Myanmar Star Tortoises *(Geochelone platynota*) as Potential Agents for Seed Dispersal

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Abstract

Seed dispersal by animals is a critical plant–animal mutualism, but saurochory (seed dispersal by reptiles) among chelonians is largely understudied. Seed dispersal by Myanmar Star Tortoises (*Geochelone platynota*) was investigated at Minsontaung Wildlife Sanctuary by using a combination of fecal analysis and germination experiments that will compare treatment (seeds ingested by tortoises) and control (seeds not ingested by tortoises) groups. In the germination test of *Ziziphus oenoplia* (Taw Zee), *Acacia catechu* (Sha) and *Azadirachta indica* (Ta–mar), germination percentages (percent of seeds that germinated during the experiment) of treatments (seeds recovered from tortoises) are greater than that of controls (uneaten seeds). The germination rate of *Ziziphus oenoplia* (Taw Zee), *Acacia catechu* (Sha) and *Azadirachta indica* (Ta–mar) seeds did not differ significantly. This study suggests that *G. platynota* may an important role as a dispersal agent in the restoration of forest at Minsontaung Wildlife Sanctuary in dry zone of Myanmar.

Keywords: seed dispersal; saurochory; Myanmar Star Tortoise; germination; dry zone

Introduction

Seed dispersal is critically important for forest restoration. Seeds are offspring of the adult parent plants. These seeds fall under the parent plants without seed dispersal activities. Therefore the competition occurs between the parents and the offspring to use the same resources such as nutrients and water. The offspring cannot get enough amount of sunlight and it does not difficult for germinate and early.

Seed dispersal by animals is a critical plant–animal mutualism that plays an important role in the gene flow, demography, distribution, and evolution of plants (Howe and Smallwood, 1982).

The falling of seeds beneath the parent plant may result in seedling facing competition, risks of inbreeding and being infected with diseases (Fragoso *et al.*, 2003). Chelonochory may be an important dispersal mechanism for plants considering many turtles and tortoises consume a variety of seeds and fruits (Ernst and Barbour, 1989).

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Mammals and birds are considered the main seed dispersal agents in tropical forests (Jordano, 2001), where most plants have fruits adapted to animal dispersal (Howe and Smallwood 1982). Although the studies conducted in arid regions indicated that tortoises of family Testudinidae may be effective seed dispersal agents (Lui *et al,* 2004), in tropical forests the role played by this group in seed dispersal has received little attention (Guzman and Stevenson, 2008).

The role played by chelonians (tortoises and turtles) in forest dynamics through seed dispersal and seedling recruitment has been largely over–looked by investigators (Traveset, 1998). No attempt has been previously made on seed dispersal by *G. platynota* yet, so the present research was conducted on *G. platynota* at Minsontaung Wildlife Sanctuary. The present study was carried out with the following objectives:

–to investigate which species of plants –if any –are dispersed by *Geochelone platynota*

–to study the effect of digestive tract of tortoise in different seed germinations at Minsontaung Wildlife Sanctuary.

Material and Methods

Study area

This study was conducted in Minsontaung Wildlife Sanctuary (21°24'–21°27'N and 95°46'–95°49'E) which is located in Natogyi Township, Myingyan District, Mandalay Region. The sanctuary was established in 1998–99 and comprises 2260 ha (8.7 sq mi). The topography of Minsontaung Wildlife Sanctuary is dominated by Minsontaung (=mountain), an isolated hill mass that rises to a maximum elevation of 398 m. The dominant flora is dry forest with abundance of Than (*Terminalia oliveri*) and Dahat (*Tectona hamiltoniana*) but occurred *Ziziphus oenoplia* (Taw–Ze), *Azadirachta indica* (Ta–mar), *Acacia catechu* (Sha) and *Leucaena glauca* (Bawza–gaing).

