ISSUES RELATING TO INVASIVES IN THE ANDAMAN ISLANDS

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ABSTRACT

A brief introduction to the problems of invasive and noxious species is followed by a brief and qualitative view of introduced species that have been easily observed on the Andaman Islands. Many of these species are have been witnessed as the culprits in adverse environmental problems. They also cause economic damage. Yet, the research done on these species is negligible. The final section of this paper presents a menu of prevention efforts, control needs, and necessary research, While the existence of the problem is evident rapid assessment of both the extent of damage caused by them as well as identifying best management practices in control and eradication measures. Finally, legal and practical hurdles to control are discussed.

In this paper I will not consider native weeds that have become locally invasive, but only truly transported 'alien' species.

KEYWORDS: invasives, introduced species, Andamans, environmental impacts.

INTRODUCTION

It was Darwin's ship the Beagle and Wallace's wayfaring ways that changed the creationist paradigm and made us aware of natural selection and the wonderful endemic mosaic of diversity in nature that Islands display. It was also ships that carried along with them an odd menagerie of human necessities, quirks, and more than a few accidental tourists. Of necessity, we, like Noah before, have carried food and provisions, some live, some growing, and some stored. The live and growing oft escaped their captivity for a quick death in the local clime, yet some survived. Companions with our foodstock were the pets and plants we took to remind us of home. A little greenery and colour to make the path look, just a bit more British. All that was fine and good to a very

limited extent as it served some purpose. But along with these were also the castaways in the stow, the ballast and the bilge—an army of marine invasives from annelid worm to zebra mussels. Yes, wherever humans have travelled, they have transported other animal and plant species with them. Some of these are animals and plants that are either useful or domesticated, such as cats, dogs, cattle, and crops such as potatoes, tomatoes and wheat. Some are caged pets that escape; mynahs are an example. Some of them travel as commensally or as parasites; these include rats and mice. Some travel completely accidentally; molluscs carried in the ballast water of ships, or birds that might be perching on a ship that sails are examples. Finally, some are deliberately released into the wild to a place that is outside their normal range, to perform some perceived benefit such as controlling a pest species.

These animals, when introduced into the wild in the place they have been taken to, may simply die out. They may establish small populations that linger on.

These introduced species, once they become established, can cause a number of problems. The species that have caused problems, the nature of these problems, and remedial measures are discussed below.

Consequences due to introduced species

Introduced animals which have become a problem, and which are also known as exotics, invasives or aliens, are now considered a major threat to endemic biodiversity. Invasive introduced species rank only second to habitat destruction as one of the threat factors to endangered species in the US: either alone or in combination. They are an important factor in the reasons why 49% of the species on the United States endangered species list are endangered (Simberloff, 2000). However, it must be noted that this is partially because invasives as a potential threat are proforma in listings (Pelkey, pers. comm..)

Simberloff states that introduced species in the United States are a greater threat to native biodiversity than pollution, harvest and disease combined.

The damage due to introduced species was assessed as US$137 billion in the US annually. Policymakers generally are still to wake up to the fact that invasives pose a major threat not only to ecosystems but to economic prosperity as well (UCS, 2001).

Simberloff (2000) gives the following examples from the U.S.:

?? Blights that have wiped out plant species and their associated moths;

??? Mussels that transform aquatic habitats by lowering densities of plankton; the cumulative loss caused by these in the Great Lakes of the USA has been estimated at around US$60 million (UCS, 2001);

?? Parasites that decimate fisheries;

?? Herbivores that decimate native vegetation;

?? Species that hybridise and cause genetic extinction of native species—like coyotes and wolves, domestic dogs and wolves.

Invasive herbivores affect plant communities in ways that are subtler than merely destroying native vegetation. They cause the homogenisation of regional biota (UCS, 2001). Introduced deer have been documented to increase the quantity of toxic chemicals in the leaves of the plants that they browse upon, a toxicity that is rapidly acquired by the plant when it is subjected to herbivory (Vourc'h et al, 2001). This would have serious repercussions for insect species that have adapted to feed on the foliage of these trees.

