Notes and comments

# The effect of samara wing presence on predation of *Acer pseudoplatanus* (Sapindaceae) seeds on the ground.

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## Abstract

The key selective pressure shaping the morphology of samaras is seen as enhancing primary wind-borne dispersal from the parent plant to the ground. However, the consequences of the samara wing of primarily wind-dispersed tree species in post-dispersal processes has not been well-studied. We explored whether the presence of this wing in *Acer pseudoplatanus* either deters or promotes predation after dispersal, either by increasing the time and energy required to predate the seed or by increasing the seed's visibility to predators. We found that wing-removed fruits were preferred, suggesting that samara presence makes seed handling more expensive for granivores. Further, we found that fewer seeds were consumed from treatments that contained the most winged seeds, thus there was no evidence of the samaras making seed-finding easier for granivores. We conclude that the presence of the wing may offer an anti-predatory benefit as well as aiding primary dispersal.

**Keywords:** *Acer pseudoplatanus*, samara, predation, seed predation, winged seed

## Introduction

Winged seeds (samaras) are primarily wind-dispersed (anemochoric) although secondary dispersal may make use of other mechanisms (e.g. water see Kowarik & Säumel, 2008; Säumel & Kowarik, 2010, 2013 and animals see Vander Wall, 1992, 1994, 2003) . The wing (part of the pericarp) encasing the seed in wind-dispersed species like *Acer* spp., *Fraxinus* spp., and *Tachigali versicolor* Standl & L.O. Williams is well-adapted for anemochory, but whether its presence affects seed predation and/or secondary dispersal by animals (zoochory) is not yet well-established.

One cross-species study concluded that in tropical habitats, anemochoric seeds tend to have lower rates of predation than zoochoric seeds (Fornara & Dalling, 2005). These findings were corroborated by a similar study comparing the predation of seeds of temperate species, which found *Acer* seeds to be preferred over *Fraxinus*, but also found that non-samaroid seeds were preferred over both samaroid species (Jinks et al., 2012). One drawback to these correlative studies is that they do not demonstrate if predation is affected by the wing itself or some other trait (e.g. chemical defences) that might differ between species, or indeed be correlated with presence of a wing.

There have been manipulative studies that have evaluated the effect of the presence of the wing itself on seed predation. However, the results from these studies differ; and aspects of their experimental designs make generalisation problematic. Fornara & Dalling (2005) compared the removal of winged seeds in one year, to the removal of unwinged seeds in a different year and concluded that predation rates were similar; however differences could have been masked by environmental differences across years (e.g. in weather). Vander Wall (1994) reported higher removal of wing-removed fruits when the whole fruit structure (seeds still encased in their samara) were simultaneously available. However, this experiment occurred in an area that featured the focal tree species very commonly. Therefore, predators may have been searching for winged seeds specifically, as they are a common food source in this habitat; the high predation rates reported seem to support this (with essentially all naturally-dropped seeds being collected within a short number of weeks by hoarding mammals). Further research is thus required in order to determine whether samara wings affect predation rates in ecosystems where a broad diversity of food is available to a broad diversity of generalist granivores. We can envisage two (non-exclusive) potential processes that affect predation quite differently. On one hand it might be that the wing increases the visual detectability of the seed simply by presenting a larger target. Conversely, it may be that the need to penetrate the encasing structure associated with the wing increases handling time and that makes the seeds less desirable. In this study, we analysed the rates of seed removal of the whole *Acer pseudoplatanus* L. fruit structure and wing-removed fruits in a wooded habitat in St Andrews, UK, to determine whether and how the samara-wing casing influences predation rate after seeds have fallen to the ground.

## Methods

*Acer pseudoplatanus* fruits were collected from forested areas around St Andrews, UK, in the autumn of 2018. Fruits were air-dried to ensure water content was similar across seeds. A random sample of samaras were selected, visually assessed for maturity, and discarded if they did not contain fully formed seeds. Samaras were randomly split between two groups termed *excised* and *whole*. The *excised* group contained wing-removed fruits, which were carefully removed from the pericarp with a sharp knife; the *whole* group contained unmanipulated whole fruits. All whole fruits had unbroken wings.

