VET nuus•news

Junie / June 2026

The Monthly Magazine of the SOUTH AFRICAN VETERINARY ASSOCIATION
Die Maandblad van die SUID-AFRIKAANSE VETERINÊRE VERENIGING



THEME

Nature Photography

CPD

The Clinical Application of Electron Radiotherapy in the Management of Cancer in Companion Animals

SAVA
South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

Access to CPD Articles:

CPD CONTINUING PROFESSIONAL DEVELOPMENT

https://www.sava.co.za/vetnews-2026/



Dagboek • Diary

Ongoing / Online 2026

SAVETCON: Webinars
Info: Corné Engelbrecht, SAVETCON, 071 587 2950,
corne@savetcon.co.za / https://app.livestorm.co/svtsos

SAVA Johannesburg Branch CPD Events
Monthly - please visit the website for more info.
Venue: Johannesburg Country Club
Info: Vetlink - https://savaevents.co.za/

CPD Course: Introduction to Animal Welfare Science
Online - self paced.
Info: https://scientificveterinaryconsulting.com/courses/animal-welfare-online-short-course/

CPD Course: Animal Research Ethics
Online - self paced.
Info: https://scientificveterinaryconsulting.com/courses/essence-of-the-sans-10386-2021-online-short-course/

June 2026

13th Int Crustacean Society Mid-Year Meeting
01-04 June
Venue: STIAS – Stellenbosch
Info: https://tcs2026.com/

NVCG Bush Break
06-07 June
Venue: Skukuza, Kruger National Park
Info: Vetlink:
https://vetlink.co.za/nvcg-bush-break-2026/

RuVASA Congress 2026
08 - 10 June
Venue: Champagne Sports Resort, Drakensberg, KZN
Info: https://vetlink.co.za/ruvasa-congress-2026/

13th Biennial SAVA & Para-Veterinary Congress

13 - 15 April 2027

Venue: To be confirmed (Gauteng)

Info: corne@savetcon.co.za



July 2026

56th Annual SASAS Congress
07 - 09 July
Venue: Lagoon Beach Hotel, Cape Town
Info: https://www.sasascongress.co.za/

SAVA Eastern Free State Congress
10-11 July
Venue: Lavender Hill Country Estate, Bethlehem
Info: conference@savetcon.co.za

Integrative Veterinary Medicine Conference
31 July - 02 August
Venue: Protea Hotel, Stellenbosch
Info: conference@savetcon.co.za

Western Cape Branch of the SAVA Congress
31 July – 01 August
Venue: Devonvale Golf & Wine Estate, Stellenbosch
Info: Vetlink on conferences@vetlink.co.za

August 2026

Hill's Nurses Hybrid Weekend
01-02 August
Venue: Cradle Moon, Muldersdrift
Info: corne@savetcon.co.za

SAVA Free State & Northern Cape Congress
14-15 August
Venue: Protea Hotel, Kimberley
Info: conference@savetcon.co.za

23rd Annual SASVEPM Congress
19 - 21 August
Venue: Sun City Resort, Rustenburg, North West
Info: https://sasvepm.org/23rd-annual-sasvepm-congress/

54th Annual PARSA Conference
31 August – 02 September
Venue: Klein-Kariba, Bela-Bela
Info: corne@savetcon.co.za

September 2026

SAVA Mpumalanga Branch
04 – 05 September
Venue: TBC
Info: conference@savetcon.co.za

Virology Africa Congress
15 - 18 September
Venue: Skukuza, Kruger National Park
Info: Vetlink: https://virologyafrica2026.co.za/

NVCG: Veterinary Masterclass: Medicine & Dermatology
19 - 20 September
Venue: Johannesburg, Midrand Premier Hotel
21 - 22 September
Venue: Protea Hotel Stellenbosch (Techno Park)
Info: https://vetlink.co.za/nvcg-roadshow-dermmed/

SAAVT Biennial Congress
30 September - 01 October
Venue: Krystal Beach Hotel, Gordon's Bay
Info: conference@savetcon.co.za

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CPD CONTINUING PROFESSIONAL DEVELOPMENT

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Keeping Members Informed and Engaged



Dear members,

It has come to my attention that, in the busyness of SAVA and the many matters currently requiring attention, we may not always be keeping members as fully abreast as we should of the work being done on behalf of the profession. I therefore wish to use this foreword to provide a brief update on some of the key areas in which the SAVA Board of Directors, committees, staff and representatives have been active.

Since the leadership changes in January, the Board has welcomed four new members. The Board has had to deal with a number of significant matters, many of which have required careful consideration, engagement and, in some instances, legal and regulatory input.

SAVA's finances remain a major priority. I wish to acknowledge the important contribution of all the directors, and particularly the new Finance Director, Dr David Pretorius, whose work in strengthening SAVA's financial oversight and assisting with the process of stabilising both SAVA and SAVETCON has been invaluable. This builds on work started over the past two years to reduce costs and improve financial controls. As part of this process, SAVA replaced the internal accountant position with the services of Robelli Accountants, resulting in a saving on these services. Work is ongoing with Robelli Accountants to improve financial systems, reporting and accountability.

Questions have also arisen from members regarding the origins of SAVA's financial challenges. These challenges developed over time and were caused by a combination of high overhead costs, budgeting and budget-management challenges related to the World Veterinary Association Congress, and the continued subsidisation of the HWSETA-funded Mentorship Programme by SAVA. I wish to confirm that, following the investigations conducted, there has been no evidence of stolen funds.

There had been an allegation relating to the unauthorised movement of funds from SAVA's investment accounts to its transactional accounts. Consequence management was implemented in respect of the employee involved. Investigations also identified poor accounting practices in the reconciliation of the WVAC finances. The encouraging news is that a significant portion of the projected losses appears to be recoverable, and Robelli Accountants is already working on this process. Precise figures will be shared with members once the relevant claims have been successfully lodged.

Further cost-reduction measures have also been implemented. The staff complement at VetHouse was reduced, and a reduction in the salary budget was negotiated. Bonuses have now been linked to individual and organisational performance rather than being treated as an automatic 13th cheque.

The downsizing of the SAVA staff complement included the employees responsible for the Mentorship Programme, due to the risk created by the funding model through HWSETA. In essence, SAVA would subsidise the programme and only receive an indication of funding approval in the last quarter of the year. Payment would then have to be followed up in March of the following year, with funds often only received around August. This situation became untenable, and the programme remained fully financed by SAVA in 2023 when HWSETA did not approve the funding proposal for that year. This, together with the significant financial outlays related to WVAC, placed SAVA in a precarious financial position from which it has not yet fully recovered.

The Mentorship Programme remains essential in providing support to community service veterinarians, who remain among the most vulnerable categories within the profession as well as creating opportunities for collaboration with para-veterinary professionals. SAVA is therefore exploring alternative sponsorship options and expansion of the programme to the continuing education of all categories of veterinary professionals, with the hope that the programme may be resumed in the 2027 financial year.

VetHouse has also seen encouraging developments, including the securing of new tenants, painting and tiling renovations, and planned improvements such as updated signage. These may seem like operational matters, but they form part of restoring confidence, improving functionality and making better use of SAVA's assets.

SAVETCON has also been scaled down as part of the broader process of ensuring financial sustainability and operational focus. While this has not been an easy process, it is necessary to ensure that SAVA and its related structures remain viable and better aligned with the needs of the profession.

Earlier this year, the Board held a strategy session during which it reflected on SAVA's role, its stakeholder relationships, and the Memorandum of Incorporation. This was an important opportunity to consider how SAVA positions itself in a changing professional, regulatory and financial environment. There remains much work to be done before the AGM, and members will be kept informed and engaged as these processes unfold. As part of this work, the Board also updated SAVA's vision and mission statements, which are available on the website. Members are encouraged to review these and provide feedback.

SAVA's representation on the South African Veterinary Council has also been strengthened. The newly appointed SAVA representative has since been elected as Deputy President of Council and is well placed to contribute meaningfully to the leadership of the Council at an important time for the profession, continuing from the sound foundations laid by Dr Brendan Tindall. The Board has also noted the concerns of members regarding lay persons providing veterinary services.

This is an area that the Board has prioritised for collaboration with the SAVC. SAVA remains committed to constructive, principled and professional engagement with the SAVC in the interests of the profession and the public.

A substantial amount of the Board's work during this period has been linked to the national Foot-and-Mouth Disease outbreak response. SAVA's focus has been to ensure that veterinarians remain relevant and that private veterinarians continue to be recognised as an essential part of the outbreak response. To this end, letters were written to the Minister, the Director-General and the relevant Deputy Director-General, and the Board sought legal opinions on various outputs from the national Department of Agriculture relating to FMD. The most recent of these was the Section 10 FMD Scheme.

SAVA, together with RuVASA and the Wildlife Group of SAVA, engaged extensively with legal advisors and submitted comments on the Scheme. A key area of focus was the question of liability, particularly in relation to the role and exposure of veterinarians involved in implementation. It is encouraging that most of SAVA's submissions were addressed in the final Section 10 Scheme, which has since been promulgated and shared with members.

The SAVA Board has also noted the recent interim court ruling in the Sakeliga case and is in communication with various stakeholders regarding its practical implications.

Another major area of work has been engagement with SAHPRA. The rescheduling of Yohimbine was a significant win for wildlife veterinary practice in the country. V-Tech and the SAVA Wildlife Veterinary Group played a significant role in securing this outcome, which reflects the value of sustained, structured engagement.

Further discussions with SAHPRA are being conducted with the aim of taking a more holistic view of the supply of veterinary medicines in South Africa. This includes the development of clearer guidance on compounding and the importation of veterinary medicines and raw materials under Section 21 of the Medicines and Related Substances Act, 101 of 1965. SAVA has requested a preliminary meeting with key stakeholders, with the intention that this process should ultimately contribute to reviewed

guidelines and regulations. We also envisage a dedicated pharmaceutical stream at the veterinary congress, as well as an indaba at which the outcomes of these engagements can be shared more broadly.

The Board also met with representatives of the AVF, who requested to be acknowledged as a SAVA stakeholder. They presented their objectives and areas of interest, and the Board will consider this relationship, together with other stakeholder relationships, at an upcoming meeting. In doing so, the Board will consider possible areas of collaboration while ensuring that SAVA's mandate, independence and accountability to its members remain clear.

SAVA also recently released a statement on the transportation of livestock by sea for slaughter at destination. This statement was informed by the outcome of the member poll and was drafted with the assistance of the Welfare and Ethics Committee, as well as veterinarians with knowledge of the matter. The statement has received attention from industry and other stakeholders, who have been invited to submit their concerns so that the Board may consider and engage on them. It is important to note that the SAVA Board acknowledges that, under the current legal framework, the practice is not outlawed. However, SAVA continues to encourage the intentional development of alternatives and the safeguarding of animal welfare through appropriate veterinary involvement and oversight.

The Animal Ethics and Welfare Committee has also developed a statement in response to renewed calls by the Boerboel Breeders Association regarding tail docking. This is another important area where SAVA must provide clear, science-based and welfare-conscious leadership, while engaging constructively with affected stakeholders. We request members to engage with clients and the public at every opportunity to explain the welfare concerns relating to tail docking.

SAVA has also continued to engage actively in the public space. Several radio interviews have been conducted on Foot and Mouth Disease, pet care, World Veterinary Day and other matters affecting animal health and the veterinary profession. These platforms are important in ensuring that the veterinary voice remains visible and that the public receives credible, balanced and practical information.

SAVA has also engaged pet insurance companies on matters affecting the profession, particularly concerns regarding negative advertising. These interactions were constructive, and we look forward to closer collaboration with these organisations.

Student engagement remains a necessary and fulfilling aspect of SAVA's mandate. SAVA, once again participated in the annual prize-giving ceremony at the Faculty of Veterinary Science in Onderstepoort, where it sponsored several prizes in recognition of excellence within the veterinary student fraternity. These engagements are important in strengthening the relationship between SAVA and future members of the profession, while affirming our commitment to supporting and encouraging the next generation of veterinarians

The work of SAVA is broad, and not all of it is always visible. Much of it happens through meetings, submissions, legal review, stakeholder engagement, committee work, financial oversight and professional representation. However, it is important that members know that this work is taking place, and that SAVA remains actively engaged in matters that affect the profession, animal health, animal welfare and the sustainability of veterinary practice in South Africa.

The SAVA Board has resolved to provide shorter, more regular snippets of Board activities so that members may remain abreast of the work in which SAVA is involved.

As always, I encourage members to remain engaged, to provide feedback, and to participate in SAVA structures and processes wherever possible. SAVA's strength lies in its members, and our ability to serve the profession depends on continued participation, trust and constructive dialogue. Be inspired by this issue of VetNews to interact creatively with your surroundings and capture special moments and images!

Groetnis,

Dr. Ziyanda Majokweni – Qwalela
President: South African Veterinary Association

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In our June edition of Vetnews 2026, we feature one of our great photographers. Dr Gary Bogden graciously supplied us with a selection of photographs out of 18 terabytes of his personal stock.



The reason why we feature him and his talent is two pronged. The first reason is that Nature Photography Day is celebrated on the 15th of June. The second reason is a personal note from Dr Bogden on what it means to him to have an interest outside of the clinical world and outside of a building.

Editor's notes / Redakteurs notas

We are very pleased to also feature one of his photographs on the front cover. I am only aware of Dr Bogden because of his class affiliation with my husband. Vetnews would like to thank Dr Bogden for the generous sharing of his fantastic photos. If you are a keen photographer or you have another pastime that takes your mind off the clinical work and feeds your soul, please reach out, as I would love to feature it as well.

June also sees the celebration of World Environment Day – 5 June, and, funny enough, World Fish and Chips day on the 5th as well, plus World Sushi Day on the 18th, World Oceans Day – 8 June, and June 22nd sees International Being-Yourself day – let us all celebrate this special occasion just to be yourself.

Other features include an ophthalmology article by Dr Anthony Goodhead on Aquarium animals and their eyes. Just a reminder that we share the planet with some very special animals.

Vetnews would like to congratulate Prof Johan Schoeman on being awarded the prestigious MT Steyn Medal. A full article will follow.

Prof Nenene Qekwana on his appointment as head of the ARC-OVR. He is the 15th incumbent in a long line of distinguished scientists to lead this important institution. We wish you every success in your new role and trust you will find the necessary support and capacity to continue driving excellence at the Onderstepoort Veterinary Research Institute.

It is also very sad to have to share the passing of Dr Daan Verwoerd, Dr Claude Jacobs and Dr Adrian Rogers.

June in South Africa is special because it marks the crisp, dry start of the winter safari season and brings National Youth Month. This time of year transforms the northern bushveld into an optimal wildlife viewing haven and kicks off the spectacular marine migration along the coast. It is also a time when nature in the northern part of the country takes a break. The colder, dry months are a breather after the vigorous growth season in summer. Fewer bugs and shorter days await.

In the Southern part of the country, the rainy season starts. Even though the winter rainfall area has already had their fair share of autumn rain. I hope with my whole heart that everybody is safe and that nature has left very little of a mark during the unprecedented storms. I hope the dams fill up and stay full well after the rainy season is over.

For us in the north, I hope we can enter a calmer period, both in nature and ourselves.

Winter Solstice falls on the 21st of June, which marks the shortest day, but nobody is naïve enough to think that is the end of winter.

May peace and calmness be your part in June.

Enjoy!

Andriette V



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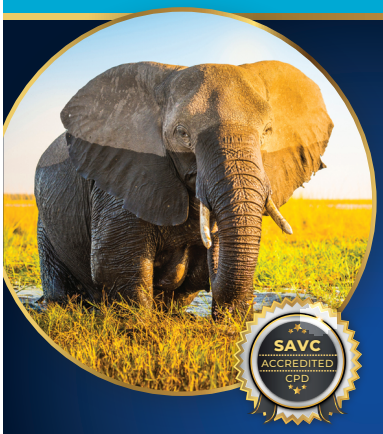
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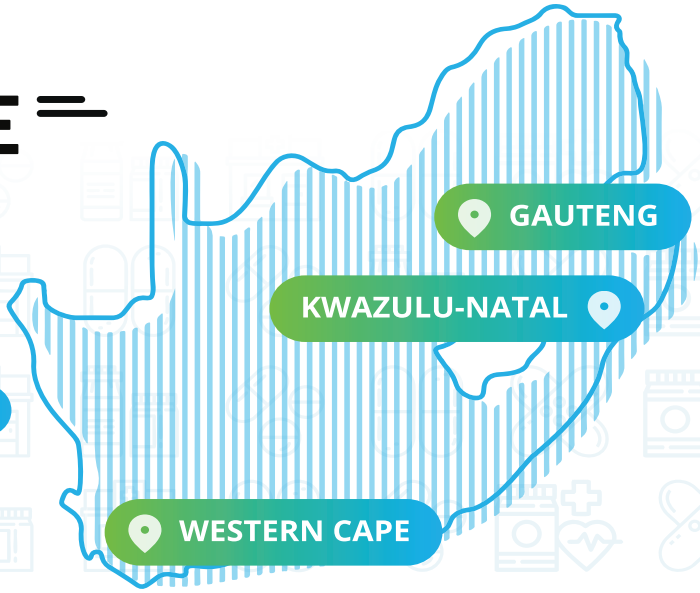
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Beyond the Clinic: How Photography Helps Veterinarians Escape the Emotional Demands of Clinical Work

Introduction

Veterinary medicine is a profession built on compassion, science, endurance, and emotional resilience. Veterinarians dedicate their lives to caring for animals, supporting pet owners, protecting livestock, and preserving animal welfare. Yet behind the rewarding aspects of the profession lies an often-overlooked reality: veterinary work can be emotionally exhausting.

Long hours, emergency cases, financial discussions with clients, euthanasia decisions, compassion fatigue, and the constant responsibility of patient care place veterinarians under significant psychological pressure. Many professionals in the field struggle to find healthy ways to disconnect from the emotional intensity of clinical environments.

For a growing number of veterinarians, photography has become more than a hobby. It has become a therapeutic escape, a creative outlet, and a way to reconnect with life outside examination rooms, operating theatres, and emergency calls.

Photography provides veterinarians with a powerful opportunity to slow down, observe the world differently, and restore emotional balance through creativity, mindfulness, and connection with nature.

The Emotional Weight of Veterinary Medicine

Veterinary professionals face unique emotional challenges that differ from those in many other healthcare fields.

Unlike human medicine, veterinarians must often balance the needs of the animal with the emotional and financial realities of the owner. Difficult conversations regarding treatment affordability, quality of life, chronic illness, and euthanasia are common.

Veterinarians are regularly exposed to:

- Animal suffering and trauma
- Emergency and critical care situations

- Emotional pet owners
- Ethical dilemmas
- Compassion fatigue
- Long working hours
- Staff shortages
- Physical exhaustion
- Financial pressures within practices
- Emotional burnout

Repeated exposure to these stressors can gradually lead to emotional exhaustion, detachment, anxiety, and reduced job satisfaction.

Because veterinary professionals are often deeply empathetic individuals, many absorb emotional stress quietly while continuing to function professionally.

This is why restorative activities outside clinical work are essential.

Photography as an Escape from Constant Responsibility

Veterinary medicine requires continuous alertness and decision-making. Every patient interaction carries responsibility.

Photography creates an entirely different mental environment.

When veterinarians step behind a camera, their focus shifts away from diagnoses, treatment plans, surgical procedures, and emergencies. Instead, attention turns toward composition, light, movement, colour, timing, and storytelling.

This transition allows the brain to move from clinical problem-solving into creative observation.

Unlike the pressure of veterinary practice, photography carries no life-or-death outcomes. There are no emergency calls, anxious clients, or urgent medical decisions attached to the process.

This psychological separation provides genuine emotional relief.

For many veterinarians, photography becomes a space where they can breathe, think clearly, and experience moments of calm without professional pressure.

Reconnecting with Animals Outside the Clinical Setting

Many veterinarians enter the profession because of their love for animals. However, clinical work sometimes changes the way animals are experienced. It often becomes a rut of seeing animals in need.

Within the clinic, animals are often associated with:

- Illness
- Injury
- Stress
- Pain
- Medical procedures
- Emergency care
- End-of-life decisions

Photography allows veterinarians to reconnect with animals in a completely different context.

Wildlife photography, pet photography, bird photography, and nature photography create opportunities to observe animals behaving naturally and peacefully.

Instead of treating illness, the veterinarian becomes an observer of beauty, instinct, personality, and movement.

This reconnection can be emotionally healing.

Watching wildlife in natural environments or photographing healthy animals at play reminds veterinarians why they fell in love with animals in the first place.

