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Biological Resource

Teaching the Vertebrate Skeletal Systems with Cast and Models Avoiding Animal Dissection

Rekha Vartak[1)], Anupama Ronad[1)], Bimalendu B. Nath[2)*]

[1)] *Homi Bhabha Centre for Science Education (TIFR), India*

[2)] *Savitribai Phule Pune University, India*

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Teaching and the study of the vertebrate skeletal systems is an integral part of any undergraduate / postgraduate animal sciences curricula. The traditional method of teaching skeletal systems has been through dissection of an animal to expose the various systems. However, with the growing concern regarding discontinuation of animal dissections and implementation of animal ethical rules in many countries, it is becoming increasingly difficult for the teaching fraternity to cover these topics in the classroom / laboratories. Here we present a method to replicate the skeletal systems of various animals using a foam fibre material. The imitations of skeletons made of this material are sturdy and can last for several years without degradation. Since they can be made to look exactly like the true biological specimen, they can be easily and interestingly used in teaching the vertebrate skeletal systems. Thus, teaching the vertebrate skeletal systems is possible without having to sacrifice animals.

Keywords: *alternatives to animal dissection, artificial bone model, teaching skeletal systems*

[*]**Author for correspondence:** Professor Bimalendu B. Nath, Department of Zoology, Savitribai Phule Pune University, Pune 411007, India. E-mail: bbnath@gmail.com

INTRODUCTION

The method of dissection for teaching anatomy and physiology of animals has been an age-old practice spanning several decades. The institutions usually purchase a skeleton from the dealers and manufacturers who supply biological educational materials especially for teaching about vertebrate skeletal systems. Nowadays, it is becoming increasingly difficult to procure animal skeletons due to ethical and legal restrictions on animal killing (Balcombe, 2000; Balcombe, 2003). This is also an issue raised by organisations such as the People for the Ethical Treatment of Animals (PETA, See website). Dissection of animals in undergraduate and post-graduate laboratories has come under severe criticism in many countries leading to widespread concern amongst educators in Zoology (Kramer, 2007; Hart *et al*., 2008). The University Grants Commission (UGC), the highest policy making body in the Indian education system, directed colleges and universities to discontinue animal dissection and has recommended to explore alternative pedagogical methods (UGC, 2011). This promulgation has put forth challenges to biology educators to replace traditional teaching methods of vertebrate anatomy with suitable alternatives (Balcombe, 2003).

The advent of software-based pedagogical tools, especially the digital dissection software as alternatives to live dissection of animals to study

vertebrate anatomy, attracted considerable attention amongst biology educators (Jukes and Chiuia, 2003; Duncan, 2008; Lalley *et al.*, 2010). Several commercial bodies got engaged in such endeavours (Jukes and Chiuia, 2003; Lalley et al., 2010). Unfortunately, so far as teaching of skeletal systems is concerned, virtual education through software-based demonstration does not give an opportunity to students to 'feel' and 'conceptualize' bones with their own hands. This pedagogical challenge has inspired us to look for alternatives.

The 3Rs principle of 'replacement', 'reduction' and 'refinement' is often referred to as the concept of alternatives (Russell and Burch, 1959). In view of this, one can witness a growing demand for discontinuation of animal dissection and instead to use 'non-animal' methods. In this paper, we have proposed imitative means of representing bones of vertebrates which can be used for testing of students' knowledge and understanding of various skeletal systems and their structure-function relationships. Several cost-effective materials such as plaster of Paris, modelling clay, foam fibre and glass fibre were tried. Among these materials, foam fibre was found to be the most convenient material for the proposed use. This material is eco-friendly as well as sturdy and therefore an excellent substitute for obtaining 'original bones' by dissecting animals. At the same time, the model proposed in this paper can be used for 'hands-on' and 'minds-on' training of comparative aspects of vertebrate skeletal systems.

MATERIALS AND METHODS

(a) Preparation of models of bones as study material

In the present study, three representative groups of vertebrates, namely Amphibia, Reptilia and Mammalia, were selected. Commercially available skeletons (one each) of frog (*Rana tigrina*), lizard (*Calotes versicolor*) and rat (*Rattus rattus*) were obtained from Namit Modellers, New Delhi, India, an authorized supplier for educational institutes. The skeletal parts were disarticulated into individual components. These skeletal items were used as templates to prepare models.

The individual pieces of bones were made dust-free and clean. Bone pieces were then coated with petroleum jelly to make the template bones non-stick to casting material. The template bones were covered and coated with plaster of Paris mixed with water (1:2) and allowed to get completely dried and harden. Subsequently, each cast was broken to obtain the mould of selected bone. Foam fibre (one of the possible sources to procure foam fibre is Kavita Trading Co., Mumbai, India) was used to get the desired shape and contour of the bone surface and was allowed to dry. The specimen was then detached from the mould and reassembled for final display. The entire process takes approximately six days from the day of procurement of the template.