Seeds were assigned randomly to one of three treatments: “cut” groups contained ten wing-removed fruits; “ten” groups contained ten wing-removed fruits and ten whole fruits; and “five” groups contained five wing-removed fruits and five whole fruits (Figure 1). The different treatment groups were placed in petri dishes along a transect following the Kinness Burn in St Andrews, UK (grid ref. NO 51244 16148). The dishes were transparent and had a diameter of 13.8cm and a lip height of 1.9cm. The density of fruits in petri dishes did not exceed that naturally found under parent trees. Petri dishes were placed five paces apart, away from the path to prevent interference from humans or dogs. The treatments were alternated between petri dishes (“cut”, “ten”, “five”), with ten dishes for each treatment.

The transect was checked every day for a period of nine days, and any debris was removed from the dish. The number of fruits remaining in each dish was recorded. If a whole samara fruit only had its seed removed, but the wing remained in the dish, it was recorded separately as a partial removal and the empty casing was removed. Dishes were refilled at each daily visit (returning the group in the petri dish to its initial condition) until spare fruits ran out (approximately around day 3). Later recordings (after dishes were no longer restocked daily) considered the expected number of fruits based on the number of seeds found on the previous day. When the fruits in a petri dish eventually fell to zero the dish was removed. Data was analysed in R version 3.6.0. We focussed on daily percentage of available fruits removed to control for different total number of fruits present in different dishes.

In order to determine what seed predators were present in our study area, camera trapping was carried out in two locations using an APEMAN 12MP 1080 Trail Wildlife Camera Trap. During camera trapping, *Acer pseudoplatanus* fruits, both excised and whole, were placed in a transparent dish in front of the camera. The camera was set to activate if movement persisted within view for five seconds, upon which a photograph was taken. Camera trapping continued for two weeks, encompassing the time during which the experiment occurred.

## Results

During camera trapping, European robins *Erithacus rubecula* L. and common wood pigeons *Columba palumbus* L. were observed to consume the seeds. Although no mammalian seed predators were recorded on camera, mouse droppings were found in several petri dishes during the experiment, as well as evidence of mammalian seed predators in the form of empty samara casings with the seed removed.

Post-hoc Tukey tests after a one-way ANOVA ($F_{2,72.9} = 13.672$, $P < 0.001$) showed that there was a difference between the "ten" treatment and the "five" and "cut" treatments for the percent of all seeds present that were removed per day; and a difference between the "cut" treatment and the "ten" treatment for the percent of wing-removed fruits removed (ANOVA $F_{2,79} = 9.106$, $P < 0.001$). The mean percentage of all fruits removed varied from 47.8% (cut) to 38.3% (five) and 13.9% (ten) (Figure 2A). The mean percent of wing-removed fruits removed varied from 47.8% (cut) to 56.6% (five) and 22.3% (ten) (Figure 2B). Taken together, these results suggest that samaras may offer an anti-predatory benefit – the more whole fruits there were in a petri dish the fewer wing-removed fruits were eaten and the fewer fruits overall that were eaten.

The percentage of whole fruits removed also differed between the "ten" and "five" treatments (Wilcoxon $W = 1617$, $p < 0.004$), with a higher mean percentage of samaras being removed from the "five" treatment (20.0% removed) than the "ten" treatment (6.1% removed) (Figure 2C). This suggests that increased fruit density does not increase seed predation: an increased number of samaras did not provide a larger visual target that caused enhanced attraction of seed predators.

When comparing the percentage of whole fruits and wing-removed fruits removed within petri dishes when equal amounts of fruits were present, we found that wing-removed fruits were removed at a higher rate than whole fruits (n = 87, mean = 41.1% ± 46.6%, median = 10%, IQR = 100 and n = 87, mean = 13.2% ± 21.8%,, median = 0%, IQR = 20, respectively: Wilcoxon signed rank: V = 1156, P < 001). This suggests that wing-removed fruits are preferred as a food source over those still encased in their samara.