Nature Photography and Mental Recovery

Many veterinarians are naturally drawn toward outdoor photography.

After spending long hours inside clinics, consultation rooms, and surgical facilities, natural environments provide sensory relief and emotional restoration.

Nature photography encourages veterinarians to spend time in:

- Forests
- Wildlife reserves
- Farms
- Wetlands
- Mountains
- Gardens
- Beaches
- Open landscapes

Exposure to natural environments has been strongly associated with reduced stress levels, improved mood, and lower mental fatigue.

Photography enhances these effects because it requires intentional observation.

The photographer begins to notice subtle details:

- Animal behavior
- Light through trees
- Feather textures
- Movement in water
- Seasonal changes

>>>10

- Patterns in landscapes
- Small moments of stillness

This level of attention slows mental activity and interrupts the constant internal processing associated with clinical stress.

For veterinarians who spend much of their professional life managing emergencies and emotional intensity, nature photography creates rare moments of peace.

Photography Encourages Mindfulness

Mindfulness refers to being fully present in the moment rather than mentally consumed by stress, worry, or future responsibilities.

Photography naturally encourages mindful behavior.

When taking photographs, the mind becomes focused on immediate sensory details rather than workplace concerns.

Photographers pay attention to:

- Framing and perspective
- Shadows and light
- Texture and detail
- Motion and timing
- Environmental sounds
- Patience and stillness

This concentration reduces mental clutter and provides temporary relief from emotional overload.

For veterinarians, even a short photography session can create mental decompression after demanding clinical shifts.

The process encourages calm observation instead of rapid decision-making.

A Creative Outlet in a Highly Structured Profession

Veterinary medicine is heavily structured and scientifically driven. Daily work involves protocols, diagnostics, surgery, medications, documentation, and clinical precision.

Photography offers creative freedom that contrasts sharply with the rigid demands of veterinary practice.

Through photography, veterinarians control:

- Perspective
- Composition
- Mood
- Storytelling
- Artistic style
- Subject matter

This creative autonomy is psychologically important.

Artistic expression allows emotional release in ways that clinical environments often do not permit.

Some veterinarians use photography to capture themes such as:

- Resilience
- Survival
- Aging
- Fragility
- Freedom
- Connection with nature
- Beauty in ordinary moments

A photograph can communicate emotion without requiring words.

For professionals who spend much of their careers suppressing stress to remain composed, creative expression becomes deeply restorative.

Processing Grief and Emotional Fatigue

One of the most emotionally difficult aspects of veterinary work is euthanasia and repeated exposure to grief.

Veterinarians often support owners during heartbreaking moments while simultaneously managing their own emotional reactions.

Over time, accumulated grief can become psychologically heavy.

Photography can help process these emotions indirectly.

Quiet moments spent photographing landscapes, wildlife, sunsets, or natural scenes often create emotional space for reflection and recovery.

Photography does not erase grief, but it can soften emotional overload by providing stillness, perspective, and healthy emotional distance from clinical environments.

Many photographers describe the experience as grounding.

The camera encourages observation instead of emotional suppression.

Building Identity Beyond Veterinary Medicine

Veterinarians often become deeply defined by their profession.

The demands of clinical work can gradually consume personal time, emotional energy, and identity.

Photography helps veterinarians maintain a sense of self outside their medical role.

A veterinarian can also be:

- A wildlife photographer

- A landscape artist
- A birding enthusiast
- A travel storyteller
- A macro photographer
- A conservation advocate

Maintaining interests beyond the profession is essential for long-term emotional well-being.

When individuals have creative passions outside work, they are less likely to experience total identity burnout.

Photography reminds veterinarians that they are more than their job title.

Wildlife Photography and Conservation Connection

For some veterinarians, photography develops into a deeper connection with conservation and environmental awareness.

Wildlife photography encourages patience, respect for ecosystems, and appreciation for biodiversity.

Veterinarians who photograph wildlife often develop a renewed sense of purpose related to:

- Animal preservation
- Habitat protection
- Environmental education
- Ethical wildlife interaction
- Appreciation for natural ecosystems

This broader perspective can be emotionally energizing.

Instead of only seeing animals in states of illness or injury, veterinarians begin seeing them as part of thriving ecosystems and living environments.

Photography becomes both creative and meaningful.

Community and Social Connection

Photography can also reduce professional isolation.

Veterinary work can be emotionally isolating, especially in high-pressure practices or rural environments.

Photography communities create opportunities for connection outside clinical settings.

Veterinarians may participate in:

- Photography clubs
- Wildlife groups
- Online photography communities
- Conservation projects
- Travel groups
- Workshops and exhibitions
- Social media creative networks

These communities allow conversations that are unrelated to clinical stress.

Social connection through shared creativity can significantly improve emotional resilience and reduce feelings of burnout.

Healthy Escapism and Emotional Sustainability

Escaping from work is not avoidance.

Healthy escapism is an important part of emotional recovery and psychological sustainability.

Without restorative activities, veterinarians may experience:

- Chronic stress
- Compassion fatigue
- Anxiety
- Depression
- Emotional numbness
- Physical exhaustion
- Reduced empathy
- Career dissatisfaction

Photography provides a constructive and emotionally healthy form of escape.

Unlike passive distractions, photography requires engagement, movement, creativity, patience, and awareness.

This active involvement helps shift mental energy away from stress and toward restoration.

For many veterinarians, photography becomes an essential part of maintaining emotional balance and career longevity.

Photography as a Lifelong Wellness Practice

One of photography's greatest strengths is its accessibility and adaptability.

A veterinarian can begin with a smartphone camera or gradually explore professional equipment and advanced techniques.

Photography also evolves continuously.

There is always something new to explore:

- Wildlife photography
- Macro photography
- Bird photography
- Portrait photography

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- Astrophotography
- Landscape photography
- Editing and post-processing
- Travel photography

This ongoing learning process stimulates curiosity, creativity, and personal growth.

These factors are important protective mechanisms against burnout and emotional stagnation.

Photography becomes more than a temporary distraction.

For many veterinarians, it becomes a long-term wellness practice that supports emotional resilience throughout their career.

Conclusion

Veterinary professionals dedicate their lives to caring for animals and supporting the people who love them. It is a profession filled with meaning, but also one that carries substantial emotional weight.

Photography offers veterinarians a powerful way to step outside the pressures of clinical work and reconnect with themselves, nature, creativity, and the world beyond the consultation room. Through the lens of a camera, veterinarians can experience stillness instead of urgency, observation instead of responsibility, and creativity instead of emotional overload. Photography cannot remove the challenges of veterinary medicine, but it can provide balance, restoration, and emotional recovery. (AI-generated)









Through the Lens How Photography Helps Balance the Emotional Demands of Veterinary Practice

Veterinary medicine is not only a profession. It is a calling built on compassion, dedication, and resilience. It is also a career that carries immense emotional responsibility. Behind every consultation, surgery, emergency call, and difficult decision is a veterinarian constantly balancing the needs of animals, clients, colleagues, and often their own emotional well-being.

For many veterinarians, finding healthy ways to decompress outside of practice is essential — not only for preventing burnout, but for maintaining perspective, creativity, and emotional balance. For me, photography has become one of those outlets.

Photography offers something entirely different from the structured, high-pressure environment of clinical work. When holding a camera, there are no treatment plans, no urgent decisions, and no expectations. It creates an opportunity to slow down, to notice detail, light, movement, and moments that might otherwise be missed in the rush of daily life.

Spending time outdoors photographing birds, wildlife & nature creates space for a mental reset. It encourages mindfulness — being fully present in a moment rather than mentally carrying the weight of work home at the end of the day. Photography allows the mind to shift gears, helping reduce stress and restore emotional energy.

Creative outlets are important, especially in professions where compassion and emotional resilience are constantly required. For me, photography has become a form of mindfulness — a gentle reminder to pause, appreciate the world around me, and return to my work feeling calmer, more focused, and grateful.

There is growing awareness within the veterinary profession about the importance of mental health and sustainable self-care. While different people find balance in different ways — whether through photography, sport, music, art, or gardening — the principle remains the same: making intentional time for activities that nourish mental wellbeing is not a luxury; it is a necessity!

Dr Gary Bogden – Through the lens

Scalable DICOM 3D-printed phantoms mimicking marine mammal bone and soft tissue

Daniel Fisher [1,3], Nazanin Minaian [1,3], Abby McClain [2] & Kwang J. Kim[10]

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As charismatic sentinel species, California sea lions (*Zalophus californianus*) are commonly found in professional care settings such as zoos, aquariums, and rehabilitation facilities, in addition to their free-ranging coastal populations. These animals frequently strand due to illness, trauma, or environmental stressors, including toxic algal blooms such as domoic acid poisoning, underscoring the need for innovative tools and training methods to improve diagnostic care, monitoring, and veterinary intervention. This study presents a systematic approach for developing scalable, 3D-printable phantoms of a California sea lion pelvis using DICOM (Digital Imaging and Communications in Medicine) standard images from computed tomography (CT) scans to aid in veterinary blood collection training. The CT image data was processed using Simpleware ScanIP software to create detailed anatomical models, emphasising the blood collection site at the caudal gluteal region and optimised for 3D printing. Through threshold-based segmentation of the DICOM data, several distinct anatomical layers were modelled separately, including a combined epidermal and dermal compliant skin shell, an adipose-rich blubber layer, a muscular layer derived from lower-density soft tissue regions, and a skeletal structure segmented from high-density bone data. This separation enabled each component to be fabricated independently using materials that closely matched their biological counterparts. Prior to fabrication, a material characterisation study was conducted using dynamic mechanical analysis (DMA) to evaluate the compressive viscoelastic properties of multiple Humimic medical gelatin compositions (Gels 0 through 5), each with distinct mechanical profiles. The apparent elastic modulus of each gel under cyclic loading was calculated from stress–strain hysteresis data. Based on these results, individual gel types were selected to best match the mechanical properties of biological tissues, including blubber, skin, muscle, and bone. The quad-layered phantom was then fabricated using a combination of high-resolution stereolithography (SLA), fused deposition modelling (FDM), and gel casting techniques. This process resulted in the successful creation of 3D-printed anatomical phantoms that mimic both the mechanical and anatomical properties of the California sea lion pelvis. The methodology presented here provides a framework for creating engineered medical training models with anatomical fidelity and tunable material properties, offering a scalable alternative to traditional approaches in both veterinary and human health education, and the potential for personalised compatible implant design and biomimetic soft robotics.

Ensuring the health and well-being of animal populations, especially non-domestic species, requires effective training in specialised care techniques. However, traditional methods of veterinary training, particularly in specialised procedures such as blood collection, often present significant challenges due to the morphological diversity across animal species[1]. This is particularly true in the case of marine mammals like the California sea lion (*Zalophus californianus*), where anatomical complexities and limited accessibility pose unique obstacles to effective training[1,2]. Currently, human and veterinary physicians use several tools in their training, such as suture kits that simulate skin, virtual surgery simulators, and animals – both alive and deceased[1,3–5]. Of the former, these tools lack the physical presence that would be provided in a more realistic training experience [1,4]. One method of introducing tactility into the learning model is to incorporate physical 3D medical models, also referred to as "phantoms". Phantoms are models that mimic the structure of anatomical features of interest based on imaging modalities (computed tomography [CT], magnetic resonance imaging [MRI], ultrasound [US]), which are used to simulate realistic clinical scenarios, allowing practitioners to develop procedural skills through tactile and repeatable training[4–9]. This study applies this concept by utilising medical imaging CT scan data to develop an anatomically accurate representation of a live marine mammal, the California sea lion, for blood collection training purposes. California sea lions are a common species featured in zoos and aquariums across the globe due to their charismatic nature. Additionally, free-ranging California sea lions serve as sentinel species for ocean health, stranding at increasing rates and entering rescue and rehabilitation facilities due to a range of causes, including illness, trauma, cancer, and environmental toxins such as domoic acid. As part of a comprehensive. diagnostic and treatment protocols, veterinary professionals routinely collect blood from these marine mammals to monitor systemic health, guide care, and assess environmental exposure[10]. At present, veterinary trainees tasked with blood collection from this species often rely on a technique highly dependent on tactile sensation[2,11]. This method involves the identification and feeling of bony landmarks in the pelvic region to orient and locate the optimal collection site, which is typically a softer tissue region located lateral to the sacral vertebrae, approximately one-third of the distance between the femoral trochanters and the base of the tail[2]. However, this approach is inherently limited by its reliance on subjective tactile sensation, which requires significant time and repeated practice to develop the precision needed for consistent and effective blood collection. While this study focuses on developing a 3D phantom model for veterinary blood collection training, the workflow of converting DICOM-standard medical images

into scalable, engineered 3D models is highly adaptable. Specifically, it can also be applied across various fields, such as soft robotics design, bioinspired engineering, and biocompatible implants for cardiac, orthopaedic, or neural augmentation applications and beyond. This study serves as a focused implementation of that broader framework, applying it towards the design and fabrication of an anatomically accurate training phantom. The following sections outline the methodology used to generate this phantom, including the image processing pipeline, materials characterisation, and fabrication strategy that together enabled the creation of a biologically representative and functionally relevant training tool.

Methods

DICOM image processing

In order to develop an anatomically accurate model of the California sea lion pelvis, DICOM-standard CT and MRI scan images, provided by the U.S. Navy Marine Mammal Program (MMP), were processed using Synopsys' Simpleware ScanIP software's comprehensive anatomical modelling imaging processing tools for segmentation, mask generation, and mesh optimisation, making it well-suited for anatomical modelling. The scans provide an initial volumetric resolution of (512 × 512 × 666 voxels, which undergo several of these image processing methods to isolate and prepare the region of interest (ROI) for 3D printing. Following the initial import of the scans into the software, the images were resampled by reducing the pixel spacing cubically to. 0.7 mm (from the default value of 0.9629 mm), improving the overall clarity for subsequent segmentation. Simpleware employs convolution matrices to analyse the surrounding pixels of interest to produce output pixels using discretised approximations of standard Gaussian distributions. Two-dimensional images are processed individually and then stacked on top of one another to produce a 3D rendering. The Simpleware ScanIP workspace, along with the default model from import, can be seen in Fig. 1a and b, respectively.

The model comprises two primary components: the skeletal structure and the soft body exterior. As DICOM images inherently store voxel density information (representing the tissue's radiodensity in Hounsfield units, HU), this allows for model segmentation via greyscale thresholding, where specific density ranges are isolated to differentiate between various biological materials. From the CT scan data, two separate masks were generated by thresholding to isolate bone structures from blubber and other soft tissues based on their unique density values. For the bones, the targeted density values ranged from 230 to 1800 HU, resulting in a relatively clean and contiguous mask after applying the Cavity Fill operation to eliminate gaps.

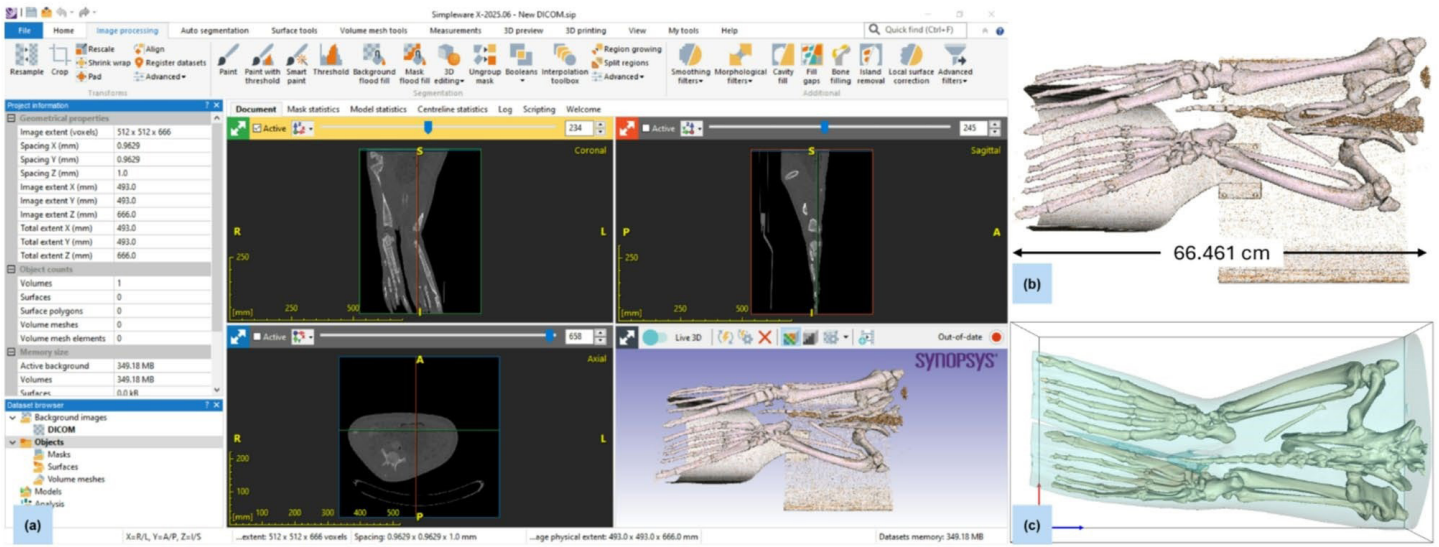


Figure 1. (a) Simpleware user workspace prior to image processing12; (b) 3D render of the raw CT scan of the sea lion's lower body; (c) Processed render of model within workspace with body at 30% opacity

The remainder of the model required a wider threshold range of – 200 to 1800 HU, resulting in an overlaying mask that included superfluous data, such as portions of the imaging machine and bed. The two body models, along with their respective greyscale-HU thresholding histograms, can be seen in Fig. 2. Cropping the scans to a tighter ROI reduced some of the extraneous data; however, additional image processing techniques were necessary to fully isolate the body. Larger floating artefacts were removed using the 3D Editing tool, which allowed for the deletion of several portions of the imaging machine bed captured during masking. Further refinement was achieved with the Smart Paint tool, which was used to 'unpaint' difficult artefacts closer to the body, as well as the Erode and Dilate tools to ensure disconnection of merged appendages and subsequent restoration of bulk.

Next, both masks were refined through larger-scale operations within the software toolbox. For the skeletal mask, a morphological close operation was applied using a spherical structuring element with a radius of 4 voxels, effectively closing small volumetric gaps. Following this, the Island Removal tool was employed, starting with a threshold of 100 voxels to remove smaller artefacts. The threshold was then iteratively increased to

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approximately 3000 voxels as additional artefacts were identified, ensuring the removal of all remaining extraneous regions. In a similar manner, the body structure mask was first morphologically closed with a spherical element of a 5 voxel radius. Considering the printability of the structure, subsequent smoothing was applied to both models. Initial smoothing was performed using the Recursive Gaussian tool, with Gaussian sigma values of 5 pixels applied isotopically. To further refine the body structure mask, the Local Surface Correction tool was applied with a search radius of 5 pixels. The result was a significantly more polished and contiguous surface, ideal for subsequent processing and 3D printing, as seen in Fig. 1c, where the body is rendered at 30% opacity. Additionally, Simpleware's Split Regions tool enables the segmentation of masks into distinct anatomical components. The skeletal model was divided into three general categories: legs, flippers, and pelvis/spine. This tool provides a means for larger-scale components to be 3D printed separately, which can be later assembled or used to target specific body components for analysis or fabrication.

3D model preparation

The next step in the workflow is to convert the masks into solid models. The bones were exported directly in standard triangle language (STL) files from the Simpleware software, requiring no additional processing. However, the body model required further refinement to prepare it to function as an overall shell to hold the bones and for gel casting, necessitating several additional steps. First, within Simpleware's 3D Preview context menu, the body model was configured to be exported as an STL with the mask elements decimated to a target of 10,000 max triangles (per part)—allowing for computationally accessible importation into the CAD software.

This resulted in a model of 137,250 elements. The model was then imported into Autodesk's Fusion 360 software, which contains a comprehensive toolset for mesh modification. Within Fusions Design: Mesh interface, the mesh was modified using the Convert Mesh feature. Given the nature of the model, the 'Organic' method was selected with High Accuracy and with the Preprocessed Holes option enabled.

With the model now converted into a solid body, Fusion's design tools can now be employed to edit the model directly. Using the Shell tool, the body was hollowed with a wall thickness of 1.00 mm, forming the negative mold. The mold was then split along a plane at the topmost surface, creating an opening for the bones to be placed and for the gel material to be cast. Several naturally occurring landmarks, such as the caudal vertebrae and metatarsal cavities, provide alignment features for later bone placement. With that, the body shell was then exported as an STL for 3D printing. The entire workflow from DICOM import to export can be seen in Fig. 3.

