



Short communication

Human disease hinders anti-poaching efforts in Indian nature reserves

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ABSTRACT

Where hunting pressure is high, anti-poaching efforts are often crucial for protecting native wildlife populations in nature reserves. However, many reserves suffer from inadequate support and provisioning of staff, especially in developing nations. In Pakke Tiger Reserve in northeastern India, we found that malarial infection is a serious hindrance for front-line patrolling staff that limits the time they can spend in the field. We assessed the consequences of malaria both for local people and park staff in the general region and its indirect effects on wildlife protection. To accomplish this we compiled data from annual epidemiological records of malaria, the number of malaria cases and associated mortality, financial costs, and loss of time spent patrolling. Over a 4-year period (2006–2009), the majority (71%) of forest department staff in Pakke Tiger Reserve suffered from malaria. Malaria treatments cost park managers nearly 3% of their total budget and caused a net loss of 44,160 man hours of anti-poaching effort. The government forest and health departments involved in the employment and health of park staff have separate missions and responsibilities, yet our findings show that a multi-disciplinary approach to conservation is essential to avoid overall systemic failure.

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1. Introduction

Nature reserves in developing nations often suffer from chronic poaching, which can have a serious impact on native wildlife populations (Terborgh et al., 2002; Laurance et al., 2006; Corlett, 2007). Anti-poaching patrols can be vital for reducing hunting pressure. To ensure effective park protection, a general rule of thumb is to aim for an anti-poaching staff density of 1 person per 20 km² (Bell and Clarke, 1986). However, the efficiency of patrolling staff also strongly depends on the logistical support, servicing, and provisioning they receive (Leader-Williams et al., 1990).

Pakke Wildlife Sanctuary and Tiger Reserve is a protected area within the Eastern Himalaya global biodiversity hotspot (Myers et al., 2000) of northeastern India. Within the reserve, the density of anti-poaching staff (1 person per 8.56 km²) is well within the suggested guidelines of 1 person per 20 km² (Bell and Clarke, 1986). Nonetheless, anti-poaching patrols are challenging for park staff, given that the reserve has undulating terrain, spans an interstate boundary, and has a long history of sanctioned hunting

(until as late as 2000). Equally significant is that malaria seriously diminishes anti-poaching activities in the reserve.

Malaria is one of the most serious human maladies in the tropics and subtropics, with around 225 million cases occurring worldwide each year (WHO, 2010). The disease is caused by protozoan blood parasites (*Plasmodium* spp.) which are largely vectored by female *Anopheles* mosquitoes. India accounts for 76% of the 2.5 million malaria cases reported annually in Southeast Asia (Kumar et al., 2007). A recent retrospective study from over 6000 areas in India estimated that 205,000 people below the age of 70 die from malaria every year, nearly half of which are adults (over 15 years old; Dhingra et al., 2010). Northeastern India, which is rich in forests and wildlife, has an especially high malarial incidence, with over five reported malaria cases per thousand people. Most other areas of India have <2 cases per thousand people (Kumar et al., 2007).

In addition to killing many people, malaria is a debilitating disease that creates a massive socio-economic burden, especially for the poor and in areas with limited access to health care (Sachs and Malaney, 2002). Malaria reduces human productivity in various ways, including efforts to promote wildlife conservation. Over a 4-year period, we assessed the impacts of malaria on anti-poaching efforts in Pakke Tiger Reserve, both by estimating its direct impact on forest patrollers and its potential downstream consequences for park protection. We used data on malaria incidence, augmented with extensive interview data, to understand how malaria hampers on-the-ground protection efforts in this internationally important wildlife reserve.

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2. Methods

2.1. Study site

Pakke Wildlife Sanctuary and Tiger Reserve (92° 36'E, 26° 54'N) spans an area of 862 km² in western Arunachal Pradesh, on the inter-state border of Assam and Arunachal in northeastern India (Velho et al., 2009). In total, 144 forest department staff are employed in the reserve; 101 are casual workers who are paid daily wages, and the rest are permanent staff. Casual workers are not entitled to paid or unpaid leave, although concessions are sometimes granted by employers. Permanent staff are entitled to 15 days of casual leave and up to 40 days of sick leave per year. Those who have worked about 240 days yearly are also entitled to earned leave. Most employees are from the *Nyishi* community and reside around the periphery of the park.

Park staff are supposed to man anti-poaching camps at all times, to conduct daily patrols to deter poachers, and act on available information to intercept poachers. At present, 24 anti-poaching camps operate within the reserve, with each camp manned by 3–4 guards who collectively patrol an area of ~20 km². These camps are equipped with wireless networks, and free medical treatment is nominally available for staff posted in camps, although many incur personal costs for treatment (see below).

During the dry season, vehicles are immediately sent for forest watchers suffering from malaria. Two major malaria-causing protozoan species, *Plasmodium vivax* and *Plasmodium falciparum*, are present in northeastern India, and some individuals suffer simultaneous infections from both species (*P. falciparum*, which is responsible for most malaria deaths, appears to be increasing in India; Dash et al., 2008). Infected individuals are treated at one of four government-run primary health centers (headquartered at Seijosa, with satellite centers at Niti Darlong, Nomarah, and Dipik) or a private clinic in the vicinity of the park. During the monsoonal season, road communication is disrupted by heavy rains and flooding, and elephants are used to access the park.

