

Building evidence for conservation globally

Journal of Threatened Taxa



10.11609/jott.2022.14.9.21751-21902
www.threatenedtaxa.org

26 September 2022 (Online & Print)
14(9): 21751-21902
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Open Access



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

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

Host
Zoo Outreach Organization
www.zooreach.org

No. 12, Thiruvannamalai Nagar, Saravanampatti - Kalapatti Road, Saravanampatti,
Coimbatore, Tamil Nadu 641035, India

Ph: +91 9385339863 | www.threatenedtaxa.org

Email: sanjay@threatenedtaxa.org

EDITORS

Founder & Chief Editor

Dr. Sanjay Molur

Wildlife Information Liaison Development (WILD) Society & Zoo Outreach Organization (ZOO),
12 Thiruvannamalai Nagar, Saravanampatti, Coimbatore, Tamil Nadu 641035, India

Deputy Chief Editor

Dr. Neelesh Dahanukar

Noida, Uttar Pradesh, India

Managing Editor

Mr. B. Ravichandran, WILD/ZOO, Coimbatore, India

Associate Editors

Dr. Mandar Paingankar, Government Science College Gadchiroli, Maharashtra 442605, India

Dr. Ulrike Streicher, Wildlife Veterinarian, Eugene, Oregon, USA

Ms. Priyanka Iyer, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India

Dr. B.A. Daniel, ZOO/WILD, Coimbatore, Tamil Nadu 641035, India

Editorial Board

Dr. Russel Mittermeier

Executive Vice Chair, Conservation International, Arlington, Virginia 22202, USA

Prof. Mewa Singh Ph.D., FASC, FNA, FNASC, FNAPsy

Ramanna Fellow and Life-Long Distinguished Professor, Biopsychology Laboratory, and
Institute of Excellence, University of Mysore, Mysuru, Karnataka 570006, India; Honorary
Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and Adjunct
Professor, National Institute of Advanced Studies, Bangalore

Stephen D. Nash

Scientific Illustrator, Conservation International, Dept. of Anatomical Sciences, Health Sciences
Center, T-8, Room 045, Stony Brook University, Stony Brook, NY 11794-8081, USA

Dr. Fred Pluthero

Toronto, Canada

Dr. Priya Davidar

Sigur Nature Trust, Chadapatti, Mavinhalla PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin Fisher

Senior Associate Professor, Battcock Centre for Experimental Astrophysics, Cavendish
Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK

Dr. John Fellowes

Honorary Assistant Professor, The Kadoorie Institute, 8/F, T.T. Tsui Building, The University of
Hong Kong, Pokfulam Road, Hong Kong

Prof. Dr. Mirco Solé

Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Vice-coordenador
do Programa de Pós-Graduação em Zoologia, Rodovia Ilhéus/Itabuna, Km 16 (45662-000)
Salobrinho, Ilhéus - Bahia - Brasil

Dr. Rajeev Raghavan

Professor of Taxonomy, Kerala University of Fisheries & Ocean Studies, Kochi, Kerala, India

English Editors

Mrs. Mira Bhojwani, Pune, India

Dr. Fred Pluthero, Toronto, Canada

Mr. P. Ilangoan, Chennai, India

Web Development

Mrs. Latha G. Ravikumar, ZOO/WILD, Coimbatore, India

Typesetting

Mrs. Radhika, ZOO, Coimbatore, India

Mrs. Geetha, ZOO, Coimbatore India

Fundraising/Communications

Mrs. Payal B. Molur, Coimbatore, India

Subject Editors 2019–2021

Fungi

Dr. B. Shivaraju, Bengaluru, Karnataka, India

Dr. R.K. Verma, Tropical Forest Research Institute, Jabalpur, India

Dr. Vatsavaya S. Raju, Kakatiya University, Warangal, Andhra Pradesh, India

Dr. M. Krishnappa, Jnana Sahyadri, Kuvempu University, Shimoga, Karnataka, India

Dr. K.R. Sridhar, Mangalore University, Mangalagangothri, Mangalore, Karnataka, India

Dr. Gunjan Biswas, Vidyasagar University, Midnapore, West Bengal, India

Plants

Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India

Dr. N.P. Balakrishnan, Ret. Joint Director, BSI, Coimbatore, India

Dr. Shonil Bhagwat, Open University and University of Oxford, UK

Prof. D.J. Bhat, Retd. Professor, Goa University, Goa, India

Dr. Ferdinando Boero, Università del Salento, Lecce, Italy

Dr. Dale R. Calder, Royal Ontario Museum, Toronto, Ontario, Canada

Dr. Cleofas Cervancia, Univ. of Philippines Los Baños College Laguna, Philippines

Dr. F.B. Vincent Florens, University of Mauritius, Mauritius

Dr. Merlin Franco, Curtin University, Malaysia

Dr. V. Irudayaraj, St. Xavier's College, Palayamkottai, Tamil Nadu, India

Dr. B.S. Kholia, Botanical Survey of India, Gangtok, Sikkim, India

Dr. Pankaj Kumar, Kadoorie Farm and Botanic Garden Corporation, Hong Kong S.A.R., China

Dr. V. Sampath Kumar, Botanical Survey of India, Howrah, West Bengal, India

Dr. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Vijayasankar Raman, University of Mississippi, USA

Dr. B. Ravi Prasad Rao, Sri Krishnadevaraya University, Anantpur, India

Dr. K. Ravikumar, FRLHT, Bengaluru, Karnataka, India

Dr. Aparna Watve, Pune, Maharashtra, India

Dr. Qiang Liu, Xishuangbanna Tropical Botanical Garden, Yunnan, China

Dr. Noor Azhar Mohamed Shazili, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia

Dr. M.K. Vasudeva Rao, Shiv Ranjani Housing Society, Pune, Maharashtra, India

Prof. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Mandar Datar, Agharkar Research Institute, Pune, Maharashtra, India

Dr. M.K. Janarthanam, Goa University, Goa, India

Dr. K. Karthigeyan, Botanical Survey of India, India

Dr. Errol Vela, University of Montpellier, Montpellier, France

Dr. P. Lakshminarasimhan, Botanical Survey of India, Howrah, India

Dr. Larry R. Noblick, Montgomery Botanical Center, Miami, USA

Dr. K. Haridasan, Pallavur, Palakkad District, Kerala, India

Dr. Analinda Manila-Fajard, University of the Philippines Los Baños, Laguna, Philippines

Dr. P.A. Sinu, Central University of Kerala, Kasaragod, Kerala, India

Dr. Afroz Alam, Banasthali Vidyapith (accredited A grade by NAAC), Rajasthan, India

Dr. K.P. Rajesh, Zamorin's Guruvayurappan College, GA College PO, Kozhikode, Kerala, India

Dr. David E. Boufford, Harvard University Herbaria, Cambridge, MA 02138-2020, USA

Dr. Ritesh Kumar Choudhary, Agharkar Research Institute, Pune, Maharashtra, India

Dr. Navendu Page, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India

Dr. Kannan C.S. Warrior, Institute of Forest Genetics and Tree Breeding, Tamil Nadu, India

Invertebrates

Dr. R.K. Avasthi, Rohtak University, Haryana, India

Dr. D.B. Bastawade, Maharashtra, India

Dr. Partha Pratim Bhattacharjee, Tripura University, Suryamaninagar, India

Dr. Kailash Chandra, Zoological Survey of India, Jabalpur, Madhya Pradesh, India

Dr. Ansie Dippenaar-Schoeman, University of Pretoria, Queenswood, South Africa

Dr. Rory Dow, National Museum of Natural History Naturalis, The Netherlands

Dr. Brian Fisher, California Academy of Sciences, USA

Dr. Richard Gallon, Ilandudno, North Wales, LL30 1UP

Dr. Hemant V. Ghate, Modern College, Pune, India

Dr. M. Monwar Hossain, Jahangirnagar University, Dhaka, Bangladesh

Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.

Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK

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: *Pipistrellus tenuis* recorded during the small mammalian fauna study, Manipur, India. © Uttam Saikia.



Age estimation of Tiger *Panthera tigris* (Linnaeus, 1758) and Lion *Panthera leo* (Linnaeus, 1758) (Mammalia: Carnivora: Felidae): applicability of cementum annuli analysis method

Vipin¹ , Chandra Prakash Sharma² , Vinita Sharma³ , Surendra Prakash Goyal⁴ , Heather Stevens⁵ & Sandeep Kumar Gupta⁶

^{1,2,4,6} Wildlife Institute of India, Dehradun, Post Box No.18, Chandrabani, Dehradun, Uttarakhand 248001, India.

^{1,5} DeerAge, Wildlife Analytical Laboratories, 2814, Brook Street No. 114, Missoula, Montana 59801, USA.

³ Department of Zoology, Central University of Jammu, Rahya-Suchani (Bagla), District, Samba, Jammu, Jammu & Kashmir 181143, India.

¹ vipinsharma_24@yahoo.com, ² cpsharma@wii.gov.in, ³ vinita302003@gmail.com, ⁴ goyalsp@wii.gov.in,

⁵ customerservice@deerage.com, ⁶ skg@wii.gov.in (corresponding author)

Abstract: We describe the applicability of the cementum annuli analysis technique for estimating the age of Tiger *Panthera tigris* and Asiatic Lion *Panthera leo* using incisor teeth. We used I₂ and I₃ incisor teeth from the right mandible of Tiger and I² and I³ from the left premaxilla of the Lion. The longitudinal sections of the teeth were prepared using an economical hand grinding technique with the help of sandpaper, followed by decalcification and staining with hematoxylin. Two cementum layers were observed under the microscope in each of the I₂ and I₃ incisor teeth of the Tiger and six cementum layers were observed in each of the I² and I³ incisor teeth of the Lion. The permanent incisors in Tiger and Lion erupt between 12 and 14 months of age; hence, we added one year to the counted number of cementum layers to estimate the final age of Tiger and Lion incisors. The age of Tiger and Lion incisors were estimated to be of three years and seven years, respectively. This method may be suitable for estimating other carnivores' age and applicable in wildlife forensic studies.

Keywords: Big cats, carnivore, epoxy, grinding, incisor, premolar, teeth, wildlife forensics.

Editor: Angie Appel, Wild Cat Network, Bad Marienberg, Germany.

Date of publication: 26 September 2022 (online & print)

Citation: Vipin, C.P. Sharma, V. Sharma, S.P. Goyal, H. Stevens & S.K. Gupta (2022). Age estimation of Tiger *Panthera tigris* (Linnaeus, 1758) and Lion *Panthera leo* (Linnaeus, 1758) (Mammalia: Carnivora: Felidae): applicability of cementum annuli analysis method. *Journal of Threatened Taxa* 14(9): 21805–21810. <https://doi.org/10.11609/jott.7727.14.9.21805-21810>

Copyright: © Vipin et al. 2022. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The study was funded by the Wildlife Institute of India, Dehradun

Competing interests: The authors declare no competing interests.

Author details: VIPIN is working as a Director of Research at DeerAge, Missoula, Montana, USA. His areas of research interest are wildlife conservation, age estimation, wildlife forensics and disease diagnosis. CHANDRA PRAKASH SHARMA is working as a Senior Technical Officer, Wildlife Forensic and Conservation Genetics Cell, Wildlife Institute of India, Dehradun. He is dealing with wildlife offence cases with morphological and other relevant techniques. Along with the primary task of developing new protocols for the identification of species from wildlife parts, he is involved in teaching and training wildlife enforcement officials in curbing illegal wildlife trade and morphological identification of wildlife articles. VINITA SHARMA is an Assistant Professor in the Department of Zoology, Central University of Jammu, Jammu and Kashmir. Her area of research is related to animal taxonomy, systematics and behavior, wildlife and conservation biology, human-wildlife conflict, wildlife forensics, comparative anatomy and geometric morphometrics. SURENDRA PRAKASH GOYAL was Scientist G and now working as a subject matter specialist at the Wildlife Institute of India, Dehradun. His research areas include wildlife ecology, field research methods, wildlife-habitat relationships of ungulates and carnivores, estimation of food habits, habitat fragmentation and corridors, use of lab methods, especially in nutritional ecology, molecular ecology, landscape genetics. HEATHER STEVENS is heading Nationwide Histology Inc providing the highest quality service for research clients and the DeerAge, Wildlife Analytical Laboratories, dedicated to quality age estimation of game animals across the United States of America. SANDEEP KUMAR GUPTA is Scientist E, Head, Department of Animal Ecology and Conservation Biology and Nodal Officer, Wildlife Forensic and Conservation Genetics Cell, Wildlife Institute of India, Dehradun. His areas of research interest are conservation genetics, wildlife forensics, evolutionary genetics of rare and endangered species. He is also undertaking teaching and training courses on illegal wildlife trade.

Author contributions: V, CPS, SPG & SKG conceived the study. V, CPS & VS carried out the laboratory work. V & HS did the data analysis. V, VS & SKG wrote the article. CPS, SKG, SPG & HS reviewed the article.

Acknowledgements: We gratefully acknowledge the support of the director and dean, Wildlife Institute of India, Dehradun.



INTRODUCTION

The age of carnivores needs to be estimated in studies about the demography of species and for understanding population dynamics (Skalski et al. 2005; Foresman 2012), age class (Angerbjorn et al. 2004; Creel et al. 2004), population monitoring trends (Barthold et al. 2016), human-wildlife interactions (Conover 2002; Frank et al. 2005), and illegal wildlife trade (Williams et al. 2015). The widely used methods for age estimation of carnivores are assessments of tooth eruption (Slaughter et al. 1974), wearing of a tooth crown (Harris 1978; Stander 1997; Gipson et al. 2000), closure of pulp chamber (Marks & Erickson 1966; Zapata et al. 1997; Binder & Van Valkenburgh 2010), and cementum analysis (Klevezal & Kleinenberg 1967; Matson 1981; White & Belant 2016).

The method to estimate the age of the Tiger *Panthera tigris* has mostly been limited to assessing tooth eruption, wearing (Mazak 1979, 1981; Miles & Grigson 2003), and gum line recession (Fàbregas & Garcés-Narro 2014). The methods described to assess the age of the Lion *Panthera leo* refer to sizes of body and mane, pigmentation on the nose, tooth wear (Schaller 1972; Smuts et al. 1978; Whitman et al. 2004; Whitman & Packer 2007; Ferreira & Funston 2010), closure of the pulp chamber (White & Belant 2016), the ratio of tooth areas (White et al. 2016), tooth eruption (Schneider 1959) and cementum analysis (Spinage 1976; Smuts et al. 1978; White & Belant 2016).

