

Documentation of a bamboo flowering event in the Ranomafana National Park and its impact on local forest ecology

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Abstract

In portions of the Old and New World tropics, infrequent flowering and seeding of bamboos have a range of impacts on vegetation structure and vertebrate life-history traits, which can dramatically change the local ecology. On Madagascar, there is little information on such mass flowering events and herein we describe one such episode from the medium altitude moist evergreen forests of the Ranomafana National Park. The climbing bamboo that underwent the large-scale flowering and seeding is *Sokinochloa chiataniae* (Poaceae: Bambusoideae: Bambuseae: Hickeliinae). Contrary to documentation elsewhere in the tropics and to some extent on Madagascar, the mass flowering event did not result in large-scale increases in rodent densities, including introduced Muridae. In contrast, there was evidence of open area granivorous birds dispersing into the forest to exploit the seed resources. The implications and causes of these patterns are discussed.

Keywords: bamboo mass flowering event, *Sokinochloa chiataniae*, Ranomafana, seed-eating birds, rodents

Résumé détaillé

Dans certaines parties des tropiques de l'ancien et du nouveau Monde, la floraison et l'ensemencement peu fréquents des bambous ont de nombreux impacts sur la structure de la végétation et sur les traits du cycle de vie des vertébrés, tels que les fluctuations de populations sur une période relativement

courte, ce qui peut changer radicalement l'écologie locale. A Madagascar, des études ont été menées sur l'écologie des bambous, souvent associés, par exemple, aux espèces dont les lémuriens se nourrissent, mais il existe peu d'informations sur de tels événements de floraison et d'ensemencement. Une série d'observations a été publiée sur les événements de floraison et d'ensemencement en masse de bambous il y a 60 ans dans les hauts plateaux du centre, décrivant un taux de reproduction élevé des rongeurs à la suite d'un événement de floraison à grande échelle de deux types de bambous dans les forêts près d'Ambositra et de Fandriana.

Dans cet article, nous décrivons un tel épisode de floraison et d'ensemencement en masse de bambou dans la forêt sempervirente humide de moyenne altitude à Vatoharanana au Parc National de Ranomafana, 21.289°S, 47.430°E, 1025 m au-dessus du niveau de la mer, du 4 au 12 mars 2023. Le bambou lianescent qui a subi la floraison et l'ensemencement à grande échelle est *Sokinochloa chiataniae* (Poaceae : Bambusoideae : Bambuseae : Hickeliinae). Une investigation sur les petits mammifères et des observations générales des oiseaux sur ce site ont eu lieu entre le 2 et le 9 octobre 2000. Une différence sur la présence des espèces d'oiseaux granivores et les résultats de piégeage des rongeurs autochtones et introduits a été remarquée entre les deux périodes d'investigation.

Sur la base des exemples mentionnés ci-dessus, le prétendu changement de l'écologie forestière associé à l'événement d'ensemencement serait l'augmentation du nombre d'oiseaux non dépendants de la forêt qui se nourrissent de graines de bambou et l'augmentation des populations de rongeurs, en particulier des espèces introduites. Les données sur des oiseaux dans le site sont basées sur des observations directes sur le terrain. Il y avait des preuves que des espèces d'oiseaux granivores de zones ouvertes se dispersent dans la forêt pour exploiter les semences de plantes. Des groupes de *Foudia* spp. ont été observés régulièrement, y compris *F. madagascariensis* et *F. omissa* picotant des graines sur le sol le long d'un sentier forestier et se suspendant sous des touffes de bambous lianescents ensemencés, du genre vraisemblablement référé à *S. chiataniae*. *Lepidopygia nana*, une espèce que

l'on trouve normalement dans les habitats forestiers dégradés et les zones en dehors des écosystèmes forestiers, a également été observée sur le site d'étude à cinq reprises et a été trouvée en train de se nourrir de graines de bambou dans une clairière autour du camp.

Les petits mammifères ont été enregistrés par des pièges à capture vivants (« Sherman » et « National ») et des pièges « pit-falls » mis en place pendant sept nuits. L'événement de floraison et d'ensemencement, cependant, n'a pas entraîné une augmentation importante de la densité de rongeurs, y compris les Muridae introduits. Il y a une différence notable entre les résultats de piégeage de 2000 et 2023, par exemple, 45 individus d'*Eliurus tanala* ont été capturés en 2000 et aucun individu de cette espèce n'a été trouvé en 2023. Une comparaison des résultats de piégeage de rongeurs entre 2000 et 2023, semble indiquer le schéma inverse basé sur le nombre prévu d'individus et d'espèces capturés. L'aspect critique est que le nombre de rongeurs piégés, incluant les individus de *Rattus rattus* introduit, est faible après l'événement de floraison et d'ensemencement à grande échelle de *S. chiataniae* et ces résultats ne sont pas attendus étant donné que ces graines pourraient servir comme leur nourriture. Les implications et les causes de ces modèles sont discutées.

