could be used by people except when montane bamboos flower and giant pandas

need alternative food (e.g., by developing plans of Tang et al.[126]).

Summary

1.1. At Wolong, *Arundinaria fangiana* and *Fargesia*·cf. *spathacea* are the major bamboos available to giant pandas, at altitudes of 2300-3400 m and 1600-2800 m, respectively. *Sinarundinaria* spp. occur on peripheral, relatively dry or disturbed sites. Larger bamboos in *Phyllostachys*, *Bambusa* and related genera occur in warmer zones, but virtually all natural bamboo forest there has been removed by the dense human population.

1.2. In the northern giant panda range, *Fargesia* and *Sinarundinaria* extend to higher altitudes, where *A. fangiana* is absent. In the south, *A. fangiana* is present, but the *Fargesia-Sinarundinaria* complex is largely replaced by the *Chimonobambusa-Qiongzhuea* complex.

2. Annual above-ground production of non-flowering bamboos averages 15-25% of biomass, i.e., about 0.2 kg (dry weight) per square m at optimal altitude for *A. fangiana*. There is much small-scale variation in growth versus decline within non-flowering stands at Wolong, but little overall relation to large-scale vegetation patterns.

3.1. The giant panda population at Wolong consumes about 0.1-2.0% of above-ground production. But pandas and other animals kill about 30-40% of fresh culm shoots before these reach full size. The seasonal preferences of giant pandas are leaves of *A. fangiana* in July-October, leaves plus new culms of *A. fangiana* in November-March, old culms of *A. fangiana* or young culm shoots of *Fargesia* in April-June.

3.2. The descent of adults at certain seasons to eat culm shoots of larger bamboos in warmer zones is a common feature throughout the range. These shoots probably provide an important nutritional supplement, which has become increasingly difficult to get due to human disturbance.

4.1. In 1973-83, several montane bamboo species have undergone monocarpic flowering and mortality over large areas, causing giant pandas to starve. Records of flowering (without panda mortality) have also been concentrated during 1886-92 (-1908) and 1930-43 (-52) in species of cool zones. These three periods have coincided approximately with the minima of a ca. 40 year precipitation cycle.

4.2. Our evolutionary hypothesis is that sexual reproduction in these bamboos is geared to dry periods, when mature plants would suffer anyway. The seed-consumer satiation hypothesis of Janzen (1976)[74] may be difficult to apply to bamboos with life-spans longer than 20 years, since biomass and reserves for seed-production can probably be accumulated within this time.

4.3. The 1983 mass-flowering of *A. fangiana* at Wolong was preceded by low culm production in 1981-83, and we suspect that precipitation was also lower than normal. Reserves not allocated to culms might have contributed substantially to flowering instead.

4.4. Different flowering and seeding patterns in warm and cool zones may require different types of explanation. An additional factor in the relatively extensive and stable bamboo stands in these mountain forests may be that competition from parent plants must be removed for seedlings to survive.

5.1. Climatic factors probably restrict bamboo forest sufficient for giant pandas to the mountains around Sichuan and some eastern hills. But within this region, there has been an increasingly rapid decline in forest cover and giant pandas, as human disturbance has spread up from major river valleys. About half of the forest has been removed, largely in the past 50 years.

5.2. To the north, west and south of the current range, river valleys draining the Tibetan Plateau have relatively dry climate, as well as human disturbance. Giant pandas cannot migrate between islands of montane bamboo forest here. Lesser pandas are less specialized on bamboo, exist at somewhat higher average altitude, and extend across SE Tibet to the Himalayas.

5.3. Most remaining giant pandas may now be threatened by further flowering and mortality of bamboo in 1982-84. Along with massive emergency feeding and rescue operations, much more basic work on bamboo biology and forest ecology will be required for sound management plans. People must be persuaded to limit their expansion and exploitation of forest resources, and to reestablish a warm-temperate buffer zone of bamboos.

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Letters to the Editor

Earle Barnhart*: **New Alchemy Bamboo Hardiness Report; 3/4/83 Trials of Hardy Bamboo on Cape Cod at the New Alchemy Institute**

At least two species of *Phyllostachys* bamboo can be observed growing in well-established groves on Cape Cod (*P. aureosulcata* and *P. flexuosa*).

To see if other species would also grow here, 17 species of bamboo were brought to Cape Cod in the spring of 1980. Species were selected for the trials from the USDA bamboo collection in Savannah, Georgia, based on potential hardiness suggested by literature and by descriptions of the origins of the plant in China. Cape Cod is normally considered to be in USDA Hardiness Zone 7 - occasionally dropping below 0 F.

WINTERS OF 1980-1981 and 1981-1982

The species we are growing are grouped below (see table) by the degree of winter damage to the foliage in the winters of 1980-1981 and 1981-1982, both unusually cold winters.

Though many of the less-hardy species appeared severely damaged in June, by mid-July every one had produced many new culms with great vigor. A number of them also put up new culms from 4 to 5 feet away from the original clump, indicating that they are spreading below ground in spite of winter damage.

WINTER OF 1982-1983

During the winter of 1982-1983, sudden arctic winds struck in January after a mild fall, and all species which were exposed to the wind suffered total leaf kill (leaves dessicating and turning tan on the plant). However, specimens of the same species which were wind-protected in a woodland situation as an understory plant remained green.

It appears that wind exposure is the most critical factor to over-wintering bamboo. The most wind-protected stands were least damaged. Even the hardy *P. aureosulcata* will die back to the ground if exposed to direct winter winds. In their native ecosystems, temperate bamboos are often understory plants growing beneath and among trees. Thus on Cape Cod they do well when grown close to windbreak trees, when protected by buildings and on wind-protected hillsides.

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* New Alchemy Institute, 237 Hatchville Rd., East Falmouth, MA. 02536.

Winter Damage	Species	USDA Plant Introduction No.
Hardy		
(Most culms, branches, and leaves remain green.)	*Phyllostachys aureosulcata*	55713
	P. congesta	80149
	P. bissetti	143540
	P. angusta	23237
Foliage Damage		
(Culms, branches, and leaves in interior of clump are green; outer leaves and branch ends dead.)	*Phyllostachys nigra*	77259
	P. flexuosa	52686
		116965
	P. dulcis	73452
	P. meyeri	116768
Foliage Die-Back		
(Only culms or lowest culm segments still green.)	*Phyllostachys aurea*	38919
		55975
	P. bambusoides	146420
	P. makinoi	195284
	P. nidularia	128769
		128779
	P. nigra (Henon)	66787
	P. pubescens	880034
	P. viridis	77257
	Semiarundinaria fastuosa	112080
Total Foliage Kill		
(No green foliage above ground)	*Arundinaria simonii*	38921
	Phyllostachys nidularia	63757

Table 1. Hardy and foliage-damage groups are listed in order of increasing foliage damage.

Notes

Notes

JOURNAL OF THE AMERICAN BAMBOO SOCIETY

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Two good quality copies of the manuscript, typed on one side only, on 8 1/2 by 11 inch paper are required. The format should follow the pattern as presented by the *Journal*. The first appearance of scientific names of the plants should be followed by the appropriate authorities. References should be listed alphabetically at the end of the paper unless they appear as footnotes. The references should then be in order of appearance at the end of the paper. Total length of the manuscript (including figures) should be no more than 30 pages of the *Journal* (about 680 words/page).

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D. Ohrnberger* and J. Goerrings**: **A Description of *The Bamboos of the World - A Preliminary Study of the Names and Distribution.***

Revised manuscript received October 19, 1984

In November, 1983, we started the publication of our series entitled *The Bamboos of the World - A Preliminary Study of the Names and Distribution of the Herbaceous and Woody Bamboos (Bambusoideae Nees v. Esenb.) - Documented in Lists and Maps.* It will be continued over some years and probably be completed in 1986. This series is composed and edited by us and is published in English in Odenthal near Cologne, West Germany.

The series has the following objectives:

1. to present a review of the available information about all bamboo species along with their geographical distribution using text and maps. Until now this information has been scattered through a mass of literature.
2. to facilitate access to this information through a comprehensive bibliography which gives the present state of knowledge to those interested in the botany and horticulture of bamboo, especially its morphology, taxonomy, and plant geography.

In setting the size and format of our work, we have followed our general objectives as closely as possible within personal, financial and temporal limitations. Our work includes a compilation of the tribes, genera, species, subspecies, etc. of all bamboos along with citations of each in the literature and a map showing the geographical limits of the plants' natural distribution. For this we evaluated all the literature which we considered important from the time of Linnaeus to the present. We have performed no taxonomic research ourselves, but rather have followed the taxonomists of today in determining systematic classifications, especially the generic definitions which form the foundations of our work.

In the case of disagreements, which occur most often in the acceptance of many of the genera, our chosen classification is not a decision for or against a given author; but rather, it is a choice based on editorial and practical considerations. We therefore regard our results as provisional. It seemed to us that our list of names could be of value only if the nomenclature and references are as complete as possible. We hope our work meets this requirement. Since we also feel it is important that the work not go out of date over the years, we plan to make appropriate revisions every 6 months to 3 years.

The following is an explanation of the parts and composition of the series. Each part is independently paged with from 7 to 60 pages. The series includes the following parts:

An introduction explaining the objectives and the system of documentation in detail. To be published soon.

A summary outline on the bamboo subfamily, its tribes and genera. The first edition contains an alphabetical list of the genera together with a scheme reflecting the relationships and size of the groups within the subfamily. Both list and scheme are

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provisionally compiled. They are published in this issue of the ABS Journal below. A later edition of this part will summarize the results of the entire work.

A bibliography of mostly taxonomic literature on bamboo. It will contain over 800 references. Those parts of the literature which have been available for evaluation in our work will be marked. To be published soon.

The genera, consisting of about 113 separate parts each dealing with a single genus. Each part is divided into two chapters: the first deals with nomenclature, the second with geographical distribution. Chapter 1 lists the names that have been applied to the genus, subgenera and sections, the species and subspecies, varieties, forms, and cultivars. In addition there is a complete list of synonyms and an abridged list of references which deal with that particular taxon. The plants are not described except for brief notes on varieties, forms and cultivars. Chapter 2 describes the natural distribution of the genus and each species. The genus distribution is usually mapped on a scale of 1:50,000,000 while the species distributions are mapped at 1:25,000,000. Altitude range, plant association, habitat climate and soil, naturalized distribution due to human intervention, and the relationship between plant and man is also mentioned when the information is available.

An index to all cited species, subspecies, varieties, forms and cultivars. Not yet published.

D. Ohrnberger*: The Genera of Bamboo
An Alphabetical Compilation of All Known Generic Names

Revised manuscript received October 19, 1984

In 1983, J. Goerrings and I started the publication of our series, *The Bamboos of the World*. The series will probably consist of over 110 single parts and be completed in 1986. Our aim as well as the arrangement and organization of the series is explained in the preceding article.

Our preparation for *The Bamboos of the World* consisted of the study of literature published over a period of more than two centuries. I started the preparatory work in 1981 and it has now found a preliminary conclusion. In the future it will be necessary to correct some deficiencies and to update the material using the latest literature.

My study of the literature enabled me to present the following comprehensive list of genera along with a tentative scheme (Table 1) which reflects the supposed relationships among the bambusoid grasses. Table 1 is a summary outline of the bamboo subfamily; it is given to the reader as a better review of the genera. I found altogether 156 generic names of which 125 have proven to follow the rules of the International Code of Botanical Nomenclature (ICBN)[1]. Since the large number of generic names makes it difficult for most of us to cope with the literature, the present list enables one to ascertain whether or not a given grass genus belongs to the subfamily Bambusoideae. I have followed C.E. Calderôn and T.R. Soderstrom (1973) who have considerably extended the circumscription of Bambusoideae to include several groups of grasses with herbaceous stems (e.g. the olyroid grasses). The list therefore includes both the woody and the herbaceous bamboos.

Not all 125 genera are acceepted by present taxonomists. In fact, I estimate that a given taxonomist accepts between 70 and 115 out of the 125. In addition, there is a particularly large amount of disagreement over the circumscription of certain genera and the grouping of genera into tribes[2]. The situation is in an unstable state of flux making it difficult for those who want to use bamboo names. Because there is now no broadly accepted systematic order, I ask the reader to be satisfied with this preliminary list and scheme which may, however, change significantly in the future.

The list contains 111 "accepted " genera of the Bambusoideae of which 85 are woody and 26 are herbaceous. I believe that many of the genera will not stand the test of time; they may well be ranked as subgenera in the future.

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[1] The list contains 158 generic names in total, of which 2 genera, *Chevalierella* A. Camus and *Microcalamus* Franchet, are here provisionally kept out of the Bambusoideae. The other 156 names include those both validly and invalidly published. As a rule spelling variants based on the same type are not given. Of the 156 names, 31 are invalid and illegitimate; this leaves 125 legitimate names.

[2] Here are two examples:

a) The well known, comprehensive genus *Arundinaria* was recently split by P.C. Keng and other Chinese authors into many genera each with few species.

b) Different Chinese authors disagree about the importance of certain morphological characteristics of the *Thamnocalamus - Fargesia - Sinarundinaria - Yushania* group. Their different circumspections of the genera causes confusion of the names. The same can be said for the *Bambusa - Lingnania - Dendrocalamopsis* group and the *Dendrocalamus - Sinocalamus - Neosinocalamus* group.

In compiling the list of genera I have followed closely the work of: T.R. Soderstrom for the woody and herbaceous American bamboos; P.C. Keng for Old World, woody bamboos, especially those from China; and S. Suzuki for the woody bamboos of Japan. The African bamboos follow mostly the work of A. Camus and W.D. Clayton. I have followed several different current workers for the Indian and Southeast Asian bamboos. Because of the lack of agreement among taxonomists concerning bamboo, there is always the danger that my reconciliation of diverse opinions has not resulted in the best possible list. I would therefore be much obliged to receive criticism and suggestions for the improvement of the list.

