

Institution: Cardiff Metropolitan University		
Unit of Assessment: UOA24: Sport and Exercise Sciences, Leisure and Tourism		
Title of case study: Exercise scientists' impact on the health, welfare and survival of critically endangered great apes: The International Primate Heart Project (IPHP)		
Period when the underpinning research was undertaken: 2006 -2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Aimee Drane	Lecturer in Cardiovascular and Exercise Physiology	January 2013 – present
Prof Rob Shave	Professor of Cardiovascular Physiology	June 2010 – January 2018
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words)		
<p>Research into the role of exercise and physical (in)activity on human cardiovascular structure and function has fundamentally underpinned understanding of cardiac health and disease in great apes. Since October 2010 Drane and Shave have worked with European zoos, great ape sanctuaries in Congo, Zambia, Cameroon and Indonesia, and national and international veterinary teams and organisations to improve the understanding, diagnosis and management of heart disease in critically endangered great apes. Specifically, they assessed cardiac health in 543 apes, provided professional development for ~200 veterinary professionals from ~80 institutions across ~35 countries, and assisted in the selection of animals for the World's largest ever chimpanzee re-introduction programme. The research has led to the generation of Pan African Sanctuary Alliance veterinary guidelines that veterinary professionals can use to identify cardiac disease in these critically endangered species. Collectively the work is contributing to the survival of the species.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>On arrival at Cardiff Met, Shave initiated a programme of research that examined the role of exercise and physical (in)activity on cardiovascular structure and function. The specific focus of this research was to understand the acute and chronic influence of exercise upon cardiac structure and function in both healthy individuals and those suffering from heart disease. The research highlighted the importance of left ventricular mechanics in the functional response of the heart to physiological (e.g., exercise and high-altitude exposure) and pathological (e.g., coronary artery disease and chemotherapy) stimuli, and characterised the physiological response of cardiac biomarkers (e.g., cardiac troponin) to exercise. This research, grounded within the sport and exercise domain, has enabled the group to develop significant expertise in the assessment of cardiac structure and function using cardiac ultrasound, electrocardiograms and cardiac biomarkers. Applying their expertise to the fields of comparative physiology and zoological medicine, the group set up the International Primate Heart Project (IPHP- http://primateheartproject.co.uk/) in 2010 to examine the role of physical activity in the evolution of the human cardiovascular system and to simultaneously improve the understanding of cardiac health and disease in great apes (e.g., Gorillas, Chimpanzees, Bonobos and Orangutans).</p> <p>Through the IPHP, Drane and Shave have worked with a number of great ape collections in different countries to complete cardiovascular assessments across the four great ape species.</p>		

This dataset includes the largest wild-born chimpanzee population ever to undergo cardiovascular assessment, and it is from this population that the majority of research outputs have been derived. As part of routine health checks completed by the specialist veterinary teams caring for these animals, Drane and Shave conducted comprehensive cardiovascular assessments (12 lead ECG, blood pressure, echocardiography and cardiac biomarkers) of each animal. In addition to informing the veterinary practitioners caring for individual animals, these data were also used to generate normal reference intervals and practical veterinary guidelines for the assessment of cardiac structure and function [R3, R5], electrical conduction [R1], and blood pressure responses to different anaesthetic protocols [R2] in wild-born chimpanzees. The data were also used to examine the feasibility of using cardiac troponin as a marker of cardiac disease in non-domesticated species including great apes [R4]. Critically, these studies have defined for the first time the normal cardiac phenotype in healthy wild-born chimpanzees. The data collected as part of the IPHP have also been used comparatively to examine the influence of physical activity patterns on the evolution of the human heart. Specifically, the data showed marked differences in both cardiac structure and function between humans and chimpanzees - supporting the hypothesis that the human heart has undergone evolutionary selection for endurance capabilities. A corollary of these findings is that human evolutionary history might explain the increasing incidence of hypertensive heart disease in post-industrialised populations no longer engaging in a physically active lifestyle [R6].

3. References to the research (indicative maximum of six references)

All of the outputs listed below were published in international peer-reviewed journals within the fields of *veterinary* science and general science. [R1] (AJVR) is in the top 25% of journals in the field in the Scimago rankings, [R2] (JZWM) is in the top 50-75% of journals in the field (but is the recognised reference point for all zoo vets), and [R6] (PNAS) is in the top 25% of interdisciplinary journals and is being returned to UOA24 as part of this submission.

