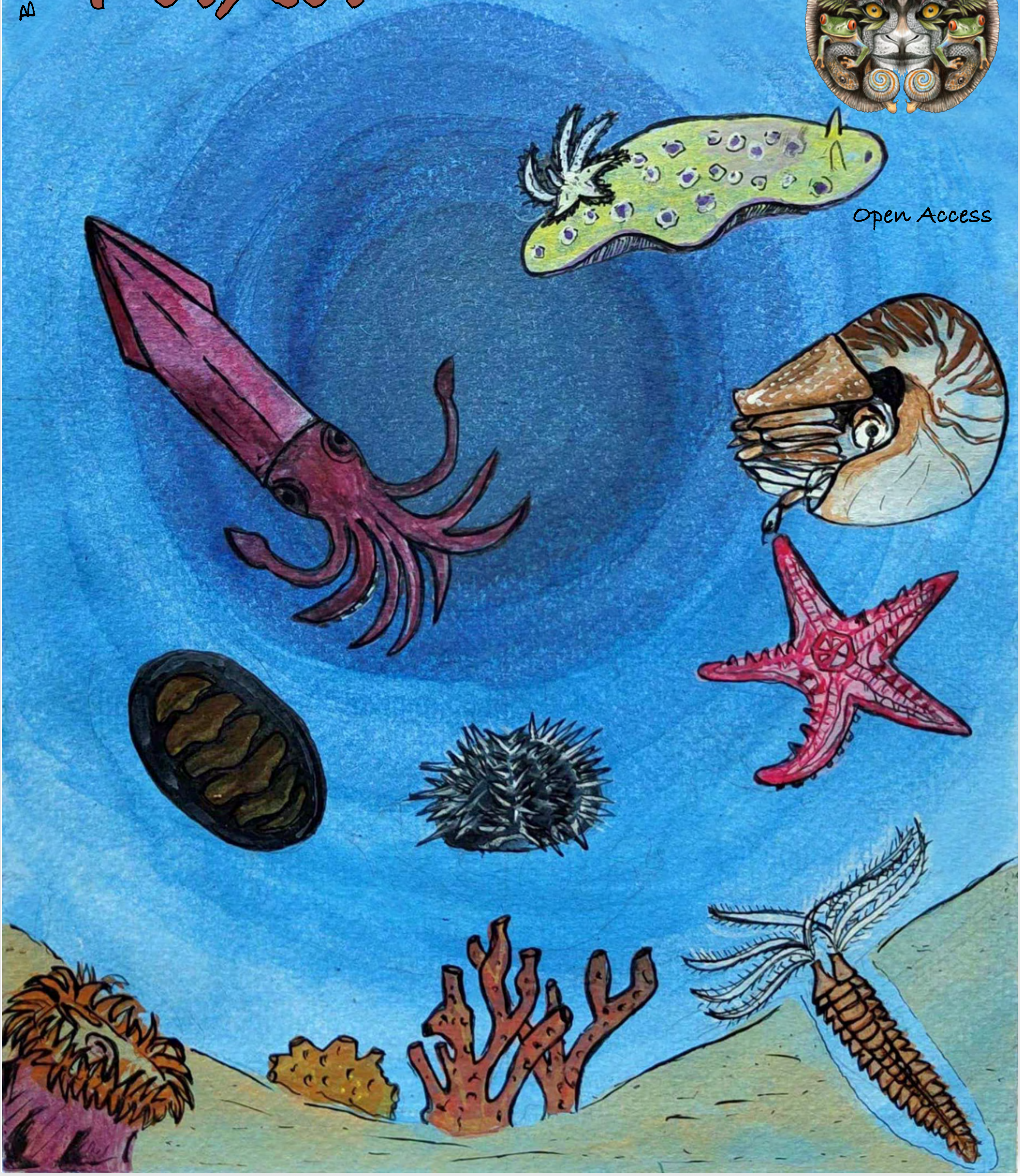
Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2023.15.6.23283-23462
www.threatenedtaxa.org

26 June 2023 (Online & Print)
15(6): 23283–23462
ISSN 0974-79t07 (Online)
ISSN 0974-7893 (Print)



Open Access

i ri t

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | .threatenedta a.or
Email: sanjay@threatenedtaxa.org

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Marine invertebrates - made with acrylic paint. © P. Kritika.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 June 2023 | 15(6): 23307–23314

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.8473.15.6.23307-23314

#8473 | Received 07 April 2023 | Finally accepted 21 May 2023

COMMUNICATION

Plastral deossification zones in the Endangered Spiny Hill Turtle *Heosemys spinosa* (Testudines: Geoemydidae) on Borneo

Siti Nor Baizurah [1] & **Indraneil Das** [2]

[1,2] Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia.
[1] sitinorbaizurahabdulmalik@gmail.com, [2] idas@unimas.my (corresponding author)

Abstract: Studies of the evolution of turtle shell morphology have raised numerous questions. In this study, five adult females and two adult males of the Endangered Spiny Hill Turtle *Heosemys spinosa* from two localities in western Sarawak in East Malaysia (Borneo) were examined for the presence of plastral deossification zones, reported as indicative of kinesis in earlier studies. A total of 52 (34 females, 18 males) radiographs demonstrated distinct poorly-ossified areas across the hyo-hypoplastral and the hypo-xiphiplastral junctures in females of straight carapace length (SCL) 143.4–211.4 mm. The feature is here interpreted as a permanent plastral hinge, which was not observed in either of the males examined. The smallest female with a weak but discernible line at the contact of these bones had a SCL of 125 mm, suggestive of minimum size of maturity in *Heosemys spinosa* in this population.

