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Julie / July 2025

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

THEME

Wildlife

South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

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Access to CPD Articles:

CPD CONTINUING PROFESSIONAL DEVELOPMENT

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Dagboek • Diary

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July 2025

55th Annual SASAS Congress
08 -10 July
Venue: Protea Hotel, The Ranch Resort, Polokwane
Info: https://www.sasascongress.co.za/

Hill's & MSD Nurses Weekend
26-27 July
Venue: Houw Hoek Hotel, Grabouw
Info: corne@savetcon.co.za

NVCG Bush Break
26-27 July
Venue: Nombolo Mdhluli Conference Centre, Skukuza, Kruger National Park, Mpumalanga
Info: https://vetlink.co.za/BUSH-BREAK-26-27-JULY-2025/

August 2025

Western Cape Branch Congress
01-02 August
Venue: Protea Hotel, Marriott Stellenbosch & Conf Centre
Info: https://vetlink.co.za/western_cape/

14th International Veterinary Immunology Symposium
11-14 August
Venue: Hilton Vienna Park, Austria
Info: corne@savetcon.co.za or visit www.ivis2025.org

22nd Annual SASVEPM Congress
20 -22 August
Venue: ANEW Resort White River, Mpumalanga, SA
Info: https://sasvepm.org/ or conferences@vetlink.co.za

September 2025

Eastern Cape and Karoo Branch Congress
12-13 September
Venue: Radisson Blu Hotel, Port Elizabeth
Info: https://vetlink.co.za/eastern_cape_and_karoo_branch/

5th International Congress on Parasites of Wildlife and 53rd Annual PARSA Conference
14-18 September
Venue: Skukuza, Kruger National Park, Mpumalanga
Info: corne@savetcon.co.za or visit www.savetcon.co.za

October 2025

Northern Natal and Midlands Branch Congress
11-12 October
Venue: Fordoun Hotel and Spa, Midlands
Info: https://vetlink.co.za/northern_natal_and_midlands/

The Middle East & Africa Veterinary Congress (MEAVC)
17 -19 October: Pre- and Main Congress Workshops
Venue: Jafza One Convention Centre, Dubai
Info: www.meavc.com

Northern Cape and Free State Branch Congress
18-19 October
Venue: To be confirmed (Bloemfontein)
Info: conference@savetcon.co.za

KwaZulu-Natal Branch Congress
25-26 October
Venue: San Lameer Resort, Southbroom
Info: www.vetlink.co.za

11th International Sheep Veterinary Congress
27-31 October
Venue: Wollongong, New South Wales, Australia
Info: https://intsheepvetassoc.org/11th-isvc-2025

10th Annual South African Immunology Society (SAIS) Congress
30 October – 01 November
Venue: Garden Court Marine Parade, Durban (KZN)
Info: corne@savetcon.co.za or visit www.savetcon.co.za

Southern Cape Branch Congress
31 October – 01 November
Venue: Oubaai Hotel Golf & Spa, George
Info: https://vetlink.co.za/southern-cape-branch/

Contents I Inhoud

VET nuus•news

Diary / Dagboek

Regulars / Gereeld

Articles / Artikels

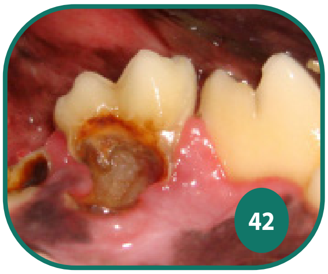
Association / Vereniging

Vet's Health / Gesondheid

Technical / Tegnies

Marketplace / Markplein

Jobs / Poste



CPD CONTINUING PROFESSIONAL DEVELOPMENT

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Dear members,

Past the Halfway Mark

This is once again a month entered with jubilation following the Comrade's marathon. I'd like to congratulate all the members of the profession who participated in the event and particularly those who met and exceeded their personal goals for the race this year. A friend once said, "If you see me running, it means something is chasing me!" I guess that dovetails well with this month's wildlife theme.

July is Wildlife Month, and from an epidemiological perspective, one is thus reminded of the role wildlife plays in the perpetuation of diseases such as Foot-and-Mouth Disease (FMD) and HPAI. These have become very important for the South African economy.

Being amid a protracted FMD event, biosecurity has rightfully become the "word of the day." The National Biosecurity Summit, held in June 2025, was a defining moment for the agricultural sector, signalling a shift to a proactive approach to disease management as well as collaborative safeguarding of our national herd and food systems. Key recommendations from the summit included legislative strengthening to enable the enforcement of disease control measures, institutional renewal to support vaccine production and rapid diagnostics, and reinforced stakeholder collaboration – all of which are necessary to improve agricultural resilience and enable trade compliance in a fast-evolving global environment. We look forward to the forthcoming summit report, which is expected to guide the implementation of these outcomes.

In this context, Foot-and-Mouth Disease control is likely to remain a dominant issue. The recently gazetted enhanced animal movement and gathering requirements provide a much-needed regulatory tool required to curb disease spread. These measures include stricter permit controls, improved traceability, and limitations on livestock movement from high-risk areas. Stakeholder awareness and buy-in will be critical in translating these legal instruments into meaningful on-the-ground impact, and veterinarians remain a key player in this process. I implore that, as opportunities become available for us to engage on multistakeholder platforms, let us engage and provide the required technical inputs on this disease. It's all hands-on deck, as Former President Thabo Mbeki would say.

At the same time, the protracted nature of the FMD outbreak is creating complex socio-economic pressures, especially in the KZN Disease Management Area, where farmers and rural communities are finding themselves in dire straits and are bearing the brunt of market access restrictions. These continued restrictions result in illegal movements, which spread the disease into other parts of the country. We thus must develop new models to facilitate safe trade.

Talking of animal movement and disease management controls, the SAVA Animal Ethics & Welfare Committee is looking for new members to join its ranks. The SAVA AEWC is a passionate group of vets committed to promoting animal welfare interests within the veterinary and social community. They have played a pivotal role in guiding on welfare issues to both SAVA FEDCO and the sector. Send expressions of interest to president@sava.co.za.

On the international front, I will attend both IVOC and WVAC 2025 during this month under the theme "Veterinary Vision 2030: Innovation, Inclusion, Impact." Key topics include climate-resilient animal health systems, digital transformation in veterinary care, global harmonisation of veterinary standards, and youth leadership in the profession. These discussions are especially relevant as we reposition South Africa's veterinary sector within a dynamic global context, while nurturing the next generation of veterinarians to ensure continuity.

The profession awaits the finalisation of the South African Veterinary Council (SAVC) election process. There has been some discontent expressed by members on various glitches experienced with the voting process. SAVA and the SAVC will continue to engage on the matter to ensure a fair process. There are many important issues to address affecting the profession, and we wish those who will emerge victorious from the election a fruitful tenure.

As we go into the 2nd half of the year, I am also looking forward to exciting technical and soft skills programmes run in partnership with Nestle Purina. These programmes will bring together the young and the young at heart. I will actively participate and trust that colleagues will respond positively to these events.

SAVA is not out of the woods yet financially, and this has led us to curtail travel to the various group and branch events. I will, as far as possible, attend those that finances permit or ask a board member in the area to represent the president. Where I am unable to reach, know that I am with you in spirit.

Colleagues, we are experiencing several challenges both as a sector and individually currently. Let us remain steadfast in our collective efforts to support each other and protect animal health, safeguard livelihoods, and uphold the veterinary profession's central role in the public good. Whatever role you play, whether through strengthening biosecurity, addressing AMR, or enabling inclusive policy dialogue, your continued contribution is vital to our success.

Thank you. Chat next month again. V

Ziyanda!

SAVA
South African Veterinary Association
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« BACK TO CONTENTS

Editor's notes / Redakteurs notas

June is a month that I will remember for the rest of my life.

Paul and I had the opportunity to spend 13 days in Angola on an Overlanding, Wild camping trip. We left home on the first of June and set foot back home just as the halftime whistle blew in the Boks against the Barbarians on Emirates DHL Park.

What hit me the hardest in Namibia was how clean the place was and how safe. We ended up one night (illegally) camping in Owamboland next to an oshona, the people were curious but very polite and friendly. Angola is very poor, with little kids begging everywhere, especially near tourist sites. The only animals we were were Dogs, cattle, pigs and goats, apart from monkeys, cane rats, and dik-dikkies offered as bushmeat. Sad indeed. Often, I wished there was something I could do for the domestic animals, especially the dogs. But then I read about dogs in my neighbouring Acornhoek that do not receive any dog food. I have 'adopted' an in situ dog close to the creche I support. Currently it is Siga nr 2. The previous one met with traffic on the Orpen road before I could have him neutered. With Nr 2, we made sure it was done timeously. He has settled down so well with the very elderly couple. He gets his vaccinations and deworming on a regular basis. What he also gets is dog food. I do not supply the top of the range, I supply good, balanced food. I believe that education and being an example go a long way to better the lives of the people. Being out of the country with very limited connection to the 'real' world gave us a chance to switch off and unwind. But it also removed us a little from reality, which in itself is not a bad thing. I can recommend this kind of thing to happen to anybody. Sleeping out in the wild may not be everybody's cup of tea, but find your breakaway.

9 things to tell your veterinary self before bed tonight

@not_another_vet_nurse

I did my best today, and that's enough

I'm allowed to rest & recharge

I will try again tomorrow

I'm grateful for even the small wins today

I'm allowed to have my moments

Any mistakes made today I will learn from tomorrow

I'm not responsible for how others reacted today

Any patient I lost or put down wasn't my fault.

I'm proud of the work I did today

Contrary to popular belief, the world does not end when you are not in the loop.

Many things seem to sort themselves out without your input and influence.

My wish is that you stay warm and maybe make life a little warmer for another person or an animal. It is, after all, Christmas in July.

Regards,
Andriette

Next month, we celebrate Women in Practice. Spam me with stories of the amazing women in Practice throughout South Africa.

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« BACK TO CONTENTS

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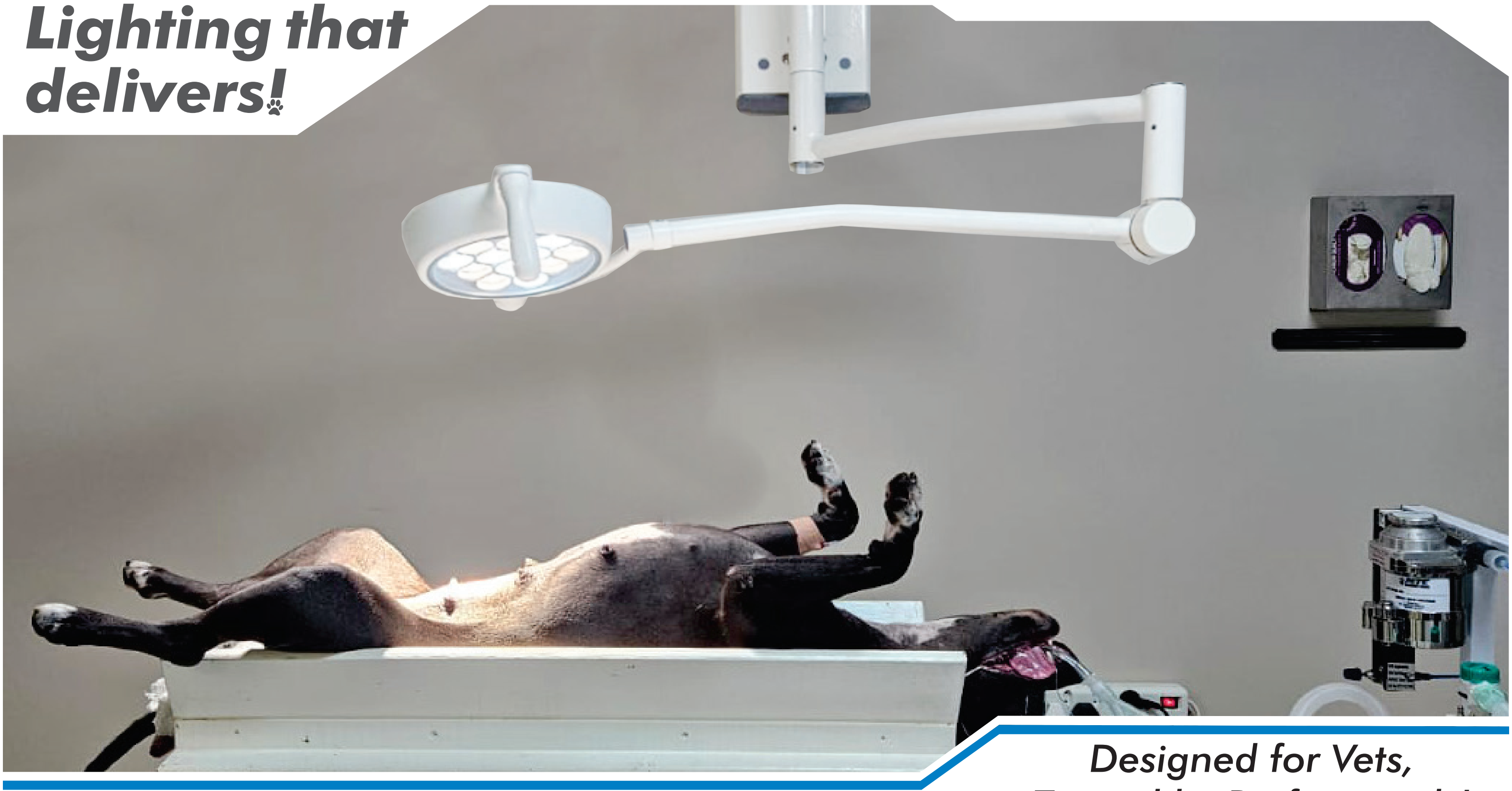

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South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

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.

Climate change as a wildlife health threat: a scoping review

Sabrina S. Greening[1*], Lucie R. Pascarosa[2], Avery L. Munster[2], Roderick B. Gagne[1] and Julie C. Ellis[1]

Abstract

Background *The definition of wildlife health continues to expand with the recognition that health is more than the absence of disease. Practitioners are working to integrate concepts such as vulnerability, adaptation, and resilience into wildlife health research, surveillance, and management actions. Here, we performed a scoping review to identify scholarly articles from 2008 onwards with a focus on climate change impacts on wildlife health. Searches were conducted in Web of Science, Zoological Record, Scopus, Ovid CAB Abstracts, and ProQuest Dissertations and Theses. Articles were screened for relevance and fed into an AI-based thematic analysis that identified recurring themes across the literature. Each theme was manually reviewed and refined to help describe the scope and depth of existing literature, identify key themes, and assess potential knowledge gaps.*

Results *In total, 2,249 citations were retrieved of which 372 were included in further analysis after applying a set of inclusion/exclusion criteria. On closer inspection, 30.4% (113/372) of the papers were focused on climate-associated impacts on vector distribution. For this reason, two thematic analyses were performed, one which only included the subset of papers focused on climate change and vector distribution (n = 113) and another including the remaining papers focused on climate-associated impacts on wildlife health (n = 259). Amongst the subset of papers focused on vector distribution, top themes included concepts related to pathogen transmission dynamics, human/public health, and pathogen prevalence, while health papers focused on concepts related to increasing temperatures, species home ranges and distribution, and changing environmental variables.*

Conclusions *A large number of the papers retrieved in the literature search focused on how climate change impacts the distribution and abundance of host, vector, and pathogen species, remaining disease-centric in their approach. Papers including themes related to management actions were limited reflecting some uncertainty on how best to respond and prepare for climate change. Further discussion is needed on how wildlife health concepts can be used to help inform on-the-ground management actions in the face of climate uncertainty, this includes the collection of baseline health data and research into health metrics that could be used as indicators of resilience at the ecosystem level.*

Background

Protecting and promoting wildlife health in the face of climate change is complex. Despite decades of climate research, there remains uncertainty surrounding the magnitude and scope of impacts climate change is having on many wildlife species [31]. Furthermore, climate change is exacerbating other concurrent anthropogenic threats to wildlife, such as habitat loss and land use change, compounding the threats faced by wildlife and the ecosystems they live in. An increased understanding of the climate-associated impacts on wildlife at multiple taxonomic, temporal, and spatial scales is critical for adaptive management and conservation [20, 37]. However, current research often focuses exclusively on how climate change will impact the emergence and transmission dynamics of infectious diseases, in particular, vector-borne diseases [34]. This is driven largely by the traditional disease-driven view of health (i.e., health is the absence of disease), but also likely reflective of the many health initiatives that remain human-centric, defining the singular role (and value of) wildlife as sources of emerging zoonotic disease. An alternative approach is research that focuses on how climate change will impact the health of wildlife. However, despite ongoing discussions, there remains ambiguity about what wildlife health means and how this translates into actionable management goals [29].