- [R1] Atencia, R., Revuelta, L., Somauroo, J. D. & **Shave, R. E.** 2015. Electrocardiogram reference intervals for clinically normal wild-born chimpanzees (*Pan troglodytes*). *American Journal of Veterinary Research*, 76, 688-93. DOI: [10.2460/ajvr.76.8.688](https://doi.org/10.2460/ajvr.76.8.688)
- [R2] Atencia, R., Stohr, E. J., **Drane, A. L.**, Stembridge, M., Howatson, G., Del Rio, P. R. L., Feltrer, Y., Tafon, B., Redrobe, S., Peck, B., Eng, J., Unwin, S., Sanchez, C. R. & **Shave, R. E.** 2017. Heart rate and indirect blood pressure responses to four different field anesthetic protocols in wild-born captive chimpanzees (*Pan Troglodytes*). *Journal of Zoo and Wildlife Medicine*, 48, 636-644. DOI: [10.1638/2016-0181.1](https://doi.org/10.1638/2016-0181.1)
- [R3] **Drane, A. L.**, Atencia, R., Cooper, S.-M., Rodriguez, P., Sanchez, C., Simcox, S., Feltrer, Y., Peck, B., Eng, J. & Moittie, S. 2019. Cardiac structure and function characterized across age groups and between sexes in healthy wild-born captive chimpanzees (*Pan troglodytes*) living in sanctuaries. *American Journal of Veterinary Research*, 80, 547-557. DOI: [10.2460/ajvr.80.6.547](https://doi.org/10.2460/ajvr.80.6.547)
- [R4] Feltrer, Y., Strike, T., Routh, A., Gaze, D., & **Shave, R.** 2016. Point-of-care cardiac troponin I in non-domestic species: A feasibility study. *Journal of Zoo and Aquarium Research*, 4, 99-103. DOI: [10.19227/jzar.v4i2.172](https://doi.org/10.19227/jzar.v4i2.172)
- [R5] **Shave, R.**, Oxborough, D., Somauroo, J., Feltrer, Y., Strike, T., Routh, A., Chapman, S., Redrobe, S., Thompson, L. & Unwin, S. 2014. Echocardiographic assessment of cardiac structure and function in great apes: A practical guide. *International Zoo Yearbook*, 48, 218-233. DOI: <https://doi.org/10.1111/izy.12026>
- [R6] **Shave, R. E.**, Lieberman, D. E., **Drane, A. L.**, Brown, M. G., Batterham, A. M., Worthington, S., Atencia, R., Feltrer, Y., Neary, J. & Weiner, R. B. 2019. Selection of endurance capabilities and the trade-off between pressure and volume in the evolution of

the human heart. *Proceedings of the National Academy of Sciences*, 116, 19905-19910.
DOI: [10.1073/pnas.1906902116](https://doi.org/10.1073/pnas.1906902116)

4. Details of the impact (indicative maximum 750 words)

As part of the IPHP, Drane and Shave have completed **543** cardiovascular assessments across the four great ape species (Gorillas, Chimpanzees, Bonobos and Orang-utans) in **21** different collections across **10** different countries. This includes the World's largest wild-born chimpanzee population (**n=339**) in Africa. IPHP research has resulted in immediate, medium and long-term impact on the **survival of individual animals** and the ongoing care, management and treatment of individual animals living in zoological collections and great ape sanctuaries. It has also informed the **World's largest ever Chimpanzee re-introduction programme** of animals back into the wild [E2, E8].

Immediate Impact: At the point of cardiac assessment, the presence of heart disease in individual animals has been ruled-in or ruled-out. For some animals this resulted in changes in treatment plans or care. For example, based on our work, **two chimpanzees** with suspected cardiac disease had ECG loop recorders surgically implanted to continuously monitor cardiac rhythm. On follow-up, one animal was found to have malignant arrhythmias and was started on therapy. Ongoing monitoring by the team has subsequently shown that the arrhythmic burden in this animal has been reduced [E1, E9]. Similarly, during an IPHP examination in 2015 a **female chimpanzee at Tchimpounga sanctuary** was found to have cardiac tamponade due to cardiac failure. Her treatment and care to the present day has been guided by Drane and Shave's work [E2]. Based on the knowledge and skills developed since the start of the IPHP project, the team have also consulted in relation to the potential of cardiac involvement in both a **viral outbreak in an Orangutan sanctuary (Nyarumintang)** [E11] and an **unknown disease causing sudden death in chimpanzees (Tacugama)**. In animals, without disease, each cardiac examination creates a reference set of "healthy" cardiac data that has been shared with the relevant care team, which will be of **clinical relevance in future assessments of heart disease**.

From the outset, the collection of data has involved close collaboration with veterinary care teams, and has facilitated significant on-site professional development related to the assessment of cardiac health for veterinarians in **21 different great ape collections** including the **Jane Goodall Institute – Tchimpounga Chimpanzee Rehabilitation Centre, Zoological Society of London, Chester Zoo, Paignton Zoo** [E10], **Blackpool Zoo, Ape Action Africa, and Limbe Wildlife Sanctuary**. This collaborative, multidisciplinary, approach was formally recognised by the **British and Irish Association of Zoos and Aquaria (BIAZA) in November 2013**, when the IPHP received the award for **significant advances in zoo and wildlife medicine** [E5].