Keywords: Biology, growth, maturity, osteology, plastron, reproductive biology, sulcus, turtle.

Bahasa: Kajian mengenai evolusi morfologi berkenaan cengkerang kura-kura merupakan topik yang menimbulkan pelbagai persoalan. Lima ekor betina dan dua ekor jantan yang matang dari spesies Terancam yang dikenali sebagai Spiny Hill Turtle (*Heosemys spinosa*), dari dua lokaliti di barat Sarawak (Malaysia Timur, Borneo) telah dikaji untuk kehadiran zon deossifikasi plastral, yang dilaporkan sebagai indikasi kinesis menurut kajian awal. Sebanyak 52 pengimejan radiografi menunjukkan kawasan ossifikasi yang kurang ketara di antara hyo-hypoplastral dan hypo-xiphiplastral dalam kumpulan kura-kura betina yang mempunyai straight carapace length (SCL) 143.4–211.4 mm. Ciri-Ciri ini dikategorikan sebagai engsel plastral yang kekal, dan tidak dilaporkan dari kumpulan kura-kura jantan yang dikaji. Betina yang terkecil menunjukkan garis yang kabur tetapi kelihatan di antara dua tulang ini pada size SCL 125 mm, yang seterusnya mencadangkan saiz kematangan minimum untuk populasi ini.

Editor: Raju Vyas, Vadodara, Gujarat, India. **Date of publication:** 26 June 2023 (online & print)

Citation: Baizurah, S.N. & I. Das (2023). Plastral deossification zones in the Endangered Spiny Hill Turtle *Heosemys spinosa* (Testudines: Geoemydidae) on Borneo. *Journal of Threatened Taxa* 15(6): 23307–23314. https://doi.org/10.11609/jott.8473.15.6.23307-23314

Funding: Niche Research Grant from the Ministry of Higher Education, Government of Malaysia (NRGS/1087/2013(01)). Research permit: Sarawak Forest Department, for issuing the permit (No. 181/JHS/NCCD/600–7/2/107; Park Permit No. WL 88/2018)

Competing interests: The authors declare no competing interests.

Author details: Siti Nor Baizurah is a PhD graduate from UNIMAS, previously worked on the herpetofauna ecology for her postgraduate studies and her research interests include ecology, anthropogenic effects on ecosystem, human wildlife conflicts and wildlife management. Indraneil Das received a D.Phil in Zoology from the University of Oxford, and was a Fulbright Fellow at Harvard University. He is currently professor at the Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, where he conducts research on the systematics and ecology of the herpetofauna of Borneo and south-east Asia.

Author contributions: SNB carried out the research work, providing data (ie: photographs, measurements) and drafted the manuscripts. ID coordinated the data and participate in writing and reviewing the manuscript. All author agreed to the final version.

Acknowledgements: This project was funded by a grant under the Niche Research Grant Scheme (NRGS), awarded by the Ministry of Higher Education, Government of Malaysia (NRGS/1087/2013(01) and a Conservation Leadership Programme (CLP) Grant. Our deepest gratitude goes to our veterinarian, Davies Belayong and his colleagues at the Animal Veterinary Clinic Kuching for assisting with radiography. We would like to acknowledge the Institute of Biodiversity and Environmental Conservation, UNIMAS for providing facilities and equipment, and would like to single out Andrew Alek Tuen, Gabriel Tonga Noweg and Rahah binti Mohamad Yaakup, and the Research, Innovation and Enterprise Centre under Lo May Chiun for managing the NRGS project. The research undertaken and animal handling procedures used in this work were approved under permits issued by the Sarawak Forest Department (No: 181/JHS/NCCD/600–7/2/107; Park Permit No: WL 88/2018). Finally, we thank our friends in IBEC, Izneil Nashriq, Anthony Pine, Veronica Martin and Wong Jye Wen for assistance with field work, and the staff of Sarawak Forestry Cooperation at Kubah National Park for permitting access to the study site, particularly, Stephen Antang and Siti Wahdaniyah.

INTRODUCTION

Evolution of turtles has produced variations in shell morphology and pelvic elements (Rivera 2008; Williams & Stayton 2019) and shell kinesis, although female plastral kinesis remains speculative in most species. The degree of kinesis depend on specializations in muscle and ligament systems, and active kinesis usually involves modifications of kinetic structures that allow flexibility through voluntary muscle connections (Pritchard 2003). In passive kinesis, modifications of muscles are not necessary and may rely on pressures exerted over certain periods, including for respiration. For instance, pelvic kinesis in *Homopus signatus* (Hofmeyr et al. 2005), posterior plastral lobe kinesis in *Heosemys spinosa* (Mertens 1942, 1971), carapacial pankinesis in *Dogania subplana* (Pritchard 1993) and *Kinixys erosa* (Pritchard 2008) have been assumed on the basis of structure, although their mechanism and function is poorly known. Shell kinesis has been reported in smaller individuals of terrestrial or semi-terrestrial species as a possible adaptation to escape predation and aid locomotion (Berlant & Stayton 2017; Cordero et al. 2018). In contrast, posterior plastral lobe kinesis reported in *H. spinosa* has been hypothesized to be part of its reproductive strategy (Waagen 1984; Moll 1985), even though the shell was once considered as akinetic, and the possibility of plastral muscle specialization has been proposed (Bramble 1974). The hinge in *H. spinosa* reportedly develops in mature females (Moll 1985), resembling the hinge position displayed in the genus *Cuora*, albeit the kinesis in *H. spinosa* is limited to the posterior part of the plastron (Pritchard 1993).