More recent wildlife health frameworks reflect our expanding understanding and definition of health – extending beyond disease and emphasising the interaction of biological, social, and environmental determinants and their impact on health [33, 38]. While there is growing recognition that wildlife health is more than just the presence or absence of disease, integrating concepts such as adaptation and resilience into health research remains limited. For wildlife populations, managing resilience shifts the focus from population-based management towards ecosystem management, whereby strategies centre on maintaining system-level characteristics and processes [3] and strengthening the capacity of the system to respond to change through adaptation [6]. Therefore, it is important in adaptation research to have an understanding of the entire system in which the population of interest is a part [15] in order to identify practical strategies that could help reduce the anticipated negative effects of climate change [16, 17]. A recent review found that only 1% of management recommendations designed to address climate-associated impacts on wildlife populations focused on aspects of health such as reproduction, survival, or disease and few recommendations representing local-scale management interventions [23]. Similar challenges are seen across much of animal health research, for instance, a review focusing on climate change impacts in livestock systems emphasised the importance of more detailed adaptation research to inform local, national, and regional policies to support livestock keepers in adapting to climate change more effectively [12]. The Intergovernmental Panel on Climate Change (IPCC refers to climate adaptation as the "process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities" [18], while resilience is the "ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner" [18]. Over the past few years, there has been considerable growth in the number of wildlife management agencies that have developed and/or implemented climate adaptation plans. For example, the adaptation strategy first published in 2012 and updated in 2021 by the National Fish, Wildlife and Plants Climate Adaptation Partnership (NFWPCAP aims to provide a framework that enables decision-makers to take actionable steps towards building ecosystem resilience and maintaining ecosystem services in the

« BACK TO CONTENTS

face of climate change [27, 28]. Such frameworks identify practical strategies that can be used to reduce the anticipated negative effects of climate change. A previous study reviewed 16 adaptation strategies developed across the United States, Canada, England, Mexico, and South Africa, related to wildlife management and biodiversity conservation [26]. The strategies could be grouped into four broad categories: land and water protection and management, direct species management, monitoring and planning, and law and policy [26]. In many cases, the health impacts of climate change are not explicitly addressed in adaptation strategies or otherwise wildlife health is still only considered through a disease-centric lens.

Given the threat of climate change to wildlife health, it is important that wildlife research, surveillance, and management continue to evolve and integrate concepts such as resilience and adaptation. We hope this review will stimulate further thinking on how to add wildlife health to the climate agenda. We gathered literature focused on climate change and wildlife health and used an artificial intelligence (AI) thematic analysis to describe the scope and depth of existing literature, identify key research themes, and identify knowledge gaps.

Methods

A scoping review was conducted to assess the size (i.e., number of papers) and scope of research focused on climate change as a threat to wildlife health. This review does not intend to synthesize or evaluate all relevant studies, such as a systematic review, but instead aims to understand broad themes across the existing literature. The checklist provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR; [36]) was consulted to help ensure key items from the scoping review are reported. A copy of the completed checklist is provided as an Additional File. Once citations had been identified and screened by the authors, an AI-based thematic analysis was used as a preliminary tool to identify patterns across the research that may point toward potential themes and/or knowledge gaps.

Search strategy and screening

The literature searches were completed over several days starting from July 15 through to July 19, 2024. The search was conducted in five databases: Web of Science, Zoological Record, Scopus, Ovid CAB Abstracts, and ProQuest Dissertations and Theses. All searches were limited to all types of publications dated from 2008 onwards with no language restrictions. Only the article titles, abstracts, and keywords were queried using the search terms listed in Table 1.

The search terms used to capture the concept of "health" were selected from a standard lexicon of threats to biodiversity conservation presented by Salafsky et al. [32], while search terms related to the concepts of "wildlife" and "climate" were discussed and selected by authors. All citations identified using the search strategy were imported into Endnote reference management software (version 21.4 Bld 18,113) where duplicates were removed using the Endnote "Find Duplicates" tool followed by a manual check to remove any duplicates that had been missed. The title and abstracts were then divided between two reviewers (LRP and ALM) and screened using a set of inclusion and exclusion criteria to determine their eligibility for use in the thematic analysis. Citations were included if studies (1) investigated or demonstrated the potential impacts of climate change on wildlife health outcomes, either at a population or animal level. If the title and abstract alone were not adequate to determine if the study should be included, the full text was used for screening.

Citations were excluded if studies (1) reported a mortality and/ or morbidity event associated with episodes of extreme weather (e.g., hurricanes, wildfires, or floods), (2) focused on the risk of zoonotic diseases to humans, (3) exclusively looked at captive animals (i.e., companion or zoo) or food production systems, (4) documenting pathogen presence/absence without assessing any impacts on wildlife health outcomes, (5) did not distinguish between climate change and other anthropogenic pressures, and (6) that discussed potential climate change impacts on their results but did not directly investigate climate change impacts. During the screening process, it became clear that a large proportion of the papers focused on ways that climate change impacts the distribution of disease vector species such as mosquitos, ticks, and flies. These papers were set aside for use in a second thematic analysis to evaluate if climate change was considered differently in papers focusing on wildlife health versus those focused on vector distribution. After the initial screening process, the remaining citations were checked by a third reviewer (SSG) to confirm the relevance of the remaining studies before accessing a PDF copy of each manuscript using EndNote's search for full-text tool. If EndNote was unable to retrieve the PDF and a PDF copy could not be obtained using a manual online search, the study was excluded from further analysis. Once the final number of papers for inclusion had been determined, linear regression models were used to help determine if the total number of papers increased by year with all models run using R statistical software (version 4.3.2 [30],).

AI-based thematic analysis

PDF copies of each paper were imported into NVivo (version 14.23.3) where auto-coding was used to identify themes across the text. For the primary analysis focused on the impacts of climate change on wildlife health, the entire text was used whilst for the secondary analysis focused on vector distribution only the abstracts were used, reducing the computational time. The NVivo autocoding feature uses a linguistic processing algorithm to generate a theme hierarchy based on reoccurring phrases in the data. To summarise, it detects themes by identifying noun phrases, grouping them under a broad parent theme, and assigning significance to themes based on how frequently each noun phrase appears [24]. Auto-coding was chosen over manual coding processes as it can provide insight across large sets of data more efficiently.

Concept	Keywords
Wildlife	"wildlife" OR "free ranging"
Health	"bacter*" OR "disease*" OR "fung*" OR "hazard*" OR "health*" OR "parasit*" OR "pollut*" OR "risk" OR "toxi*" OR "viral*" OR "virus*" OR "poison*"
Climate	"climate change" OR "global warming"

Table 1: Search terms used to conduct a review of climate change research papers focused on wildlife health and climate change. Concepts were combined using "AND" as the Boolean operator

>>>10

The themes and noun phrases identified using auto-coding were reviewed manually (SSG) and refined by merging, moving, or deleting themes and noun phrases that were thought to be incorrect when interpreting them in context. Only a small proportion of the auto-coded themes and noun phrases were deleted, many of which were related to a study's methodology for example, themes such as "Linear regression" or "Bayesian analysis" were removed. Other auto-coded themes were deleted if the theme was identified in less than 5% of the papers and could not be merged with another theme. Merging was more commonly performed on noun phrases and only occurred if two themes or noun phrases could be linked by a common idea or could be considered one and the same. For example, the noun phrases "Public health" and "Human health" were merged to form a single noun phrase. Rarely was a new parent theme created manually with the exception of the "Species" theme which has "Moose (*Alces alces*)" and "White-tailed deer (*Odocoileus virginianus*)" nested as noun phrases. It was thought important to keep these noun phrases as they were found in high frequency throughout the papers related to climate change impacts on vector distribution however, they did not fit into any existing parent theme. Noun phrases were also moved from one parent theme to another. For example, the AI auto-coding placed the noun phrase "Habitat management and protection" under the "Habitat" theme before it was manually moved under the "Management" theme. It could be argued that this noun phrase could belong to both parent themes, however, "Management" was selected based on the interpretation of the text segments that had been assigned during the auto-coding process. In the end, very few edits were made to the auto-coded parent themes with most of the manual corrections centred around the movement of noun phrases.

Results

Search Results

The literature search yielded 2,249 citations (after removing duplicates) of which only 372 (16.5%; 372/2,249) met the inclusion criteria after being screened by all three reviewers. Of these 259 (69.6%; 259/372) contributed to the analysis focused on climate change and wildlife health while 113 citations (30.4%; 113/372) made up the vector distribution subset (Fig. 1). The datasets analysed during the current study are available in the Scholarly Commons: The University of Pennsylvania's open-access institutional repository; https:// repos itory. upenn. edu/ handle/ 20. 500. 14332/ 60593.

The number of citations retrieved varied across each year (Fig. 2) with results from the linear regression model suggesting that approximately 60% of the variance in the number of citations related to climate change and wildlife health could be accounted for by yearly changes ($R^2 = 0.637$; p-value = 0.0001).

In comparison, yearly changes accounted for approximately 50% of the variance in the number of citations related to climate change and vector distribution ($R^2 = 0.498$; p-value = 0.0016).

AI-based thematic analysis—climate change and wildlife health

A total of 17 parent themes and 103 noun phrases were identified across the 259 citations focused on climate change and wildlife health (Table 2 and Supplementary Table 1). The top noun phrases identified across all the papers focused on concepts related to

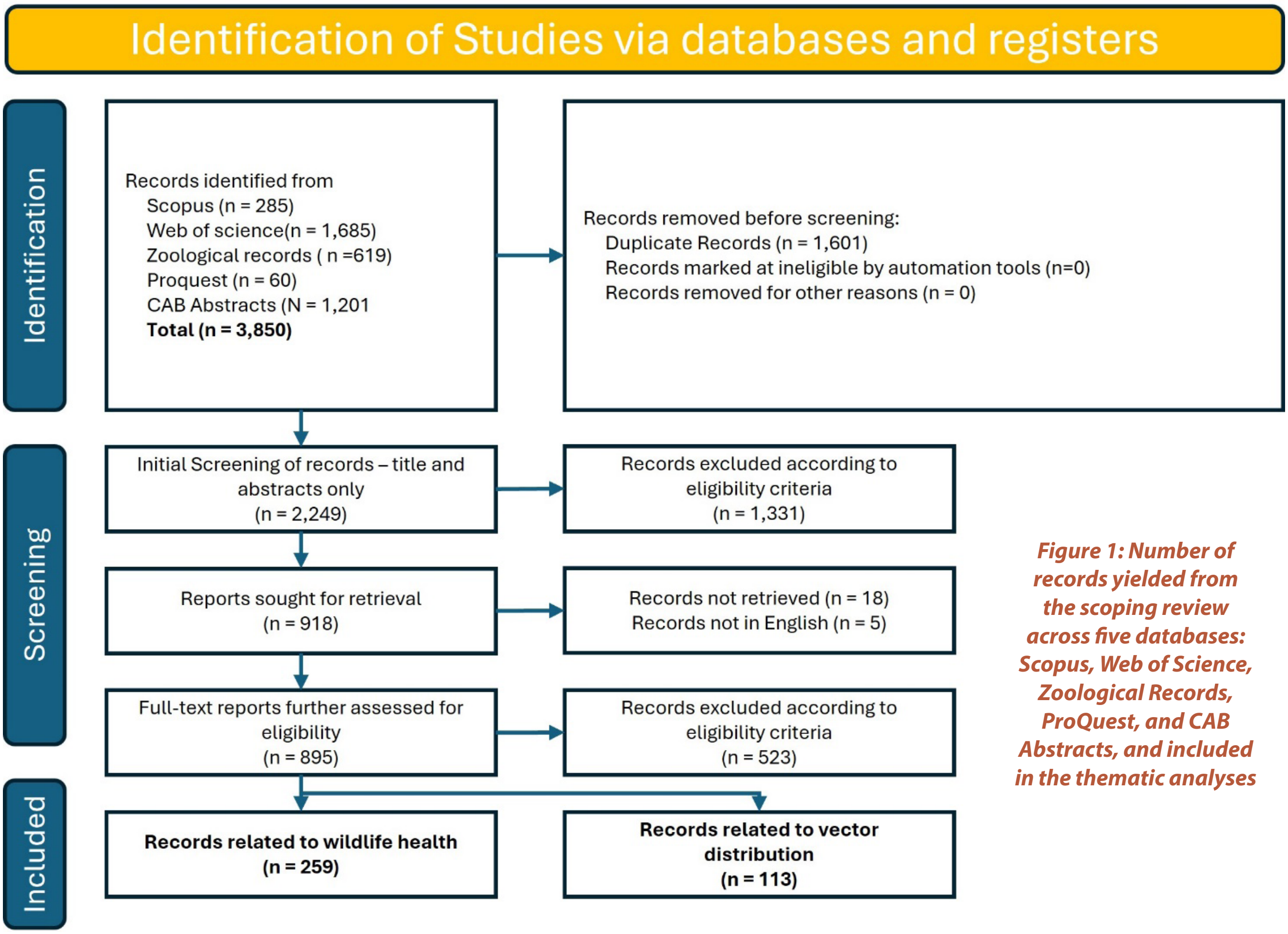

Figure 1: Number of records yielded from the scoping review across five databases: Scopus, Web of Science, Zoological Records, ProQuest, and CAB Abstracts, and included in the thematic analyses

« BACK TO CONTENTS

increasing temperatures (*n* = 152; 58.7% papers), species home ranges and distribution (*n* = 108; 41.7% papers), changing environmental variables (*n* = 86; 33.2% papers), animal body size and/or mass (*n* = 69; 26.6% papers), and increasing different aspects of temperature including heat stress, and water temperatures (*n* = 68; 26.3% papers) across only a small proportion of the papers focused on concepts related to fungal diseases (*n* = 5; 1.9%), critical habitats (*n* = 6; 2.3% papers), genetic effects/impacts (*n* = 6; 2.3% papers), proliferative kidney disease (*n* = 6; 2.3% papers), and climate policies and planning (*n* = 7; 2.7% papers).

When combined, the theme with the fewest number of noun phrases captured concepts related to management including habitat management and protection.

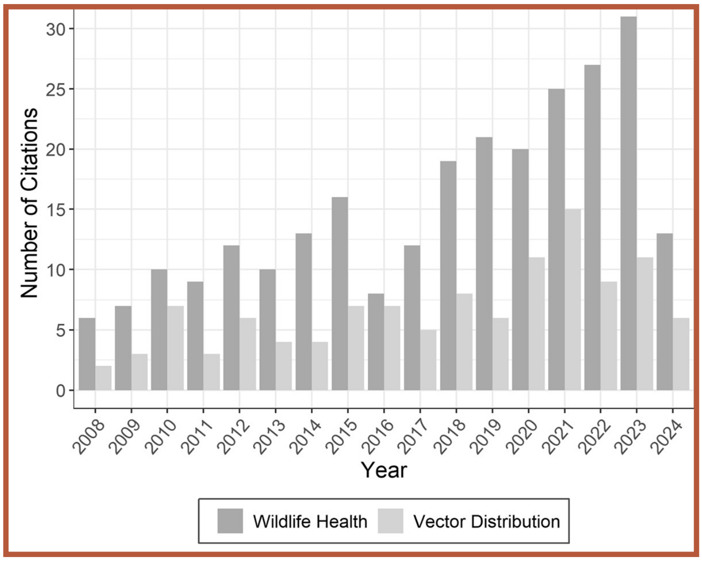

Figure 2: A breakdown of the number of citations by year yielded from a scoping review looking at wildlife health and climate change (n = 259) and vector distribution and climate change (n = 113)

Parent theme	No. of noun phrases in the parent theme	Top noun phrase in the parent theme	No. of papers with parent theme included (%)
Temperature	5	Increasing temperatures	175 (67.6)
Species	8	Amphibian and reptile species	173 (66.8)
Habitat	15	Habitat suitability	147 (56.8)
Population	8	Population response and trends	132 (51.0)
Variables	4	Changing environmental variables	128 (49.4)
Response	6	Physiological stress response	123 (47.5)
Distribution	3	Species home ranges and distribution	114 (44.0)
Body	3	Body condition	111 (42.9)
Disease	12	Infectious diseases	103 (39.8)
Survival	5	Reproductive success and survival	9 (38.2)
Water	3	Increasing water temperatures	91 (35.1)
Host	6	Host immunology	86 (33.2)
Effects	8	Direct effects	85 (32.8)
Level	6	Sea level	82 (31.7)
Human	3	Anthropogenic climate change	54 (20.8)
Parasite	5	Parasite prevalence	53 (20.7)
Management	3	Habitat management and protection	52 (20.1)

Table 2: A breakdown of the parent themes (n = 17) identified using AI-based thematic analysis including 259 papers related to climate change impacts on wildlife health. A full list of the noun phrases within each theme is presented in the Supplementary Material

When com- extreme temperature events, winter temperatures, and bining noun phrases, the top theme identified looked at critical temperature thresholds. Noun phrases identified

AI-based thematic analysis—climate change and vector distribution

Across the 113 papers focused on vector distribution, a total of 13 parent themes and 58 noun phrases were identified (Table 3 and Supplementary Table 2). The top noun phrases focused on concepts related to pathogen transmission dynamics (*n* = 46; 40.7% papers),

>>>12

human/ public health (*n* = 46; 40.7% papers), pathogen prevalence (*n* = 32; 28.3% papers), *Ixodes spp.* (*n* = 27; 23.9% papers), and tickborne pathogens (*n* = 27; 23.9% papers). The top theme identified when considering the combined frequency of noun phrases captured within each theme included aspects related to pathogens including the identification of many pathogen species, namely *Yersinia pestis*, *Babesia* spp., *Borrelia* spp., and *Rickettsia* spp. Noun phrases identified across only a small proportion of the vector distribution papers focused on concepts related to vector abundances (*n* = 2; 1.8%), vector biology and/ or ecology (*n* = 2; 1.8%), vector competence (*n* = 3; 2.7%), host immune competence (*n* = 4; 3.5%), and *Rhipicephalus* spp. (*n* = 4; 3.5%).