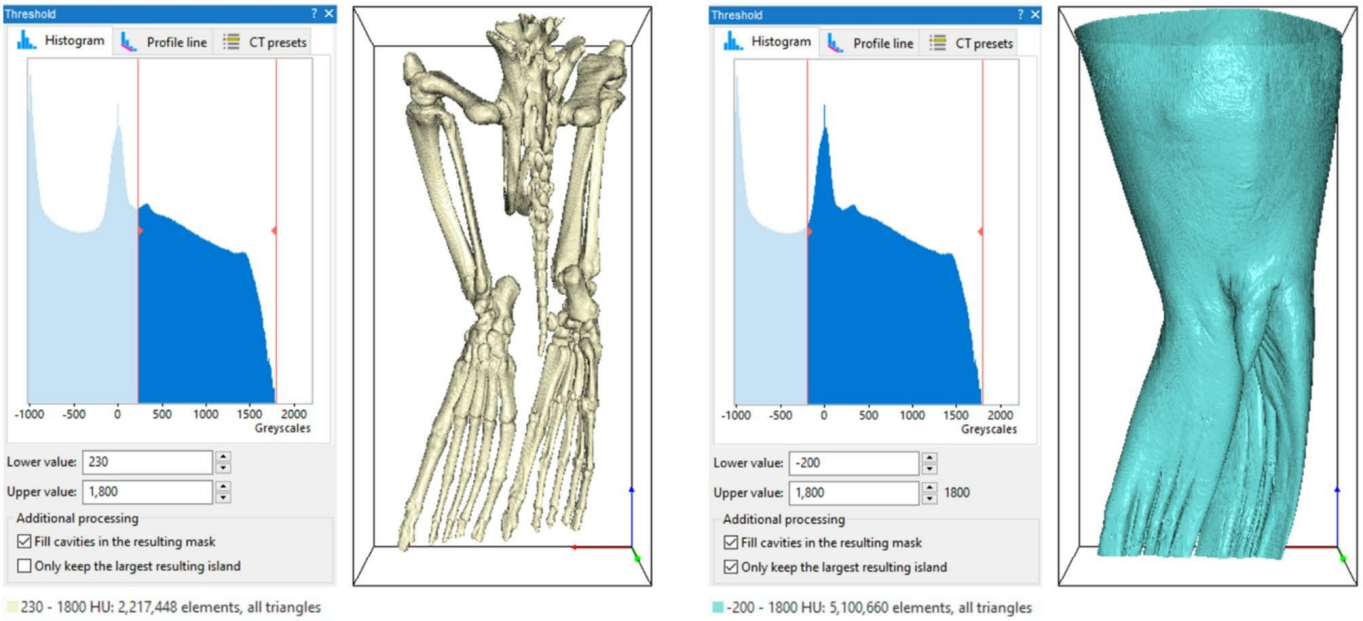


Figure 2. Threshold histogram of CT voxel greyscale intensity distributions mapped to Hounsfield units used for segmentation, with resulting 3D models; (Left) Bone threshold (230–1800 HU); (Right) Soft-tissue threshold (– 200 to 1800 HU)

Materials characterization

To identify materials for the anatomical phantom such that its mechanical properties closely mimic those of real sea lion tissue, the materials used were characterized through a series of mechanical tests to achieve optimal material matching. A specialized ballistic gelatin material developed by Humimic Medical™ was selected for this study to simulate the blubber layer of the California sea lions due to its stability, ease of casting, clarity, and the availability of multiple formulations tailored to mimic a range of biological tissues[13]. The gels used in this study are denoted as Humimic Gel 0 through Gel 5. Gel 0, the firmest, is used for dense structures like cartilage or fibrous tissues, while Gel 5, the softest, replicates delicate tissues such as brain matter or blood clots[14,15]. Intermediate gels, such as Gel 2 and Gel 3, are designed to simulate

softer tissues, including fat and muscle, with viscoelastic properties similar to biological counterparts[16,17]. The gelatin samples were conventionally cast in 10 cm diameter casting dishes, displayed in Fig. 4 (Left). Each Humimic sample container shown in Fig. 4 (Right) was first melted in an oven at 125 °C for four hours until all visual bubbles dissipated, following manufacturer specifications[18]. The cast gels were then allowed to cool at room temperature for 12 h. Samples were cut in circular cross-sections using a hollow punch of 10 mm diameter with a uniform cross-sectional thickness of approximately 5 mm, measured using a digital micrometre. Each sample container, alongside its respective punched specimens, is shown in Fig. 4. Table 1 details corresponding measurements for each gel sample tested.

All mechanical tests were performed using a PerkinElmer Pyris Diamond Dynamic Mechanical Analyser (DMA), with gel specimens placed in the DMA's isothermal chamber at 20 °C ± 1 °C, ensuring stable temperature conditions across all experiments. The experimental setup can be seen in Fig. 5. Compressive stress–strain hysteresis loading tests were performed on the Humimic gel to 25% strain at 1% strain/minute for three continuous loading cycles.

Each gel specimen was compressed by 1 mm at a strain rate of 0.25 mm/min, with a data sampling rate of 1 reading per 5 s (12 samples per minute) over a period of 36 min.

A hold of 2 min was applied between cycles to ensure steady-state and zero conditions on the load cell.

The linear elastic regions were approximated using a linear fit in OriginLab software with 95% confidence and prediction bands, determining the apparent elastic modulus of each gel and the corresponding goodness-of-fit statistics.

Phantom fabrication

Fabricating a biologically realistic training phantom requires deliberate material selection to replicate the distinct mechanical properties of the materials being modelled.

Four distinct components were individually created to capture a quad-layered morphology: the skeletal structure, a compliant skin shell representing the dermis and epidermis, an adipose-rich blubber layer, and an internal muscular layer.

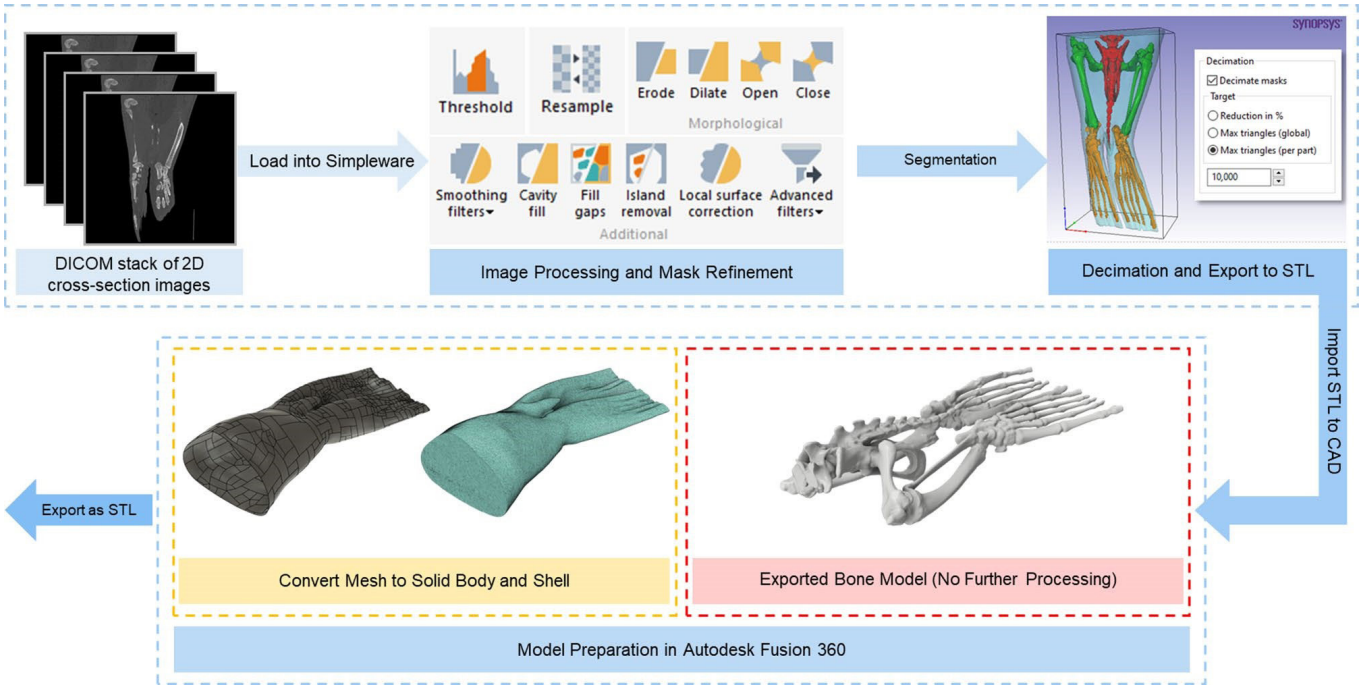


Figure 3. Workflow for developing multi-material 3D-printed anatomical phantoms from CT imaging data. A DICOM stack of 2D cross-sectional CT images was imported into Synopsys Simpleware ScanIP for image processing, segmentation, and mask refinement. Bone and soft tissue components were segmented separately and exported as STL files following decimation. The bone STL model was imported directly into Autodesk Fusion 360 for print preparation, while the soft tissue shell underwent mesh conversion and surface processing prior to mould generation

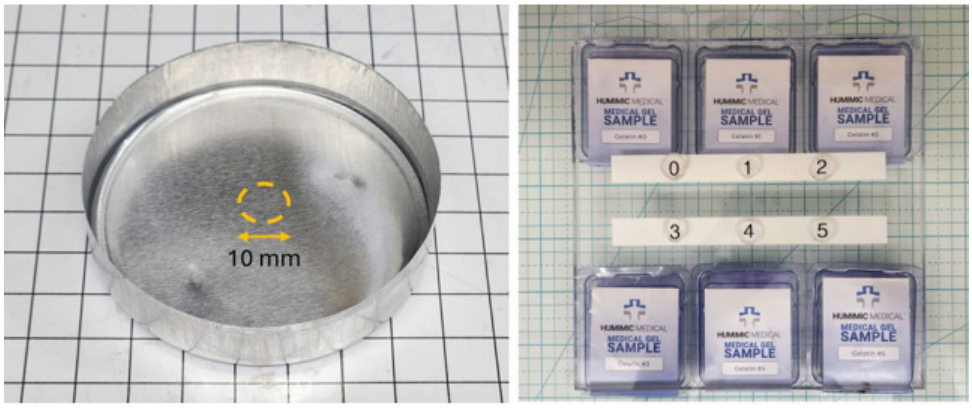


Figure 4. (Left) Aluminium casting dish (10 cm diameter) with cured gel. Samples were extracted at the circular visual indicator using a 10 mm diameter hollow punch; (Right) Humimic gel samples of formulations #0—#5 tested within the PerkinElmer Pyris Diamond Dynamic Mechanical Analyser (DMA)

Sample Dimension	Gel 0	Gel 1	Gel 2	Gel 3	Gel 4	Gel 5
d_0 (mm)	9.8 ± 0.5	9.8 ± 0.5	10.01 ± 0.5	9.83 ± 0.5	9 ± 0.5	9.61 ± 0.5
t_0 (mm)	4.45 ± 0.001	4.53 ± 0.001	5.15 ± 0.001	5.38 ± 0.001	6 ± 0.001	4.07 ± 0.001

Table 1. Original thickness (t0 [mm]) and diameter (d0 [mm]) measurements of tested Humimic gel samples were recorded using a digital micrometre alongside respective dimensional uncertainty



Figure 5. (Left) Experimental setup for dynamic mechanical analysis (DMA) testing; (Left) PerkinElmer Pyris Diamond DMA system; (Right) Close-up of testing chamber with a Humimic gel sample mounted for compressive testing[19]

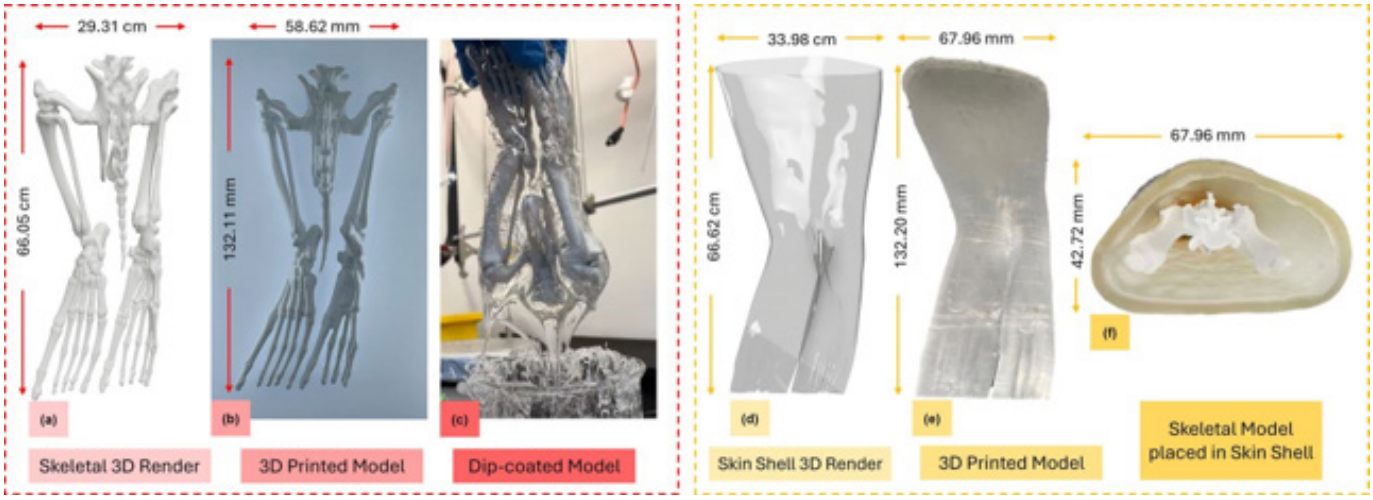


Figure 6. Phantom model components; (a) Full size skeletal model 3D render; (b) Corresponding 3D-printed bone model at 20% scale; (c) Dip-coating of bone in Humimic Gel 0 to simulate tendon and muscle attachment; (d) Full size 3D render of the compliant skin shell; (e) Final shell printed in Flexible 80A resin at 20% scale; (f) Superior view of staged phantom showing printed skeleton positioned within the compliant skin shell prior to gel cast

Body Region	Material	20% (mL)	25% (mL)	40% (mL)
Casted Components				
	BlubberHumimic	Gel	027.5	± 0.553.7 ± 0.5220.0 ± 0.5
	MuscleHumimic	Gel	586.2	± 0.5168.4 ± 1.0689.6 ± 1.0
3D Printed Components				
Skin Bone	Formlabs Flexible 80A	17.32 ± 0.9	45.9 ± 2.3	138.57 ± 6.9
	Formlabs Draft	29.3 ± 1.5	57.19 ± 2.9	234.2 ± 11.7

Table 2. Estimated material volumes for each modelled tissue layer based on Simpleware ScanIP segmentation. Volumes are calculated for 20, 25 and 40% scale models

The skeletal structures were 3D printed using a Formlabs Form 3 SLA (stereolithography) printer at up to a resolution of 25 µm, producing models at 20, 25 and 40% scale relative to the original CT scan, with 40% being the maximum stable size given the 3D printer build volume. At each respective scale, a variety of Formlabs proprietary photopolymer resins were used across different prototypes, including Rigid 10 K, Tough 1500, and Draft. Once cured, the skeletal models were gradually dip-coated in heated and evacuated Humimic Gel 0 to simulate tendon, ligament, and muscular tissues closely associated with bone. This layer mimics the stiffer properties of soft tissue near joints and attachment points, which aids in force transfer in contrast to the more compliant muscle tissue further from the bone—often referred to as the "belly" of the muscle[20]. Furthermore, the dip-coating method was motivated by its novelty as a layer-wise fabrication method, resulting from the assumed no-slip condition of the viscous Humimic Gel 0, as well as its thermal sensitivity and insulating properties. Figure 6 shows the final bone print along with the dipping procedure. Considering that the final model is intended for physical handling and training use, the outer shell was fabricated to balance flexibility with structural resilience. This skin shell was also SLA printed using Elastic 50A and Flexible 80A resins to explore differences in compliance under handling without compromising the clarity of internal anatomical structures visible through the surface, as seen in Fig. 6. In addition to serving as an external skin analogue, the shell also functioned as a negative mould for casting the inner blubber and muscle layers using Humimic gelatin. This dual-purpose design simplified assembly and ensured a cohesive structure with proper alignment between internal and external components.

For the blubber layer, volume calculations were performed using a control volume analysis in Autodesk Fusion 360. The total internal volume of the entire model was determined from the body properties menu of the outer soft tissue mesh, yielding a value of 42.48 m^3. This volume was then normalised to the appropriate scale (20, 25 or 40%) and used to calculate the amount of Humimic Gel 0 and Gel 5 required for casting the blubber and muscle layers, respectively. The relative percentages of these soft tissues were measured using Simpleware's Volume Fraction tool, determining the volume percentage of the blubber and muscle with respect to the total volume of the model. The volumes of the bone and skin shell were directly extracted from the original DICOM-based segmentations and carried forward into the 3D printing workflow. A summary of the calculated volume fractions and estimated material quantities for each anatomical layer is presented in Table 2.

Before casting the 20% scale model, 86.2 mL of Humimic Gel 5 and 27.5 mL of Gel 0 were measured in 100 mL graduated cylinders. The samples were heated to 125 °C for 4 h while simultaneously evacuating in a Napco Model 5831 vacuum oven at approximately −25 inHg. The assembled mould was suspended in an ice bath. Humic Gel 0 was heated and slowly poured in a spiral pattern along the inner walls of the mould, allowing the highly viscous gel to coat the surface uniformly and settle gently. Once the blubber layer was cast, the skeletal model was inserted and aligned in its anatomically correct position using the naturally occurring alignment features of the mould at the tail and pelvic flippers. The more compliant soft tissue layer, representing muscle, was then cast using heated Humimic Gel 5.

This layer was poured until level with the top of the phantom, as shown in Fig. 7a. After curing for 24 h to complete gel cross-linking, heat polishing was selectively applied to the exposed upper surface using a heat gun to smooth imperfections, while avoiding deformation of the skin shell. This process is shown in Fig. 7b. A superior view of the heat-polished phantom can be seen in Fig. 7c, along with a colour overlay indicating the distinct layers of the model (Fig. 7d).

Results

The following results detail the characterisation and validation of materials selected for use in the quad-layered phantom, specifically those of the gels that had undergone dynamic mechanical analysis (DMA) testing to approximate their elastic properties under cyclic loading conditions. This data then informed the selection of materials to mimic biological soft tissues such as blubber and muscle. Additional components, including the skeletal structure and outer shell, were evaluated based on manufacturer-reported mechanical data and relevant literature. The final phantom outcome was assessed for anatomical fidelity and structural integrity to validate the performance of the proposed image-to-phantom workflow.

The apparent elastic moduli of the Humimic gels were approximated using stress–strain data obtained during cyclic compressive loading tests to approximately 25% strain at 1% strain/minute. Mechanical testing involved three continuous loading cycles, and the resulting hysteresis loops were analysed (Fig. 8, left). Linear fits were applied to the elastic loading regions of the stress–strain curves, with 95% confidence bands used to ensure statistical robustness (Fig. 8, right). Due to the viscoelastic nature of the gels, the calculated apparent elastic moduli reflect an approximated stiffness under cyclic loading conditions rather than a static elastic modulus as typically defined. The slopes of these linear fits were recorded for each gel and are presented as effective stiffness values under cyclic loading conditions. These experimental values were then compared to both manufacturer-reported data and the previously published results of Laughlin et al. in Table 3 for validation[7,19].

The differences between the reported apparent elastic moduli values may stem from variations in testing methodology, including cyclic loading and viscoelastic contributions. The results highlight the significant differences in viscoelastic properties among the gel types, which align with their intended use cases. Stiffer gels, such as Gel 0 and Gel 1, are better suited for applications requiring higher load-bearing capacities, while softer gels like Gel 4 and Gel 5 more closely mimic the behaviour of highly deformable biological tissues. These observations have informed the selection of gels that closely replicate the mechanical characteristics of California sea lion blubber and muscle, where the viscoelastic response plays a key role in energy dissipation.

In addition to the DMA testing of the Humimic gels, other materials used in the phantom, such as the skeletal structure and outer shell, were selected based on manufacturer-reported mechanical properties and their alignment with literature values for biological materials. Table 4 presents a comparison of elastic and flexural modulus values for blubber, muscle, and bone against potential 3D printing resins and gels used in this study.