Shell kinesis harbours numerous advantages, including predation survival, locomotion and facilitation of the passage of large eggs in small turtles. Accordingly, variation in the turtle shell has been speculated to be affected by multiple pressures, including phylogenetic, environmental and reproduction, in which plastral kinesis is one result of those pressures (Angielczyk et al. 2011). It is important to note that plastral modifications is usually expressed strongly in adults of both sexes in kinetic species (Ernst & Barbour 1989). Consequently, a number of studies (reviewed in Cordero & Quinteros 2015) discusses the adaptations of shell kinesis to habitat preferences, while sexually dimorphic kinesis must be related to reproduction strategy benefits, although a recent study suggests that the evolutionary structure of shell kinesis may stem from more complex relationships between ecological, phylogeny, and developmental processes in turtles (Cordero et al. 2018).

In the present study, we examine adults of the Spiny Hill Turtle from two free-ranging populations in Sarawak, East Malaysia (northwestern Borneo), in order to understand plastral kinesis (represented by plastral sulcus). Specifically, we will try to ascertain if the feature is restricted to females, the specific plastral bones associated with sulcus, the minimal size of animal that correlates with the development of the feature, and finally, if there are seasonality in variation of the feature.

MATERIALS AND METHODS

Data on plastral morphology were collected within a larger study on the spatial and thermal ecology of the Spiny Hill Turtle from two localities in western Sarawak, northern Borneo. The first was from Kubah National Park (headquarters at 1.6115^{0}N, 110.1964^{0}E, WGS 84), a protected area of 2,230 ha, located within the Matang Massif, the second from forests attached to a privately-owned farmland (1.3073^{0}N, 110.5037^{0}E, WGS 84), around the township of Serian (Image 1). Vegetation types represented include mixed dipterocarp forest, Kerangas (Bornean heath forest) and submontane forests (Hazebroek & Morshidi 2000). Data were obtained between 11 April 2017 and 30 January 2019 from five females that were fitted with temperature sensitive transmitters (Holohil™ Ri2B and Holohil™ PD-2T) for a study of spatial and thermal ecology, during which the present study was conducted. Animals were brought to a veterinary clinic for radiography and released at the point of encounter within a week.

Radiography procedures were conducted by a qualified veterinarian. A Sedecal Apr-Vet (Model E7239X) radiographic unit was used to produce three views per individual (dorsal, ventral and lateral positions). Each exposure was 78 kV (25 mA to 320 mA) for 0.08 sec, following which individuals were weighed using a digital scale (Camry/ ACS-3—JC31). General anaesthesia was not used in the procedure, and depending on the mobility of the individual turtle, manual restraints with tape was used. An Xscan Radiology Application (Version 2.10) was used to edit the image obtained, prior to examination.

OBSERVATIONS AND DISCUSSION

A total of 34 radiographic images were taken of five females, which displayed a distinct sulcus, presumably comprising connective tissue, across the midbody,

