Adaptations of *Desmos chinensis* (Annonaceae) fruits for promoting spatial and temporal separation of seedlings

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Abstract

Although apocarpy (unfused carpels) reduces pollination success, it was hypothesized that it retains in most species in Annonaceae as latter development of fruit traits promote spatial and temporal separation of seedlings, which compensate for constraints in genetic variation by floral structures (Saunders, 2020). Apocarpous *Desmos chinensis* (Annonaceae), which disperses as single-seeded segments of monocarps (called as 'fruitlets' below), was investigated in this study for its dispersal way by birds, characteristics of constriction sites between fruitlets and change in seed germination rate as fruit ripens. Results show that changes in fruit colour and mechanical strength of constriction sites during fruit ripening may promote temporal separation of seed dispersal by birds, while it is hypothesized that the lower extensibility and water proportion of constriction sites between overripe seeds may be adaptations for spatial separation of fruitlets in regions with low seed disperser density.

Introduction

Apocarpy (unfused carpels) is likely to reduce pollination success as pollen tube growth across carpels is often impossible, leading to the failure of some carpels to form seeds (Endress, 1982; Saunders, 2020). It was hypothesized that apocarpy is retained in most early divergent angiosperms, as it is selected for latter development of fruit traits that encourage the independent and distant dispersal of fruits and seeds (Saunders, 2020). In Annonaceae, an apocarpous species dominating family, it has been shown that having fruits dispersing through single-seeded segments of monocarps (referred to as 'fruitlets' below), are correlated with higher diversification rates (Xue et al.,2020). Therefore, adaptations of bird-dispersed species *Desmos chinensis* (Annonaceae), which disperses by fruitlets, is investigated in this study.

Four hypotheses on *D. chinensis* fruit traits tested in this paper: (1) fruitlets are the dispersal units of *D. chinensis* and frugivorous birds show different preferences to fruitlets of different colours (and hence different stages of maturation); (2) there is a decrease in the mechanical strength required to separate fruitlets as they become more mature; (3) there are variations in water content of constriction sites between fruitlets of different colours that may affect the ease of abscission zone breakage; (4) there are no differences between germination percentage of seeds from fruitlets in different colours.

Materials and Methods

D. chinensis monocarps progressively matures from apex to base.

Ripeness of *D. chinensis* fruitlets were represented by their exocarp colour and surface wrinkles, fruitlets classified into: 'greenish yellow' (simplified as 'Y'), 'orange' ('O'), 'red' ('R'), 'black' ('B') and 'overripe' ('OV').

Immature fruit

Ripening fruit

Fully ripened fruit, with black wrinkled overripe fruitlets

Field studies and fruit collection of *D. chinensis* were undertaken from October 2021 to February 2022 in 7 field sites.

Field observation

- Two 90-minute-long fixed-point field observations were done for observing fruitlet consumption behaviour by birds
- Bird species, length of time the bird spent on each monocarp and fruit, also number and colour of single-seeded segments consumed were recorded for each bird visit

Tensile strength of constriction sites (n = 121 monocarps)

- Measured using Texture analyzer with 180 Degree Peel Rig fixture
- Monocarps pre-treated by embedding the two ends in cylinders of wax to prevent tensile grips from damaging fleshy fruitlets before test

Water proportion of constriction sites (n = 455 constriction sites)

- Calculated as: [(fresh weight - dry weight) / fresh weight] ✕ 100%
- Constriction sites dehydrated using oven at 70 °C until weight is stable

Non-parametric Kruskal–Wallis test and Post hoc Dunn's test were performed to identify any pairs of significantly different medians.

Germination experiment (n = 80 seeds)

- Seeds were planted in moist soil in partially sealed plastic zip bags in the laboratory in December after removal of pulp
- Germinated seeds (with appearance of the radicle) were counted in mid-March

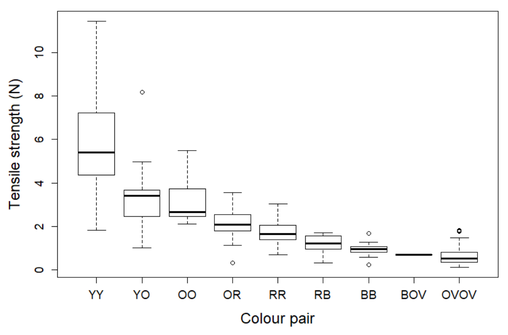
Results and Discussion

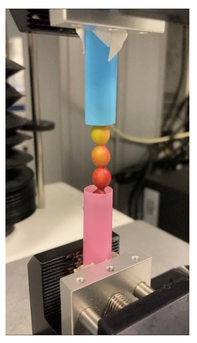
Field observation

- Four bird visits by red-whiskered bulbuls (*Pycnonotus jocosus*) were recorded, birds showing pulling and twisting actions to fruitlets
- Only black fruitlets from the outermost part of monocarps were consumed

Tensile strength of constriction sites

- Decreasing trend in tensile strength shown, significant differences between medians exist between most colour groups





- Median of extensibility of OVOV constriction sites is significantly lower than extensibility of constriction sites in other colours except BOV

Water proportion of constriction sites

- Median of water proportion of OVOV is significantly lower comparing to most colour groups

Germination experiment

- The germination percentages of seeds from fruitlets in different colours are similar, all among 75-100% with no increasing nor decreasing trend shown

→ Delay in visual cue recorded (indication of fruit maturation VS seed maturation), may help in reducing dispersal of unviable seeds

Hypothesis: during fruit ripening:

Change in visual cue (preference of birds on fruit colour) +
Mechanical strength (increase in ease of constriction site breakage)
→ Encouraging temporal separation of fruitlet consumption event by birds and thus temporal and spatial separation of seedlings

Hypothesis: seed dispersal in regions with low seed disperser density:

Significantly lower water content of constriction sites between overripe seeds
→ Brittle (low extensibility) OVOV constriction sites encourage separation of fruitlets and their rolling to different directions after fruit falling → promoting spatial seed dispersal

References

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