A note on wildlife poisoning cases from Kerala, South India

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Abstract
Wildlife poisoning is an important conservation threat for endangered species in India. There are no publications in the scientific literature that identify the specific poisons or chemicals involved in wildlife poisoning cases from the state of Kerala. In this report, all cases of wildlife mortality recorded between 2011 and 2013 at the office of the Assistant Forest Veterinary Officer, Periyar Tiger Reserve in Kerala were reviewed and cases where poisoning was considered as a differential diagnosis were identified. Specific poisons or chemicals were identified in three cases, while in a fourth, poisoning was determined to have occurred based on physical traces of the poison in gut contents. The poisons identified include carbofuran (a carbamate pesticide) in a bonnet macaque (Macaca radiata), warfarin (a rodenticide) in a mortality event involving four wild boars (Sus scrofa), endosulfan (an organochlorine pesticide) toxicity in a gaur (Bos gaurus) and imidacloprid (a neonicotinoid pesticide) toxicity in a wild adult Asian elephant (Elephas maximus). This communication thus reports for the first time on the specific chemical compounds identified in wildlife poisoning cases from Kerala state and argues for greater regulation of the sale and use of such toxic compounds in India.

Keywords Wildlife · Poisoning · Kerala · Carbofuran · Rodenticide · Neonicotinoid · Endosulfan

Introduction
Poisoning is an important cause of wildlife mortality, and in some instances has been responsible for extensive population declines (Green et al. 2004). Primary exposure to poisons occurs when wildlife is intentionally poisoned for hunting (Ogada 2014) or due to human-wildlife conflict (Venkataramanan et al. 2008; Ragothaman and Chirukandoth 2012). Accidental poisoning may occur by secondary exposure to poisons in the environment or via contaminated food sources. Examples include pesticide residues in Irrawady dolphins living in contaminated water bodies (Kannan et al. 2005) and Sarus cranes consuming monocrotophos-treated grains (Pain et al. 2004), respectively.

In all such instances, non-target wildlife may also be unintentionally poisoned when they scavenge on carcasses containing high concentrations of poisons (Kalaivanan et al. 2011; Molenaar et al. 2017).

Although the threats posed by intentional or accidental poisoning to wildlife in India have long been recognised (Spillett 1967), statistics on the proportion of wildlife deaths attributable to poisoning are lacking. Poisons or chemicals detected in wildlife in India include organochlorine (OC) (Kannan et al. 2005; Pathak 2011), organophosphate (OP) (Pain et al. 2004; Kalaivanan et al. 2011) or carbamate pesticides (Venkataramanan et al. 2008) and rodenticides (Ragothaman and Chirukandoth 2012). Ragothaman and Chirukandoth (Ragothaman and Chirukandoth 2012) listed 15 separate incidents of pesticide poisoning in wildlife between 2000 and 2010, including six instances (40%) of OP and four instances (27%) of carbamate pesticide poisoning.

However, wildlife mortality due to poisoning may be under-reported in India, either because poisoning is not considered as a possible cause; carcasses are found in advanced stages of decomposition or cases are lost to follow up after submission of tissue samples to testing laboratories (personal observation). This is true in the case of wildlife mortality...
reporting from the south Indian state of Kerala with its rich biodiversity owing to the Western Ghats, a global biodiversity hotspot which runs across the entire length of the state (Gunawardene et al. 2007). A search of the scientific literature on five databases (PubMed, Web of Science, Scopus, Ovid, ProQuest) and Google Scholar using the search terms “wildlife”, “poison*” and “Kerala” did not find any publications that identified the specific poison or chemical implicated in suspected poisoning events in the state. The four publications that mentioned wildlife poisoning in Kerala used generic terms such as ‘rodenticides’ (Jayahari and Jayson 2007), merely identified poisoning as the potential or confirmed cause of death (Cheeran 2007; Rohini et al. 2015) or provided anecdotal evidence (e.g. poisoning of elephants by ’Folidol’, an OP pesticide) (Spillett 1967). Knowledge of the specific chemical compounds involved in wildlife mortality events is the first step in enabling government agencies to implement regulatory measures that can prevent incidents of poisoning or help populations that have suffered declines to recover (e.g. impact of the diclofenac ban on vulture recoveries) (Paudel et al. 2016). To fill this knowledge gap, this report provides details of the specific poisons/chemical compounds detected in wildlife mortality events from Kerala over a 2-year period.

Methods

Periyar Tiger Reserve (PTR) in central Kerala has the services of a full-time wildlife veterinarian designated as Assistant Forest Veterinary Officer (AFVO). The AFVO deals with treatment of ill and injured wildlife, assists in human-wildlife conflict resolution and conducts necropsies and disease surveillance in PTR and adjoining wildlife reserves. For this report, all cases of wildlife mortality recorded between January 2011 and March 2013 were reviewed. Cases were identified where poisoning was considered as a differential diagnosis based on circumstantial evidence, necropsy lesions or the need to rule out poisoning as a cause of death when no lesions were identifiable in decomposed carcasses. Records of mortality events prior to and after this period were not immediately accessible and have not been included in the review.