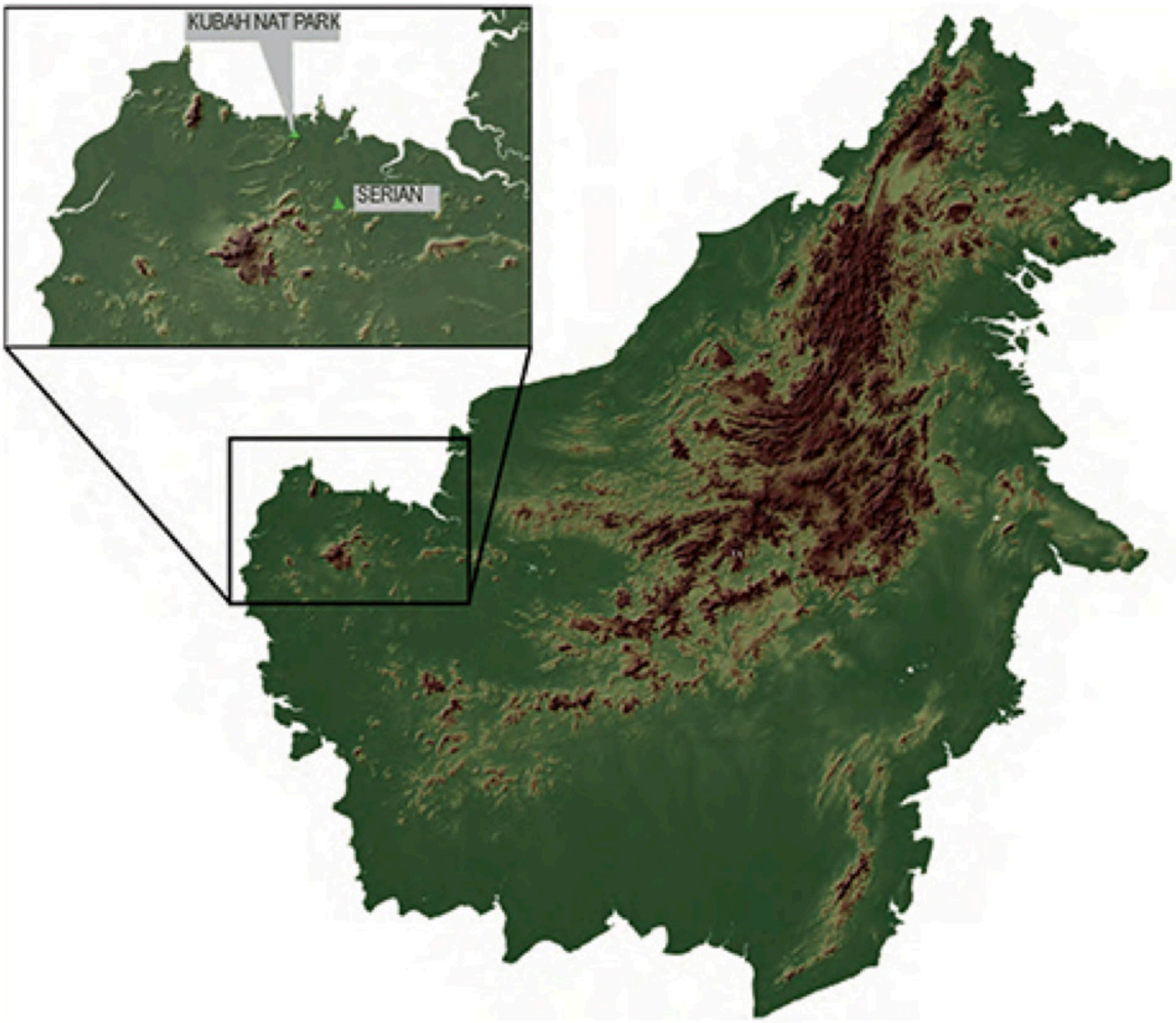


Image 1. Map of north-western Borneo; expanded area to top right show locations of study sites at Kubah National Park and the township of Serian, Sarawak State, East Malaysia.

specifically transversely between the hyoplastral-hypoplastral bones, and the hypoplastral & xiphiplastral bones, under the abdominal and femoral scute regions. None of the 18 radiographs of the two males showed evidence of a sulcus (refer to Image 5), which has been referred in the literature as indicative of a plastral hinge (Mertens 1942, 1971; Bramble 1974; Waagen 1984). The feature is known to exist only in adult females of the species (Moll 1985), presumably to facilitate oviposition and perhaps to allow the passage of large eggs (Yasukawa et al. 2001; Joyce et al. 2012). Other sexually dimorphic features have been listed in Baizurah & Das (2021). Images 2–4 indicate that kinesis of plastral elements may be shown by *H. spinosa* as seen in two females (SNB 638 and SNB 641) across time. The smallest female (mean SCL of 125.1 mm) was beginning to display presence of such a gap (Image 3) indicating possible size at maturity of females in *H. spinosa*. Examination of the radiographs of these individuals do not indicate a greater development of the hinge at any particular month, as might be expected if the hinge becomes functional only periodically, for the passage of the eggs.

Previous studies have discussed that pelvic aperture dimensions may be a limiting factor in reproductive output, and how it relates to sexual dimorphism in some turtles (Clark et al. 2001; Matysiak et al. 2017; Cordero et al. 2018). Apart from pelvic size variation and reduced relative plastral length in males in increasing reproduction output, plastral kinesis can serve a similar function in increasing reproduction output. Plastral kinesis is thought to reduce pelvic strain in females during egg-laying (Legler 1960; Yasukawa et al. 2001). The first

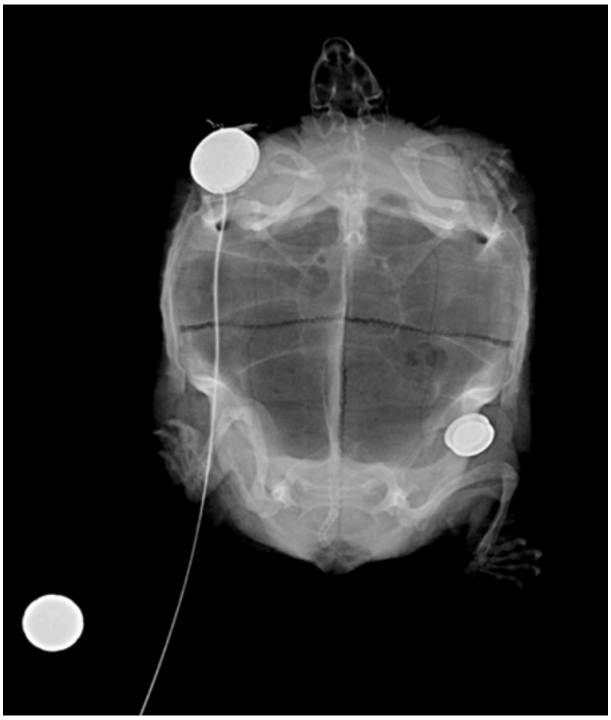


Image 2. Radiographs of plastron showing sulcus at juncture of hyo-hypoplastra of an adult (SCL 191 mm) female *Heosemys spinosa* (SNB 643). Image taken in November 2018. Also visible in this and the subsequent images are the externally-attached radio-transmitter, and an iButton, implanted for a larger study of movement and thermoregulation in the species.

Table 1. Details of *Heosemys spinosa* radiographically examined.

Identification	Sex	Total radiographs	Locality
SNB 637	Male	16	Kubah NP
SNB 638	Female	14	Kubah NP
SNB 639	Male	2	Kubah NP
SNB 641	Female	12	Kubah NP
SNB 642	Female	2	Kubah NP
SNB 643	Female	4	Kubah NP
SNB 640	Female	2	Serian

record of a plastral hinge in *H. spinosa* was by Mertens (1942, 1971), followed by the detailed examination of two females by Waagen (1984), who speculated that the structure is rather weak in adult females. Hence the likelihood that kinesis serves a probably protective mechanism is unlikely. It is important to note that these descriptions are not supported by histological data hence lacking the information needed to functionally validate female-specific plastral kinesis in *Heosemys*. Waagen (1984) described the hinge as consisting of fibrous tissues internally that did not appear to change with body size, although the possibility of temporal change was mentioned. As described in that study, the present one found that the structure does not remain distinct year round, the deossification of bones presumed related to oviposition, not affected by seasonal changes, as evidenced in our radiographs (see Images 1–3). However, we have no indication that any of our females were preparing to reproduce, and no mating behaviour was observed. Previous literature on reproduction of *H. spinosa*, albeit in captivity, stated that copulation is typically triggered by rain showers, and egg deposition usually occurs in March-July (Herman 1993; Goetz 2007). In Sarawak (northwestern Borneo), high humidity and temperatures are encountered throughout the year, and periods associated with high rainfall events occur between November and March, with the passage of the north-east monsoons, and a weaker one between May and September, coinciding with the south-west monsoons (Sa'adi et al. 2019).

