UNDERGRADUATE SUMMER VACATION SCHOLARSHIP AWARDS – FINAL SUMMARY REPORT FORM 2018/19
NB: This whole report will be posted on the Society's website therefore authors should NOT include sensitive material or data that they do not want disclosed at this time.

Name of student:

Rebecca Eden

Name of supervisor(s):

Dr Matthew Mason

Project Title: (no more than 220 characters)

3D reconstructions of the Miocene rodent *Diamantomys*, from micro-CT scans

Project aims: (no more than 700 words)

The rodent *Diamantomys* is known only as a fossil from the lower Miocene of Africa. Although good specimens have been found, there are few available descriptions of cranial structures. Based on an examination of the teeth, *Diamantomys* has been placed as a basal offshoot of the Thyronomyoidea, a group which includes the bathyergid mole-rats and the cane rat *Thryonomys* (Barbière & Marivaux, 2015).

The middle ear of mammals is of disproportionate importance to mammalogy because of its unusual evolutionary history and its variability between living groups. It has been used for taxonomic purposes and is also considered in functional studies, in which ear adaptations are linked to hearing in particular environments. Mole-rats show some unusual anatomical features of their ears which have been regarded either as specializations to a subterranean environment (Burda et al., 1992), or as degenerate (Mason et al., 2016). As a fossil relative of the mole-rats, examination of the ears of *Diamantomys* could help us to distinguish between these two interpretations. A second point of interest relates to the fact that, in an earlier study, the middle ear cavity of *Diamantomys* was likened to that of both African and South American rodents (Lavocat, 1978). A more detailed examination to include the inner ear too, now possible using high-resolution micro-CT reconstructions, could shed light on the ongoing debate about when the South American rodents of this group diverged from their African relatives.

We were loaned four *Diamantomys* specimens collected in Uganda. These are almost complete skulls, but being embedded within rock they remained undescribed. In this project, we used high-resolution micro-CT scans to produce 3D reconstructions of these fossil specimens, with a special focus on the ear regions. Measurements were taken of cranial width, the volume of the auditory bulla and the area of the tympanic membrane, and these were compared with measurements taken from extant rodent species in the same taxonomic group (Ctenohystrica), some of which we were able to examine directly. One of our goals was to determine whether the ear of *Diamantomys* more closely resembles those of bathyergid mole-rats or that of *Thryonomys*, in terms of form and function. A secondary aim of the project was to identify, examine and describe parts of the anatomy of *Diamantomys* which had not previously been described in the literature.

References

Barbière, F. & Marivaux, L. (2015) Phylogeny and evolutionary history of hystricognathous rodents from the Old World during the Tertiary: new insights into the emergence of modern "phiomorph" families. In: *Evolution of the Rodents: Advances in Phylogeny, Functional Morphology and Development* (eds Cox, P.G. & Hautier, L.), pp. 87-138. Cambridge: Cambridge University Press.

Burda, H., Bruns, V. & Hickman, G.C. (1992) The ear in subterranean Insectivora and Rodentia in comparison with ground-dwelling representatives. I. Sound conducting system of the middle ear. *Journal of Morphology* 214: 49-61.

Mason, M.J., Cornwall, H.L. & Smith, E.S. (2016) Ear structures of the naked mole-rat, *Heterocephalus glaber*, and its relatives (Rodentia: Bathyergidae). *PLoS One* 11: e0167079.

Lavocat, R. (1978) Rodentia and Lagomorpha. In: *Evolution of African Mammals* (eds Maglio, V.J. & Cooke, H.B.S.), pp. 69-89. Cambridge: Harvard University Press.

Project Outcomes and Experience Gained by the Student (no more than 700 words)

Becky produced 3D reconstructions from the CT scans of all four fossil specimens using Stradwin software. These were compared to previously published photographs and descriptions to verify identity, and it was determined that they were indeed specimens of *Diamantomys*. The highest resolution scan was reconstructed in more detail to model the structures of the inner and middle ears, including the cochlea, semi-circular canals, tympanic cavity and some isolated ossicles. Several parts of our fossil specimens which Becky was able to reconstruct had not previously been described in *Diamantomys* to our knowledge, including all seven cervical vertebrae, preserved in situ, plus an unknown bone that we believe could be the basihyoid. Several of the mandibles remained articulated with the skulls, which is uncommon.

As well as this fossil work, Becky examined the ears of four species of extant rodents: the first time she had dissected under a microscope. This gave her an insight into the wide variety of form and function of the mammalian middle ear, as well as some experience in soft tissue anatomy.

From a comparison of the fossil reconstructions with the living rodent species, the middle and inner ear structures of *Diamantomys* were found most closely to resemble those of *Thyronomys*, consistent with placing *Diamantomys* as a basal offshoot of the Thyronomyoidea. The ears did not show the characteristic features of bathyergid mole-rat ears; our interpretation is that the *Diamantomys* ear represents the primitive auditory morphology for this group, with bathyergids evolving from there in a different and likely degenerative direction.