Parent theme	No. of noun phrases in the parent theme	Top noun phrase in the parent theme	No. of papers with parent theme included (%)
Pathogens	9	Pathogen transmission dynamics	85 (75.2)
Host	8	Host population density	56 (49.6)
Ticks	9	Ixodes spp.	54 (47.8)
Human	2	Human/public health	51 (45.1)
Disease	3	Zoonotic diseases	42 (37.2)
Health	6	Wildlife health	41 (36.3)
Control	4	Surveillance systems	36 (31.9)
Wildlife	3	Wildlife habitats	28 (24.8)
Factors	3	Environmental factors	27 (23.9)
Virus	4	Tick-borne encephalitis virus	26 (23.0)
Range	2	Range expansion or shifts	26 (23.0)
Species	2	Moose (Alces alces)	15 (13.3)
Vector	3	Vector biology and ecology	7 (6.2)

Table 3: A breakdown of the parent themes (n = 13) identified using AI-based thematic analysis including 113 papers related to climate change impacts on vector distribution. A full list of the noun phrases within each theme is presented in the Supplementary Material

Discussion

This scoping review provides insight into how climate change is being integrated into the wildlife health literature. In total, 2,249 citations were retrieved from the literature search and after applying a set of inclusion/ exclusion criteria, a total of 372 papers were used in one of two thematic analyses. In many of the papers excluded from the analysis, climate change was not considered the focus of the paper but rather added as a discussion point that reflects on how research findings might be impacted by climate change. Across the papers included in further analysis, it became clear that over one-third of papers were related to the distribution of different vector species including mosquitoes, ticks, and flies. For this reason, two thematic analyses were performed. Vectorborne diseases are expected to increase with climateassociated changes in vector density, activity periods, life cycles, and geographical distribution.

The World Organisation for Animal Health (WOAH) has highlighted this growing concern in its latest "Animal Health Situation Worldwide" report [4]. However, similar to the dominant "public health" theme found across the papers focused on climate change and vector distribution in this study, much of the concerns related to vectors remain on impacts to human and livestock diseases with the importance of wildlife species limited to their role as reservoir hosts. Many of the papers also assume that the impact of climate change on vector distribution will result in a universal increase in infectious disease although in many cases this is likely an oversimplification. The disease process relies on many interacting factors between the host, the pathogen and/or vector, and their environment all of which will be impacted by climate change in different ways, leading to declines or shifts in disease just as often as increases [22, 35].

Several themes not related to disease emerged across the papers focused on wildlife health and climate change including "temperature" as the top theme. This is a good indication that many of the papers focus on more than just infectious diseases and are looking at other health impacts such as heat or thermal stress although a more in-depth breakdown of the themes is needed to see if this theme recently emerged or can be found across all the study years. It is also important to note that climate change is not limited to increases in temperature alone. Other stressors such as changing precipitation patterns will also impact health and disease, and these stressors have not been captured in any of the themes [13]. The focus on temperature could reflect the uncertainty inherent in future climate predictions. These uncertainties add to the challenge of managing for climate change and emphasise the importance of spreading the risk by using a diversity of management strategies and having a means by which the impact, or any potential unintended consequences, of each strategy can be evaluated both in the short- and long-term [3, 10].

« BACK TO CONTENTS

The top theme across the papers focused on the effects of vector distribution and climate change focuses on different aspects related to the "pathogen" including pathogen prevalence. This may reflect the importance of disease and/or pathogen surveillance systems in wildlife health. Documenting the presence or absence of pathogens has always been central to surveillance, however, there is growing recognition that surveillance systems must move beyond simply "putting points on a map" or "doing surveillance for surveillance sake" and instead be used to help generate information that can support evidence-based recommendations for the protection and promotion of healthy wildlife populations [5, 8]. For example, the collection of long-term baseline health data including information on pathogen occurrence is rarely prioritised, making it difficult to track trends over time, disentangle climate-associated impacts, and draw evidence-based conclusions.

Wildlife exists in complex systems and how health is quantified or assessed can vary depending on the definition of health being used and at what scale you are looking at. This variation in scale is captured in the theme focused on "levels" with some papers looking at an individual or species level versus others that look at a population or community level. Quantifying health at different scales plays a huge role in determining how health is measured and moving beyond a focus on disease processes. For example, health metrics such as blood chemistry are focused on an individual animal while at a species level metrics such as population counts or species interactions are more important [2, 21]. Several individual-based health metrics were identified as themes including body condition, body size or mass, physiological stress responses, and host behavioural responses, while it is not clear what other metrics were used to study health impacts across the different levels. Identifying wildlife health metrics, across different levels, allows actionable health frameworks that can scale from the animal (e.g., targeted antibiotic use) to the ecosystem (e.g., providing corridors of connectivity between optimal habitats). These approaches can move us beyond the detection of pathogens and their pathology towards healthy wildlife [1].

Understanding health effects at different levels can help identify relevant health metrics and targets, which is critical to guide potential management actions that may be used to reach those targets [14]. In a review of 261 studies looking at health assessments for population monitoring in noncaptive vertebrate species, the most common metrics used included taxa blood analysis, body composition assessments, physical examination, and faecal analyses however, only a limited number of papers discussed how these metrics could be used to inform decision-making processes without further integrating a physiological or ecological understanding of species resilience [21]. In addition, these metrics are all focused on the individual level whereas wildlife management often occurs at the population level or above, with a recent shift to adaptive management approaches at the ecosystem level as a way of managing for resilience. Taking an ecological perspective on management is a more holistic approach compared to using single species to guide decision-making as it considers the problem in context including both important ecological interactions and interactions at the human-wildlife interface (Mascia et al., [25]. It is also necessary to explain in more details the inclusion (eligibility) criteria and reason why large proportion of the articles were excluded from the study. Consequently, please address potential concerns that may arise from th2003). Additional themes, concerned with indirect effects, long-term effects, cascading effects, or sublethal effects, further highlight some of the challenges in defining and measuring wildlife health and the potential additive effects of climate change on health which are often not considered in health frameworks.

When examining the themes identified in this study, it is important to consider the limitations both in the search strategy and AI-based thematic analysis. A variety of keywords were used to capture the central concepts: wildlife, health, and climate change. However, with any search strategy, it is hard to assess the scope and magnitude of papers that have been missed or the biases introduced by the keywords. This may be of particular importance when considering the expanding definition of wildlife health and how defining health is complicated by the different terminology used across disciplines. For example, an ecologist may be more likely to use terms such as "fitness" instead of "health." Nevertheless, it is important to note that out of the 2,249 records that resulted from the literature search, only 16.5% (372/2,249) remained after applying the eligibility criteria suggesting that the search terms could have been further assessed to help narrow the search and reduce the number of papers that were outside the scope of this review. A large proportion of the papers were removed during the inclusion/exclusion process because they discussed how climate change would potentially impact their findings, particularly concerning the prevalence of pathogens and/or diseases, but did not directly investigate climate change impacts on wildlife health outcomes. These papers highlight the difficulty in assessing the impact of climate change without a large amount of retrospective or baseline data for both health and climate. The eligibility criteria may have also resulted in papers being excluded from the thematic analysis inappropriately, however, having such criteria is important to help standardise the inclusion/exclusion process between reviewers.

It is also important to acknowledge that by using an AI tool for auto-coding themes, there is a risk of misclassification as the algorithm is based on pattern recognition and lacks human insight or context. In this study, many of the auto-coded noun phrases were either moved into different themes or broken down/split to create a new noun phrase. For example, the noun phrase "body temperature" was initially included under the theme "temperature" but was combined with the noun phrases "body size/mass" and "body condition" to create a new parent theme with the understanding that they are all related to physiological measurements. This highlights the importance of manually reviewing the themes. Nevertheless, the use of AI auto-coding followed by a manual review still takes considerably less time than manually coding the themes and showcases how AI tools can facilitate the initial stages of qualitative data analysis, especially in cases where there is a large amount of data. An important next step in this analysis would be to build a thematic map or network to start exploring the relationships between codes and themes [7]. For instance, in this analysis, moose (*Alces alces)* were one of only two wildlife species identified in a theme; however, on further exploration, you can see that all the papers identified under the theme "moose" are also captured under the themes related to "increasing temperatures" and "*Dermacentor* tick species". This is unsurprising given the evidence for increasing winter tick (*Dermacentor albipictus*) burdens due to increasing temperatures and its impact on calve survival [9, 19] and adult cow reproduction rates [11]. A thematic map would also help reflect the complexity of wildlife health and further highlight potential knowledge gaps. For example, "increasing temperatures" was the

>>>14

top noun phrase but it remains unclear if these papers assessed the impact of increasing temperature on disease agents or direct effects on the wildlife host.

Overall, this review highlights how much of the climate and health research has focused on investigating changes in the geographical or altitudinal distribution of pathogens, parasites, and vectors. The importance of this research cannot be understated however, more needs to be done to link these changes to wildlife health outcomes. To do this, a crucial next step would be to identify relevant health metrics and targets that could be used to assess health across different levels of an ecosystem. Furthermore, our ability to untangle the impacts of climate change amid other anthropogenic threats that are acting synergistically is difficult without long-term baseline health data and robust climate predictions.

Conclusion

As the term "wildlife health" continues to evolve, it is important to discuss the various factors that contribute to wildlife health, particularly as climate change presents a threat with considerable uncertainty. The thematic analysis presented in this study reveals what central ideas are driving wildlife health research and where the potential gaps may lie. The findings show that wildlife health is complex and operates at many different levels. This complexity has been captured in many of the recent definitions; however, health metrics that can be used to help inform on-the-ground management actions or build resilience are still missing and instead the focus has been on how climate change may impact species distribution. It is clear that successful wildlife management needs to incorporate climate change into the response to other health threats and to implement strategies that mitigate impacts related to climate change. Doing so requires research to determine how wildlife can withstand climate driven threats and how management of wildlife can help achieve healthy and resilient populations.

Abbreviations

PRISMA-ScR	Preferred Reporting Items for Systematic reviews and MetaAnalyses extension for Scoping Reviews
AI	Artificial Intelligence
IPCC	Intergovernmental Panel on Climate Change
NFWPCAP	National Fish, Wildlife and Plants Climate Adaptation Partnership

Supplementary Information

The online version contains supplementary material available at https:// doi. org/ 10. 1186/ s12917- 025- 04516-2.

Additional file 1. PRISMA_ScR_Checklist.pdf. A completed checklist provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018) showing what key items from the scoping review are reported.

Additional file 2.

Data availability

The citations yielded from the scoping review and analysed during the current study are available in the Scholarly Commons: The University of Pennsylvania's open-access institutional repository, https:// repos itory. upenn. edu/ handle/ 20. 500. 14332/ 60593.

References

Aguilar XF, Leclerc LM, Association KA, Hunters E, Organization T, Hunters O, Committee T, Mavrot F, Roberto-Charron A, Tomaselli M, Mastromonaco G, Gunn A, Pruvot M, Rothenburger JL, Thanthrige-Don N, Jahromi EZ, Kutz S. An integrative and multi-indicator approach for wildlife health applied to an endangered caribou herd. Sci Rep. 2023;13:e16524.

Aleuy OA, Kutz S, Mallory ML, Provencher JF. Wildlife health in environmental impact assessments: are we missing a key metric? Environ Rev. 2023;31:348–59.

Allen CR, Cumming GS, Garmestani AS, Taylor PD, Walker BH. Managing for resilience. Wildl Biol. 2011;17:337–49.

Awada L, Murillo AC, Hutchison J, Tizzani P, Weber-Vintzel L. 2024. Animal Health Situation Worldwide. WOAH Technical Working Document. 91st General Session of the World Assembly of Delegates. Paris, France. Report No.: 91GS/Tech-01/En. Available from: https:// www. woah. org/ app/ uploa ds/ 2024/ 05/ gs91- 2024- wd- tech- 01- animal- health- situat ion- en. pdf.

Barroso P, López-Olvera JR, Kiluba wa KilubaGortázar TC. Overcoming the limitations of wildlife disease monitoring. Res Dir: One Health. 2024;2:e3.

Biggs HC, Rogers KH. An adaptive system to link science, monitoring, and management in practice. In: Toit JT, Rogers KH, Biggs HG, editors. The Kruger experience: ecology and management of savanna heterogeneity. Washington, D.C., USA: Island Press; 2003. p. 59–80.

Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3:77–101.

Cardoso B, García-Bocanegra I, Acevedo P, Cáceres G, Alves PC, Gortázar C. Stepping up from wildlife disease surveillance to integrated wildlife monitoring in Europe. Res Vet Sci. 2022;144:149–56.

Debow J, Blouin J, Rosenblatt E, Alexander C, Gieder K, Cottrell W, Murdoch J, Donovan T. Effects of winter ticks and internal parasites on moose survival in Vermont, USA. J Wildl Manag. 2021;85:1423–39.

Eaton MJ, Terando AJ, Collazo JA. Applying portfolio theory to benefit endangered amphibians in coastal wetlands threatened by climate change, high uncertainty, and significant investment risk. Front Conserv Sci. 2024;5:e3389.

Ellingwood DD, Pekins PJ, Jones H, Musante AR. Evaluating moose Alces alces population response to infestation level of winter ticks Dermacentor albipictus. Wildl Biol. 2020;2020:1–7.

Escarcha JF, Lassa JA, Zander KK. Livestock under climate change: a systematic review of impacts and adaptation. Climate. 2018;6:54–71. 13. Hofmeister EK, Moede Rogall G, Wesenberg K, Abbott RC, Work TM, Schuler K, Sleeman JM, Winton J. 2010. Climate change and wildlife health: direct and indirect effects. USGS Fact Sheet. Reston, Virginia, USA. Report No.: 2010–3017. Available from: https:// pubs. usgs. gov/ publi cation/ fs201 03017.

Hofmeister EK, Ruhs EC, Fortini LB, Hopkins MC, Jones L, Lafferty KD, Sleeman JM, LeDee O. Future directions to manage wildlife health in a changing climate. EcoHealth. 2022;19:329–34.

Folke C, Hahn T, Olsson P, Norberg J. Adaptive governance of socialecological systems. Annu Rev Environ Resour. 2005;30:441–73.

Hannah L, Midgley GF, Lovejoy TE, Bond WJ, Bush M, Lovett JC, Scott D, Woodward FI. Conservation of biodiversity in a changing climate. Conserv Biol. 2002;16:264–8.

Inkley DB, Anderson MG, Blaustein AR, Burkett VR, Felzer B, Griffith B, Price J, Root TL. Global climate change and wildlife in North America. Technical review 04–2. The Wildlife Society, Bethesda, Maryland; 2004.

IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridg: Cambridge University Press; pp. 555–64. 19. Jones H, Pekins PJ, Kantar L, Sidor I, Ellingwood DD, Lichtenwalner A, O'Neal M. Mortality assessment of moose (Alces alces) calves during successive years of winter tick (Dermacentor albipictus) epizootics in New Hampshire and Maine (USA). Can J Zool. 2018;97:22–30.

Kamboj R, Kamboj S, Kamboj S, Kriplani P, Dutt R, Guarve K, Grewal AS, Srivastav AL, Gautam SP. Chapter 1 - Climate uncertainties and biodiversity: An overview. In: Srivastav A, Dubey A, Kumar A, Narang SK, Khan MA, editors. Visualization Techniques for Climate Change with

« BACK TO CONTENTS

Machine Learning and Artificial Intelligence. Cambridge, MA, USA: Elsevier; 2023. p. 1–14.

Kophamel S, Illing B, Ariel E, Difalco M, Skerratt LF, Hamann M, Ward LC, Méndez D, Munns SL. Importance of health assessments for conservation in noncaptive wildlife. Conserv Biol. 2022;36:e13724.

Lafferty KD, Mordecai EA. 2016. The rise and fall of infectious disease in a warmer world. F1000Research 5:F1000 Faculty Rev-2040. https:// pubmed. ncbi. nlm. nih. gov/ 27610 227/.

Ledee OE, Handler SD, Hoving CL, Swanston CW, Zuckerberg B. Preparing wildlife for climate change: How far have we come? J Wildl Manag. 2021;85:7–16.

Lumivero. 2023. Revolutionizing text data analysis with AI autocoding with NVivo. Available from: https:// lumiv ero. com/ resou rces/ blog/ revol ution izing- text- data- analy sis- with- ai- autoc oding- with- nvivo/

Mascia M, Brosius JP, Dobson T, Forbes BC, Nabhan G, Tomforde M. Conservation and the social sciences. Conserv Biol. 2003;17:649–50.

Mawdsley JR, O'Malley R, Ojima DS. A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. Conserv Biol. 2009;23:1080–9.

National Fish, Wildlife and Plants Climate Adaptation Partnership (NFWPCAP). 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington, DC, USA. Available from: https:// toolk it. clima te. gov/ tool/ natio nal- fish- wildl ife- and- plants- clima te- adapt ation- strat egy.