## Discussion

The "ten" treatment consistently had the lowest mean percentage of removed fruits across all categories (all, wing-removed, and whole fruits removed). The mean percentages of all fruits and wing-removed fruits alone removed from the "cut" and "five" treatments were not significantly different. These findings suggest that seed predators do not struggle to find seeds that have been removed from their wing. On the contrary, the fact that the treatment that contained the most fruits (ten wing-removed fruits and ten whole fruits) was the least predated suggests that the samara wing may reduce the attractiveness of the encased seeds to seed predators as well as obscuring potentially more energetically-beneficial wing-removed fruits. If fewer winged fruits are present, the wing-removed fruits are less covered and thus more easily visible to predators. Comparison of whole fruit and wing-removed fruits removal rates within petri dishes showed that wing-removed fruits are removed at a higher rate. This further confirms that seed predators prefer wing-removed fruits, likely as they require time and energy in order to be consumed. Wing-removed fruits may thus provide a higher net energy benefit than whole fruits (Daneke & Decker, 1988; Wang et al., 2014).

The less crowded petri dishes (n = 10) (i.e. those with a lower fruit and seed density) were more heavily predated than the more crowded petri dishes (n = 20), despite the "ten" treatment containing double the amount of wing-removed fruits to the "five" treatment. This suggests that the samara wing obscures visual searches for seeds. This is supported by Tanaka (1995), who found that for two out of three tested *Acer* species, seeds with wings obscured by leaf litter were more likely to escape seed predation. Another study has also found that winged seeds whose wings are shed or obscured by leaf litter are less likely to be predated (Vander Wall, 1994). However, when removal speed of *Pinus jeffreyi* Balf. seeds both with and without wings were compared, it was found that winged fruits were found and removed faster than wing-removed fruits (Vander Wall, 1994). We suspect that the difference lies in our more complex environment of seeds and granivores than Vander Wall's system where predators were specifically targeting the most commonplace seeds in their local environment.

Ultimately the samara wing encasing the seed will rot away, releasing the seed itself in a manner mimicked by our experimental excising. The rate at which this happens has not been studied and is likely strongly influenced by aspects of the microhabitat such as dampness. Samaras tend to be shed from a single tree over an extended period of up to several months, so our experimental situation of simultaneous free and encased seeds may mimic a situation where early-released samaras have rotted away and the released seeds mingle on the ground with later-released samaras. Our experiment suggests not just that the samara may offer an anti-predatory benefit to the seed it encases, but later-falling samaras may offer some protection (through physically covering) seeds released from earlier-falling samaras. Further exploration of the importance of this effect would be greatly aided by investigation of the rate of samara decay.

In summary, our experiment shows that in an environment where a broad array of seeding plant species support a diverse group of granivores – that the samaras that some plants produce may offer protection from granivores on the ground as well as aiding in wind-borne initial dispersal to the ground. Greater exploration of post-primary-dispersal processes is warranted to improve current understanding of the evolution of selective pressures on samaras.

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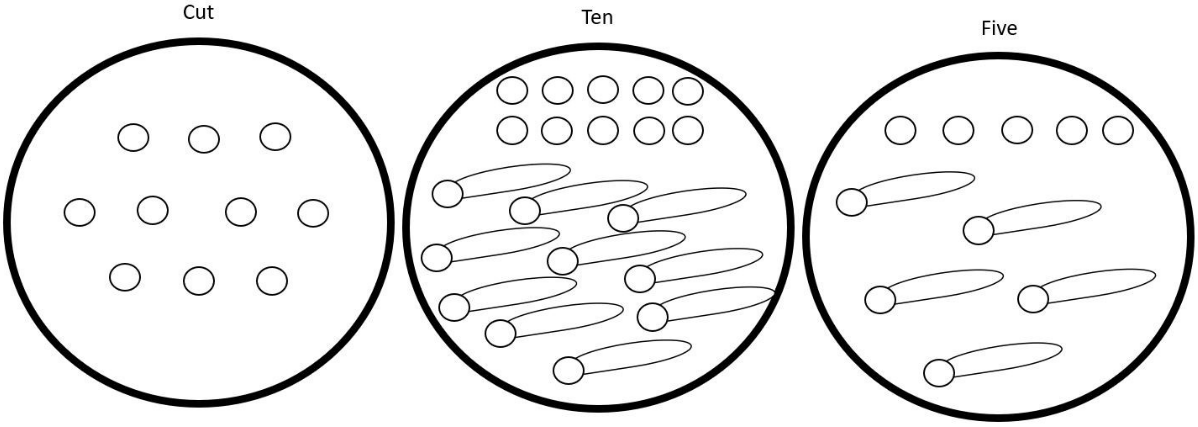