Mots-clés : événement de floraison/ensemencement de bambou, *Sokinochloa chiataniae*, Ranomafana, oiseaux granivores, rongeurs

Introduction

One of the intriguing aspects of bamboos (Poaceae, Bambusoideae) is that populations of numerous species flower simultaneously and these mass flowering events can be at intervals of several decades or longer (Janzen, 1976). As has been documented from different areas of Asia, Africa, and the Neotropics, the seeding episodes result in changes of local forest ecosystems and impacts in nearby agricultural areas associated with rodent damage. As bamboo seed stocks increase, including considerable quantities falling to the ground, there is an augmentation in reproductive rates of rodent populations exploiting this resource (Suzuki *et al.*, 2022). Further, raptors key-in on these population fluctuations and modify accordingly some of their life-history traits (Ojeda & Chazarreta, 2018). Subsequently, for certain bamboo species there is large-scale die-off after seeding, which results in

forest structure changes. These modifications in turn reduce bamboo resources for different vertebrates consuming portions of these plants and leads to dramatic declines in their populations (Li *et al.*, 2014; Tian *et al.*, 2019). In some cases, after the bamboo seed stock has been depleted, the local rodent communities at the upper portion of their population cycling can disperse into nearby agricultural areas and feed extensively on ripening field grain or cause extensive damage to village grain stores (John & Nadganda, 2002; Aplin & Lalsiamliana, 2010; Chakma *et al.*, 2019; Haque, 2022; Koshy *et al.*, 2022). A few tropical bird species feed extensively on the seeds of bamboo, but given the irregularity of this resource, these taxa tend to show patterns of nomadism to track food (Areta *et al.*, 2009, 2013; Cockle & Areta, 2013). In summary, simultaneous with widespread and irregular pulses during bamboo mass flowering events, there are subsequent changes in forest structure, large-scale movements of normally non-forest dwelling animals into forests and forest-dwelling animals out of forests, and all of this results in a certain level of ecological "havoc" (Marchesini *et al.*, 2009; Sertse *et al.*, 2011).

On Madagascar, studies have been conducted on the ecology of bamboos, often associated with, for example, lemurs that feed on the vegetative portions of these plants (King *et al.*, 2013; Tan *et al.*, 2022). However, few details are available about bamboo mass flowering and seeding events. A series of observations were published on this topic nearly 60 years ago from the Central Highlands. Rakotomanana (1966) noted that in the last portion of 1964 there was a large-scale flowering event of two types of bamboos in the forests near Ambositra and Fandriana, one a creeper vine type (*volohaferana* and based on the common name most likely *Sokinochloa brachyclada*, S. Dransfield, unpublished data) and the other growing as a culm (*volovahy* and based on the common name most likely *Hickelia madagascariensis*, S. Dransfield, unpublished data). A short time later, in early 1965, these forested areas were invaded by different forms of rodents, and based on Rakotomanana's description these were for the most part members of the genera *Rattus* and *Mus* (family Muridae), both introduced to the island, rather than endemic forest-dwelling rodents of the subfamily Nesomyinae. Based on Rakotomanana's extrapolations, in an area of approximately 100,000 ha something on the order of 5000 tons of bamboo seed were produced. With this level of food availability, rodents reproduced at high rates

within forest and then moved to nearby agricultural areas, dramatically reducing production, and this ecological havoc led to local human famine. Some aspects of Rakotomanana's (1966) observations are summarized by Zehrer (1998).

With the above information forming the needed background, we present herein observations in the Ranomafana National Park on forest vertebrate ecology during a bamboo mass flowering event. The identification on the flowering bamboo is given, and other associated data. Further, the site in question had been surveyed 23 years earlier and differences in the presence of seed eating birds are given, as well as trapping results of locally occurring native and introduced rodents. On the basis of the examples mentioned above, the hypothesized changes in forest ecology associated with this event would be an augmentation in the number of non-forest dependent birds feeding on bamboo seed and increase in rodent populations, in particular non-native species.

Methods

Study site

The fieldwork and associated observations took place in the Région de Vatovavy, ex-Province de Fianarantsoa, Ranomafana National Park, Vatoharanana, 21.289°S, 47.430°E, 1025 m above-sea-level, from 4 to 12 March 2023. From the study site to the nearest cleared forest is approximately 1.7 km and to the forest edge is 2.0 km.

Bird observations

Records of birds at the site are based on direct field observations by one observer largely dedicated to this activity and another person making fewer regular observations. No bird netting was conducted in 2023, as had been done during a 2000 inventory of the same site (Raherilalao *et al.*, 2001).

