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Late fruiting in *Sapium sebiferum*: an effective dispersal strategy

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Abstract: Time of fruiting and their ripening plays an important role in attracting prospective dispersers in plant species. We have been monitoring a stand of *Sapium sebiferum,* an alien invasive species in order to document its phenology and seed dispersal patterns. Unlike majority of the plant species in the western Himalaya which fruit during monsoon, fruits of *S. sebiferum* mature and dehisce during November - December. This being winter season in the Himalaya, wherein resources are scarce, *S. sebiferum* is able to attract a large number of frugivorous birds which increase the chances of wider seed dispersal. Thus, late fruiting seems to be of much advantage for this species and possibly one of the reasons for its success in the Himalayan foothills.

Key words: Birds, frugivory, fruiting, *Sapium sebiferum*, seed dispersal.

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Spread of invasive species is a contemporary ecological issue. Recent studies have documented advancement of such species in the Himalayan biodiversity hotspot (McDoughall *et al.* 2011; Shah & Reshi 2014). One amongst them is the Chinese tallow tree, *Sapium sebiferum* (Jaryan *et al.* 2007). It is a fast growing deciduous tree reaching a height of upto 15 m and possesses several traits which make it a successful invader. These include multiple modes of reproduction, high fecundity, precocity, wide ecological amplitude, faster litter decomposition, and gets dispersed through multiple agents including humans, birds and water (Jaryan *et al.* 2007; Lin *et al.* 1958). *Sapium sebiferum* has been implicated in loss of native species and modification of habitats in different parts of the world (Bruce *et al.* 1997; Cameron & Spencer 1989).

It is with this background that we have been monitoring phenology and growth characteristics of *S. sebiferum* in a part of West Himalaya. For this, we marked a site of 30 m × 35 m permanently. The site is located at 32° 6' 18" N and 76° 33' 22" E, at an altitude of 1300 m asl in Palampur, Himachal Pradesh. The area receives annual rainfall of ca. 2500 mm while the temperature ranges from 3 to 19 °C and from 18 to 34 °C during winters and summers, respectively. The site lies close to human habitation and is typically a woodland where no artificial plantation has been raised. Common native trees at the site are *Celtis australis*, *Ehretia acuminata*, *Ficus palmata*, *Grewia optiva*, *Persea odoratissima*, *Pinus roxburghii*, *Prunus cerasoides*, *Pyrus pashia* and *Syzygium cumini.* Dominant shrubs include *Berberis lycium*, *Rosa brunonii* and *Rubus ellipticus.*

Four individuals of *S. sebiferum* were marked for phenological monitoring and fruit estimation (Jaryan *et al.* 2013, 2014). Fruit size and weight (n = 100) were determined using vernier callipers and digital balance, respectively. Bird species feeding on the tree species were opportunistically noted for

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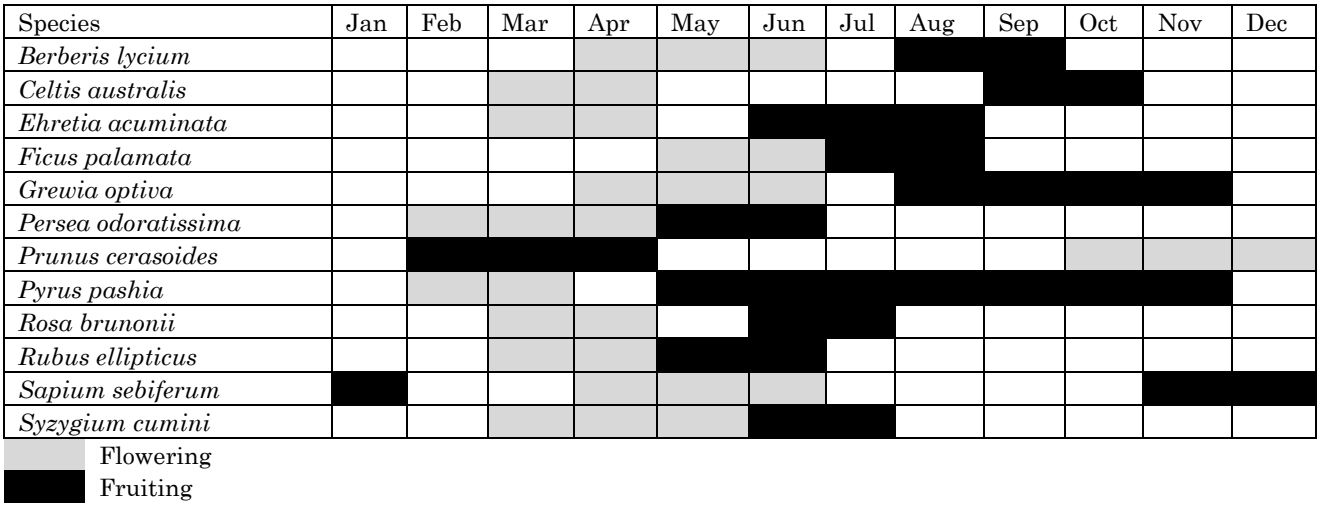