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While Rigid 10 K resin exhibited a modulus range of 7,500–11,000 MPa (closely approximating the mechanical behaviour of mammalian bone), Draft resin was ultimately selected due to its improved durability during fabrication. This material provided a practical compromise between mechanical rigidity and fracture resistance, addressing the fragility observed in initial Rigid 10 K prints. For the gels, Humimic Gel 0 and Gel 5 demonstrated approximate stiffness values of approximately 0.0139 MPa and 0.0021 MPa, respectively.



Figure 7 . (a) Casting the final soft tissue layer (20% scale model) using Humimic Gel 5, poured to fill the remaining mould volume; (b) Heat polishing the exposed top layer to smooth surface imperfections without damaging the skin shell; (c) Superior view of phantom model after heat polish; (d) Colour overlay of the distinct phantom components. The Gel 0-dip-coated skeletal structure (magenta) is embedded within the Humimic Gel 5 soft-tissue layer (yellow) and enclosed by the compliant outer shell (blue)

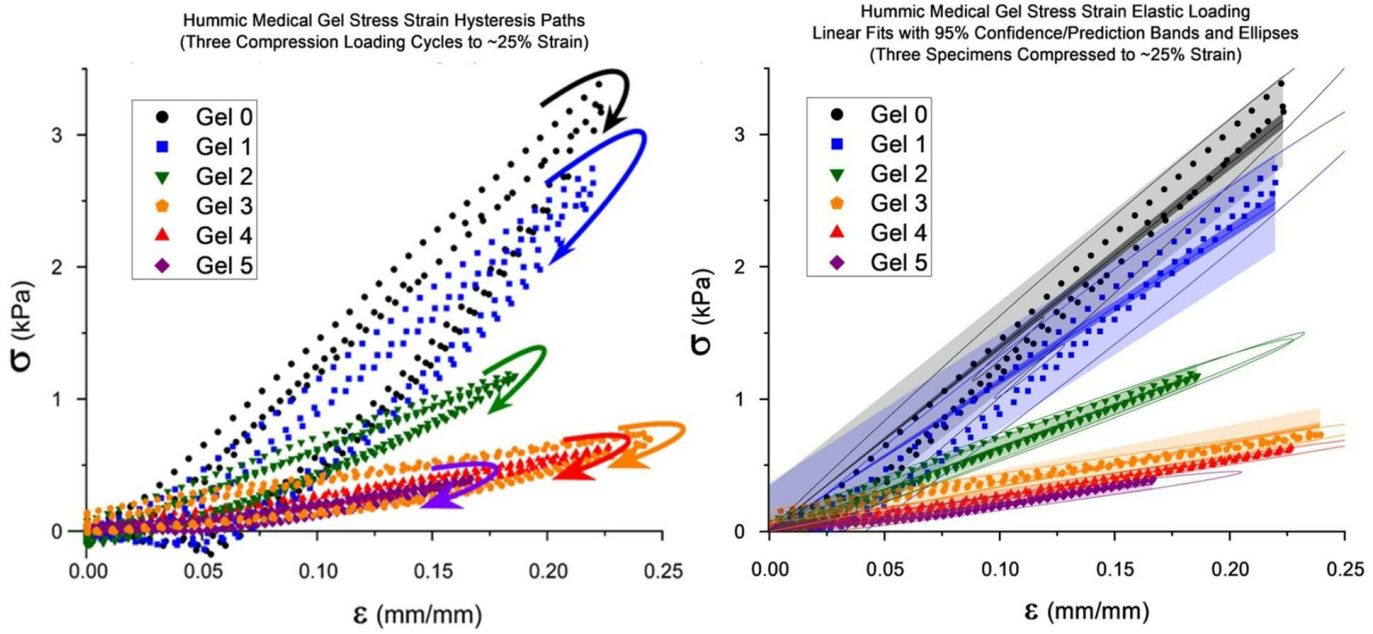


Figure 8 . (Left) Compressive stress–strain hysteresis loops of Humimic Medical Gel to 25% Strain for three continuous loading cycles; (Right) Corresponding linear fit with 95% confidence and prediction bands

Measurement	Gel 0	Gel 1	Gel 2	Gel 3	Gel 4	Gel 5
E (kPa)	13.9 ± 0.13	11.3 ± 0.14	6.37 ± 0.03	3.35 ± 0.04	2.69 ± 0.01	2.13 ± 0.02
Pearson's r	0.995	0.9992	0.998	0.99	0.999	0.994
Coefficient of Determination (R^2)	0.99	0.985	0.996	0.98	0.997	0.988
Laughlin et al.[7] E (kPa)	92.02 ± 16	49.05 ± 5	36.57 ± 7	25.55 ± 5	17.02 ± 7	Not measured
Laughlin et al.[7] Reported R^2	0.97	0.96	0.98	0.97	0.91	Not measured
Humimic Reported E (kPa)	570[14]	370[21]	260[16]	190[17]	150[22]	100[15]

Table 3. Compressive stress–strain elastic loading of Humimic Medical Gel to 25% strain for three continuous loading cycles with linear fit statistics, with comparison to reported values

Biological Component	Sea Lion Value [MPa]	Biomimetic Material	Value [MPa]
Apparent Elastic Modulus			
Blubber	0.2–3.9[23]	Humimic Gel 0	0.0139
Muscle	0.0212–0.0282[24]	Humimic Gel 5	0.0021
Flexural Modulus			
Bone	10,000–14,000[25]	Formlabs Rigid 10 K	6,000–10,000[26]
		Formlabs Draft	600–2,300[27]
		Formlabs Tough 1500 V2	900–137027,28
Ultimate Tensile Strength			
Skin (Dermis + Epidermis)	7.37–30.26[23]	Formlabs Elastic 50A V2	3.428,29
		Formlabs Flexible 80A	8.9[30]

Table 4. Comparison of mechanical properties for California sea lion anatomical structures and selected biomimetic materials. Property types include apparent elastic modulus, flexural modulus, and ultimate tensile strength

Approaching the reported ranges for sea lion blubber and muscle tissues[23,24] and serving as practical, transparent analogues demonstrating 4 distinct layer stiffnesses mimicking nature.

Table 4 additionally summarises the ultimate tensile strength values for the phantom's outermost layers, focusing on skin and subdermal structures. Elastic 50A and Flexible 80A resins were evaluated for use in printing the compliant outer shell. Although both materials fall below the full tensile strength range reported for sea lion skin (7.37–30.26 MPa), Flexible 80A demonstrated a higher tensile strength (8.9 MPa) and was ultimately favoured for its balance of compliance, structural integrity, and transparency when compared to the Elastic 50A model.

Based on the results of mechanical testing and material comparisons, a quad-layer phantom of the California sea lion pelvis was successfully fabricated.

The final model integrates a rigid skeletal core, a soft tissue gel base, a blubber-analogue gel layer, and a flexible outer shell, each constructed from materials selected to match the mechanical behaviour of their biological counterparts. Figure 9 displays the completed phantom, demonstrating visual clarity of internal features and anatomical contouring alongside the expected 3D render from Simpleware.

The phantom retained anatomical fidelity throughout the fabrication process and demonstrated structural coherence during physical handling, with no significant delamination or visible distortion between layers. Internal structures remained visible through the outer shell when printed using Flexible 80A, enabling both tactile and visual feedback. These results validate the proposed image-to-phantom workflow as a viable approach for developing multi-material anatomical models for training and bioinspired applications.

Discussion

The development of a scalable anatomical phantom of the California sea lion represents a significant step toward enhancing veterinary training methods for marine mammals. The anatomical fidelity of the 3D-printed model, combined with the viscoelastic properties of the Humimic medical gelatin, suggests strong potential for effective use in veterinary training for blood collection.

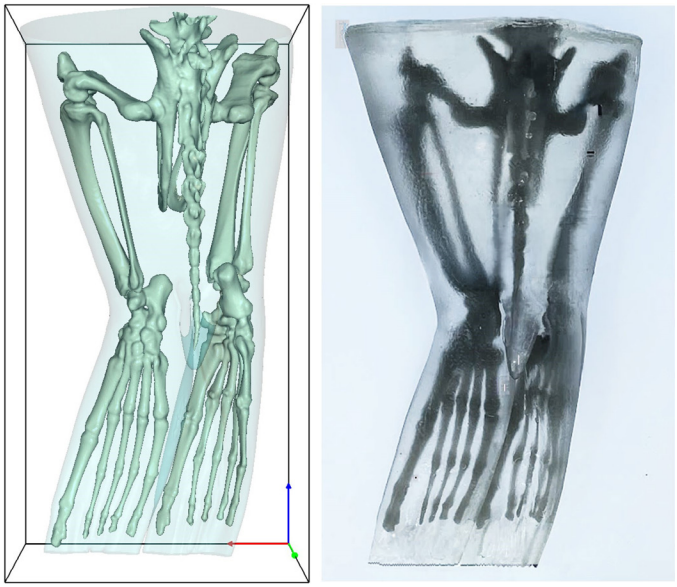


Figure 9. Comparison of (left) original 3D render from Simpleware and (right) the final 20% scale fabricated phantom model. The printed model closely replicates internal skeletal features and anatomical contours with clear visual fidelity

Regarding usage, the 3D-printed phantoms offer several advantages. The clear body of the phantom aids in visualising the internal structures during practice, enhancing the learning experience by combining tactile feedback with visual cues. Furthermore, unlike with live animal training, the phantom allows for repeated practice sessions without ethical concerns, allowing trainees to gain confidence and refine their technique in a controlled, low-pressure environment. Additionally, the scalable nature of the model means it can be adapted to various species and scenarios, further broadening its applicability in veterinary education.

Several remarks can be made regarding the software process and workflow used in developing the phantom. While the accessibility of DICOM-standard medical scans enables precise anatomical modelling, the software process itself can be highly subjective, often relying on the user's judgment for tasks such as segmentation, mask generation, and morphological operations. This subjectivity introduces variability, making the process as much an art as it is a science.

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Material	Per item (pack)	Unit price	20% Qty	20% Cost	25% Qty	25% Cost	40% Qty	40% Cost	100% Qty	100% Cost
Humimic Medical Gel 0	$42.98 (0.68 kg)[14]	$0.06321/g	24.2 g	$1.53	47.3 g	$2.99	193.6 g	$12.24	3030 g	$191.21
Humimic Medical Gel 5	$42.98 (0.68 kg)[15]	$0.06321/g	77.4 g	$4.89	151.17 g	$9.56	619.2 g	$39.14	9675 g	$611.56
Formlabs Flexible 80A Resin	$209 (1 L)[30]	$0.209/mL	17.32 mL	$2.22	45.9 mL	$9.59	138.57 mL	$28.96	2165.2 mL	$452.53
Formlabs Draft Resin	$159 (1 L)[27]	$0.159/mL	29.3 mL	$4.66	57.19 mL	$9.09	234.2 mL	$37.24	3623.69 mL	$576.17
Total Cost			$10.82		$31.23		$117.58		$1,831.47	

Table 5. Material amount and cost at four scales (20, 25, 40 and 100%). Unit prices are based on manufacturer pricing. Humimic gel masses were derived from the volumes listed in Table 2 using density values from the material data sheet[14,15]

Furthermore, the large file sizes associated with high-resolution scans and detailed models present challenges in terms of storage, processing power, and workflow efficiency. Optimising the software pipeline to handle these demands more seamlessly could greatly enhance the usability of this approach.

Characterising viscoelastic materials, such as the Humimic gels used in this study, presents unique challenges due to their time-dependent stress–strain behaviour. The apparent elastic moduli reported in this study were approximated from stress–strain data obtained during cyclic compressive loading, where the hysteresis loops depicted the energy loss during loading and unloading cycles. While the apparent elastic modulus values align relatively well with previous studies, they are significantly lower than the manufacturer-reported values[7,13].

This discrepancy likely arises from differences in testing methodologies, including strain rates, testing instruments, and temperature. Despite these variations, the recent calibration of the DMA and the high goodness-of-fit values for the elastic loading region suggest that the reported results accurately represent the mechanical properties under the specific testing conditions.

Regarding fabrication, the use of a reusable SLA-printed skin shell provided an efficient and effective method for casting the internal layers of the phantom. Acting both as the external anatomical structure and the negative mould, the shell simplified the alignment of the skeletal model and enabled control over wall thickness and gel distribution. Humimic medical gelatin served as the casting material for the blubber and muscle layers, offering excellent clarity, tunable compliance, and reusability well-suited for repeated training use. Formlabs Draft resin was selected for the skeletal structure due to its balance between mechanical strength and durability. The retrieved Simpleware Scan IP volume fractions compared favourably with marine mammal blubber thickness cited in the literature. Although typical sea lion blubber varies throughout the body, the measured full-scale model blubber thickness of 1.0 ± 0.1 cm was slightly lower than the approximated thickness of 1.6 ± 0.1 cm for the pelvic region of the average reported thickness values of fellow members of the Otariidae "eared seal" family, the Steller sea lion (*Eumetopias jubatus*)[3,31].

Therefore, the difference in pelvic region blubber thickness was reconciled due to species differences between the modelled California sea lion and the quantitative reference available in the literature being limited to Steller sea lions as the reference species most anatomically similar. However, this can be expected given that the California sea lion can be significantly smaller than the Steller sea lion[32].

Some limitations were observed during the fabrication process. The casting process requires precise temperature control and careful handling to prevent defects, such as bubbles or incomplete fills. While Rigid 10 K provided higher stiffness values closer to cortical bone, they were prone to fracturing during fabrication and handling. Draft, by contrast, retained sufficient rigidity both during the fabrication process and in test usage. Despite its successful outcome, the development of this phantom model involved extensive trial-and-error across segmentation, material selection, and fabrication stages, highlighting the iterative and time-intensive nature of translating medical imaging data into functional, anatomically accurate training tools. Future work could explore alternative materials or custom gel formulations to more accurately replicate biological performance.

The scalability of the presented fabrication workflow is an important aspect of its utility for training applications. In principle, the process can be implemented at any size, with the primary theoretical limitation being the build volume of the 3D printer and the practical limitations arising from material cost and shipping logistics. A full-scale model, corresponding to an adult California sea lion, which can reach lengths of up to 1.8 m to 2.4 m for females and males, respectively, would provide the most accurate anatomical training experience. However, smaller-scale models may be preferable when portability, material efficiency, or cost are key considerations.

The same digital workflow can be readily scaled to either context, offering flexibility to institutions with varying resources or instructional goals. Beyond fabrication feasibility, scalability also impacts material use and associated cost. Table 5 outlines estimated material requirements and total costs for different size scales, illustrating how larger models, while offering greater anatomical fidelity, increase material demand proportionally.

Anatomical variability among sea lions, such as differences in age, sex, and body condition, primarily influences overall body dimensions and soft-tissue thickness rather than the relative positioning of vascular landmarks used in blood collection. As such, the presented model captures the essential anatomical features necessary for procedural training across a representative range of adult morphologies. Future work may incorporate morphometric data from multiple individuals to expand this approach into a scalable model library, supporting a wider range of training scenarios and species-specific variations.

Beyond its immediate application in veterinary training, the workflow presented here of converting DICOM-standard medical images into scalable, engineered 3D models has broader relevance across multiple disciplines. Similar imaging-based modelling frameworks can support soft robotics design, bioinspired engineering, and the development of biocompatible implants for cardiac, orthopaedic, or neural applications. Recent advances in soft materials and electroactive systems have shown that image-driven fabrication pipelines can bridge biological form and functional engineering design[33-35]. In this context, the phantom fabrication process described here not only serves as a case study in species-specific model development but also as a scalable approach for reproducing complex biological architectures for diverse research and training purposes.

Conclusion

In this study, a phantom model of a California sea lion pelvis was successfully fabricated for blood collection training. Using the described workflow, DICOM-standard medical images were converted into 3D models through Simpleware ScanIP software, enabling the fabrication of an anatomically accurate engineered model with material properties that closely resemble their biological counterparts. Dynamic mechanical analysis (DMA) was employed to characterise the material stiffness of the Humimic gelatin material at the caudal gluteal blood collection site, emphasising the purpose of material matching in order to simulate the tactile response trainees would expect on the live animal.

With a fabrication time of approximately three days, the phantom model demonstrates adaptability for a wide range of anatomical training purposes – provided relevant medical images are available.

Future research will focus on enhancing the functionality of the phantom model. Viscosity testing of artificial blood using a viscometer will ensure that the simulated fluid dynamics closely mimic those of real blood, further improving the training experience. In addition, incorporating smart materials for sensing feedback can be seamlessly integrated into the structure of the model, allowing real-time monitoring of trainee performance. The compatibility between these smart materials and medical gels will also be investigated to address challenges in integration.

The future direction of this research will be toward integrating compliant electroactive materials into the phantom. Electroactive polymers (EAPs) such as polyvinyl chloride (PVC) gels, hydrogels with additive conductors (carbon nanotubes, polyaniline, etc.) and ionic polymer-metal composites (IPMCs) are novel candidates for phantom electroactive platforms[36–40]. Inspired by Hunt et al.'s incorporation of coiled polymer actuators into a biomimetic harbour porpoise pectoral flipper, similar methodologies using Simpleware ScanIP data may be applied to further electroactive polymer biomimicry[41].

These advancements will contribute to developing versatile medical phantom models, broadening their applications in training and soft robotics. By combining innovative material science with computational modelling, this research lays the groundwork for a new generation of customizable and responsive training tools.

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Author contributions

N.M. and D.F. conceived the experiments(s), N.M. processed and modeled the CT scan data, D.F. fabricated the models and conducted materials testing, N.M., D.F., and K.J.K analyzed the results, A.M. provided the CT scan data, initial concept, and advised on California sea lion biology and blood collection procedure, K.J.K. is the supervisor of D.F. and N.M., All authors reviewed the manuscript.

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Declarations Competing interests

The authors declare no competing interests.

Additional information

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Evidence of long-term survival gains in Panthera from modern zoological facilities supports their role in integrated conservation

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ABSTRACT

The accelerating global biodiversity crisis emphasises the need for ex situ programs to complement in situ conservation. Modern zoological facilities, committed to conservation, education, and research, have significantly evolved, yet public and political scrutiny persists, particularly regarding Panthera species. Here, we evaluated long-term trends in survival-related metrics in all five extant Panthera species born in zoos from 1874 to 2022. Using data from 41,244 individuals, we applied Bayesian survival models to estimate life expectancy, lifespan equality, and first-year survival across six historical periods by species and sex. All three metrics increased Zoo significantly through time (life expectancy: +0.89 ± 0.43 years per decade; lifespan equality: +0.114 ± 0.006 per decade, first-year survival: +0.023 ± 0.003 per decade). Individuals born in the most recent decade lived nearly five years longer on average (a 1.7-fold increase) than those born in the early 20th century, with more individuals reaching older ages. Jaguars showed the highest values, and a sex difference was observed only in lions. Moreover, life expectancy and lifespan equality were strongly correlated, confirming progressive improvement in management, husbandry and veterinary care standards in modern facilities. Finally, zoo-born lions now surpass their wild counterparts in life expectancy and lifespan equality. These findings demonstrate that modern facilities sustain longer and more equitable lifespan in *Panthera*, strengthening their demographic stability and genetic value. Enhanced conditions of life and longevity reinforce the contribution of *ex situ* populations to species recovery, supporting the integrated *One Plan Approach* for *Panthera* conservation.

1. Introduction

The accelerating loss of habitats and animal species over the last five decades (Cowie et al., 2022) has accentuated the role of *ex situ* conservation efforts (IUCN SSC, 2014; Ceballos et al., 2015; IUCN, 2024). Without assurance, populations maintained in conservation-driven zoological facilities, species such as the Przewalski's horse (*Equus ferus przewalskii*) and the Guam kingfisher (*Todiramphus cinnamominus*), would now be extinct (Bolam et al., 2020). Although too many problematic substandard establishments still exist, the modern or accredited zoological facilities have, over the last 150 years, undergone a major transition from their traditional role as repositories with living animal collections (Beer et al., 2023; Vincelette, 2024) to facilities committed to advancing conservation, enhancing animal welfare, and promoting education and research (Gray, 2017). These facilities are increasingly integrated into regional, continental, and/or global associations, establishing shared standards for husbandry, population management and animal welfare, with compliance ensured through accreditation programs (Hutchins and Smith, 2003; Hutchins et al., 2003; WAZA, 2023). In recognition of this, the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) acknowledges the significant contributions that modern zoological facilities, aquaria, and botanical gardens (referred to as "zoos" or "facilities" hereafter) bring to conserving wild animals, fungi and plants, through species management, *via* cooperative population management programs, and knowledge accumulation (IUCN SSC, 2023).