Numerous functional traits usually emerge late in turtle ontogeny, including development of fibrous tissues, which are known to progress slowly via repatterning of tissue which is acquired over the growth period (Cordero et al. 2018). The gradual process may explain the changes in hyo-hypoplastral, and hypo-xiphiplastral regions we noted across time. For instance, hatchling plastron shape of kinetic-shelled species undergoes differentiation post embryonic stages, especially in area where the hinge presumably occurs, as they reached maturity, in contrast to akinetic species which undergoes plastron differentiation at extreme and posterior ends (Cordero et al. 2019). Lastly, extrinsic factors such as abundance of resources and rainfall are known to affect reproductive cycles in some species (Akani et al. 2005; Loehr et al. 2011; Graham et al. 2015). Our radiographic observations suggest that hyo-hypoplastral and hypo-xiphiplastral kinesis in *H. spinosa* is possibly influenced by reproductive needs, developing during ontogeny, and may not be associated with local climate.

REFERENCES

Angielczyk, K.D. (2011). Adaptive evolution of plastron shape in emydine turtles. *Evolution* 65(2): 377–394. https://doi.org/10.1111/j.1558-5646.2010.01118.x

Akani, G.C., M. Francesco, M. Angelici, S. Wariboko, E. Politano, E. Filippi & L. Luiselli (2005). Reproductive seasonality and clutch size of sympatric Hinge-back Tortoises (*Kinixys erosa* and *Kinixys homeana*) in southern Nigeria (Reptilia, Testudines: Testudinae). *Aldrovandia* 1: 111–115.

Baizurah, S.N. & I. Das (2021). Sexual dimorphism in *Heosemys spinosa* (Testudines: Geoemydidae) from Sarawak, Borneo. *Herpetology Notes* 14: 1231–1235. https://www.biotaxa.org/hn/