Introduced weeds also increase fire frequency, besides reducing biodiversity, reducing the habitat available to wildlife, disrupting nutrient cycling, increasing topsoil loss and altering soil micro-climate(Belsky & Gelbard ,2000).

On land, humans can either introduce invasives deliberately or accidentally. Domestic livestock and pet animals are deliberate introductions. Crop seeds may be contaminated, or livestock may carry unwanted pests and pathogens. By sea, ships often take on water in special tanks to increase their weight, and this ballast water is released into another area, usually a port, when cargo is to be loaded. Ship ballast alone can transport up to 7000 species every day, ranging from cholera bacteria to fish (UCS, 2001); other estimates state that over 10,000 species may be transported daily by this method (Pauchard, in prep.). Debris created by human activity, which is discarded in the sea, has also been identified recently as a cause of transport of invasives from one part of the worlds to another (Barnes, 2002**).**

Many factors affect the establishment and success of invasives. The richness of a community makes it more resistant to invasion by exotics on a small spatial scale, as demonstrated by studies on grassland plots (Kennedy et al, 2002). However, this is not true at larger spatial scales: Blackburn & Duncan (2001) report that the factors that correlated well with the successful introduction of bird species globally were that the introduction took place within the same biogeographical zone, that the latitude of origin was similar to the latitude of introduction, and that the species had a wide geographical distribution within its original range. According to Ricciardi & Rasmussen (1998) other attributes include a propensity to commensalisms. They state that the relation to aquatic invaders, salinity tolerance, a high genetic variability, and the ability to exploit ballast water are also important for the successful introduction of marine organisms.

Livestock grazing has largely been ignored as a cause of helping invasives establish themselves, but it certainly plays an important role on a local and regional scale. Livestock carry seeds, both in their dung and on their coats. They graze preferentially on native species, creating space for invasives. Soil compaction, reduction in vegetation cover and increase in disturbance by livestock also increase the invasibility of the habitat they utilise, as do the increases in wind and water erosion on the disturbed soil surface (Belsky & Gelbard, 2000).

On both a local and a regional scale, temperature (as measured by the number of days when the temperature rises above 5^{o}C) and the presence of roads and other transport links in England have been shown to affect invasive weed distribution (Collingham et al, 2000). Pauchard (in prep.) hypothesises that transport links and other man-mediated mechanisms are crucial to enabling global movement of invasives as a first step to their introduction. The shape of the habitat that can potentially be invaded also plays a role in determining how fast it is invaded; stream habitats generally are invaded more slowly than habitats that are rectangular (Cumming, 2002). Continental rainforest fragments resist invasion by exotic plants, whereas oceanic islands tend to have a higher invasibility (Teo *et al*, 2003).

The one in ten rule appears to apply for invasions: one in ten imported species appear in the wild, one-tenth of these become naturalised, and one-tenth of the naturalised species

become invasive; this however can be altered with repeated introductions at particular sites (Williamson & Fitter, 1996; quoted by Pauchard, in prep.). Key to the success of invasives is the success of the dispersal mechanism; a failure at any of the global, regional and local levels can prevent a species from becoming an invasive in an area (Pauchard, in prep Invasives also appear to do better in man-modified habitats such as wastelands and lawns as compared to primary forest (Teo *et al*, 2003).Besides impacting the environment, introduced species show changes in themselves. For example, they tend to be larger than in their native habitats (Grosholz & Ruiz, 2003). This may be due to the fact that their parasites are often left behind (Turchin et al, 2003), and also their pathogens (Mitchell & Power, 2003Predicting which species can be successful invaders can be determined sometimes by examining whether they have a successful invasion history elsewhere. Also, examining their impacts in other places they have invaded would give an idea of the impact they would have at new sites (Ricciardi & Rasmussen, 1998).

While a rich body of literature on invasives and their control has been developed in other countries, there is a lacuna in India. Current research on invasives within India is confined largely to noting the presence of *Lantana* and *Eupatorium* within protected areas, and water hyacinth on wetlands and waterways.