Amongst the various age determination methods available, the cementum analysis method has been recommended for its accuracy (Mundy & Fuller 1964; Marks & Erickson 1966; Klevezal & Kleinenberg 1967; Craighead et al. 1970; Willey 1974, Grue & Jensen 1979; Johnston et al. 1987; Matson et al. 1993; Mbizah et al. 2016; Vipin et al. 2018). The described technique does not need a costly microtome for tooth sectioning, so most of the items required are generally available in a standard lab (Vipin et al. 2018).

To date, studies on age estimation of South Asian mammals through cementum layer analysis are limited to Chital *Axis axis* (Vipin et al. 2018). Here we present the applicability of this method for estimating the age of Tiger and Asiatic Lion.

MATERIAL AND METHODS

We used Tiger mandible and Lion skull from Wildlife Forensic and Conservation Genetics Cell's repository. We tested the applicability of the developed method to estimate the age of an incisor (I_3) from the mandible

of a Tiger seized in the illegal wildlife trade, which was sent to Wildlife Institute of India, Dehradun, for species confirmation.

Sample collection and preparation of longitudinal section of teeth

Canines of Tigers and Lions are in high demand compared to other species' teeth in the illegal wildlife trade. Hence, in comparison to other types, the chances of their availability for determining age are limited. In both species, the permanent incisors number is six times more than premolar (PM^2), which is a plus point if some tooth gets damaged during processing for cementum analysis. Therefore, we selected incisors in the current study and based on the availability of their types, the incisors were extracted.

Two permanent incisor teeth (I_2, I_3) out of three were used from the right mandible of a Tiger (Image 1A, B, C) and two incisors (I^2, I^3) from the left premaxilla of a Lion. The teeth from the Tiger mandible were extracted by boiling it in water for ten minutes, after which they detached easily from the mandible. From the Lion premaxilla, the teeth were removed with the help of pliers with utmost care so that the periodontal membrane remained intact. We used the protocol described by Vipin et al. (2018) for preparing the longitudinal sections of the incisor teeth with a thickness of around 57 μm with steps, as shown in Image 2. We then used a Leica DMR microscope to examine the tooth sections.

Calculation of age from cementum annuli

In felids, all permanent incisors except I^3 erupt before other teeth (Miles & Grigson 2003). In Tiger, the permanent tooth eruption starts between 8.8–9.5 months and completes at the age of 12–14 months (Mazák 1979, 1981). In Lion, permanent I^1, I_1, I^2, I_2 fully erupts between 9–11 months and I^3 and I_3 start erupting by the end of this period (Smuts et al. 1978). I^3 and I_3 completely replace their deciduous counterparts at the age of 12 to 14 months, while P^2 starts erupting between this period in Lions (Smuts et al. 1978). Though no published data related to age estimation of Tiger using cementum analysis is available; many researchers have used permanent incisors, canine, and second premolar teeth to develop age estimation methods in Lions utilizing this technique (Smuts et al. 1978; Cheater 2006; White & Belant 2016). The time taken by different tooth types for their permanent eruption has been reported unequal in other species of carnivores and ungulates (Zapata et al. 1995; Azorit et al. 2004). In P^2 of African Lions, it is established that the first rest is formed in the second

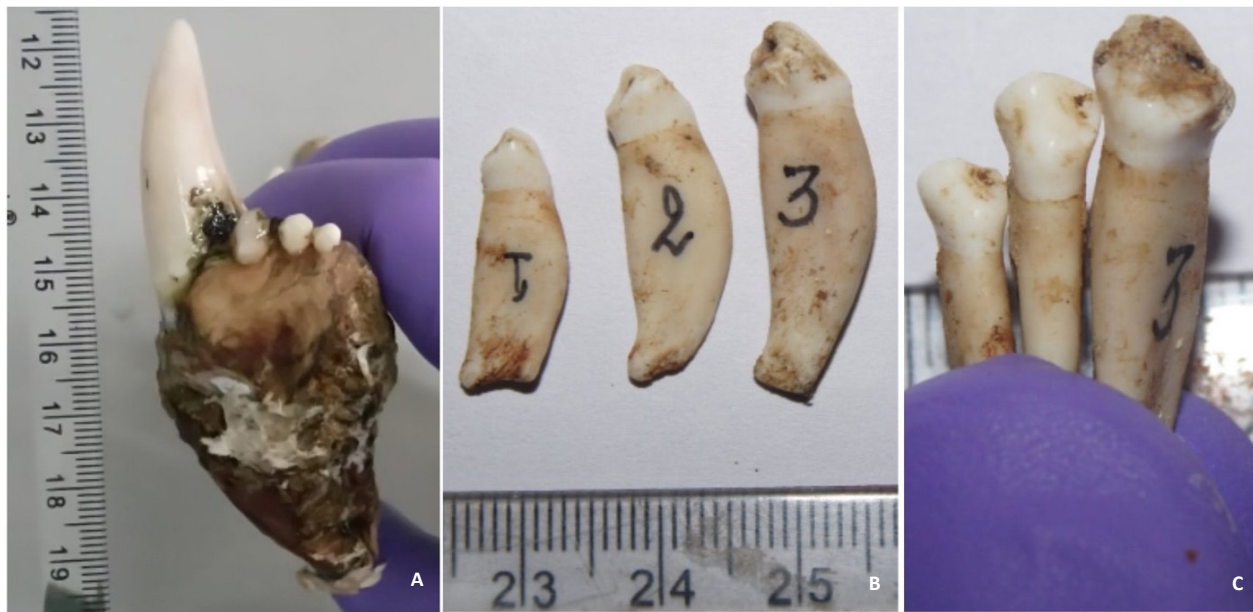


Image 1. Tiger mandible: A—extracted incisors (I_1 , I_2 , I_3) | B—side view | C—lingual view

year of age, so we had to add one to the counted number of cementum lines to estimate the final age (White & Belant 2016). We counted the acellular cementum layer in the root portion of the teeth, which is formed annually and stains dark with hematoxylin (Matson et al. 1993). Therefore, we added a minimum of one year in both species' final age estimation. The presence of one cementum layer in a permanent incisor tooth of Tiger and Lion indicates that the animal has lived one year at least. The age of sectioned teeth in years was calculated according to the formula

$$\text{Age in year} = \text{Number of cementum layers} + 1 \text{ year}$$

The cementum layers in the incisor teeth were photographed wherever these were seen distinctly and clearly.

RESULTS

The teeth sections of the Tiger showed two cementum layers for I_2 (Image 3 A, B, C) and I_3 (Image 4 A, B); thus, the Tiger's age was estimated to be three years. The Lion had six cementum layers in I^2 (Image 5A, B) and I^3 (Image 6); therefore, Lion's age was estimated to be seven years

We found two dark cementum layers on the Tiger's incisor seized in the illegal wildlife trade; hence its age was estimated as three years (Image 7). Therefore, the developed method may also be applied to estimate the age of tigers in the illegal wildlife trade.

DISCUSSION

White & Belant (2016) used paired PM^2 teeth for estimating the age of free-ranging African Lions of unknown age through cementum line count and showed that cementum layer count in PM^2 is unsuitable for ageing Lions. Their analysis revealed that in 19 out of 31 PM^2 pairs, the cementum line count differed by 1–2 lines and even increased to seven lines for other pairs. According to Smut et al. (1978), cementum lines in canine teeth of Lions complied significantly with their known ages. So to compare the results of White & Balent (2016) about Asiatic Lions, a large sample size of the PM^2 teeth is needed, or more incisors or a different tooth type needs to be analysed for cementum layer count. In ungulates, the accuracy of age estimation through cementum analysis decreases with the age of the specimens (Hamlin et al. 2000). More research is necessary to assess whether this is also true for carnivores.

