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Population characteristics, germination and proposed management of *Elaeocarpus joga* Merr. on Guam: a regionally endemic tree.

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Abstract—Seventy *E. joga* Merr. trees were measured in native limestone forest habitat. The population is highly skewed towards large, mature trees; eighty-four percent of the trees were over 30 cm diameter at breast height (DBH). Fruit production was high but natural recruitment seemed to occur rarely with only 11 seedlings recorded. The probable factors affecting *E. joga* demography, such as lack of dispersal, introduced ungulates, and high insect concentrations are discussed. Techniques for seed extraction and germination are presented. Based on the results of this study, we offer recommendations for the integrated management of this tree species.

Introduction

Elaeocarpus joga Merr. occurs only on Guam and Rota in the Mariana Islands and Palau in the western Caroline Islands. On Guam, it grows on limestone and limestone-based soils identified as Ritidian-Rock outcrop complex and Guam cobbly clay loam soils, respectively (Young 1988). It is a large tree (up to 15 m tall) with distinct horizontal and pagoda-like branching (Stone 1970). Larger edible fruits, many seeds falling near the parent tree, and a dense seedling bank beneath the parent tree characterize many tropical climax tree species (Whitmore 1992). While *E. joga* fruits are relatively small, this tree can be considered a climax species on Guam. However, seedling banks beneath parent trees are absent. Schreiner (1997) observed this as well and identified a high incidence of feral pig (*Sus scrofa*) sign at *E. joga* trees on Guam. The population characteristics and factors adversely affecting *E. joga* are similar to those identified in the decline of *Serianthes nelsonii,* a federally endangered tree now represented by only one mature naturally occurring tree on Guam (USFWS 1994, Wiles et al. 1996).

Significant populations of native birds and fruit bats, historically likely to have been responsible for seed dispersal and perhaps seed viability, are now lacking from Guam's forest due to the brown tree snake (*Boiga irregularis*) predation (Savidge 1986, Wiles et al. 1995). Adequate control of insect populations is probably not occurring due to the almost complete loss of insectivorous birds and changes in the lizard community as a result of brown tree snake predation and

lizard introductions. (Rodda & Fritts 1992, Campbell 1996). Introduced pigs (*S. scrofa*) and deer (*Cervus mariannus*) are known to feed on a variety of native plants, seeds, and fruits (Wheeler 1979, Conry 1989). As a result, some mature native trees manage to survive under several adverse elements, with little or no population recruitment.

Raulerson & Rinehart (1991) suggested that in order for *E. joga* seeds to be viable naturally, fruits probably needed to pass through the digestive system of "pigeon-sized" birds. The digestive processes may contribute to the thinning of or penetrate the hard interior endocarp that encloses the seeds. Viable populations of Mariana fruit-doves (*Ptilinopus roseicapilla*) and white-throated ground-doves (*Gallicolumba xanthonura*) have not occurred on Guam since 1986, and localized populations of introduced Philippine turtle doves (*Streptopelia bitorquata*) continue to be impacted by brown tree snake predation (Conry 1988). The only surviving large native bird is the Mariana crow (*Corvus kubaryi*) and an estimated 16 crows still survive on Guam (C. Aguon pers. comm). While crows are known to feed on *E. joga* fruits (C. Aguon, pers. comm.), their role in dispersal and the role of digestive processes and seed viability are unknown. Mariana fruit bats (*Pteropus mariannus*) still occur on Guam in a small colony of approximately 150-300 animals. While they are reported to feed on fruits and flowers of *E. joga* (Wiles and Fujita 1992), their role in fruit dispersal or seed viability is unknown.

Field studies suggest that insect damage, herbivory by introduced ungulates, and lack of dispersal are factors affecting recruitment of *E. joga.* In this study we present the first data substantiating a skewed demography for *E. joga*, probable reasons for the lack of regeneration, and a simple technique for germination. We consider this an important initial step towards understanding and managing *E. joga* on Guam, as well as the island's native forests.

Methods

Study Area

Mature *E. joga* trees were located on limestone-based substrates along Route 3A and the FAA access road in northern Guam and along the High Road at the U.S. Navy Ordnance Annex in southwest Guam (Figure 1). The woody plants growing on this substrate require a long time to form into an integrated community (Raulerson & Rinehart 1991). Common trees in the study area include *Aglaia mariannensis, Piper guamensis, Guamia mariannae, Pandanus tectorius, Eugenia reinwardtiana,* and *Triphasia trifolia. E. joga* were measured for diameter at breast height (DBH), seedling searches were conducted, and three trees in northern Guam served as seed sources. Seed density was determined by randomly tossing a 0.5 m^2 quadrat one time beneath trees that had recently produced fruits. All fruits with in the quadrat were counted and the count was converted to 1 m^2. Insects were observed but not collected or identified beneath naturally occurring trees and in containers of planted seeds.