Invasives in the Andamans

The exotics recorded in the Andamans are given in Table 1. A number of them feature on the IUCN database on invasives (ISSG, 2002). Examining their impacts elsewhere as suggested by Picciardi & Rasmussen (1998) would enable informed guesses as to what their impacts here would be. The wild species of interest are:

Animals

Acridotheres tristis (Common Mynah). This bird has been introduced from mainland India, not being found previously in the Andamans. While detailed studies have not been done, its numbers have increased considerably over the last decade. In rural areas it appears to have replaced the Glossy Stare (*Aplornis panayensis*) at a number of sites: these are now generally only seen in forested patches. It may have affected other endemic bird species by competing with them for nest sites and food resources, though this might

not necessarily affect the populations of indigenous birds (eg. see Koenig, 2003). It is on the IUCN list of "hundred worst invasives", having become a serious problem in many other places that it has been introduced into. A study that assesses the impacts of this species is required urgently.

Axis axis (Spotted Deer*).* Introduced sometime between 1915 and 1930, these animals have spread all over North, Middle and South Andaman Islands, including the islands close to the coast. They are found in Ritchie's archipelago as well. In the Labyrinth Islands that form the Mahatma Gandhi Marine National Park, they are not found on Grub Island, which is the smallest island. They were first reported on Jolly Buoy Island about five years ago, and now there are at least fifteen individuals on this 93 ha island (area estimated in Ali & Aul, in review). They are not found on Little Andaman or on South Sentinel Island. They are good swimmers and are often seen out at sea swimming between islands. They have also been established on islands with no known freshwater sources, though rainfall is high enough for this not to be a problem.

A recent study (Ali & Aul, in review) shows the damage done by these deer. In areas where they were found, the regeneration of forest trees was found to be very low. Two species that were not browsed, *Lagerstromia hypoleuca* in rain forest, and *Pongamia pinnata* in littoral forest, were the predominant species that regenerated wherever deer were found; these were not browsed.

Eradication of the deer here may not even result in the forest reverting back to its original conditionA recent study in New Zealand pinpoints several factors that could make forest changes irreversible after introduced deer have browsed them. These include diet switching from litter and garbage to palatable species as populations are reduced, the spread of less preferred species, changes in successional pathways, the lack of seeds required to re-establish populations, and the increased susceptibility of the landscape to unpalatable invasives (Coomes *et al*, 2003).

A graphic example of what can happen if deer are not eradicated can be observed on Ross Island, near Port Blair. The deer population on this island has gone unchecked. The natural vegetation has been almost completely eliminated. There are very few tall trees left. There is practically no undergrowth, and no regeneration of trees is seen anywhere

on the island. Extensive signs of soil erosion can be seen all over the island, as there is no vegetation cover to hold the soil.

Axis deer have caused problems on other islands as well. In Hawaii, control measures have been advocated (eg. Waring, 1996). In New Zealand, deer of the genus *Cervus* have caused problems. They have caused major changes to the undergrowth in forests, and prefer to browse on short tree species associated with early successional stands. (Coomes *et al*, 2003).

Elephas maximus (Elephant). There are 31 animals that have been censussed on Interview Island off North Andaman Island (Ali, in press), and there are another few animals that have gone feral on North Andaman Island itself. Both populations belonged to a timber contractor who went bankrupt in 1962 and released his timber elephants into the wild. The population had gone up to seventy animals a decade earlier (Sivaganesan & Kumar, 1995), but this may have been an overestimate (Ali, in press). The earlier study had documented the reduction in the amount of cane and screw-pine (*Pandanus tectorius*) available on Interview; the latest study found that these had disappeared almost totally.

A large number of trees had been debarked by elephants on Interview Island as well, leading to their dying. Gaps had opened up in the canopy. The deer present appeared to ensure that these gaps would not be regenerated with trees (Ali & Aul, in review). Overall, the consequence of having elephants present was to accelerate the rate of degradation by the deer.