2.2. Data collection

We assessed the impact of malaria on anti-poaching activities over a 4-year period (2006–2009) by using a combination of annual epidemiological reports from the primary health center at Seijosa (which is located near the Pakke Tiger Reserve headquarters), from registers of the forest department, and from records of medical expenses incurred by park staff to treat malaria. We also interviewed 20 park staff to characterize their personal medical expenses and the extent to which patrolling was affected. Further, we visited local medical facilities near the park and interviewed doctors and other health practitioners to assess their malaria treatment courses, the expenses these incurred for patients, and the limitations they faced. Mean monthly rainfall data for 2006–2009 were extracted from precipitation datasets generated by MODIS (Moderate Resolution Imaging Spectroradiometer) satellite coverage for the geographic coordinates of Pakke Tiger Reserve.

3. Results

3.1. Malaria impacts on local residents

At the primary health center at Seijosa, a total of 2353 malaria cases were reported during our 4-year study. Malaria incidence peaks in the warmer months, from May through August (Fig. 1). Using data from the Seijosa primary health center, we found a strong positive relationship between the mean monthly numbers of reported malaria cases and malaria-related deaths ($F_{1,10} = 54.5$,

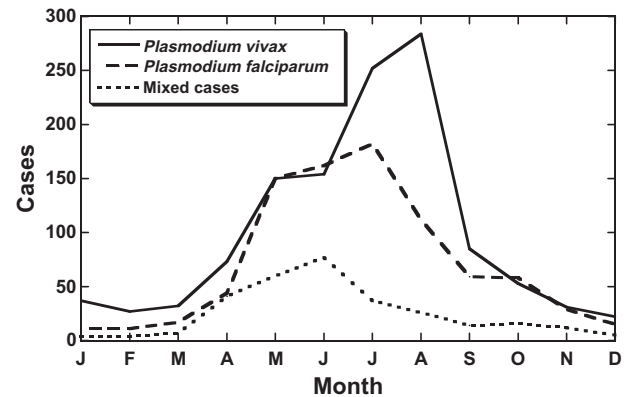


Fig. 1. The number of malaria cases reported over a 4-year period (2006–2009) near Pakke Tiger Reserve in northeastern India (data from the Seijosa Primary Health Center). Separate lines are shown for infection by *Plasmodium vivax*, *P. falciparum*, and mixed infections, in which patients are simultaneously infected by both malaria species.

$R^2 = 84.5\%$, $P < 0.0001$; linear regression). The mortality rate of patients diagnosed with malaria was 12.9%. When available, chloroquine and primaquine phosphate tablets used for malaria treatment are provided free of cost at the Seijosa center, but other drugs and diagnostic test kits usually had to be purchased from a nearby pharmacy at the patient's expense.

3.2. Malaria impacts on reserve staff

Among the 144 forest department staff, most (70.8%) suffered from malaria during our 4-year study. In total, 15 deaths were recorded among the staff or their immediate family members. Of the 20 staff we interviewed, 90% had previously visited a private health clinic because needed medicines were not available at the nearby government-run primary health center. At the private facilities, the cost per patient for the prescribed line of treatment, often involving in-patient care and treatment with intravenous fluids, ranged from \$50–155 (2250–7000 rupees). This cost should be reimbursed by the forest department but was often delayed or unpaid because of insufficient department funds. In addition, severely ill staff were referred to larger hospitals, where each incurred costs ranging from \$33–133 (1500–6000 rupees). Hence, when a forest guard contracts malaria, they must typically contribute the equivalent of 1.5 times their monthly salary towards treatment.

From 2006 to 2009, park authorities spent 2.8% of their total annual budget of ~\$197,200 (~8875,000 rupees) for treating staff suffering from malaria. In addition, the department faced unpaid bills of \$4400 (200,000 rupees) that were owed to employees for overdue reimbursements. Thus, malaria represents a serious cost for the forest department, both via the loss of funds earmarked for park protection and its impacts on anti-poaching efforts.

3.3. Malaria impacts on anti-poaching activities

The 24 anti-poaching camps in Pakke Tiger Reserve are operated 24 h a day in all seasons. Assuming an average of 3.5 guards per camp, a total of 735,840 man-hours is required each year to maintain anti-poaching activities. Among 101 staff directly involved in anti-poaching work, 92 cases of malaria were reported during our study. For infected park guards, the duration of absence from work resulting from malaria and its treatment, recovery, and convalescence usually takes 20 days. This amounts to a loss of at least 44,160 man-hours of effort over 4 years, which is equivalent

to having one anti-poaching camp running at half-strength for the entire 4-year period.

