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Srivari Illam, No. 61, Karthik Nagar, 10th Street, Saravanampatti, Coimbatore, Tamil Nadu 641035, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

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continued on the back inside cover

Cover: A male Scarlet Skimmer perching on vegetation by the banks of a waterbody. Ink and watercolour illustration by Anandita Pascal.

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COMMUNICATION

Preliminary investigation on morphometrics and habitat of the Indian Flapshell Turtle *Lissemys punctata* (Bonnaterre, 1789) (Reptilia: Trionychidae) in rural wetlands of Alappuzha, Kerala, India

Sajan Sunny [1], Appiyathu Saraswathy Vijayasree [2], Nisha Thomas Panikkaveetil [3] & E. Sherly Williams [4]

[1,2,3]PG and Research Department of Zoology, Fatima Mata National College (Autonomous), Chemmanmukku Railway Station Rd, Jawahar Nagar, Karbala, Kollam, Kerala 691001, India.
[4]Department of Environmental Sciences, Karyavattom Campus, University of Kerala, Thiruvananthapuram, Kerala 695581, India.
[1] sajanbhai29@gmail.com, [2] sreevidyaviji@gmail.com (corresponding author), [3] nisha.thomasp@rediffmail.com, [4] sherlyrobnet@gmail.com

Abstract: Turtles require significant conservation attention due to their low reproductive output and delayed maturity. We analysed the morphometry of Flap-shell Turtle *Lissemys punctata* from selected wetland sites in Alappuzha District, Kerala, India, to address the problem of suboptimal habitats for the species outside protected areas. Information was collected through surveys of local inhabitants, and live specimens. From our surveys in 11 sites that were identified as the habitats for Black Pond Terrapin *Melanochelys trijuga* and *L. punctata*, *M. trijuga* was predominantly found in Mannarassala (Haripad) and *L. punctata* in Karthikappally. Our preliminary morphometric analysis revealed potential links between shell dimensions and the wetland's water quality, contributing to habitat assessment and species management. Our questionnaire study indicated a decline in *L. punctata* population, primarily due to their exploitation for food and medicinal purposes, emphasizing the urgent need for targeted conservation efforts to ensure the species' survival outside protected areas.

Keywords: Conservation, environmental stressors, field surveys, human exploitation, late maturity, protected areas, population decline, reproductive output, species management, water quality.

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Author details: Dr Sherly Williams E: an environmental biologist, former professor and head of Department of Department of Environmental Sciences, University of Kerala, India, specialist in artificial breeding technology for endangered fishes of aquaculture importance for their conservation; fish biology and aquatic pollution. Dr. Nisha Thomas P: associate professor, PG and Research Department of Zoology, Fatima Mata National College (Autonomous), Kollam. Research interests include aquatic toxicology with specialization in stress physiology, environmental biology and microbiology. Sajan Sunny: working as junior research fellow (SERB funded project) in Fatima Mata National College (Autonomous), Kollam. M.Phil and Post Graduate Holder under University of Kerala. Two years research experience in field surveys and freshwater turtle identification. Dr. Vijayasree A S: assistant professor, PG and Research Department of Zoology, Fatima Mata National College (Autonomous), Kollam. Research interests include biodiversity conservation, fish physiology and comparative endocrinology.

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INTRODUCTION

The Indian Flapshell Turtle *Lissemys punctata* (Bonnaterre, 1789) is a freshwater turtle found in tropical South Asian countries such as India, Sri Lanka, Bangladesh, Nepal, Myanmar, and Pakistan. The femoral flaps that stretch from the shell to envelop the limbs are its distinctive features. A flapshell turtle can grow up to 370 mm long and survive for roughly 20 years (Das 1995, 2011). While adults have oval shells, young ones have round shells. They live in freshwater bodies like shallow lentic waters of lakes, rivers, streams, ponds, and marshes as well as artificial storage tanks, and canals dug for irrigation. They prefer sandy or muddy water bottoms because they may easily burrow into them. Monitoring health of the body and the habitat of *L. punctata*, a vulnerable freshwater turtle species, is crucial for effective in situ conservation efforts (Rashid & Swingland 1997; Das 2011). The morphometrical characteristics of *L. punctata* and water quality of the lake they inhabit are intricately linked with the turtles' health and survival, being directly influenced by the physicochemical properties and pollution levels of their aquatic environment (Baruah et al. 2016).