Funambulus pennanti (Five-striped palm Squirrel). This was introduced in Port Blair, and has now spread to Wandoor on South Andaman. Since there is no other mammalian diurnal arboreal seedeater, it may not have much competition. Seed predation by this animal in a habitat that has not been adapted by it may have adverse consequences on forest regeneration, and a detailed study is required.

Lissemys punctata (Flapshell Turtle). This has been recorded in the Port Blair area and may affect the populations of freshwater invertebrates and fish. These were probably introduced as household pets.

Muntiacus muntjak (Barking Deer). This was introduced along with Spotted Deer. Small

populations are found on Middle Andaman. These would affect native vegetation in the same way as the Spotted Deer do, and have the potential of causing environmental damage if they are not controlled. It may be noted that these animals are sometimes found in dense forest both in mainland India and in South East Asia, so it could adapt to the forests here more easily than the Spotted Deer has.

Domesticated animals that have gone feral include:

Felis catus (Cat). This has gone feral in a number of places. It has been observed to feed on the nestlings of endemic birds and is likely to pose a serious threat to some species.

Canis familiaris (Dog). Dogs have gone feral in several places in the Andamans. They have been observed digging up sea turtle nests on beaches, and are a serious cause of mortality to nesting adult turtles as well. These are hunted as they come ashore to lay eggs, and killing of turtles by feral dogs has been observed on most of the nesting beaches on the islands where dog populations have established themselves. These dogs have formed packs and have been seen attacking and killing Spotted Deer (this is not necessarily a bad thing), and are the only predator these animals have in the islands. However the other damage done by dogs make it necessary to control their feral population.

Bos taurus (Cattle). Herds of cattle have been observed in the middle of the Jarawa (Tribal) Reserve. Jarawa tribals do not hunt them for eating, and so they are left undisturbed. They damage the native vegetation. The extent to which this damage occurs has not been documented. *Capra hircus* (Goat). These were introduced on Barren Island (known so because of its lava fields) in the last century, and are now advertised as a unique species, since they are supposed to survive on salt water. This claim appears to have been a gimmick to attract tourists, and has recently been debunked (Chandrasekharan *et al*, 2003). The vegetation cover on Barren Island has been obviously affected by goats. The number of tree species present appears to be very small relative to other islands**,** suggesting that regeneration is confined to these few species. Ground flora is sparse, and has been noticeably browsed wherever seen (personal observation, 2003).

Goats were also introduced on to Narcondam Island in the 1970's to provide meat for the police outpost there. They have multiplied and caused severe degradation to the

indigenous vegetation here (Sankaran, personal comment). Attempts are being made to eradicate them now from this place.

Agathina fulica (Giant African Snail). These were introduced by the Japanese during their occupation of the islands in the 1940's, as a food supplement. This snail has become a serious pest of vegetable crops in the islands—which are themselves introduced but are commercially valuable species

No quantitative assessment of the damage caused by invasive animals has been made here since the data has not been gathered. I merely note presence of these invasives here and point out that these invasives have caused serious problems elsewhere.. A proactive approach is called for before the magnitude of the damage becomes certain and self evident, as in the case of the chital.

Plants

Parkinson (1923) recorded a hundred species of introduced plants from the Andaman Islands. These can be categorized roughly into the following broad categories: 24 are non-ornamental trees, 30 are ornamental trees, shrubs and creepers, 40 are fruit or vegetable herbs, shrubs and trees. Six have been found growing wild. These are *Urena lobata*, *Acacia farnesiana*, *Calotropis gigantea*, and 3 species of *Solanum*. Since 1923 there have obviously been many more introduced species that have naturalised, since the scale of settlement has gone up by over an order of magnitude. These have however not been documented. The species observed growing wild nowadays include *Eicchornia crassipes*, or water hyacinth, and this has been observed choking up freshwater bodies.

The majority of weeds seen growing on wasteland appear to be exotic. *Eupatorium* and *Parthenium* are observed in abundance everywhere in the Andamans.