Results and discussion

Eleven separate wildlife mortality events recorded between January 2011 and March 2013 met the selection criteria mentioned above. In ten instances, post-mortem tissue samples were submitted in saturated salt solution for toxicological analyses to the Regional Chemical Examiners Laboratory (RCEL), Ernakulam, one of three government laboratories in Kerala providing toxicological testing services free of charge to government departments (Chemical Examiner’s Laboratory Department 2017) (Table S1). Test results were reported as positive or negative for a specific poison after analyses of processed samples by thin layer chromatography (TLC) and a second method (gas chromatography–mass spectrometry or ultraviolet spectrophotometry). Detection of coloured spots with a retardation factor ($R_f$) value equal to that of a reference compound during TLC confirmed presence of the poison. Specific poisons/chemicals were detected in three cases, although concentrations were not reported. In the other seven instances, negative test results were reported. In a fourth case where tissue samples were not submitted for analyses, poisoning was determined to be the cause of death based on lesions and physical presence of the chemical compound in gastric contents. These four cases are described in detail below.

1. Imidacloprid in an Asian elephant

A wild adult female Asian elephant (Elephas maximus) was found dead in a commercial cardamom plantation adjoining a forest reserve in Ayyappankovil range, Kattappana in November 2011. The carcass lay next to a demolished shed that had been used to store and prepare pesticides including imidacloprid (a systemic neonicotinoid pesticide), quinalphos and chlorpyriphos (OP pesticides). The elephant was suspected to have consumed water from a barrel which was used to dilute pesticides prior to spraying, whereby it may have been poisoned. Lesions observed included marked lingual and corneal cyanosis, diffuse pulmonary haemorrhage and hepatomegaly with subcapsular haemorrhages. The presence of large numbers of dead or moribund flies in the elephant’s mouth and around the carcass (Fig. 1), as well as dead gastric bots (commonly of the oestrid fly Cobboldia...
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soning after consuming pesticide-laced food. However, Chirukandoth 2012). Based on these findings, the ma-
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names (e.g. ‘Furadan’) (Cheeran 2007; Ragothaman and
Chirukandoth 2012). Based on these findings, the ma-
caque was suspected to have died of carbofuran poi-
soning after consuming pesticide-laced food. However,
no tissue samples were submitted for toxicological
analyses.
Poisoning with neonicotinoid pesticides has been reported
in humans (Cimino et al. 2017), domestic animals (Caloni
et al. 2016) and small vertebrate wildlife such as birds and
fish (Gibbons et al. 2015). Exposure to pesticides, including
imidacloprid, was suspected to be associated with the occur-
rence of congenital deformities and reproductive problems in
chimpanzees and baboons in Uganda (Krief et al. 2017).
However, to the author’s knowledge, this is the first report
of mortality of a large wild mammalian species linked to
imidacloprid consumption. This highlights the need for further
studies on the use of neonicotinoid pesticides and their im-
acts on wildlife and the wider environment. Such studies,
sorely lacking in the Indian context, are urgently needed given
the accumulating evidence globally of their role in population
declines of bees as well as non-target invertebrate species
(Pisa et al. 2015).
2. Endosulfan in a gaur
In August 2012, an adult male gaur (Bos gaurus) carcass
was found in PTR in a forest patch on the border between
Kerala and the adjoining state of Tamil Nadu, abutting a large
commercial tea plantation. As the carcass was partially
decomposed and lay close to the plantation where pesticide
use was likely, samples of hepatic tissue and gut contents were
submitted for toxicological analyses. Endosulfan, a toxic OC
pesticide, was detected in all tissue samples. Given the state of
decomposition of the carcass and absence of information on
tissue concentrations of endosulfan, it was not possible to
attribute death to pesticide exposure. It was considered more
likely that long-term exposure occurred by consumption of
pesticide-laden foliage or water around the plantation.
3. Carbofuran in a Bonnet Macaque
The carcass of an adult female bonnet macaque
(Macaca radiata) was found on the terrace of a build-
ing in Kumily town, adjoining PTR, in October 2011.
Necropsy lesions included severe ocular cyanosis and
pulmonary congestion and marked splenomegaly. The
stomach was filled with undigested food mixed with
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analyses.
The report also reinforces the need for considering poisoning as a differential diagnosis in investigations of wildlife mortality events, irrespective of whether the primary cause of mortality can be established or not. This is particularly relevant given the proximity of wildlife habitats to human settlements and agricultural land in biodiversity-rich regions of the world such as India (Ragothaman and Chirukandoth 2012). A thorough investigation of the immediate environment and circumstances of the mortality may raise suspicion of poisoning as a differential diagnosis. However, as is often the case in free-ranging wildlife mortalities, carcasses may be too decomposed at the time of detection for a necropsy to pinpoint the cause of death. Toxicological analyses can help to rule out poisoning or identify other causes for concern for wildlife, environmental and human health. Wildlife could even act as sentinels of environmental contamination, exemplified in this report by the detection of compounds such as endosulfan and imidacloprid. Wildlife researchers must make full use of the toxicological testing services provided free of charge by government laboratories like the RCEL in Kerala, and possibly other Indian states, to investigate the occurrence and impacts of poisoning.

Finally, the study highlights how pesticides continue to be easily available and inadequately regulated in India. Their use in public responses to human-wildlife conflict in India has been reported previously (Madhusudan 2003; Cheeran 2007; Venkataramanan et al. 2008). Since being banned in India in 2011 (Dhillon 2017), endosulfan has continued to be available for agricultural use, and human exposures have also been reported (Menezes et al. 2017), highlighting the lax implementation of existing regulations. The frequent involvement of such toxic compounds in animal and human deaths in India points to the need for strengthening legislation that regulates their availability and use without affecting their application in agricultural and allied sectors (Ragothaman and Chirukandoth 2012). Doing so will have wide-ranging benefits, extending beyond wildlife health and conservation to human and environmental health.

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