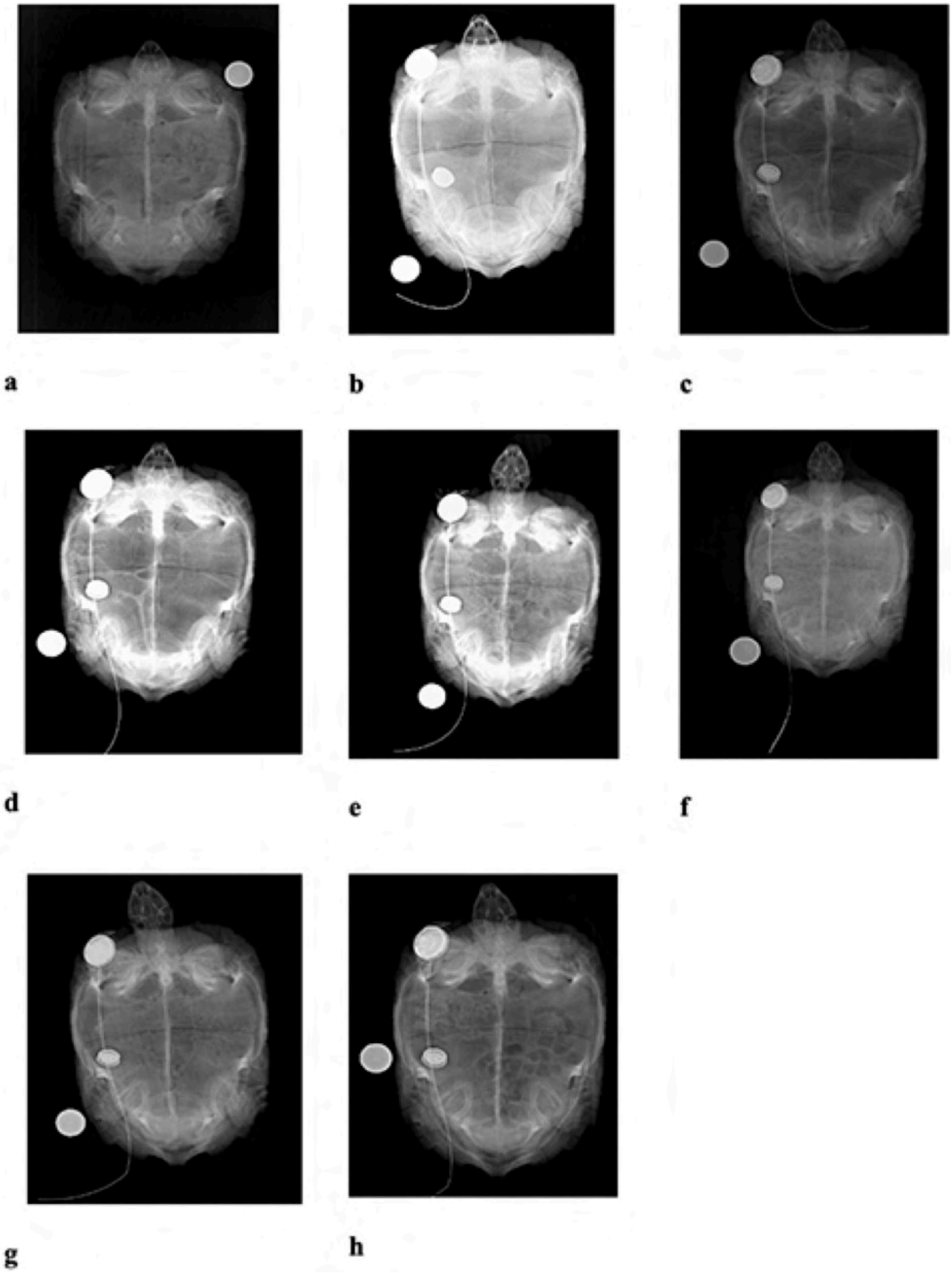


Image 3. Radiographs of plastron showing sulcus at junctures of hyo-hypoplastra and hypoplastra-xiphiplastra of a female *Heosemys spinosa* (SNB 638). Straight carapace length (SCL in mm) as follows: a) 191.33; b) 195.46; c) 198.12; d) 198.12; e) 201.3; f) 208.31; g) 210.06; h) 210.53. Diameter of scale markers = 22 mm. a) Aug-2017; b) Oct-2017; c) Dec-2017; d) Feb-2018; e) April 2018; f) Nov-2018.

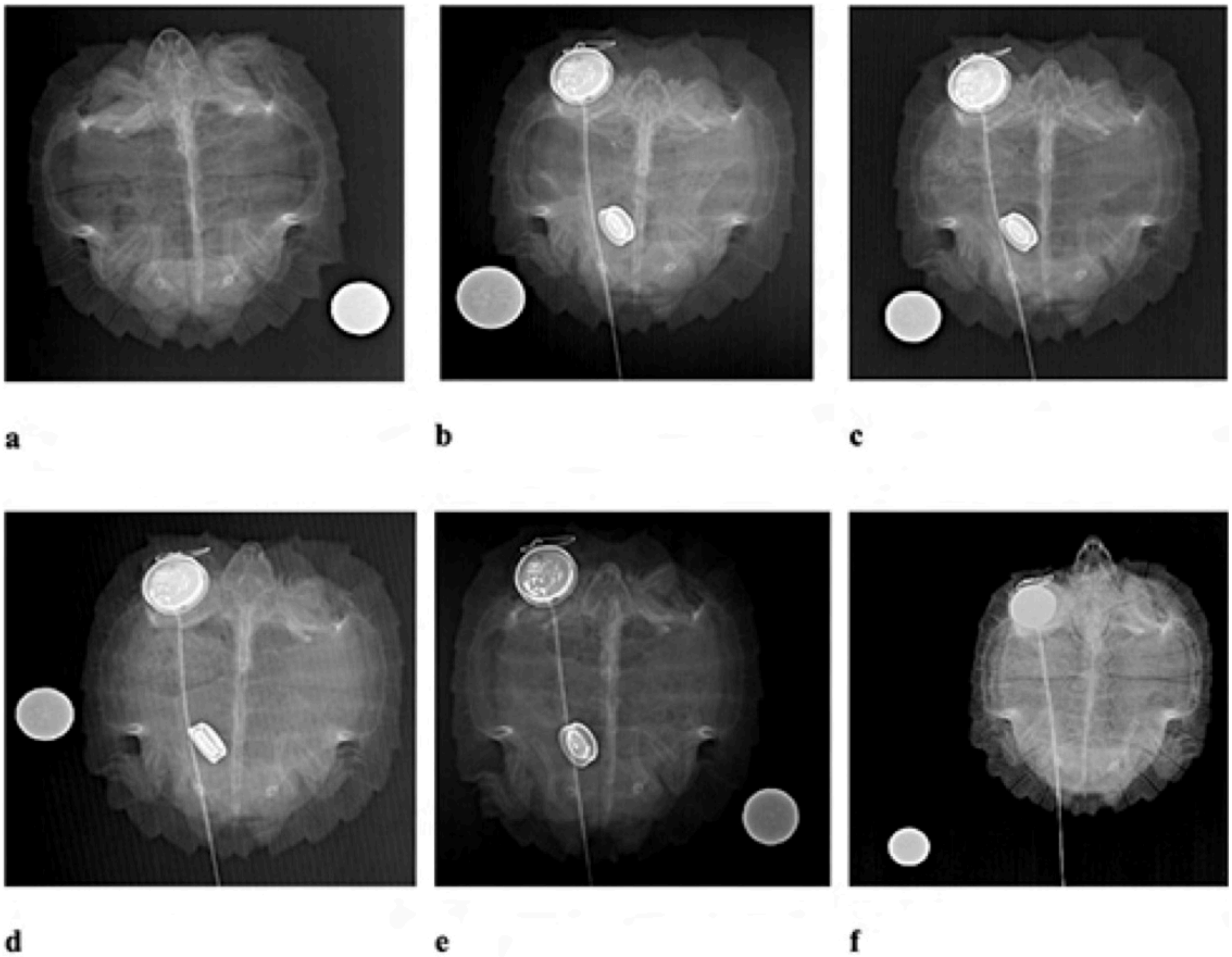


Image 4. Radiographs of plastron showing sulcus at junctures of hyo-hypoplastra and hypoplastra-xiphiplastra of a female *Heosemys spinosa* (SNB 641). Straight carapace length (SCL in mm) as follows: a) 125.1; b) 126.2; c) 126.96; d) 128.52; e) 131.07; f) 143.29. Diameter of scale markers: 22 mm.