The following annotations should be helpful in understanding the list of genera and the scheme in Table 1. Each entry on the list begins with the genus name in italics. Those in bold italics are "accepted" genera in that they are legitimate[3] according to ICBN rules and are somewhat broadly accepted by taxonomists. The non-accepted genera are given as synonyms and are followed by an "=" sign[4]. The name of the genus is followed by the author's name and the publication year[5]. If there are two author names separated by "ex", the publication will be listed under the second name. Joint authors are separated by "&". Some of the genera have been grouped into tribes (taxonomic units consisting of one or more related genera). The tribal names end in "-EAE"; they are given in capital letters inclosed in parentheses. Many genera can not at present be assigned to a tribe. The tribal assignments should be regarded as provisional even for those not followed by a question mark. The tribe ARUNDINARIEAE has been divided into 3 subtribes by P.C. Keng. The names of the subtribes end in "-INAE" and follow the tribal name within the parentheses. Next is given the designation "woody" or "herbaceous" which describes the type of bamboo making up the genus. Finally the number of species for each genus is given. Note that this is the generally accepted number of different species and not the usually much greater number of validly published names. The number of species for a given genus is still in doubt because of the difficulty in generic assignment. The total number of species for all genera is, however, a much more reliable number. I find that the bamboo subfamily now consists of 1030 to 1100 generally accepted, described species. Of the total, 880 to 940 (about 85%) are woody bamboos and 150 to 160 (about 15%) are herbaceous. In Table 1, the number of species is given in parentheses for each group. This helps to gain an impression of their sizes.

The Genera

Achroostachys Bentham, 1881, = *Athroostachys* Bentham

Acidosasa C.D. Chu & C.S. Chao, 1979, (ARUNDINARIEAE: ARUNDINARIINAE), woody, 4 sp.

Actinocladum McClure ex Soderstrom, 1981[6], (ARUNDINARIEAE), woody, 1 sp.

Alvimia Calderón, 1978[7], woody, 1? sp.

Ampelocalamus S.L. Chen, T.H. Wen & C.Y. Sheng, 1981, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 2 sp.

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[3] Exceptions are the recently established genera *Alvimia* and *Omeiocalamus* for which a valid publication is at present not known.

[4] For simplicity, no distinction has been made between taxonomic and nomenclatural synonyms.

[5] The complete references are not given here. They will appear in a special bibliography to be published in this journal in the near future.

[6] Not to be confused with *Actinocladus* E. Meyer, 1847, (Umbelliferae).

[7] nom. nud. (without description). New, not yet described genus; cf. Soderstrom, 1981, in *Amer. J. Bot.*, 68:1373.

Anomochloa Brongniart, 1851, (ANOMOCHLOEAE), herbaceous, 1 sp.
Aphonina Necker, 1790, = *Pariana* Fusée-Aublet
Apoclada McClure, 1967, (ARUNDINARIEAE), woody, 4 sp.
Arberella Soderstrom & Calderón, 1979[8], (OLYREAE), herbaceous, 3 sp.
Arthrostylidium Ruprecht, 1839, (ARTHROSTYLIDIEAE), woody, 21 sp.
Arundarbor Rumphius ex O. Kuntze, 1891, = *Bambusa* Schreber
Arundinaria Michaux, 1803[9], (ARUNDINARIEAE: ARUNDINARIINAE), woody, 1 sp.
Athroostachys Bentham, 1883, woody, 1 sp.
Atractantha McClure, 1973, woody, 9-10 sp.
Atractocarpa Franchet, 1887, = *Puelia* Franchet
Aulonemia Goudot, 1846, (ARTHROSTYLIDIEAE), woody, 25 sp.

Bambos Retzius, 1788, = *Bambusa* Schreber
Bambus Blanco, 1837, = *Bambusa* Schreber
Bambus J.F. Gmelin, 1791, = *Bambusa* Schreber
Bambusa Mutis ex Caldas, 1809, = *Bambusa* Schreber
Bambusa Schreber, 1789[10], (BAMBUSEAE), woody, 91 sp.
Bashania P.C. Keng & T.P. Yi, 1982, (ARUNDINARIEAE: ARUNDINARIINAE), woody, 2 sp.
Beesha Kunth, 1822, = *Melocanna* Trinius
Beesha Munro, 1868, = *Ochlandra* Thwaites
Bonia Balansa, 1890, (BAMBUSEAE), woody, 1 sp.
Brachystachyum Y.L. Keng, 1940, (SHIBATAEEAE), woody, 1 sp.
Brasilocalamus Nakai, 1933, = *Merostachys* Sprengel
Buergersiochloa Pilger, 1914, (BUERGERSIOCHLOEAE), herbaceous, 1 sp.
Bulbulus Swallen, 1964, = *Rehia* Fijten
Burmabambus P.C. Keng, 1982, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 1 sp.
Butania P.C. Keng, 1982, (ARUNDINARIEAE; THAMNOCALAMINAE?), woody, 1 sp.

Cephalostachyum Munro, 1868, (MELOCANNEAE), woody, 17 sp.
Chevalierella A. Camus, 1933[11], herbaceous, 2 sp.
Chimonobambusa Makino, 1914, (SHIBATAEEAE), woody, 3 sp.
Chimonocalamus C.J. Hsueh & T.P. Yi, 1979, (ARUNDINARIEAE: THAMNOCALAMINAE?), woody, 11 sp.
Chloothamnus Buse, 1854, = *Nastus* Jussieu
Chusquea Kunth, 1822, (CHUSQUEEAE), woody, 82 sp.
Colanthelia McClure & E.W. Smith, 1973, woody, 7 sp.
Coliquea Steudel ex Bibra, 1853, = *Chusquea* Kunth
Cryptochloa Swallen, 1942, (OLYREAE), herbaceous, 7 sp.

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[8] Not to be confused with *Arberiella* D.D. Pant & D.D. Nautiyal, 1960, which is a name for fossil sporangia from the Carboniferous of Africa.

[9] According to P.C. Keng and other Chinese taxonomists, *Arundinaria* is considered a monotypic genus containing the single species, *Arundinaria gigantea* (Walter) Muhlenberg, native to North America.

[10] nomen conservandum (conserved name).

[11] H. Jacques-Félix assigned *Chevalierella* to the bambusoid grasses in 1955. Previous authors treated this genus under other subfamilies. More details are needed before confirming an assignment to the Bambusoideae.

Decaryochloa A. Camus, 1947, woody, 1 sp.
Dendragrostis Nees von Esenbeck ex Munro, 1868, = *Chusquea* Kunth
Dendrocalamopsis (L.C. Chia & H.L. Fung) P.C. Keng, 1983[12], (BAMBUSEAE), woody, 8 sp.
Dendrocalamus Nees von Esenbeck, 1834, (DENDROCALAMEAE), woody, 25 sp.
Dendrochloa C.E. Parkinson, 1933, (BAMBUSEAE), woody, 1 sp.
Diandrolyra Stapf, 1906, (OLYREAE), herbaceous, 1 sp.
Dinochloa Buse, 1854, (MELOCANNEAE), woody, 20 sp.
Drepanostachyum P.C. Keng, 1983, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 4 sp.

Ekmanochloa Hitchcock, 1936, (OLYREAE), herbaceous, 2 sp.
Elytrostachys McClure, 1942, woody, 2 sp.
Eremitis Doell, 1877, (PARIANEAE), herbaceous, 1 sp.

Fargesia Franchet, 1893, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 14 sp.
Ferrocalamus C.J. Hsueh & P.C. Keng, 1982, (ARUNDINARIEAE: SASINAE), woody, 1 sp.
Froesiochloa G.A. Black, 1950, (OLYREAE), herbaceous, 1 sp.

Gelidocalamus T.H. Wen, 1982, (ARUNDINARIEAE: SASINAE), woody, 5 sp.
Gigantochloa Kurz ex Munro, 1868, (DENDROCALAMEAE), woody, 16 sp.
Glaziophyton Franchet, 1889, woody, 1 sp.
Greslania Balansa, 1872, (BAMBUSEAE), woody, 4 sp.
Guadua Kunth, 1822[13], (BAMBUSEAE), woody, 28 sp.
Guaduella Franchet, 1887[14], (PUELIEAE), herbaceous, 6 sp.

Hellera Schrader ex Doell, 1877, = *Strephium* Schrader ex Nees von Esenbeck
X Hibanobambusa Maruyama & H. Okamura, 1979, (SHIBATAEEAE?), woody 1 sp.
Hickelia A. Camus, 1924, (HICKELIEAE), woody, 2 sp.
Himalayacalamus P.C. Keng, 1983, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 1 sp.
Hitchcockella A. Camus, 1925, woody, 1 sp.
Houzeaubambus Mattei, 1910, = *Oxytenanthera* Munro

Indocalamus Nakai, 1925, (ARUNDINARIEAE: SASINAE), woody, 25 sp.
Indosasa McClure, 1940, (SHIBATAEEAE), woody, 18 sp.
Irulia Beddome, 1873, = *Ochlandra* Thwaites
Ischurochloa Buse, 1854, = *Bambusa* Schreber

Klemachloa R.N. Parker, 1932, (BAMBUSEAE), woody, 1 sp.

Leleba Nakai, 1933, = *Bambusa* Schreber
Leleba Rumphius ex Schultes, 1830, = *Bambusa* Schreber

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[12] L.C. Chia and H.L. Fung treat *Dendrocalamopsis* as a subgenus of *Bambusa*.
[13] McClure and some present authors treat *Guadua* as a subgenus of *Bambusa*.
[14] Published as *Guadella*.

Lepideilema Trinius, 1831, = *Streptochaeta* Schrader ex Nees von Esenbeck
Leptaspis R. Brown, 1810, (PHAREAE), herbaceous, 10 sp.
Leptocanna L.C. Chia & H.L. Fung, 1981, (MELOCANNEAE), woody, 1 sp.
Lingnania McClure, 1940[15], (BAMBUSEAE), woody, 12 sp.
Lithachne Palisot de Beauvois, 1812, (OLYREAE), herbaceous, 4 sp.
Ludolfia Willdenow, 1808, = *Arundinaria* Michaux

Maclurolyra Calderón & Soderstrom, 1973, (OLYREAE), herbaceous, 1 sp.
Macronax Rafinesque, 1808, = *Arundinaria* Michaux
Mapira Adanson, 1763, = *Olyra* Linnaeus
Matudacalamus Maekawa, 1961, = *Aulonemia* Goudot
Melocalamus Bentham, 1883, (MELOCANNEAE), woody, 2 sp.
Melocanna Trinius, 1821, (MELOCANNEAE), woody, 3 sp.
Merostachys Sprengel, 1825, (ARTHROSTYLIDIEAE), woody, 24 sp.
Microbambus K. Schumann, 1897, = *Guaduella* Franchet
Microcalamus Franchet, 1889[16], herbaceous, 5 sp.
Microcalamus Gamble, 1890, =*Neomicrocalamus* P.C. Keng
Miegia Persoon, 1805, = *Arundinaria* Michaux
Mniochloa Chase, 1908, (OLYREAE), herbaceous, 2 sp.
Mustelia Cavanilles ex Steudel, 1840, = *Chusquea* Kunth
Myriocladus Swallen, 1951, woody, 20 sp.

Nastus Jussieu, 1789, (BAMBUSEAE), woody, 23 sp.
Neobambus Y.L. Keng ex P.C. Keng, 1948, = *Sinobambusa* Makino ex Nakai
Neohouzeaua A. Camus, 1922, (MELOCANNEAE?), woody, 5 sp.
Neomicrocalamus P.C. Keng, 1983, (ARUNDINARIEAE: THAMNOCALAMINAE?), woody, 2 sp.
Neosasamorpha Tatewaki, 1940, = *Sasa* Makino & Shibata
Neosinocalamus P.C. Keng, 1983, (DENDROCALAMEAE), woody, 3 sp.
Neurolepis Meisner, 1843, (CHUSQUEEAE), woody, 9 sp.
Nipponobambusa Muroi, 1940, = *Sasaella* Makino
Nipponocalamus Nakai, 1942, = *Pleioblastus* Nakai

Ochlandra Thwaites, 1864, (MELOCANNEAE), woody, 11 sp.
Oligostachyum C.P. Wang & G.H. Ye, 1982, (ARUNDINARIEAE: ARUNDINARIINAE), woody, 1 sp.
Olmeca Soderstrom, 1981, woody, 2 sp.
Olyra Linnaeus, 1759, (OLYREAE), herbaceous, 34 sp.
Omeiocalamus P.C. Keng, 1982[17], (ARUNDINARIEAE: THAMNOCALAMINAE), woody, ? sp.
Oreiostachys Gamble ex Koorders, 1908, = *Nastus* Jussieu
Oreobambos K. Schumann, 1896, (BAMBUSEAE), woody, 1 sp.

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[15] L.C. Chia and H.L. Fung treat *Lingnania* as a subgenus of *Bambusa*.

[16] *Microcalamus* Franchet was treated under the bambusoid grasses by its author and several botanists subsequently (H.E. Baillon, 1893; E.G. Camus, 1913; H. Prat, 1936). Authors of today assign the genus to a distinct subfamily, the Panicoideae, as did F. Butzin in 1970. More details on the genus are needed to reconsider its position within the system.

[17] In *Journ. Bamboo Res.*, 1:9,18, nom. nud. (without description). New, not yet described genus.

Oreocalamus Y.L. Keng, 1940, (SHIBATAEEAE), woody, 2 sp.
Otatea (McClure & E.W. Smith) Calderón & Soderstrom, 1980, woody, 2-3 sp.
Oxytenanthera Munro, 1868, (DENDROCALAMEAE), woody, 16 sp.

Pariana Fusée-Aublet, 1775, (PARIANEAE), herbaceous, 38 sp.
Perrierbambus A. Camus, 1924, woody, 2 sp.
Pharus P. Browne, 1756, (PHAREAE), herbaceous, 7 sp.
Phyllostachys Siebold & Zuccarini, 1843[18], (SHIBATAEEAE), woody, 41 sp.
Piresia Swallen, 1964, (OLYREAE), herbaceous, 4 sp.
Planotia Munro, 1868, = *Neurolepis* Meisner
Platonia Kunth, 1829, = *Neurolepis* Meisner
Pleioblastus Nakai, 1925, (ARUNDINARIEAE: ARUNDINARIINAE), woody, 26 sp.
Pseudocoix A. Camus, 1924, (MELOCANNEAE), woody, 1 sp.
Pseudosasa Makino ex Nakai, 1925, (ARUNDINARIEAE: SASINAE), woody, 13 sp.
Pseudostachyum Munro, 1868, (MELOCANNEAE), woody, 1-2 sp.
Puelia Franchet, 1887, (PUELIEAE), herbaceous, 6 sp.