We recommend validating the current procedure while estimating age based on cementum layer count. Matson et al. (1993) suggested two main tests for validating the cementum analysis for estimating age, namely the "blind" duplicate test when two or more teeth are available and using a tooth of known age but without having the prior knowledge of its age. Teeth of known age were not available for both species; however, all incisor teeth showed clear and distinct cementum layers. The periodontal membrane in all studied teeth

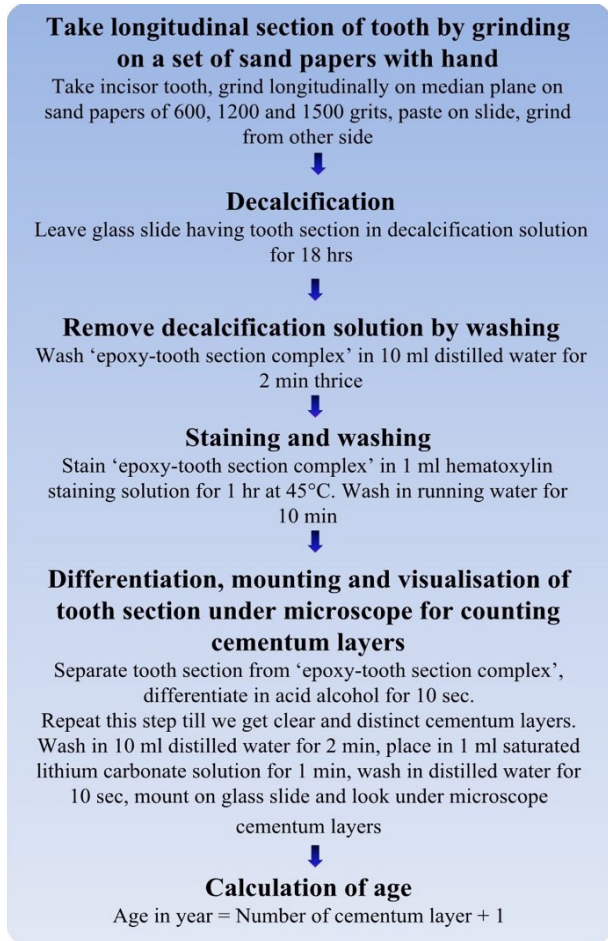


Image 2. Flow chart of the procedure followed for age determination through cementum layer count in incisor tooth.

confirms that all cementum layers were present in the longitudinal sections. Hence, the current method can show all cementum layers clearly and distinctly in incisor teeth.

The same protocol may be applied to develop age estimation protocols for other mammal species.

REFERENCES

Angerbjorn, A., P. Hersteinsson & M. Tannerfeldt (2004). Arctic Foxes: Consequences of resource predictability in the Arctic Fox—two life history strategies, pp. 164–172. In: MacDonald, D.W. & C. Sillero-Zubiri (eds.). *Biology and Conservation of Wild Canids*. Oxford University Press, New York, 450 pp. <https://doi.org/10.1093/acprof:oso/9780198515562.003.0008>

Azorit, C., J. Muñoz-Cobo, J. Hervás & M. Analla (2004). Ageing through growth marks in teeth of Spanish Red Deer (*Cervus elaphus hispanicus*). *Wildlife Society Bulletin* 32(3): 702–710.

Barthold, J.A., A.J. Loveridge, D.W. Macdonald, C. Packer & F. Colchero (2016). Bayesian estimates of male and female African Lion mortality for future use in population management. *Journal of Applied Ecology* 53(2): 295–304. <https://doi.org/10.1111/1365-2664.12594>

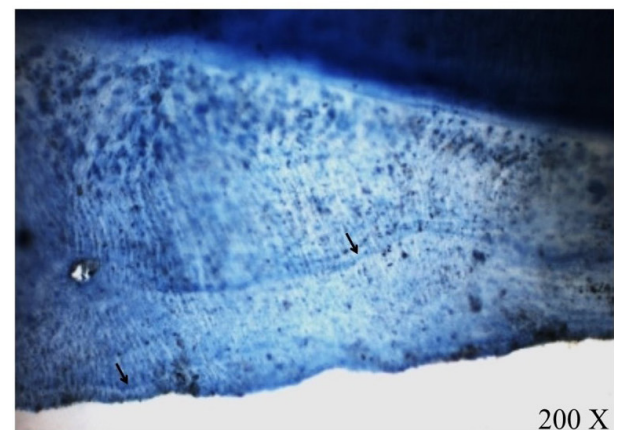
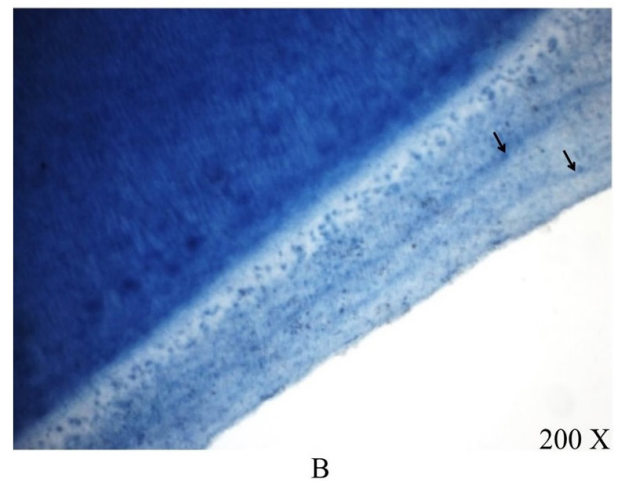
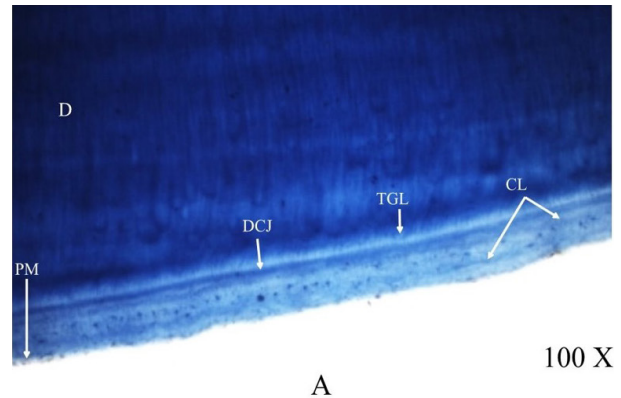


Image 3. The longitudinal section of I₂ tooth of Tiger showing two cementum layers in three different regions (A, B and C) under 100X and 200X magnifications. D—dentine | TGM—Tome's Granular Layer | CL—Cementum Layer | DCJ—Dentine Cementum Junction | PM—Periodontal Membrane.

Binder, W.J. & B. Van Valkenburgh (2010). A comparison of tooth wear and breakage in Rancho La Brea sabertooth cats and dire wolves across time. *Journal of Veterinary Palaeontology* 30(1): 255–261.

Cheater, A. (2006). Use of the upper second premolar for age determination of the African Lion (*Panthera leo*) in sub-saharan Africa, for purposes of remote monitoring. Tshwane University of Technology, Tshwane, South Africa.