The physicochemical parameters of lake inhabited by *L. punctata*, including pH, dissolved oxygen, temperature, and nutrient levels can help to assess the suitability of the habitat for its long-term survival (Bhupathy & Vijayan 1989; Dutta et al. 2022). Morphometric measurements, such as carapace length, width, and height, as well as limb & head dimensions, can provide insights into the species' growth, development, and adaptations to their environment (Hossain et al. 2013). Integrating the findings from morphometrical analysis and water quality assessment can contribute to a comprehensive understanding of the species' ecology and the pressures it faces in its natural environment (Moll & Moll 2004). A lack of comprehensive conservation work will cause many species of turtles and tortoises to go extinct in the next few decades (Turtle Conservation Fund 2003). The current study aims to do a thorough morphometric examination of *L. punctata* (Image 1), encompassing measures of body weight, plastron length, carapace width, and carapace length, so that the health of *L. punctata* and its environment may be tracked with the use of this data to develop management plans and targeted conservation initiatives (Rhodin et al. 2018).

METHODS

Visits were made to upper Kuttanad Taluk and Karthikapally of Alappuzha District (Image 2). In the study areas, based on their habitats, both the species of turtles *M. trijuga* (called Karayaama or land turtle/tortoise) and *L. punctata* (called Vella aama or water turtle/tortoise) were observed respectively. Data about the flapshell turtles was compiled using the questionnaire survey approach. Random inquiries were posed to the villagers who lived close to the wetlands. A total of 15 *L. punctata* turtles, (female = 10, male = 4 and one juvenile) were measured and weighed in the least invasive way possible. In adults, sexes were distinguished by differences in length of limbs, tail, and configurations (Das 1995). Morphological parameters were measured using flexible meter tape and ruler scale nearest to 0.1 cm, and weight was loaded on electronic weighing balance nearest to 0.1 g. The data of the present study was undertaken with 20 associations comprising of each turtle morphometrics. Based on mean values of males and females, the percentage of 14 morphometric characteristics were calculated (Table 1). The statistical analysis was done using statistiXL 2.0 for Microsoft Excel 2016. Regression test was used to analyze data pertaining to the different morphometric measurements of *L. punctata* and deduce the importance of the correlation coefficient at the two-tailed level.

Image 1. Indian Flapshell Turtle *Lissemys punctata*. © Sajan Sunny.

RESULTS

Questionnaire & Field Surveys

A total of 150 people, representing a range of ages (14–80), participated in the survey. Ninety percent of respondents were interested in providing information about turtles, whereas 10% showed little interest in gathering data about them. The fishing community in the Alappuzha District is well known, and they were crucial in aiding in the turtle capture utilizing different kinds of nets.