Qiongzhuea C.J. Hsueh & W.T. Yi, 1980, (SHIBATAEEAE), woody, 6 sp.

Racemobambos Holttum, 1956, (ARUNDINARIEAE?), woody, 15 sp.
Raddia Bertoloni, 1819, (OLYREAE), herbaceous, 2 sp.
Raddiella Swallen, 1948, (OLYREAE), herbaceous, 7 sp.
Rehia Fijten, 1975, (OLYREAE), herbaceous, 1 sp.
Reitzia Swallen, 1956, (OLYREAE), herbaceous, 1 sp.
Rettbergia Raddi, 1823, = *Chusquea* Kunth
Rhipidocladum McClure, 1973, (ARTHROSTYLIDIEAE), woody, 10 sp.

Sasa Makino & Shibata, 1901, (ARUNDINARIEAE: SASINAE), woody, 38 sp.
Sasaella Makino, 1929, (ARUNDINARIEAE: SASINAE), woody, 13 sp.
Sasamorpha Nakai, 1931, (ARUNDINARIEAE: SASINAE), woody, 6 sp.
Schizostachium Griffith, 1851, = *Cephalostachyum* Munro
Schizostachyum Nees von Esenbeck, 1829, (MELOCANNEAE), woody, 45 sp.
Scirpobambos O. Kuntze ex Pilger, 1906, = *Oxytenanthera* Munro
Semiarundinaria Makino ex Nakai, 1925, (SHIBATAEEAE), woody, 11 sp.
Shibataea Makino ex Nakai, 1933, (SHIBATAEEAE), woody, 4 sp.
Sinarundinaria Nakai, 1935, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 13 sp.
Sinoarundinaria Ohwi, 1931, = *Phyllostachys* Siebold & Zuccarini
Sinobambusa Makino ex Nakai, 1925, (SHIBATAEEAE), woody, 17 sp.
Sinocalamus McClure, 1940, (DENDROCALAMEAE), woody, 5 sp.
Stemmatospermum Palisot de Beauvois, 1812, = *Nastus* Jussieu
Strephium Schrader ex Nees von Esenbeck, 1829, (OLYREAE), herbaceous, 2 sp.
Streptia Richard ex Doell, 1880, = *Streptogyna* Palisot de Beauvois
Streptochaeta Schrader ex Nees von Esenbeck, 1829, (STREPTOCHAETEAE), herbaceous, 3 sp.
Streptogyna Palisot de Beauvois, 1812, (STREPTOGYNEAE), herbaceous, 2 sp.

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[18] nomen conservandum (conserved name)

Sucrea Soderstrom, 1981, (OLYREAE), herbaceous, 3 sp.
Swallenochloa McClure, 1973, (CHUSQUEEAE), woody, 9 sp.

Teinostachyum Munro, 1868, (BAMBUSEAE), woody, 3 sp.
Tetragonocalamus Nakai, 1933, (SHIBATAEEAE), woody, 1 sp.
Thamnocalamus Munro, 1868, (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 4-6 sp.
Thyrsostachys Gamble, 1894, (MELOCANNEAE), woody, 2 sp.
Triglossum Fischer, 1812, = *Arundinaria* Michaux

Yadakeya Makino, 1929, = *Pseudosasa* Makino ex Nakai
Yushania P.C. Keng, 1957[19], (ARUNDINARIEAE: THAMNOCALAMINAE), woody, 12 sp.

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[19] Not to be confused with *Yushunia* Kamikoti, 1934, (Lauraceae).

Table 1

Tentative Scheme of Related Groups Among the Bambusoid Grasses
With Approximate Number of Species in Each

Subfamily: **BAMBUSOIDEAE** (1030-1100)

Herbaceous Bamboos (150-160)

Tribe	Genera
STREPTOGYNEAE (2)	*Streptogyna (2)*
ATOMOCHLOEAE (1)	*Anomochloa (1)*
STREPTOCHAETEAE (3)	*Streptochaeta (3)*
PHAREAE (17)	*Leptaspis (10), Pharus (7)*
PARIANEAE (39)	*Eremitis (1), Pariana (38)*
BUERGERSIOCHLOEAE (1)	*Buergersiochloa (1)*
OLYREAE (75)	*Alberella(3), Cryptochloa (7), Diandrolyra (1), Ekmanochloa (2), Froesiochloa (1), Lithachne (4), Maclurolyra (1), Mniochloa (2), Olyra (34), Piresia (4), Raddia (2), Raddiella (7), Rehia (1), Reitzia (1), Strephium (2), Sucrea (3)*
PUELIEAE (12)	*Guaduella (6), Puelia (6)*
Doubtfully Assigned to Bambusoideae*	*Chevalierella (2), Microcalamus (5)*

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* More details are needed on the genus *Chevalierella* A. Camus, and on genera of the subtribe MICROCALAMINAE Butzin (type: *Microcalamus* Franchet), which were placed under the panicoid grasses.

Table 1 Continued

Subfamily: **BAMBUSOIDEAE** (1030-1100)

Woody Bamboos (880-940)

Supertribe: **BAMBUSATAE** (445-475)

Tribe	Genera
MELOCANNEAE (108)	*Cephalostachyum (17), Dinochloa (20), Leptocanna (1), Melocalamus (2), Melocanna (3), Neohouzeaua? (5), Ochlandra (11), Pseudocoix (1), Pseudostachyum (1-2), Schizostachyum (45), Thyrostachys (2)*
BAMBUSEAE (173)	*Bambusa (91),Bonia (1), Dendrocalamopsis (8), Dendrochloa (1), Greslania (4), Guadua (28), Klemachloa (1), Lingnania (12), Nastus (23), Oreobambos (1), Teinostachyum (3)*
DENDROCALAMEAE (65)	*Dendrocalamus (25), Gigantochloa (16), Neosinocalamus (3), Oxytenanthera (16), Sinocalamus (5)*
HICKELIEAE (2)	*Hickelia (2)*
SHIBATAEEAE (111)	*Brachystachyum (1), Chimonobambusa (9), x Hibanobambusa? (1), Indosasa (18), Oreocalamus (2), Phyllostachys (41), Qiongzhuea (6), Semiarundinaria (11), Shibataea (4), Sinobambusa (17), Tetragonocalamus (1)*
Supertribe: **ARUNDINARIATAE** (390-410)	
CHUSQUEEAE (100)	*Chusquea (82), Neurolepis (9), Swallenochloa (9)*
ARTHROSTYLIDIEAE (80)	*Arthrostylidium (21), Aulonemia (25), Merostachys (24), Rhipidocladum (10)*
ARUNDINARIEAE (221) **Subtribe** THAMNOCALAMINAE (67)	*Ampelocalamus (2), Burmabambus (1), Butania? (1), Chimonocalamus? (11), Drepanostachyum (4), Fargesia (14), Himalayacalamus (1), Neomicrocalamus? (2), Omeiocalamus (?), Sinarundinaria (13), Thamnocalamus (4-6), Yushania (12)*
ARUNDINARIINAE (34)	*Acidosasa (4), Arundinaria (1), Bashania (2), Oligostachyum (1), Pleioblastus (26)*
SASINAE (101)	*Ferrocalamus (1), Gelidocalamus (5), Indocalamus (25), Pseudosasa (13), Sasa (38), Sasaella (13), Sasamorpha (6)*
No Subtribe Assigned (20)	*Actinocladum (1), Apoclada (4), Racemobambos? (15)*
No Tribe Assigned (45-55)	*Alvimia (1?), Athroostachys (1), Atractantha (9-10), Colanthelia (7), Decaryochloa (1), Elytrostachys (2), Glaziophyton (1), Hitchcockella (1), Myriocladus (20), Olmeca (2), Otatea (2-3), Perrierbambus (2)*

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McClure, F.A., 1957-1963. Typification of the Genera of the Bambusoideae, (I-V). *Taxon*, 6:199-210; 8:208-209; 9:194; 11:141; 12:127.

Ohrnberger, D. and J. Goerrings, 1983-1986(?). *The Bamboos of the World - A Preliminary Study of the Names and Distribution of the Herbaceous and Woody Bamboos (Bambusoideae Nees v. Esenb.) - Documented in Lists and Maps.* Odenthal near Cologne. (Consisting of more than 100 single parts; up to now 41 parts have been published.)

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D. Ohrnberger* and J. Goerrings**: **The Bamboos of the World - A Preliminary Study of the Names and Distribution of the Herbaceous and Woody Bamboos (Bambusoideae Nees v. Esenb.) - Documented in Lists and Maps**

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GENUS
SASAELLA

Chapter 1: Nomenclature (by D. Ohrnberger)

The genus *Sasaella* was established by Tomitaro Makino in 1929 to separate many Japanese species from *Sasa* and *Arundinaria*. However, many authors from both hemispheres did not recognize *Sasaella*, which still remains a questionable genus. We follow here the nomenclature of the Japanese botanist Sadao Suzuki, who revised the genus in 1976. A few years later in 1979, his fellow countryman Gen Murata revised and retransferred the taxa of *Sasaella* into *Arundinaria*, a treatment which was not widely noticed outside Japan. Murata recognizes as many species as does Suzuki, but their circumscriptions of the species and infraspecific taxa differ, often considerably. This matter reflects the large vegetative variability of the species and results in a confusing nomenclature. To minimize confusion which might arise, I have fully inserted Murata's names as synonyms into the Suzuki nomenclature used here and give brief notes on the main distinction of the varieties within certain species. Descriptions and a key to the taxa, both in English, are included in Suzuki's work (1976, 1978, 1980)[1]. There are also descriptions and a key covering Murata's nomenclature in his works published in 1979, but in Japanese only.

There are 14 species, 10 varieties and 14 forms listed in the present work. Of these taxa, 1 species (*Sasaella reikoana*) and 4 forms are not well known or not validly published. Possibly, the color forms might more reasonably be treated as cultivars. The references cited here are abbreviated; full references will be found in a bibliography to appear in a later number of this journal. The publication year of a given reference is followed by its page numbers. An asterisk, *, indicates that the work contains one or more figures of the taxon concerned, these being helpful for identification in many ways.

The Genus

Sasaella Makino, 1929:15 - Nakai, 1932:75 - Koidzumi, 1941:296 - Muroi, 1941:351 - S. Suzuki, 1976:97 - S. Suzuki, 1978:61 - Haubrich, 1981:25
(tribe ARUNDINARIEAE: subtribe SASINAE - cf. P.C. Keng, 1982:10)
type: *Sasaella ramosa* (Makino) Makino - cf. McClure, 1957:208

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* Wiesenstrasse 5, 8901 Langweid a. L., West Germany.
** St. - Sebastianus - Strasse 2, 5068 Odenthal, West Germany.

[1] S. Suzuki: 1976, in *Journ. Jap. Bot.*, 51: 97-103, 151-158, 220-224, 269-277; 1978, *Index to Japanese Bambusaceae*: 61-62, 234-269; 1980, in *Journ. Jap. Bot.*, 55: 28.

Arundinaria Sect. *Bambusoides* Makino and Shibata in Makino, 1900:20, partly

Nipponobambusa Muroi, 1940:89 - Muroi, 1941:463 - Muroi, 1956:334-336 - cf. McClure, 1960:194 - Muroi in Sugimoto, 1961:463 - cf. P.C. Keng, 1983:150
type: *Nipponobambusa sawadae* (Makino) Muroi - cf. McClure, 1960:194

Sasa Makino and Shibata, 1901:18, partly - Nakai, 1925:149, partly

Arundinaria (not Michaux, 1803): in the sense of Nakai, 1934:567 - Murata in Kitamura and Murata, 1979:37, and Murata, 1979:137

The Species

Sasaella bitchuensis (Makino) Makino ex Koidzumi, 1941:296 - Hatusima, 1976 - S. Suzuki, 1976:221 - S. Suzuki, 1978:250,361,*
Sasa bitchuensis Makino, 1914:31 - Nakai, 1925:143
Arundinaria bitchuensis (Makino) Koidzumi, 1938:252 - Murata in Kitamura and Murata, 1979:383

Jobo-zasa (Japanese)

var. *bitchuensis*:
leaf sheaths: glabrous.

Sasaella bitchuensis var. ***tashirozentaroana*** (Koidzumi) S. Suzuki, 1976:221 - S. Suzuki, 1978:250,361
Arundinaria tashirozentaroana Koidzumi, 1935:163 - Murata in Kitamura and Murata, 1979:383, excluding the synonyms *A. horiyoshitakana, A. iyasakaensis, A. praestantissima, and A. tsutsuiana*
Sasaella tashirozentaroana (Koidzumi) Koidzumi, 1941:298

Arundinaria fallax Nakai, 1936:221
Sasaella fallax (Nakai) Nakai ex Koidzumi, 1941:296

Guzyo-shino (Guji-shino) (Japanese)

var. *tashirozentaroana:*
leaf sheaths: puberulous.