Conover, M. (2002). Resolving human-wildlife conflicts: the science

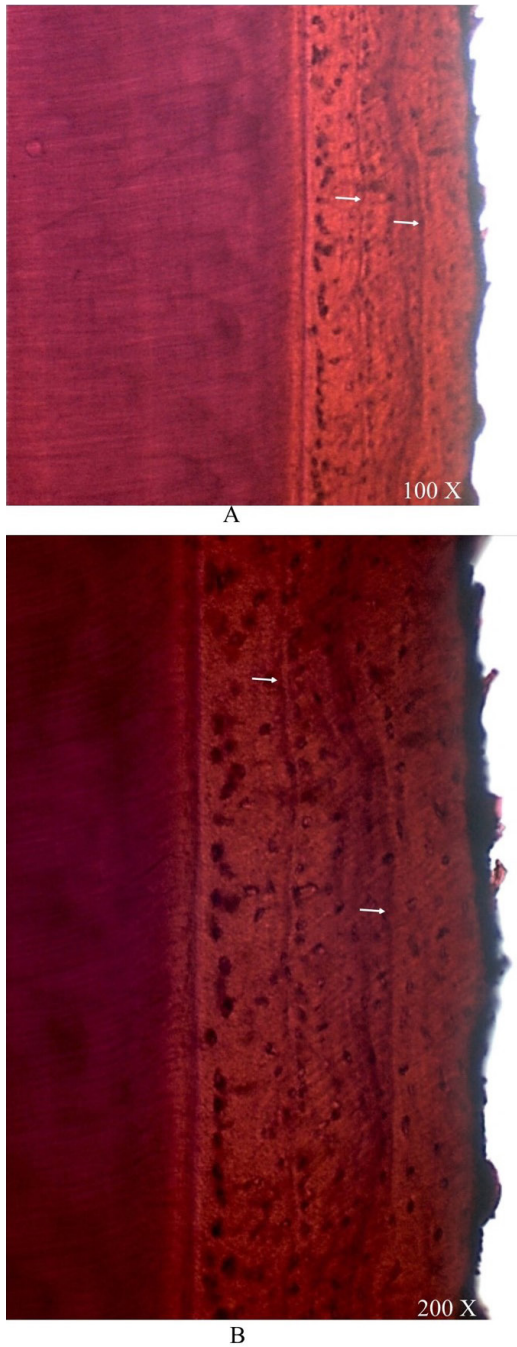


Image 4. The arrows in the longitudinal section of I_3 of the Tiger showing two cementum layers at 100X and 200X magnifications.

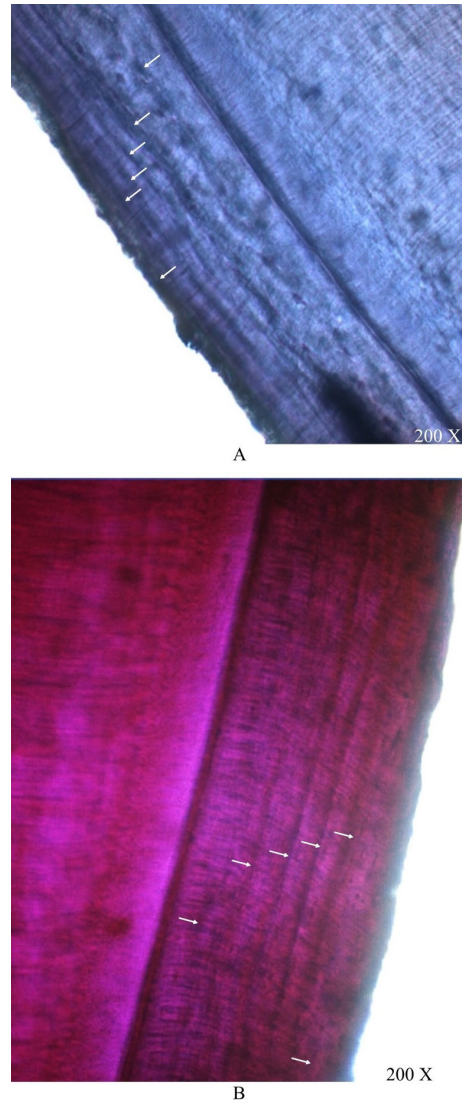


Image 5. The arrows in the longitudinal section of I^2 of the Lion showing six cementum layers in two different regions (A and B).

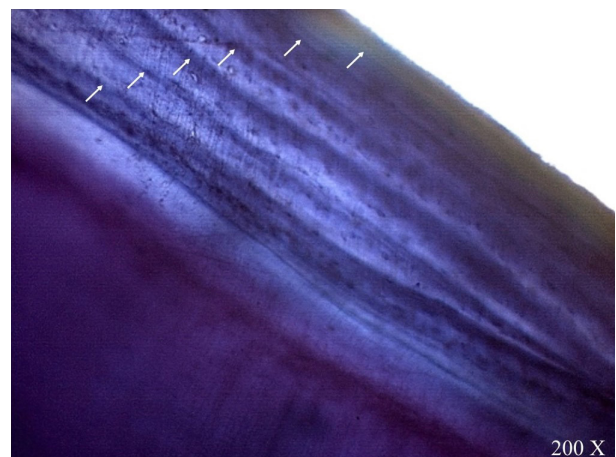


Image 6. The arrows in the longitudinal section of I^3 of the Lion showing six cementum layers.

of wildlife damage management. Lewis Publishers, Boca Raton, Florida, 418 pp.

Craighead, J.J., F.C. Craighead & H.E. McCutchen (1970). Age determination of Grizzly Bears from fourth premolar tooth sections. *Journal of Wildlife Management* 34: 353–363.

Creel, S., M.G.L. Mills & J.W. McNutt (2004). African Wild Dogs: Demography and population dynamics of African Wild Dogs in three critical populations, pp. 337–350. In: Macdonald, D.W. & C. Sillero-Zubiri (eds.). *Biology and conservation of wild canids*. Oxford University Press, New York, 450 pp. <https://doi.org/10.1093/acprof:oso/9780198515562.003.0022>

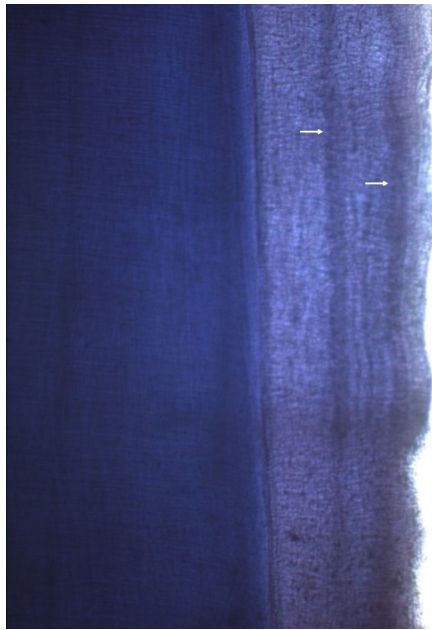


Image 7. The arrows in the longitudinal section of I₃ from seized Tiger skeleton showing two cementum layers.