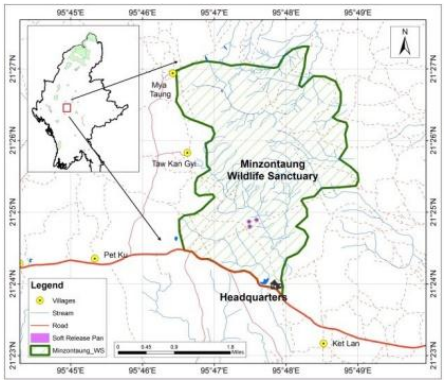

Fig 1. Map of Study Area (Minsontaung Wildlife Sanctuary)

Study Periods

The study period was lasted from January 2018 to December 2019.

Germination experiments

Methods

To determine which species of plants disperses by *Geochelone platynota,* feces were collected directly from tortoises being monitored as part of an on–going reintroduction project at Minsontaung Wildlife Sanctuary (Platt &Platt, 2016). Tortoises generally defecate upon capture while being handled. In addition, untagged tortoises were collected in the wild and brought back to the station for overnight defecation. Then, seeds from fruits (or foliage) ingested by tortoises were recovered by washing feces in fine–mesh sieve. Seeds were identified by direct comparison with fruits collected in the study area. Once identified, seeds were planted in soil–filled trays to determine if passage through the digestive tract affects germination (treatment group). For comparison, seeds collected directly from parent plants that have not been ingested by a tortoise were planted alongside the treatment group. Planting methods were different from natural conditions (e.g, garden soil, seeds buried rather than placed on surface, etc) but seeds of different treatments were subject of uniform germination conditions. All germination trails for the same species began on the same date and were terminated when the seed never germinated.

Results

A total of 97 feces were collected from January 2018 to December 2019. The seeds of 7 species of plants were recovered from the tortoises' feces. Among them, seeds of three species were selected for germination experiments because of the occurrence of seeds in the feces of the tortoises and the sufficient number of mature seeds which were available from local plants at the period of the experiments.

Ziziphus oenoplia (Taw–Ze)

The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 70 (±10.95) and 40 (±17.88), respectively in 2018 (table 1). The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 60 (±17.88) and 46.66 (±24.22), respectively in 2019 (table 1). There was significantly different among the four treatments (ANOVA; $F(3, 20) = 3.218$, $P= 0.045$) after 2018 and 2019 data was pooled. Germination percentage of seeds from feces was significantly greater than control seeds (2018) and control seeds (2019) (Post Hoc LSD, $P= 0.01$ and 0.04 respectively. There were no differences in germination rate among all treatments (Table 1).

Azadirachta indica (Ta–mar)

The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 60 (±17.88) and 53 (±24.22), respectively in August 2018 (table 2). The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 37.5 (±17.88) and 25 (±24.22), respectively in August 2019 (table 2). There was marginally significant differences among the four treatments (ANOVA; $F(4, 31) = 2.474$, $P = 0.065$) after 2018 and 2019 and data was pooled. The germination rates were not different among treatments (Table 2).

Acacia catechu (Sha)

The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 66.66 (±24.22) and 60.0 (±28.28), respectively in March 2019 (table 3). The mean germination percentage for seeds recovered from the tortoises' feces and control seeds was 72.0 (±23.47) and 56.0 (±20.65), respectively in August 2019 (table 3). There was no significant difference among the four treatments (ANOVA; $F(3, 28) = 0.840$, $P = 0.483$) after 2018 and 2019 and data was pooled. The germination rate did not differ among all experiments (Table 3).