In parallel, growing public awareness of animal cognition, sentience, and emotional capacities has heightened societal sensitivity to the welfare of animals maintained *ex situ* (Clubb and Mason, 2007; Marino, 2011). Among the species receiving intense scrutiny from public activism and scientific debate regarding their presence in zoos, the five species of the genus *Panthera*—lion (*P. leo*), jaguar (*P. onca*), leopard (*P. pardus*), tiger (*P. tigris*), and snow leopard (*P. uncia*)—are particularly targeted (Clubb and Mason, 2007; Bandeli et al., 2023; Born Free, 2024). Meanwhile, *in situ* populations of all five species continue to decline, with four of them currently listed as *Threatened* on the IUCN Red List of Threatened Species (IUCN, 2024). These declines are largely driven by human-carnivore conflict, habitat loss and fragmentation, and other anthropogenic pressures (Goodrich and Miquelle, 2005; Krafte Holland et al., 2018; Packer et al., 2019). In this context, conservation scientists stress the value of *ex situ* populations as an integral component of long- term strategies for *Panthera* conservation (Byers et al., 2013;

Bolam et al., 2020; Funston et al., 2023; Smith et al., 2023), including the maintenance of assurance populations allowing for safeguarding and maximising the global genetic diversity of species (Ballou et al., 2010). However, the success of *ex situ* programs for *Panthera* relies on a critical mass of accredited facilities working together. Their role is central to the SSC's *One Plan Approach* (Byers et al., 2013), which advocates the integration of *in situ* and *ex situ* management to achieve coherent species- level conservation outcomes. To ensure that modern zoological facilities can fully realise this pivotal role, it is essential to confirm that the gradual change in husbandry and management practices for *Panthera* species positively impacted *ex situ* populations.

Husbandry and veterinary care for *Panthera* species have advanced markedly over the last 150 years (Table S1, Conservation Science Alliance, 2024). For example, studbooks were established in the 1960s to enable coordinated breeding programs (Blomqvist, 1995; Christie, 2010; Tilson et al., 2016), and nutritionally balanced diets were introduced in the mid-20th century (Ratcliffe, 1966), resulting in reduced animal mortality rates (Wackernagel, 1966). Therefore, advances in species knowledge, veterinary medicine, and husbandry practices for *Panthera* species (Table S1) should be reflected in gradual increases in measurable improvements in demographic parameters, such as survival-related metrics. Animal health, a central pillar of welfare (Mellor et al., 2020), is closely linked to longevity, as longer lifespans are typically associated with improved health and wellbeing (Diener and Chan, 2011; Weiss et al., 2011; Walker et al., 2012). Consequently, mortality and survival rates serve as robust proxies for assessing population-level welfare and living conditions across species (Walker et al., 2012), including humans (Aburto et al., 2020).

Yet, demographic indicators such as life expectancy and lifespan equality provide a more precise framework for evaluating environmental quality (Colchero et al., 2016, 2021; Aburto et al., 2020). Life expectancy measures the average expected lifespan within a population, whereas lifespan equality quantifies the variation in lifespans: higher equality indicates more uniform survival conditions, whereas lower equality signals greater disparities in age at death. Human demographic studies demonstrate that improved environments simultaneously increase both metrics (Colchero et al., 2016; Aburto et al., 2020), while deteriorating conditions reduce at least one (Aburto and Beltran-Sanchez, 2019). In addition, juvenile survival is closely tied to maternal care in many species (Meier, 1986), with advances in maternal care and neonatal husbandry have demonstrably directly improved juvenile survival across taxa (Saunders et al., 2014; Edwards et al., 2019). Together, life expectancy, lifespan equality, and juvenile survival constitute a robust suite of survival-based indicators for assessing how evolving standards and practices in modern zoological facilities have affected zoo *Panthera* populations over time.

Previous family-level analyses suggested increases in some survival metrics for felids in zoos between 1950 and 2019 (Roller et al., 2021). However, demographic responses to environmental change are shaped by species- and sex-specific life histories (Tidi`ere et al., 2016; Staerk et al., 2025). *Panthera* species exhibit divergent life-history strategies shaped by ecological niches and social structures (Kleiman and Eisenberg, 1973). For instance, lions, characterised by pronounced sexual dimorphism, female cooperative breeding, and intense male competition (Packer et al., 1988), are likely to display distinct demographic patterns compared to the other four solitary species. This strengthens the importance of providing species- and sex-specific results. Finally, a recurring assertion that animals in zoos experience reduced longevity compared to their wild counterparts is often used to question the adequacy of zoological conditions (*e.g.*, Atkinson and Lindsay, 2022; Born Free, 2024). Yet, existing comparisons are limited by methodological inconsistencies, including the use of different lifespan metrics (*e.g.*, maximum observed *vs.* mean lifespan) or statistical approaches due to the difficulty in finding long-term monitored populations in the wild, which hinders direct comparison. Comparing life expectancy and lifespan equality between recent zoo and free-ranging populations using harmonised methods would allow for a consistent evaluation of potential differences. This approach would also help determine whether current husbandry practices in modern zoological facilities provide conditions that are at least matching those observed in wild populations.

This study investigates whether 150 years of development in modern zoological facilities have led to significant changes in life expectancy, lifespan equality, and juvenile survival in males and females of the five *Panthera* species. We analysed individual life-history records for 41,244 *Panthera* individuals born and housed in zoos between 1874 and 2022, as recorded in the Species360 Zoological Information Management System (ZIMS, Species360, 2025). We applied Bayesian survival models (Colchero et al., 2012) to estimate first-year survival, life expectancy and lifespan equality across six historical periods, while disaggregating by species and sex. First, we assessed temporal trends in each metric, explicitly testing for inter- and sex-specific differences and expecting a positive trend over time. Second, where metrics showed significant positive trends over time, we examined the association between life expectancy and lifespan equality, where a positive correlation would indicate improved living conditions for *Panthera* in modern facilities over time.

Finally, we compared the recent zoo-based estimates with available free-ranging data to assess differences in life expectancy and lifespan equality between *ex situ* and *in situ* populations, thereby evaluating the adequacy of modern zoological facilities in providing suitable environments for *ex situ Panthera* populations. This comparison was possible for lions only, as comparable data were lacking for the other four species. This study aims to be a significant step toward bridging the gap between scientific expertise and societal debates regarding the presence of *Panthera* species in modern facilities. By documenting long- term demographic changes, it contributes to informing future policy decisions and highlights the importance of evidence-based husbandry, resource investment, and research in enhancing the welfare and conservation value of animals in modern facilities.

2. Discussion

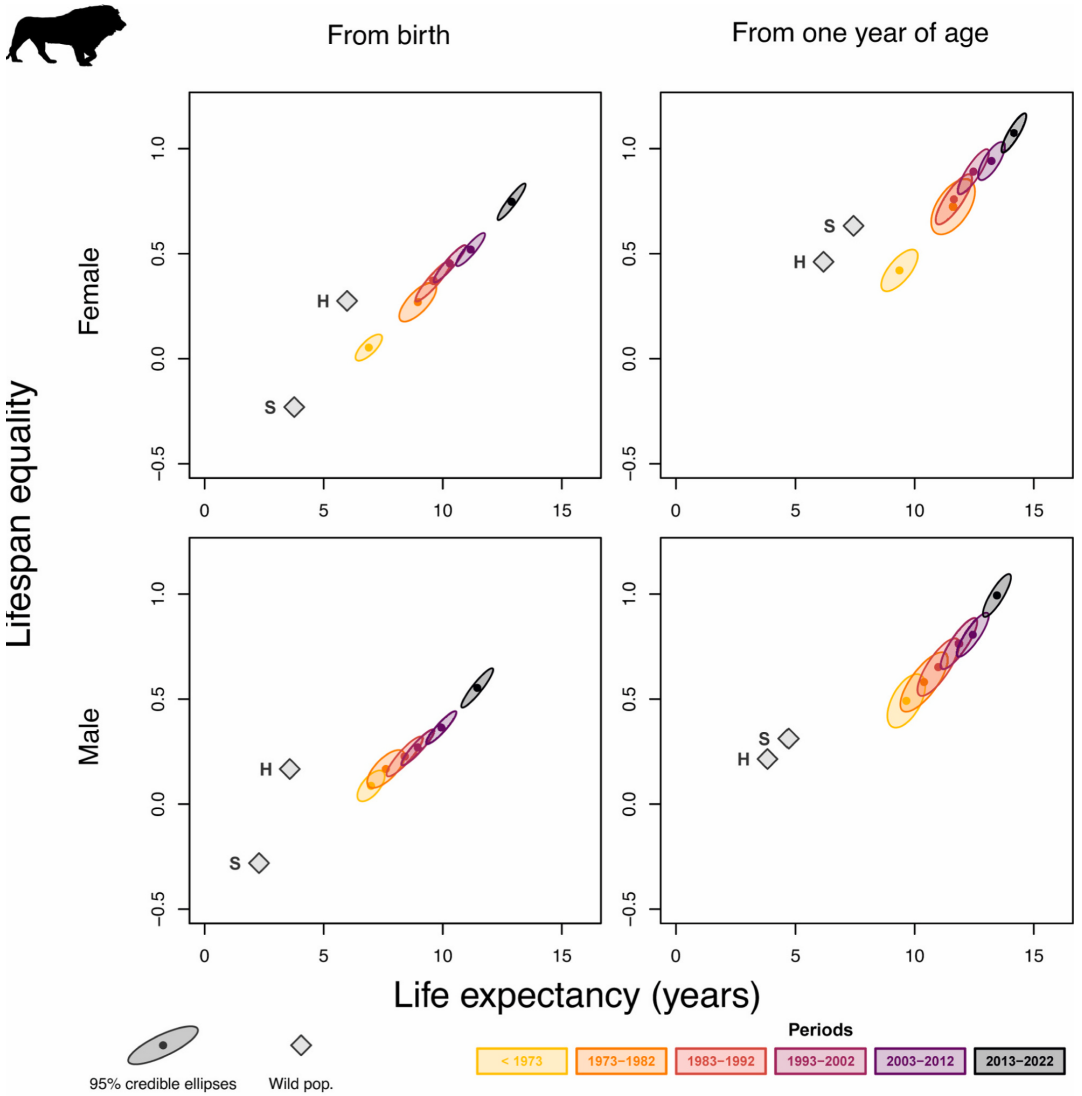
Our results revealed a progressive and significant increase in first- year survival, life expectancy and lifespan equality for males and females of the five *Panthera* species born in modern zoological facilities between 1874 and 2022. Life expectancy increased on average by 0.89 ± 0.43 years per decade, lifespan equality by 0.114 ± 0.006, and first- year survival by 0.023 ± 0.003. Individuals born in the recent decade live nearly five years longer on average (a 1.7-fold increase) compared to those born in the early 20th century. Furthermore, a greater proportion of individuals now reach older ages, reflecting substantial advancements in management practices over time.

These findings do not only result from the reduced first-year mortality but also from enhanced survival at all ages, as confirmed by analyses at age one onward. Species differences emerged, with jaguars exhibiting the highest first-year survival, life expectancy, and lifespan equality, while lions and snow leopards showed the lowest values. Notably, only lions displayed significant sex differences, with females surpassing males in all three metrics. Finally, lions born in modern zoological facilities now live longer and exhibit greater lifespan equality than their wild counterparts. These findings demonstrate that improvements in zoo management practices have translated into substantial survival gains, evidenced by longer and more equitable lifespans, meaning a higher proportion of individuals have the possibility to reach older ages.

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Improvement in the conditions of life provided by modern zoological facilities

Our findings revealed a simultaneous increase in life expectancy and lifespan equality over time among *Panthera* species in modern zoological facilities. These gains were not driven by a few exceptionally long-lived individuals but instead reflect population-level benefits, with a greater proportion of individuals reaching older ages. This pattern validated, for *Panthera* species, the trends previously suggested by Roller et al. (2021) and goes one step further as such tandem increases are recognised as a valid indicator of improved environmental conditions and living standards in both human and non-human populations (Colchero et al., 2016; Aburto et al., 2020). Comparable trends have been reported for marine mammals (Tidiere et al., 2023) and primates (Colchero et al., 2021) under human care, suggesting that these improvements are not species- specific but instead reflect a broader shift in modern zoological management (Martin et al., 2025). Moreover, first-year survival significantly increased over time for both sexes across all five *Panthera* species, pointing to improved care of pregnant females and neonates (Saunders et al., 2014; Edwards et al., 2019). The persistence of positive trends excluding the first year of life further confirms that husbandry improvements extend beyond reductions in early mortality. These trends align with theoretical predictions that enhanced veterinary care, nutrition, environmental enrichment, social management, and husbandry values obtained for free-ranging populations are systematically lower than the mean and 95% CI obtained for the 2013–2022 zoo populations for both sexes and both starting ages.



Comparison of lions' life expectancy and lifespan equality, estimated at birth and age one, between six zoo populations living at different periods (coloured markers) and two free-ranging populations (diamonds). For the zoo populations, the markers indicate the mean values obtained per sex and period, and the ellipses indicate the 95% confidence interval around the mean. Diamonds indicate life expectancies and lifespan equalities for two free-ranging populations (S: Serengeti; H: Hwange), with values derived from parameters extracted from Barthold et al. (2016). The life expectancy and lifespan equality

(Table S1, Conservation Science Alliance, 2024) promoted survival across all life stages. The consistency of these patterns across diverse mammalian taxa provides compelling evidence that modern zoological management practices are enhancing the conditions of life of their animals through standardised and evidence-based husbandry practices, population management and veterinary care (Martin et al., 2025). However, as current research has focused on large, long-lived, charismatic mammals, likely due to sociopolitical interest, further studies are needed on a wider range of mammals and other taxa, such as birds or amphibians, to validate these findings more broadly.

Overall, our results suggest that gradual advancements in husbandry, veterinary care, and population management over the past 150 years have notably improved living conditions for *Panthera* species in modern zoological settings. However, while Species360 members are distributed worldwide, the majority are located in Europe and North America, suggesting that our findings may primarily reflect trends from these regions, where data coverage is most extensive. It is also important to acknowledge that not all existing institutions meet these modern standards; many

substandard establishments persist worldwide. For instance, only 10% of European zoos are accredited by the European Association of Zoos and Aquariums (EAZA website, 2025). Nevertheless, Species360 membership, which requires consistent data recording and financial commitment, generally reflects an institutional investment in best practices, animal management, and collaboration within the professional zoo community. Moreover, approximately 70% of Species360 members belong to at least one regional or global zoo and aquarium association (Species360, 2025), strengthening their commitment to conservation, research, education and welfare objectives.

Species-specific differences in averages but not in the rate of improvement

Our analyses revealed clear species-specific differences in average first-year survival, life expectancy, and lifespan equality across *Panthera* species: jaguars consistently exhibited the highest values across all periods, while lions and snow leopards showed the lowest. Although these differences may stem from intrinsic biological traits, variation in husbandry practices, or their interaction, the similar rate of improvement across species suggests that the observed disparities primarily reflected species-specific evolutionary histories rather than differences in husbandry quality. The high lifespan equality already achieved in jaguars, tigers, and snow leopards further suggests that, for these species, current management practices may be approaching the biological limits of survival improvements. In contrast, lions and leopards may still have potential for further gains.

Species' ecological and evolutionary histories provide key insights into these results (Gaillard et al., 2016; Healy et al., 2019; Yuan et al., 2023). Jaguars, for instance, evolved in resource-rich tropical forests with abundant prey (Kleiman and Eisenberg, 1973), promoting low extrinsic mortality and favouring the evolution of a slower pace of life and extended lifespan. Their solitary behaviour further enhances ecological flexibility and resilience to new environments such as those provided by zoological facilities. In contrast, snow leopards, adapted to harsh, mountainous environments with limited prey and elevated extrinsic mortality (Jackson et al., 2010), exhibit a faster life history: smaller body size, earlier sexual maturity, and shorter maximum lifespan (Tacutu et al., 2012). Therefore, these differences align with the life history theory and help explain the species' demographic patterns in zoological facilities.

Interestingly, our findings do not support, for the *Panthera* at least, the reported negative correlation for 33 carnivore species between median home range size and captive infant mortality (Clubb and Mason, 2007). Snow leopards, with a relatively small median home range (38.9 km^2), exhibited the lowest first-year survival in zoological facilities, while jaguars, with larger home ranges (89.7 km^2), demonstrated the highest first-year survival. Furthermore, lions have the largest reported median home range (148.3 km^2) but a first-year survival rate quite similar to tigers (48.4 km^2) and leopards (33.5 km^2) in modern facilities. Notably, lions live in social prides requiring extensive territories to support group dynamics. Therefore, these results suggest that social structure and species-specific life history traits may play a more significant role than home range size alone.

In leopards, improvements appeared largely confined to juvenile survival, with no significant increases in life expectancy or lifespan equality detected beyond the first year. These limited gains may reflect both biological and management-related factors. Given the species' broad geographic range and pronounced subspecific diversity (Jacobson et al., 2016), differences in adaptation to *ex situ* environments, and thus survival patterns, likely occurred between subspecies. While this pattern is illustrated by leopards, subspecies-level heterogeneity likely affects all five *Panthera* species. Subspecies designations were inconsistently recorded in ZIMS, precluding subspecies-level analyses and risking bias where certain subspecies dominate institutional

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CREDO

SAVA
South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

We, the members of the Association, resolve at all times:

- To honour our profession and the Veterinary Oath
- To maintain and uphold high professional and scientific standards
- To use our professional knowledge, skills and resources to protect and promote the health and welfare of animals and humans
- To further the status and image of the veterinarian and to foster and enrich veterinary science
- To promote the interests of our Association and fellowship amongst its members.

Ons, die lede van die Vereniging, onderneem om te alle tye:

- Ons professie in ere te hou en die Eed na te kom
- 'n Hoë professionele en wetenskaplike peil te handhaaf en te onderhou
- Ons professionele kennis, vaardigheid en hulpbronne aan te wend ter beskerming en bevordering van die gesondheid en welsyn van dier en mens
- Die status en beeld van die veearts te bevorder en die veeartsenykunde te verryk
- Die belange van ons Vereniging en die genootskap tussen sy lede te bevorder.

holdings (*e.g.*, the Amur leopard, *P. p. orientalis*). Notably, differences in reproductive, but not survival, parameters have been highlighted between tiger subspecies in zoological facilities (Tidi`ere et al., 2021). This stresses the need for subspecies-resolved analyses, such as using studbook data, to disentangle evolutionary, ecological, and management effects.

Genetic factors may also constrain gains. In leopards, founding populations likely had reduced genetic diversity, raising concerns about inbreeding depression (Conservation Science Alliance, 2024). Similar risks have been reported for lions and tigers (Atkinson et al., 2018), emphasising the importance of coordinated genetic management across *Panthera* to complement husbandry advances. Overall, species- and subspecies-informed strategies remain essential: refining husbandry protocols to match ecological and behavioural requirements, alongside rigorous genetic management, will be key to sustaining *ex situ Panthera* conservation.

Sex differences in averages but not in the rate of improvement

Interestingly, although all five *Panthera* species exhibited promiscuous or polygynous mating systems (Clutton-Brock, 1989), with strong male-male competition for access to mates and therefore an expected female survival advantage (Tidi`ere et al., 2015; Staerk et al., 2025), we detected significant sex differences only in lions. In this species, females demonstrated higher first-year survival, life expectancy, and lifespan equality than males. This finding aligned with well-documented sex-biased mortality in lions, both in the wild and in human care, where males experience elevated risks due to intense intrasexual competition and dispersal (Packer et al., 1988; Barthold et al., 2016). Additionally, lions were the only social *Panthera* species in which females cooperatively share the costs of parental care, which may further enhance their survival and longevity (Clutton-Brock, 1991; Staerk et al., 2025).

In contrast, no significant sex differences were detected in the other, solitary *Panthera* species, likely reflecting the reduced sex-specific selective pressures associated with their life histories. Furthermore, in zoo environments, the costs of male-male competition are attenuated and have been shown to diminish sex differences in survival for mammals and birds compared to their wild counterparts (Staerk et al., 2025). For example, male jaguars lived significantly longer (3.5 years) than females in the wild (Olson et al., 2019), but this difference was not significant here in an *ex situ* environment. Our findings stressed the crucial importance of integrating species- and sex-specific considerations into demographic and welfare evaluations (Gissi et al., 2024).