Medium-term Impact: In addition to the education of individual professionals that occurred during the assessment of animals, since 2011, Drane and Shave have also been invited to present their research findings and lead educational and professional development workshops at numerous key and highly prestigious veterinary conferences and meetings (e.g., The Great Ape Health Masterclass at the Joint American, European and International Veterinary Societies Annual Conference, Zoological Society of London Great Ape Education Days, Pan African Sanctuary Alliance (PASA) veterinary meetings, and to the Orangutan Veterinary Advisory Group (OVAG) meetings) [E3, E4]. Moreover, veterinary professionals from the UK and overseas have visited Drane and Shave to improve their knowledge, understanding and practical skillset. These formal and informal educational events have provided theoretical and hands-on teaching activities for **~200 veterinary professionals** involved in the care of captive, semi-captive and wild great apes from across the world [E3, E4]. Accordingly, the reach of the research goes beyond captive zoo populations to those animals being cared for in sanctuaries and in the wild. The relevance of Drane and Shave's work in relation to the training of veterinary professionals and the immediate and long-term care of animals has been recognised through endorsement from a number of **national and international organisations** involved in great ape care including BIAZA [E5], PASA and OVAG [E3, E4].

Long-term Impact: The generation of standardised cardiac assessment protocols and the development of normal reference data for cardiac health in wild born chimpanzees is of **clinical**

relevance for all chimpanzees being assessed for heart disease. These data have and will continue to facilitate better care, treatment and management of animals in **zoos, sanctuaries and the wild.** They also form the basis of the recent **PASA veterinary guidelines** for the assessment of cardiac health in great apes written by Drane and Shave (<https://umnadvet.instructure.com/courses/321/pages/ape-cardiac-health; 12>). Beyond the initial diagnosis, individual treatment and longitudinal monitoring of animals with disease, the data collected by the IPHP have also informed the **largest ever Chimpanzee re-introduction programme in Africa** [E2, E8]. Specifically, using the normative reference data the IPHP has helped the Jane Goodall Institute's veterinary team select healthy animals, free of cardiac disease, to join the group of Chimpanzees being prepared for release. Accordingly, the work has not only had significant impact on individual animals and collections in zoos and sanctuaries but is also contributing to ongoing efforts aimed at ensuring the **survival of the species** [E2]. In addition to zoological advances this work has and will continue to examine the evolutionary origins of cardiovascular disease in humans [E7].

5. Sources to corroborate the impact (indicative maximum of 10 references)

- [E1] Zoological Society of London – This testimonial thanks the IPHP for assisting with the implant of cardiac loop recorders (December 2013), the assessment of overall cardiac health and the ongoing analysis of cardiac data for two chimpanzees with known cardiac disease.
- [E2] Jane Goodall Institute – A testimonial written to thank the IPHP for assisting with assessing and improving the health, not only of individual chimpanzees but large groups of animals as part of the release programme.
- [E3] Orangutan Conservancy – Testimonial to thank the IPHP for providing cardiac lectures, cardiac ultrasound and cardiopulmonary resuscitation training for veterinarians caring for orangutans at two annual conferences of the Orangutan Veterinary Advisory Group.
- [E4] Chester Zoo and Pan African Sanctuary Alliance – Testimonial recognising the work of the IPHP with Chester Zoo, OVAG and the PASA.
- [E5] BIAZA Award for significant advances in zoo and wildlife medicine.
- [E6] Assessing Cardiac Health in Great Apes – Chapter of the PASA Veterinary Healthcare Manual.

Press, media and social media reports:

- [E7] New York Times article "What apes can teach us about our heart health":
<https://www.nytimes.com/2019/10/09/well/move/what-apes-can-teach-us-about-our-heart-health.html>
- [E8] Jane Goodall Institute Congo – youtube video of the collaboration with the IPHP
<https://www.youtube.com/watch?v=KA9UzxYQEIA>
- [E9] Whipsnade (ZSL) loop recorder:
<http://www.itv.com/news/anglia/2013-07-10/whipsnade-zoo-chimpanzees-first-to-be-fitted-with-heart-monitors/>
- [E10] Paignton Zoo Gorilla assessment and Collaboration:
<https://www.paigntonzoo.org.uk/explore/news/detail/gorilla-helps-human-heart-research>
<http://www.bbc.co.uk/news/uk-england-devon-18723916>

Impact case study (REF3)

[E11] Veterinarian Blog from the Borneo Orangutan Survival Foundation on how the IPHP was helping at Nyaru Menteng:

<http://volunteerveterinarian.blogspot.co.uk/2015/12/the-international-primate-heart-project.html>

[E12] Letter on behalf of the Ape Health Development Team to confirm the contribution of Drane and Shave to the Pan African Sanctuary Alliance (PASA) veterinary guidelines