

[Special Feature]

Exotic Seeds on the Feathers of Migratory Birds on a Stopover Island in Korea

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ABSTRACT: Migratory birds, by crossing significant ecological barriers, carry and may subsequently introduce exotic seeds into new ecological zones during period of migration. The study of epizoochory, which includes seed dispersal by adhesion to bird feathers, has been relatively neglected compared to the study of seed dispersal by frugivores. To determine whether exotic seeds are being imported to stopover islands by migrating birds, and to estimate the quantity of seeds of exotic species being introduced, we examined migratory birds that were captured in mist nets for attached exotic plant diaspores in 2008 and 2009 on Hongdo Island, Korea. From a total of 3,947 birds examined, we found exotic seeds of Japanese Chaff Flowers (*Achyranthes japonica*) attached to three species of migratory birds (0.08%; Eurasian Bittern *Botaurus stellaris*, Swinhoe's Rail *Coturnicops exquisitus* and Oriental Turtle Dove *Streptopelia orientalis*). Despite the low occurrence of *A. japonica* seeds on the external parts of birds, the results suggest that migratory birds may be potential dispersing agents for *A. japonica*, a species that is currently threatening native ecosystems on many islands in Korea.

Key words: epizoochory, Japanese Chaff Flower (*Achyranthes japonica*), seed dispersal, Hongdo Island

INTRODUCTION

Seed dispersal is the process of departure of seeds away from the parent plant (Howe and Smallwood 1982). Because plants have relatively limited mobility, external agents are often involved in the transport of plant fruits and seeds. Although some plants with explosive fruits or creeping diaspores have the ability to self-disperse their seeds, the major dispersal agents for most plant species are water, wind, and animals (Howe and Smallwood 1982). Among these agents, animals can disperse seeds in a variety of ways. For example, seeds can be dispersed by scatter-hoarding birds, mammals, and ants (Sorensen 1986). Moreover, endozoochory or the dispersal of seeds through the digestive tract of frugivores, that consume fruits and swallow seeds, is a common and well-documented mutualistic interaction between animals and plants subsequently dispersing seeds (Howe and Smallwood 1982, Sorensen 1986, Jordano 1995, Fukui

2003). However, seed dispersal by adhesion on animal fur and feathers, known as epizoochory, is also a distinctive dispersal mechanism, because epizoochorous fruits or seeds do not provide the dispersing agent with a nutritional or energetic reward (Sorensen 1986).

Many researchers have focused on the ecological functions of endozoochory and the nature of mutualistic interactions between animal dispersers and plants (e.g., Jordano 1995, Fukui 2003), while epizoochory has only been investigated to a limited extent (Sorensen 1986). However, epizoochorous seed dispersal seems to be the more important mechanism on islands because seeds dispersed by external adhesion have the potential for longer distance dispersal than do frugivores or wind-dispersed seeds (Vivian-Smith and Stiles 1994). At present, most evidence for epizoochorous seed dispersal is anecdotal or is concentrated on terrestrial mammals; only a few quantitative studies have focused on avian dispersers (Sorensen 1986, Vivian-Smith and Stiles 1994). In Korea, several studies have reported seed dispersal

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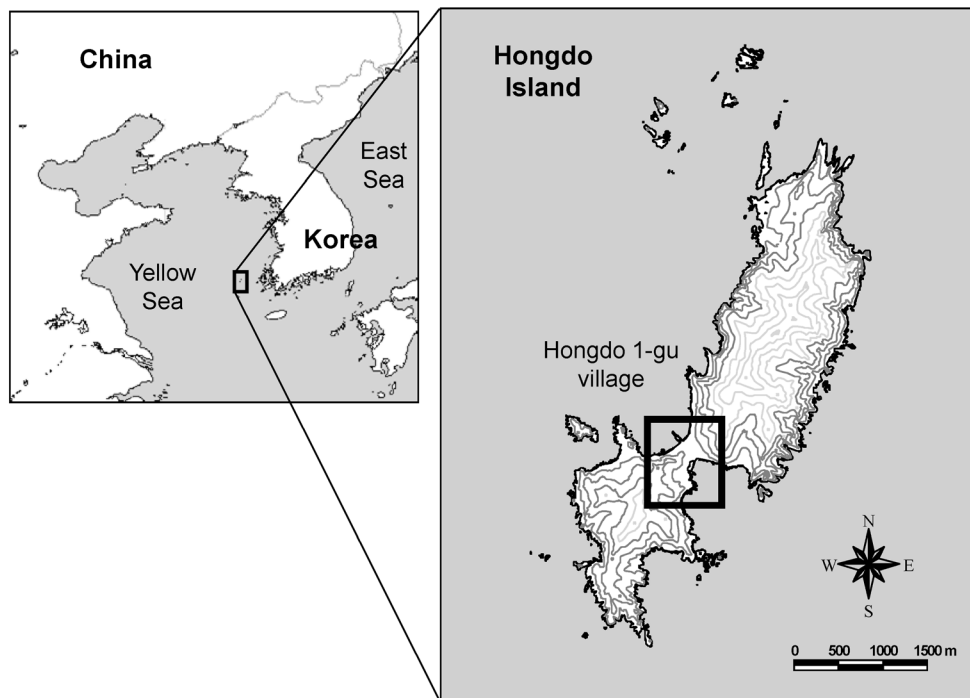


