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Human crocodile conflict on the Cauvery river delta region, Tamil Nadu, south India

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Abstract
Conflict between humans and crocodiles on the Cauvery river delta region is discussed. Four instances of situations were recorded, namely attacks on people (fatal and non-fatal), the capture of crocodiles from nearby inhabited areas, translocation of crocodiles to other areas of the River, and crocodiles entering human habitation. Distances between translocation sites and non fatal attacks averaged 10.12 Km, whilst distance between fatal attacks averaged 58.73 Km.

Keywords: Mugger crocodile, conflict, Cauvery River, Tamil Nadu

Introduction
Mugger crocodiles (*Crocodylus palustris*), are a wide-ranging species, encompassing the 70th to 90th parallels. They occur in isolated and communal aggregations throughout their distribution in India, Sri Lanka, Nepal and Iran [1]. Habitat specialists, they occur in small streams, rivers man-made lakes, and dams throughout their range. The mugger is extinct in the wild in Bhutan and Myanmar, and likely to be extinct in Bangladesh [2] and Pakistan (Chang *et al*. 2012) [3]. Reports of conflict with people have been reported numerous times, in the fifteen states ([1]) mugger inhabit.

Materials and Methods
The Cauvery River Delta study region focused on was between the towns of Tiruchirapalli (Trichy), and Chidambaram, Tamil Nadu. It constitutes about 200 kilometres of the Cauvery River, much of what is dried down to a few main-stay pools near the villages of Anaikarai, and Vakaramarri, in February – May. The river branches into two at the Grand Anicut, namely the Vennar and Cauvery [4]. Human population density along the Cauvery has been estimated at 350 people/km^2 [5].
A combination of records from onsite interviews, information from news-paper releases, and the Fire and Rescue Departments, Cuddalore District, were used as a database. An online archive of crocodile attacks [6] was accessed to collect further instances of conflict. Localities of conflict gleaned from newspaper articles and television, were entered into Google Earth ™ to geo-tag villages/towns where HCC had occurred. Tiruchchirappalli, Ariyalur, Cuddalore, and Namakkal, were the primary Districts where incidents of conflict occurred.
Conflicts were divided on the basis of situation, in the way of attacks on people (fatal and non-fatal outcomes), capture of crocodiles from nearby inhabited areas, translocation of crocodiles, and crocodiles entering human habitation. Crocodile captures and translocations had no relation to one another, as these instances occurred in unique months and/or years.

Results
A total of seven fatal attacks between the years 2009 – 2019. 2015 and 2017 accounted for the majority of fatal attacks (2 in 2015 and 2 in 2017, 54.2% accumulatively,), while 2009, 2013, and 2018 had one fatal attack per annum (accumulatively, 42.8%). July and November comprised the highest number of attacks (two in each month), with single occurrences in January, February, and April. Age for male fatal attacks (N= 5) averaged 60 ±6.91(50 - 65) years. A single female attacked was aged 45 years, and in one instance age was unknown.
A total of 12 non-fatal attacks occurred in between 2019 – 2019. One attack each occurred in 2010 and 2011 (cumulatively 14%), 2012 – 2015, and 2019 had two attacks per annum

(cumulatively 67%), and 2016 had three non-fatal attacks (20% cumulatively). 2009, 2017, and 2018 had no non-fatal attacks. March and July had the highest instances, three in each month. August had two instances of non-fatal attack, and April – June, and September had one instance each. Non-fatal attack ages averaged 42 (±18.84, 12-60).

The majority of captures occurred in 2011 (3; 25%). 2012 and 2013 accounted for two captures each (cumulatively 34%). In 2014 there was a single capture (8%), 2016 and 2017 had two captures each (34% cumulatively), 20019, 2010, 2015, 2018, and 2019 had no reported captures. Primary factors causing captures are often requests by people living on agricultural farms, residential properties, and nearby canals from the main river.