During the project, Becky learned about the process behind creating micro-CT scans and how they can be used in palaeontology to visualise specimens, non-invasively and without laborious fossil preparation techniques. Creating and analysing the skull reconstructions, as well as her experience with micro-dissection, has given her an in-depth understanding of cranial anatomy. Becky wrote up her findings in an extensive report, which gave her valuable practice in writing in the style of a scientific paper.

Overall, Becky gained experience with many different techniques and skills which will be transferable to the research project component of the final year of her current zoology degree, as well as to any further research she pursues. We are collaborating with a French team, with which we are sharing our reconstructions, and intend to produce in due course a joint paper on the anatomy of *Diamantomys* with Becky as a co-author.

Please state which Society Winter or Summer Meeting the student is intending to present his/her poster at:

Summer 2020

Proposed Poster Submission Details (within 12 months of the completion of the project) for an AS Winter/ Summer Meeting – (no more than 300 words)

The poster will focus on the techniques and methodology associated with reconstructing fossil anatomy using micro CT scanning in lieu of traditional fossil preparation techniques, displaying images of *Diamantomys* produced at different stages of the reconstruction process. There will be a focus on parts of the anatomy that have not previously been described, as well as on the detailed anatomy of the middle and inner ears which we can compare to those of living rodent species.

Brief Resume of your Project's outcomes: **(no more than 200-250 words)**.
The title of your project and a brief 200-250 word description of the proposed/completed project. The description should include sufficient detail to be of general interest to a broad readership including scientists and non-specialists. Please also try to include 1-2 graphical images (minimum 75dpi). NB: Authors should NOT include sensitive material or data that they do not want disclosed at this time.

3D reconstructions of the Miocene rodent *Diamantomys*, from micro-CT scans

Four unprepared fossil specimens, most likely of the extinct rodent *Diamantomys*, were investigated using micro-computed tomography (micro-CT). Reconstructions of the four skulls (A-D) made using the program Stradwin can be seen in Figures 1 and 2. Several of the reconstructions showed articulated mandibles and vertebrae, which would be hard to preserve in traditionally-prepared fossils. The reconstructions allowed us to confirm some of the descriptions available in the literature, and revealed new parts of the anatomy of this animal. The middle and inner ear structures were reconstructed in greater detail: the tympanic cavity, site of the tympanic membrane, cochlear spirals, semi-circular canals and a displaced malleo-incus unit are all shown in Figure 2. The ear reconstructions were compared with the middle and inner ears of several extant rodent species in the Ctenohystrica group to which *Diamantomys* belongs, including chinchillas and naked mole-rats. The ear of *Diamantomys* was similar in morphology to that of the cane rat *Thyronomys*, adding weight to previous studies based on a consideration of tooth morphology, which concluded that *Diamantomys* was a basal offshoot of the Thryonomoidea. However, ear structures were quite different to those of bathyergid mole-rats, which appear to have degenerate hearing. This study forms part of an ongoing project on the structure, function and evolution of the ctenohystrican ear.

