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Eradication of Invasive House Crow (*Corvus splendens*) from Socotra Island, Republic of Yemen: Lessons Learned from 15 Years of Facing a Bird Invasion

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ABSTRACT: The house crow is one of the most invasive bird species in the world, affecting more than 25 nations around the Indian Ocean, Arabian Peninsula, and Southeast Asia. It causes problems for development, public hygiene, biodiversity, tourism, and traffic. House crows arrived in 1995 on Socotra Island, Yemen Republic, coming from mainland Yemen by ship. Socotra Island is a UNESCO World Heritage Site, having a unique ecosystem with a larger number of endemic species. Ongoing management did not achieve eradication of the species for more than a decade; however, it kept numbers of the breeding population low. The last 13 birds were finally eradicated in April 2009, thanks to techniques and experienced personnel from abroad and support by the Small Grant Programme of the Global Environmental Facility. More vigilance in dealing with this species, as well as a better transfer of international knowledge to local managers, are required to tackle problems caused by invasive house crows in the affected regions.

KEY WORDS: birds, bounties, *Corvus splendens*, eradication, house crow, introduced species, monitoring, population control, regional cooperation, reinvasion, shooting, Socotra Island, Yemen

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INTRODUCTION

The house crow (*Corvus splendens*) is one of the world's most invasive bird species (GISD 2007), increasingly spreading among the regions in which it has been introduced (Nyari et al. 2006). This bird is known for its abilities to populate new territories and survive under a variety of sometimes unfavourable conditions (Lever 2006). The house crow has been shown to affect various sectors of human society, e.g., agriculture, tourism, human health, and traffic and transport (Ryall 1992b), as well as being a menace to biodiversity. House crows eat crops and damage orchards (Dhindsa et al. 1991, Feare and Mungroo 1990). They disturb tourists and ordinary citizens with their loud calls, as well as their heavy defecations, and they will aggressively attack when attempting to steal food. This species transmits pathogens that affect people and domestic animals (Al-Sallami 1991, Copper 1996, Roy 1998), and it can also pose a bird strike risk to aeroplanes when occurring close to airfields. Furthermore, the species is responsible for the reduction or severe depletion of native species, including small reptiles and amphibians, birds, and mammals, but also insects, fish, and domestic animals (GISD 2007). While lack of data permits no quantification of such losses and disturbances, in the areas that are newly colonized by this bird species the impact is believed to be high.

The house crow is native to India and parts of its neighbouring countries, where the species is closely associated with man (Ali 2002). Negative effects are most visible in areas where the bird did not occur before,

i.e., in the 25 or more countries where it has been introduced throughout Africa, the Middle East, and Southeast Asia (Ryall 1994, 1995, 2002). In most of the affected countries, no control projects or operations against the house crow are undertaken or maintained, for a variety of reasons. Mainly, it is a lack of funding and expertise within the countries affected, thus not allowing for large-scale operations, let alone cooperation between neighbouring countries. This is hampering activities of single nations or organisations, because successful eradication can rarely be achieved in such circumstances.

Eradications attempts are, for the moment, restricted to island environments. Some mainland sites that are isolated ecologically or geographically can be treated like islands (Veitch and Clout 2002), and such areas qualify for possible eradication programmes.

PROJECT SITE

Socotra Island belongs to the Republic of Yemen, although it is situated around 350 km off the coast and is closer to the horn of Africa than to mainland Yemen (Figure 1). With 3,500 km² of land area, Socotra is a large island. However, it is not a densely populated island, due to its remote location and its desert environment. Furthermore, the challenging economic living conditions in the few towns and villages, which house an unknown but small number of citizens and military personnel, contribute to the island's low population. The island has a high endemism among plants (65% of approximately 900 species are endemic) and among some groups of animals (up to 90% of insects and reptiles are