Sasaella bitchuensis var. ***tashirozentaroana*** f. ***praestantissima*** (Koidzumi) S. Suzuki, 1976:222 - S. Suzuki, 1978:250,362
Arundinaria praestantissima Koidzumi, 1937:277 - Murata in Kitamura and Murata, 1979:383, as a synonym under *A. tashirozentaroana*
Sasaella praestantissima (Koidzumi) Koidzumi, 1941:297

Arundinaria horiyoshitakana Koidzumi, 1936:165 - Murata in Kitamura and Murata, 1979:383, as a synonym under *A. tashirozentaroana*
Sasaella horiyoshitakana (Koidzumi) Koidzumi, 1941:296

Arundinaria iyasakaensis Koidzumi, 1939:114 - Murata in Kitamura and Murata, 1979:383, as a synonym under *A. tashirozentaroana*

Sasaella iyasakaensis (Koidzumi) Koidzumi, 1941:297

Arundinaria tashirozentaroana in the sense of Murata in Kitamura and Murata, 1979:383, partly

Ohba-shino (Japanese)

Sasaella caudiceps (Koidzumi) Koidzumi, 1941:296 - S. Suzuki, 1976:224 - S. Suzuki, 1978:364,*

Arundinaria caudiceps Koidzumi, 1937:65 - Murata in Kitamura and Murata, 1979:382, as a synonym under *A. muramatsuana*

Arundinaria tiutaroana Koidzumi, 1938:252 - Murata in Kitamura and Murata, 1979:382, as a synonym under *A. muramatsuana*
Sasaella tiutaroana (Koidzumi) Koidzumi, 1941:298

Arundinaria muramatsuana in the sense of Murata in Kitamura and Murata, 1979:382, partly

Oni-gujo-shino (Japanese)

Sasaella hidaensis (Makino) Makino, 1929:15 - S. Suzuki, 1977:369 - S. Suzuki, 1978:252,362,* - S. Suzuki, 1981:218
Sasa hidaensis Makino, 1926:46
Arundinaria hidaensis (Makino) Nakai, 1934:569 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, excluding the synonym *A. kishinoana*
Sasaella iwatekensis var. *hidaensis* (Makino) S. Suzuki, 1976:271

Arundinaria imadatensis Koidzumi, 1937:66
Sasaella imadatensis (Koidzumi) Koidzumi, 1941:297

Sasa minoensis Koidzumi, 1937:75

Arundinaria yamadoriana Koidzumi, 1939:115
Sasaella yamadoriana (Koidzumi) Koidzumi, 1941:298

Hishu-zasa (Japanese)

var. *hidaensis*:
leaf sheaths: glabrous.

Sasaella hidaensis f. ***kishinoana*** (Koidzumi) S. Suzuki, 1977:369 - S. Suzuki, 1978:252,362

Arundinaria kishinoana Koidzumi, 1935:21 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *A. hidaensis* var. *hidaensis*
Sasaella kishinoana (Koidzumi) Koidzumi, 1941:297.
Sasaella iwatekensis var.*hidaensis* f. *kishinoana* (Koidzumi) S. Suzuki, 1976:272

Arundinaria sikokiana Koidzumi, 1941:254
Sasaella sikokiana Koidzumi, 1941:254, as a synonym

Arundinaria hidaensis in the sense of Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, partly

Iwami-shino (Japanese)

Sasaella hidaensis var. ***muraii*** (Makino and Uchida) S. Suzuki, 1978:254,362,* - S. Suzuki, 1981:219
Sasaella uchidae var. *muraii* Makino and Uchida, 1936:82, as "*uchidai*"
Arundinaria hidaensis var. *muraii* (Makino and Uchida) Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, excluding the synonyms *A. tenuifolia, A. yenaensis, Pleioblastus koriyamensis,* and *Sasaella novoagrariae*

Sasa cochlearispatha Koidzumi, 1934:17

Semiarundianria elegantissima Koidzumi, 1935:21 - Murata, 1979:144, as a synonym under *Arundinaria hebechlamys* var. *hebechlamys*
Arundinaria elegantissima (Koidzumi) Koidzumi, 1937:276
Sasaella elegantissima (Koidzumi) Koidzumi, 1941:296

Arundinaria hebechlamys Nakai, 1934:575 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, excluding the synonyms *A. kariwaensis, A. kogasensis,* and *Sasaella uchidae*
Sasaella hebechlamys Nakai, 1932:75, not validly publ. - Nakai, 1934:575, as a synonym

? *Arundinaria hortensis* Nakai, 1934:575, excluding the synonym *A. variegata* var. *viridis* f. *humilis*
? *Sasaella hortensis* (Nakai) Nakai ex Koidzumi, 1941:296 - Muroi, 1963:46 - Hatusima, 1976 - S. Suzuki, 1976:375, excluding the synonym *Arundinaria variegata* var. *viridis* f. *humilis* - Muroi and H. Okamura, 1977:144,59*

Arundinaria hosidaikitiana Koidzumi, 1935:20 - S. Suzuki, 1978:362, as "*hoshidaikitiana*", as a synonym

Sasaella iwatekensis Makino and Uchida in Makino, 1929:15 - Makino and Nemoto, 1931:1400 - Nakai, 1932:75 - S. Suzuki, 1976:269 - Hatusima, 1976
Sasa iwatekensis Makino and Uchida in Makino, 1929:15, as a synonym
Arundinaria iwatekensis (Makino and Uchida) Nakai, 1934:569
Sasaella hidaensis var. *iwatekensis* (Makino and Uchida) S. Suzuki, 1977:369

Arundinaria kimurai Nakai, 1936:221
Sasaella kimurai (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria longipes Nakai, 1934:746 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:139, as a synonym under *A. hashimotoi* f. *minaguchii*
Sasaella longipes (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria praeumbrans Koidzumi, 1941:61
Sasaella praeumbrans Koidzumi, 1941:61, as a synonym

Arundinaria retropila Nakai, 1934:747
Sasaella retropila (Nakai) Nakai ex Koidzumi, 1941:297

Sasa siroyamensis Makino ex Koidzumi, 1934:152 - Makino ex Koidzumi, 1935:19, as a synonym

Arundinaria siroyamensis (Makino ex Koidzumi) Makino ex Koidzumi, 1935:19
Sasaella siroyamensis Makino ex Koidzumi, 1935:19, as a synonym

Arundinaria hosidaikitiana var. *spanolongitricha* Koidzumi, 1940:76

Arundinaria teijiroana Koidzumi, 1935:21
Sasaella teijiroana (Koidzumi) Koidzumi, 1941:298

Yàbu-zasa, Miyagi-zasa (Japanese)

var. *muraii*:
leaf sheaths: puberulous.

Sasaella hidaensis var. **muraii** f. **yenaensis** (Koidzumi) S. Suzuki, 1977:369 - S. Suzuki 1978:254,363
Arundinaria yenaensis Koidzumi, 1937:216 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *A. hidaensis* var. *muraii*
Sasaella yenaensis (Koidzumi) Koidzumi, 1941:298
Sasaella iwatekensis f. *yenaensis* (Koidzumi) S. Suzuki, 1976:271
Sasaella hidaensis var. *iwatekensis* f. *yenaensis* (Koidzumi) S. Suzuki, 1977:369

Sasaella novoagrariae Koidzumi, 1943:115 - Murata, 1979:143, as a synonym under *Arundinaria hidaensis* var. *muraii*
Arundinaria novoagrariae Koidzumi, 1943:115, as a synonym

Arundinaria tenuifolia Koidzumi, 1938:252 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *A. hidaensis* var. *muraii*
Sasaella tenuifolia (Koidzumi) Koidzumi, 1941:298

Arundinaria tsutsuiana Koidzumi, 1938:253 - Murata in Kitamura and Murata, 1979:383, as a synonym under *A. tashirozentaroana*
Sasaella tsutsuiana (Koidzumi) Koidzumi, 1941:298

Arundinaria hidaensis var. *muraii* in the sense of Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, partly

Yena-shino (Japanese)

Sasaella hisauchii (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1400 - Nakai, 1932:75 - S. Suzuki, 1976:223 - S. Suzuki, 1978:258,363,*
Pseudosasa hisauchii Makino, 1925:2 - Makino, 1926:22, as a synonym - Makino, 1928:16
Sasa hisauchii (Makino) Makino, 1926:22
Arundinaria hisauchii (Makino) Nakai, 1934:569, not Makino in Tsuboi, 1916
Nipponobambusa hisauchii (Makino) Muroi in Sugimoto, 1961:453

Arundinaria hakonensis Nakai, 1934:749, based on *Pseudosasa hisauchii* - Honda, 1939:389 - Murata in Kitamura and Murata, 1979:383
Sasaella hakonensis (Nakai) Nakai ex Koidzumi, 1941:296

Arundinaria yamakitensis Makino, 1926:4
Pleioblastus yamakitensis (Makino) Makino, 1926:11 - Nakai, 1933:237

Nipponobambusa yamakitensis (Makino) Muroi, 1942:212 - Muroi in Sugimoto, 1961:464
Sasaella yamakitensis (Makino) Muroi ex Hatusima, 1976

Hime-suzu-dake, Kitayama-zasa (Japanese)

Sasaella ikegamii (Nakai) S. Suzuki, 1976:223 - Nakai, 1934:576, as a synonym - Hatusima, 1976 - S. Suzuki, 1978:256,363,*
Arundinaria ikegamii Nakai, 1934:576 - Murata in Kitamura and Murata, 1979:383 - Murata, 1979:141
Nipponobambusa ikegamii (Nakai) Sasamura, 1960:56, not validly publ.

Arundinaria tajimana Koidzumi, 1935:163
Sasaella tajimana (Koidzumi) Koidzumi, 1941:297

Kariha-shino (Kariwa-shino), Kariha-zasa (Kariwa-zasa), Tajima-shino (Japanese)

Sasaella kogasensis (Nakai) Nakai ex Koidzumi, 1941:297 - S. Suzuki, 1976:274 - S. Suzuki, 1978:266,364,*
Arundinaria kogasensis Nakai, Dec. 1934:745 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *A. hebechlamys* var. *hebechlamys*

Arundinaria kariwaensis Koidzumi, 1937:276 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *A. hebechlamys* var. *hebechlamys*
Sasaella kariwaensis (Koidzumi) Koidzumi, 1941:297

Arundinaria hebechlamys in the sense of Murata in Kitamura and Murata, 1979:382 and Murata, 1979:143, partly

Kogashi-azuma-zasa (Kogashi-adzuma-zasa) (Japanese)

var. *kogasensis*:
leaf sheaths: pubescent

Sasaella kogasensis f. ***uchidae*** (Makino ex Uchida) S. Suzuki, 1976:275, as "*uchidai*" - S. Suzuki, 1978:364
Sasaella uchidae Makino ex Uchida, 1936:82, as "*uchidae*" - Makino ex Uchida, 1931:177, not validly publ. - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, as a synonym under *Arundinaria hebechlamys* var. *hebechlamys*

Arundinaria hebechlamys in the sense of Murata in Kitamura and Murata, 1979:382, and Murata, 1979:143, partly

Kemuku-zasa (Japanese)

Sasaella kogasensis var. ***yoshinoi*** (Koidzumi) S. Suzuki, 1976:275 - S. Suzuki, 1978:266,364
Arundinaria yoshinoi Koidzumi, 1935:174

Sasaella yoshinoi (Koidzumi) Koidzumi, 1941:298
Arundinaria hebechlamys var. *yoshinoi* (Koidzumi) Murata in Kitamura and Murata, 1979:382, and Murata, 1979:144, excluding the synonym *A. muroiana*

Arundinaria kesenensis Koidzumi, 1936:198
Sasaella kesenensis (Koidzumi) Koidzumi, 1941:297 - S. Suzuki, 1978:364, as "*kesensis*", as a synonym

Arima-shino, Kesen-shino (Japanese)

var. *yoshinoi:*
leaf sheaths: glabrous.

Sasaella kogasensis var. ***gracillima*** S. Suzuki, 1980:28 - S. Suzuki, 1978:268,364,*, not validly publ.

Hime-shino (Japanese)

var. *gracillima*:
leaf sheaths: pubescent; culms and leaves: smaller in size.

Sasaella leucorhoda (Koidzumi) Koidzumi, 1941:297 - Muroi, 1941:355 - S. Suzuki, 1978:260,363,* - S. Suzuki, 1981:218
Pleioblastus leucorhodus Koidzumi, May 1934:15
Arundinaria leucorhoda (Koidzumi) Koidzumi, Oct. 1934:151 - Nakai, 1935:820 - Murata in Kitamura and Murata, 1979:381 - Murata, 1979:142
Sasaella atamiana f. *leucorhoda* (Koidzumi) S. Suzuki, 1978:363, as a synonym

Arundinaria koyana Nakai, 1935:807 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:142, as a synonym under *A. leucorhoda* f. *atamiana*
Sasaella koyana (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria shinanoana Koidzumi, 1937:67 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:142, as a synonym under *A. leucorhoda* f. *atamiana*
Sasaella shinanoana (Koidzumi) Koidzumi, 1941:297

Arundinaria leucorhoda f. *atamiana* in the sense of Murata in Kitamura and Murata, 1979:381, and Murata, 1979:142, partly

Tango-shino, Tango-shinochiku (Japanese)

var. *leucorhoda*:
leaf sheaths: glabrous or sparsely pilose on the lowermost sheaths.

Sasaella leucorhoda f. ***atamiana*** (Nakai) S. Suzuki, 1981:218 - S. Suzuki, 1978:260,363, not validly publ.
Arundinaria atamiana Nakai, Sept. 1934:573
Sasaella atamiana (Nakai) S. Suzuki, 1976:272, excluding the synonyms *Arundinaria*

koyana, and *A. shinanoana* - Makino ex Nakai, 1932:75, not validly publ. - Nakai, 1934:573, as a synonym
Arundinaria leucorhoda f. *atamiana* (Nakai) Murata in Kitamura and Murata, 1979:381, and Murata, 1979:142, excluding the synonyms *A. koyana*, and *A. shinanoana*

Atami-shino, Atami-nezasa (Japanese)

Sasaella leucorhoda var. **kanayamensis** (Nakai) S. Suzuki, 1981:218 - S. Suzuki, 1978:262,363,*, not validly publ.
Arundinaria kanayamensis Nakai, Dec. 1934:743 - Nakai, 1935:819
Sasaella kanayamensis (Nakai) Nakai ex Koidzumi, 1941:297
Sasaella atamiana var. *kanayamensis* (Nakai) S. Suzuki, 1976:273
Arundinaria leucorhoda var. *kanayamensis* (Nakai) Murata, 1979:142

Arundinaria hukudana Koidzumi, 1936:42
Sasaella hukudana (Koidzumi) Koidzumi, 1941:296

? *Sasa mollissima* Koidzumi, 1935:171
? *Arundinaria mollissima* (Koidzumi) Koidzumi, 1937:72 - Koidzumi, 1935:171, as a synonym

Arundinaria muroiana Koidzumi, 1937:67 - Murata in Kitamura and Murata, 1979:382, and Murata, 1979:144, as a synonym under *A. hebechlamys* var. *yoshinoi*
Sasaella muroiana (Koidzumi) Koidzumi, 1941:297 - Hatusima, 1976

Ke-sueko-zasa (Japanese)

var. *kanayamensis*:
leaf sheaths: pilose throughout.