Prevention in the islands

Controlling the influx of new species into the islands is obviously critical, since preventing potential invasives from establishing themselves is more cost effective than control. One of the most important steps to be taken is the sterilisation of ballast water (UCS, 2001). Whereas regulations exist in some places that ballast water is to be exchanged at mid-sea before entry into a port, this is either not done properly, or is

observed in the breach. No regulations exist for Indian ports. While the presence of aquatic invasives has not been studied or documented in these islands, it would be surprising if the problem did not exist. It would largely caused due to transport in ballast water.

Wood that is being transported often carries pest species that become invasives at the destination point of the wood. Since wood imports into the Andaman Islands do not take place this is not likely to be a problem here. However, pests may have been introduced from here into mainland India, something that again has not been studied or documented. Treating packing wood before use is the preferred method of control (UCS, 2001).

At the moment, there is a port check to prevent wildlife items being taken out of the islands. This needs to be expanded in scope to prevent any animal species from coming in. Proper fumigation or other sterilisation procedures need to be adopted for food materials and seed stock coming in, to eliminate invasive contaminants.

Bringing in any outside species for any purpose, needs a proper environmental impact assessment done. Some invasives have been brought in with good intentions, that have then gone wild and created problems. For instance water hyacinth was first brought in as an ornamental plant. African Giant Snails were brought in as a food supplement, as were the goats. We risk repeating these mistakes as was evident at a recent seminar in Port Blair. Substantial interest was shown in new agricultural and aquacultural technologies developed by organisations in mainland India. These included fast-growing fish as a food supplement as well as *Trichogamma* wasps for the control of rice pests (Kesavan, 2003). A major NGO is likely to be contracted by the A & N Administration to introduce these technologies into the islands—which one. Both these have the potential for becoming invasives that may cause immense environmental damage in other forms, and extreme care needs to be exercised in introducing them here.

Finally, prevention would include the spaying and netering of pets brought in from the mainland, an insistence that native plants be used for all landscaping, and attempting to locate local plant varieties that have commercial value to replace exotic vegetables. The Karen and Chota Nagpur communities that were brought into the islands as forest labour in the 1920's have already developed a rich lore in using indigenous plants for food.

Possible Control Measures

With herbivores the recommended technique is total eradication. The eradication of herbivores from islands has been particularly successful (UCS, 2001). In the islands this would be the ideal solution for the introduced spotted deer. There has been a discussion on this issue on the internet recently, and the majority of scientists who participated were for allowing culling; one even pointed out that India has a legal obligation under Section 8 h) of the Convention on Biodiversity to eradicate these deer from the islands. However, recent changes in the Wildlife Protection Act, 1972 have taken away the authority of the Chief Wildlife Warden to cull any populations of wild animals. Added to this, there is a very marked reluctance on the part of the Ministry of Environment and Forests (MOEF) to take any decision that could be construed as a precedent. A simple solution to this would be to automatically declare any species found outside its normal historical range as vermin. There is reluctance to take this step as well. For the moment, sterilisation and translocation can be tried on a small scale.

The above would also apply to the feral goat populations on Barren Island and Narcondam Island. The wildlife laws are relevant here because both these are protected areas. With elephants the problem is more complex because of the emotive issues involved in any control. Here trapping and translocation to mainland India seems to be a workable option since most of the animals on Interview Island are young. This operation, if properly done, should pay for itself, since young elephants command a high price on the mainland.

Pet animals such as cats and dogs should be licensed and should wear a license tag at all times to distinguish them from stray or feral animals. The animals that have gone feral need to be eradicated since they pose a serious threat to wildlife. Sterilisation is problematic in this instance, since they are not approachable at all, and tranquillising animals would prove to be extremely difficult. At the moment culling seems to be the only feasible option.

Sterilisation is likely to work for deer in a few places, such as Ross Island near Port Blair, where the deer population has had an impact on its resources that is so obvious that even the tourists comment on it. However, the effects of a sterilisation campaign would be

noticeable only after a long period of time, as mortality reduces the existing population. It may also be an option for the male elephants on Interview Island and on North Andaman Island.