Fig. 1. Study area (Hongdo 1-gu village) on Hongdo Island, Shinan-gun, Jeonnam Province, Korea.

following passage through bird digestive systems (You et al. 1994, Choi and Chae 2007); however, to our knowledge there have been no reports of adhesive seed dispersal by birds.

Rose and Polis (2000) suggested five major types of interactions involving migratory and transient species on islands: predation, parasite and pathogen transmission, competition, zoogeomorphology, and cascading events. Among the migratory animal taxa, birds may act as particularly efficient dispersers of exotic seeds by traveling long distances and crossing significant ecological barriers such as seas and deserts. Therefore, avian migrants are thought to be responsible for the introductions of many exotic plants and may initiate cascading events on isolated islands by dispersing seeds (Vivian-Smith and Stiles 1994, Rose and Polis 2000).

In this study, we examined patterns of seed adhesion on the external parts of migrating birds that stopover on Hongdo Island to determine whether exotic seeds are being imported to stopover islands in Korea by adhesion to birds and to estimate the quantity of exotic seed being imported to these islands by migratory birds.

MATERIALS AND METHODS

Study Area

We conducted surveillance for epizoochorous diaspores

at Hongdo 1-gu on Hongdo Island, Shinan-gun, Jeonnam Province, Republic of Korea. Hongdo Island (N 34° 41', E 125° 11') is located 115 km from the southwestern part of the Korean Peninsula (Fig. 1). The island is an important stopover site for migratory birds during their migratory crossing of the Yellow Sea between Korea and China.

Epizoochorous Diaspore Surveillance

In 2008 and 2009, we set three mist nets (2.5 m × 12 m; mesh sizes: 32 and 38 mm) daily from 07:00 to 18:00 to capture migratory birds on Hongdo Island. Birds trapped from March to December were ringed, measured, and then released following the banding scheme of the Korean National Park Migratory Birds Center (NPMBC). We examined all birds captured for plant seeds on their external parts before their release, and collected samples of the seeds for subsequent species-level identification.

RESULTS

We trapped and examined a total of 3,947 birds from 117 species on Hongdo Island from March to December in 2008 and 2009. In 2008, plant diaspores were found attached to only two of 1,777 birds examined: one Eurasian Bittern (*Botaurus stellaris*) and one Swinhoe's Rail (*Coturnicops exquisitus*). Eighteen diaspores were attached to the nape, back, and crural feathers of the

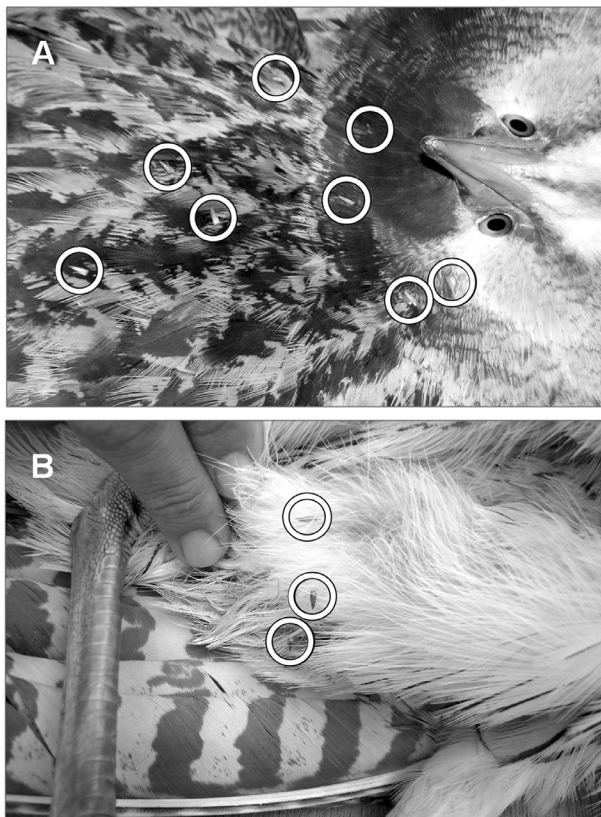


Fig. 2. Seeds of the Japanese Chaff Flower (*Achyranthes japonica*) attached on (A) back and (B) crural feathers of a Eurasian Bittern (*Botaurus stellaris*).

bittern, which was captured on 1 November 2008 (Fig. 2), and one diaspore was attached to the lore of the rail, which was captured on 2 November 2008 (Fig. 3). All of the diaspores found on these two migratory birds in 2008 were seeds of Japanese Chaff Flowers (*Achyranthes japonica*). In 2009, of the 2,170 birds examined, only one Oriental Turtle Dove (*Streptopelia orientalis*) captured in December bore a single seed of *A. japonica* on its tail feather.