Fig. 1. Flowering and fruiting duration of some commonly occurring plant species.

Table 1. Altitudinal distribution and monthly duration during which the birds were observed on the fruits of *Sapium sebiferum*.

Birds	Altitudinal migration (m asl)*	Month
Black lored yellow tit (*Parus xanthogenys)*	700-2200	Dec-Feb
Blue-throated barbet (*Megalaima asiatica)*	250-2200	Dec- Feb
Blue whistling thrush (*Myophonus caeruleus*)	250-4000	Dec-Feb
Brahminy maina (*Sturnia pagodarum*)	250-1900	Dec-Feb
Common myna (*Acridotheres tristis*)	250-2900	Jan-Feb
Gold finch (*Carduelis carduelis*)	2000-4000	Jan- Feb
Great barbet (*Megalaima virens*)	400-2900	Dec-Feb
Great tit (*Parus major*)	250-2200	Nov-Feb
Green-backed tit (*Parus monticolus*)	250-3200	Dec-Feb
Jungle babbler (*Turdoides striata*)	250-1200	Dec-Feb
Himalayan bulbul (*Pycnonotus leucogenys*)	250-2600	Nov-Feb
House sparrow (*Passer domesticus)*	250-2900	Dec-Feb
Indian grey hornbill (*Ocyceros birostris*)	250-1000	Dec-Feb
Jungle crow (*Corvus macrorhynchos*)	250-4200	Dec- Feb
Red vented bulbul (*Pycnonotus cafer*)	250-1900	Nov-Feb
Rose ringed parakeet (*Psittacula krameri*)	250-2100	Dec-Feb
Rufuous tree pie (*Dendrocitta vagabunda*)	250-1300	Dec-Feb
Rufous sibia (*Heterophasia capistrata*)	400-3300	Jan-Feb
Slaty headed parakeet (*Psittacula himalayana*)	400-3300	Jan-Feb
Yellow billed blue magpie (*Urocissa flavirostris*)	600-2900	Dec-Feb

*Besten (2009).

complete one year and identified using relevant literature (Ali 1996; Besten 2009).

Based on daily recordings we prepared a phenological calendar of the species (Jaryan *et al.* 2014) and documented its characteristics (Jaryan *et al.* 2013). During the process it was observed that fruit of *S. sebiferum* ripens during November-December (Fig. 1). Prior to this time, the green immature fruits of *S. sebiferum* are camouflaged amongst the dark green leaves.