Table. 1. Results of germination test of seeds from feces and uneaten seeds for *Ziziphus oenoplia*

Germination rate (weeks)	(seeds from feces)	(uneaten seeds)	(seeds from feces)	(uneaten seeds)
1	0	0	0	0
2	0	0	0	0
3	9	8	7	5
4	10	4	8	4
5	2	0	3	5
6	0	0	0	0
Total (percent) Germinated	21 (70.0%)	12 (40.0%)	18 (60%)	14 (46.66%)
No. Seeds Overall	30	30	30	30

Table. 2. Results of germination test of seeds from feces and uneaten seeds for *Azadirachta indica*

Germination rate (weeks)	(seeds from feces)	(uneaten seeds)	(seeds from feces)	(uneaten seeds)
1	0	0	0	0
2	0	4	9	1
3	3	7	3	6
4	7	5	0	1
5	4	0	0	0
6	4	0	0	0
7	0	0	0	0

Total (percent)	18 (60%)	16(53.3%)	12 (37.5%)	8 (25%)
No. Seeds Overall	30	30	32	32

Table. 3. Results of germination test of seeds from feces and uneaten seeds for *Acacia catechu* (Sha)

Germination rate (weeks)	(seeds from feces)	(uneaten seeds)	(seeds from feces)	(uneaten seeds)
1	9	1	0	0
2	7	6	10	6
3	3	10	7	10
4	1	1	11	3
5	0	0	8	7
6	0	0	0	2
7	0	0	0	0
Total (percent) Germinated	20 (66.66%)	18 (60.0%)	36 (72%)	28 (56%)
No. Seeds Overall	30	30	50	50

Discussion

Seed dispersal is critically important for forest restoration. Seeds obtained from fecal samples revealed to be those of *Ziziphus oenoplia, Azadirachta indica, Acacia catechu, Diospyros burmanica, and* three kinks of grasses species. Myanmar star tortoises dispersed *Ziziphus oenoplia, Azadirachta indica, Acacia catechu* plant species in Minsontaung Wildlife Sanctuary because these seeds were found in the feces of tortoises.

Seeds which land at a distance from the parent plants will have greater survival success than those which fall beneath the source plants (Howe and Smallwood, 1982). Myanmar star tortoises are capable of retaining seeds in digestive tracts from 3 days to 23

days. Thanda Swe (2004) recorded that Myanmar star tortoises moved from 56 (m) to 211.041 (m) per day. So, Myanmar star tortoises may also disperse seeds by transporting seeds away from the parent plants.

Ingestion by *Geochelone platynota* altered the proportion of seeds that germinated for all species. The effects of ingestion by chelonians (Lui *et al*. 2004) and other vertebrates (Traveset, 1998) have recorded similar results. The higher germination percentages of tortoises ingested seeds in comparison to uneaten seeds indicates that tortoises digestion enhances germination. Joanne Braun and Brooks (2004) noted that five species (*Arisaema triphyllum, Podophyllum peltatum, Phytolacca Americana, Prunus serotina* and *Vitis aestivalis*) had higher germination percentages for ingested than non ingested seeds. Myanmar star tortoises might act the same manner.

The study showed that tortoise gut's passage enhanced seed germination percentage. Seeds from the feces had higher percentage of germination as compared to uneaten seeds in recent germination tests. This agreed with Rick and Bowman (1961), who described that the gut passage of Galapagos tortoises improved the germination of the Galapagos tomato seeds. Liu *et al*.(2004) reported that the gut passage of the Florida box turtle (*Terrapene Carolina bauri*) greatly enhanced the germination percentage and germination rate of *Serenoa repens* seeds but decreased the germination percentage of *Thrinax morrissii* and *Byrsonima lucida* seeds.

The results are different due to the different tortoise species and seeds species used in the studies. However, seed dispersal is important in that seeds may escape distance and density dependent predation below parental plants (Connel, 1970).

In other studies of reptile–mediated seeds dispersal, there were no differences in germination rate between seeds from the feces and uneaten seeds (Moll and Jansen, 1995; Harley *et al*. 2000). In recent results, the rate of germination was not significantly different between treatments and controls in all plants species.

Seed dispersal is important in that seeds may escape distance and density dependent predation below parental plants and therefore have higher survival probabilities (Connel, 1970). So Myanmar Star Tortoises may be regarded as the important disperser agents in the restoration of forests in dry zone ecosystem.

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