Impact of *Prosopis juliflora* on nesting success of breeding wetland birds at Vettangudi Bird Sanctuary, South India

Influence of exotic plant invasions on the structure and functional attributes of native ecosystems has been extensively documented and debated[1–3]. The complex interactions of invasive species with native ecosystems make invasion ecology an interesting and important area of research. *Prosopis juliflora* (family Mimosoideae) native to South and Central America was introduced in India to meet the fuel-wood requirements of the rural poor and to restore degraded lands[4]. Now it has become an aggressive weed in several parts of the country and poses a serious threat to native biodiversity[5]. Bird species and their habitats are declining worldwide[6] due to various threats, viz. habitat fragmentation, climate change, higher nest predation, etc.[7–9]. Changing ecological conditions across the globe are creating new threats to birds and identifying these emerging threats will help design suitable strategies to conserve them. Though *P. juliflora* occupies vast stretches in the country, its impact on nesting success of wetland birds has not been examined. Here we report the negative impact of *P. juliflora* on nesting success of birds in Vettangudi Bird Sanctuary (10°10′N and 78°20′E), which comprises three village ponds, viz. Periya and Chinna Kollukudipatti and Vettangudipatti in Sivagangai district, Tamil Nadu, South India. This sanctuary is protected by the Forest Department and also by the local community informally. The vegetation in the sanctuary is dominated by the exotic tree, *P. juliflora* and the native tree, *Acacia nilotica.*

Bird censuses are conducted annually in the sanctuary by the Forest Department normally in the month of January often involving students/scholars from local colleges and universities. The present authors participated in the census organized by the Forest Department in January 2011. The bird species were identified and recorded with the help of forest officials and local people (Table 1). The survey revealed 17 species from ten families of which 2 species, viz. *Anhinga melanogaster* and *Threskiornis melanocephalus* fall under the near threatened (NT) category of IUCN. No species-wise data were collected to study the influence of exotic plant species on the nesting success of birds. Obtaining triplicates for all the 17 species in a reserve is a taunting task. Our observations

Table 1. List of nesting birds with IUCN status in Vettangudi Patti, Sivagangai district, Tamil Nadu, South India

Zoological name	Common name	IUCN status	Family	Distribution range
Anhinga melanogaster	Darter, African Darter and oriental Darter	NT	Anhingidae	Bangladesh, Cambodia, India, Indonesia, Lao People's Democratic Republic, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka and Vietnam
Microcarbo niger	Little cormorant	LC	Phalacrocoracidae	Asia, Europe, Africa and America
Nycticorax nycticorax	Black-crowned night heron	LC	Ardeidae	United States, Central America and West Indies
Ardea cinerea	Grey Heron	LC	Ardeidae	Native throughout temperate Europe and Asia, and also parts of Africa
Ardeola grayii	Indian pond heron	LC	Ardeidae	South African countries, Burma, Bangladesh, Malaysia and Singapore
Bubulcus ibis	Cattle Egret	LC	Ardeidae	North America, Spain, Portugal, Asia, Africa and Europe
Ardea alba	Great White Egret	LC	Ardeidae	North and South America, Asia and Australia
Mesophoyx intermedia	Intermediate Egret, Yellow-Billed Egret	LC	Ardeidae	Oceania, Africa, Asia and Australia
Egretta garzetta	Little Egret	LC	Ardeidae	Europe, Africa, Asia and Australia
Anastomus oscitans	Asian Open-bill	LC	Ciconiidae	Tropical southern Asia
Plegadis falcinellus	Glossy Ibis	LC	Threskiornithidae	Europe, Africa, Asia, Australia, Atlantic and the Caribbean region of the Americas
Threskiornis melanocephalus	Black-headed Ibis	NT	Threskiornithidae	Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam
Himantopus himantopus	Black-winged Stilt	LC	Recurvirostridae	South Asian countries, Africa and America
Actitis hypoleucos	Common Sandpiper	LC	Scolopacidae	Temperate and subtropical region of Europe and Asia and America
Anas querquedula	Garganey	LC	Anatidae	Africa, Asia and Australasia
Tachybaptus ruficollis	Little Grebe	LC	Podicipedidae	Europe, Asia and Africa
Amaurornis phoenicurus	White-breasted Water hen	LC	Rallidae	Asia