Sasaella masamuneana (Makino) Hatusima and Muroi in Sugimoto, 1961:475 - Muroi, 1963:6,* - Hatusima, 1976 - S. Suzuki, 1976:99 - Muroi and H. Okamura, 1977:144,60* - S. Suzuki, 1978:234,358,*
Pleioblastus masamuneanus Makino, 1929:5 - Makino and Nemoto, 1931:1378 - Nakai, 1933:236 - Nakai, 1934:280,*
Nipponocalamus masamuneanus (Makino) Nakai, 1942:359
Arundinaria masamuneana (Makino) Murata in Kitamura and Murata, 1979:380, and Murata, 1979:138, excluding the synonym *Pleioblastus yakushimensis* - Makino, 1929:5, as a synonym - Masamune, 1956:255, not validly publ.?

Sasa arakii Makino ex Koidzumi, 1934:17
Arundinaria arakii (Makino ex Koidzumi) Koidzumi, 1935:161
Sasaella arakii (Makino ex Koidzumi) Makino ex Koidzumi, 1941:296

Arundinaria arvensis Koidzumi, 1937:65
Sasaella arvensis (Koidzumi) Koidzumi, 1941:296

Arundinaria atropurpurea Nakai, 1934:574
Sasaella atropurpurea Makino and Nakai, 1932:76, not validly publ. - Nakai, 1934:574, as a synonym

Sasaella auriculata Koidzumi, 1943:165
Arundinaria auriculata Koidzumi, 1943:165, as a synonym

Arundinaria babataneyosiana Koidzumi, 1940:75
Sasaella babataneyosiana (Koidzumi) Koidzumi, 1941:296, as "*babataneyoshiana*"

Arundinaria epitricha Nakai, 1934:574
Sasaella epitricha Nakai, 1932:75, not validly publ. - Nakai, 1934:574, as a synonym

Arundinaria glabra Nakai, 1934:743
Nipponobambusa glabra (Nakai) Muroi, 1940:90
Sasaella glabra (Nakai) Nakai ex Koidzumi, 1941:296

Sasaella inuii Makino ex Koidzumi, 1934:68 - Koidzumi, 1935:161, as a synonym - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:139, as a synonym under *Arundinaria hashimotoi* f. *hashimotoi*
Arundinaria inuii (Makino ex Koidzumi) Koidzumi, 1934:151

Arundinaria kiboensis Nakai, 1934:577
Sasaella kiboensis (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria koshiensis Koidzumi, 1937:277 - Murata in Kitamura and Murata, 1979:380, as a synonym under *A. sasakiana*
Sasaella koshiensis (Koidzumi) Koidzumi, 1941:297

Arundinaria minomarsa var. *lasioclada* Koidzumi, 1939:114

Arundinaria magohukuana Koidzumi, 1938:113 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:139, as a synonym under *A. hashimotoi* f. *hashimotoi*
Sasaella magohukuana (Koidzumi) Koidzumi, 1941:297

Sasaella minaguchii Makino and Koidzumi in Koidzumi, 1934:16
Arundinaria minaguchii (Makino and Koidzumi) Makino ex Koidzumi, 1935:20
Arundinaria hashimotoi f. *minaguchii* (Makino and Koidzumi ex Koidzumi) Murata in Kitamura and Murata, 1979:381, and Murata, 1979:139, excluding the synonyms *A. longipes* and *A. phalerata*

Arundinaria minomarsa Koidzumi, 1937:217
Sasaella minomarsa (Koidzumi) Koidzumi, 1941:297

Arundinaria ogamiensis Koidzumi, 1935:82 - Murata in Kitamura and Murata, 1979:380, as a synonym under *A. sasakiana*
Sasaella ogamiensis (Koidzumi) Koidzumi, 1941:297

Arundinaria glabra var. *pilosa* Koidzumi, 1937:276

Arundinaria rhyncantha Koidzumi, 1935:91,161 - Murata in Kitamura and Murata, 1979:380, as a synonym under *A. sasakiana* - different spelling "*rhynchantha*", "*rhyncanta*", "*rhycantha*"
Sasaella rhyncantha (Koidzumi) Koidzumi, 1941:297

Pleioblastus tanegasimensis Makino and Koidzumi in Koidzumi, 1934:15 - Murata, 1979:138, as "*tanegashimensis*", as a synonym
Nipponocalamus tanegasimensis (Makino and Koidzumi) Nakai, 1942:366
Arundinaria tanegasimensis (Makino and Koidzumi) Masamune, 1956:256

Sasa tangoensis Koidzumi, 1934:21 - Murata in Kitamura and Murata, 1979:380, as a

synonym under *Arundinaria sasakiana*
Sasaella tangoensis (Koidzumi) Koidzumi, 1934:68 - Koidzumi, 1941:297
Arundinaria tangoensis (Koidzumi) Koidzumi, 1935:20

Arundinaria zifukuensis Nakai, 1953:27
Nipponocalamus zifukuensis (Nakai) Honda, 1957:382

Arundinaria hashimotoi in the sense of Murata in Kitamura and Murata, 1979:381, and Murata, 1979:138, partly
Arundinària sasakiana in the sense of Murata in Kitamura and Murata, 1979:380, partly

Kurio-zasa, Genkei-chiku (Japanese)

var. *masamuneana*:
leaf sheaths: glabrous

Sasaella masamuneana f. ***albostriata*** not validly publ.
Sasaella glabra f. *albostriata* Muroi, 19..? - Muroi and H. Okamura, 1977:143,59*, with Japanese description - Haubrich in Newsletter Amer. Bamboo. Soc. IV(3) May 1983, as "*glabra albo-striata*", not validly publ.

leaves: with stripes in white or cream.

Sasaella masamuneana f. ***aureostriata*** not validly publ.
Sasaella glabra f. *aureostriata* Muroi, 19..? - Muroi and H. Okamura, 1977:143,59*, with Japanese description

leaves: with stripes in yellow.

Sasaella masamuneana f. ***hashimotoi*** (Makino) S. Suzuki, 1976:101 - S. Suzuki, 1978:234,358
Pleioblastus hashimotoi Makino, 1933:45
Arundinaria hashimotoi (Makino) Koidzumi, 1935:20 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:138, excluding the synonyms *A. magohukuana*, *A. trichophila*, and *Sasaella inuii*
Sasaella hashimotoi (Makino) Makino ex Koidzumi, 1941:296 - Muroi, 1941:138

Arundinaria akiensis Nakai, 1934:742
Sasaella akiensis (Nakai) Nakai ex Koidzumi, 1941:296

Arundinaria cappattama Koidzumi, 1937:216
Sasaella cappattama (Koidzumi) Koidzumi, 1941:296

Arundinaria elongatifolia Koidzumi, 1941:260, based on *A. longifolia* Koidzumi, not Fournier
Sasaella elongatifolia Koidzumi, 1941:260, as a synonym

Arundinaria kitanoensis Nakai, 1935:370
Sasaella kitanoensis (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria longifolia Koidzumi, 1937:216, not Fournier, 1886
Sasaella longifolia Koidzumi, 1941:260, as a synonym

Sasaella nagaha Muroi, 1941:355 - Murata, 1979:139, as a synonym under *Arundinaria hashimotoi* f. *hashimotoi*

Arundinaria phalerata Koidzumi, 1935:16 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:139, as a synonym under *A. hashimotoi* f. *minaguchii*
Sasaella phalerata Koidzumi, 1935:16, as a synonym

Arundinaria sakaigunensis Koidzumi, 1941:254
Sasaella sakaigunensis Koidzumi, 1941:254, as a synonym

Arundinaria santanensis Koidzumi, 1935:162
Sasaella santanensis (Koidzumi) Koidzumi, 1941:297

Pleioblastus yakusimensis Nakai, 1934:199,* - S. Suzuki, 1976:102, as "*yakushimensis*", as a synonym - Murata in Kitamura and Murata, 1979:380, and Murata, 1979:138, as a synonym under *Arundinaria masamuneana*
Nipponocalamus yakusimensis (Nakai) Nakai, 1942:368

Ohsaka-zasa (Osaka-zasa) (Japanese)

Sasaella masamuneana var. ***amoena*** (Nakai) S. Suzuki, 1976:103 - S. Suzuki, 1978:234,359
Arundinaria amoena Nakai, 1934:741
Sasaella amoena (Nakai) Nakai ex Koidzumi, 1941:296

Arundinaria macrostachya Koidzumi, 1936:127, not Nees von Esenbeck, 1834
Sasaella macrostachya Koidzumi, 1941:260, as a synonym

Arundinaria megastachys Koidzumi, 1941:260, based on *A. macrostachya* Koidzumi, not Nees von Esenbeck - Murata in Kitamura and Murata, 1979:380, as a synonym under *A. sasakiana*
Sasaella megastachys Koidzumi, 1941:260, as a synonym

Yomogida-kochiku (Japanese)

var. *amoena*:
leaf sheaths: puberulous.

Sasaella masamuneana var. ***amoena*** f. ***muramatsuana*** (Koidzumi) S. Suzuki, 1976:103 - S. Suzuki, 1978:234,359
Arundinaria muramatsuana Koidzumi, 1935:82 - Murata in Kitamura and Murata, 1979:382, excluding the synonyms *A. caudiceps* and *A. tiutaroana*
Sasaella muramatsuana (Koidzumi) Koidzumi, 1941:297

Yuri-shino (Japanese)

Sasaella ramosa (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1401 - Nakai, 1932:76 - Muroi, 1963:6,* - Maekawa, 1969:705,* - Hatusima, 1976 - S. Suzuki, 1976:152 - Muroi and H. Okamura, 1977:144,60* - S. Suzuki, 1978:240,359,* - McClintock, 1983:191-195,*

Arundinaria ramosa Makino, 1900:22 - Nakai, 1934:570 - Murata in Kitamura and Murata, 1979:379,*, and Murata, 1979:137, excluding the synonyms *A. otayana*, and *A. iwabuchii*

Bambusa ramosa Makino in S. Honda, 1900:37, not validly publ. - Makino, 1900:62, not validly publ. - Makino, 1900:23,30, as a synonym

Sasa ramosa (Makino) Makino and Shibata, 1901:24 - Matsumura, 1905:97 - E. G. Camus, 1913:20 - Tsuboi, 1916:53,* - Nakai, 1925:150 - Makino, 1928:8 - Ohwi, 1965:139 - Lawson, 1968:163

Pleioblastus viridistriatus var. *agrestis* Makino, 1926:11, as "*viridi-striatus*"
Arundinaria viridistriata var. *agrestis* Makino, 1926:12, as a synonym
Sasa agrestis (Makino) Makino, 1928:20
Sasaella agrestis (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1400 - Nakai, 1932:75
Arundinaria agrestis (Makino) Nakai, 1934:567

Arundinaria chikatsuafumiana Koidzumi, 1935:161
Sasaella chikatsuafumiana (Koidzumi) Koidzumi, 1941:296

Arundinaria confusa Nakai, 1939:521
Sasaella confusa (Nakai) Honda, 1957:386

Arundinaria decipiens Nakai, 1939:521
Sasaella decipiens (Nakai) Honda, 1957:386

Arundinaria dimorpha Hackel ex Nakai, 1935:805
Sasaella dimorpha (Hackel ex Nakai) Nakai ex Koidzumi, 1941:296

Arundinaria ramosa var. *distichophylla* Koidzumi, 1940:77
Arundinaria distichophylla (Koidzumi) Koidzumi, 1941:209
Sasaella distichophylla Koidzumi, 1941:209, as a synonym

Arundinaria exsaniosa Koidzumi, 1935:81
Sasaella exsaniosa (Koidzumi) Koidzumi, 1941:296

Sasa hannoensis Makino, 1926:16
Sasaella hannoensis (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1400

Arundinaria incantans Koidzumi, 1934:152
Sasaella incantans (Koidzumi) Koidzumi, 1941:297

Arundinaria kisoensis Koidzumi, 1939:192
Sasaella kisoensis Koidzumi, 1939:192, as a synonym

Sasa komiyamana Makino and Hisauchi in Makino, 1928:21
Sasaella komiyamana (Makino and Hisauchi) Makino, 1929:15 - Makino and Nemoto, 1931:1400 - Nakai, 1932:75
Arundinaria komiyamana (Makino and Hisauchi) Nakai, 1934:569
Nipponobambusa komiyamana (Makino and Hisauchi) Muroi, 1957:74, not validly publ.

Arundinaria kunimiana Koidzumi, 1941:210
Sasaella kunimiana Koidzumi, 1941:210, as a synonym

Sasa matsushimensis Makino, 1928:16
Sasaella matsushimensis (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1401
Arundinaria matsushimensis (Makino) Makino ex Koidzumi, 1941:295

Arundinaria musashiensis Nakai, 1934:578 - Murata in Kitamura and Murata, 1979:379, as "*musasiensis*", as a synonym
Sasaella musashiensis Makino and Nakai ex Nakai, 1932:75, not validly publ. - Nakai, 1934:578, as a synonym

Arundinaria nikkoensis Nakai, 1934:578
Sasaella nikkoensis Makino and Nakai ex Nakai, 1932:76, not validly publ. - Nakai, 1934:578, as a synonym
Nipponobambusa nikkoensis (Nakai) Muroi, 1957?, not validly publ.? - Ueda, 1960:7, not validly publ.