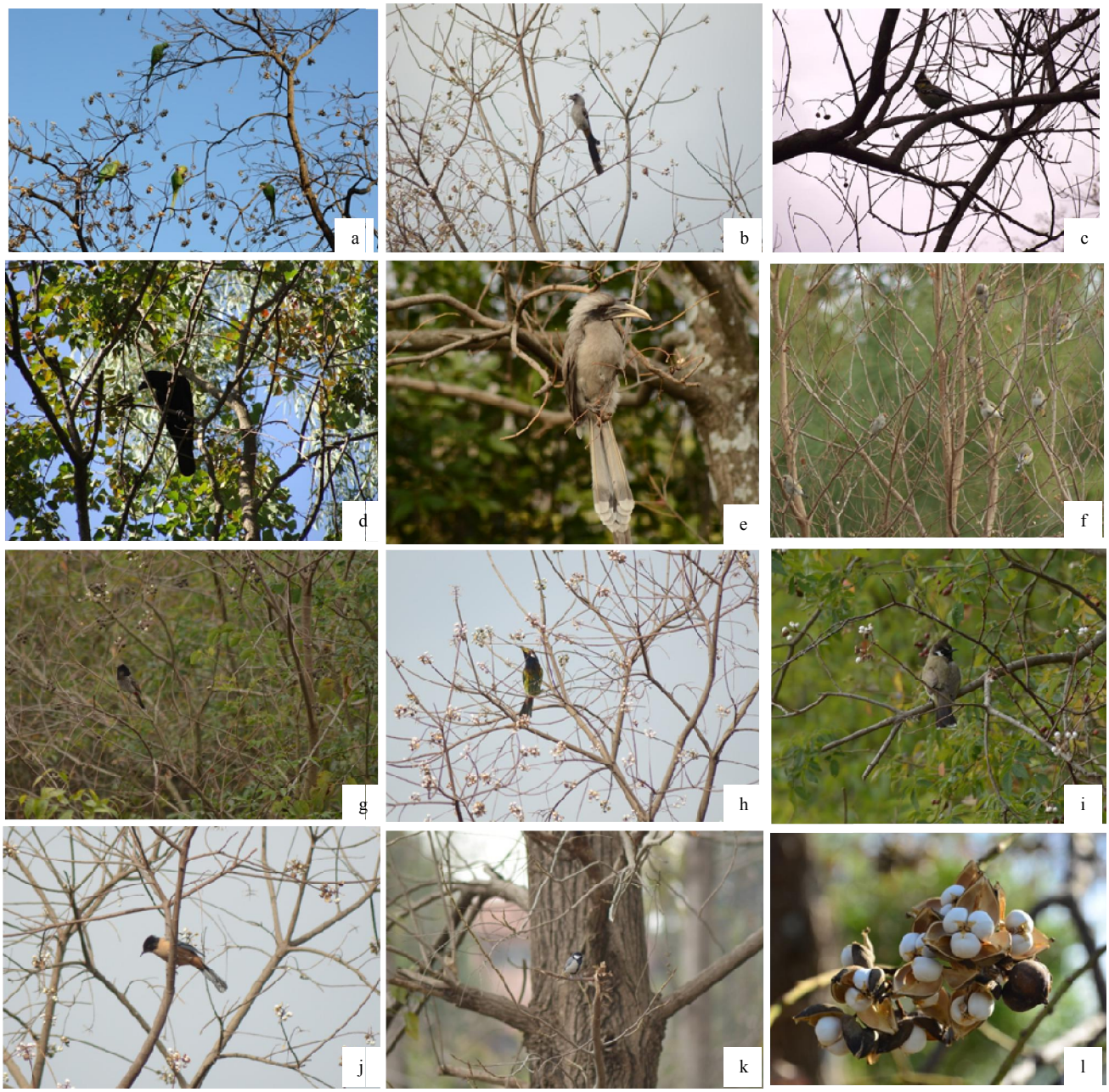

Fig. 2. Some of the bird species recorded feeding on *Sapium sebiferum* (a: Rose ringed parakeet, b: Rufous tree pie, c: Black lored yellow tit, d: Jungle crow, e: Indian grey hornbill, f: Gold finch, g: Red vented bulbul, h: Great barbet, i : Himalayan bulbul, j: Rufous sibia, k: Great tit, and l: dehisced fruits of *Sapium sebiferum* exposing the seeds).