National Fish, Wildlife, and Plants Climate Adaptation Partnership (NFWPCAP). 2021. Advancing the national fish, wildlife, and plants climate adaptation strategy into a new decade. Association of Fish and Wildlife Agencies, Washington, DC, USA. Available from: https:// toolk it. clima te. gov/ tool/ natio nal- fish- wildl ife- and- plants- clima te- adapt ation- strat egy.

Radcliffe RW, Jessup DA. Wildlife health and the North American model of wildlife conservation. J Zoo Wildl Med. 2022;53:493–503.

R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. 2023. Available from: https:// www.R- proje ct. org.

Rangwala I, Moss W, Wolken J, Rondeau R, Newlon K, Guinotte J, Travis WR. Uncertainty, complexity and constraints: How do we robustly assess biological responses under a rapidly changing climate? Climate. 2021;9:177–205.

Salafsky N, Salzer D, Stattersfield AJ, Hilton-Taylor C, Neugarten R, Butchart SHM, Collen B, Cox N, Master LL, O'Connor S, Wilkie D. A Standard lexicon for biodiversity conservation: Unified classifications of threats and actions. Conserv Biol. 2008;22:897–911.

Stephen C. Toward a modernized definition of wildlife health. J Wildl Dis. 2014;50:427–30.

Stephen C. Chapter 2 – Overview of climate change and animal health. In: Stephen C, Duncan C, editors. Climate Change and Animal Health. New York, NY, USA: CRC Press; 2023. p. 23–40.

Thomas MB. Epidemics on the move: climate change and infectious disease. PLoS Biol. 2020;18:e3001013.

Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann Intern Med. 2018;169:467–73.

Wilkening JL, Magness DR, Harrington A, Johnson K, Covington S, Hoffman JR. Incorporating climate uncertainty into conservation planning for wildlife managers. Earth. 2022;3:93–114.

Wittrock J, Duncan C, Stephen C. A determinants of health conceptual model for fish and wildlife health. J Wildl Dis. 2019;55:285–97.

Managing Wildlife Disease Under Climate Change

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For many land management agencies, climate change presents an unprecedented circumstance where native species' ranges are shifting, natural processes are transforming, and previously innocuous stressors can have outsized impacts (Feldmen et al., 2017; Pecl et al., 2017; Byers 2020; Cohen et al., 2020; Rohr & Cohen, 2020). In this space, conservation practices and traditional land-management policy can conflict. This divergence is particularly apparent for agencies such as the United States National Park Service (NPS) that, despite existing in a world changing rapidly under modern human influence, are steeped in long-established policies to maintain natural conditions. How NPS policy and its implementation evolve are critical not only to the agency and its stakeholders but as an example for other natural resource management organizations with similar preservation missions.

The NPS is mandated to preserve plant and animal species native to park ecosystems and restore natural processes and communities whenever possible (NPS, 2006). Historical management approaches were relatively straightforward: preserve the natural condition defined as 'the condition that would occur in the absence of human dominance over the landscape' and manage where threats of resource impairment exist and management is prudent and feasible (NPS, 2006). The climate crisis presents an unparalleled challenge not only in identifying prudent and feasible management under such rapid change but even in determining what species and processes should be considered native or natural. This complexity is evident when dealing with animals and plants and further multiplied for infectious diseases. Complexities of infectious disease ecology, the range of projected environmental changes, and the diversity of pathogens,[1] vectors, and hosts will make it challenging to both define and protect 'native' and 'natural' resources, requiring decisions under increasing uncertainty.

Infectious disease dynamics are complex and sensitive to a range of global changes. Climate change can impact geographic or temporal patterns of infectious diseases, but these impacts are often not uniform, predictable, or generalizable across systems (Lafferty, 2009; Cohen et al., 2020). Diseases that involve multiple reservoir or vector species are more likely to be affected by climate change and likely more difficult to model and manage (Rohr et al., 2011). Temperature affects the development of pathogens, hosts, and vectors as well as their habitat and range in multiple ways. For example, higher temperatures can accelerate the development and reproductive rate of ectothermic organisms such as ticks and mosquitoes, resulting in a larger vector population and higher risk of disease transmission, but if it is too hot and dry, this can create inhospitable conditions for vectors and limit their geographic range (Kutz et al., 2009; Liao et al., 2015; van Panhuis et al., 2015; Onyango et al., 2020; Faiman et al., 2017). Higher mean temperatures can also affect temporal disease patterns, for example by causing earlier questing (i.e., host-searching) season for ticks, or by limiting the hours of the day that are suitable for tick questing due to high heat and low humidity (Brownstein et al., 2005; Tagliapietra et al., 2011; Monaghan et al., 2015). Changes in precipitation due to climate change may impact the occurrence and spread of disease, but the direction and magnitude of impacts are difficult to predict at smaller scales, and will likely vary across the landscape and interact with temperature in unpredictable ways (Harrigan et al., 2018; Hahn et al., 2015; Gardner et al., 2012; Eisen et al., 2010; Shaman et al., 2005; Koenraadt and Harrington, 2008; Herrmann and Gern, 2013; Berger et al., 2014; Cohen et al., 2020). Precipitation-responsive diseases, such as anthrax, hemorrhagic vector-borne diseases, plague, and hantavirus, may see more significant peaks of activity during larger rainfall events, but these may be interspersed with longer periods of inactivity during prolonged and more significant droughts (Engelthaler et al, 1999; Eads & Hoogland, 2017; Walsh et al., 2018). Additionally, variability in temperature and precipitation abnormalities and thermal mismatch, which typically advantages smaller organisms such as parasites and pathogens, can also significantly influence disease dynamics, reducing fitness of cold- or constant-climate adapted species while benefitting species adapted to warmer climates and limiting the geographic range of each (Eads & Hoogland, 2017; Cohen et al., 2020).

For pathogens, hosts, and vectors whose life cycles are limited by temperature extremes, higher mean temperatures will likely cause a poleward shift in geographical range (Lafferty, 2009). The ranges of previously separated populations (pathogens, hosts, and/or vectors) may begin to overlap under a changing climate regime, resulting in novel disease assemblages or the expansion of disease risk into new areas. For example, this has been observed as the meningeal worm of white-tailed deer encounters moose and elk populations, or when lifecycle changes occur, as has been observed in muskox lungworms that have expanded their range and accelerated their development under warmer temperatures, with significant clinical impacts on their host (Kutz et al., 2009; Wetzel and Weigl, 1994; Pickles et al., 2013; Feldmen et al., 2017; Kafle et al., 2020). Similarly, as host populations disappear or decrease on

« BACK TO CONTENTS

the landscape, so too will the pathogens dependent on these species for survival. Although research has shown that a decrease in biodiversity often results in increased disease risk (Civitello et al., 2015; Keesing et al., 2010; Orrock et al., 2011; Johnson et al., 2009; Johnson and Thieltges, 2010; Johnson et al., 2013ab), climate change could also decrease the prevalence and geographic extent of some diseases.

Historically, disease in free-ranging animals was considered a natural process inherent to the functioning of a park ecosystem, and the NPS did not routinely intervene or attempt to manage disease impacts unless overt public health impacts existed (Sellars, 1997). Disease can be a natural process and is indeed at some level a component of a healthy ecosystem. Traditionally, native disease-causing organisms warranted the same protection as other flora and fauna. However, the re-examination of disease origins, in part aided by rapid advances in genetic and other classification techniques, led to the realization that observed diseases were in many cases a result of exotic pathogens or anthropogenic impacts (Meager and Meyer, 1994; NPS, 2002a, b; Wobeser, 2002). This recognition of the nonnative origin and anthropogenic drivers of some major diseases required broadened disease management approaches in free-ranging wildlife.

Today, most if not all ecosystems are impacted by significant external stressors, most notably land-use changes, loss of habitat connectivity, introduced species, changes in species abundance and density, and climate change. These external stressors have already significantly impacted both disease occurrence and wildlife populations such that current disease processes are rarely a completely natural process. Disease is a highly complex process influenced by both infectious and non-infectious factors. Changes in any of the three components of the disease triad – host, agent, or environment – can influence disease outcomes significantly, even if the underlying pathogen itself remains unchanged (Daszak et al., 2001). Diseases are more likely to have significant impacts in a system that has experienced disturbance, whereas non-disturbed systems are more ecologically resilient to disease impacts or introductions (Wobeser, 2002). Active management of diseases should therefore no longer be a last resort but considered a critical tool to 'mitigate unacceptable impacts from external stressors' through a harm reduction approach (Colwell et al., 2012; Fisichelli et al., 2016; Stephen et al., 2018). In a wildlife health context, "rather than focusing on obstacles and deficits, [harm reduction] deals with securing critical resources to stay well" (Stephen et al., 2018). Critical harmreduction strategies for wildlife have included enhancement of wildlife corridors, facilitating genetic exchange across populations, enhancing forage and habitat resources, and reducing impacts of human-wildlife interactions, among others, whether the threats are direct (i.e., vehicular collisions, hunting, or resource competition) or indirect (i.e., reduced reproduction, foraging, and movements due to human presence aversion) (Stephen & Wade 2018; Sleeman et al., 2019; Gallagher, 2020).

Under climate change, 'natural conditions may be both increasingly difficult to characterize and ineffective as a guide for desired future conditions' (NPS, 2012). This is particularly true for pathogens and associated diseases. The difficulty and expense in detecting pathogens in free-ranging systems, their rapidly evolving nature, and the lack of historical information on diseases prevent the classification of native versus exotic for many pathogens. As a result, despite NPS policy striving 'to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems', a maturation in NPS policy interpretation was required. The decision of how and when to manage infectious disease in practice is currently based on disease impacts and processes as opposed to disease characteristics (native vs non-native) or drivers (i.e., evolutionary rate, community structure, climate change) (Aguirre et al., 1994, 1995; NPS, 2000, 2006). Whether the pathogen is native or non-native, management is often necessary under anthropogenic change to reduce or prevent local extirpation, genetic compromise, or other impacts on an affected population, as in the case of native epizootic hemorrhagic disease in endangered Florida

Key deer. On the other hand, management may be unnecessary when impacts do not compromise population viability, as in the case of climate-driven range expansion of epizootic hemorrhagic disease in white-tailed deer (NPS, 2002a, b; Stallknecht et al., 2015; Zuliani et al., 2015).

Management response to zoonotic diseases creates an additional need for contemporary interpretation. Management Policies (NPS, 2006) directs action in situations where 1) human health and safety are at risk, a disease can be controlled, and human behaviour modification, resource use modification, or closures are not effective in protecting human health and safety as determined by public health; 2) disease may pose a threat to adjacent lands, or 3) exotic pathogens that can be managed are threatening native resources. Although this guidance might be interpreted to encourage interventions for diseases that threaten human health even when natural resource impacts result from these interventions, NPS Management Policies section 1.4.3 states:

> Congress, recognizing that the enjoyment by future generations of the national parks can be ensured only if the superb quality of park resources and values is left unimpaired, has provided that when there is a conflict between conserving resources and values and providing for the enjoyment of them, conservation is to be predominant.

In this context, visitor use of a park may be unacceptable if visitor health can only be preserved through actions that could impair future use or appreciation of native species. In this era of rapid change, more work is needed to proactively identify unacceptable impacts from management actions, as well as visitation itself, to prevent these decisions from being made during a crisis.

Climate change is one of many human influences on natural systems. The real risk comes in the rapid and understudied direct impacts, the yet unknown ways in which this and other anthropogenic stressors synergize to impact natural resources, and the limited time that we have to act to prevent irreversible change that threatens natural resources and human civilization alike (IPCC, 2014). Although existing policy can be re-interpreted to accommodate a harm reduction approach, we argue that new or updated Management Policies, Executive Orders, or Congressional Mandates should prioritize and standardize a harm reduction approach and mobilize new and existing resources to better characterize ecosystem 'health' and factors that can promote ecological resilience. Managers of national parks and other protected areas are encouraged to take a holistic, preventative approach to infectious disease and evaluate management options from the disease-impact perspective rather than the categorization of a specific organism or pathogen. Broader understanding, and therefore data, on the health of our natural resources and pre-

>>>18

determined levels of acceptable impacts and risks are necessary to maximize positive outcomes when management is warranted. Overall, climate change will create more uncertainty and greater susceptibility of populations to stressors such as disease. Taking a harm-reduction approach to conserving natural resources is therefore not only prudent but our responsibility and the best available framework for mitigating impacts.

REFERENCES

Aguirre AA, Hansen DE, Starkey EE (1994) Animal Disease Issues in the National Park System clarified by nationwide survey. Park Science 14:14–15

Aguirre AA, Hansen DE, Starkey EE (1995) Special initiative project: animal disease issues in the national park system. US. Dept Interior National Park Service, Pacific Northwest Region Cooperative Park Studies Unit Technical Report NPS/PNROSU/NRTR-93/16. 126pp.

Berger KA, Ginsberg HS, Dugas KD, Hamel LH, Mather TN

(2014) Adverse moisture events predict seasonal abundance of Lyme disease vector ticks (Ixodes scapularis). Parasites & Vectors 7:181–189

Brownstein JS, Holford TR, Fish D (2005) Effect of Climate Change on Lyme Disease Risk in North America. Ecohealth

2(1):38–46

Byers, J.E. (2020) Effects of climate change on parasites and disease in estuarine and nearshore environments. PLoS Biology 18(11): c3000743.

Civitello DJ, Cohen J, Fatima H, Halstead NT, Liriano J, McMahon TA, Ortega CN, Sauer EL, Sehgal T, Young S, Rohr JR (2015) Biodiversity inhibits parasites: Broad evidence for the dilution effect. Proceedings of the National Academies of Sciences U S A 112(28):8667–8671

Cohen, J.M., Sauer, E.L., Santiago, O., Spencer, S., Rohr, J.R. (2020) Divergent impacts of warming weather on wildlife disease risk across climates. Science 370(6519): eabb1702.

Colwell, R., Avery, S., Berger, J., Davis, G.E., Hamilton, H., Lovejoy, T., Malcom, S., Mcmullen, A., Novacek, M., Roberts, R.J. and Tapia, R (2012) Revisiting Leopold: resource stewardship in the national parks. National Park System Advisory Board Science Committee, Washington, DC, USA.

Daszak P, Cunningham AA, Hyatt AD (2001) Anthropogenic environmental change and the emergence of infectious diseases in wildlife. Acta Tropica 78(2):103–116

Eads EA, Hoogland JL (2017) Precipitation, climate change, and parasitism of prairie dogs by fleas that transmit plague. Journal of Parasitology 103(4):309–319

Eisen, L., Barker, C.M., Moore, C.G., Pape, W.J., Winters, A.M., Cheronis, N. (2010) Irrigated agriculture is an important risk factor for West Nile virus disease in the hyperendemic LarimerBoulder-Weld area of North Central Colorado. Journal of Medical Entomology 47(5):939–51. Available from: http://ope nurl.ingenta.com/content/xref?genre=article&issn=0022-2585&volume=47&issue=5&spage=939

Engelthaler DM, Mosley DG, Cheek JE, Levy CE, Komatsu KK, Ettestad,P.... Bryan, R. T. (1999) Climatic and Environmental Patterns Associated with Hantavirus Pulmonary Syndrome, Managing Wildlife Disease Under Climate Change 409

Four Corners Region. United States. Emerging Infectious Diseases 5(1):87–94

Faiman, R., Solon-Biet, S., Sullivan, M., Huestis, D.L., Lehmann, T. (2017) The contribution of dietary restriction to extended longevity in the malaria vector Anopheles coluzzii . Parasites and Vectors 10(156). https://doi.org/10.1186/s13071-017-2088-6.

Feldman RE, Peers MJL, Pickles RSA, Thornton D, Murray DL (2017) Climate driven range divergence among host species affects range-wide patterns of parasitism. Global Ecology and Conservation 9:1–10

Fisichelli NA, Schuurman GW, Hawkins-Hoffman C (2016) Is 'resilience' maladaptive? Towards an accurate lexicon for climate change adaptation Environmental Management 57:753– 758

Gardner AM, Hamer GL, Hines AM, Christina M, Walker ED, Ruiz MO (2012) Weather variability affects abundance of larval Culex (Diptera: Culicidae) in storm water catch basins in suburban Chicago. Journal of Medical Entomology 49(2):270–276

Gallagher, C. (2020) Making a case for harm reduction in invasive species management: the St. Kitts 'monkey problem'. In: Animals, Health, and Society, C. Stephen (editor), London, UK: CRC Press, pp 296–304.