article/view/67247

Berlant, Z.S. & C.T. Stayton. (2017). Shell morphology in the Kinosternidae: functional and evolutionary patterns. *Herpetologica* 73(1): 30–42. https://www.jstor.org/stable/26534350

Bramble, D.M. (1974). Emydid shell kinesis: biomechanics and evolution. *Copeia* 1974(3): 707–727. https://www.jstor.org/stable/1442685?origin=crossref

Clark, P.J., M.A. Ewert & C.E. Nelson (2001). Physical apertures as constraints on egg size and shape in the Common Musk Turtle, *Sternotherus odoratus. Functional Ecology* 15(1): 70–77. https://doi.org/10.1046/j.1365-2435.2001.00494.x

Cordero, G.A. & K. Quinteros (2015). Skeletal remodelling suggests the turtle's shell is not an evolutionary straitjacket. *Biology Letters* 11(4): 1–5. https://doi.org/10.1098/rsbl.2015.0022

Cordero, G.A., K. Quinteros & F.J. Janzen (2018). Delayed trait development and the convergent evolution of shell kinesis in turtles. *Proceedings of the Royal Society B* 285(1888): 20181585. https://doi.org/10.1098/rspb.2018.1585

Cordero, G.A., S. Stearns, K. Quinteros, C.M. Berns, S.M. Binz & F.J. Janzen (2019). The postembryonic transformation of the shell in emydine box turtles. *Evolution and Development* 21: 297–310. https://doi.org/10.1111/ede.12307

Ernst, C.H. & R.W. Barbour (1989). *Turtles of the World.* Smithsonian Institution Press, Washington, D.C., 313 pp.

Goetz, M. (2007). Husbandry and breeding of the Spiny Turtle *Heosemys spinosa* (Gray, 1831) at the Durrell Wildlife Conservation Trust. *Radiata* 16(2): 1–15.

Graham, S.P., C.K. Ward, J.S. Walker, S. Sterrett & M.T. Mendonca (2015). Sexual dimorphism and seasonal variation of reproductive hormones in the Pascagoula Map Turtle, *Graptemys gibbonsi. Copeia* 2015(1): 42–50.

Hazebroek, H.P. & A.K.A. Morshidi (2000). *National Park of Sarawak*. Natural History Publication (Borneo) Sdn Bhd., Kota Kinabalu.

Herman, D.W. (1993). Reproduction and management of the southeast Asian Spiny Turtle (*Heosemys spinosa*) in captivity. *Herpetological Natural History* 1(1): 97–100.

Hofmeyr, M.D., B.T. Henen & V.J.T. Loehr (2005). Overcoming environmental and morphological constraints: egg size and pelvic kinesis in the smallest tortoise, *Homopus signatus. Canadian Journal of Zoology* 83: 1343–1352. https://cdnsciencepub.com/doi/10.1139/z05-132

Joyce, W.G., N. Micklich, S.F.K. Schaal & T.M. Scheyer. (2012). Caught in the act: The first record of copulating fossil vertebrates. *Biology Letters* 8: 846–848. https://royalsocietypublishing.org/doi/10.1098/rsbl.2012.0361

Legler, J.M. (1960). Natural history of the Ornate Box Turtle, *Terrapene ornata ornata* Agassiz. *University of Kansas Publications, Museum of Natural History* 11: 527–669.