**Figure 1.** Experimental set-up. The small circles indicate wing-removed fruits while the more complex shapes indicate whole fruits. Petri dishes were alternated on the transect in this order ("cut", "ten", "five").

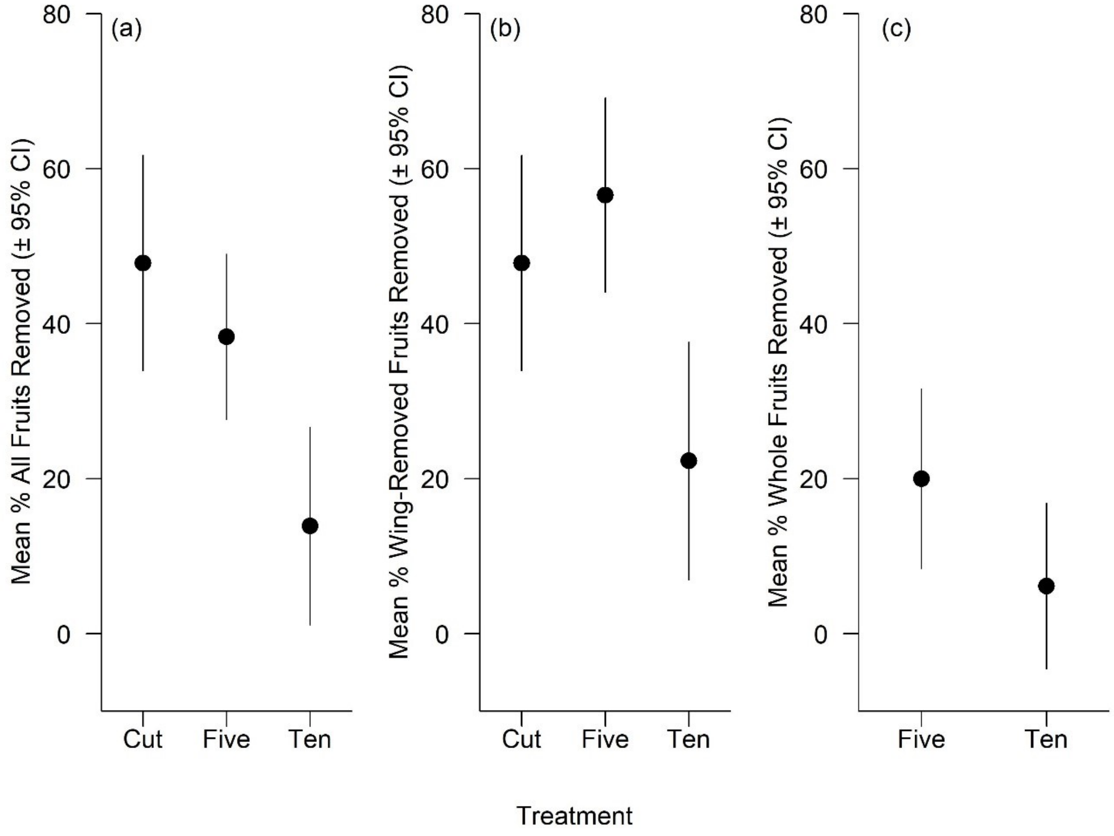

**Figure 2. (A)** Percentage of all samaras (wing-removed fruits and whole fruits) removed per treatment. Fewer fruits were removed from the "ten" treatment than either of the other treatments. **(B)** Percentage of wing-removed fruits removed per treatment. Fewer seeds were removed from the "ten" treatment than either of the other treatments. **(C)** Percentage of whole fruits removed per treatment. Fewer fruits were removed from the "ten" treatment than from the "five" treatment.