Comparison between recent zoo and wild populations

Our analyses revealed that lions in recent zoological populations exhibited both higher life expectancy and greater lifespan equality than those in the two free-ranging populations examined. Importantly, these gains emerged clearly for both metrics and sexes after the 2010s, reflecting a steady improvement in environmental quality and animal care within modern zoological facilities over time. While these results are encouraging, they should be interpreted with caution, as two wild populations cannot be considered as fully representative of all free- ranging lions. The Serengeti population, for instance, occupies a nutrient-rich ecosystem largely protected from human interference and has reached the carrying capacity of its environment (Packer et al., 2005; Barthold et al., 2016; Conquet et al., 2024), an indicator of effective *in situ* conservation in the Serengeti National Park, Tanzania. Similarly, the Hwange population, despite exposure to trophy hunting at park boundaries and occasional human-wildlife conflicts, remains stable and growing under sustained management effort in northern Zimbabwe (Barthold et al., 2016; Loveridge et al., 2016).

Both populations are well studied and considered successfully managed, providing meaningful benchmarks for comparison. That modern zoological lions outperform these well-managed free-ranging populations in both life expectancy and lifespan equality strengthens the progress achieved in husbandry, veterinary care, and environmental enrichment over the past decades. These results provide empirical support for the role of contemporary zoological facilities as key contributors to *Panthera leo* conservation, aligning with the broader framework of *ex situ* efforts integrated within species-level conservation strategies (Byers et al., 2013; Funston et al., 2023).

Long-term studies on large felids are scarce, and no sex-specific life tables for wild populations have been published for the other *Panthera* species, but available data support similar conclusions. For example, fewer than 10% of wild jaguars live longer than 13 years (Olson et al., 2019), while more than 50% of those born in modern facilities in the 2013–2022 period exceed this age. For leopards, approximately 30% of females in the Sabi Sand Game Reserve (South Africa) reached 12 years of age (Balme et al., 2013), while more than 50% reached that age in the most recent period in zoological facilities. Similarly, few Amur tigers (*P. tigris altaica*) living on and near the Primorski Krai (Russia) were expected to survive 7 years, mostly due to poaching and human-tiger conflicts (Goodrich et al., 2008), but half of those born in modern zoological facilities exceed 12 years of age. Unfortunately, no robust longevity data exist for wild snow leopards due to their elusive behaviour and harsh mountainous habitat (Jackson et al., 2010), which highlights the importance of *ex situ* populations in increasing knowledge about this species.

Our results align with growing evidence that animals across many taxa have lower mortality rates and have the potential to live longer under modern *ex situ* management than in the wild (Ricklefs and Scheuerlein, 2001; Lemaître et al., 2013; Tidi`ere et al., 2016, 2023; Colchero et al., 2021). They also mirror patterns observed in other taxa, such as primates (Colchero et al., 2021) and marine mammals (Tidi`ere et al., 2023), which exhibit higher life expectancy and lifespan equality in zoos in recent periods than in their natural habitats. These findings do not support persistent claims that zoo-housed animals have shorter life expectancies, and consequently poorer conditions of life, compared to their wild counterparts (Clubb and Mason, 2007; Clubb et al., 2008). Some of these critiques may stem from misinterpretation or misuse of the scientific literature (*e.g.*, Born Free, 2024). Conversely, the higher values of life expectancy and lifespan equality observed in zoo populations may also reflect the deteriorating environmental conditions faced by their wild counterparts, driven by escalating anthropogenic pressures resulting in the ongoing biodiversity crisis (Cowie et al., 2022).

Challenges and opportunities arising from increased longevity in the zoo Panthera populations

Extended lifespans, akin to trends observed in human populations, introduced new challenges for *ex situ* populations, such as the emergence of age-related diseases as more individuals reach old age (Lombard and Witte, 1959; Longley, 2011; Vincze et al., 2022; Kitchener, 2023). The rise of geriatric conditions has prompted a shift in management practices of felids toward proactive health monitoring, early diagnosis, and preventive care to delay or mitigate disease onset (Longley, 2011). For instance, chronic kidney disease, commonly associated with ageing, contributed to nearly 40% of adult and geriatric snow leopard deaths in zoos (Womble et al., 2021). This condition can be managed through diet adjustments and regular monitoring of renal functions, with ultrasound examinations now forming a standard component of *Panthera* health management (AZA Lion Species Survival Plan, 2012; AZA Jaguar Species Survival Plan, 2016; Tilson et al., 2016; Biddle, 2022). Overall, advances in veterinary and geriatric care now prioritise improving quality of life through effective pain management,

tailored diets, and habitat modifications that accommodate physical limitations (Brando and Chapman, 2023; Nieuwland and Meijboom, 2023). However, this extended lifespan in an *ex situ* environment also provides unique opportunities to better understand ageing or disease progression in long-lived carnivores (Tidiere et al., 2024).

An additional challenge arising from the growing number of ageing individuals is ensuring the demographic sustainability of the *ex situ Panthera* meta-population. As more non-reproductive animals reach advanced ages, they may exert growing pressure on space-limited facilities. Addressing this emerging challenge requires careful management of reproductive strategies to maintain genetic diversity, demographic stability, and long-term sustainability. It is also essential to account for ethical and cultural considerations surrounding ageing and end-of-life care in managed populations (*e.g.*, Clauss et al., 2025). Although improved husbandry practices, veterinary care and living conditions benefit individuals and populations, lifespan extension should not be pursued as an end in itself. From both welfare and conservation perspectives, the objective should be healthy, reproductively viable populations rather than simply increasing longevity.

From longevity gains to conservation impact

The marked increase in longevity observed among *Panthera* species in modern zoological facilities extends far beyond improved husbandry or veterinary care standards: it strengthens the broader conservation framework for these apex predators. Longer-lived individuals reflect healthier, more stable populations, which are fundamental to the success of conservation breeding programs. Advances in nutrition, medical care, and environmental enrichment have produced more robust and reproductively capable animals (Martin et al., 2025), thereby reinforcing the sustainability of *ex situ* populations.

Longevity is often positively correlated with lifetime reproductive success in female felids (Pettorelli and Durant, 2007). In zoological settings, longer lifespans increase reproductive opportunities, enhancing demographic stability and preserving genetic diversity, two essential prerequisites for maintaining viable assurance populations. This demographic resilience is critical for maintaining self-sustaining, genetically viable assurance populations that can serve as a buffer against catastrophic losses in the wild. Genetic diversity, in turn, enhances adaptive potential, ensuring that populations remain capable of responding to changing environmental conditions, and supporting the IUCN SSC's *One Plan Approach* (Byers et al., 2013; IUCN SSC, 2023), which integrates *ex situ* and *in situ* management to achieve cohesive species-level conservation outcomes.

Longer lifespans also provide unique opportunities for scientific research that contributes to our understanding of big cats (Loh et al., 2018; Hvilsom et al., 2020; Kogler et al., 2020¨). Longitudinal data collected from birth to death enable researchers to study life-history traits, reproductive patterns, health trajectories, and ageing processes that cannot be easily obtained in the wild (Tidiere et al., 2024). This is particularly crucial for elusive or endangered species such as the snow leopard (Jackson et al., 2010), for which no robust life tables exist due to the challenges of long-term field monitoring. Therefore, *ex situ* populations remain, for now, the only viable source of comprehensive demographic data for this species. These insights directly inform *in situ* management by improving understanding of species biology, disease ecology, and reproductive physiology, which can be applied to population reinforcement or reintroduction programs.

As apex predators, *Panthera* species play a pivotal ecological role in maintaining trophic balance and ecosystem health (Estes et al., 2011; Ripple et al., 2014; Ceballos et al., 2015). Yet, they face escalating threats from habitat loss, poaching, and human-wildlife conflict (IUCN, 2024). Modern zoological facilities act as conservation reservoirs, sustaining genetically diverse, behaviourally competent and disease-free populations that can support field programs through reinforcement, head-starting, or reintroduction. Their success depends on consistently high management standards (Wingfield and Sapolsky, 2003; Morgan and Tromborg, 2007; Walker et al., 2012), enhancing the global capacity for genetic exchange, thereby mitigating inbreeding risks and sustaining evolutionary potential. By serving as both living gene banks and centres of knowledge, *ex situ Panthera* populations reinforce and complement *in situ* conservation, embodying a tangible bridge between scientific research, education, and species survival in the wild.

Moreover, longer-lived *Panthera* individuals enable deeper public engagement and conservation awareness. Observing thriving, healthy big cats behaving naturally strengthens their role as ambassadors for their wild counterparts, fostering empathy and societal commitment to biodiversity conservation (Bruni et al., 2008; Godinez and Fernandez, 2019; McNally et al., 2024). Sustaining collaboration among accredited facilities is crucial to preserving the demographic, genetic, and educational value that underpins *Panthera* conservation across both *ex situ* and *in situ* contexts.

Conclusion

Our results demonstrate a clear link between the historical rise of accredited facilities (*i.e.*, those focused on education, conservation and research) and the progressive increase in first-year survival, life expectancy, and lifespan equality for the five *Panthera* species over the past 150 years. These findings provide robust, quantitative evidence that modern zoological facilities now offer living conditions that enable longer, healthier and more stable *Panthera* populations, thereby strengthening their contribution to species conservation.

By participating in coordinated breeding programs, supporting field conservation initiatives, advancing research and engaging the public, accredited facilities play a pivotal role in the global effort to safeguard *Panthera* from extinction. Their success depends on scientifically informed husbandry and collaborative population management across a critical mass of accredited facilities. However, this progress could be jeopardised if legislative actions aimed at restricting the keeping of *Panthera* species fail to distinguish between accredited, conservation-driven facilities and substandard establishments. Maintaining high management and health standards is essential to ensure the continued production of behaviourally competent, disease-free, and genetically suitable individuals capable of supporting both *ex situ* and *in situ* programs.

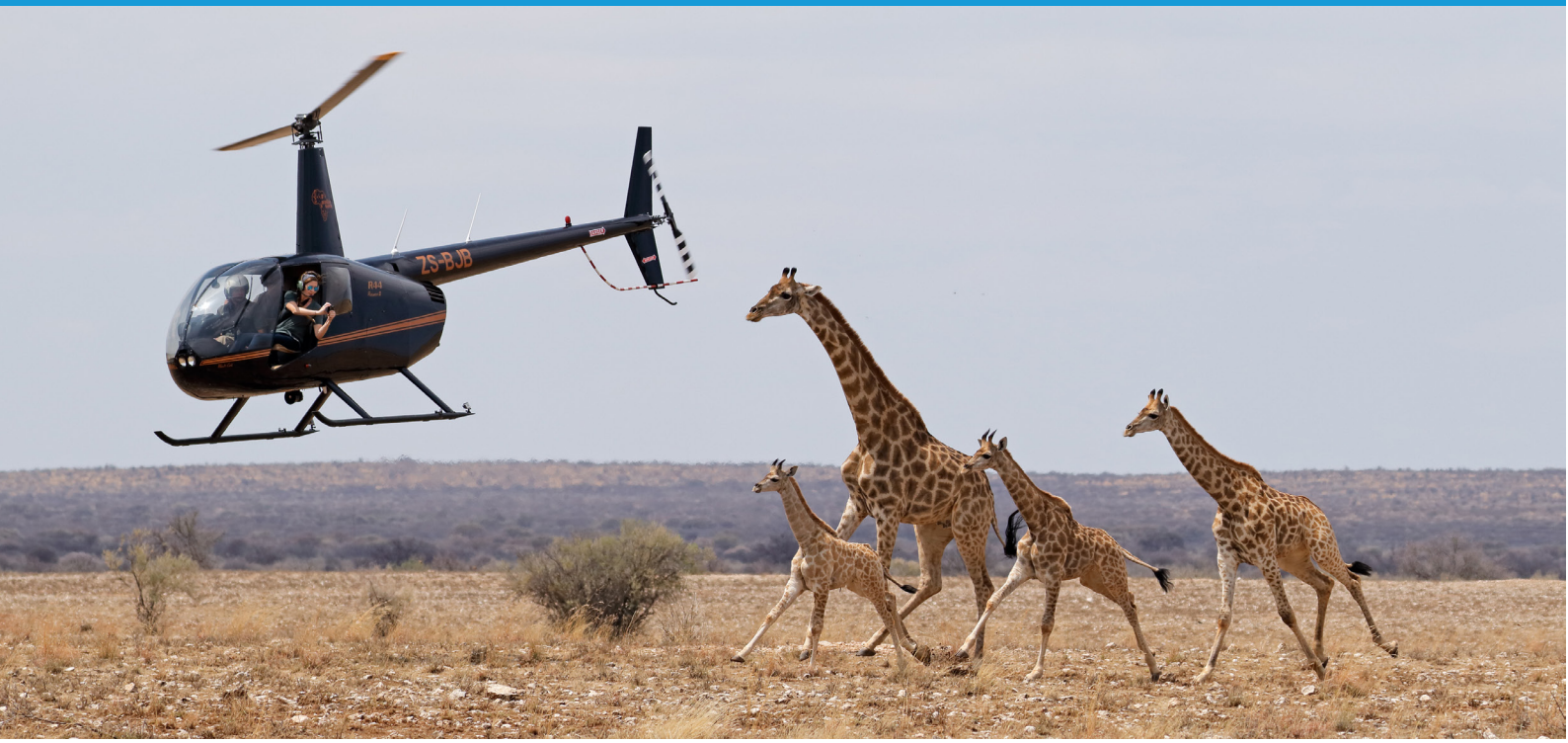
As more individuals reach advanced ages, zoological facilities face new challenges related to ageing populations, reproductive management and long-term sustainability. Addressing these challenges requires developing age-, sex-, and species-specific care strategies grounded in scientific evidence. Ultimately, the steady improvement in the longevity and survival of *Panthera* under human care highlights the critical role of modern and accredited zoological facilities as partners in integrated conservation strategies. Their contribution bridges the gap between *ex situ* and *in situ* conservation, reinforcing the collective capacity to preserve biodiversity in a rapidly changing world.

Appendix A. Supplementary data

Supplementary data to this article can be found online at : https://doi. org/10.1016/j.biocon.2026.111773

SILENT POISON: WHAT GIRAFFE RESEARCH IS TEACHING US ABOUT HIDDEN THREATS IN WILDLIFE HEALTH

Dr Zandre van Selms



When veterinarians think about the major threats wildlife populations are facing, the usual suspects come to mind: infectious diseases, habitat destruction, poaching, drought, and nutritional stress. Yet, emerging research suggests that another danger may be quietly affecting wildlife health— environmental contamination by toxic substances. Unlike an infectious outbreak, toxic exposure often develops slowly, silently, and without obvious clinical signs until long-term damage has already occurred.

Two recent studies conducted on giraffes in South Africa's Rooipoort Nature Reserve have highlighted how complex the interaction between nutrition, habitat selection, and environmental contamination can become. Together, these studies provide valuable insight into how animals balance energetic demands with habitat utilisation, while also revealing how the same survival strategies may unintentionally expose wildlife to chronic toxic threats.

For wildlife veterinarians working in wildlife production systems, conservation medicine, and ecosystem health, these findings are increasingly important. **They reinforce the growing reality that animal health cannot be separated from environmental health.**

The first study focused on giraffe movement ecology and energetic demands within Rooipoort Nature Reserve. Using GPS tracking collars and habitat utilisation analysis, researchers evaluated how giraffes selected habitats and browse species throughout changing seasonal conditions. The findings demonstrated that giraffes repeatedly preferred areas containing nutrient-rich browse plants such as camel thorn, buffalo thorn, and umbrella thorn trees. These species provide the critical protein and energy requirements required to sustain body condition, optimal reproduction, and survival during periods of environmental stress. From a veterinary and physiological perspective, these findings are highly relevant. Nutritional ecology directly influences immune competence, reproductive performance, growth, and resilience against disease. Understanding habitat selection, therefore, extends beyond behaviour — it becomes fundamental to the understanding of long-term population health.

However, the second study introduced **a concerning and unexpected dimension** to this ecological picture. Researchers investigating **heavy metal contamination** within the same reserve identified elevated concentrations of toxic metals, **particularly thallium**, in both browse vegetation and water sources utilised by giraffes. **Alarmingly, many of the same tree species preferentially selected for their nutritional value also contained measurable heavy metal concentrations.**

Thallium is especially concerning because of its high toxicity and ability to bioaccumulate within biological systems. Although acute poisoning may produce overt neurological and gastrointestinal signs, chronic low-level exposure is far more difficult to detect in free-ranging wildlife populations. Animals may continue feeding, reproducing, and appearing clinically normal while experiencing a gradual physiological decline over time.

The study suggested that giraffes may unknowingly be caught in what ecologists refer to as an "ecological trap." The very resources that maximise survival during periods of nutritional stress may simultaneously increase toxic exposure. In other words, giraffes are selecting the best available forage from a nutritional standpoint, yet those same browse species may carry hidden toxic burdens.

For veterinarians, this raises important questions regarding unexplained subclinical disease processes in wildlife populations. **Chronic heavy metal exposure has been associated with immunosuppression, reduced fertility, organ dysfunction, oxidative stress, neurological impairment, and poor long-term fitness across multiple species**. These effects may not immediately present as obvious mortality events, making them easy to overlook during routine wildlife assessments.

In wildlife medicine, unexplained reproductive decline, poor calf survival, altered behaviour, reduced disease resistance, or poor body condition are often attributed primarily to nutrition, parasites, infectious disease, or environmental stress. While these factors remain critically important, toxicology may represent an underappreciated component of the diagnostic picture.

What makes the Rooipoort findings particularly significant is that they occurred inside a protected reserve that would outwardly appear ecologically healthy. This challenges a common assumption in conservation medicine — that protected status automatically equates to environmental safety. Pollution pathways may originate from historical mining activity, agricultural runoff, atmospheric deposition, industrial contamination, or complex geological processes that persist long after initial exposure sources are forgotten.

The implications extend far beyond giraffes alone. Similar processes may be affecting antelope species, elephants, predators, birds, and even livestock sharing overlapping ecosystems. The intersection between wildlife health, livestock production, environmental toxicology, and ecosystem monitoring is becoming increasingly important under the broader One Health framework.

As environmental pressures continue to intensify across Africa, veterinarians are likely to play an increasingly important role in ecosystem surveillance and early detection of emerging threats. **Wildlife health monitoring can no longer focus exclusively on pathogens and visible disease.** Environmental toxicology, nutritional ecology, and habitat quality assessment may become equally important tools for understanding population health dynamics.

This is where collaborative partnerships between researchers, veterinarians, conservationists, and industry become essential. Companies that support scientific research and field-based conservation initiatives can contribute meaningfully to the advancement of wildlife health knowledge. V-Tech's involvement in supporting ongoing research initiatives with these investigators reflects a growing commitment within the veterinary industry to contribute not only products and technologies, but also practical support for scientific investigation and long-term ecosystem health monitoring.

Ultimately, the greatest danger posed by toxic contamination may be how easily it escapes detection. A reserve may appear pristine on the surface while carrying invisible physiological risks underneath. The Rooipoort studies remind us that conservation is not only about protecting animals from visible threats; it is also about understanding the hidden environmental pressures shaping wildlife health every day.

For veterinarians, these findings serve as an important reminder: **when evaluating wildlife health challenges, the silent poisons within ecosystems may deserve far more attention than we currently give them.**

Acknowledgements

Special acknowledgement is extended to Prof. Francois Deacon and his team from the University of the Free State for granting permission to reference the published studies and for personally providing images used in support of this article. His contribution to ongoing giraffe ecological and toxicological research is greatly appreciated.



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SAVA

South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

VISION AND MISSION STATEMENTS

Vision:

To be the leading voice of veterinarians, advancing excellence, integrity, and impact for South Africa's veterinary profession.

Mission:

To unite and advance the veterinary profession through collaboration, excellence, and advocacy, promoting integrity, sustainability, and impact in animal health and welfare, public health, food security, and community well being.

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CALL FOR NOMINATIONS FOR SAVA AWARDS AND HONORARY MEMBERSHIP 2026

DEADLINE: 31 JULY 2026

Nominations for the SAVA Awards are invited. These awards are conferred on persons who have made exceptional and significant contributions in the fields of Veterinary Science, or the Veterinary Profession and they serve as a prestigious form of recognition of distinguished service. They require sufficient but concise justification for the nomination in the category selected, as outlined in the criteria listed for each category. The presentation of awards will be made at a suitable venue and occasion identified by SAVA and this usually occurs every second year to coincide with the Gala Dinner of the SAVA Biennial Congress. Please adhere to the nomination guidelines as set out below.