DISCUSSION

The Japanese Chaff Flower (*Achyranthes japonica*) is a common perennial herb widely distributed in Korea, China, and Japan, and is used in traditional medicines and as a functional food additive due to its reported antibiotic and physiological effects (Jung et al. 2008). Although *A. japonica* is a native species in mainland Korea, it is considered an invasive species for many Korean islands. Over the past several decades, *A. japonica* has been introduced by feral domestic goats (*Capra hircus*) and humans onto islands where breeding colonies



Fig. 3. A seed of the Japanese Chaff Flower (*Achyranthes japonica*) attached on the lore of a Swinhoe's Rail (*Coturnicops exquisitus*).

of seabirds occur, particularly the Swinhoe's Storm Petrel (*Oceanodroma monorhis*) (Lee et al. 2009). It competes with native herbs and increases mortality and breeding failure rates among seabirds on the affected islands (Lee et al. 2009).

Our evaluation of epizoochory by birds on a migratory stopover island, confirmed that autumn migrating birds can bear seeds of the exotic plant, *A. japonica*. Eurasian Bitterns and Swinhoe's Rails, two of the bird species that bore seeds on their feathers in this study, are both wading birds often observed near grasslands, rice paddies, marshes, and wetlands (Lee et al. 2000), areas where *A. japonica* is typically found. The Oriental Turtle Dove, one individual of which was found carrying a seed in December 2009, is also a ground-feeding species. Although we have no information about the origins of the seeds found on the birds in this study, they have increased opportunities for contact with *A. japonica* during the autumn fruiting season which occurs prior to their departure from the mainland on their southward migration. Particularly, Eurasian Bitterns and Swinhoe's Rails migrate significant distances from breeding areas in Russia to wintering ranges in southern China (Lee et al. 2000), and could therefore disperse seeds of *A. japonica* to remote islands far from existing stands of the plant in mainland Korea.

Seeds of *Achyranthes aspera* have been transported by seabirds such as noddies (*Anous* spp.) and terns (*Sterna* spp.) to Aldabra Atoll in the Indian Ocean (Diamond 1979). Our observations suggest that some birds, especially wading birds (e.g., bitterns, egrets, herons, and rails) and ground-feeding non-passerines, may also transport exotic *A. japonica* to stopover islands through epizoochory. However, only 0.08% of the birds that

we examined here carried exotic diaspores, and only small numbers of diaspores were attached to the birds. Moreover, no passerines, which are the most abundant migrants in the study area, bore seeds on their plumage, which suggests that ground-dwelling or wading birds may be more important agents of epizoochorous seed dispersal due to their habitats and relatively larger body sizes. Previous studies of external seed loads have also suggested a more important role of seabirds (Diamond 1979) and waterfowls (Vivian-Smith and Stiles 1994) than passerines. Therefore, our results suggest that dispersal of exotic plant seeds via avian epizoochory occurs infrequently on stopover islands in Korea.

We conclude that migratory birds can bear, and may act as dispersers of seeds of exotic plants to stopover islands in Korea. Our study confirmed that feathers of three migrating non-passerines bore seeds of the exotic plant, *A. japonica*, an invasive species that is threatening native vegetations and breeding seabird colonies on remote islands. Because both the rate of occurrence of *A. japonica* seeds on the examined birds and the numbers of diaspores per affected individual were low, the rate of seed dispersal by migratory birds via epizoochory is probably low; epizoochory by birds may be less effective than seed dispersal by adhesion to humans or other large mammals. However, the possibility of transport of exotic seeds on migratory birds should not be overlooked, because infrequent visitors on islands may initiate cascading events that can influence island community structure and species succession with effects from the base of the island food web upward (Rose and Polis 2000) and because epizoochory has the potential to result in long distance seed dispersal (Vivian-Smith and Stiles 1994). Our findings reveal a new possible mechanism of *A. japonica* dispersal by birds, that should be considered by researchers and conservation managers attempting to eradicate exotic species and to restore native vegetation and seabird breeding colonies in Korea.

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