Hahn MB, Monaghan AJ, Hayden MH, Eisen RJ, Delorey MJ, Lindsey NP, Nasci RS, Fischer M (2015) Meteorological conditions associated with increased incidence of West Nile virus disease in the United States, 2004–2012. Am J Trop Med Hyg. 92(5):1013–1022

Harrigan RJ, Thomassen HA, Buermann W, Smith TB (2012) A continental risk assessment of West Nile virus under climate change. Global Changes in Biology 20(8):2417–2425

Herrmann C, Gern L (2013) Survival of Ixodes ricinus (Acari: Ixodidae) nymphs under cold conditions is negatively influenced by frequent temperature variations. Ticks and Tick-Borne Diseases 4:445–451

IPCC Intergovernmental Panel on Climate Change (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the

Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Johnson PTJ, Lund PJ, Hartson RB, Yoshino TP (2009) Community diversity reduces Schistosoma mansoni transmission, host pathology and human infection risk. Proceedings of the Royal Society b: Biological Sciences 276(1662):1657–1663

Johnson PTJ, Thieltges DW (2010) Diversity, decoys and the dilution effect: how ecological communities affect disease risk. Journal of Experimental Biology 213(6):961–970

Johnson PTJ, Preston DL, Hoverman JT, LaFonte BE (2013) Host and parasite diversity jointly control disease risk in complex communities. Proceedings of the National Academy of Sciences 110(42):16916–16921

Johnson PTJ, Preston DL, Hoverman JT, Richgels KLD (2013) Biodiversity decreases disease through predictable changes in host community competence. Nature 494(7436):230

Kafle, P., Peller, P., Massolo, A., Hoberg, E., Leclerc, L.M., Tomaselli, M., Kutz, S. (2020) Range expansion of muskox lungworms track rapid arctic warming: implications for geographic colonization under climate forcing. Scientific Reports 10(17323). https://doi.org/10.1038/s41598-020-74358-5

Keesing F, Belden LK, Daszak P, Dobson A, Harvell CD, Holt RD, Hudson P, Jolles A, Jones KE, Mitchell CE, Myers SS, Bogich T, 410 D. Buttke et al.

Ostfeld RS (2010) Impacts of biodiversity on the emergence and transmission of infectious diseases. Nature 468(7324):647–652

Koenraadt CJM, Harrington LC (2008) Flushing effect of rain on container-inhabiting mosquitoes Aedes aegypti and Culex pipiens. Journal of Medical Entomology 45:28–35

Kutz SJ, Jenkins EJ, Veitch AM, Ducrocq J, Polley L, Elkin B, Lair S (2009) The Arctic as a model for anticipating, preventing, and mitigating climate change impacts on host-parasite interactions. Veterinary Parisitology 163(3):217–228

Lafferty KD (2009) The ecology of climate change and infectious diseases. Ecology 90(4):888–900

Liao CM, Huang TL, Cheng YH, Chen WY, Hsieh NH, Chen SC, Chio CP (2015) Assessing dengue infection risk in the southern region of Taiwan: implications for control. Epidemiology of Infections 143(5):1059–1072

Meagher M, Meyer ME (1994) On the origin of brucellosis in bison of Yellowstone National Park: a review. Conservation Biology 8(3):645–653

Monaghan AJ, Moore SM, Sampson KM, Beard CB, Eisen RJ (2015) Climate change influences on the annual onset of Lyme disease in the United States. Ticks and Tick-Borne Diseases 6(5):615–622

National Park Service (NPS) (2000) Final Environmental Impact Statement and bison management plan for the state of Montana and Yellowstone National Park (December 20, 2000) from US Department of the Interior National Park Service and US Department of Agriculture US Forest Service and Animal Plant Health Inspection Service 2000. Final Environmental Impact Statement and bison management plan for the state of Montana and Yellowstone National Park (December 20, 2000) from US Department of the Interior National Park Service and US Department of Agriculture US Forest Service and Animal Plant Health Inspection Service

National Park Service (NPS) (2002a) Director's Guidance Memorandum on Proposed oral vaccination of certain wildlife species in units of the National Park System with an oral rabies vaccine. 20 Feb 2002.

National Park Service (NPS) (2002b) Director's Guidance Memorandum on Chronic Wasting Disease: NPS Response to Chronic Wasting Disease of Deer and Elk, Memorandum (July 26, 2002) from R. Jones to provide regions and parks guidance on the NPS response to CWD.

National Park Service (NPS) 2006. The Guide to Managing the National Park System. Washington, DC: U.S. Department of the Interior, National Park Service.

National Park Service (NPS) (2012) Applying National Park Service

« BACK TO CONTENTS

Management Policies in the Context of Climate Change. Washington, DC: U.S. Department of the Interior, National Park Service. Available: https://www.nps.gov/subjects/climatech ange/upload/PM-12-02-Management-in-Context-Climate-Change508Compliant.pdf

Onyango MG, Bialosuknia SM, Payne AF, Mathias N, Kuo L, Vigneron A, DeGennaro M, Ciota AT, Kramer LD (2020) Increased temperatures reduce the vectorial capacity of Aedes mosquitoes for Zika virus. Emerging Microbes and Infections 9(1):67–77

Pecl GT, Arau´jo MB, Bell JD, Blanchard J, Bonebrake TC, Chen IC, Clark TD, Colwell RK, Danielsen F, Evenga˚rd B, Falconi L (2017) Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science

355(6332):1–9

Pickles RS, Thornton D, Feldman R, Marques A, Murray DL

(2013) Predicting shifts in parasite distribution with climate change: a multitrophic level approach. Global Changes in Biology 19(9):2645–2654

Rohr, J.R., Dobson, A.P., Johnson, P.T.J., Kilpatrick, A.M., Paull, S.H., Raffel, T.R., Ruize-Moreno, D., Thomas, M.B. (2011) Frontiers in climate change-disease research. Trends in Ecology and Evolution 26(6):270–7. Available from: http://www.pubme dcentral.nih.gov/articlerender.fcgi?artid=3374867&tool=pmcentrez &rendertype=abstract.

Rohr, J.R., Cohen, J.M. (2020) Understanding how temperature shifts could impact infectious disease. PLoS Biology

18(11):e3000938.

Sellars RW (1997) Preserving Nature in the National Parks: A History, New Haven: Yale University Press, pp 400

Shaman J, Day JF, Stieglitz M (2005) Drought-induced amplification and epidemic transmission of West Nile virus in southern Florida. Journal of Medical Entomology 42:134–141

Sleeman JM, Richgels KLD, White CL, Stephen C (2019) Integration of wildlife and environmental health into a One Health approach. Reviews in Science and Technology 38(1):91–102

Stallknecht DE, Allison AB, Park AW, Phillips JE, Goekjian VH, Nettles VF, Fischer JR (2015) Apparent increase of reported hemorrhagic disease in the midwestern and northeastern USA. Journal of Wildlife Diseases 51(2):348–361. https://doi.org/ 10.7589/2013-12-330

Stephen, C., Wade, J. (2018) Wildlife Population Welfare as Coherence Between Adapted Capacities and Environmental Realities: A Case Study of Threatened Lamprey on Vancouver Island Frontiers in Veterinary Science 5: https://doi.org/10.338 9/fvets.2018.00227.

Stephen, C., Wittrock, J., Wade, J. (2018) Using a Harm Reduction Approach in an Environmental Case Study of Fish and Wildlife Health. EcoHealth 15(6). https://doi.org/10.1007/s103 93-017-1311-4.

Tagliapietra V, Rosa R, Arnoldi D, Cagnacci F, Capelli G, Montarsi F, Hauffe HC, Rizzoli A (2011) Saturation deficit and deer density affect questing activity and local abundance of Ixodes ricinus (Acari, Ixodidae) in Italy. Veterinary Parasitology 183:114–124 van Panhuis, W.G., Choisy, M., Xiong, X., Chok, N.S., Akarasewi, P., Iamsirithaworn, S., Lam, S.K., Chong, C.K., Lam, F.C., Phommasak, B., Vongphrachanh, P., Bouaphanh, K., Rekol, H., Hien, N.T., Thai, P.Q., Duong, T.N., Chuang, J.H., Liu, Y.L., Ng, L.C., Shi, Y., Tayag, E.A., Roque, V.G. Jr, Lee, Suy, L.L., Jarman, R.G., Gibbons, R.V., Velasco, J.M., Yoon, I.K., Burke, D.S., Cummings, D.A. (2015) Region-wide synchrony and traveling waves of dengue across eight countries in Southeast Asia. Proceedings of the National Academies of the Sciences U S A 112(42):13069–74.

Walsh MG, de Smalen AW, Mor SM (2018) Climatic influence on anthrax suitability in warming northern latitudes. Scientific Reports 8(1):9269. https://doi.org/10.1038/s41598-018-27604-w

Wetzel EJ, Weigl PD (1994) Ecology implications for flying squirrels (Glaucomys spp.) of effects of temperature on the in vitro development and behavior of Strongyloides robustus. American Midland Naturalist 131:43–54

Wobeser G (2002) Disease management strategies for wildlife. Reviews in Science and Technology 21(1):159–178

Zuliani, A., Massolo, A., Lysyk, T., Johnson, G., Marshall, S., Berger, K., Cork, S.C. (2015) Modelling the Northward Expansion of Culicoides sonorensis (Diptera: Ceratopogonidae) under Future Climate Scenarios. PLoS One 10(8):e0130294.

Toward an integrative molecular approach to wildlife disease

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Abstract: *Pathogens pose serious threats to human health, agricultural investment, and biodiversity conservation through the emergence of zoonoses, spillover to domestic livestock, and epizootic outbreaks. As such, wildlife managers are often tasked with mitigating the negative effects of disease. Yet, parasites form a major component of biodiversity that often persist. This is due to the logistical challenges of implementing management strategies and to insufficient understanding of host-parasite dynamics. We advocate for an inclusive understanding of molecular diversity in driving parasite infection and variable host disease states in wildlife systems. More specifically, we examine the roles of genetic, epigenetic, and commensal microbial variation in disease pathogenesis. These include mechanisms underlying parasite virulence and host resistance and tolerance, and the development, regulation, and parasite subversion of immune pathways, among other processes. Case studies of devil facial tumour disease in Tasmanian devils (*Sarcophilus harrisii*) and chytridiomycosis in globally distributed amphibians exemplify the broad range of questions that can be addressed by examining different facets of molecular diversity. For particularly complex systems, integrative molecular analyses present a promising frontier that can provide critical insights necessary to elucidate disease dynamics operating across scales. These insights enable more accurate risk assessment, reconstruction of transmission pathways, discernment of optimal intervention strategies, and development of more effective and ecologically sound treatments that minimize damage to the host population and environment. Such measures are crucial when mitigating threats posed by wildlife diseases to humans, domestic animals, and species of conservation concern.*

Introduction

Integrative molecular approaches have yielded novel insights into human disease at a variety of scales. Independent and concurrent analysis of genetic, epigenetic, and commensal microbial diversity has elucidated proximate and ultimate drivers of disease state and transformed the understanding of pathogenesis, transmission, and treatment (Pacis et al. 2014; Hand 2016). Similar analyses have only recently appeared within the context of wildlife disease and conservation science. We argue that the adoption of diverse molecular methods in wildlife disease will provide a more thorough appreciation of mechanisms that underlie host disease states and ultimately translate into more effective population monitoring, management, and conservation.

Wildlife disease can pose significant threats to human health, agricultural investment, and biodiversity conservation through the emergence of zoonoses, spillover to domestic livestock, and epizootic outbreaks (Daszak et al. 2000). Initially, theoretical models suggested that disease-mediated declines would halt transmission before host extinction could occur (Anderson & May 1979). Although this is true for many pathogens with density-dependent transmission, these well-defined thresholds are often nonexistent for host-parasite systems with more nuanced transmission structures (Getz & Pickering 1983). Complications include free-living parasite stages, endangered hosts sharing parasites with abundant reservoir populations, and systems with frequency-dependent transmission (Lafferty & Gerber 2002; Lafferty et al. 2015). Consequently, managers are tasked with mitigating wildlife disease in systems of varying complexity. Yet, the elimination of harmful parasites remains elusive due to the logistical challenges of reaching adequate proportions of wildlife, limited monetary and veterinary resources, and insufficient understanding of the numerous drivers underlying host disease state.

Environmental, immunological, behavioural, demographic, physiological, and molecular mechanisms contribute to the expression of host disease phenotype (Fig. 1). Although many of these factors have been reviewed elsewhere, a comprehensive understanding of molecular diversity in the context of wildlife disease is lacking. In many studies, *molecular diversity* is considered synonymous with *genetic diversity*, but this fails to consider 2 additional components critical to proper immune functioning in hosts: epigenetic gene regulation and commensal microbial communities.

We reviewed recent advances in understanding the molecular underpinnings of wildlife disease and examined how molecular methods can inform the management of disease dynamics operating across scales. We considered numerous examples to highlight questions that can be addressed with each molecular data type (i.e., parasite genetics, host genetics, epigenetic gene regulation, and commensal microbial variation). Two pathogens serve as our primary examples: devil facial tumour disease (DFTD) in Tasmanian devils (*Sarcophilus harrisii*) and chytridiomycosis in globally distributed amphibians (Table 1). These diseases lie at the frontier of applying an integrative molecular approach to wildlife disease, and demonstrate the numerous insights that can be gleaned from adopting these methods.

Genetic Analyses of Wildlife Disease

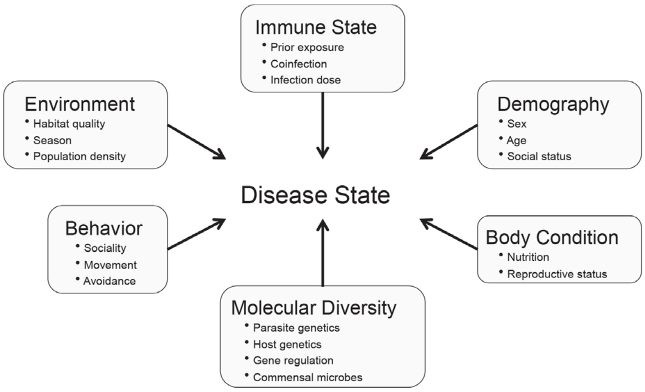


Figure 1. Factors affecting host disease state. Though presented as discrete categories, factors and subfactors often co-occur and interact to form a complex web of connections driving host disease state across scales. See examples in Supporting Information for more information on factors, subfactors, and interactions.

« BACK TO CONTENTS

Two central concepts have emerged in the history of genetic analyses and disease: parasite virulence and host resistance and tolerance are genetically based traits, and hosts and parasites are locked in a coevolutionary arms race, constantly evolving to obtain a mutational advantage over one another. Although this race is often asymmetrical due to the shorter generation time of pathogens, variation is the key driver of evolutionary change for both players. Thus, the application of molecular genetic techniques to the study of wildlife disease has typically focused on characterizing genetic diversity in parasites and their hosts and leveraging that information to discern selection on parasite transmission and host immunity. Technology has evolved from microsatellite markers through gene sequences to genomic data sets, but the core questions remain. It is the ability to address these questions that is considerably enhanced by large-scale data sets and the increasing array of programs with which to analyze them.

Parasite Genetics

The study of parasite genetics has moved from broad-brush pathogen identification (McManus & Bowles 1996) to more nuanced elucidation of complex transmission dynamics (Webster et al. 2016). This is particularly important when managing endangered populations threatened by generalist parasites. Under these scenarios, multi-host transmission can be the difference between population persistence and local extinction. For example, disease remains a primary threat to endangered Ethiopian wolves (*Canis simensis*) (Randall et al. 2004; Gordon et al. 2015). Though their population is too small to sustain pathogens such as canine distemper virus and rabies, the large population of dogs nearby is consistently identified as the source of disease outbreaks through viral sequencing. This renders both wolves and dogs critical targets for management.

Studies of parasite genetics can also be used to identify the subtle mechanisms underlying infection and *virulence* or damage to the host through parasite interactions (Schmid-Hempel 2011).

These mechanisms can arise through mutation or horizontal gene transfer and facilitate processes such as toxin production, host cell invasion, and immune evasion that enable parasites to infect, propagate, transmit, and in some cases switch hosts (Hacker & Kaper 2000; Geoghegan et al. 2016). Avian influenza, for example, undergoes frequent mutation to sequentially infect the host respiratory tract and avoid sites of infection that limit transmission (Reperant et al. 2012). For *Mycoplasma gallisepticum*, the bacterial pathogen that causes conjunctivitis in House Finches (*Haemorhous mexicanus*), quantitative genetic tools paired with disease phenotype data suggest rapid evolution of increased transmission potential and virulence upon emergence in a new host population (Hawley et al. 2013). By elucidating the specific molecular mechanisms underlying infection and virulence, one can pursue refined diagnostic tools, vaccination strategies, and therapeutic interventions (Johnston et al. 1999). Genomic analyses comparing pathogenic *Batrachochytrium* spp., the causative agent of chytridiomycosis, with free-living relatives, for example, reveal evolutionary adaptations for pathogenicity and infection strategies employed by different species (Farrer et al. 2017).