1. GOLD MEDAL OF THE SAVA

Awarded to any person, in recognition of outstanding and sustained scientific achievement, with a major impact in the field of veterinary science in South Africa. The medal will only be awarded once to a particular person, and there will be one award per year. The award requires a very comprehensive curriculum vitae and motivation.

2. PRESIDENT'S AWARD

Awarded to any veterinarian registered with the SAVC in recognition of outstanding service to and advancement of the veterinary profession in South Africa. The award will only be bestowed once on a particular person, and there will be one award per year. The award requires a very comprehensive curriculum vitae and motivation. .

3. BOSWELL AWARD

Awarded to any member of the SAVA for eminent service rendered to the profession through the SAVA. The award may be bestowed upon more than one person in a particular year.

4. CLINICAL AWARD OF THE SAVA

Awarded to any veterinarian or group of veterinarians who are registered with the SAVC and have excelled in applied veterinary practice. There is a limit of one award per clinical discipline per year. Past recipients become eligible for another award after a period of five years, for a different contribution.

5. RESEARCH AWARD OF THE SAVA

Awarded to one or more veterinarians for a body of research related to Veterinary Science, and published in scientific journals, that has made an important contribution to a particular field of study. Recipients of this award may be eligible for nomination for new original research. Submission to the Awards Committee may be made by candidates themselves.

6. YOUNG VETERINARIAN OF THE YEAR AWARD

Awarded to one veterinarian registered with the SAVC per year, younger than 35 years of age or who has not been registered for longer than 10 years and who has made a significant contribution to veterinary science in his / her work sphere.

7. SOGA MEDAL

Awarded in recognition of exceptional community service rendered by a veterinarian registered with the SAVC or a veterinary student enrolled at a South African veterinary faculty. In addition to veterinary-related services, other forms of community service may be considered to support the nomination.

8. CITATION OF THE SAVA

The SAVA may bestow a citation upon one or more persons, including non-veterinarians, in recognition of specific achievements and / or meritorious contributions to the veterinary profession or the SAVA. More than one citation may be bestowed per year.

9. HONORARY LIFE MEMBER

Any SAVA member who has rendered long and outstanding service to the veterinary profession may be awarded Honorary Life Membership. Honorary Life Membership will not be granted to more than three people in one year.

10. HONORARY ASSOCIATE LIFE MEMBER

Any person who is not a veterinarian and who has rendered outstanding service to veterinary science, or the veterinary profession may be awarded honorary associate life membership. Honorary Associate Life Membership will not be granted to more than three people in one year.

All nominations must be supported by:

- Submissions must be made on the official nomination form available from the SAVA office.
- A brief motivation in terms of the conditions of the specific award, including the impact the work of the nominee has had. Evidence supporting the motivation, such as testimonials, may be included.
- A full *curriculum vitae* of the nominee, including a list of publication(s) where applicable and all the contact details of the nominee.
- Copy (ies) of the relevant publication(s) in the case of the Research Award.
- It should be clearly understood that all SAVA Awards are conferred for contributions that have been made specifically in a South African context and not elsewhere.

Please note that:

- Any member of the SAVA may submit nominations, while others making nominations must include the support and signature of a SAVA member. Nominators are encouraged to channel their nominations via a SAVA Group or Branch.
- Non-SAVA members may be nominated for all categories except the Boswell Award and Honorary Life Membership.
- Unsuccessful nominations of previous years may, at the discretion of the Awards Committee, be held over for consideration in the following year.
- Where the nominator and seconder have indicated their permission, award categories of nominations could be changed by the Awards Committee.
- Members of the Awards Committee are permitted to propose or second candidates for awards, on condition that they recuse themselves when such nominations are discussed.

The onus is on members to submit appropriate nominations by the due date.

Failure to comply with the above will lead to disqualification of the nomination.

All nominations, in electronic format, marked for the attention of Prof G Bath, Chairperson, Awards Committee of the SAVA, must reach the SAVA office, Debbie Breeze by

FRIDAY, THE 31ST JULY 2026

Nomination forms may be obtained from Ms Debbie Breeze 012 346 1150 or please send an email to debbie@sava.co.za

In Memoriam

Adrian (Podge) John Frederick Rogers

1946 – 2026



Adrian was born in Durban on the 11th of May 1946. His parents were Mary and John Rogers, who was a banker at Barclays. All his schooling took place in Pietermaritzburg - Merchiston Prep School, followed by Maritzburg College from 1958 to 1962.

He did his national service in 1963 and the next year at Natal University, before going on to study at Onderstepoort from 1965 to 1968, where he achieved his BVSc. As he had a bursary, he started working in the abattoir for the Johannesburg Municipality but broke his contract after only six months to work for Jack Boswell at Sandown Clinic. During this time, he played first division rugby at Wanderers and met his future wife, Bryony Pritchard.

In 1970, Adrian travelled to the UK with Bryony and classmates Roger Turner and Rick Petersen, doing locums to afford a camper van, so that they could see Europe, and during those travels, met up with former classmate Pete Shires.

He and Bryony then spent some of 1971 in Australia, before returning to South Africa and settling briefly in Johannesburg, before Adrian took up a position in Westville with Drs Amos and Clow.

He and Bryony married in 1972, after which he started a practice in Scottburgh, and they welcomed their first son, Adam, in 1973. Sons Dylan (1975) and Kerr (1977) followed, before the family moved up the coast in 1978 to Amanzimtoti, where Adrian bought a second practice.

He eventually went into partnership with Budgie Perchman, and the pair went on to open a practice in Park Rynie, as well, before ultimately splitting the Scottburgh and Amanzimtoti practices between them.

Adrian sold the Toti practice in 2000 and embarked on travelling annually to the UK to do six-month locums and travel. He and Bryony did this for several years before retiring to Pennington down the south coast. It was also during this time that Adrian went into partnership with Petwise and owned three vet shops.

Adrian loved his sport and was a big Sharks rugby fan, whilst his other interests included hiking, golf, scuba diving, cooking and running. He completed over 50 marathons, including five Comrades and five Two Oceans.

Adrian leaves behind Bryony, his three sons, and six grandchildren.

Gareth Bath

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Dr Jean-Claude Jacobs
1934 – 2026



Claude was born in Belgium but went to school in the Belgian Congo (now the Democratic Republic of Congo), where his family moved to, and his father was a medical practitioner in the government service. After qualifying at Onderstepoort in 1958, he went home for a year before joining the S.W.A. (now Namibian) Veterinary Services as State Veterinarian in the Kaokoveld.

Back in the Belgian Congo in 1961, he was employed by a large ranching company with 30000 head of cattle. By 1967, the political situation in that country had become so bad and insecure that he returned to South Africa, where he joined the S.A. Veterinary Service in June 1968 and was stationed in Louis Trichardt (now Makhado). He married Jocelyne Mathieu in Belgium in September 1969, and at that time, they probably also bought their little farm, Somershoek, beyond the town in the Soutpansberg.

After becoming naturalised in 1972, he was transferred to Sibasa in Venda and put in charge of the Veterinary Services of the Venda and Gazankulu homelands. When Venda became independent in 1979, he was seconded to its Government Services as Head of the Veterinary Services, in which capacity he served until his retirement in October 1993 to Somershoek. This was their frequent weekend escape during all those years, and a peaceful wooded montane abode ever since.

During his professional life, he also took part in official missions to Gabon, Equatorial Guinea and the Comoros Islands with the objective of developing livestock farming in those countries. In Gabon, he also took part in the training of people to become stock farmers and was involved in a study to evaluate the level of trypano-tolerance of the Ndama cattle. His characteristic minuscule handwriting and frequent corrections in his reports exasperated Jocelyn, who had to type them (before computers!).

He was our classmate and close friend ever since, and we stayed over at Somershoek several times. His hobbies included small-scale farming, listening to classical music, as well as making movies and putting them on DVD and tape. He was a real gentleman, a gentle, unassuming, selfless family man and a respected colleague.

Tragedy was no stranger to them. They lost their son, Gilles, due to an aircraft accident when he served in the Belgian Air Force and a grandson due to a motor accident, leaving them with 5 grandchildren. They had 2 daughters, Anne and Pascale.

Anne resided with them at Somershoek during their later years and admirably supported and cared for them. Jocelyne died in November 2024. Claude's health gradually deteriorated, and he died, aged 92, on the 9th of May 2026 after a few days in hospital.

We sorely miss Claude and will cherish our fond memories of him and the times we shared.

Neels & Ingrid Roos



We honour and remember the contributions made by our colleague who recently passed away.

Dr Daniel Wynand (Daan)Verwoerd: 1933 – 2026

We honour his contribution to our profession and society in general and pray thathis family and loved ones will find the strength to carry them through these times of bereavement.

Influential Life Coaching

WHEN LIFE SUDDENLY CHANGES



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Author of the published book "Life outside your comfort zone. Better and beyond all expectations".
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http://www.life-coach-directory.co.za/mats-abatzidis

Greetings everyone, and I hope that the introduction to winter has been kind to everyone! Life has a way of arriving uninvited. One day, you're managing your schedule, your responsibilities, and your familiar version of normal. The next, a major challenge lands in your lap: a sick family member needs care, a partner loses a job, your business must be restructured to survive, your income drops unexpectedly, your home life becomes more complicated, or a personal crisis forces you to rethink everything. Suddenly, the old rules don't seem to apply, and your mind starts doing that very unhelpful thing where it tries to solve the entire future before lunch.

If that sounds familiar, take a breath. **You are not failing. You are adapting**. Professionals are often trained to solve problems, stay composed, and keep moving. But when a serious life disruption hits, the goal is not to "power through" with a heroic smile plastered on your face. The goal is to respond intelligently, protect your energy, and keep moving in a way that is sustainable. That is not a weakness. That is a strategy. Here are three practical strategies that can help immediately.

1. Shrink the problem to the next right step

When a major challenge appears, the brain tends to inflate it into a giant, shapeless monster. "How will I do this for the next six months?" "What if everything falls apart?" "How do I fix all of this now?" These questions are understandable, but they are often terrible starting points. Instead, shrink the problem. Ask: **What is the next right step in the next 24 hours?**

If you're caring for a sick family member, that might mean arranging medication, calling a doctor, or asking one person to help with meals. If your business is facing a downturn, it might mean reviewing cash flow, contacting your top three clients, or pausing non-essential spending. If your household budget has suddenly tightened, it might mean identifying one expense to cut today and one support option to explore this week. If you've experienced a major personal setback, the next step might simply be getting sleep, making one phone call, or writing down what absolutely must be handled first. This approach reduces panic. Not all at once. Not magically. But enough to **restore a sense of direction**.

A useful rule: don't ask yourself to solve the whole crisis. Ask yourself to **solve the next hour**. Then the next one. You're not building a cathedral in a thunderstorm. You're laying one brick at a time. **Immediate action**:

Write down three columns:

Must do today	Can wait	To be delegated/deleted

Be ruthless. In a crisis, "important" and "urgent" are not the same thing.

2. Reduce your load without guilt

Many professionals are excellent at carrying too much for too long. We call it resilience until it turns into exhaustion, wearing a nice shirt. Leads to burnout, resentment and even compassion fatigue. When life changes suddenly, one of the most powerful things you can do is reduce the load. That may mean lowering your standards temporarily, saying "No" more often, asking for help, or letting certain things be "good enough" instead of perfect.

If you're caring for an elderly parent, maybe the house is less tidy, meals are simpler, and some social obligations disappear for a while. If your company is going through restructuring, maybe some initiatives are paused, meetings are shortened, and perfection gives way to survival. If your income drops, maybe the budget gets revised, travel stops, and the fancy coffee is officially on sabbatical.

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This is not a defeat. This is triage. The problem with crisis mode is that people often try to preserve everything: their old schedule, their old expectations, their old identity, their old level of productivity. That's exhausting and usually impossible. Instead, **focus on what matters right now**.

Ask: What can be paused/simplified/outsourced/shared/postponed, or dropped? What do I genuinely need to keep functioning? You are allowed to adapt your life to reality. Reality is very persuasive.

Immediate action:

Choose one area and make it easier within the next hour. Examples - have groceries delivered instead of shopping in person; cancel/postpone one non-essential commitment; set up automatic payments; ask one person for specific help; simplify one work process.

Small reductions create immediate relief. **Relief creates capacity**. Capacity creates better decisions, less stress, motivation and peace.

3. Build a support system before you feel ready

Most people under pressure often isolate themselves. They think, "I should handle this," or "I don't want to burden anyone," or "I'll ask for help once I get organised." The trouble is that organisation is often exactly what the crisis has stolen. **Support is not a luxury. It's infrastructure**. This may mean practical support, emotional support, or professional support.

A colleague may help cover a deadline. A friend may drive you to an appointment. A sibling may take over a weekly task. A coach, therapist, HR partner, financial advisor, doctor, or trusted mentor may help you think clearly when your own thoughts are running around in a panic with loud shoes on.

If you're restructuring a business, support might include a financial consultant, legal advisor, or peer network. If you're managing a personal crisis, it may include family, faith communities, employee assistance programs, or local services.

If you've taken on caregiving, it may include respite care, meal trains, and anyone willing to handle logistics so you can keep going.

The key is to ask clearly. Specific requests are easier to answer and more likely to be fulfilled. **People often want to help, but they need direction**.

Examples:

"Can you pick up groceries on Thursday?"

"Can you take the kids for two hours this weekend?"

"Can you review this budget with me?"

"Can you sit with me while I make these calls?"

Immediate action:

Send one message today asking for one concrete form of help. Keep it short. Keep it honest. Keep it human.

Moving forward, even if the path is messy. Major life challenges don't ask for permission, and they rarely arrive with clear instructions. But **you do not need to have everything figured out to move forward. You only need enough clarity to take the next step.**

Remember: Shrink the problem. Reduce the load. Build support.

It's not sound glamorous, but it works. And in difficult seasons, "works" is deeply underrated. You may feel stretched. You may feel uncertain. You may even feel a little ridiculous trying to maintain professionalism while your life is doing cartwheels behind the scenes. That is normal. The goal is not to be unshaken. The goal is to **remain engaged, adaptable, and kind to yourself** while you navigate what's in front of you.

There will be hard days, but **there will also be surprisingly good moments**: a helpful conversation, one solved problem, a small financial win, a calmer afternoon, a decision that makes things feel less impossible. These moments matter. They are signs that life is still moving, and so are you. You are not behind. You are in process, which is how progress usually happens.

Next month, we will continue looking at more ideas for improving our quality of life and overall performance both at work and at home.

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Aquarium Animals and Their Eyes

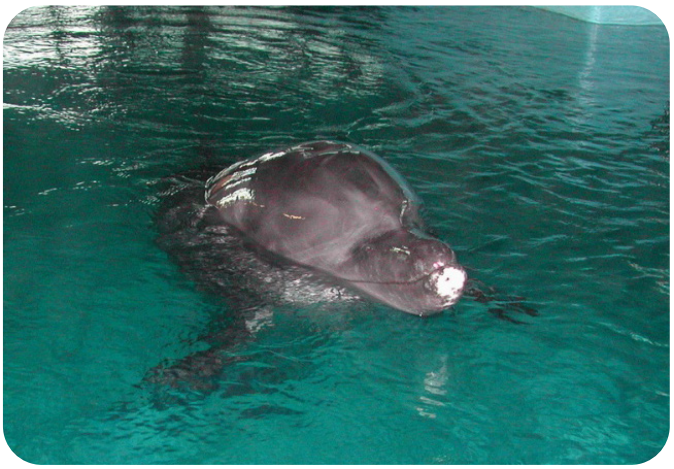
Dr Anthony Goodhead
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Three aquatic animals always attract delight when viewed in the wild or in aquariums. These include dolphins, turtles, and Penguins. Each species has unique adaptations to its aquatic existence, and its eyes are no different. Let's look at the main ophthalmic features of these animals.

1] Dolphins:

The order Cetacea contains the whales, dolphins, and porpoises. Cetaceans are aquatic mammals that evolved from their terrestrial ancestors over 50 million years ago. The suborder contains the Odontoceti, or toothed whales, which include the family Delphinidae, dolphins. Dolphins possess unique ocular anatomical and physiological adaptations enabling effective vision underwater and, to a lesser degree, aerial vision. Their visual system must accommodate for dramatic differences in refractive indices between air and water while functioning in variable light intensity environments. Despite a common perception that dolphins rely primarily on echolocation, vision remains a critical sensory modality in navigation, prey detection, social communication, and environmental assessment.





The dolphin globe is relatively large, laterally positioned, and generally slightly flattened rather than perfectly spherical.

Characteristic globe features include:

Large **globe** relative to skull size.

A large **circumorbital conjunctival gland** is located within the eyelids, deep to the palpebral musculature and is most developed medially. This is a seromucous tubular type gland that has multiple excretory ducts that drain through pores in the conjunctiva. These animals produce a copious amount of thick, viscous mucinous tears. The mucins and other products, such as lysozymes, lactoferrin and albumen, maintain a healthy tear film that provides protection to the ocular surface.

Sclera: The average scleral thickness has been measured at 5.43 mm. The thick sclera provides structural support and resistance to hydrostatic pressure when diving, as well as providing protection from mechanical trauma.

Cornea: Like most aquatic species, the cornea and anterior segment have a relatively flattened curvature, resulting in a globe that has a shorter axial length than its diameter. The average axial length of the bottlenose dolphin globe was measured at 29.13 mm. Dolphins have a relatively small cornea compared with terrestrial mammals. The refractive index of the cornea [1.37] and aqueous humour is similar to water [1.33], so the corneal surface does not provide light refraction as would be the case in terrestrial animals. It is the large spherical lens that provides sufficient refraction to focus light onto the retina. A similar situation applies to fish.

Lens: A further adaptation to ensure emmetropia under water is the lens structure. In order to eliminate spherical aberration, the

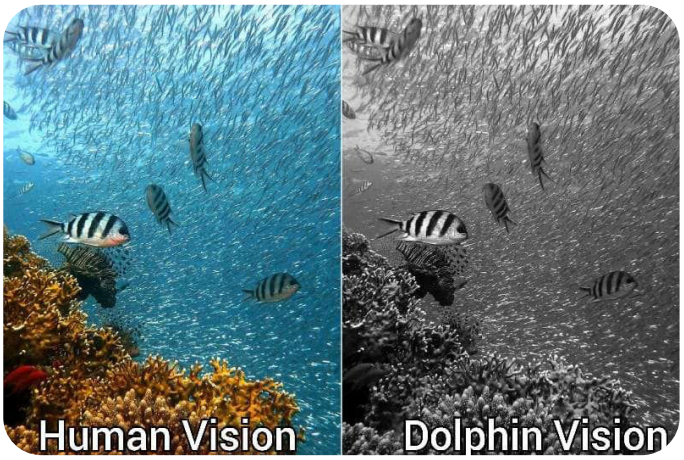
lens has multifocal optics, which is achieved by a heterogeneous lens structure, wherein the outer layers have a lower refractive index than the inner nucleus. [This concept was discussed in a recent VetNews article on pupil shapes]. Accommodation in dolphins is thought to be further managed by axial displacement (anterior translation) of the lens due to an increase in intraocular pressure (IOP), via contraction of the massive retractor bulbi muscle, versus the change in lens shape by ciliary body musculature. The latter are poorly developed in dolphins.

Pupil: The pupil is horizontally shaped at its midposition, with two pupils forming [one medial and one temporal) when maximally constricted. This allows light entering the pupil to be directed through different zones of the multifocal lens at once. This may possibly allow some colour vision in the blue-green spectrum, or improve differences in brightness. Most dolphin pupils also have an operculum, which is a protuberance of the dorsal aspect of the pupil. This is mobile and can allow a change of the pupil shape [oval shape] in low light intensities.



Retina: The retina of all dolphin species evaluated to date is similar to that of terrestrial mammals, with the same layers in the neural retina and the retinal pigment epithelium. It is a rod-dominated retina with a holangiotic blood supply. When considering the ganglion cell distribution, one finds two clearly defined areas of higher ganglion cell density located nasally and temporally, approximately 15 to 16 mm from the optic disk, with a thin band of ganglion cells that connect these two regions passing beneath the optic disk. When a dolphin looks at an object underwater, it positions itself sideways and observes the object with one eye using the nasal area of high ganglion cell density. Then, when the dolphin surfaces above the water, it uses the temporal area of high ganglion cell density to observe the object. Dolphins are considered to be monochromats and see in black and white hues. The echolocation ability will further assist "vision". The tapetum encompasses the entire fundus and is described as fibrous (tapetum fibrosum). It comprises 5-7 layers, which is more than seen in terrestrial animals.