(b) Practices using skeletal models

The fabricated skeletal models were used in designed tasks for vertebrate anatomy which were pre-tested in trial rounds on high school science students under the Government-funded National Biology Olympiad Programme of the Biology Cell, Homi Bhabha Centre for Science Education (HBCSE), TIFR. These artificial animal bones were used in an experimental test during the 19th International Biology Olympiad (IBO) held at Mumbai by framing a laboratory task under Animal Anatomy and Physiology. The laboratory task (Practical Test 2, Task 1, Study of Animal Skeletal Systems; total points 54; duration 45 minutes), comprising comparative study of skulls, vertebral columns and limbs of frog, lizard and rat, can be viewed at the IBO website. The task was performed by 220 students from 55 countries.

RESULTS AND DISCUSSION

The purpose of the present study was to use the models as an alternative to actual skeletons especially since there are restrictions on sacrificing of animals in various countries. In view of this, foam fibre models of the skeletal systems (Figures 1 A - C) were provided to each of the 220 students at the 19th International Biology Olympiad. The task and models were presented to the juries of participating countries (about 100 members) prior to executing the same to the students. The models were examined by the juries and they readily approved the models for the proposed use.

The performance of the students post the experimental test was analysed. An alternative method to give the proposed task would have been to provide images of the various skeletal systems of the three animals. However, it is often found that any three-dimensional structure given in pictorial form becomes too straightforward for deductions if the various parts are labelled while it may be too difficult to interpret if these parts are not labelled. Thus, the use of skeletal mimics would reduce the risk of either over-simplifying the task or making it too difficult. This was reflected in the correlation coefficient between the scores of students in this lab and the overall performance (total score) of students. The correlation coefficient was found to be 0.71 which is considered to be a satisfactory score.

With the advent of software-based pedagogical tools, especially the emergence of digital dissection software, the alternative to live dissection of animals for the demonstration of skeletal parts have been accomplished by many educational institutes worldwide (Jukes and Chiuia, 2003; Lalley *et al*., 2010). However, hands-on training of skeletal systems apparently suffered a compromising pedagogy, because software-based virtual dissection cannot replace the realistic understanding of skeletal components when students comprehend the shapes and contours by touching the bones with their own hands and learn how to differentiate one from another. Therefore, the models presented here can address this issue effectively.

Also, our study design ruled out the influence of factors like age groups, differences of teaching environments and ethnicity by executing the task in the 19th IBO, because the participants were high school students but had different 'teaching-learning' backgrounds, ethnicity and cultural roots. On the basis of our analysis we can conclude that the artificially made imitations of skeletal components could be successfully used in testing students' knowledge and understanding of various structures and the structure-function relationships of various parts.

Visual exposure to skeletal systems on the computer screen does not satisfy the student inquisitiveness and therefore real-time exposure to imitation of animal bones can provide students with intellectual satisfaction. Mimics of bones presented in this paper can be touched and handled by the students, thereby can compensate pedagogical lacunae of the use of 'Information and Communication Technology.' We hope, the alternative materials proposed here to replace animal dissection for teaching vertebrate skeletal systems will partly resolve the ethical issues being encountered by biology educators.