Disease characteristic	Devil facial tumour disease (DFTD)	Chytridiomycosis
Host	Tasmanian devils (Sarcophilus harrisii)	Amphibians
Infectious agent	Transmissible cancer cells	Batrachochytrium dendrobatidis fungus
Distribution	Tasmania, Australia	Global
Transmission mode	Allograft cells from contact with infected devils (especially biting)	Contact with infected individuals or local environment
Pathology and conservation concern	DFTD is characterized by aggressive, ulcerated tumours on the face and mouth of infected devils. Infection and mortality rates are extremely high, with most deaths caused by starvation or metastases and organ failure occurring within 6 months of tumour development. Since its first observation in 1996, DFTD has rapidly spread throughout the natural range of Tasmanian devils and remains the primary conservation concern threatening this iconic species. DFTD's status as a transmissible cancer renders it an ideal candidate for integrative molecular analyses, as these techniques can elucidate origin, transmission mode, and mechanisms of immune evasion.	Chytridiomycosis is an infectious skin disease implicated in driving amphibian declines on a global scale. Since its formal description in 1997, chytridiomycosis has been documented in over 700 amphibian species with multiple fungal strains, interacting in a variety of environmental contexts. Perhaps unsurprisingly, it is characterized by high levels of variability in morbidity and mortality of hosts. Integrative molecular analyses of chytridiomycosis can address the molecular bases of host resistance and tolerance, fungal virulence, and environmental mediation of disease progression, and ultimately lead to novel management strategies.
Disease caused by a similar infectious agent	Canine transmissible venereal tumour in dogs	Pseudogymnoascus destructans causes white-nose syndrome in bats
Sources	*Bender et al. 2014; Pye et al. 2016*	*Van Rooij et al. 2015; Lips 2016*

Table 1. Background information on devil facial tumour disease and chytridiomycosis

>>>22

This represents a promising direction in chytridiomycosis research because parasite variability has been implicated in driving disease outcomes in hosts. Similar analyses of *Plasmodium* spp. suggest mechanisms of immune evasion in mosquito vectors (Molina-Cruz et al. 2015) and have identified loci associated with antimalarial drug resistance under positive selection (Shen et al. 2017). Genetic tools have also located hotspots of polygenomic malaria infection, where hosts harbour multiple parasite strains simultaneously (Rice et al. 2016). Considered together, this information enables better monitoring of where malaria transmission and polygenomic infection rates are high and suggests possible molecular mechanisms for disease control.

To pursue these research and management goals, genetic analyses have been conducted on a wide range of parasite taxa (Supporting Information). Going forward, it is critical to focus on additional pathogens in multi-host systems occurring in geographically diverse populations, particularly where spillover is likely. Further, it is important to perform comparative analyses in the contexts of host phenotype, genotype, and environment (Lazzaro & Little 2009).

Host Genetics

Studies of host genetics tend to focus on resistance, tolerance, and diversity. *Resistance* can be defined as the ability to eliminate parasites from the host, whereas *tolerance* imposes limits on the parasite's negative effects (Best et al. 2008, 2009; R˚aberg et al. 2009). Host fitness is intimately coupled with these traits and forms a significant component of their underlying mechanistic and molecular processes. In both cases, the prevailing paradigm is based on the assumption that genetic diversity at immune loci buffers hosts from disease risk. As such, demography resulting in genomic diversity loss (e.g., inbreeding) is often associated with increased likelihood of disease-mediated population decline (Spielman et al. 2004).

Early researchers examining host genetics in wildlife disease adopted a broad definition of *genetic diversity*. Employing neutral microsatellite markers, they calculated summary statistics to determine whether host genetics correlated with disease state. Although many reported significant relationships (Coltman et al. 1999), others failed to identify strong associations between neutral diversity and disease (Schwensow et al. 2007). This led many to question the efficacy of using neutral markers as a proxy for genome-wide variation (V¨ali et al. 2008) and ultimately shifted the field toward a more targeted immunogenetic approach.

In vertebrate systems, the major histocompatibility complex (MHC) dominated the literature. Critical to adaptive immunity, this hypervariable gene family encodes for MHC molecules that bind to antigens and display them on cell surfaces to initiate an immune response. This renders MHC variation a convenient target for candidate gene approaches. For example, analyses of Tasmanian devils threatened by DFTD suggest that low MHC diversity in hosts may provide means of immune evasion for this transmissible cancer (Siddle et al. 2007). Similar analyses in amphibians show associations between MHC diversity and survival in frogs experimentally infected with the pathogenic fungus *Batrachochytrium dendrobatidis* (Bd) and host species known to be Bd resistant (Fu & Waldman 2017).

The MHC-based explorations of host disease state consider only one aspect of immunity, however. Many other genes (e.g., Toll-like receptors) also aid host defence (Acevedo-Whitehouse & Cunningham 2006). Further, specific genes often associate with disease state more strongly than summary statistics of genetic variation (Bateson et al. 2016); thus, treating MHC diversity as a proxy for larger-scale immunogenetic variation may eventually prove too reductionist.

Genomic methods are increasingly used by conservation scientists to pursue more comprehensive analyses. Since publication of the first human genome, technological advances have rendered whole genome sequencing accessible for wildlife studies. Even when whole genomes are unavailable, restriction enzyme-based methods rapidly and affordably generate genome-wide data (Davey & Blaxter 2010). For example, genomic analyses confirmed low levels of standing variation in Tasmanian devils, identified geographic structuring of host populations, enabled reconstruction of DFTD emergence and transmission pathways, and supported allograft transmission of this contagious cancer (Murchison et al. 2012; Grueber et al. 2015; Morris et al. 2015; Hendricks et al. 2017).

Although in accordance with earlier MHC-based studies, genomic analyses enabled deeper understanding of the roles host and cancer genomics play in DFTD pathogenesis. They additionally positioned genetic diversity maintenance as a top conservation priority for wild and captive devil management.

We hope that more systems will benefit from similarly comprehensive analyses. Although the trend toward genome-level data comes with inherent difficulties, it provides critical insight into complex disease dynamics. By integrating the study of parasite and host genomics, wildlife managers can leverage better understanding of parasite virulence, transmission, and host disease state toward more effective prevention and management.

Host Gene Regulation in Immunity

For the immune system to properly function, genes must produce their corresponding antigen binding, recognition, and signaling proteins. Gene regulatory variation therefore arises as another contributor to host disease state. If an underlying genotype for host immunity is transcriptionally silenced, infection becomes likely. For example, suppression of inflammatory response genes in bats may allow them to asymptomatically harbor viruses that are highly damaging to nonvolant mammals (Brook & Dobson 2015; Banerjee et al. 2017).

Epigenetic mechanisms (e.g., DNA methylation, histone modification, etc.) can alter the expression of immune genes in response to environmental stimuli, thereby inducing or preventing an immune response (Morandini et al. 2016). Thus, effective immunity requires action from both genetic and epigenetic dimensions of the host genome: the genetic capacity to recognize and respond to a diverse array of parasites, the concerted expression of those genes, and the ability to overcome immune escape efforts.

The functional link between epigenetics and immunity is a burgeoning field. Although many studies focus on tumour growth, autoimmune disorders, and developmental changes, increasing attention is being paid to epigenetic mechanisms operating in infectious disease (Pacis et al. 2014; Zhao et al. 2015).

From the perspective of resistant hosts, fine-tuned regulation of immune genes and tissues targeted by pathogens may enable early detection and eradication of infecting parasites, as seen in some frogs experimentally infected with Bd (Ellison et al. 2014).

Where tolerance is preferred, suppression of these genes and their resultant processes (e.g., strong inflammatory responses) may ultimately lessen morbidity, as seen in bats infected with viruses (Banerjee et al. 2017).

Yet, it often appears that epigenetic alterations worsen disease outcomes for hosts. In accordance with the coevolutionary arms race, many parasites manipulate host epigenomes to facilitate immune evasion and withinhost proliferation (Paschos & Allday 2010). For example, *Leishmania* protozoans are hypothesized to alter DNA methylation patterns in macrophages to downregulate host defenses and promote parasite survival (McMaster et al. 2016).

Similarly, infection with influenza viruses and coronaviruses may induce histone modifications that alter immune signaling in favor of infecting parasites (Sch¨afer & Baric 2017). Such phenomena remain active areas of research, as scientists seek to uncover the diverse mechanisms used by parasites to circumvent host immunity (Supporting Information). Within wildlife systems, the field of ecological epigenetics has focused primarily on changes induced by behavior, diet, and environmental conditions. Only a few researchers have linked these changes to immune processes (Isaksson 2015), and fewer still have examined differences in gene regulation between host populations. In 1 example, Ellison et al. (2014) compared transcriptome data from 4 sympatric frog species with different Bd susceptibility. When exposed to a pathogenic strain of Bd, resistant species exhibited downregulation of skin inflammatory pathways and upregulation of genes pertaining to skin-barrier integrity and cell-mediated immune responses. These patterns suggests that resistant hosts maintain skin and immune functioning during infection. This contrasts susceptible species, which often succumb to immunosuppression and disease-mediated disruption of the skin barrier. Together, these results reveal important processes involved in chytridiomycosis morbidity and mortality across species.

Perhaps the strongest example of an integrative genomic, transcriptomic, and epigenetic approach to understanding disease pathogenesis occurs at the intersection of cancer and infectious disease with DFTD. Although genomic analyses revealed insights about host diversity and disease transmission, they have not elucidated specific mechanisms underlying emergence and immune evasion of this transmissible cancer. To address these questions, Murchison et al. (2010) considered functional variation alongside traditional genetic markers. Host and parasite genetics confirmed that tumours were genetically distinct from hosts and clonal in origin. Analyses of devil and tumour transcriptomes suggest that DFTD first arose in a mutated Schwann cell. Even though these cells function in local immunity, the Schwann cell origin of DFTD does not sufficiently explain the capacity of tumour cells to evade the immune system. More likely mechanisms appeared in analysis of expression profiles, which revealed upregulation in molecules associated with immune evasion and downregulation in molecules associated with tumour suppression. Considered alongside MHC-based and genomic analyses (Grueber et al. 2015; Morris et al. 2015), it seems that low immunogenetic diversity in hosts decreases the immune system's probability of detecting tumours that fail to display MHC class I molecules on their cell surfaces (Siddle et al. 2007, 2013). This failure appears to result from epigenetic changes that induce downregulation of antigen-processing genes in cancerous cells, which then allows tumour cells to slip under the immune system's radar. Critically, this may be reversible through epigenetic or immunological manipulation, which suggests a promising new direction for treatment (Siddle et al. 2013).

In the case of DFTD, chytridiomycosis, and other wildlife diseases, analyses of gene regulation provide a powerful tool for identifying mechanisms underlying pathogenesis and pursuing novel targets for treatment (Kungulovski & Jeltsch 2016). Yet, questions remain about the factors that operate alongside hosts and parasites to induce these changes. Recent evidence suggests that epigenetic mechanisms interact with commensal microbial communities inhabiting hosts, thus participating in regulatory cross-talk between the immune system, epigenome, and microbiome (Levy et al. 2015; Celluzzi & Masotti 2016). The importance of this cross-talk has yet to be elucidated, but mounting evidence suggests that a more complex understanding of immune regulation is needed.

Commensal Microbes and Dysbiosis

Studies of humans and model systems increasingly extol the importance of microbiomes in immunity. Commensal microbes have been implicated in developing the host immune system, shielding hosts from infection by competing with invaders, regulating immune responses through altered gene expression and immune signaling, and aiding resolution of responses once parasites are cleared (Supporting Information). Extreme examples are the fungal microbiomes of many plants that have self-organized into symbiotic immune systems that possess all the classic features of vertebrate immune systems (e.g., self- and nonself recognition and short- and long-term memory) (Berendsen et al. 2012).

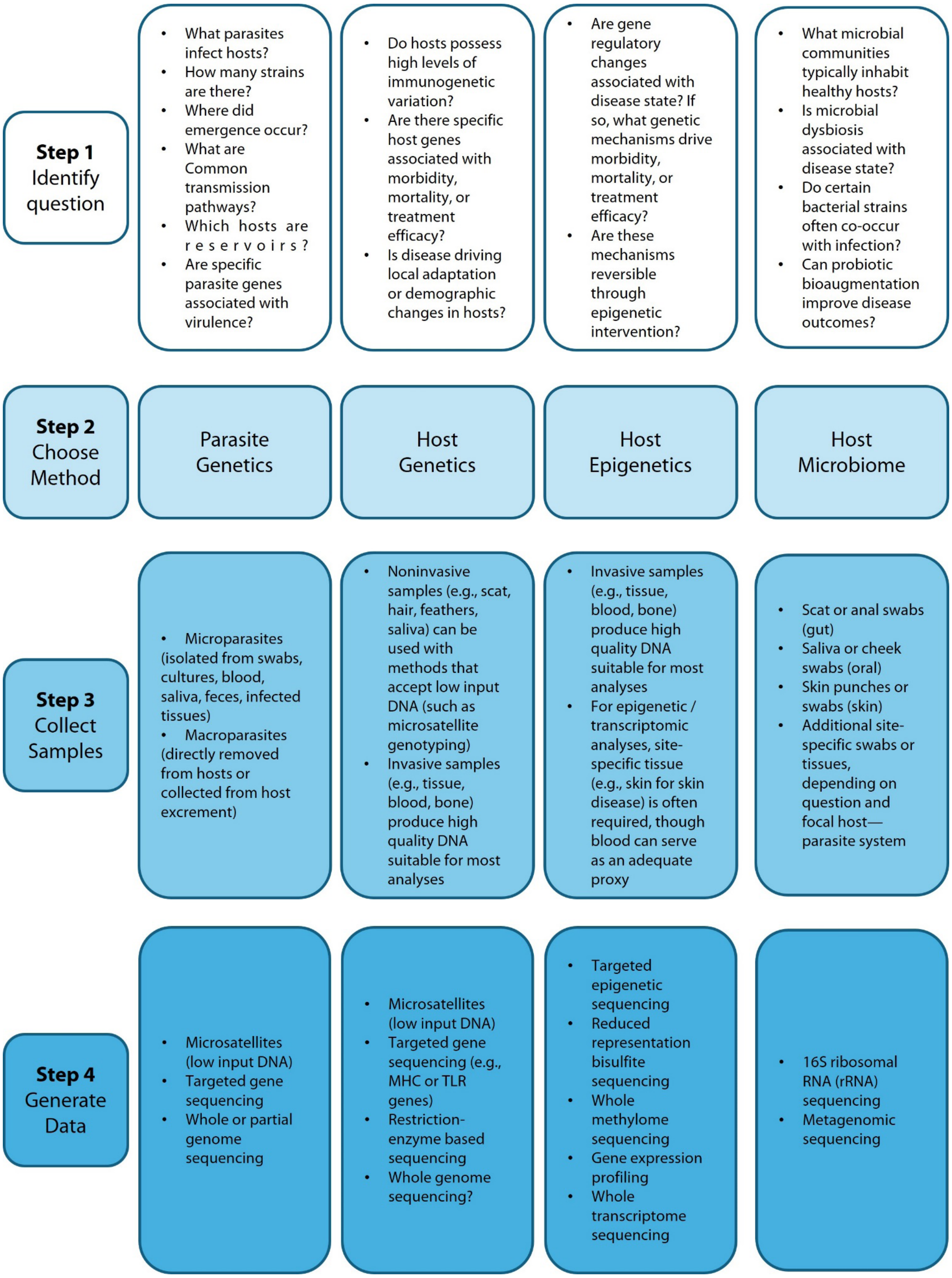
Unlike other aspects of host biology, microbial communities are both stable and flexible, rendering them particularly useful to immunity. Core microbiota, or resident commensals that consistently colonize certain body sites, are largely determined by host genetics (Goodrich et al. 2014). Healthy community composition is often taxon specific and putatively results from long-term coevolution (Colston & Jackson 2016). Transient and temporary resident microbes primarily derive from environmental and behavioral sources (Candela et al. 2012). These can rapidly change to reflect different external conditions or parasitic infections and may even function in larger scale adaptation of hosts (Shapira 2016).

In the absence of infection, commensal microbial communities aid homeostasis and are critical to host defense (Honda & Littman 2016). Yet, microbes do not present an impenetrable front. Termed *dysbiosis*, disruption of healthy microbial communities is often associated with autoimmunity and disease pathogenesis (Petersen & Round 2014). As a result, microbial analyses of human diseases have skyrocketed in the last decade as researchers seek to elucidate mechanisms underlying pathology and design novel treatments (Knight 2015).

The need for studies examining the role of microbial communities in wildlife disease is increasingly recognized (Redford et al. 2012). Many primarily seek to characterize microbiome structure in healthy individuals. For example, Cheng et al. (2015) sequenced microbial communities from wild and captive Tasmanian devils and noted distinct differences between them. This establishes a baseline for comparison with communities disrupted by captivity and DFTD. In other systems, such as chytridiomycosis, research has moved away from descriptive studies toward manipulative experiments seeking novel treatment options. Many amphibian species naturally harbor skin bacteria known to secrete metabolites harmful to Bd. Commensal microbial communities have therefore been associated with differing disease

>>>24

outcomes in host populations (Jani et al. 2017). In an effort to commandeer this phenomenon for disease management, treatment of *Rana muscosa* with Bd-resistant bacteria drastically decreased mortality in experimental trials (Harris et al. 2009). Similar results were reported for experimental manipulations of *Anaxyrus boreas* microbial communities, where the loss of Bd-inhibitory bacteria increased infection rates and the application of resistant bacteria increased survival (Kueneman et al. 2016). However, probiotic bioaugmentation may not be universally applicable as frog species harbor unique communities that differ in response to manipulation (Kueneman et al. 2014; Küng et al. 2014). In the case of probiotic-resistant species, community composition may act as a sentinel for estimating susceptibility across populations (Becker et al. 2015). By focusing on community structure and function, adoption of a multiomic approach may mitigate this difficulty through design of more effective taxon-specific probiotic therapies (Rebollar et al. 2016).