Sasa okadana Makino, 1928:6
Sasaella okadana (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1401 - Nakai, 1932:76
Arundinaria okadana (Makino) Nakai, 1934:570

Sasa saitoana Koidzumi, 1935:89

Arundinaria sakaii Nakai, 1936:222
Sasaella sakaii (Nakai) Nakai ex Koidzumi, 1941:297

Sasa sasaelloides Makino and Uchida, 1936:82
Arundinaria sasaelloides (Makino and Uchida) Muroi, 1937 - Makino ex Koidzumi, 1941:297, as a synonym
Sasaella sasaelloides (Makino and Uchida) Makino ex Koidzumi, 1941:297

Arundinaria sugimotoi Nakai, 1934:747
Sasaella sugimotoi (Nakai) Nakai ex Koidzumi, 1941:297

Arundinaria toyomurensis Nakai, 1934:748
Sasaella toyomurensis (Nakai) Nakai ex Koidzumi, 1941:298

Arundinaria tsukubensis Koidzumi, 1940:77
Sasaella tsukubensis (Koidzumi) Koidzumi, 1941:298

Arundinaria vagans Gamble, 1915:350 - Nakai, 1933:236 - Lawson, 1968:114
Sasaella viridistriata var. *vagans* (Gamble) Nakai, 1932:76 - Nakai, 1934:568,749, as a synonym
Arundinaria viridistriata var. *vagans* (Gamble) Nakai, 1934:749 - Rehder, 1949:637 - Stover, 1983:29
Pleioblastus viridistriatus f. *vagans* (Gamble) Muroi in Sugimoto, 1961:71 - Hatusima, 1976:613 - S. Suzuki, 1978:330,373
Pleioblastus viridistriatus (var.) *vagans* (Gamble) Makino ex Lawson, 1968:114, as a synonym
Pleioblastus kongosanensis cv. *vagans* (Martin and Demoly, 1979:17)

Arundinaria ramosa var. *viridiflora* Nakai, 1934:571

Arundinaria yonoskei Nakai, 1935:808
Sasaella yonoskei (Nakai) Nakai ex Koidzumi, 1941:298 - as "*yohnosukei*"

Arundinaria pygmaea (not Kurz ex Teijsmann and Binnendijk, 1866): in the sense of

Mitford, 1896:49-50 - Nicholson, 1902:783 - ? Houzeau de Lehaie, 1908
Bambusa pygmaea (not Miquel, 1866): in the sense of Mitford, 1896:112-113 - Bean, 1914:218

Arundinaria viridistriata (not Makino ex Nakai, 1934): in the sense of Crouzet, 1981:49

Azuma-zasa (Adzuma-zasa) (Japanese)

var. *ramosa*:
leaf sheaths: glabrous

Sasaella ramosa f. ***tomikusensis*** (Nakai) S. Suzuki, 1976:155 - S. Suzuki, 1978:240,360
Arundinaria tomikusensis Nakai, 1934:744
Sasaella tomikusensis (Nakai) Nakai ex Koidzumi, 1941:298
Arundinaria ramosa f. *tomikusensis* (Nakai) Murata in Kitamura and Murata, 1979:379, and Murata, 1979:137

Arundinaria nakashimana Koidzumi, 1937:67
Sasaella nakashimana (Koidzumi) Koidzumi, 1941:297

Arundinaria otayana Koidzumi, 1935:162 - Murata in Kitamura and Murata, 1979:379, and Murata, 1979:137, as a synonym under *A. ramosa* var. *ramosa* f. *ramosa*
Sasaella otayana (Koidzumi) Koidzumi, 1941:297

Arundinaria pubescens Nakai, 1934:746, not Hackel, 1903

Arundinaria tsurumatiana Koidzumi, 1939:114
Sasaella tsurumatiana (Koidzumi) Koidzumi, 1941:298

Tomikusa-zasa, Asahi-shino, Handa-shino (Japanese)

Sasaella ramosa f. ***flavostriata*** Uchida, 19..? - Hatusima, 1976, as "*flavo-striata*" with Japanese description

leaves: with stripes in yellow.

Sasaella ramosa f. ***albostriata*** Muroi, 19..? - Muroi and H. Okamura, 1977:145,61*, with Japanese description

leaves: with stripes in white (or cream?).

Sasaella ramosa var. ***latifolia*** (Nakai) S. Suzuki, 1976:156, excluding the synonyms *Arundinaria nambuensis* and *A. yessaensis* - S. Suzuki, 1978:240,361
Arundinaria ramosa var. *latifolia* Nakai, 1934:571

Sasaella benten Makino and Nakai ex Nakai, 1932:75, not validly publ. - Nakai, 1934:571 as a synonym 1934, as a synonym

Arundinaria velutina Nakai, 1934:580

Sasaella velutina Makino and Nakai ex Nakai, 1934:580, as a synonym - Hatusima, 1976, not validly publ.

Ohba-azuma-zasa (Oba-adzuma-zasa), Benten-zasa (Japanese)

var. *latifolia*:
leaf sheaths: puberulous.

Sasaella ramosa var. ***latifolia*** f. ***trichophila*** (Koidzumi) S. Suzuki, 1976:157 - S. Suzuki, 1978:240,361
Arundinaria trichophila Koidzumi, 1935:83 - Murata in Kitamura and Murata, 1979:381, as a synonym under *A. hashimotoi* f. *hashimotoi*
Sasaella trichophila (Koidzumi) Koidzumi, 1941:298

Oni-urajiro-shino (Japanese)

Sasaella ramosa var. ***suwekoana*** (Makino) S. Suzuki, 1976:157 - S. Suzuki, 1978:242,361,*
Sasa suwekoana Makino, 1928:7
Sasaella suwekoana (Makino) Makino, 1929:15 - Makino and Nemoto, 1931:1401 - Nakai, 1932:76 - Muroi, 1963:46 - Muroi and H. Okamura, 1977:146,64*
Arundinaria suwekoana (Makino) Nakai, 1934:573
Arundinaria ramosa var. *suwekoana* (Makino) Murata in Kitamura and Murata, 1979:380, and Murata, 1979:138

Sueko-zasa (Suweko-zasa) (Japanese)

var. *suwekoana*:
leaf sheaths: glabrous; leaf blades: longitudinally wrinkled.

Sasaella reikoana (Muroi) Muroi, 19..? - Muroi and H. Okamura, 1977:145,61*, not validly publ.
Nipponobambusa reikoana Muroi, 1940:90 - Muroi, 1963:19

Reiko-shino (Japanese), cf. Ueda, 1960:7

A doubtful species, neither mentioned by S. Suzuki nor Murata.

Sasaella sadoensis (Makino ex Koidzumi) S. Suzuki, 1976:151 - Makino ex Nakai, 1934:572, as a synonym - Makino ex Koidzumi, 1935:13, as a synonym - S. Suzuki, 1978:238,359,*
Pleioblastus sadoensis Makino ex Koidzumi, June 1934:68
Arundinaria ramosa var. *sadoensis* (Makino ex Koidzumi) Nakai, Sept. 1934:572 - Makino and Nemoto, 1936:859

Arundinaria sadoensis (Makino ex Koidzumi) Makino ex Koidzumi, 1935:19 - Makino and Nemoto, 1936:860 - Murata in Kitamura and Murata, 1979:381 - Murata, 1979:140
Nipponobambusa sadoensis (Makino ex Koidzumi) Muroi, 1940:89
Nipponocalamus sadoensis (Makino ex Koidzumi) Nakai, 1942:363

Sado-zasa, Sado-nezasa (Japanese)

Sasaella sasakiana Makino and Uchida in Makino, 1929:15 - Makino and Nemoto, 1931:1401 - Nakai, 1932:76 - Koidzumi, 1943:164, partly - S. Suzuki, 1976:151 - Hatusima, 1976 - Muroi and H. Okamura, 1977:145,62* - S. Suzuki, 1978:236,359,*
Arundinaria sasakiana (Makino and Uchida) Nakai, 1934:572 - Murata in Kitamura and Murata, 1979:380, excluding the synonyms
Nipponobambusa sasakiana (Makino and Uchida) Muroi, 1956:331; cf. Chase, 1962:439 - Muroi in Sugimoto, 1961:464 - Muroi, 1963:20
Sasa sasakiana Crouzet, 1981:87, not validly publ.

Toge-dake, Toge-zasa (Japanese)

Sasaella sawadae (Makino) Makino ex Koidzumi, 1941:297 as "*sawadai*" - Hatusima, 1976 - S. Suzuki, 1976:157 - Muroi and H. Okamura, 1977:146,62* - S. Suzuki, 1978:244,361,*
Pleioblastus sawadae Makino, 1927:3, as "*sawadai*" - Makino and Nemoto, 1931:1379 - Makino ex Nakai, 1932:70
Arundinaria sawadae (Makino) Nakai, 1934:573, as "*sawadai*" - Makino, 1927:3, as a synonym - Murata in Kitamura and Murata, 1979:380
Nipponobambusa sawadae (Makino) Muroi, 1940:89, as "*sawadai*"; cf. McClure, 1960:194 - Muroi, 1963:6,20,*
Sasaella marunoi Hatusima, 1972:36 - Hatusima, 1976, as "*marunoana*"

Hakone-medake, Hakone-shino (Japanese)

var. *sawadae*:
leaf sheaths: glabrous.

Sasaella sawadae var. ***aobayamana*** S. Suzuki, 1978:61 as "*sawadai*" - S. Suzuki, 1978:246,361,*, as "*aobayamensis*"

Aobayama-zasa (Japanese)

var. *aobayamana*:
leaf sheaths: puberulous.

Sasaella shiobarensis (Nakai) Nakai ex Koidzumi, 1941:297 - Muroi, 1941 - S. Suzuki, 1976:220 - S. Suzuki, 1978:248,361,* *Arundinaria shiobarensis* Nakai, 1934:579

Arundinaria aikawensis Nakai, 1935:369
Sasaella aikawensis (Nakai) Nakai ex Koidzumi, 1941:296

Arundinaria sadoensis var. *infrapilosa* Koidzumi, 1940:77 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:140, excluding the synonym *A. yessaensis*
Nipponobambusa sadoensis var. *infrapilosa* (Koidzumi) Muŕoi, 1940

Arundinaria iwabuchii Koidzumi, 1937:66 - Murata in Kitamura and Murata, 1979:379, and Murata, 1979:137, as a synonym under *A. ramosa* var. *ramosa* f. *ramosa*
Sasaella iwabuchii Makino ex Koidzumi, 1937:66, as a synonym

Arundinaria nikkomontana Koidzumi, 1940:77
Sasaella nikkomontana (Koidzumi) Koidzumi, 1941:297

Arundinaria sedenicola Koidzumi, 1940:229
Sasaella sedenicola (Koidzumi) Koidzumi, 1941:297

Shiobara-zasa (Japanese)

var. *shiobarensis*:
leaf sheaths: pilose with long hairs.

Sasaella shiobarensis f. ***mitinokuensis*** (Koidzumi) S. Suzuki, 1976:221 - S. Suzuki, 1978:248,361
Arundinaria mitinokuensis Koidzumi, 1940:76
Sasaella mitinokuensis (Koidzumi) Koidzumi, 1941:297
Arundinaria sadoensis var. *infrapilosa* f. *mitinokuensis* (Koidzumi) Murata, 1979:141

Juan-shino (Japanese)

Sasaella shiobarensis var. ***yessaensis*** (Koidzumi) S. Suzuki, 1978:248,361
Arundinaria yessaensis Koidzumi, 1937:278 - Murata in Kitamura and Murata, 1979:381, and Murata, 1979:140, as a synonym under *A. sadoensis* var. *infrapilosa*
Sasaella yessaensis (Koidzumi) Koidzumi, 1941:298

Arundinaria nambuensis Koidzumi, 1941:210
Sasaella nambuensis Koidzumi, 1941:210, as a synonym

Arundinaria sadoensis var. *infrapilosa* in the sense of Murata in Kitamura and Murata, 1979:381, and Murata, 1979:140, partly

Yessa-shino (Japanese)

var. *yessaensis*:
leaf sheaths: puberulous with minute hairs as well as long ones.

Chapter 2: Distribution (by J. Goerrings and D. Ohrnberger)

Sasaella is endemic to Japan. The genus has a latitudinal range from about 30° to 41° North with a distributive center on Honshu. Species of *Sasaella* are neither reported from the northernmost parts of Japan (Hokkaido and the Kuriles) nor from the southernmost parts (the Ryukyu Islands).

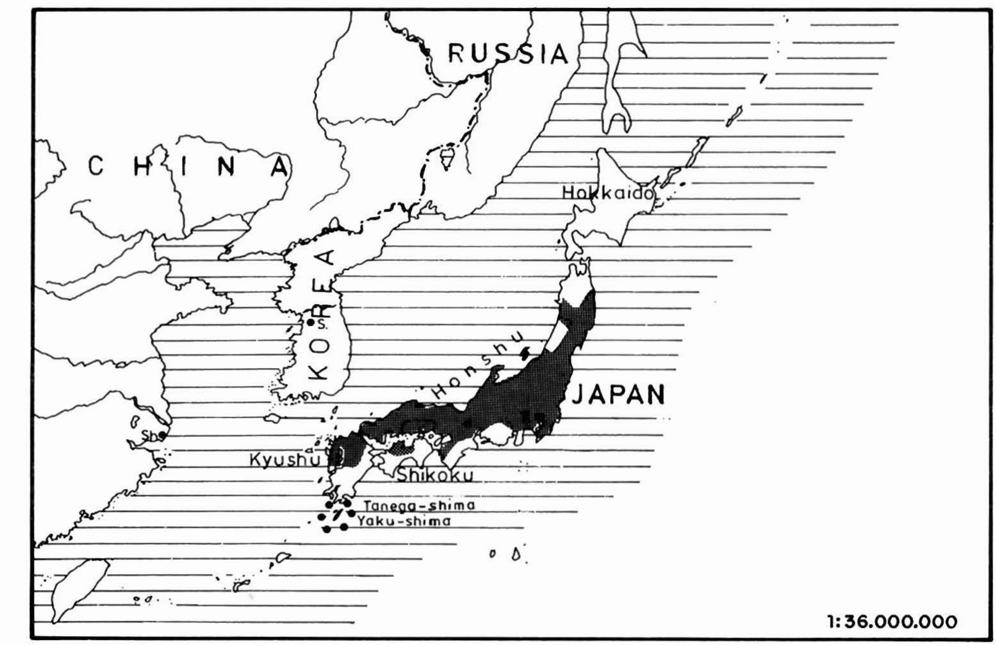

Figure 1. *Sasaella*
Japan: Honshu, Shikoku, Kyushu, Tanega-shima and Yaku-shima Islands.