The **Orbital anatomy** differs markedly from terrestrial mammals: Incomplete or reduced bony orbit [see skull image, arrow] - The globe is partially protected by orbital soft tissues rather than a fully enclosed bony orbit. There is extensive periocular adipose and connective tissue support around the strong extraocular muscles.



Dolphins are able to move their left eye independently of the right eye. There is also complete decussation at the optic chiasm (hence they do not have consensual pupillary light reflex) and lateral placement of the eyes, suggesting a predominantly panoramic mode of vision at the expense of depth perception. Front, directed globes would enhance stereopsis, which provides a good depth of view. They also have independent eyelid movements. One amazing concept is that dolphins have unihemispheric sleep. That is, they shut down one hemisphere of their brain to sleep, and close the opposite eye. Thus, when the left half of the brain sleeps, the right eye will be closed. During sleep, the other half of the brain controls breathing functions and monitors the environment, including vision.



The most common pathology the author has encountered in dolphins is the development of cataracts and keratopathy. Ulcers also seem to be a commonly reported finding in dolphins in captivity.

Concerning the keratopathy problem, the pathology seems to be similar, but the location is different. These include:

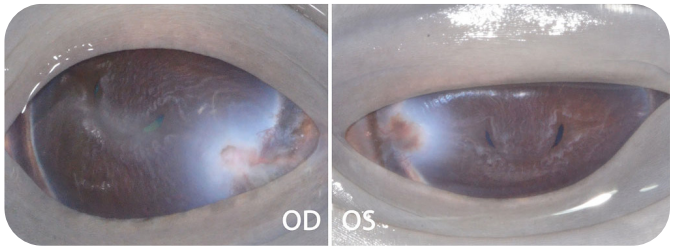
Medial keratopathy is the most common corneal disease of cetaceans, with a prevalence of 53.9%. Early in the disease, pigment just medial to the medial limbus begins to migrate toward the limbus, then crosses the limbus and migrates into the adjacent cornea.

Temporal keratopathy is similar to medial keratopathy in presentation but occurs, as its name suggests, at the temporal conjunctiva, limbus, and cornea [6%].

Horizontal keratopathy can be transient in its initial presentation and is the second most common ocular lesion affecting dolphins in human care. Horizontal keratopathy was reported to occur in 22.8% of animals.

Axial keratopathy is a close third in incidence; it was reported to occur in 24.4% of animals.

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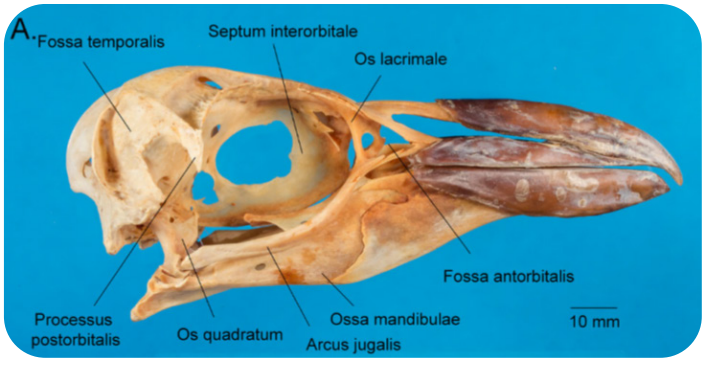
From: Wild and Exotic Ophthalmology Vol 1 2022 Ed: Montiani-Ferreira, Moore, Ben-Shlomo

2] Penguins:

Penguins are flightless [for at least 70 million years] aquatic birds. Almost all species are native to the Southern Hemisphere, with the exception being the Galapagos penguin that lives near the equator. In general, the 17 penguin species can be categorised into those that live in warm temperate [such as South Africa] or cold weather zones [such as Antarctica]. Penguins are adapted well to both a terrestrial and an aquatic lifestyle.



Globe: Like most birds, the globe is large and occupies a large proportion of the skull. It can be flat, tubular or globose [spherical]. However, in penguins, their spherical-shaped eyes do not conform to the usual globose avian eye, where a scleral depression forms where the anterior segment meets the posterior segment, and for this reason, it has been termed a quasi-spherical globe shape. Like dolphins, the globe is slightly flattened, which minimises the optical effect of the aquatic environment, and together with a more rounded lens and a powerful accommodative mechanism, results in near emmetropia in both air and water.



Penguins have three pairs [most birds have 1-2 pairs] of over and under plate scleral ossicles that form a firm ring around the globe, and this seems to counteract the distortion tendencies of hydrodynamic pressure when swimming underwater at high speed.

Eyelid: There are both dorsal and ventral eyelids, as well as the membrana nictitans rostrally, which is a translucent membrane that slides laterally to cover the globe. There is generally more movement in the lower lid than in the upper lid; in these two lids, movements are relatively slow as they are moved by smooth rather than skeletal muscle fibres. Some species only fully close their eyes when they sleep.

Nasolacrimal ducts: Penguins lack nasolacrimal ducts and have small lacrimal glands. They also possess a lateral nasal gland (the supraorbital gland), which is surrounded by a capillary bed. The role of this gland is to extract sodium chloride from the blood circulation and excrete the salt through the bill as a brine nasal secretion, allowing penguins to survive in the saltwater environment, without access to freshwater.

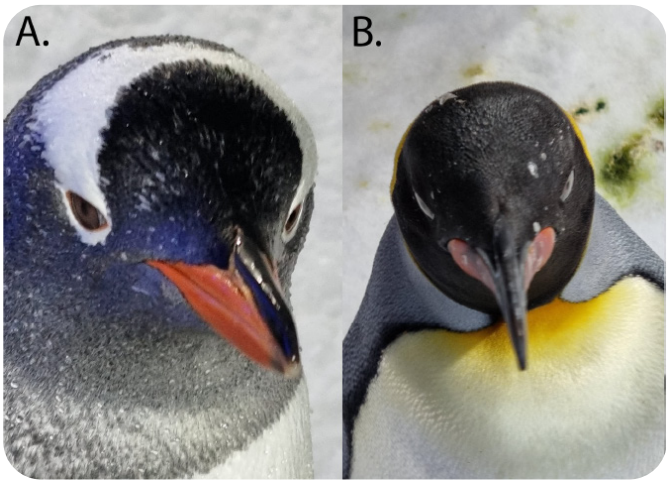
Lens: The lens is large and spherical, and together with its accommodative ability compensates for the loss of corneal refractive power in the water, as we saw with dolphins.

Refractive studies have shown that penguins are near emmetropic both in the water and on land.

Retina: Retinal ganglion cell topography mapping has shown that penguins have a horizontal visual streak. The horizontal visual streak allows a panoramic view of the horizon, which aids in the detection of predators, prey, and conspecifics. An area of dense aggregation of giant retinal ganglion cells (gigantocellularis) that forms an additional vertical visual streak has been noted in the temporal retina of several penguin species. This temporal vertical visual streak improves penguins' visual function in the three-dimensional marine environment by allowing better vertical sampling in the frontal visual field, which aids with prey location across different depths in the water column. However, the use of a highly sensitive outwards-facing horizontal streak is supported by the observation of side-to-side head weaving when Magallanes penguins approach a target directly in front of them.

Most birds are tetrachromatic; that is, they have four visual pigments in their colour-differentiating cones. These cones may be described on the basis of the opsin that they contain: RH2 (rhodopsin type 2), SWS1 (short-wave type 1), SWS2 (short-wave type 2), and LWS (long-wave) cones. The opsins in the retina of all extant penguin species have been sequenced, and the RH2 gene was found to be non-functional. Thus, all penguins are **trichromats**. Loss of the RH2 opsin is also seen in all mammals and may relate to a period of nocturnal evolution. It appears that penguins do not have a fovea. The latter is the very focal area of intense photoreceptor concentration.

There is limited binocular overlap in penguins because the eyes face more laterally than rostrally, although both pupils are visible at the same time in these penguins in the air. (**A**) Gentoo penguin *Pygoscelis papua*; (**B**) King penguin *Aptenodytes patagonicus*. Stereopsis also requires integration of the image from each eye to detect horizontal disparity. Unlike in mammals, birds have a completely crossed chiasm.



Ref: An Overview of the Penguin Visual System, PW. Hadden and J Zhang, Vision, 2023, 7, 6.

Intraocular Pressure: The intraocular pressure (IOP) of the African penguin was found to be 27–31 mmHg.

The most common penguin ocular pathology seen by the author is cataracts. This has been observed whilst examining the African Penguin, Rockhopper and King penguins. Lens-induced uveitis [from hypermature cataracts has also been noted, and severe uveitis leading to glaucoma following systemic infection from chronic bumblefoot. Cataract surgery is challenging in these birds, as achieving mydriasis can be difficult, as the iris has striate muscles that require skeletal muscle relaxants. The anterior chamber is very shallow, and most birds have a better visual outcome when the entire lens capsule is removed. It appears the lens capsule can become intensely fibrotic and opaque if left behind.





A Rockhopper penguin with an enucleated globe as a result of cataracts, end-stage lens-induced uveitis and secondary glaucoma.

3] Turtles:

Sea turtle ocular anatomy is similar to that of other chelonians, with several adaptations for aquatic life, as we have discussed for dolphins and penguins.

Globe: This is small in relation to body size. It is positioned rostrolaterally on the skull, and is encased in a bony orbit with a complete orbital rim.



Adnexa: The eyelids are well developed and mobile, and the lower lid shows the most mobility during blinking. Keratinised epithelium covers the outer surface, whilst internally is a conjunctival surface. Sea turtles such as the loggerhead possess a non-mobile, keratinised structure arising from the temporal bulbar conjunctiva. In the Leatherback sea turtle, the third eyelid is further adapted and has a unique folded or pleated lining of the conjunctiva, allowing a greater surface area for mucous secretion. The paired lacrimal glands themselves are each located posterior and ventral to the globe within the orbit of all marine turtle species. They contain cells that secrete Na^+ and Cl^- by active transport into the conjunctival sac to maintain homeostasis in a high-salt marine environment. No chelonian species has been documented to possess a nasolacrimal duct.



Cornea: Turtles also have a flattened cornea, a spherical lens, and a thickened, partially ossified sclera. The iris has skeletal muscles, making it difficult to achieve mydriasis for examination purposes, as well as allowing good lens visualisation during cataract surgery. Recent studies have shown that neuromuscular blockade alone is insufficient to cause mydriasis in red-eared slider turtles (*Trachemys scripta elegans*) and that adrenergic agents may be required, in conjunction with neuromuscular blockade, to achieve mydriasis. Rocuronium bromide is a nondepolarizing neuromuscular blocking agent which has a more rapid onset of action compared to vecuronium and has been shown to assist in mydriasis.

Sclera: The sclera is supported by plate-like ossicles extending from the limbus to the globe equator, and by a cartilaginous cup extending posteriorly from the equator to the region of the lamina cribrosa. The number and shape of ossicles are species dependent and may provide support for the corneoscleral sulcus during accommodation.

Cornea: The cornea of aquatic turtles is generally flatter with less refractive power (combined with a spherical lens for more emmetropia underwater), while the cornea of terrestrial species is more spherical, with greater refractive power.

Iris: The chelonian iris features a round pupil, a variably pigmented stroma (often matching the colour pattern of the conjunctiva and eyelid skin), and striated sphincter and dilator musculature.



As in other vertebrates, the turtle iris is highly vascular, with a large diameter, thick-walled arterial circle peripherally and many small-diameter vessels throughout the iris stroma.

Lens: The turtle lens is relatively soft, and it is supported by ciliary processes, which contact a dense annular pad (similar to the avian lens). The lens of marine turtles is more globoid than that of freshwater turtles, assuming a greater degree of refractive power in saltwater environments where the cornea is poorly refractive.

Retina: The retina of turtles and tortoises is devoid of blood vessels (anangiotic). However, unlike other reptiles, the chelonian retina does not possess a vascularized conus papillaris. Therefore, the entire turtle retina must rely primarily on the outlying choriocapillaris to support cellular metabolism and removal of metabolic waste. There is a focal region of increased cone density, likely contributing to the greatest visual acuity (area centralis). The area centralis manifests as a thin horizontal band which corresponds to a horizontal band of dark pigment on the iris to regulate incoming light, and it is also the region that these turtles reflexively orient toward the horizon.

When performing a clinical ophthalmic examination on turtles, one should begin by observing the turtle or tortoise in a calm, safe location with no physical restraint. Whenever possible, this should take place in the animal's home environment. Special attention should be paid to locomotion, head movements, visual recognition

of food items, and overall appearance (obvious wounds, facial asymmetry, lameness, or other abnormalities). This is especially important in patients who have sustained recent trauma, as they may display neurologic deficits or injuries which affect the clinician's ability to restrain or anaesthetise them safely.

Depending upon the species, the consensual PLR may be slow and/or less pronounced under normal conditions. Intraocular pressure (IOP) may be measured in the clinical setting by applanation or rebound tonometry. Because digital pressure upon the neck (as occurs during head restraint to prevent head retraction into the shell) will significantly increase the intraocular pressure, it should be avoided during measurement. The slightest touch to the eye or eyelids resulted in forceful closure of the eyelids and globe retraction, so ideally, one needs to stabilise instrumentation and view without touching the head region or applying pressure to the adnexa or neck.

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2. Phacoemulsification cataract surgery in the loggerhead turtle (Caretta caretta): surgical technique and outcomes in 10 cases H D. Westermeyer, A G. Cook, C Harms S Boylan. Veterinary Ophthalmology. 2019; 22:644–650.
3. Wild and Exotic Ophthalmology Vol 1 2022 Ed: Montiani-Ferreira, Moore, Ben-Shlomo





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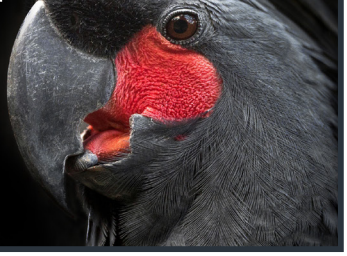
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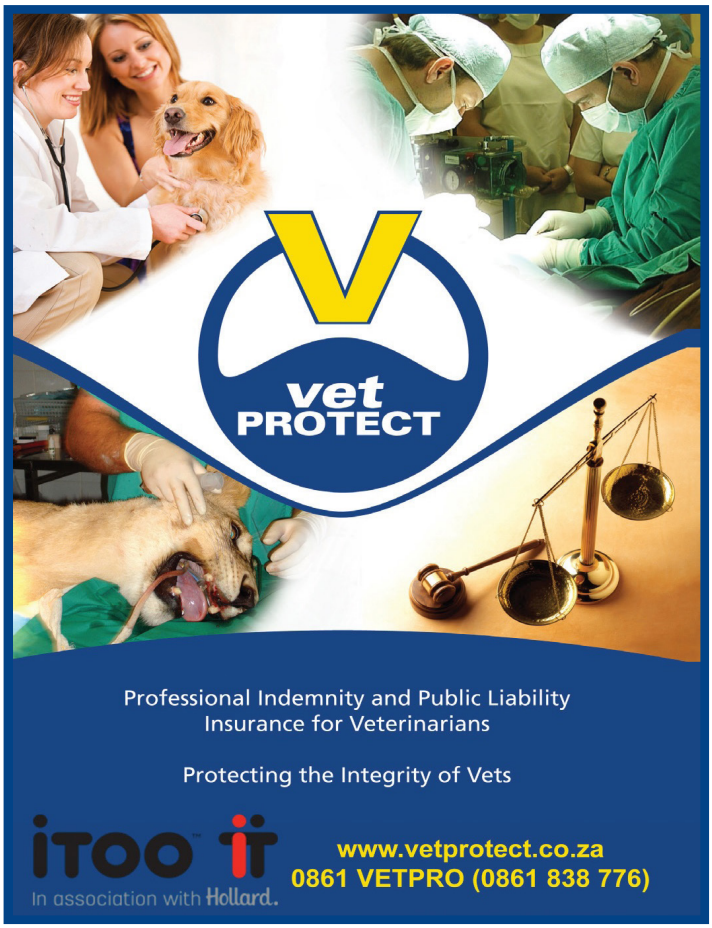
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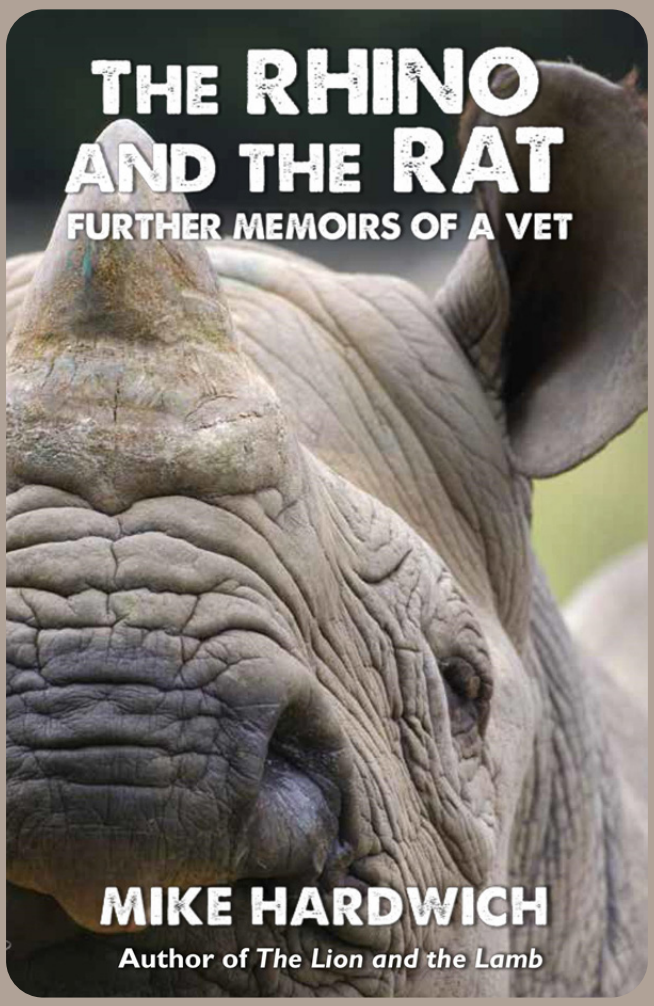
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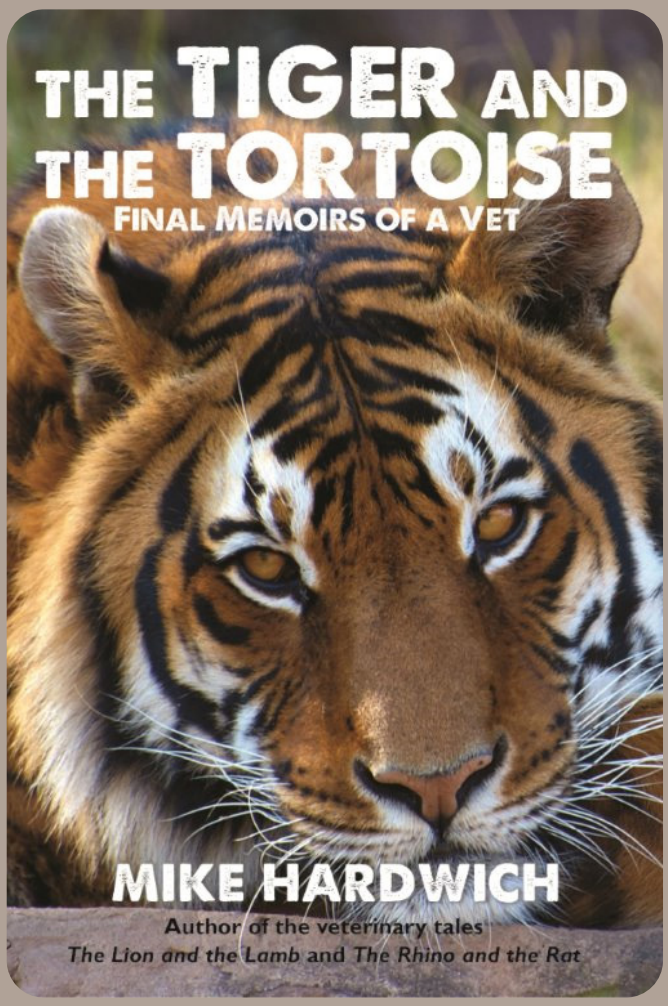


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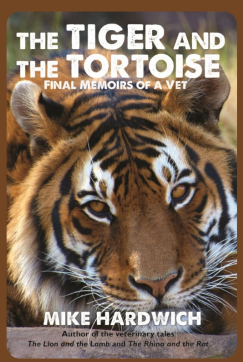




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