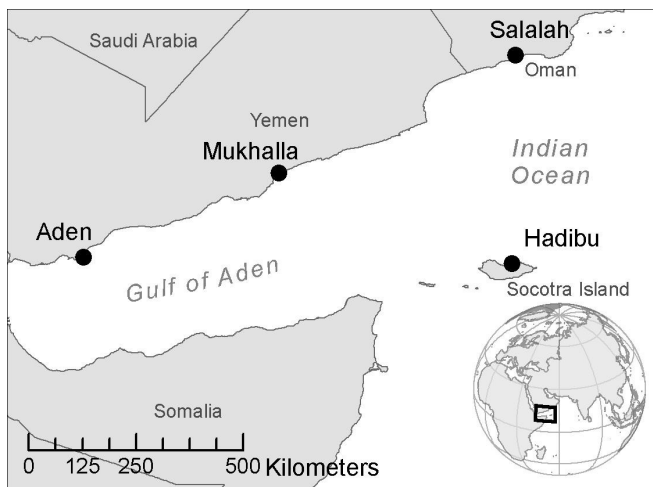


Figure 1. Socotra Island lies approximately 350 km off the coast of Yemen.

endemic).

Socotra became an UNESCO World Heritage Site in 2007, which demonstrates the value of the island for the region's biodiversity but also its value for tourism. The island's environment is threatened by uncontrolled development and its surrounding waters by illegal fishing; however, invasive animals were not considered a main threat for many years.

The house crow arrived on Socotra Island in 1995 or 1996, when one pair was thought to have been transported by ship and then establish themselves in the north of the island. The house crows ship-assisted spread across the region is well known and often reported for this species (Kinneer 1942, Jennings 2004, Ryall 2008), but no special attention to port sites was ever given anywhere in the region to prevent the species' arrival and establishment. Their arrival on the island was not unexpected, since mainland Yemen, especially the city of Aden, harbours a huge and well-established population of house crows that had been released by the British colonial powers at the end of the 19th century. Populations are growing in neighbouring countries and the wider region (Ryall and Meier 2008). This was all known to the authorities at the moment of the first crows' arrival on Socotra Island.

House crows have had long and severe impact on all sectors of society and nature on mainland Yemen and are a declared pest species. While the bird's impact in the port city of Aden and elsewhere on the mainland is significantly negative (Ash 1984) and was known to most people, no efforts to prevent the birds' introduction to Socotra, nor an immediate attempt to eradicate the arrived birds, was undertaken. Thus, following their arrival, nothing was done for the next 3 years to limit their process of establishing a breeding population. Lack of communication or awareness cannot solely be blamed for decision to ignore the arrival of house crow, although modern means of communication, such as the Internet, did not exist in Yemen at that time. As the birds' arrival followed shortly after the intense 1994 civil war had rampaged the country, authorities had more challenges to face than to look into minor environmental problems.

However, the international organisations and individual experts working for decades on studying Socotra Island's unique flora and fauna should have raised the issue of crow invasion more vocally and demanded the needed control measures. The silence of such knowledgeable stakeholders cannot be fully explained without detailed knowledge.

The birds settled along the valley running across the island capital Hadibu, and at its peak the house crow breeding colony numbered 23 birds (Omar Al-Saghier, pers. comm.). The site is a shallow stream coming from the mountains in the island's interior and running into the sea in the north. The valley is planted with palm trees along the stream and runs along the edge of the town. The character of the area is rural, with gardening and keeping of domestic animals in the backyards of houses being common feature.

A further common image of the river is the major garbage pollution all along its banks, making it an ideal environment for a human-dependent species like the house crow. Contributing to the problem is the fact that the rest of the island does not have a garbage collection scheme funded by a European Union arrangement, as exists in the capital Hadibu itself. Hence, the stream running across the valley is a massive accumulation of garbage and food for scavenging, omnivorous birds like the house crow.

The birds nested in tall palm trees next to houses, and the population began to grow through successful breeding. Without native enemies, the crows existed safely, and all available resources were used by the birds for living. Likely due to the garbage and other resources along the stream, the establishing house crows have been very sedentary at this site over all the years of their presence on Socotra.