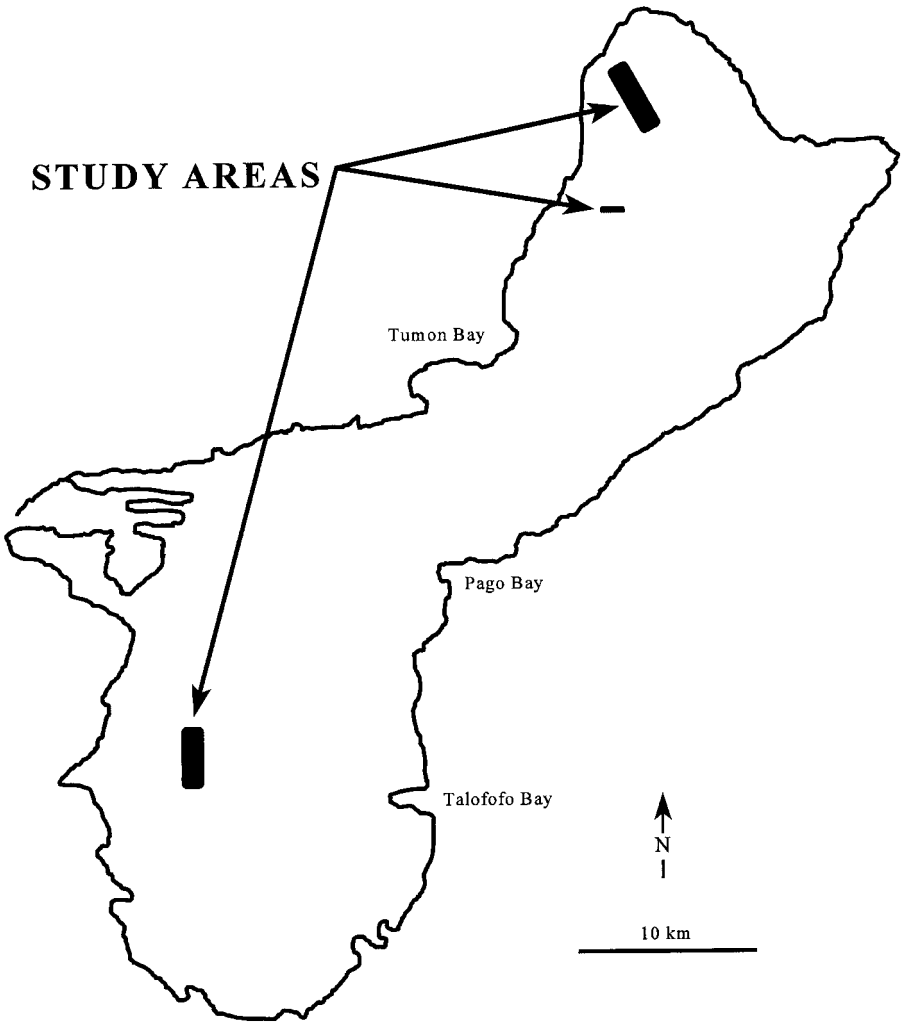

Figure 1. Map of Guam showing the location of study areas for *E. joga* Merr. along Route 3A and the FAA access road in northern Guam and the High Road at the U.S. Navy Ordnance Annex in southwest Guam.

Seed Preparation and Germination

The thin exocarp and hard/fibrous mesocarp were removed down to the hard endocarp. The endocarp was allowed to dry for 2–4 days in an air-conditioned room prior to seed extraction. A vice-grip was used to carefully compress the endocarp so that splitting would occur lengthwise. Smaller pieces of the endocarp still containing seeds were similarly split. Endocarps that were split without drying did not cleave well and seed damage and loss was high. Initially, an attempt was made to extract as many seeds as possible from each endocarp; this was pos-

sible but time-consuming. Therefore, some endocarps were simply split open to expose only one or more seeds.