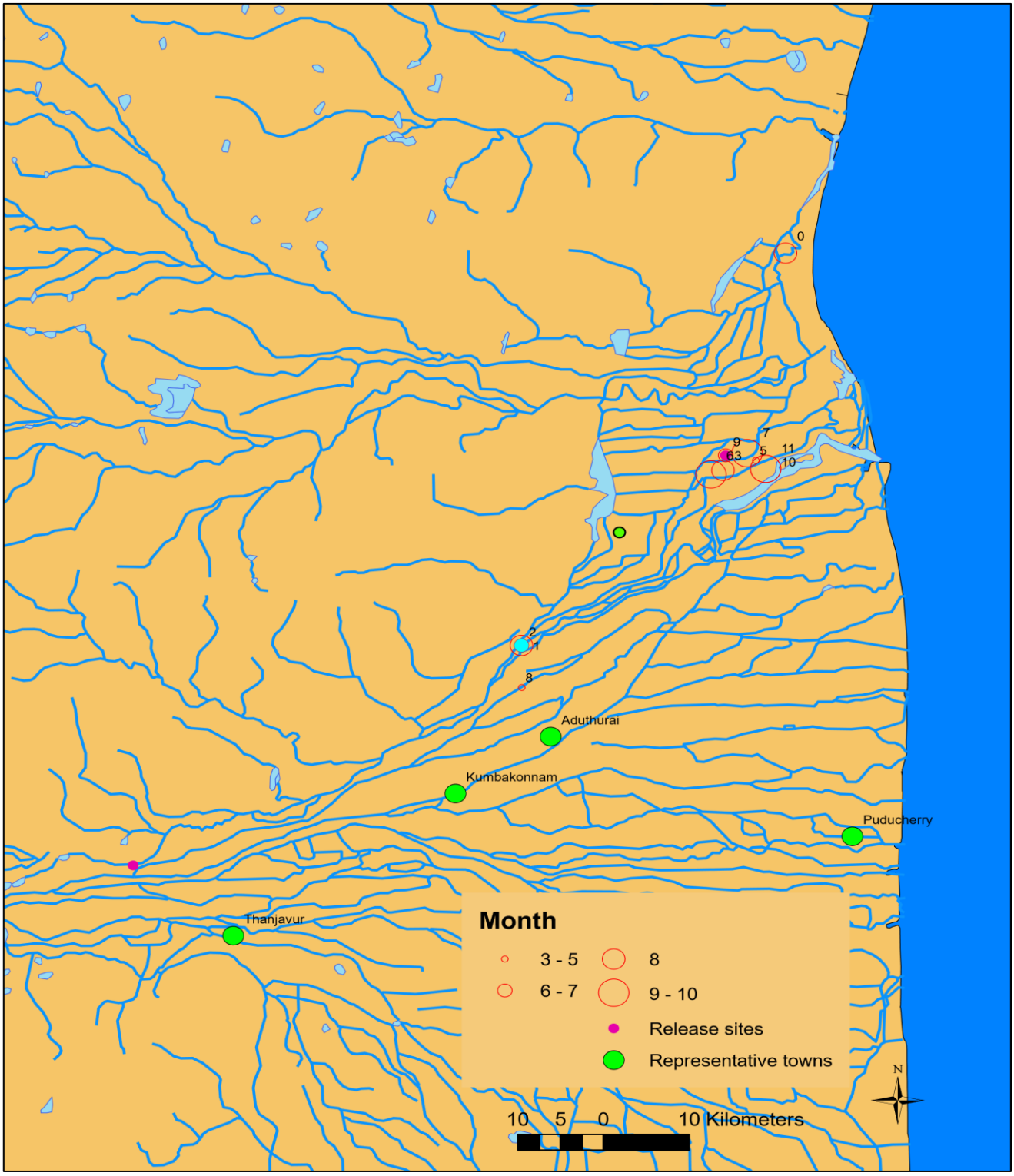

Fig 1: Locations of non-fatal attacks between 2009 – 2019 on the Cauvery River,

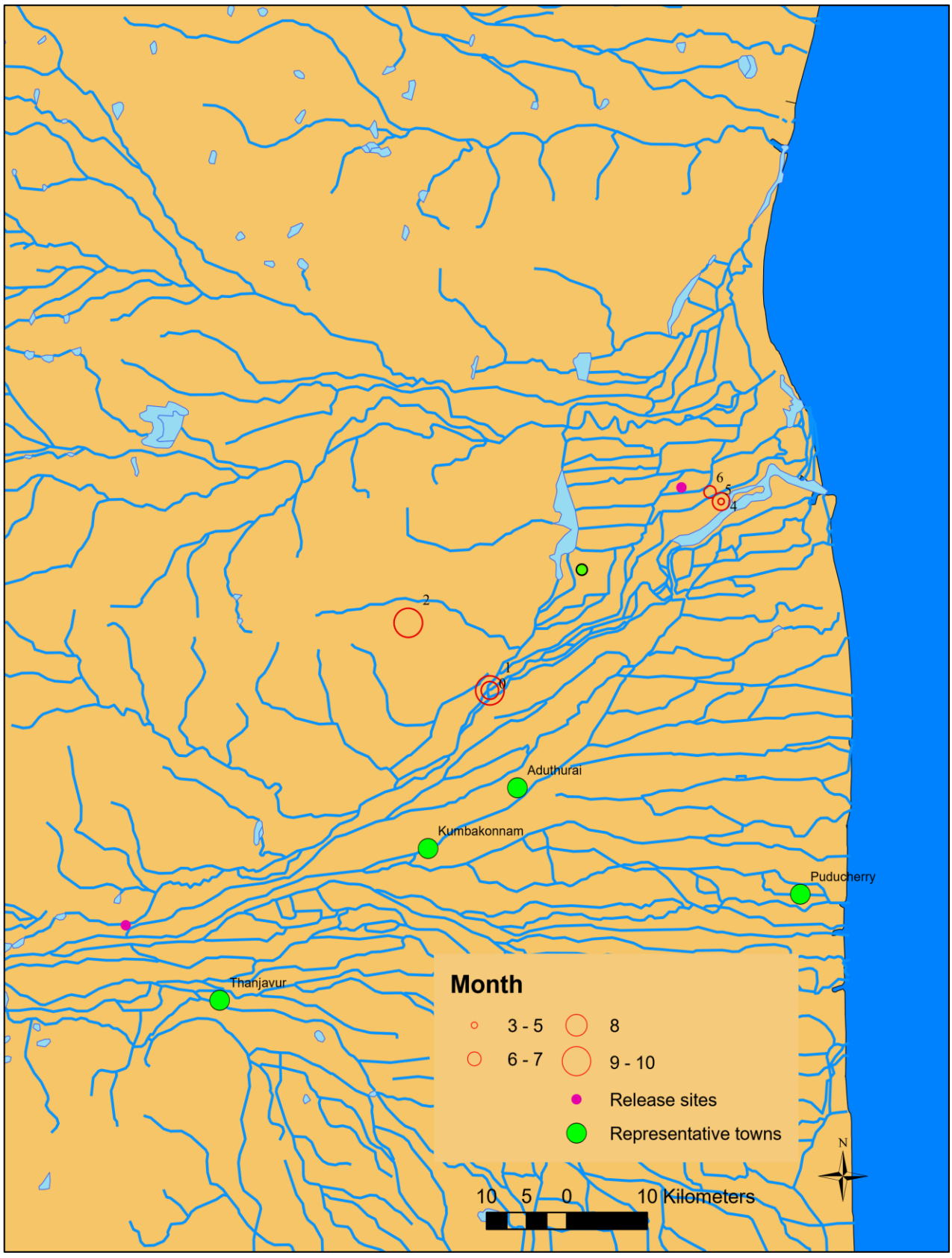

Fig 2: Locations of fatal attacks between 2009 – 2019 on the Cauvery River, symbols represent month of occurrence.

Crocodiles entered human habitation a total of 11 times. Annum wise 2009 accounted for four instances of entry (36%), 2010, 2011, 2013, and 2017 represented one instance of entry each (28% cumulatively), and 2018 had three entries (27%). Entry was in May and June (1 time each; 18% cumulatively), October (3 times; 27%), November (5 times;45%), and once in December (9%).

Regarding activity wise comparisons between fatal and non-fatal attacks, a large percentage, of outcomes were labelled as unknown (46% and 40%, respectively). As a means to compare, within and between these outcomes, unknown outcomes were excluded from calculations. Sans unknown outcomes, activities when fatal attacks occurred were equally high when washing something, bathing, and fishing (N=2;

15.4% in each case, for a sum of 46.2%). Provoking a crocodile occurred in one instance (7.7%).

Activities people were engaged in when non-fatal attacks occurred were dominated by fishing (N=3), followed by bathing (N=2; 22.2%) and washing something (N=2; 22.2%), and involvement of livestock (N=1; 11.1%) and provoking (N=1; 11.1%)