Small mammal trapping

Two types of trapping devices, live traps (Sherman and National) and pitfall buckets, were used to capture small mammals at Vatoharanana and following the methodological details outlined in Soarimalala *et al.* (2001) associated with an inventory at the same site between 2 and 9 October 2000. Herein we concentrate on the results from the live traps, which yielded the vast majority of rodent captures and very few in the pitfall traps. Each trap line consisted of 100 traps (80 Sherman and 20 National) in place for seven nights. Traps were baited

with peanut butter and checked each day soon after dawn and in the latter portion of the afternoon, when the bait was replaced.

Results

Bamboo species in flower and seed

On the basis of a climbing bamboo specimen collected 8 March 2023 at Vatoharanana (SMG 21625), which will be deposited in the herbarium at the Parc Botanique et Zoologique de Tsimbazaza, Antananarivo (TAN), the taxon involved in the mass flowering event was identified as *Sokinochloa chiataniae* S. Dransf., a member of the Hickeliinae, an endemic subtribe of Malagasy bamboos (Dransfield, 2016; Rakotonasolo *et al.*, 2023). Based on a botanical field survey in 2000, climbing bamboos formed an important component of the forest understory at Vatoharanana (Randriatafika & Rakotovo, 2001). The recently described genus *Sokinochloa* and its constituent species were previously placed in the genus *Cephalostachyum*, with *S. chiataniae* placed in *C. cf. viguieri* A. Camus and a second species occurring in the Ranomafana National Park, *S. brachyclada*, formerly considered as *C. perrieri* A. Camus; these two taxa are differentiated based on leaf and flower size and other morphological characters (Dransfield, 2016). The two species of *Sokinochloa* at Ranomafana are not known to occur in sympatry, but this may be associated with the lack of detailed field collections.

Herbarium specimens provide the means to extrapolate some details on the flowering cycle of *Sokinochloa* spp. at Ranomafana. In 1996 and 1998 flowering specimens were collected of two climbing bamboos now considered *S. chiataniae* and *S. brachyclada*. On the basis of field data presented in Tan (1999), there was a flowering episode of *S. chiataniae* in December 1997, with a peak in November 1998, and this occurred in geographically limited areas, particularly on hillsides; stands started to die about three months thereafter. When SD visited Ranomafana in 2001, she found numerous bamboo seedlings, which were subsequently identified as *S. cf. chiataniae* (Dransfield, 2016). On the basis of current data, if these young plants were from the seeds of the flowering period of 1997 and 1998 and the next flowering episode was in 2023, this gives a life cycle of about 25 years.

Birds

Several granivorous bird species were observed at Vatoharanana between 4 and 10 March 2023, concurrent with the seeding of *Sokinochloa chiataniae*. On the basis of direct field observations, flocks of *Foudia* spp. (Ploceidae) were observed regularly, that is to say numerous times per day; these included observations of *F. madagascariensis*, generally a species of open areas or the forest edge, and *F. omissa*, a forest-dwelling species. For example, on 5 March approximately 50 individuals were found foraging in the understory and picking seeds off the ground along a forest trail, as well as dangling underneath clumps of seeding climbing bamboo, presumably *S. chiataniae*. These groups were composed of birds in mostly brown plumage (female, immature or non-breeding male) and identified as *F. madagascariensis* and a few individuals referable to the same species in male breeding plumage (predominantly red) were also observed. Additionally, *F. omissa* was observed daily between 4 and 10 March, mostly in small foraging flocks of 3 to 5 individuals, also in the understory feeding on seeding climbing bamboo. Another bird species, *Lepidopygia nana* (Estrildidae), was also observed at the study site on five occasions between 6 and 8 March. This species is normally found in degraded forest habitats and zones outside of forest ecosystems, but a pair was observed on several occasions foraging on bamboo seed in a forest clearing around the Vatoharanana camp. In short, there was a distinct movement of seed-eating non-forest-dwelling bird species into Vatoharanana across at least 1.7 km, and in most cases a minimum of 2 km, of primary or largely intact forest, which coincided with the mass flowering of *S. chiataniae*.

On the basis of mist netting conducted at Vatoharanana between 2 and 9 October 2000, over the course of five days with 10 mist nets, each 12 m long, a total of 109 individual birds were captured. A single individual of *F. omissa* was netted and no example of *F. madagascariensis* or *L. nana* was trapped (Raherilalao *et al.*, 2001). Further, during local point count surveys at the site conducted during the same period in 2000, no individual of the genus *Foudia* or *Lepidopygia* was recorded (Raherilalao *et al.*, 2001).