Some members of the Environmental Protection Authority (EPA) were concerned about the unrestricted growth of the population, and by 1998 a bounty system was installed. It paid increasing amounts of money to mere teenagers for climbing the nests and removing the chicks and eggs. Over a period of 10 years, more than 550 chicks and eggs were removed, making this system, to a certain degree, an effective control method. Whilst it managed to keep the numbers very low, it was costly and it did not achieve eradication of the species, despite the continuing collection efforts.

In 2008, it became clear that the future funding source for this scheme would not exist anymore, since the Italian government development fund that had provided funding for environmental development (and was also the source for the bounty payments) was not extending its program. It became obvious to some people from the EPA, as well as the co-authors of this publication, that without these bounty payments, the population of the house crow on Socotra Island would start to develop to its full extent. It was known from other locations that approximately 100 birds could, within 4 years, grow into a population of 2,000 (Ali 2003), so the threat was severe. Investigations such as Ryall's (1992a) gave reasons for significant concern, especially the growing impact of the house crow on native bird species. It was decided that the eradication of the population would be necessary.

Former eradication attempts had demonstrated that neither trapping by EPA personnel nor attempted shooting of the crows using marksmen from the Yemeni Army had resulted in any birds being killed; thus, it was recognised that no abilities for eradication existed on the island or within the country itself. The use of foreign expertise was the next step, and a cooperative project aiming for the quick eradication of the house crow from Socotra Island was founded at the end of 2008. Planning for the eradication started right away, and decisions were made regarding the timing, personnel, and methods.

METHODS

Poisoning with avicides like Starlicide™ (DRC 1339) is the most commonly used technique to kill house crows in large numbers, and this had been successfully applied in mainland Yemen before (Jennings 1992). However, as Socotra Island has a high population of two species of vultures, no poisoning was permitted to take place. Use of toxicant was also ruled out by the project team, due to the small population of house crows on Hadibu and the narrow (two-week) time frame permitted by the authorities to implement the control project.

Significant restrictions on control methods existed from the beginning, and these constraints made project planning more difficult. Because many potential alternatives were not viable, the decision to shoot all of the birds was soon agreed upon by all parties as the proper method to apply. The largest problem was that all planning would be done only through remote communication, and neither of the two foreign individuals in the project team had been to Socotra before, so they had inexact knowledge of the situation. Further, there was no funding available for them to make a preliminary visit to the island. However, the only other alternative was to abandon the project altogether, which was unacceptable. Therefore, project planning information began to be shared from Socotra Island to Europe and vice-versa. Fortunately, information on the Socotra Island house crows delivered by on-site personnel proved to be very accurate, as a professional and reliable crow monitoring scheme had been implemented by Socotra Island EPA personnel from the outset. Without these pre-project surveillance efforts, the whole project would not have been possible to execute successfully.

Shooting was carried out by an experienced marksman/hunter who had previously worked in eradication projects involving other species. From his experience, he knew of the need to apply control methods in a way that kept the house crows naïve about the aim of the project as long as possible. Three different types of guns, as well as appropriate ammunition, were brought to Socotra for project use. The import of silenced .17 HMR and .22R/F rifles, as well as an automatic shotgun, were authorised by the Yemeni Interior Ministry and fully supported by all the authorities involved.

The project took place from mid to late April 2009. On the third day following the control team's arrival on Socotra, shooting commenced. The gun used first was the silenced .22 calibre rifle, and shooting was done from the camouflaged window of an EPA-owned 4×4 Jeep. The presence of senior EPA staff guaranteed a quick and

secure journey across the village, once crows had been seen at locations along the valley. The 2-person shooting team was partially guided to certain locations by the observer, who was the third person in the team. Occasional additional support by other EPA personnel was received.

Since the shooting took place on the outskirts of the island's capital, residents quickly became aware that foreign people with guns were driving around in their neighbourhood. Due to the traditional, conservative, Muslim way of living in Hadibu, and also the fact that in Yemen most households have their own weapons, the permanent presence of the senior author (as an EPA official) within the project team secured the safety of the shooters and facilitated communicating to the local population the reasons for their activities. Thus, the residents were completely in favour of the measures taken, and they supported the activities passively by not interrupting, as well as actively, by showing where house crows had been seen, heard, or were feeding, roosting, and nesting.