Distances between capture site Kattumunnarkoil (N=7 instances) and non fatal attacks averaged 17.59 ± 10.0 (; 0 – 41) Km. Distance to this capture site and fatal attacks (averaged 63.78 ±88.8 (17.7 – 197) Km. Captures from Vakarmarri tank (N=5 instances) and non fatal attacks averaged 2.65 ± 1.64 (0 – 4.9) Km, whilst distance to fatal attacks averaged 53.68 ±77 (3.53 – 188.5) Km. Distances between release and capture sites was consistently longer in fatal attacks as compared to non-fatal attacks. At the town of Anakarai, a combination of mugger crocodiles being fed on fish trash (largely *Pterygoplichthys* sp.), fatal, and non-fatal attacks, occurred. Tables one and two summarize year, month, local, activity, and outcome of fatal and non-fatal attacks.

Table 1: Summary of fatal attacks, FID numbers relate to locations positioned on the map.

FID	Year	Month	Location	Activity	Outcome (identity number if from CrocBite database)
0	2017	7	Anaikarai	Fishing	Fatal attack
1	2017	11	Anaikarai	Unknown	Fatal attack
2	2009	11	Melaru Canal	Grazing	Fatal attack
3	2018	2	Nandimangalam	Bathing	Fatal attack
4	2013	7	Perampattu	On bank, standing or walking	Fatal attack
5	2015	1	Perampattu	Unknown	100-5409 (fatal attack)
6	2015	4	Selakodi	Bathing	Fatal attack

Table 2: Summary of non-fatal attacks, FID numbers relate to locations positioned on the map.