NT, Near threatened; LC, Least concern.

reveal that there is no species specification in the nesting behaviour of birds. Photographs were taken (Nikon D80) of the nest locations in *P. juliflora* and *A. nilotica* and compared qualitatively. The number of nests per tree, eggs per nest, number of fallen eggs and chicks and final population at the fledgling stage were recorded in *P. juliflora* and *A. nilotica* for one reproductive cycle (September 2010 to January 2011) for all species together. The number of nests per tree was counted visually with the help of binoculars (Olympus, DPS I). Thirty nests from 20 native trees and 30 nests from 20 exotic trees were randomly selected along the transect and the number of eggs per nest was counted when the birds were out of the nests. The number of broken eggs and fallen chicks under the selected trees (selected for visibility from the bank) along the periphery of the sanctuary (from 20 exotic and 20 native trees) was counted. The percentage of fallen eggs and chicks on the ground per nest was calculated using the formula

$$\frac{\text{Number of fallen eggs/chick per tree}}{\text{Total number of nests per tree}} \times 100.$$

The number of individuals from 75 nests of *P. juliflora* (from 20 trees) and 75 nests of *A. nilotica* (from 20 trees) was counted at fledgling stage using binoculars. The randomly selected (along the transect) observable nests were included for the present study.

On *A. nilotica*, nests were mostly located at nodes with more than two branches. Nests were distributed at different heights with mostly one nest per node (Figure 1 *a*). On the other hand, nests in *P. juliflora* were distributed not only at nodes, but all along the branches as well (Figure 1 *b*). The number of nests per tree was significantly higher in *P. juliflora* (mean ± SE = 50.7 ± 18.3) compared to *A. nilotica* (mean ± SE = 20.8 ± 8.2; $t = 12.6$, d$f = 148$, $P < 0.001$). There is no significant difference in the number of eggs per nest between *P. juliflora* (3.13) and *A. nilotica* (3.06). The number of fallen eggs and chicks on the ground was significantly higher under *P. juliflora* ($n = 20$; mean ± SE = 1.3 ± 2.1) than *A. nilotica* ($n = 20$; mean ± SE = 0.25 ± 0.19; $t = 3.08$, d$f = 38$). The percentage of fallen eggs and chicks on the ground per nest was 2.82 and 1.47 for *P. juliflora* and *A. nilotica* respectively. The number of fledglings per nest was significantly higher in *A. nilotica* (mean ± SE = 1.74 ± 1.07) when compared to *P. juliflora* (mean ± SE = 1.18 ± 0.97; $t = 3.86$, d$f = 38$, $P < 0.001$). There were four or more individuals (including parents) per nest found in *A. nilotica* but only three individuals were recorded in *P. juliflora* at the end of the reproductive season (approximately 120 days from hatching). The nests with one fledgling were higher in *P. juliflora* when compared to *A. nilotica* (Figure 2).

The present study clearly shows that the invasive tree *P. juliflora* poses significant threat to the nesting success of wetland birds. The available literature on the impacts of invasive plants on bird diversity highlights the following facts: (i) they can draw the birds into new areas which are previously unsuitable for them and expose them to unfamiliar risk[10]; (ii) alter local bird assemblage pattern[11]; (iii) alter prey–predator interaction[12]; (iv) change the nesting season[13]; (v) increase the rate of nest predation[14] and (vi) provide low-quality habitats[12]. While the specific reason for the low nesting success in *P. juliflora* still needs to be ascertained, we suspect that the branching pattern might play a role. The branching angle in *A. nilotica* is 40–130°, while in *P. juliflora* it is mostly between 165° and 190°. This might result in greater sliding of eggs and chicks from the nests in *P. juliflora* (Figure 1 *c* and *d*). The variation in the population structure of birds at the end of the reproductive cycle in *A. nilotica* and *P. juliflora* (Figure 1 *e* and *f*) is clear evidence of the negative impacts of exotic organisms. The branching architecture of *P. juliflora* stretches out sideways and overlaps each other[15] and this may be the reason for maximum mortality in *P. juliflora*. Schmidt and Whelan[16] reported that plant architecture