- Fàbregas, M.C. & C. Garcés-Narro (2014). Validation of gum-line recession as a reliable technique to age Tigers. *European Journal of Wildlife Research* 60(6): 947–950. <https://doi.org/10.1007/s10344-014-0869-1>
- Ferreira, S. & P.J. Funston (2010). Age assignment to individual African Lions. *South African Journal of Wildlife Research* 40(1): 1–9.
- Foresman, K.R. (2012). Carnivores in hand, pp. 130–51. In: Boitani, L. & R.A. Powell (eds.). *Carnivore ecology and conservation: A handbook of techniques. Techniques in ecology and conservation*. Oxford University Press, New York, 506 pp. <https://doi.org/10.1093/acprof:oso/9780199558520.003.0006>
- Frank, L.G., R. Woodroffe & M.O. Ogada (2005). People and predators in Laikipia District, Kenya, pp. 286–304. In: Woodroffe, R., S. Thirgood & A. Rabinowitz (eds.). *People and Wildlife: conflict or coexistence?* Cambridge University Press, New York, 517 pp. <https://doi.org/10.1017/CBO9780511614774.019>
- Gipson, P.S., W.B. Ballard & R.M. Nowak (2000). Accuracy and precision of estimating age of Gray Wolves by tooth wear. *Journal of Wildlife Management* 64: 752–758.
- Grue, H. & B. Jensen (1979). Review of the formation of incremental lines in tooth cementum of terrestrial mammals. *Danish Review of Game Biology* 11: 1–48.
- Hamlin, K.L., D.F. Pac, C.A. Sime, R.M. DeSimone & G.L. Dusek (2000). Evaluating the accuracy of ages obtained by two methods for Montana ungulates. *Journal of Wildlife Management* 64(2): 441–449. <https://doi.org/10.2307/3803242>
- Harris, S. (1978). Age determination in the Red Fox (*Vulpes vulpes*) and evaluation of technique efficiency as applied to a sample of suburban foxes. *Journal of Zoology* 184(1): 91–117.
- Johnston, D.H., D.G. Joachim, P. Bachmann, K.V. Kardong, R.E.A. Kardong Stewart, L. Dix, M.A. Strickland & I.D. Watt (1987). Ageing furbearers using tooth structure and biomarkers, pp. 228–243. In: Novak, M., J.A. Baker, M.E. Obbard & B. Malloch (eds.). *Wild furbearer management and conservation in North America*. Ontario Trappers Association, Toronto, 1150 pp.
- Klevezal, G.A. & S.E. Kleinenberg (1967). Age determination of mammals from annual layers in teeth and bones. Severtsov Institute of Animal Morphology, Academy of Science of the USSR, Moscow, 128 pp. (in Russian)
- Marks, S.A. & P.W. Erickson (1966). Age determination in Black Bear. *Journal of Wildlife Management* 30: 389–410.
- Matson, G., L. Van Daele, E. Goodwin, L. Aumiller, H. Raynolds & H. Hristienko (1993). *A laboratory manual for cementum age determination of Alaskan Brown Bear first premolar teeth*. Matson's Laboratory, Milltown, Montana, 52 pp.
- Matson, G.M. (1981). *Workbook for cementum analysis*. Matson's Laboratory, Milltown, MT, 30 pp.
- Mazak, V. (1979). *Der Tiger Panthera tigris*. Second edition, Neue Brehm Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt (GDR), 228 pp.
- Mazák, V. (1981). *Panthera tigris*. *Mammalian Species* 152: 1–8.
- Mbizah, M.M., G. Steenkamp & R.J. Groom (2016). Evaluation of the applicability of different age determination methods for estimating age of the endangered African Wild Dog (*Lycaon pictus*). *PLoS One* 11(10): e0164676. <https://doi.org/10.1371/journal.pone.0164676>
- Miles, A.E.W. & C. Grigson (2003). *Colyer's Variations and diseases of the teeth of animals*. United Kingdom: Cambridge University Press, 692 pp.
- Mundy, K.R.D. & W.A. Fuller (1964). Age determination in Grizzly Bear. *Journal of Wildlife Management* 28: 863–866.
- Schaller, G.B. (1972). *The Serengeti Lion: a study of predator–prey relations*. University of Chicago Press, 504 pp.
- Schneider, K.M. (1959). Zum Zahndurchbruch des Löwen (*Panthera leo*) nebst Bemerkungen über das Zahnen einiger andere Grosskatzen und der Hauskatze (*Felis catus*). *Der Zoologische Garten* 22: 240–361.
- Skalski, J., K. Ryding & J. Millspaugh (2005). *Wildlife demography: Analysis of sex, age, and count data*. Elsevier Academic Press, Burlington, MA, 656 pp.
- Slaughter, B.H. R.H. Pine & N.E. Pine (1974). Eruption of cheek teeth in Insectivora and Carnivora. *Journal of Mammalogy* 55(1): 115–125.
- Smuts, G.L., J.L. Anderson & J.C. Austin (1978). Age determination of the African Lion (*Panthera leo*). *Journal of Zoology* 185(1): 115–146.
- Spinage, C.A. (1976). Incremental cementum lines in the teeth of tropical African mammals. *Journal of Zoology* 178(1): 117–131.
- Stander, P.E. (1997). Field age determination of Leopards by tooth wear. *African Journal of Ecology* 35(2): 156–161.
- Vipin, V. Sharma, S.K. Gupta, C.P. Sharma, K. Sankar & S.P. Goyal (2018). Development of a fast and low-cost age determination method in Spotted Deer, *Axis axis*. *Folia Zoologica* 67(3–4): 186–197. <https://doi.org/10.25225/fozo.v67.i3-4.a9.2018>
- White, P.A., D. Ikanda, L. Ferrante, P. Chardonnet, P. Mesochina & R. Cameriere (2016). Age estimation of African Lions *Panthera leo* by ratio of tooth areas. *PLoS One* 11(4): e0153648. <https://doi.org/10.1371/journal.pone.0153648>
- White, P.A. & J.L. Belant (2016). Individual variation in dental characteristics for estimating age of African Lions. *Wildlife Biology* 22(3): 71–77. <https://doi.org/10.2981/wlb.00180>
- Whitman, K., A. Starfield, H. Quadling & C. Packer (2004). Sustainable trophy hunting of African Lions. *Nature* 428 (6979): 175–178. <https://doi.org/10.1038/nature02395>
- Whitman, K.L. & C. Packer (2007). A hunter's guide to ageing Lions in eastern and southern Africa. Safari Press, 46 pp.
- Willey, C.H. (1974). Ageing Black Bears from first premolar tooth sections. *Journal of Wildlife Management* 38: 97–100.
- Williams, V.L., D.J. Newton, A.J. Loveridge & D.W. Macdonald (2015). Bones of contention: An assessment of the South African trade in African Lion *Panthera leo* bones and other body parts. TRAFFIC, Cambridge & WildCRU, Oxford, 128 pp.
- Zapata, S.C., A. Travaini & M. Delibes (1995). Comparacion entre varias tecnicas de estimacion de la edad en Zorros, *Vulpes vulpes*, de Doñana (sur de la peninsula iberica). *Doñana Acta Vertebrata* 22: 29–50.
- Zapata, S.C., R.G. Perea, J.F. Beltrán, P. Ferreras & M. Delibes (1997). Age determination of Iberian Lynx (*Lynx pardinus*) using canine radiograph and cementum annuli enumeration. *Zeitschrift für Säugetierkunde* 62: 119–123.

Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
Dr. John Noyes, Natural History Museum, London, UK
Dr. Albert G. Orr, Griffith University, Nathan, Australia
Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
Dr. Nancy van der Poorten, Toronto, Canada
Dr. Kareen Schnabel, NIWA, Wellington, New Zealand
Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
Dr. K.A. Subramanian, Zoological Survey of India, New Alipore, Kolkata, India
Dr. P.M. Sureshan, Zoological Survey of India, Kozhikode, Kerala, India
Dr. R. Varatharajan, Manipur University, Imphal, Manipur, India
Dr. Eduard Vives, Museu de Ciències Naturals de Barcelona, Terrassa, Spain
Dr. James Young, Hong Kong Lepidopterists' Society, Hong Kong
Dr. R. Sundararaj, Institute of Wood Science & Technology, Bengaluru, India
Dr. M. Nithyanandan, Environmental Department, La Ala Al Kuwait Real Estate. Co. K.S.C., Kuwait
Dr. Himender Bharti, Punjabi University, Punjab, India
Mr. Purnendu Roy, London, UK
Dr. Saito Motoki, The Butterfly Society of Japan, Tokyo, Japan
Dr. Sanjay Sondhi, TITLI TRUST, Kalpavriksh, Dehradun, India
Dr. Nguyen Thi Phuong Lien, Vietnam Academy of Science and Technology, Hanoi, Vietnam
Dr. Nitin Kulkarni, Tropical Research Institute, Jabalpur, India
Dr. Robin Wen Jiang Ngiam, National Parks Board, Singapore
Dr. Lionel Monod, Natural History Museum of Geneva, Genève, Switzerland.
Dr. Asheesh Shivam, Nehru Gram Bharti University, Allahabad, India
Dr. Rosana Moreira da Rocha, Universidade Federal do Paraná, Curitiba, Brasil
Dr. Kurt R. Arnold, North Dakota State University, Saxony, Germany
Dr. James M. Carpenter, American Museum of Natural History, New York, USA
Dr. David M. Claborn, Missouri State University, Springfield, USA
Dr. Kareen Schnabel, Marine Biologist, Wellington, New Zealand
Dr. Amazonas Chagas Júnior, Universidade Federal de Mato Grosso, Cuiabá, Brasil
Mr. Monsoon Jyoti Gogoi, Assam University, Silchar, Assam, India
Dr. Heo Chong Chin, Universiti Teknologi MARA (UiTM), Selangor, Malaysia
Dr. R.J. Shiel, University of Adelaide, SA 5005, Australia
Dr. Siddharth Kulkarni, The George Washington University, Washington, USA
Dr. Priyadarsanan Dharma Rajan, ATREE, Bengaluru, India
Dr. Phil Alderslade, CSIRO Marine And Atmospheric Research, Hobart, Australia
Dr. John E.N. Veron, Coral Reef Research, Townsville, Australia
Dr. Daniel Whitmore, State Museum of Natural History Stuttgart, Rosenstein, Germany.
Dr. Yu-Feng Hsu, National Taiwan Normal University, Taipei City, Taiwan
Dr. Keith V. Wolfe, Antioch, California, USA
Dr. Siddharth Kulkarni, The Hormiga Lab, The George Washington University, Washington, D.C., USA
Dr. Tomas Ditrich, Faculty of Education, University of South Bohemia in Ceske Budejovice, Czech Republic
Dr. Mihaly Foldvari, Natural History Museum, University of Oslo, Norway
Dr. V.P. Niyal, Wildlife Institute of India, Dehradun, Uttarakhand 248001, India
Dr. John T.D. Caleb, Zoological Survey of India, Kolkata, West Bengal, India
Dr. Priyadarsanan Dharma Rajan, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Bangalore, Karnataka, India

Fishes

Dr. Neelesh Dahanukar, IISER, Pune, Maharashtra, India
Dr. Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, México
Dr. Heok Hee Ng, National University of Singapore, Science Drive, Singapore
Dr. Rajeev Raghavan, St. Albert's College, Kochi, Kerala, India
Dr. Robert D. Sluka, Chiltern Gateway Project, A Rocha UK, Southall, Middlesex, UK
Dr. E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India
Dr. Davor Zanella, University of Zagreb, Zagreb, Croatia
Dr. A. Biju Kumar, University of Kerala, Thiruvananthapuram, Kerala, India
Dr. Akhilesh K.V., ICAR-Central Marine Fisheries Research Institute, Mumbai Research Centre, Mumbai, Maharashtra, India
Dr. J.A. Johnson, Wildlife Institute of India, Dehradun, Uttarakhand, India
Dr. R. Ravinesh, Gujarat Institute of Desert Ecology, Gujarat, India

Amphibians

Dr. Sushil K. Dutta, Indian Institute of Science, Bengaluru, Karnataka, India
Dr. Annemarie Ohler, Muséum national d'Histoire naturelle, Paris, France

Reptiles

Dr. Gernot Vogel, Heidelberg, Germany
Dr. Raju Vyas, Vadodara, Gujarat, India
Dr. Pritpal S. Soorae, Environment Agency, Abu Dhabi, UAE.
Prof. Dr. Wayne J. Fuller, Near East University, Mersin, Turkey
Prof. Chandrashekher U. Rivonker, Goa University, Taleigao Plateau, Goa, India
Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

Birds

Dr. Hem Sagar Baral, Charles Sturt University, NSW Australia
Mr. H. Byju, Coimbatore, Tamil Nadu, India
Dr. Chris Bowden, Royal Society for the Protection of Birds, Sandy, UK
Dr. Priya Davidar, Pondicherry University, Kalapet, Puducherry, India
Dr. J.W. Duckworth, IUCN SSC, Bath, UK
Dr. Rajah Jayapal, SACON, Coimbatore, Tamil Nadu, India
Dr. Rajiv S. Kalsi, M.L.N. College, Yamuna Nagar, Haryana, India
Dr. V. Santharam, Rishi Valley Education Centre, Chittoor Dt., Andhra Pradesh, India
Dr. S. Balachandran, Bombay Natural History Society, Mumbai, India
Mr. J. Praveen, Bengaluru, India
Dr. C. Srinivasulu, Osmania University, Hyderabad, India
Dr. K.S. Gopi Sundar, International Crane Foundation, Baraboo, USA
Dr. Gombobaatar Sunde, Professor of Ornithology, Ulaanbaatar, Mongolia
Prof. Reuven Yosef, International Birding & Research Centre, Eilat, Israel
Dr. Taej Mundkur, Wetlands International, Wageningen, The Netherlands
Dr. Carol Inskipp, Bishop Auckland Co., Durham, UK
Dr. Tim Inskipp, Bishop Auckland Co., Durham, UK
Dr. V. Gokul, National College, Tiruchirappalli, Tamil Nadu, India
Dr. Arkady Lelej, Russian Academy of Sciences, Vladivostok, Russia
Dr. Simon Dowell, Science Director, Chester Zoo, UK
Dr. Mário Gabriel Santiago dos Santos, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real, Portugal
Dr. Grant Connette, Smithsonian Institution, Royal, VA, USA
Dr. M. Zafar-ul Islam, Prince Saud Al Faisal Wildlife Research Center, Taif, Saudi Arabia