FID	Year	Month	Location	Activity	Outcome (identity number if from CrocBite database)
0	2010	8	Allapakam	Provoking	Non-fatal attack
1	2019	7	Anaikarai	Unknown	Non-fatal attack
2	2019	6	Anaikarai	Fishing	Non-fatal attack
3	2014	7	Kaattukoodalur	Unknown	Non-fatal attack
4	2015	3	Kattumannarkoil	Fishing	100-5989 (non-fatal attack)
5	2015	3	Lalgudi	Bathing	100-5459 (non – fatal attack)
6	2016	4	Pazhayanallur	Washing something	100-6044 (non-fatal attack)
7	2011	10	Pulamedu	Clothe washing	Non-fatal attack
8	2013	10	Saliyanthoppu	Dog or livestock involved	100-3773 (non- fatal attack)
9	2015	3	Thiruppanandal	Unknown	Non-fatal attack
10	2016	5	Vakarmarri Tank	Unknown	Non-fatal attack
11	2012	10	Vallambadugai	Unknown	Non-fatal attack
12	2013	9	Vallambadugai	Bathing	Non-fatal attack

Discussion.

In the current work, data on conflict with crocodiles varied from detailed accounts of activities when attacks occurred, to very basic information, sometimes only a location and date. Many narrators related the attack period in months or years ago, with no accurate dates. This may relate to remote areas where attacks occur, and results in the highest category, unknown cause of attack, in both circumstances. The use of cast nets requires entry into water bodies, up until at least waist level. Locally constructed Styrofoam "rafts" are also used to cast nets from. A fisherman interviewed who had been bitten twice using the latter method, and was still observed fishing, was indifferent to the danger in spite of his previous non-fatal bites. Attitudes towards crocodiles primarily focused on the need to remove them from water bodies on the main Cauvery River, nearby tanks, and irrigation canals. Both the south-west and north-east monsoons which provide this area with rain would seem to play a role in incidents with crocodiles. Higher water levels equate to crocodiles moving into terrestrial areas. Conversely, low water levels led to overland migrations in search of water and had crocodiles entering households/yards, in the landscape of the Cauvery with a high level of human disturbance.

The highly clustered locals of both fatal and no-fatal attacks, towards the Bay of Bengal may reflect higher human and crocodile density in these areas, but more information on the movements of crocodiles is needed. The relationships between release sites, capture sites, and conflict, are intricately weaved together.

Studies on the saltwater crocodile (Kay, 2004) [7], Nile crocodile (Calverley & Downs 2015) [8], and American alligator (Fujisaki *et al*. 2014) [9] lend credence to the fact that this may be universal among the Crocodylia. In at least one instance, a tail-clipped mugger crocodile in Gujarat was known to home back to the site of capture following translocation (Vyas & Bhavsagar 2009) [10].

Both the city of Vadodara in the state of Gujarat (Vyas, 2005) [11], and Kota in Rajasthan (Whitaker, N. 2008) [12] for example, are cities with dense human populations, and have increasing levels of human-crocodile conflict in the nearby rivers. Vasava *et al*. (2015) [13] in their report note people are happy to live alongside mugger in the village of Charotar, Gujarat, another example being parts of the state of Goa, where crocodiles are revered and clay models made of them (Kulkarni *et al*. 2012) [14], relative to a good harvest.

A captive centre for crocodiles from the Cauvery, as has been done in Chhattisgarh (Rai & Raj, 2015) [15], may be part of a solution. As a conservation strategy, these captive facilities for "nuisance animals", conversely reflect head starting centres initiated for the "grow and release" program in the 1980s'. With a large part of rural India dependent on the land/water interface for their daily needs, mitigative measures are difficult to initiate. Measures developed by state forest departments for compensation vary between monetary, employment opportunities within the Forest Department, and in some scenarios, no compensation is given, in particular

when residents are fishing within protected areas, i.e. Project Tiger sanctioned areas.

Conclusions

A total of 7 fatal attacks and 12 non-fatal attacks were recorded between 2009 – 2019. Age was not a factor in either case, nor was gender of the victim. Fishing, bathing, and washing utensils, clothes, or other material dominated the activities when people were attacked. Causes of attacks on people were unclear, with a large number of unknown outcomes. This could relate to mixed accounts or no witnesses in the vicinity.

Translocation of crocodiles would seem currently necessary, this being perhaps the sole incentive for people to agree to living with an ambush predator. Like much of rural India, people depend on the land/water interface for bathing, washing clothes, fishing. Extensive outreach education programmes about 'living with crocodiles' are needed.

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