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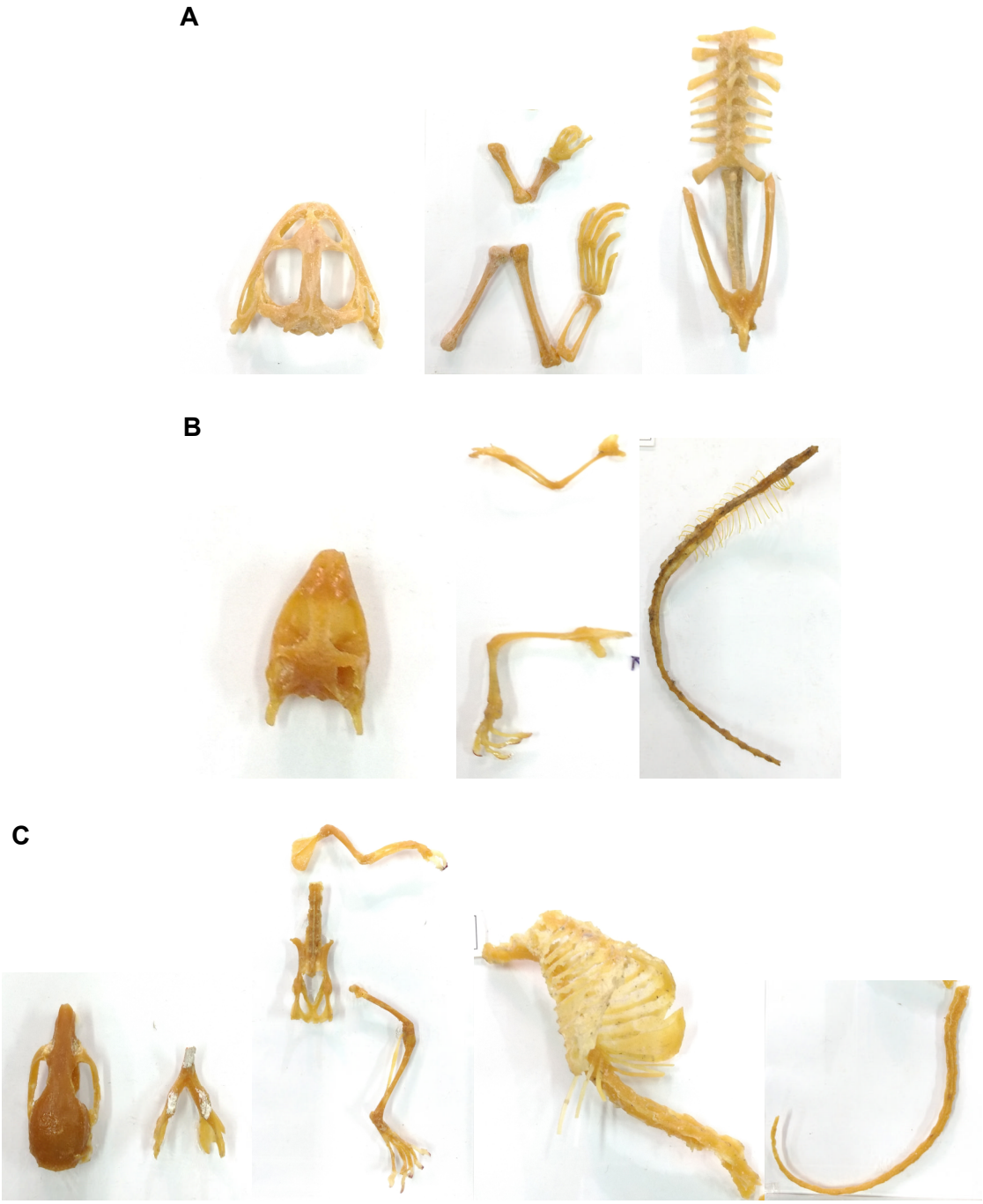

Figure 1: Artificial bones which are imitations of (A) Frog (B) Lizard (C) Rat skeletal systems

REFERENCES

Balcombe, J. (2000) *The Use of Animals in Higher Education: Problems, Alternatives and Recommendation.* The Humane Society Press, Washington D. C.

Balcombe, J. (2003) Assessment of alternatives in education. *In*: Jukes, N. and Chiuia, M. (eds.) *From Guinea Pig to Computer Mouse: Alternative Methods for a Progressive, Humane*

Education, 2nd ed. p. 40 – p. 53. InterNICHE, Leicester, England.

Duncan, A. (2008) Chalk Talk - To dissect or not: Student choice-in-dissection laws ensure the freedom to choose. *Journal of Law and Education* **37**: 283-289.

Hart, L. A., Wood, M. W. and Hart, B. L. (2008) *Why Dissection? Animal Use in Education,* Greenwood Press, Westport, CT.

Jukes, N. and Chiuia, M. (2003) *From Guinea Pig to Computer Mouse: Alternative Methods for a Progressive, Humane Education, 2nd ed.* InterNICHE, Leicester, England.

Kramer, M. G. (2007) Humane education, dissection and the law. *Animal Law Review* **13**: 281-298.

Lalley, J. P., Piotrowski, P. S., Battaglia, B., Brophy, K. and Chugh, K. (2010) A comparison of V-frog to physical frog dissection. *International Journal of Environmental and Science Education* **5**: 189-200.

Russell, W. M. S. and Burch, R. L. (1959) *The Principles of Humane Experimental Techniques.* Methuen and Co., London.

UGC (2011) Guidelines for discontinuation of dissection and animal experimentation in Zoology / Life Sciences in a phased manner. *Report of University Grants Commission.* New Delhi, India.

WEBSITES

IBO 2008 Practical Test

IBO 2008 Practicals CCL.pdf (p.26-p.38)

http://www.ibo-info.org/exams/ibo-2008-india/IBO-2008%20Pract.pdf/view

People for the Ethical Treatment of Animals (PETA)

How animals are collected and killed for dissection and the alternatives you can choose. *In*: *The PETA Guide to Animals and the Dissection Industry.*

https://www.peta.org/wp-content/uploads/2014/11/animalind.pdf