Mammals

Dr. Giovanni Amori, CNR - Institute of Ecosystem Studies, Rome, Italy
Dr. Anwaruddin Chowdhury, Guwahati, India
Dr. David Mallon, Zoological Society of London, UK
Dr. Shomita Mukherjee, SACON, Coimbatore, Tamil Nadu, India
Dr. Angie Appel, Wild Cat Network, Germany
Dr. P.O. Nameer, Kerala Agricultural University, Thrissur, Kerala, India
Dr. Ian Redmond, UNEP Convention on Migratory Species, Lansdown, UK
Dr. Heidi S. Riddle, Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA
Dr. Karin Schwartz, George Mason University, Fairfax, Virginia.
Dr. Lala A.K. Singh, Bhubaneswar, Orissa, India
Dr. Mewa Singh, Mysore University, Mysore, India
Dr. Paul Racey, University of Exeter, Devon, UK
Dr. Honnavalli N. Kumara, SACON, Anaikatti P.O., Coimbatore, Tamil Nadu, India
Dr. Nishith Dharaiya, HNG University, Patan, Gujarat, India
Dr. Spartaco Gippoliti, Socio Onorario Società Italiana per la Storia della Fauna "Giuseppe Altobello", Rome, Italy
Dr. Justus Joshua, Green Future Foundation, Tiruchirappalli, Tamil Nadu, India
Dr. H. Raghuram, The American College, Madurai, Tamil Nadu, India
Dr. Paul Bates, Harison Institute, Kent, UK
Dr. Jim Sanderson, Small Wild Cat Conservation Foundation, Hartford, USA
Dr. Dan Challenger, University of Kent, Canterbury, UK
Dr. David Mallon, Manchester Metropolitan University, Derbyshire, UK
Dr. Brian L. Cypher, California State University-Stanislaus, Bakersfield, CA
Dr. S.S. Talmale, Zoological Survey of India, Pune, Maharashtra, India
Prof. Karan Bahadur Shah, Budhanilakantha Municipality, Kathmandu, Nepal
Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraja, Indonesia
Dr. Hemanta Kafley, Wildlife Sciences, Tarleton State University, Texas, USA

Other Disciplines

Dr. Aniruddha Belsare, Columbia MO 65203, USA (Veterinary)
Dr. Mandar S. Paingankar, University of Pune, Pune, Maharashtra, India (Molecular)
Dr. Jack Tordoff, Critical Ecosystem Partnership Fund, Arlington, USA (Communities)
Dr. Ulrike Streicher, University of Oregon, Eugene, USA (Veterinary)
Dr. Hari Balasubramanian, EcoAdvisors, Nova Scotia, Canada (Communities)
Dr. Rayanna Hellem Santos Bezerra, Universidade Federal de Sergipe, São Cristóvão, Brazil
Dr. Jamie R. Wood, Landcare Research, Canterbury, New Zealand
Dr. Wendy Collinson-Jonker, Endangered Wildlife Trust, Gauteng, South Africa
Dr. Rajeshkumar G. Jani, Anand Agricultural University, Anand, Gujarat, India
Dr. O.N. Tiwari, Senior Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India
Dr. L.D. Singla, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India
Dr. Rupika S. Rajakaruna, University of Peradeniya, Peradeniya, Sri Lanka
Dr. Bahar Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2019–2021

Due to paucity of space, the list of reviewers for 2018–2020 is available online.

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.

Journal of Threatened Taxa 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,
No. 12, Thiruvannamalai Nagar, Saravanampatti - Kalapatti Road,
Saravanampatti, Coimbatore, Tamil Nadu 641035, India
ravi@threatenedtaxa.org



www.threatenedtaxa.org

OPEN ACCESS



The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

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

September 2022 | Vol. 14 | No. 9 | Pages: 21751–21902

Date of Publication: 26 September 2022 (Online & Print)

DOI: 10.11609/jott.2022.14.9.21751-21902

Article

Diversity, distribution, and abundance status of small mammalian fauna (Chiroptera: Rodentia: Eulipotyphla) of Manipur, India

– Uttam Saikia & A.B. Meetei, Pp. 21751–21768

Review

Conservation of Tiger *Panthera tigris* in Nepal: a review of current efforts and challenges

– Pramod Ghimire, Pp. 21769–21775

Communications

Effects of visitor disturbance on tetrapod vertebrates in the Horton Plains National Park, Sri Lanka

– D.M.T. Dhananjani & W.A.D. Mahaulpatha, Pp. 21776–21785

Population density and nesting behaviour of Indian Giant Squirrel *Ratufa indica* (Erxleben, 1777) in Bhimashankar Wildlife Sanctuary, Western Ghats of Maharashtra, India

– Ganesh Rathod, Erach Bharucha & Kranti Yardi, Pp. 21786–21796

First camera-trap confirmation of Tibetan Brown Bear *Ursus arctos pruinosus* Blyth, 1854 (Mammalia: Carnivora: Ursidae) with a review of its distribution and status in Nepal

– Madhu Chetri, Pp. 21797–21804

Age estimation of Tiger *Panthera tigris* (Linnaeus, 1758) and Lion *Panthera leo* (Linnaeus, 1758) (Mammalia: Carnivora: Felidae): applicability of cementum annuli analysis method

– Vipin, Chandra Prakash Sharma, Vinita Sharma, Surendra Prakash Goyal, Heather Stevens & Sandeep Kumar Gupta, Pp. 21805–21810

Hematological value of captive Asian Elephants *Elephas maximus* around Chitwan National Park, Sauraha, Nepal

– Roshan Ghimire, Sagar Regmi, Rakshya Shrestha, Amir Sadaula & Janardan Dev Joshi, Pp. 21811–21817

Foraging strata and dietary preferences of fifteen species of babblers in Sarawak, Malaysia

– Jayasilan Mohd-Azlan, Attiqqah Fadzilah Sopian, Andrew Alek Tuen & Chong Leong Puan, Pp. 21818–21825

Effects of wind farm on land bird composition at Kachchh District, Gujarat, India

– Selvaraj Ramesh Kumar, P.R. Arun & A. Mohamed Samsoor Ali, Pp. 21826–21835

New records of odonates from Trongsa and Zhemgang, central Bhutan with a checklist of Jigme Singye Wangchuck National Park

– Mer Man Gurung, Cheten Dorji, Abir Man Sinchuri, Sanjit K. Rai, Karma C. Dendup & Vincent J. Kalkman, Pp. 21836–21844

Land snails of Guwahati, Assam, India

– Girindra Kalita, Pp. 21845–21852

Morphology characterization and phytochemical overview of the Moluccan Ironwood *Intsia bijuga* (Colebr.) Kuntze, a living collection of Purwodadi Botanic Garden, Indonesia

– Melisnawati H. Angio, Elga Renjana & Elok Rifqi Firdiana, Pp. 21853–21861

Woody plant wealth of Therikadu Reserve Forest, Tuticorin, India: a checklist

– V. Muneeswaran & M. Udayakumar, Pp. 21862–21869

Invasive alien plant species of Hassan District, Karnataka, India

– G.M. Prashanth Kumar & Shiddamallayya Nagayya, Pp. 21870–21890

Notes

First photographic evidence of the Binturong *Arctictis binturong* (Raffles, 1821) from Nepal

– Madhu Chetri, Purna Bahadur Ale, Tulasi Prasad Dahal & Karan Bahadur Shah, Pp. 21891–21894

First record of *Chlorophorus jucundus* (Perroud, 1855) (Coleoptera: Cerambycidae: Cerambycinae) from Maharashtra, India

– Yogesh K. Mane & Sunil M. Gaikwad, Pp. 21895–21897

First record of the swallowtail moth *Epiplema adamantina* Inoue, 1998 (Lepidoptera: Uraniidae: Epipleminae) from western Himalaya, India

– Lekhendra & Arun Pratap Singh, Pp. 21898–21899

Visceral tetrathyridiosis *Mesocestoides* sp. (Cestoda: Cyclophyllidae) in a wild Barn Owl *Tyto alba* - a first report and new host record

– P.G. Vimalraj & A. Latchumikanthan, Pp. 21900–21902

Publisher & Host