The germination trials occurred at the primary author's residence in northern Guam. A combination (3:1) of commercial potting soil and local loam soil were mixed together and placed in standard black 20 cm-high seedling bags with drainage holes. Fifty seeds and approximately 10 split endocorps were planted approximately 1.3 cm deep or left on the soil surface and were given minimal care. The bags with seeds were then placed 61–91 cm off the ground on a wooden and wire mesh bench beneath a canopy of tangen-tangen (*Leucaena leucocephala*) and *Hibiscus tiliaceus.* The bench and seedlings bags were adjacent to a maintained yard. Seeds were hydrated with tap water as needed and exposed only to some late afternoon sun.

Results

The trees measured had a mean DBH of 53.9 cm (SD = 26.7, n = 70), with most trees (84%) having diameters ranging from 30 to 140 cm (Figure 2). Only 4% (n = 3) of the trees had DBHs < 15 cm. The pattern of sizes was similar between the north and south study areas. Searches resulted in only 11 seedlings under three trees. The most recorded under any tree was eight. An initial measurement of fruit production yielded 174 fruits per m^2 (n = 3, SD = 66), which we considered high.

Most fruits used in germination trials had 3–4 seeds, but some contained 5. On average, fruits measured 16 mm in diameter and seeds measured 8.6 × 3.6

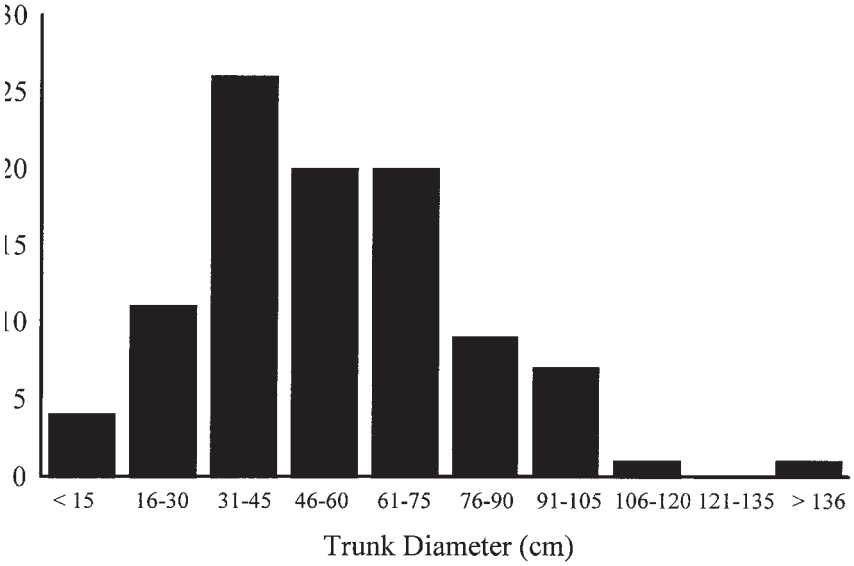

Figure 2. Distribution of trunk diameters (DBHs) of *Elaeocarpus joga* Merr. (n = 70) on Guam, Mariana Islands, in 1997.

mm. Germination took up to 3 weeks but was common in both seeds and split endocarps. Approximately 80% of loose seeds germinated and in 80% of the split endocarps at least one seed germinated. Based on field observations of fruits that had fallen beneath parent trees, we identified ants and beetles as being able to penetrate into the endocarp and eventually destroy the seeds. During germination trials, insects, particularly ants, destroyed many loose seeds as well as seeds in endocarps.

Discussion

Field observations identified high fruit production but lack of recruitment and an absence of a seedling bank under or near canopies of mature *E. joga* trees in several study areas. General observations indicate that this problem occurs island-wide. These characteristics are similar to those seen in the population of *S. nelsonii*, another native tree species in decline, which is also impacted by introduced ungulates and insects (USFWS 1994, Wiles et al. 1996). Fortunately, the distribution and abundance of large *E. joga* trees are such that a localized catostrophic event (e.g. severe typhoon, forest fire) would not jeopardize the population on Guam. However, management of existing trees to enhance seed viability would likely prevent localized extinctions.

Based on field observations we suspect that insects are the primary factor preventing the establishment of seedling banks under mature trees. We concur with Schreiner (1997) that herbivory, mastication of fruits and seeds, and indiscriminate rooting and wallowing by introduced pigs and deer are likely also occurring. The germination trials results suggest that away from naturally occurring trees, high germination rates are possible.