Rodents

In total, 700 trap nights were accrued at Vatoharanana in March 2023 (Table 1), which yielded the capture of

Table 1. Comparison of trapped rodent species and capture rates for live traps (Sherman and National) for seven nights of capture or 700 trap-nights. * = species introduced to Madagascar. The data from 2000 are taken from Soarimalala *et al.* (2001).

Species	Number captured in each year	
	2000	2023
Family Nesomyinae		
<i>Eliurus minor</i>	4	6
<i>Eliurus tanala</i>	45	0
<i>Eliurus webbi</i>	1	4
<i>Nesomys audeberti</i>	4	1
<i>Nesomys rufus</i>	21	1
Family Muridae		
* <i>Rattus rattus</i>	3	0 ¹
Total number of captured rodents	78	14
Cumulative trap success	11.1%	2.0%

¹ Two subadult *Rattus rattus* were captured in the pitfall traps, but the live traps did not yield any individuals of this species.

14 individual rodents with a trap success rate of 2.0%, which included four species belonging to the endemic subfamily Nesomyinae. No introduced *Rattus rattus* was captured in the live traps, but two subadults were obtained in the pitfall traps.

In contrast, between 2 and 9 October 2000, with the same bait, trap types, and trapping effort, 78 different rodents were captured with a trap success of 11.1%. Five species of nesomyine rodents and three individuals of *R. rattus* were obtained. There were notable differences between the trapping results of 2000 and 2023, including, for example, 45 individuals of *Eliurus tanala*, being captured in 2000 and not a single individual of this species in 2023. At least a portion of these differences might be associated with seasonal differences of the two inventory periods superimposed on rodent population cycles, but as noted below there have been changes in the forest structure of Vatoharanana which might be an explanatory factor in the differences between 2000 and 2023.

As a generality, in the eastern moist evergreen montane forests of Madagascar, most *Eliurus* spp. commence their reproductive cycle in the last quarter of the year and population augmentation, which includes the recruitment of young individuals, is towards the end of the same calendar year or the start of the next year (Carleton *et al.*, 2022). A comparison of the rodent trapping results between 2000 and 2023, indicate a different pattern based on the number of captured individuals and species and perhaps the late 2022/2023 breeding season was delayed or other factors, such as the passage of a devastating cyclone resulted in heavy mortality. An important aspect is that we did not find elevated

numbers of trapped rodents, including introduced *Rattus*, after the large-scale flowering event of *Sokinochloa chiataniae*, as might be anticipated.

Discussion

Two aspects are often associated with large-scale mass flowering of bamboo populations in different portions of the tropics:

1. Local movement of granivorous bird species to the area the bamboo flowered, which exploit seed resources.
2. Notable increases in local rodent reproduction, particularly members of the family Muridae, with population explosions.

With regards to birds, we indeed observed displacement of at least 2 km from the forest-edge and of normally non-forest-dwelling granivorous bird species into the native forests of Vatoharanana. The two such species, *Foudia madagascariensis* and *Lepidopygia nana*, were clearly exploiting seeds associated with a local mass flowering event of *Sokinochloa chiataniae*. With the exception of *F. omissa*, we have no evidence of any other endemic forest-dwelling granivorous bird species taking advantage of the bamboo seed resource, either from this study or from the wider literature.

For small mammals and based on other examples of large-scale seeding of bamboos elsewhere in the tropics, it would be anticipated that rodent populations would have increased substantially during the large-scale flowering event. This was not the case and, moreover, we found no evidence of local populations of *Rattus rattus* increasing in numbers.

Explanations as to why rodent populations did not increase as anticipated are uncertain but might be related to two phenomena that can affect forest communities. The forests of Vatoharanana have dramatically changed in structural aspects between 2000 and 2023. The upper story was distinctly more open than during the latter survey, which would impact the local ecology of forest-dependent vertebrate species, including scansorial species in the genus *Eliurus*. The general Ranomafana area has been the subject of major cyclonic/tropical depression events over the past two decades that resulted in a considerable number of tree falls and canopy defoliation. Using a database (Historical Hurricane Tracks, <https://coast.noaa.gov/hurricanes>) of intense storms that impacted the area, these include:

Freddy in 2023 (just before our inventory) – Category 5

Batsirai in 2022 – Category 4

Emnati in 2022 – Category 1

Ava in 2017 – Category 2

Chedza in 2015 – Tropical Depression

Indala in 2007 – Category 4

Gafilo in 2004 – Category 5

The impact of these storms and general patterns of climate change have resulted in the decline of certain lemur species in the same forest block (Dunham *et al.*, 2011).

A second explanation might be associated with the passage of zoonotic diseases or fluctuating changes in parasites that resulted in the decline of the rodent population, falling outside of typical population cycles. This latter explanation requires further field and laboratory research.

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