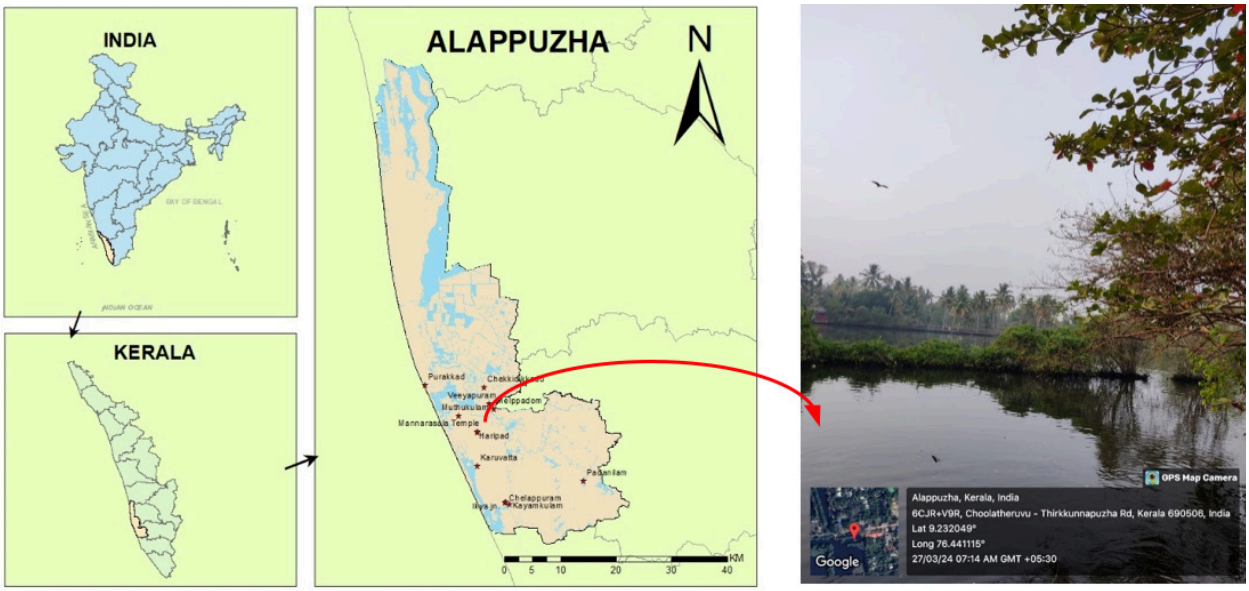

Image 2. Map depicting the study area.

According to the results of the survey, Mannarassala has higher *M. trijuga* population while Karthikapally has higher *L. punctata* population. The local people are unaware of the species' endangered status. *Melanochelys trijuga* was observed to be intensively utilized for medicinal and commercial purposes whereas *L. punctata* are hunted and traded for meat consumption. A good number of turtles (*M. trijuga*) are protected with the belief of sanctity in the temple pond of Mannarassala, Ambalappuzha of Alappuzha district. The illegal collection of turtle eggs for consumption and traditional medicine was observed to pose a threat to the survival of turtles, as it can significantly reduce reproductive success and contribute to a population decline. In some locations of Karthikapally, turtles were seen to be hunted for food and for traditional medicines.

Morphometrics

The shell height of males varied from 11.0 –13.5 cm (mean 11.8 ± 1.1 cm) and that of females varied from 13.0–17.0 cm (mean 14.8 ± 1.4 cm). The mean length of males and females were 17.8 cm and 22.0 cm, respectively. It was observed that the mean length of females were 1.2 times greater than the males. The weight of male turtles varied 0.42–0.78 kg with a mean value of 0.56 ± 0.16 kg and that of females varied from 0.7 kg to 1.53 kg with a mean value of 1.08 ± 0.31 kg. The mean weight of females were approximately two times greater than the males (Table 1). From the regression analysis, it was evident that all the correlation coefficients had positive values (Table 2), and when the size or length increases, the associated covariate, i.e., weight also increases.

The correlation coefficient between straight carapace length (SCL) & curved carapace length (CCL) was 0.961. The F-value from ANOVA was 155.4 indicating that CCL increases with increase in SCL. The correlation coefficient between SCL & straight carapace width (SCW) was 0.96. The F-value of 150.98 showed that SCW increases with increase in SCL. The correlation coefficient between SCL & straight plastron length (SPL) was 0.938. The F-value of 95.63 showed that when SCL increases SPL also increases. The correlation coefficient between SCL & straight plastron width (SPW) was 0.951. The F-value from ANOVA of 124.201 showed that SCL increases with increase in SPW. The correlation coefficient was found significant in all the above cases. The correlation coefficient between CCL & curved carapace width (CCW) was 0.952. The F-value from ANOVA was 124.590. So, it showed CCW increases as CCL increases. The correlation coefficient was significant. Similarly, all the parameters are correlated and are significant because $p < 0.01$. The shell height of male *L. punctata* was 24.29% whereas that of females was 75.71%. The carapace lengths (SCL and CCL) of males and females were 24.8% and 75.20%, respectively. Carapace width (SCW and CCW) of the males was 25% and females was 75%, plastron length (SPL and CPL) of males was 23.5% and females was 76.5%. Plastron width (SPW and CPW) of males was 25.06% and females 74.94% and the body weight of males was 17.30% and females 82.7%. It was found that all the regression equations related to the morphometric analysis are correlated and their values are significant (Tables 2, 3, & 4).

Table 1. Measurements of adult male and female Flapshell Turtle *Lissemys punctata*.