3.4. Possible links between malaria and poaching

The monthly incidence of malaria cases and deaths is strongly and positively related to average monthly rainfall (Fig. 2). Malaria incidence peaks in the monsoonal months of July and August (Fig. 1), which is also when park authorities face an annual financial crunch (Tana Tapi, pers. comm.). During this wet period, road communication is disrupted from heavy downpours and elephants are the only means to transport staff suffering any illness. Anecdotal evidence from interviews of local residents living around Pakke Tiger Reserve suggests that poaching increases during the monsoon months. In rainy conditions, poachers can more easily avoid detection as they make very little noise while hiking on wet leaf litter (Tangru Miji, pers. comm.). At other times of the year, dry leaf litter makes it difficult to move quietly, potentially alerting both the target species of hunters and patrolling park guards.

4. Discussion

In Pakke Tiger Reserve in northeastern India, efforts to limit wildlife poaching are hindered by a high incidence of malaria among park staff. In this context, malaria has very real impacts on park enforcement efforts and cost, and also takes a serious toll on the health, personal finances, and even survival of park guards.

Our study focused on a single nature reserve, but there is no question that other reserves in India face comparable challenges from malaria. For instance, 93% of the land area of Mizoram state in northeastern India is predicted to have areas favorable for malaria (Srivastava et al., 2001). Many reserves in northeastern India occur in high-malaria zones, including Dampa Wildlife Sanctuary in Mizoram state, Kaziranga National Park in Assam state (Prakash et al., 1997), and Namdapha National Park and Tiger Reserve in Arunachal Pradesh state (Prashanth, 2010). Malaria is also an acute problem in the Simlipal Biosphere Reserve in central-eastern India (Rout and Thatoi, 2009; Aditya Panda, pers. comm.) and in the Terai Arc along the India–Nepal border, which contains 12

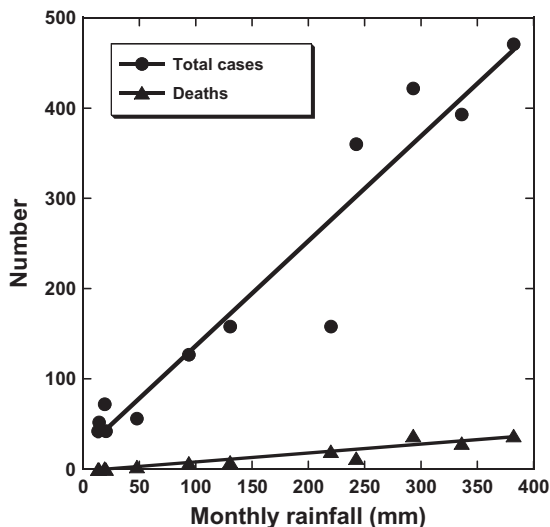


Fig. 2. Strong relationships between average monthly rainfall and the number of reported cases of malaria infection and malaria-caused deaths near Pakke Tiger Reserve in India, from 2006–2009 (malaria data from the Seijosa Primary Health Centre). The relationships between monthly rainfall and malaria cases ($F_{1,10} = 121.3$, $R^2 = 92.4\%$, $P < 0.0001$) and deaths ($F_{1,10} = 94.6$, $R^2 = 90.4\%$, $P < 0.0001$) are highly significant (linear regressions).

nature reserves (Seidensticker et al., 2010). Staffs in these and many other nature reserves are likely to suffer chronic challenges from malaria.

Our findings highlight a need for incorporating multi-dimensional approaches such as conservation medicine into mainstream protected-area management (Koch, 2005). Some tropical diseases are known to deter human and cattle intrusion into wildlife habitats (Cleaveland et al., 2003). Beyond this, however, we believe the impacts of human diseases on the viability of nature-conservation areas have received surprisingly little attention. At Pakke Tiger Reserve, poachers might conceivably be deterred by malaria during the monsoons, but anecdotal evidence from interviews with local residents suggests that poaching actually increases during this period. Further studies (using data from interviews of poachers, forest-department reports, and analyses of staff morbidity and mortality) should address whether poaching is in fact facilitated by the high prevalence of malaria among anti-poaching staff during monsoons.

The dilemma facing the managers of Pakke Tiger Reserve results from an interplay of factors such as the institutional failure of the public health sector, the physical remoteness of the reserve, and the high prevalence of malaria in this region. Although the responsibilities of the forest and health departments are clearly differentiated in India, we believe that effective action from both is needed to ensure a successful conservation outcome. In the near term, donations by private individuals or corporations could help to alleviate the financial burden of disease being borne by the forest department, although an ultimate solution will require improved health services in the region.

In an effort to reduce malaria incidence at Pakke Tiger Reserve, in March 2010 we distributed 120 permethrin-treated Olyset mosquito nets to staff stationed at anti-poaching camps. Only three cases of malaria were reported as of December 2010, which is well after the expected peak in malaria cases during the monsoon season. This rate of infection is perhaps 8–10 times lower than would otherwise be expected. Although insecticide-treated nets are supposed to be distributed as part of a nation-wide National Vector-borne Disease Control Program in India, we did not see any nets used among park staff or in villages. This suggests that some relatively simple counter-measures such as insecticide-treated nets could significantly improve the welfare and effectiveness of park guards in regions where malaria and other mosquito-vector-borne diseases are prevalent.

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