The fruits of the species are three lobed capsules with one seed in each lobe. Fully mature fruits range from 13.2 to 16.2 mm in diameter, and 1 to 1.69 g in weight (n = 100, from different trees). Seeds of the species are 6.8 × 6.7 mm - 8.2 × 9.5 mm in dimension and weigh between 130 to 200 mg. They remain attached to the placenta after dehiscence and onto the tree. This may be advantageous to the plant as dropping of fruits/seeds on the ground may reduce its visible appeal. Crowding at the base of the plant may lead to increased competition amongst the seedlings and a consequent loss of recruitment. Also, recruitment away from the mother plant may help in avoiding predation and pathogen (Hyatt *et al.* 2002). Importantly, *S. sebiferum* also reproduces sexually by

formation of root suckers that allows it to colonize areas close to the parent tree.

We recorded as many as 20 bird species including migrants feeding on the fruits of *S. sebiferum* during the winter season (Table 1). At any time of the year, such a congregation of birds was not observed in any other tree species at the site. It is obvious that during summer, monsoon and autumn there were ample resources for the birds while winters are limited by food (Fig. 1). With the arrival of winter, fruits of *S. sebiferum* mature and become available to frugivorous birds. It is interesting to note that foliage of *S. sebiferum* turns bronze and becomes prominent during autumn/winter. This coincides with availability of fruits (Jaryan *et al.* 2014). We have reported average number of seed per mature tree to be 60000 ± 20000 (Mean ± SD) at this site (Jaryan *et al.* 2013). During the lean season, these heavily loaded plants are visible from a distance and the dehisced fruits with white seeds on the dark branches are prominent. This is unlike majority of the plant species at the site, whose fruits mature during the monsoon (July to September).Taking average seed production per mature tree to be 60000 and average seed weight to be 150 mg, seed biomass per mature tree works out to be 9000 g. Studies on foraging patterns of *Pycnonotus cafer* have revealed that on an average 57 seeds of *Carissa spinarum*, each weighing 80.8 mg, are removed by the species in a day (Mishra & Gupta 2005). Thus, considering the resource scarcity during winter season, substantial resources are available on *S. sebiferum* that may be attracting the bird species. Himalayan bulbul, Red vented bulbul and Great tit were the most common species (Fig. 2). Species such as hornbills, parakeets, tree pies and crows that forage on the species during winter months are known to be long range dispersers (Bodare *et al.* 2013; David *et al.* 2015). These birds help in dispersal of the species (Gifford & Armacost 2012; Gosper *et al.* 2005; Renne *et al.* 2002). Considering that a single long range disperser can help wider dispersal of the species, an assemblage of many long range dispersers will certainly benefit *S. sebiferum*. Accessibility of fruits (Whelan & Willson 1994) and their abundance (Korine *et al.* 2000; Sallabanks 1993) are other key factors that attract dispersers. Thus, easily accessible fruits in large quantity by *S. sebiferum* are further advantageous to the species.

It is well documented that owing to limited availability of food resources, plant species fruiting during winters may be able to attract a large and diverse set of dispersers who themselves are desperately searching for food (Gervias & Wheelwright 1994; Whelan & Willson 1994). Inability to establish dispersal mutualisms, with new species in a region of introduction, may severely limit the spread of alien species (Gosper *et al.* 2005). Rapid spread of *Crataegus monogyna* in North America has been attributed to mutualism (Sallabanks 1993).

Sapium sebiferum was first reported from Kangra, Himachal Pradesh in the early twentieth century (Parker 1984) and since then it is expanding rapidly (Jaryan *et al.* 2007). Occupying empty niches may one of the reasons behind the success of this species. Once an invasive species finds such a niche, it successfully occupies it, uses the surplus resources, and perpetuates its population (Hierro *et al.* 2005). Herein, dispersal by birds may play a crucial role. Reports of higher germination rates and longer viability in seeds of *S. sebiferum* that have passed through the avian digestive tract are already available (Renne *et al.* 2001). Thus, ensuring dispersal by birds may facilitate invasiveness in some plant species. On the larger front of plant invasion studies, this renders support to the views (Aslan 2011) that for predicting invasiveness, patterns and processes of dispersal especially by birds become important.

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