Parameters	Males (n = 4)		Females (n = 10)	
	Range	Mean ± SD	Range	Mean ± SD
Straight Carapace Length SCL (cm)	14.5–17	16.25 ± 1.32	17.5–23	19.7 ± 2.05
Curved Carapace Length CCL (cm)	16.5–19	17.87 ± 1.31	19–26	22 ± 2.8
Straight Carapace Width SCW (cm)	11.5–15	13.25 ± 1.55	14–18.7	15.68 ± 1.5
Curved Carapace Width CCW (cm)	15.2–18.5	16.55 ± 1.51	17.5–22.5	19.85 ± 1.82
Straight Plastron Length SPL (cm)	13.5–16	14.5 ± 1.08	15.5–22.3	18.88 ± 2.22
Curved Plastron Length CPL (cm)	14.7–17	15.67 ± 0.96	17–23	19.9 ± 2.25
Straight Plastron Width SPW (cm)	12–13.5	12.62 ± 0.75	12.5–17.5	15.1 ± 1.79
Curved Plastron Width CPW (cm)	12.5–14	13.37 ± 0.75	13.5–19	16.05 ± 1.97
Head Length HL (cm)	8–15	12.37 ± 2.13	16–18	15.9 ± 1.1
Head Width HW (cm)	2–3.5	2.75 ± 0.64	2.3–4.5	3.63 ± 0.66
Head Circumference H.CIR (cm)	8–10	9.25 ± 0.95	8–14	11.5 ± 2.01
Body Circumference (cm)	29–31.5	29.5 ± 1.68	30.5–39.5	35.4 ± 3.53
Shell Height (cm)	11–13.5	11.87 ± 1.1	13–17	14.8 ± 1.47
Body Weight (kg)	0.42–0.78	0.56 ± 0.16	0.7–1.53	1.08 ± 0.31

Table 2. Relationship based on carapace data.

Parameters	Correlation coefficient	F	Regression (y = bx + a)
SCL – CCL	0.961*	155.4*	CCL = SCL*1.04 + 1.51
SCL – SCW	0.96*	150.98*	SCW = SCL* 0.774 + 0.46
SCL – SPL	0.938*	95.63*	SPL = SCL*0.886 + 1.535
SCL – SPW	0.951*	124.201*	SPW = SCL*0.673 + 1.811
CCL– CCW	0.952*	124.59*	CCW = CCL*0.797 + 2.209
CCL – CPL	0.954*	131.774*	CPL = CCL*0.87 + 0.540
CCL – CPW	0.957*	140.279*	CPW = CCL* 0.683 + 1.003
SCL – HL	0.76*	17.797*	HL = SCL*0.508 + 5.42
CCL – HL	0.709*	13.13*	HL = CCL*0.439 + 5.711

* denotes significance [$p < 0.01$]

Table 3. Relationship based on head data.

Parameters	Correlation Coefficient	F	Regression Equation (y = bx + a)
HL – HW	0.553*	5.726*	HW = HL*0.174 + 0.779
HL – HC	0.729*	14.772*	HC = HL*0.66 + 0.987

* denotes significance [$p < 0.01$]

Table 4. Relationship based on body data.

Parameters	Correlation Coefficient	F	Regression Equation (y = bx + a)
BH – BW	0.882*	41.851*	Log weight = Log height*2.648 – 0.086
BH – Circumference	0.94*	98.291*	Cicumference = BH*2.128 + 3.885

* denotes significance [$p < 0.01$]

Habitat Assessment

The average values of physicochemical parameters in Muthukulam Lake of Karthikapally area (Alappuzha district) are listed in Table 5. The water quality test yielded a pH value of 7.35. It demonstrated the lake's rather alkaline composition. This alkalinity may be caused by the local population's usage of detergents. These bodies of water might potentially become eutrophic. There would be a possibility of eutrophication in these water bodies. The dissolved oxygen (DO) was found to be 4.7 mg/L, showing anticipated microbial activities. Hardness of the water proclaimed the extremely high levels of calcium and magnesium in the lake. High levels of chloride (> 5,000 mg/L), fluoride (1.39 mg/L), and sulphate (348.67 mg/L) was detected in the water during the present study indicating high levels of freshwater pollution. The high values on electrical conductivity showed maximum ionic concentration of the lake. Low values of iron were detected (0.39 mg/L) and nitrate (4.75 mg/L) showed a moderate value. The high amount of total dissolved solids (TDS) (> 10,000 mg/L) indicated the concentration of dissolved ions in water. The presence of harmful organisms was demonstrated by the massive amounts of *Escherichia coli* and total coliforms in lake water.

Table 5. Water quality parameters of the studied lakes (Muthukulam, Karthikapally).