Step 1 Identify question	• What parasites infect hosts? • How many strains are there? • Where did emergence occur? • What are Common transmission pathways? • Which hosts are reservoirs? • Are specific parasite genes associated with virulence?	• Do hosts possess high levels of immunogenetic variation? • Are there specific host genes associated with morbidity, mortality, or treatment efficacy? • Is disease driving local adaptation or demographic changes in hosts?	• Are gene regulatory changes associated with disease state? If so, what genetic mechanisms drive morbidity, mortality, or treatment efficacy? • Are these mechanisms reversible through epigenetic intervention?	• What microbial communities typically inhabit healthy hosts? • Is microbial dysbiosis associated with disease state? • Do certain bacterial strains often co-occur with infection? • Can probiotic bioaugmentation improve disease outcomes?
Step 2 Choose Method	Parasite Genetics	Host Genetics	Host Epigenetics	Host Microbiome
Step 3 Collect Samples	• Microparasites (isolated from swabs, cultures, blood, saliva, feces, infected tissues) • Macroparasites (directly removed from hosts or collected from host excrement)	• Noninvasive samples (e.g., scat, hair, feathers, saliva) can be used with methods that accept low input DNA (such as microsatellite genotyping) • Invasive samples (e.g., tissue, blood, bone) produce high quality DNA suitable for most analyses	• Invasive samples (e.g., tissue, blood, bone) produce high quality DNA suitable for most analyses • For epigenetic / transcriptomic analyses, site-specific tissue (e.g., skin for skin disease) is often required, though blood can serve as an adequate proxy	• Scat or anal swabs (gut) • Saliva or cheek swabs (oral) • Skin punches or swabs (skin) • Additional site-specific swabs or tissues, depending on question and focal host—parasite system
Step 4 Generate Data	• Microsatellites (low input DNA) • Targeted gene sequencing • Whole or partial genome sequencing	• Microsatellites (low input DNA) • Targeted gene sequencing (e.g., MHC or TLR genes) • Restriction-enzyme based sequencing • Whole genome sequencing?	• Targeted epigenetic sequencing • Reduced representation bisulfite sequencing • Whole methylome sequencing • Gene expression profiling • Whole transcriptome sequencing	• 16S ribosomal RNA (rRNA) sequencing • Metagenomic sequencing

Figure 2. Steps in the application of molecular methods to wildlife disease. In step 1, the question of interest must be identified. In step 2, the molecular method selected needs to address the chosen question. In step 3, samples need to fit the selected method and financial and logistical constraints of sampling the host–parasite system. In step 4, the molecular dataset must be appropriate for addressing the question with the collected samples. For complex systems characterized by multiple questions, relevant methods are combined to adopt an integrative molecular approach. See Supporting Information for case studies in which molecular techniques informed management of wildlife disease.

Applying an Integrative Molecular Approach to Conservation

When examined in isolation, genetic, epigenetic, and microbial variation can provide key information about wildlife disease ecology that informs conservation. Although implementing these methods in wildlife comes with the inherent challenges of limited sampling opportunity, lack of reference genomes for nonmodel organisms, and high start-up costs of learning new laboratory and analytical techniques, it remains a worthwhile and versatile endeavor. Depending on the resources available, ability to collect samples, complexity of the host– parasite system, and questions most relevant to effective conservation, managers can pick and choose the methods that best address their needs (Fig. 2). Further, decreased sequencing costs and increasingly user-friendly analytical pipelines have rendered these methods accessible to studies of nonmodel organisms.

When multiple questions arise and resources allow, applying an integrative molecular approach represents an exciting new frontier in wildlife disease ecology. Concurrent examination of interconnected factors within molecular diversity can elucidate patterns and processes relevant to complex wildlife disease systems. As evidenced in case studies of DFTD and chytridiomycosis, analysis of genetic, gene regulatory, and microbial variation provides important insight into pathology, transmission dynamics, and novel avenues of treatment. For DFTD, genetic and transcriptomic analyses were needed to

« BACK TO CONTENTS

distinguish host from parasite, confirm allograft transmission and Schwann cell origin of the disease, and discover means of immune evasion through suppression of immune signaling amid minimal immunogenetic diversity in hosts. These insights have since informed management strategies, including ongoing treatment development and management of captive insurance populations (Pye et al. 2016). In the case of chytriodiomycosis, genetic and transcriptomic analyses have furthered understanding of immune processes involved in species-specific resistance to fungal infection, and microbial analyses have provided promising new treatment options through bioaugmentation with naturally Bd-resistant microbes (Bletz et al. 2013; Woodhams et al. 2016).

Overall, application of molecular methods will enable more effective monitoring and management of at-risk populations. Depending on questions and data types examined (Fig. 2), understanding of wildlife disease prevalence, pathology, and persistence can be improved. Parasite genetics can refine diagnostic techniques, reconstruct transmission pathways, and identify genes underlying virulence. Similar analyses in hosts can characterize host population structure, patterns of immunogenetic diversity, and specific genes associated with resistance and tolerance strategies. Further examination of gene regulatory diversity can identify specific mechanisms underlying successful parasite invasion and host morbidity that may serve as targets for epigenetic intervention. Finally, commensal microbial analyses can elucidate patterns of dysbiosis associated with host disease state and suggest probiotic bioaugmentation as a novel treatment strategy. Especially when considered alongside other drivers of disease state (Fig. 1), molecular analyses present innumerable opportunities to advance management of wildlife disease and mitigate threats posed to human and domestic animal health, agricultural systems, and wildlife populations. From examination of the human literature, it is evident that the technology for molecular analyses exists. The urgency of many conservation problems suggests that it is time these methods are applied to studies of wildlife disease.

Supporting Information

Tables containing additional citations serving as examples of factors affecting host susceptibility (Appendix S1), genetic analyses of parasites (Appendix S2), epigenetic, microbial, and integrative molecular analyses in human and model systems (Appendix S3), and molecular analyses informing wildlife conservation (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

References available on request.

The research uncovered a complex bacterial community in the mouths of hippos: 41 different species, many of them typically found in aquatic environments and capable of causing opportunistic infections in humans

The Hidden Dangers Beneath: What Hippo Bites Reveal About Antibiotic Resistance

The common hippopotamus occurs in rivers, lakes and wetlands in sub-Saharan Africa and is known for its aggressive behaviour when defending its territory and its young. Massive and surprisingly agile on land, hippopotami lead an amphibious lifestyle. They are often misrepresented as comical river dwellers. Yet, its reputation among local communities tells a darker, more sobering tale.

Unlike crocodiles, which are feared for their stealth and aquatic ambushes, hippopotami (Hippopotamus amphibius) present a double threat—equally dangerous on land and in water. With powerful jaws and razor-sharp long canine teeth, they are capable of inflicting grievous wounds. For those who survive an attack, however, the danger doesn't end with the bite.

Until recently, little was known about the bacteria that live in the mouths of these formidable creatures. But a groundbreaking, novel study led by Prof Anita Michel, research professor at the Faculty of Veterinary Science of the University of Pretoria (UP), with a research focus on bacterial zoonotic diseases transmitted at the wildlife-livestock-human interface, has illuminated a new layer of risk.

"We knew the injuries were extraordinary, especially with the exceptional biting force hippos possess," she explains, "but we didn't fully understand the link between the microbes and the severe complications from wound infections the clinicians had to deal with."

Prof Michel and her team which included Dr Annelize Jonker, a veterinary specialist bacteriologist from the faculty and Mr Francois Roux, an ecologist from the Mpumalanga Tourism and Parks Agency (MTPA), examined the oral bacteria of 34 healthy hippopotami captured during routine wildlife operations in the Mpumalanga province.

What they discovered was a complex bacterial community: 41 different species, many of them typically found in aquatic environments and capable of causing opportunistic infections in humans.

"This was the first time anyone systematically studied the bacterial flora of hippos' mouths," says Prof Michel. "And what we found was concerning—not just the types of bacteria, but their resistance to some of the most commonly used antibiotics."

The team tested the bacteria against a panel of antibiotic drugs and found moderate to high resistance to commonly prescribed treatments like amoxicillin/clavulanate and early-generation cephalosporins. These are staples in emergency medicine, especially for bite wounds from dogs and cats.

« BACK TO CONTENTS

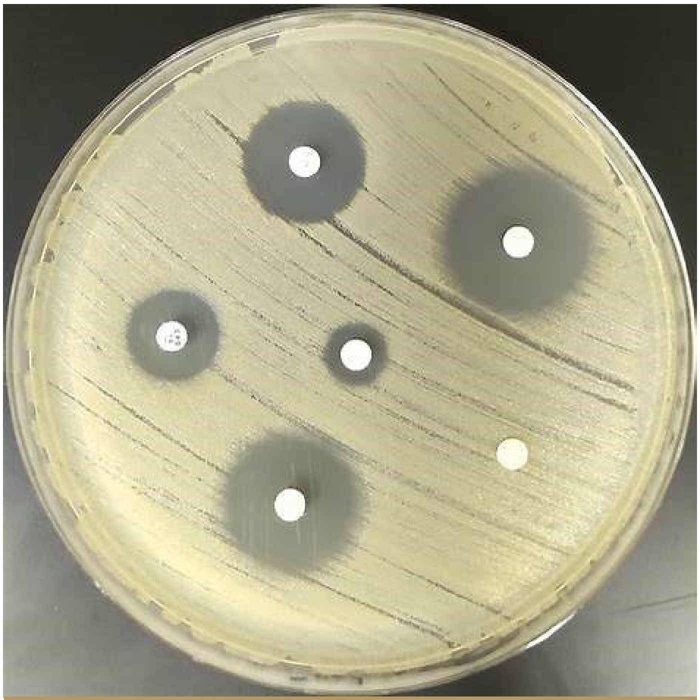
But as Prof Michel points out, “Using these standard antibiotics for a hippo bite may delay effective treatment and allow infections to take hold.”

Conversely, the study revealed that antibiotics from the tetracycline, aminoglycoside, and quinolone families were more effective, offering a potential lifeline in future cases. Yet, even with these options, time remains a critical factor.

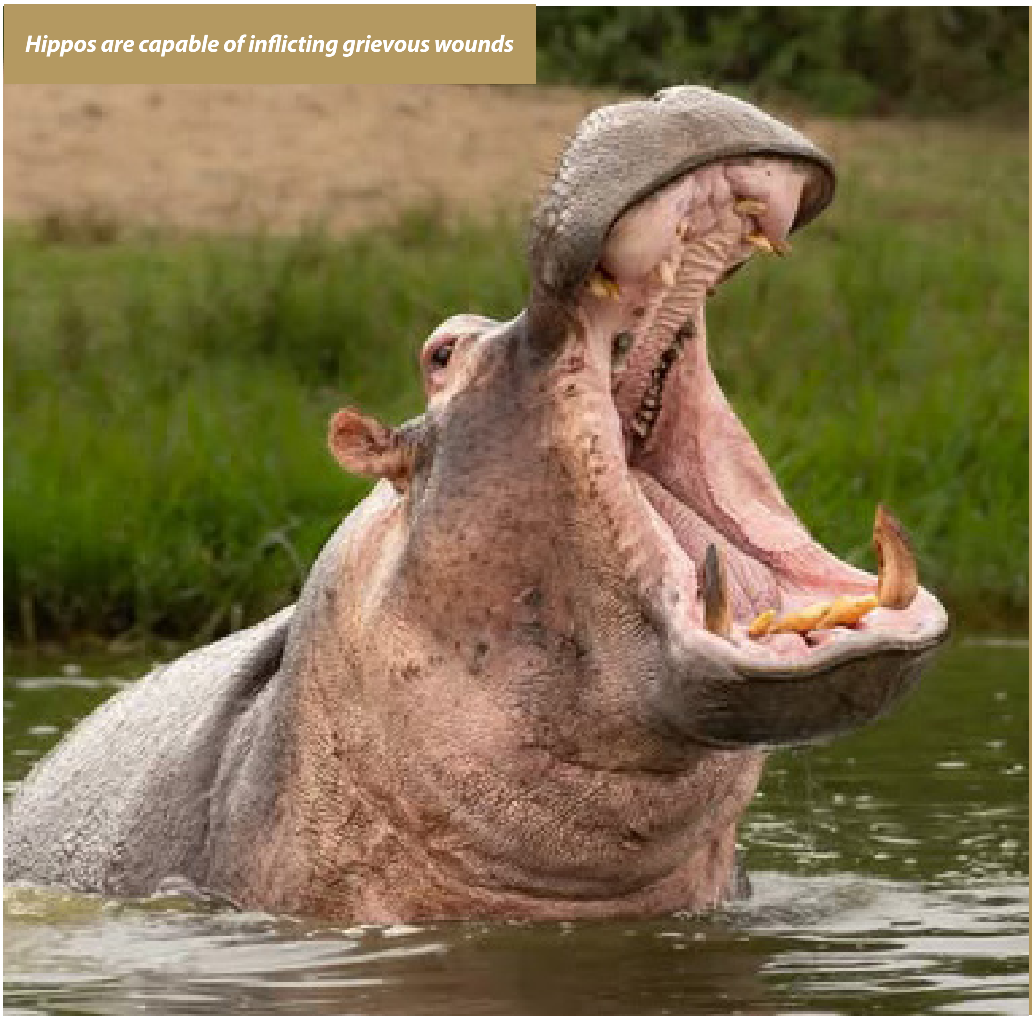
The researchers strongly recommend that wound cultures be taken as early as possible to identify the exact pathogens involved to ensure the best outcome for the patient admitted to a hospital. “It is critically important that wound infections, whether in animals or humans, are treated early on with an effective antibiotic regimen aligned with the expected causative infectious agents,” Prof Michel says.

The implications of this study extend beyond individual injuries. It offers a stark reminder that antibiotic resistance is not just a clinical or hospital issue—it is a wildlife issue too, shaped by ecosystems, species interactions, and the limits of human preparedness.

“Our goal,” says Prof Michel, “is to work in a One Health approach with healthcare providers in regions where humans and wildlife intersect to ensure that they are not caught off guard. When you’re dealing with a hippo bite, minutes matter—and so does the right antibiotic.” V



An antibiogram to determine the antibiotic resistance



Hippos are capable of inflicting grievous wounds

Click here for the published article in One Health Outlook:

https://bit.ly/OneHealthOutlook2025

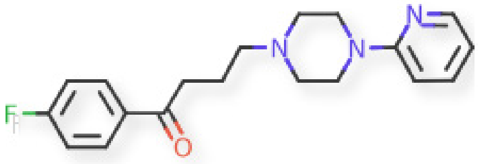
VS

MEDICINE SUPPLY CRISIS FOR LARGE ANIMAL PRACTICES

By J.G. du Toit

Veterinarians continue to experience problems with the availability of critical veterinary medicines due to the SA Health Products Regulatory Authority (SAHPRA) refusing the importation of the Active Pharmaceutical Ingredients (API's). Applications to import API's going back to June 2023 are either refused or not processed, and the situation is getting critical with another two essential veterinary medicines, Azaperone and Isometamidium.

Why do wildlife veterinarians prefer to use Azaperone?



Chemical structure

Azaperone is a compound with the molecular formula C19H22FN3O. Its chemical structure is characterised by a piperazine ring substituted with a 3-(4-fluorobenzoyl)propyl group and a 2-pyridinyl group.

FDA (Source)

Mechanism of action

Azaperone, a tranquiliser of the butyrophenone family, is often used for short-term tranquilisation or in combination with opioids (etorphine/fentanyl) and/or alpha-2 adrenergic agonists (Detomidine/medetomidine). Butyrophenones have dopaminergic (D2) antagonistic effects, resulting in tranquilisation and the potentiation of immobilisation. Further, azaperones' effect on the alpha1-adrenergic receptors results in peripheral vasodilation.

Azaperone counteracts the respiratory depressant effect of opiates, and given to rhinos at therapeutic doses, it produces deeper breathing. Azaperone also has effects on the central and peripheral noradrenergic system.

It causes slight bradycardia with reduced cardiac output and dilation of peripheral blood vessels with a drop in blood pressure (important with opioids in rhino immobilisation). All effects of azaperone have worn off after 6 – 8 hours (short acting, which is important because there is no product that can be used as an antidote). Immobilised animals are not at risk or vulnerable after immobilisation.

Indications for use specifying the target species

- In some species, such as African elephants that are sensitive to opioid-induced hypertension, the addition of azaperone may reduce the risk of pulmonary oedema.
- Short half-life makes it a safe sedative to use in all herbivorous wildlife species.
- Mixtures - In recent years, mixtures containing a very low dose of potent opioid combined with a higher dose of the alpha-2 adrenergic agonist medetomidine, either alone or in combination with azaperone, have gained increasing popularity.

Advantages of azaperone

- The product is safe to use in wildlife with the right drug combinations.
- The product takes effect in 20 minutes.
- It is short-acting, and it is not necessary to administer an antidote.
- A relatively cheap product that makes darting of less expensive wildlife species possible.
- Suppresses aggression in swine species.
- It will prevent adrenaline-induced cardiac fibrillation.
- Will lower blood pressure, especially in rhinos.
- The product is concentrated (100 mg/mℓ) and can be compounded in a dart with a small volume of 2 mℓ. However, the commercial product Stresnil is 40 mg/mℓ and does not fit into a 2 mℓ dart with most commonly used immobilisation combinations.
- Can mix easily with water-soluble immobilising agents. The latter cannot mix with Valium, which is not water soluble and will precipitate.