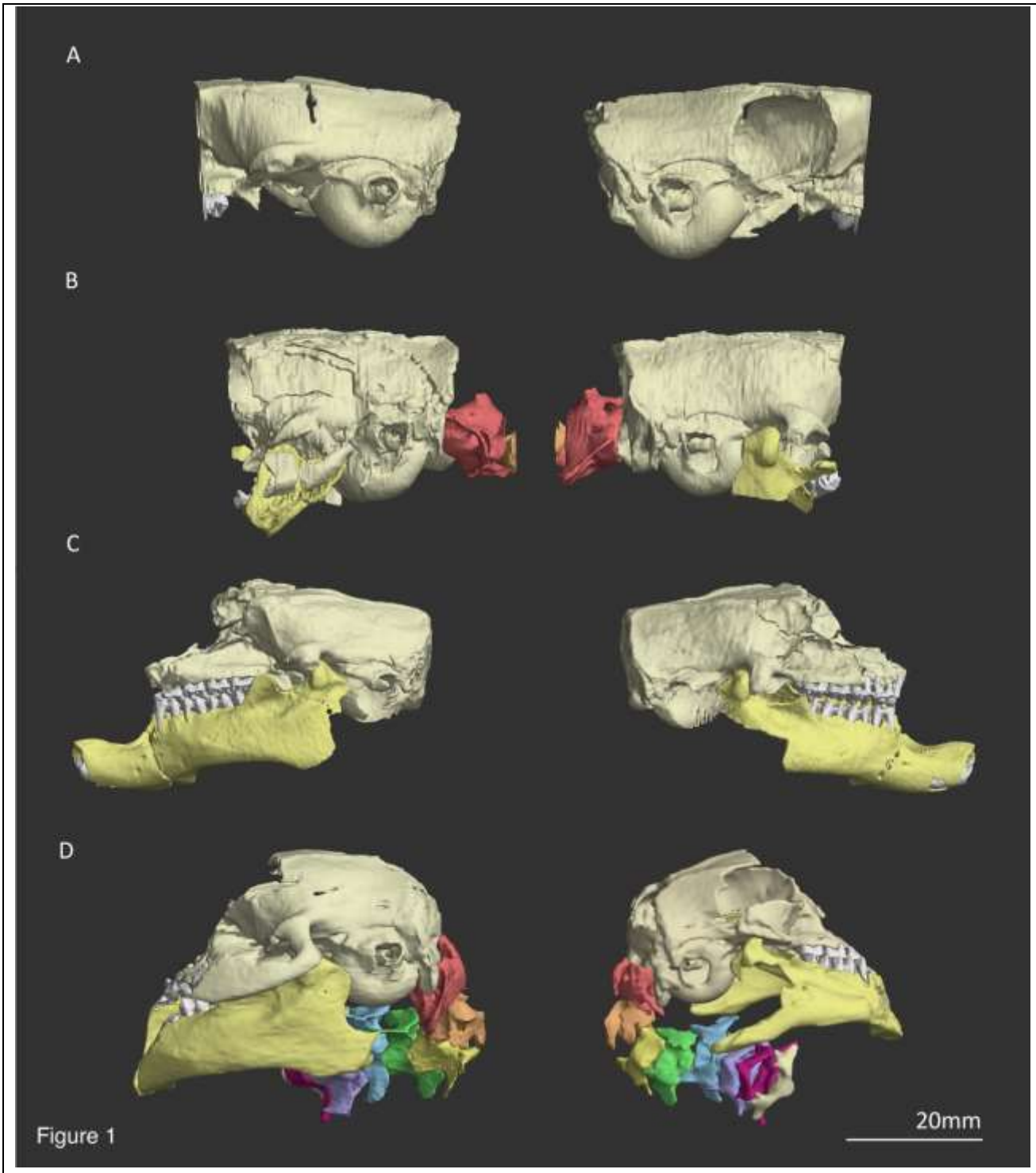

Figure 1: left and right lateral views of the reconstructions made of four *Diamantomys* fossils, A-D.

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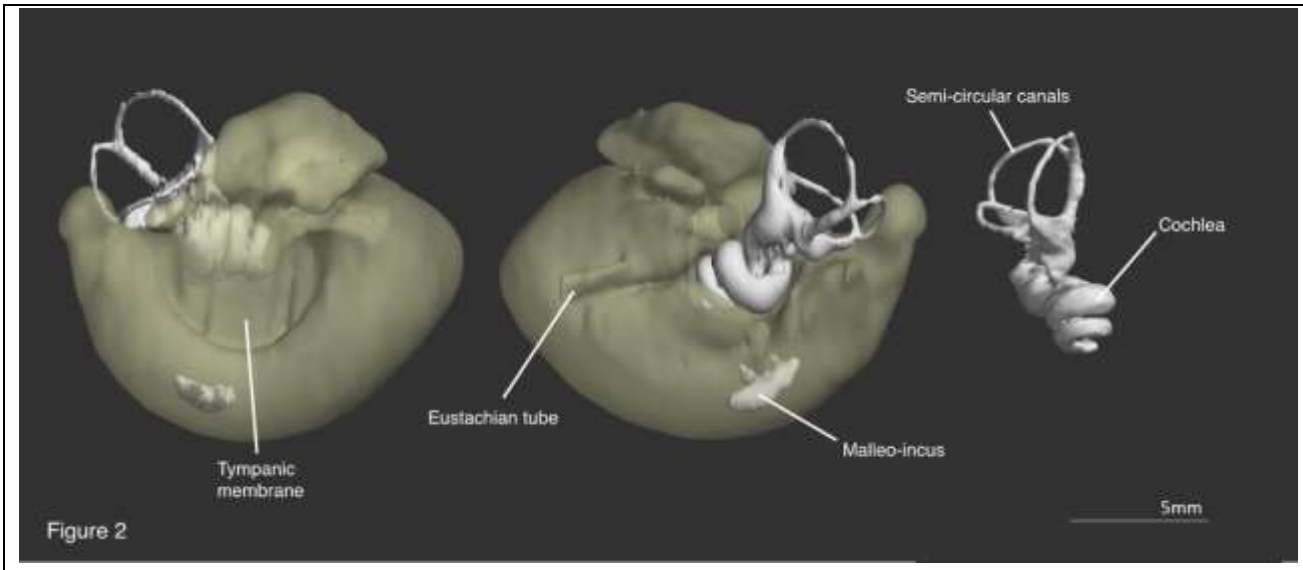

Figure 2: right middle and inner ear structures of *Diamantomys*.

Other comments: (no more than 300 words)

As the supervisor of this project, I would like to add that I was very pleased with how it progressed. Becky put many hours into producing extremely careful and detailed manual reconstructions of these skulls. One should not underestimate how difficult it is to distinguish visually between bone and rock in tomograms, especially for a student with no previous experience of such work. She also proved very competent at micro-dissection. I am confident that the results of this short project will ultimately be publishable and I look forward to involving Becky in this process as an author.

We would both like to thank the Anatomical Society for the funding which made this project possible.

Signature of student: *Rebecca Eden* *Date:* 15.10.19

Signature of supervisor *Matthew Mason* *Date:* 26.10.19

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