RESULTS

After Day 1 of the shooting, 6 birds (half of the known population) had been killed. Although the house crows were not yet able to identify the shooter, observer, or the car as a threat, the remaining birds became more cryptic and careful, and less obvious. On Day 2, shooting of the next 3 birds took place; however, the use of the silenced .17 HMR rifle with high-power ammunition was necessary, as shooting had to occur from a longer range, due to the birds' behaviour.

After this, the last 3 known remaining house crows were very shy. They started to leave the area, flying to a neighbouring valley 2 - 3 km away, and they strongly avoided staying at a site once they noted the presence of the observer or the jeep. In order to discourage the shy behaviour demonstrated by the crows after just 2 days of direct persecution, it was decided that a day of observation would be useful to give the crows some safety, but also to re-count the remaining birds and identify possible shooting locations for use in the coming days.

On Day 4, the shotgun was first used. The loud report made when this gun was fired meant it was a less desirable tool in urban or village settings; nevertheless, it was an important tool for the project's continuing success. Thus, one crow was intercepted and shot while flying between the two valleys, and a second crow of the day was shot whilst a local person was climbing a known nesting tree to remove nesting material and/or eggs. From previous project experience, it was known that the crows would attack any human within the proximity of their nest, and so the project team used this to attract a bird to the site.

The last known bird was shot in the early afternoon of Day 4, after 2 hours' observation and studying any patterns evolving from its erratic flying and nervous behaviour. By then, the observer within the team had clearly been identified as a threat, and the crow kept its distance from this person. As the bird was using the same trees and even the same branches as lookout posts, it allowed the shooter to get in position under one tree. The

bird had then been purposely driven toward that particular tree by the observer, using its “repellence-reaction”. After getting permission from the Imam, the final killing shot was delivered from the yard of a small, temporarily unused mosque.

After more than 500 man-hours of monitoring on foot, in cars, and from rooftops, no further crows were seen, heard, or reported. Yet, an appeal was put out within the local community for any further crow sightings, with an increased bounty offered for any information. Seven days after the last bird was shot, just as the team was about to depart from the island, a report came in that a single crow was seen and heard circling over the Hadibu Valley. EPA personnel tried to find this bird’s origin and clarify its movement patterns and behaviour. However, they failed, as the single crow disappeared, then came back two days later, and disappeared again. The control team went back to shoot this last bird, which was seen as the most dangerous bird because it was not known about before, and there was a high likelihood that it was a single nesting individual, probably located in the aforementioned neighbouring valley. After 4 days of observation and pursuit, this final bird was shot in Hadibu Valley, again using the magnum shotgun.

In total, 13 birds were shot in 15 days, ending a 15-year-old problem that had the potential to become a major issue for not only the island’s fauna and flora but also its human residents.

DISCUSSION

The house crow on Socotra Island provided a case study of how invasive birds are often regarded, and what is necessary to achieve effective extermination. The immediate reaction to the arrival of the alien founder pair of house crows was to “doing nothing”. This led to successful establishment of the birds on the island, and subsequent population growth. Monitoring was identified as being necessary by concerned EPA personnel, who conducted this effort. As a result of the information collected, it was clear that a “doing nothing” approach was not useful, and the authorities decided to attempt a population control scheme.

Although this control scheme was implemented with a hope of eradication of house crows from Socotra Island, the system was not able to deliver such goal. The bounty system that paid individuals who collected eggs and chicks from nests, as described above, resulted in an effect that was beneficial over a period of years, as the sedentary habit of the house crows made egg and chick collection easier. Nevertheless, it is known that such bounty systems do not achieve eradication by themselves. This is because those conducting the bounty program often are not sufficiently organised to detect and target overlooked individuals or nest sites. Furthermore, a long-term economic incentive is not an ideal driving force for a quick eradication, since the funds provided contributed to the income of the collectors’ families, who had an interest in seeing such income continue, which would not occur if eradication were achieved.