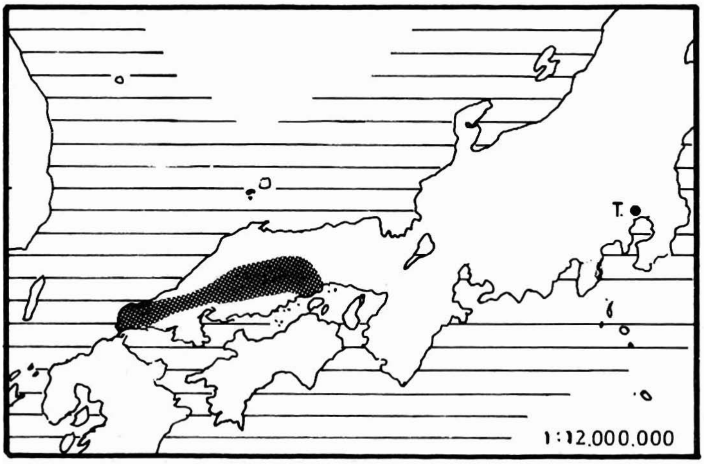

Figure 2. *Sasaella bitchuensis* var. *bitchuensis*
Japan: Honshu: Endemic to the Chugoku district.

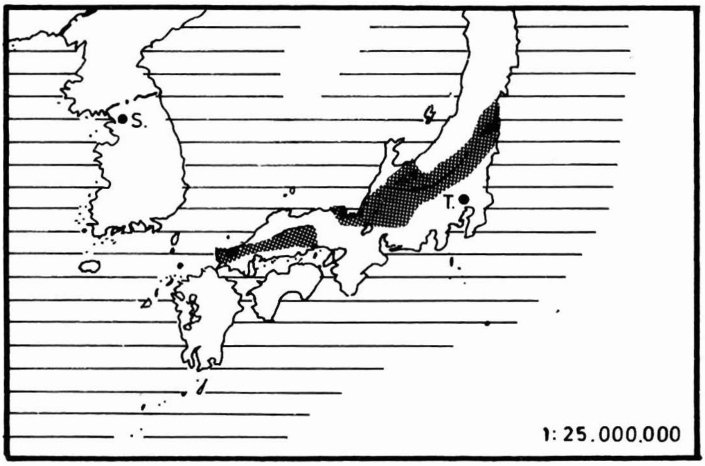

Figure 3. *Sasaella bitchuensis* var. *tashirozentaroana*
Japan: Honshu.

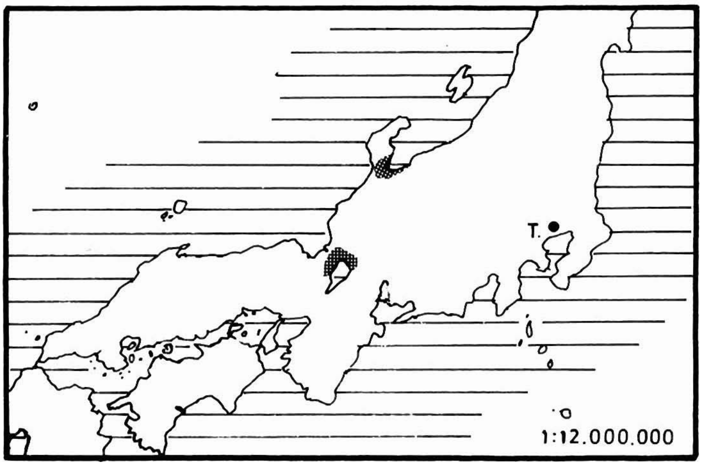

Figure 4. *Sasaella caudiceps*
Japan: Central Honshu, very rare.

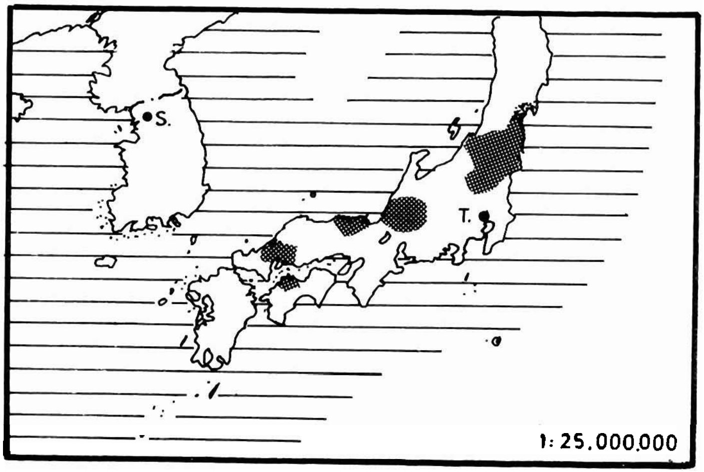

Figure 5. *Sasaella hidaensis* var. *hidaensis*
Japan: Honshu and Shikoku.

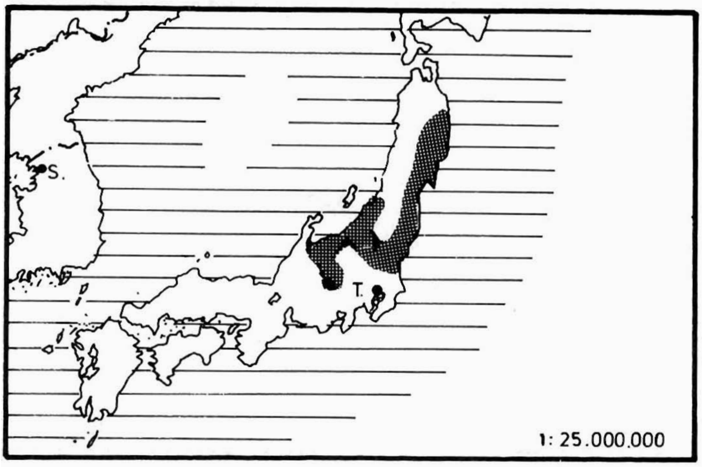

Figure 6. *Sasaella hidaensis* var. *muraii*
Japan: Northern and central Honshu.

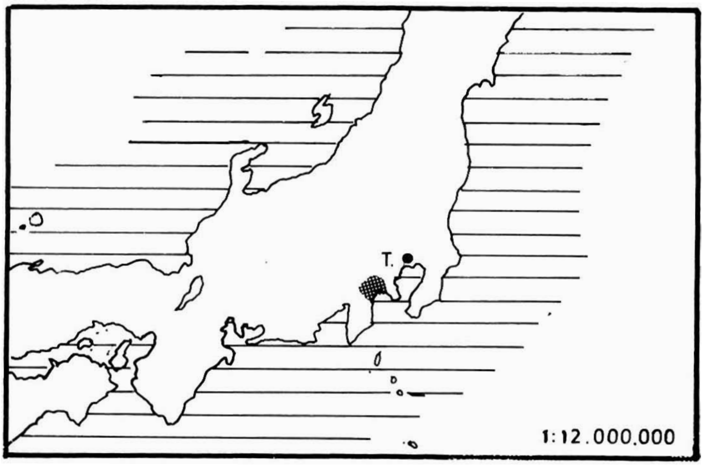

Figure 7. *Sasaella hisauchii*
Japan: Central Honshu: Prov. Sagami: Endemic to the Mt. Hakone and its vicinity.

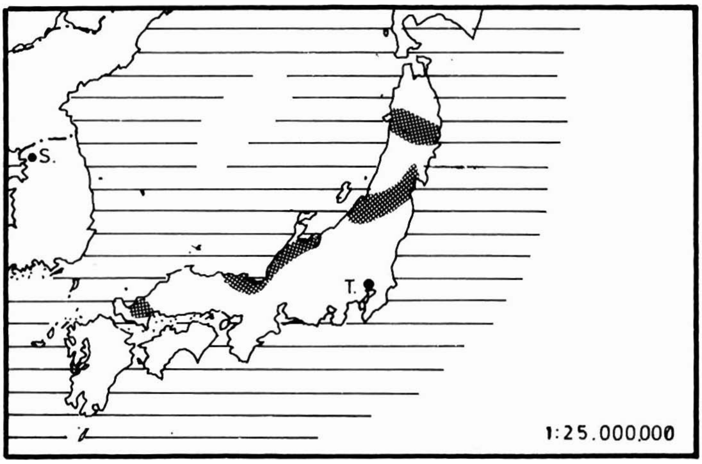

Figure 8. *Sasaella ikegamii*
Japan: Honshu, rather rare.

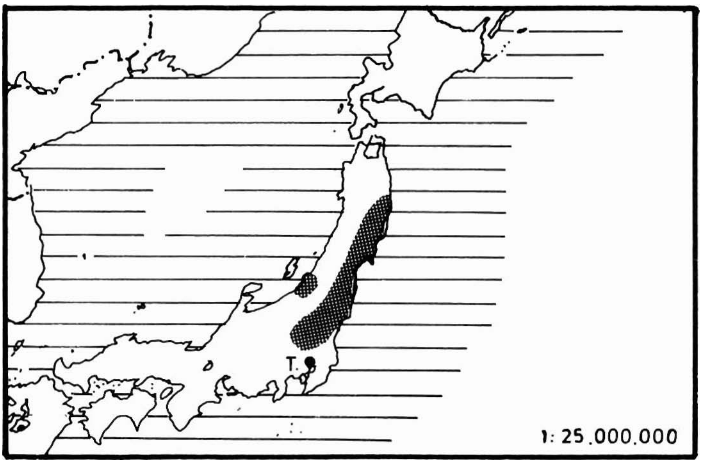

Figure 9. *Sasaella kogasensis* var. *kogasensis*
Japan: Northern and central Honshu, rather rare.

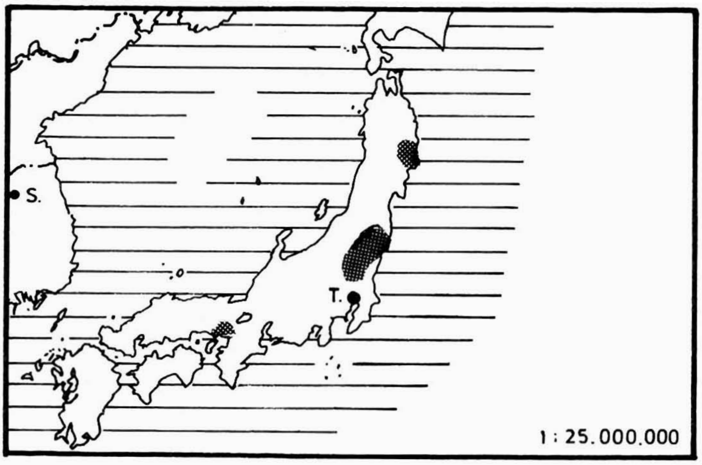

Figure 10. *Sasaella kogasensis* var. *yoshinoi*
Japan: Honshu.

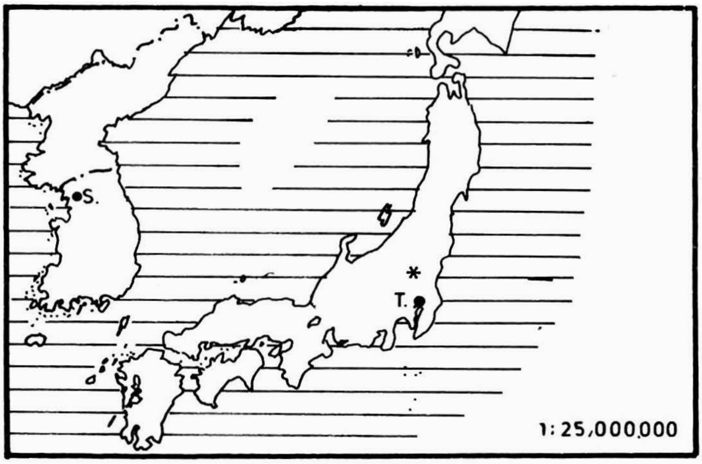

Figure 11. *Sasaella kogasensis* var. *gracillima*
Japan: Honshu: only known in cultivation, mainly cultivated in the Kanto district.

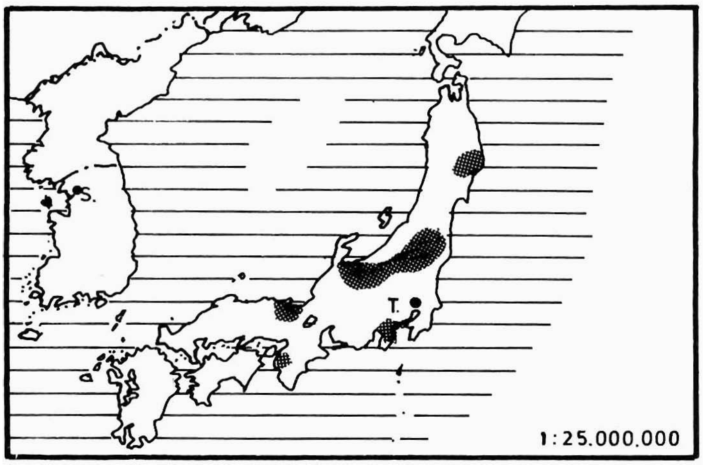

Figure 12. *Sasaella leucorhoda* var. *leucorhoda*
Japan: Honshu, rather rare.

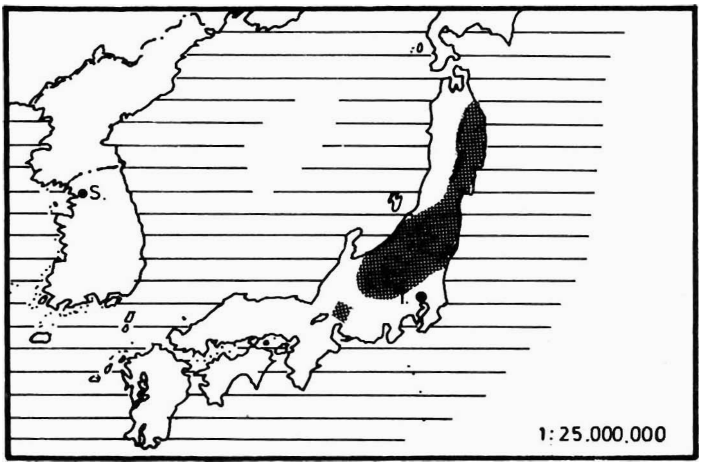

Figure 13. *Sasaella leucorhoda* var. *kanayamensis*
Japan: Northern and central Honshu.