Concentrations of insects may be higher under fruiting trees where food resources are most abundant. The complete loss of insectivorous birds and changes in the lizard community only exacerbates these concentrations. We believe that insects are the primary factor affecting recruitment of *E. joga*. Identification and control of insects would be directly applicable to all trees and may provide useful information of entire forest communities over larger geographic areas. Dispersal of fruits away from mature trees may increase the likelihood of successful seed germination (Whitmore 1992) but the lack of birds and fruit bats likely precludes this from occurring. The role that introduced pigs and deer may play in *E. joga* fruit dispersal is unknown. A few seeds are able to germinate under mature trees but the lack of sapling-size *E. joga* indicates that either direct mortality as a result of insect and ungulate herbivory prior to germination or indirect mortality as a result of indiscriminate rooting and trampling by ungulates is occurring.

Based on this study we offer the following recommendations for management of *E. joga*:

1. Construct ungulate exclosures beneath the crowns of mature trees to provide protected sites for fruits and seeds. This method of ungulate control has been

successful in the area surrounding the only naturally occurring *S. nelsonii* on Guam, but insects still need to be controlled.

2. Use local fruits as a source of seed stock for propagation. Our results show that native seeds are viable and easily germinated. Diseases, viruses, and degradation of local genotype as a result of importing seeds are issues that would only compound the management of *E. joga.*

3. Develop a nursery for propagating *E. joga,* as well as other native forest trees.

4. Disperse fruits to known locations in the wild and monitor germination success. We view this as a quasi-natural action to remove fruits from areas of high insect concentrations under mature trees to areas we suspect will have lower insect concentrations, where no *E. joga* are presently located.

Our observations and conclusions are based on data from one native tree species. Studies of other native trees on Guam and a comparative study of *E. joga* on Rota or Palau to assess the demographic structure and level of recruitment in these populations where most species of birds and fruit bats persist at relatively normal densities may reveal that the characteristics of *E. joga* on Guam, such as skewed demography and lack of recruitment under mature trees, are typical. However, we strongly suspect that the presence of introduced ungulates and insects along with the lack of fruit bats and birds is adversely affecting *E. joga,* as well as other native trees on Guam.

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References

Campbell, E. W. 1996. The effects of brown tree snake (*Boiga irregularis*) predation on the island of Guam's extant lizard assemblages. Unpublished PhD dissertation, The Ohio State University, Columbus, Ohio. 91 pp.

Conry, P. J. 1988. Ecology of the wild (feral) pig (*Sus scrofa*) on Guam. Technical Report 7, Division of Aquatic and Wildlife Resources, Mangilao, Guam. 60 pp.

Conry, P. J. 1988. High nest predation by brown tree snakes on Guam. Condor 90: 478–482.

Raulerson, L. & A. Rinehart. 1991. Trees and Shrubs of the Northern Mariana Islands. Coastal Resources Management, Saipan. 120 pp.

Rodda, G. H. & T. H. Fritts. 1992. The impact of an introduced colubrid snake *Boiga irregularis* on Guam's lizards. Journal of Herpetology 26: 166–174.

Savidge, J. A. 1987. Extinction of an island forest avifauna by an introduced snake. Ecology 68: 660–668.

Schreiner, I. H. 1997. Demography and recruitment of selected trees in limestone forest of Guam in relation to introduced ungulates. Micronesica 30: 169–181.

Stone, B. C. 1970. The flora of Guam. Micronesica 6: 1–659.

U.S. Fish and Wildlife Service. 1994. Recovery plan for *Serianthes nelsonii.* U.S. Fish and Wildlife Service, Portland, Oregon. 46 pp.

Wheeler, M. E. 1979. The biology of the Guam deer. Technical Report 3, Division of Aquatic and Wildlife Resources, Mangilao, Guam. 53 pp.

Whitmore, T. C. 1992. An introduction to tropical rain forests. Clarendon Press, Oxford. 226 pp.

Wiles, G. J. & M. S. Fujita. 1992. Food plants and economic importance of flying foxes on Pacific islands. *In* D. E. Wilson, G. L. Graham (eds), Pacific Islands flying foxes: Proceedings of an International Conservation Conference. U.S. Fish and Wildlife Service, Biological Report 90(23): 24–34.

Wiles, G. J., C. F. Aguon, G. W. Davis & D. J. Grout. 1995. The status and distribution of endangered animals and plants in Northern Guam. Micronesica 28: 31–49.

Wiles, G. J., I. H. Schreiner, D. Nafus, L K. Jurgensen & J. C. Manglona. 1996. The status, biology, and conservation of *Serianthes nelsonii* (Fabaceae), an endangered Micronesian tree. Biological Conservation 76: 229–239.

Young, F. J. 1988. Soil Survey of Territory of Guam. Soil Conservation Service, U.S. Department of Agriculture, Guam. 166 pp.

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