While the bounty did not result in eradication, nevertheless the impact of this system was immensely important to provide the ground for the later eradication,

since without the earlier efforts the population of house crows would have been too large for the April 2009 shooting program to have been successful in such a brief time period. The main achievement was clearly that further population growth was halted and the otherwise unavoidable explosion of the population and its spread across the whole island was prevented.

As it was recognized that the bounty program was having some effect on controlling the population, an increase in the rewarded money was implemented in an effort to achieve greater results; however, the effect of this increase on control of the house crow population is not known. The increase in bounty payments, within a few years, to 500% of the initially-paid money demonstrates the desires behind the activity in this specific case. Clearly, the increase put pressure on the resources to pay for all the bounty system activities, and it also called the long-term sustainability of this program into question.

Considering the species involved here, eradication would have been the only adequate measure to apply right after the bird’s initial arrival at Socotra. For eradication to be implemented, however, certain preconditions are demanded. Two of them are that a technique is applied which puts all individuals at the same risk of getting removed, and that this is done quicker than the target species can replace removal loss by intensified breeding.

Two eradication efforts were initiated by EPA, however both failed completely. The first attempt involved purchasing crow live traps and establishing these traps along the Hadibu Valley. Their failure can be blamed on that fact that no training was delivered to EPA personnel involved, and no one had prior experience in operating these traps for this particular species. Thus, no birds were successfully captured, and these wood-and-wire traps soon disappeared. The lack of guidance or assistance by the international organisations present on the island clearly hampered this effort, which also resulted in the loss of the significant resources used to buy and ship the traps to the island.

The second attempt involved the deployment of 5 members of the Yemeni defence forces, who attempted to shoot the house crows using AK-47 assault rifles and live ammunition. Due to the military members’ inexperience with the vigilant and careful house crows, combined with an increasing level of shooter impatience, no bird was shot and the effort was abandoned after a week.

These two failed eradication attempts led to the feeling, among the people on Socotra Island and within EPA, that neither trapping nor shooting were adequate methods to eradicate house crows. This led to a general conclusion that nothing could be done to remove this invasive species from the island. However, the recognition that loss of funding for the bounty program would result an unchecked expansion of the house crow provided an immediate reason to attempt the final, successful eradication effort.

The risk of reinvasion unfortunately prevails. The lessons learned from the ‘doing nothing’ approach, which followed the first house crows’ arrival on Socotra, support the current monitoring efforts, as close vigilance secures the island against a neglected arrival of new

house crows. To make eradication a lasting effect, the issue of reinvasion has to be addressed carefully. The new arrival or re-establishment of house crows on Socotra Island must be prevented. EPA personnel are well aware of the need for continued monitoring and vigilance, and quick action could be organised if a new bird should appear. However, it is not possible to impact the most likely mode of transport that house crows would likely use to arrive at Socotra, as the island is highly dependent upon ship traffic.

Therefore, the best way to secure achieved success on the island and minimise the risk of reinvasion is to control or (ideally) eradicate the closest source populations of house crow. In this regard, of particular concern is the major population of house crow on the mainland coast of Yemen. Due to this population's enormous size in and around the city of Aden, it cannot be eradicated by anything less than a multi-year, intensive control programme. The planning, financing, and implementation of such a programme would, however, have highest priority, not only to protect Socotra, but also to remove the major source population of this invasive species from the whole region. If implemented successfully, such an eradication would demonstrate to the public that such a challenging task can indeed be achieved.

Additionally, for the direct protection of Socotra, it would be necessary to also eradicate house crows from city of Salalah, Sultanate of Oman. Ship traffic between Salalah and Socotra is regular, and the island receives many goods from this city, which is closer to Socotra than the main ports on mainland Yemen. At the moment, the house crow population in Salalah is around 180 individuals, so eradication in Salalah would not be too difficult to achieve. Additionally, eradication of tiny populations of house crows in less than a dozen villages and towns between the Yemeni port city of Mukhalla and Salalah, Oman, would mean that a coastal area of more than 1,500 km would be clear of house crows, thus minimising the risk of birds being re-transported to Socotra. Such an effort, if undertaken, would be the first-time-ever implementation of a cross-border project against the alien house crow in this region.

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