Figure 1. ***a***, ***b***, Nesting in *Acacia nilotica* (***a***) and *Prosopis juliflora* (***b***). ***c***, Sliding of egg in *P. juliflora*. ***d***, dropped chick under *P. juliflora*. ***e***, ***f***, Aggregation of migratory birds at the end of the reproductive cycle in *A. nilotica* and *P. juliflora* respectively.

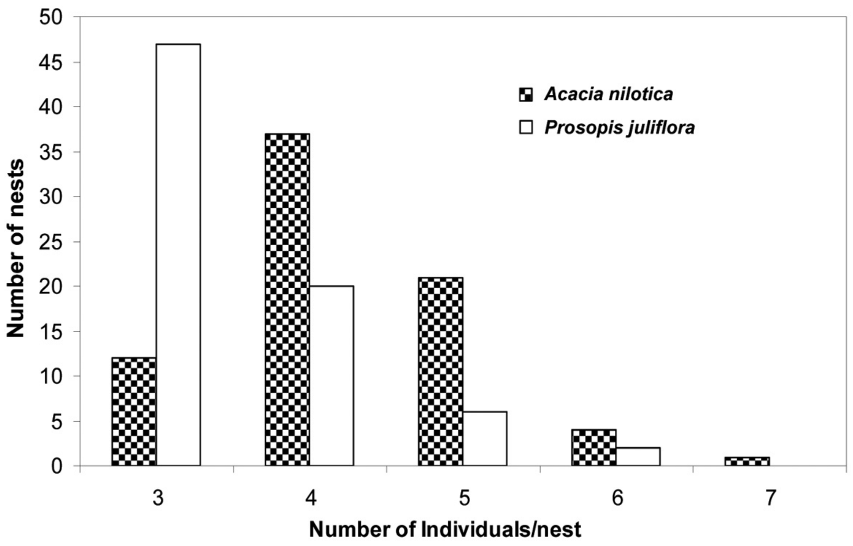

Figure 2. Comparison of number of individuals (including parents) at the fledgling stage per nest of migratory birds in *P. juliflora* and *A. nilotica* in the Vettangudi Bird Sanctuary, South India.

may influence predation rate. The plant architecture of *P. juliflora* is such that it might result in disturbance and mortality of eggs and chicks, when birds take evasive action against predation attempts. Gurevitch and Padilla[17] reported that population declination of 68 bird species in USA has been attributed to exotic organisms. The ecological relationship between introduced plants and native bird species is multifaceted[18]. There is a strong need for additional studies to address both general and species-specific aspects of this phenomenon, especially since these findings inform the choice between invasion prevention or impact mediation[18]. In India, studies relating to diversity and distribution of exotic plants and birds are limited[19]. There are 12 bird sanctuaries in Tamil Nadu, out of which 5 are already infested by *P. juliflora* (Tamil Nadu Forest Department website). The remaining sanctuaries are also likely to be susceptible to invasion by this species, because of climatic similarity. Therefore, regular mechanical removal of *P. juliflora* before arrival of the birds to the sanctuary needs to be carried out to avoid further loss of bird diversity.

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S. CHANDRASEKARAN[1,*]
K. SARASWATHY[2]
S. SARAVANAN[3]
N. KAMALADHASAN[1]
N. ARUN NAGENDRAN[2]

[1]*Department of Plant Sciences,*
School of Biological Sciences, and
[3]*School of Energy Sciences,*
Madurai Kamaraj University,
Madurai 625 021, India
[2]*Thiagarajar College,*
Madurai 625 009, India
**For correspondence.*
e-mail: krishnanasc@yahoo.co.in