Harvest appears to be the only method of controlling freshwater aquatic vegetation such as water hyacinth. Budgets for this should be provided to the *panchayats* in the islands**.**

For several other species, research is required to establish the best means of control. Squirrels, Mynahs and sparrows have not spread to Middle and North Andaman yet, and control measures, if implemented soon, may succeed relatively cheaply. However, the best methods to be used require research.

Legal hurdles to control

The biggest stumbling block to control at the moment is the Wildlife Protection Act, 1972, which ironically creates problems for the very species it is supposed to protect. Many of the species that are invasive in the Andamans are protected by this legislation on mainland India. These include Spotted Deer, elephant, and Common Mynah. Permission for any culling or other control programme is no longer in the hands of the Chief Wildlife warden of the Andamans after the latest amendments to the Act, but must come from the MOEF. This adds considerable delay to the decision making process in the unlikely event of permissions actually being granted, and would lead both to avoidable damage to these fragile ecosystems as well as added expenditure. Another legal issue is the presence of these animals in protected areas. Permission to hunt in these areas would be problematic, and these areas are precisely those where the damage to the ecosystems would have the most adverse consequences.

Practical hurdles to control

A practical hurdle in implementing control measures is the likelihood of conflicts with animal rights activists. The lives of individual animals is likely to be more important to this group than the environmental and economic damage caused by them, as well as the fact that, due to overcrowding a lot of these animals will die from starvation and disease.

A colleague working on the issue overseas comments that 'I get nailed by animal rights groups for controlling bullfrogs' (Govindarajulu, *pers. com*.). Another major problem is that of monitoring. Censussing animals such as deer in rain forest is very difficult. A recent initiative in New Zealand (Forsyth *et al*, 2003) uses pellet grouping densities (PGD). This requires a long term effort, as well as populations of known densities to validate the results. These ideally would be captive populations in enclosures, and these would have to be created.

Accurate numbers may however not be necessary. The lack of these is a convenient bureaucratic hurdle to block culling programmes. If the browse damage is evident then control is necessary.

CONCLUSIONS

There has been practically no research done on either the environmental or economic consequences of introduced invasives in India. While this paper concentrates on the Andamans, the lack of knowledge is true of mainland India as well. Problems that have been identified include the large-scale alterations of native ecosystems in the islands, and current legislation to retain these ecosystems in a pristine state is deficient.

Urgent research efforts are required to understand the extent of the problem and to institute prevention and control measures for invasives. Legal changes may be necessary to expedite the removal of exotics.

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TABLE 1. List of exotics recorded from the Andaman Islands. An * before the name indicates that this species is on IUCN's list of "The hundred worst invasive species" (ISSG, 2002). Highlighted species need clearance under the Wildlife Protection Act, 1972 for control measures to be implemented.

SCIENTIFIC NAME	TYPE	ENGLISH NAME
**Achatina fulica*	land invertebrate	Giant African Snail
**Acridotheres tristis*	land bird	Common Myna
Axis axis	land mammal	Spotted Deer, Chital
Bos taurus	land mammal	Cattle
Canis familiaris	land mammal	Domestic Dog, Feral Dog
**Capra hircus*	land mammal	Goat
**Eichhornia crassipes*	aquatic plant	Water Hyacinth
Elephas maximus	land mammal	Elephant
**Felis catus*	land mammal	Domestic Cat, House Cat
**Funambulus pennanti*	arboreal mammal	Five Striped Palm Squirrel
Lantana camara	land plant	Largeleaf Lantana
**Leucaena leucocephala*	land plant	Ipilipil, Subabul
Lissemys punctata	aquatic reptile	Flapshell Turtle
Muntiacus muntjak	land mammal	Barking Deer
**Mus musculus*	land mammal	Field Mouse, House Mouse
?*Opuntia stricta*	land plant	Cactus, Erect Pricklypear
?*Parthenium hysterophorus*	land plant	Congress Grass
Passer domesticus	land bird	House Sparrow
Rattus norvegicus	land mammal	Brown Rat, Norway Rat
**Rattus rattus*	land mammal	Black Rat