Chemical Parameters				
	Characteristics	**Unit**	**Maximum acceptable limits (Freshwater)**	**Result**
1	Turbidity	NTU	70	6.5
2	pH at 25˚C		6.0 – 9.0	7.35
3	Total dissolved solids	mg/L	1000	>10000
4	Total Hardness	mg/L	200 – 600	>5000
5	Calcium	mg/L	75	561
6	Magnesium	mg/L	150	923
7	Chloride	mg/L	250	>5000
8	Electrical conductivity	micro mhos/cm	2000	39160
9	Sulphate	mg/L	250	348.67
10	Fluoride	mg/L	1.5	1.39
11	Iron	mg/L	1	0.39
12	Nitrate	mg/L	10	4.75
13	Dissolved Oxygen	mg/L	4.5 – 10.3	4.7
Biological Parameters				
14	Total coliforms		Shall not be detected/100 ml	Present
15	E. Coli/100 ml		Shall not be detected/100 ml	Present

DISCUSSION

The present preliminary study provides the first step in understanding the morphometric characteristics and habitat conditions of the Indian flap-shelled turtle, *L. punctata*, in the Muthukulam (Alappuzha) Kerala, India. The results of the present study showed maximum CCL and CW by the males and females of *L. punctata*, was in accordance with published findings (Yadava & Prasad 1982; Bhupathy & Vijayan 1991). The length of head, forelimbs, hindlimbs, and body circumference of males and females revealed in the present investigation agreed with literature (Auffenberg 1981; Agarwal 1987; Shrestha 1997). The juvenile turtle noted by us, had dark striped pattern which tend to reduce with growth (Smith 1931; Das 1995).

The present study found that the female turtles were twice as large in carapace length, carapace width, plastron length, plastron width, and body weight compared to males, consistent with literature (Moll 1984; Bhupathy & Choudhury 1995). The higher body size and weight of females are likely adaptations to accommodate the energy requirements for egg production and brooding, which is an essential reproductive strategy in turtles (Gibbons 1990; Janzen & Paukstis 1991). Our preliminary regression analysis yielded a positive correlation of shell dimensions, which agrees with the literature (Ling & Palaniappan 2011; Hossain et al. 2013; Talukdar et al. 2021). These significant associations indicate that the growth and development of different body parts in *L. punctata* are closely linked, and the measurement of one parameter can be used to reliably predict the value of another (Kuchling & Kuchling 1999; Zuffi et al. 1999). The data represented here has a rather higher number of variables than turtle sample size, which may generate chances for overfitting issue (p>N). The randomness of chances might produce pseudo correlations. Future attempts of improving the current preliminary study must aim to overcome these caveats, as postulated here.

The unsuitable water quality values revealed by us in the Muthukulam (Kayamkulam) lake, with high levels of dissolved solids, hardness, chloride, fluoride, sulfate, *E. coli,* and total coliforms, mirror previous studies on freshwater bodies in Kerala (Das & Jain 2017; Kumar et al. 2015). The alkaline pH, low dissolved oxygen, and high electrical conductivity of the lake water indicate eutrophication, which is a common issue in many water bodies due to human activities, like the detergents use and agricultural runoff (Sharpley et al. 1994; Carpenter et al. 1998; Smith 1998). The high levels of nitrates in the lake water also suggest the presence of organic pollutants, which can have detrimental effects on the aquatic flora and fauna, including the *L. punctata* population (Camargo et al. 2005; Camargo & Alonso 2006). The implications of the poor water quality in the *L. punctata* habitat are significant, as turtles are known to be sensitive to environmental changes and pollution (Davenport & Wrench 1990; van Dijk et al. 2014; Benn et al. 2021). Krishnakumar et al. (2009) studied the distribution, habitat preferences, and conservation status of *L. punctata* in Kerala and reported that the species is widely distributed across the state, but its populations are threatened by habitat degradation, pollution, and illegal harvesting.

In a global context, the challenges faced by freshwater turtles, including *L. punctata*, are not limited to India and its neighboring regions. A review by Buhlmann et al. (2009) on the conservation status of freshwater turtles worldwide revealed that more than 50% of these species are threatened with extinction, primarily due to habitat loss, pollution, and overexploitation. To secure the long-term survival of these endangered species, the authors emphasized the necessity of all-encompassing conservation initiatives that include habitat restoration, pollution prevention, and sustainable resource management. To sum up, this work offers important new information about the morphometric traits and environmental circumstances of the Flap-shelled Turtle of southern Kerala. Future studies and conservation plans targeting *L. punctata* and other freshwater turtle species in the area can be built upon the data and analysis provided here.

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