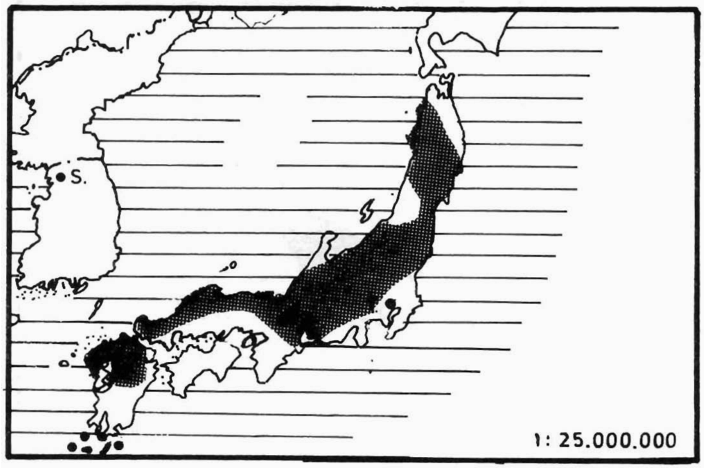

Figure 14. *Sasaella masamuneana* var. *masamuneana*
Japan: Honshu, Kyushu, Tanega-shima and Yaku-shima Islands.

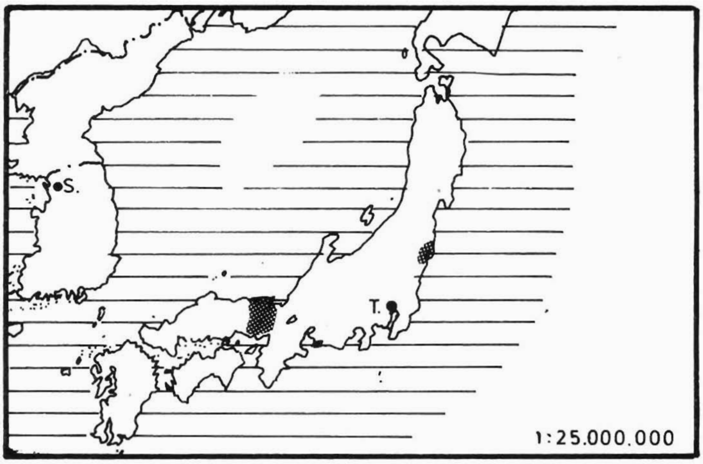

Figure 15. *Sasaella masamuneana* var. *amoena*
Japan: Honshu.

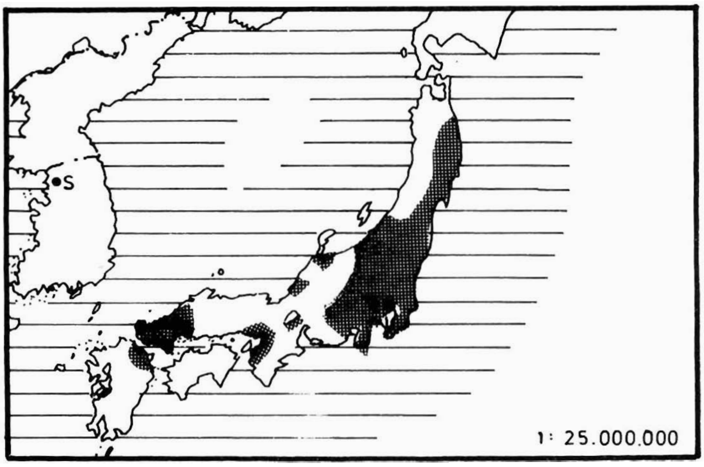

Figure 16. *Sasaella ramosa* var. *ramosa*
Japan: Honshu and Kyushu.

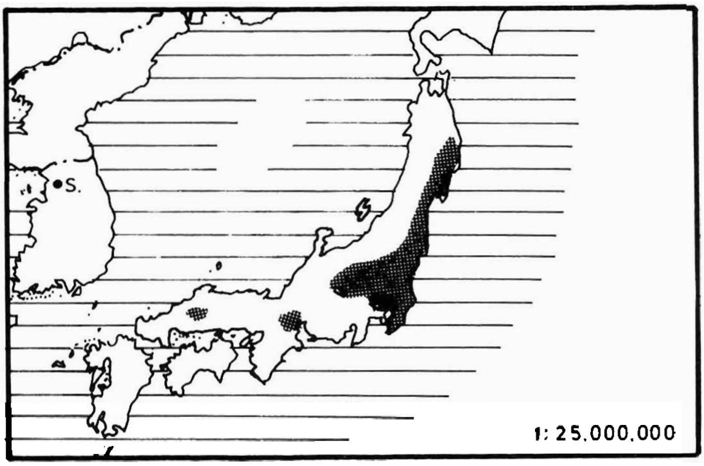

Figure 17. *Sasaella ramosa* var. *latifolia*
Japan: Honshu.

Figure 18. *Sasaella ramosa* var. *suwekoana*
Japan: Northern Honshu, rare.

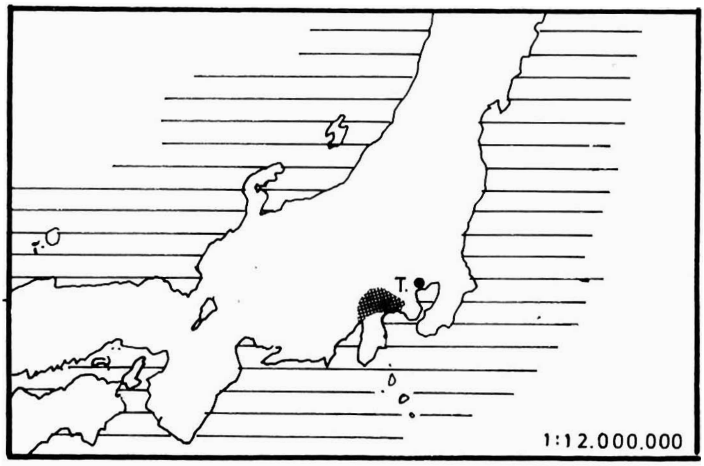

Figure 19. *Sasaella reikoana*
Japan: Honshu: Fuji-Hakone District.

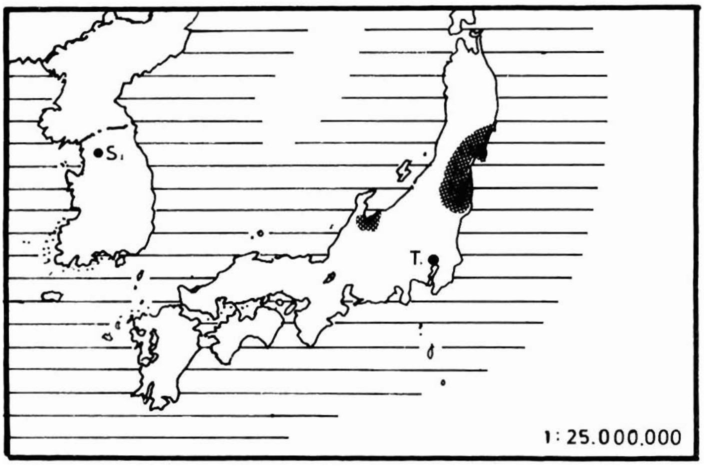

Figure 20. *Sasaella sadoensis*
Japan: Northern and central Honshu.

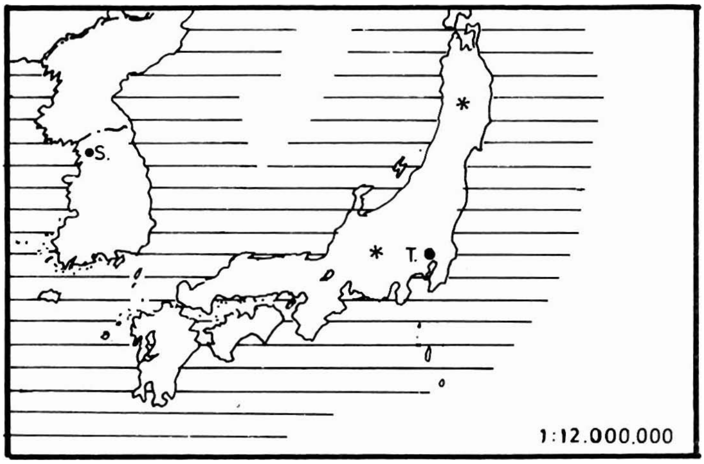

Figure 21. *Sasaella sasakiana*
Japan: Northern and central Honshu, known only in cultivation, rarely cultivated in the Tohoku District.

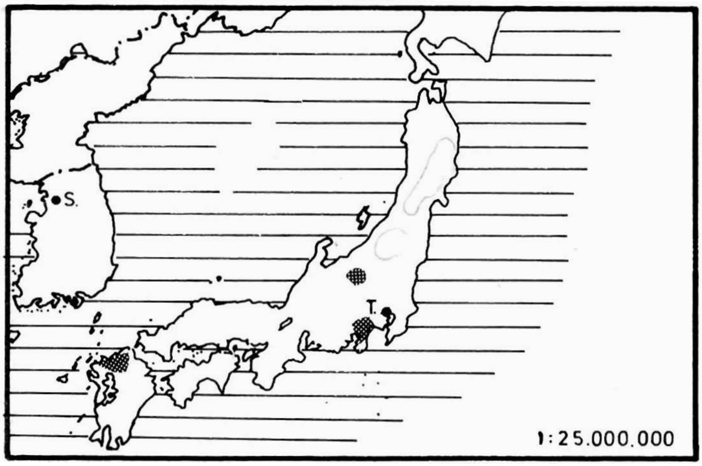

Figure 22. *Sasaella sawadae* var. *sawadae*
Japan: Central Honshu and Kyushu, very rare.

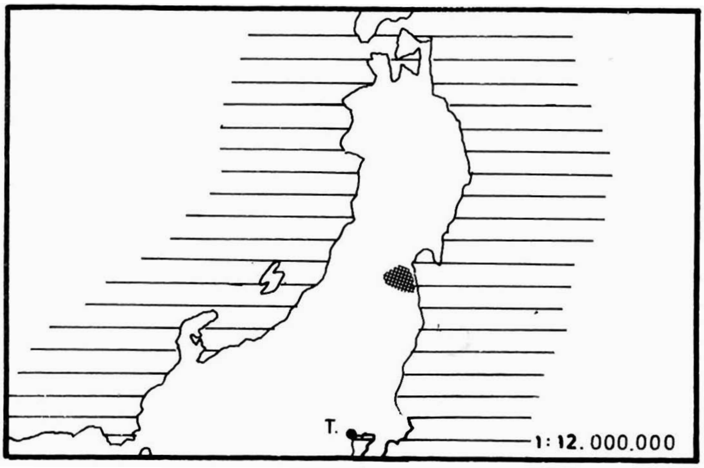

Figure 23. *Sasaella sawadae* var. *aobayamana*
Japan: Northern Honshu: Miyagi prefecture: endemic to Aobayama near Sendai.

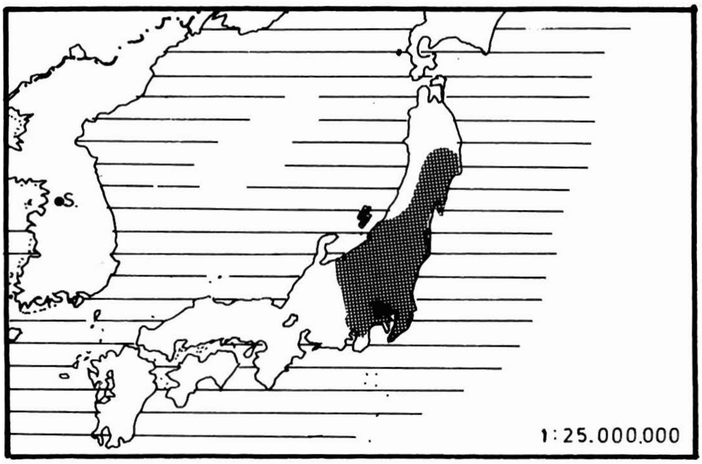

Figure 24. *Sasaella shiobarensis* var. *shiobarensis*
Japan: Northern and central Honshu.

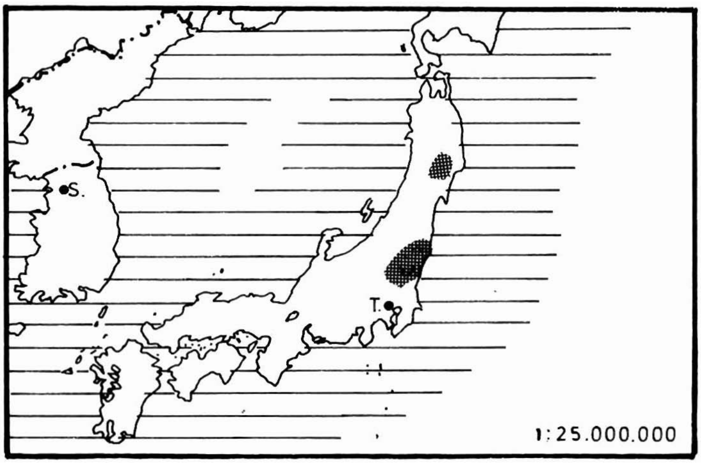

Figure 25. *Sasaella shiobaresis* var. *yessaensis*
Japan: Northern and central Honshu.

Letters to the Editor

Richard W. Pohl*: ***Phyllostachys aureosulcata* in Iowa**

We have no previous records of successful cultivation of any bamboos outdoors in Iowa. The following collection was taken from the Campus of Luther College in northeastern Iowa (Latitude ca. 43 degrees). The plants were growing vigorously and the college was thinking of eradicating them because of their spreading propensities. The plants grew next to a building and may have been somewhat protected.

Phyllostachys aureosulcata McClure. Campus of Luther College, Decorah, Iowa. A. Branhagen 41. 18 October, 1984 (ISC).

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Two good quality copies of the manuscript, typed on one side only, on 8 1/2 by 11 inch paper are required. The format should follow the pattern as presented by the *Journal.* The first appearance of scientific names of the plants should be followed by the appropriate authorities. References should be listed alphabetically at the end of the paper unless they appear as footnotes. The references should then be in order of appearance at the end of the paper. Total length of the manuscript (including figures) should be no more than 30 pages of the *Journal* (about 680 words/page).

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