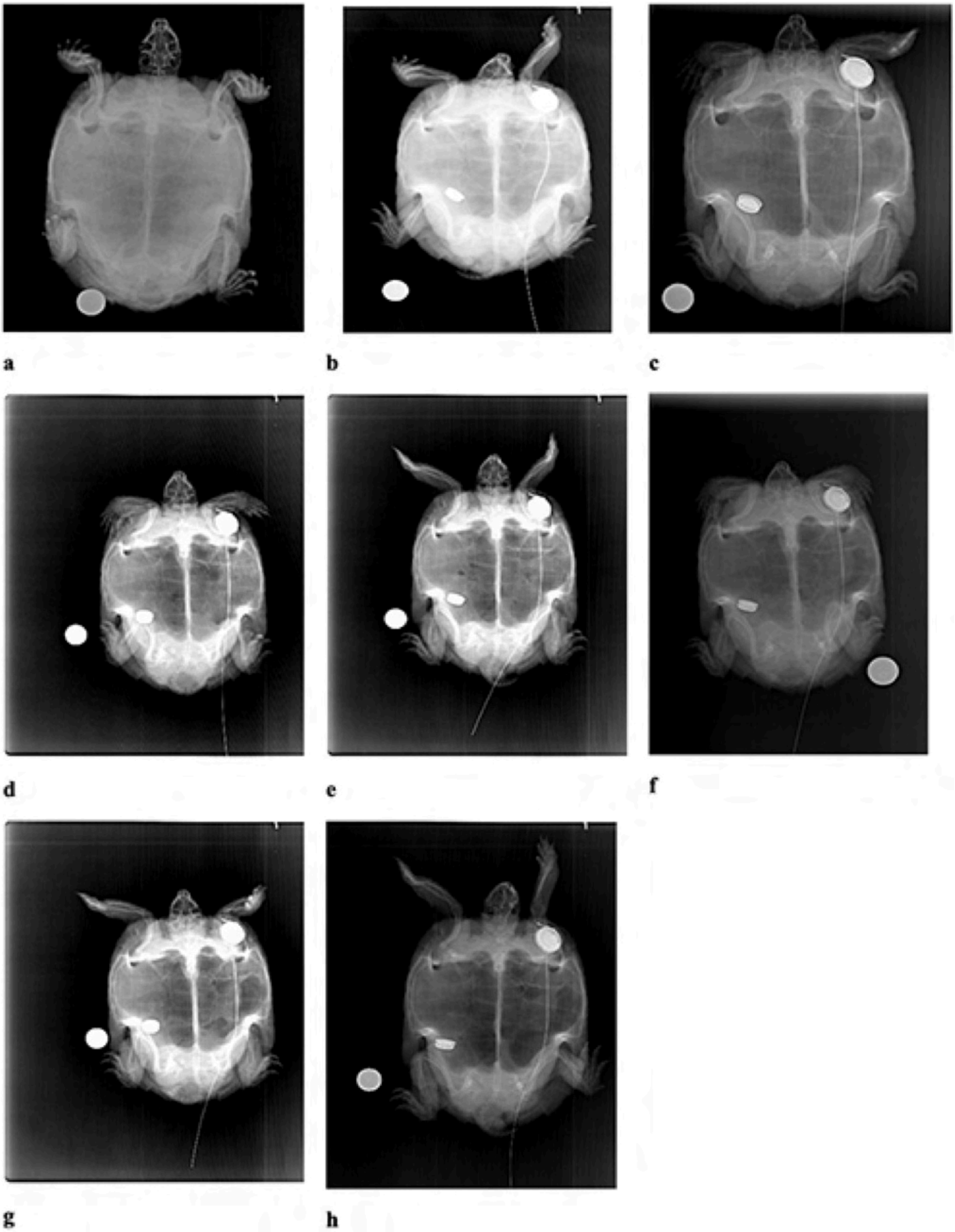


Image 5. Radiographs of plastron of a male *Heosemys spinosa* (SNB 637). Straight carapace length (SCL) 637 mm. Straight carapace length (SCL in mm) as follows: a) 198.2; b) 200.8; c) 205.1; d) 218.5; e) 223.19; f) 225.91; g) 231.27; h) 237.72. Diameter of scale markers: 22 mm.

Loehr, V.J.T., B.T. Henen & M.D. Hofmeyr (2011). Reproductive responses to rainfall in the Namaqualand Speckled Tortoise. *Copeia* 2011(2): 278–284. https://www.jstor.org/stable/41261877

Matysiak, A., A.W. Malecha, H. Jakubowski, E.T. Sadowska, P. Koteja & P. Tryjanowski (2017). Sexual dimorphism, asymmetry and the effect of reproduction on pelvis bone in the bank vole, *Myodes glareolus. Mammal Research* 62(3): 297–306. https://doi.org/10.1007/s13364-017-0317-1

Mertens, R. (1942). Zwei bemerkungen über Schildkröten Südost-Asiens. *Senckenbergiana* 25(1/3): 41–46.

Mertens, R. (1971). Die Stachelschildkröte (*Heosemys spinosa*) and ihre Verwandten. *Salamandra* 7(2): 49–54.

Moll, E.O. (1985). Comment: sexually dimorphic plastral kinesis– the forgotten papers. *Herpetological Review* 16: 16.

Pritchard, P.C.H. (1993). Carapacial pankinesis in the Malayan Softshell Turtle, *Dogania subplana. Chelonian Conservation and Biology* 1(1): 31–36. https://chelonian.org/wp-content/uploads/file/CCB%20Vol%201%20No%201%20(1993)/Pritchard_1993a.pdf

Pritchard, P.C.H. (2003). Akinesis and plastral scute homologies in *Sternotherus* (Testudines: Kinosternidae). *Chelonian Conservation and Biology* 4(3): 671–674. https://chelonian.org/wp-content/uploads/file/CCB_Vol_4_Nos1-4(2001-2005)/Pritchard_2003.pdf

Pritchard, P.C.H. (2008). Evolution and structure of the turtle shell, pp. 45–84. In: Wyneken, J., M.H. Godfrey & V. Bels (eds.). *Biology of Turtles: From Structures to Strategies of Life*. CRC Press, Boca Raton, Florida, USA.

Rivera, G. (2008). Ecomorphological variation in shell shape of the freshwater turtle *Pseudemys concinna* inhabiting different aquatic flow regimes. *Integrative and Comparative Biology* 48(6): 769–787. https://doi.org/10.1093/icb/icn088

Sa'adi, Z., S. Shahid, T. Ismail, E.-S. Chung & X.-J. Wang (2019). Trends analysis of rainfall and rainfall extremes in Sarawak, Malaysia using modified Mann–Kendall test. *Meteorology and Atmospheric Physics* 131: 263–277. https://doi.org/10.1007/s00703-017-0564-3

Waagen, G.N. (1984). Sexually dimorphic plastral kinesis in *Heosemys spinosa*. *Herpetological Review* 15(2): 33–34.

Williams, C. & C.T. Stayton (2019). Effects of sutured pelvic elements: a comparison of pleurodire and cryptodire shell mechanics. *Herpetologica* 75(2): 123–133. https://doi.org/10.1655/D-17-00066

Yasukawa, Y., R. Hirayama & T. Hikida (2001). Phylogenetic relationships of Geoemydine turtles (Reptilia: Bataguridae). *Current Herpetology* 20(2): 105–133. https://www.jstage.jst.go.jp/article/hsj2000/20/2/20_2_105/_pdf/-char/en

WILD ZOOREACH Threatened Taxa

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

o r o hr t d is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa

.threatenedta a.or

i ri t

2 2 o 1 o g :2 2 2 2

Date of Publication: 26 June 2023 (Online & Print)

DOI: 10.11609/jott.2023.15.6.23283-23462

Communications

Short Communications

ot

Book Review

Publisher & Host

WILD ZOOREACH

hr t d