Effect on the industry

- Animal mortalities can be expected to increase during capture operations.
- Animal mortalities can be expected to increase during quarantine periods.
- Capture costs will increase.
- The increase in capture costs may influence ranchers not to sell animals at auctions, with a loss of income for owners.
- Owners would rather hunt animals at a cost to biodiversity.
- Owners who will not sell on game auctions will lead to a loss of income for wildlife veterinarians.

The role of the wildlife veterinarian

I foresee that claims will slowly build up due to financial losses in the industry. The wildlife veterinarians must organise themselves through the wildlife group and build up a database with forensic evidence of animal losses; date, species, age, sex, value and reason for the mortality related to drugs not available. This data can be used in a court of law if necessary.

How do large animal veterinarians control trypanosomiasis?

Trypanosomiasis

During 1920 – 1965, game animals were killed to eliminate wildlife that hosts the trypanosoma parasite. A total 778 152 animals were killed in Botswana, Zimbabwe and KwaZulu-Natal. This method

Tsetse control officers shooting wildlife to eliminate the host (Source OVI)

« BACK TO CONTENTS

was eventually stopped by the pressure of conservationists. The next method was to target the tsetse fly that transmits the parasite between animals. The flies were sprayed with DDT using aircraft. The first spraying was done on 26 November 1845. The tsetse fly was largely eliminated in the early 1950s with this spraying method. Using 230 Harris traps, the number of flies caught in them dropped from 22,007 in November 1945 to 3705 in March 1946 and by September 1946, 291 Harris traps caught only 405 flies. The influence on the environment was severe on apex species such as the fish eagle. The eggs of the birds did not hatch. In 1953, the spraying with DDT was stopped when only one fly was caught.

Epidemiology

The ***agent,*** a tsetse-borne trypanosomiasis, is a widespread protozoal disease affecting wildlife, livestock and people in sub-Saharan Africa. African animal trypanosomiasis (AAT) is a very important disease of domestic livestock in sub-Saharan Africa. According to the Food and Agriculture Organisation of the United Nations (FAO), it is probably the only disease which has profoundly affected the settlement and economic development of a major part of a continent. Animal trypanosomiasis affects the health and productivity of livestock. It occurs in 37 sub-Saharan countries covering about 9 million km^2, an area which corresponds approximately to one-third of Africa's total land area.

Aerial spraying in Zululand with DDT to kill the tsetse fly (Source: Bookshop)

The epidemiology of AAT in tsetse-infected areas of Africa is determined by four biological factors, namely: trypanosomes, tsetse flies, reservoir hosts and livestock. The *Trypanosoma brucei* complex comprises three morphologically identical subspecies: *T. brucei brucei, T. b. rhodesiense*, and *T. b. gambiense*. Only *T. brucei brucei* is pathogenic to cattle; the other subspecies cause acute sleeping sickness in humans in East Africa and chronic sleeping sickness in West Africa.

Trypanosoma parasite (Source: OVI)

The ***vector***, tsetse flies (*Glossina* spp.), are found only in Africa. They are the biological and/or mechanical vector of trypanosomes and constitute a potent and constant threat to humans and livestock over much of sub-Saharan Africa. Tsetse feed exclusively on blood. They are holometabolous insects with females giving birth to full-grown larvae, which rapidly pupate in the soil. The tsetse fly is very sensitive to environmental conditions and will not survive in areas that are too hot, too dry, or too high above sea level. The ***hosts*** are several usually dark coloured wildlife species such as warthog, bush pig, duiker, bush buck, kudu, buffalo, black rhino, and monitor lizard.

These animals are the natural hosts of tsetse and may acquire prolonged, symptomless trypanosome infections. Nagana is still a controlled disease in South Africa, and it has reappeared in northern KwaZulu-Natal. The tsetse was present in the areas north and east of the Lebombo Mountains. With climate change, the tsetse fly moved west towards Pongola and south to Matubathuba.

Clinical signs

The clinical signs in cattle are a fluctuating fever, listlessness, anaemia, loss of weight and enlarged lymph nodes. Wild animals can carry the parasites without showing signs of the disease and therefore serve as a source of infection for tsetse flies.

Treatment

Trypanocidal drugs are the most widely applied method that farmers use to treat and prevent trypanosomiasis in sub-Saharan Africa. Currently, the three large animal practices that treat cattle with Isometamidium chloride save the lives of about 20,000 head of cattle per annum. These cattle belong to communal farmers.

Conclusion

Urgent intervention at the ministerial level is required to find a workable solution for this crisis. Under the current conditions, veterinarians are compromised and cannot offer proper veterinary care to wildlife and livestock. There are already two appeal applications with the Minister of Health brought by V-Tech to obtain access to Yohimbine and Trilostane, but the list appears to be getting longer by the day. We can only hope that SAHPRA will engage with interested parties to find workable solutions to avert a further crisis.

SAVA AWARDS

2024 AWARDS

South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

SAVA Commendation - 2024

TIn recognition of sustained and selfless services to indigent animal owners.

DR KATHERYN KOTZE

Prof Gareth Bath, Ms Claudia Cloete (receiving the Commendation on behalf of Dr Katheryn Kotze) and Dr Ziyanda Majokweni

Frame sponsored by

SAVA Community Veterinary Clinics

Since graduation in 2014, Katheryn Kotze has been involved in promoting and improving animal welfare. Initially with the Wetnose Animal Rescue Centre, in 2018 she established the Rooikoppies Veterinary Clinic and in June 2023 the Rooikoppies CVC, intending to improve animal welfare and provide outreach work.

She recognised that the unplanned breeding of dogs and cats in disadvantaged communities played a key role in perpetuating the poor conditions of companion animals in these areas.

Working with seven animal welfare organizations, she has provided an excellent, appropriate veterinary service to indigent communities in her area, especially the provision of high-standard pet sterilisations in these communities.

The number of animals sterilized per year has risen from around 3500 to over 11,000 – a very laudable and valuable service to animal welfare and the owners of these animals. The total number of sterilisations done by the team under her supervision over the period from 2018 to 2023 amounts to over 36,000. Katheryn Kotze has been an inspiring example of selfless service and therefore receives a Commendation from the South African Veterinary Association. V

Young Veterinarian of the Year - 2024

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.

DR ROWAN LEEMING

Dr Rowan Leeming with Dr Johan Oosthuyse from V-Tech, Prof Gareth Bath and Dr Ziyanda Majokweni

Following graduation in 2015, Rowan Leeming found his hopes fulfilled when he succeeded in his application to serve his Compulsory Community Service year at Ezemvelo KZN Wildlife, centred at Hluhluwe.

« BACK TO CONTENTS

Award sponsored by V-Tech®

Guided by his mentors Dave Cooper and others, he was immediately exposed to rhino capture and translocation and was involved in more than 30 such operations within the first 2 months.

Rowan gladly and fully accepted the challenges and opportunities presented and by July 2016 he was entrusted with the darting of rhinos from a helicopter.
By the end of the year, he had darted over 110 rhinos from helicopters. His supervisors were clearly impressed by his progress and skills, so at the end of his CCS year, they found funding to continue his services on a contract basis.

This was repeated until 2022 when he was permanently employed by EKW, where in 2024 he was promoted to Chief Veterinarian. Poaching of rhinos was becoming an increasing problem and Rowan became involved in forensic postmortems to assist with prosecutions, as well as extensive de-horning of both black and white rhino populations in affected Parks.

In 8 years, Rowan Leeming has become proficient in immobilizing and translocating many iconic species, including 1300 rhinos, 350 wild dogs, 70 elephants and 150 lions.

This has facilitated the strategic transfer of wildlife to and from several wildlife reserves within South Africa and other countries in Africa.

His recognition as an expert so early in his veterinary career makes Rowan a very fitting recipient of the SAVA's Young Veterinarian of the Year Award.

SAVA
South African Veterinary Association
Suid-Afrikaanse Veterinêre Vereniging

Honorary Associate Life Membership - 2024

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.

MS ELIZE NICHOLAS

Ms Elize Nicholas with Dr Ziyanda Majokweni and Prof Gareth Bath.

Complex organisations like the South African Veterinary Association require considerable skills, leadership and teamwork to function effectively. The many contributions made by Elize Nicholas over 25 years have had a major impact on the smooth and efficient functioning of the SAVA. She quickly learnt how to manage the multiple aspects of its numerous constituent parts, and she is credited with a major achievement in overcoming the difficulties inherent in the changes that were required in the organisation, building and transferring to the new VetHouse. For this, Elize was awarded a SAVA Citation in 2009.

Organising and ensuring the smooth running of meetings for the Board of Directors, Federal Executive Council, AGMs, 4 Committees and all the other SA activities takes tact, firmness, teamwork and excellent interpersonal and communication skills – qualities that Elize as SAVA Secretary has in abundance. Altogether these duties comprise a multiplicity (more than 172) of tasks to be carried out annually, each one time-consuming and requiring meticulous attention to detail. Her reliability has been impeccable, and she is regularly entrusted with confidential matters, particularly in the Ethics and Mediation Committee.

AWARDS CONTINUE »

Keeping the interests and values of the SAVA and its membership uppermost in mind has earned Elize the highest regard and respect of a series of Presidents, Board Directors, Federal Councillors and Committees, as well as member veterinarians and a succession of VetHouse employees.

Above and beyond the call of duty, Elize Nicholas shows a real interest in the well-being of all SAVA members, keeping in touch with former officeholders and other veterinarians.

The SAVA is deeply indebted to Elize Nicholas for 25 years of superior, dedicated service to our profession and the Association, and she fully deserves recognition in the form of Honorary Associate Life Membership of the SAVA.

Research Award – 2024

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.

DR GARETH ZEILER

A consistent output of high-quality research has been a feature of Dr Zeiler's veterinary career. Of 52 articles in peer-reviewed journals, in which he was either a senior or co-author, 42 dealt with various aspects of anaesthesia or immobilisation in a wide variety of domestic and wild animals.

He has become internationally acknowledged for his expertise in anaesthesia and immobilisation, and he has edited a book on the subject as well as contributed to 13 of the chapters.

The full impact of his research is revealed firstly in his studies focused on the use of the impala as a research model for African antelope. In a series of 5 research articles, he and co-workers have provided a scientific basis for the safe capture, immobilisation and captive care of impalas. This includes the comparison of anaesthetic and immobilisation drug combinations indicating preferred options. By identifying the physiological effects of the drugs used in capture and anaesthesia, Dr Zeiler's research has made important contributions to the identification and lowering of associated risks. Good boma management has been identified, and together these research articles have helped to establish the usefulness of the impala as a research model for African antelope.

The second series of 4 articles deals with problems associated with blood loss and inappropriate fluid therapy in cats during surgery, leading to preventable deaths. By measuring clinical bio-markers including haemograms and acid-base measurements, the team under his leadership has provided comprehensive knowledge of the effects of rapid fluid replacement and has provided a novel clinical tool, in the form of a scoring system, for acute haemorrhage in cats under anaesthesia. These findings will enable improved decisions and appropriate treatment of cats suffering from acute haemorrhage under anaesthesia.

These targeted and well-designed studies published in peer-reviewed journals are clear evidence of excellence in veterinary research and Dr Gareth Zeiler is therefore the 2024 recipient of the Research Award of the SAVA.

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Dr Magda Germishuyse rceiving the Research Award on behalf of Dr Gareth Zeiler from Dr Johan Oosthuyse (V-Tech). Dr Ziyanda Majokweni and Prof Gareth Bath looks on

« BACK TO CONTENTS

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CALL FOR NOMINATIONS FOR SAVA AWARDS AND HONORARY MEMBERSHIP 2025

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, Sonja Ludik by
FRIDAY, THE 31ST JULY 2025
Nomination forms may be obtained from Ms Sonja Ludik
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The SAVA stress hotline, where colleagues make themselves available to talk to members in need through difficult situations or to refer them for professional help. For assistance, please contact our hotline on 0800 21 21 21.

Members can also contact one of our mentors:

Ken Pettey: 082 882 7356, ken.pettey@gmail.com

Aileen Pypers: 072 599 8737, aileen.vet@gmail.com

Willem Schultheiss: 082 323 7019, Willem.schultheiss@ceva.com

Mike Lowry: 084 581 2624, mikelowry@sai.co.za

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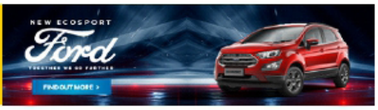

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Guardians of the Gate: Unpacking Veterinarians' Legal Muscle in South African Food Safety

Trudie Prinsloo (Legalvet Services)

This article is intended to provide information and educate veterinarians on relevant aspects of the law. It is not intended as personal legal advice. SAVA is not responsible or liable for any advice or other information provided herein.

The integrity of the food supply chain is paramount to safeguarding both public and animal health. Often operating behind the scenes, veterinary professionals have significant, often underappreciated, legal authority in ensuring the safety of animal-derived food products.

This article aims to highlight the key legal powers and responsibilities vested in veterinarians. Food safety legislation is contained in several acts and regulations, including the Meat Safety Act and the Animal Diseases Act, which empowers vets to navigate their crucial role in protecting the nation's food supply.

The Meat Safety Act

The cornerstone of meat safety regulation is the Meat Safety Act. Its primary objective is to ensure the safety and hygiene of meat and meat products intended for both human and animal consumption. The Act empowers registered veterinarians significantly, particularly when they are officially designated as "meat inspectors."

It's important to note that veterinarians are not automatically empowered to act as meat inspectors solely by virtue of their veterinary registration. The Act outlines a process for the appointment of meat inspectors, which involves authorization by the designated official of the Department of Agriculture, Land Reform and Rural Development (DALRRD).

Once appointed as meat inspectors, veterinarians are legally vested with substantial powers, including the right to enter premises where animals are slaughtered or meat is processed, handled, stored, or transported. They have the authority to inspect animals, meat, and related facilities to ensure compliance with hygiene standards and regulations. T

his includes conducting ante-mortem inspections of live animals before slaughter and post-mortem inspections of carcasses and organs to identify any signs of disease or contamination that could render the meat unsafe.

Furthermore, authorized veterinarians have the legal power to take samples of meat and related materials for laboratory analysis. If meat or meat products do not comply with safety standards or are deemed unfit for consumption, authorized veterinarians have the authority to seize and condemn such products.

The Act and its regulations also outline the legal requirements for the marking, handling, storage, and transportation of meat, and designated veterinarians play a crucial role in overseeing adherence to these standards. It's important for veterinarians to be aware of the offences and penalties associated with non-compliance with the Meat Safety Act and its regulations. The veterinarian's professional observations and documented findings can be critical in legal prosecutions.

The Animal Diseases Act

The Animal Diseases Act primarily aims to prevent the introduction and spread of animal diseases, but it plays a vital role in ensuring food safety, particularly concerning zoonotic diseases. Most relevant is the controlled diseases listed with their specific regulatory measures aimed at prevention and eradication of these diseases. These diseases must be reported to the relevant State Veterinarians. All veterinarians have a legal obligation to report any suspicion or confirmed cases of controlled diseases. This early reporting is crucial for preventing the widespread transmission of diseases that could potentially impact animal health and subsequently the safety of animal-derived food products.

Regarding controlled zoonotic diseases, such as brucellosis and tuberculosis, the Act and its regulations prescribe specific measures that veterinarians are responsible for implementing. These include regular testing of animals, reporting of suspicious cases and complying with movement restrictions, and quarantine procedures when implemented by the relevant State Veterinarians. These measures are essential in preventing the entry of diseased animals or their products into the food chain, thereby safeguarding food safety.

« BACK TO CONTENTS

The link between effective animal disease control, as mandated by this Act, and a safe food supply chain cannot be overstated. Veterinarians, both in the state and private sectors, are at the forefront of this effort, and understanding their legal responsibilities in identifying, reporting, and controlling animal diseases is fundamental to their role in food safety.

Other Relevant Legislation

Beyond the Meat Safety Act and the Animal Diseases Act, other legal frameworks contribute to food safety. The Foodstuffs, Cosmetics and Disinfectants Act while primarily focused on human food safety standards, has implications for the quality and safety of animal-derived ingredients and products. Veterinarians involved in the production or processing of animal products should be aware of relevant standards outlined in this Act.

Furthermore, local municipal by-laws can impose specific regulations related to animal keeping, abattoirs, and food handling within their jurisdictions. Practicing veterinarians involved with these practices should familiarise themselves with any such by-laws relevant to their area of practice. For veterinarians involved in the export of animal products, adherence to specific national and international export regulations, often requiring veterinary certification and compliance, is a legal necessity.

Practical Implications and Empowering Veterinarians

Understanding these legal powers and responsibilities is not merely an academic exercise but has direct implications for veterinarians' daily work. It empowers them to confidently exercise their authority when officially designated as meat inspectors and to fulfil their disease reporting and control obligations. Staying informed about the latest amendments to these Acts and their regulations is crucial.

Conclusion

South African veterinary professionals are indispensable guardians of food safety, wielding significant legal muscle through legislation such as the Meat Safety Act and the Animal Diseases Act. While formal appointment is required to act as meat inspectors, veterinarian's proactive role in disease control and adherence to relevant regulations forms a critical line of defence in ensuring a safe and healthy food supply for the nation. Embracing these legal responsibilities within the One Health framework is essential for safeguarding both animal and human well-being.

If you have any questions, please feel free to contact me at trudie@legalvetservices.co.za V

i The Meat Safety Act, No. 40 of 2000
ii The Animal Diseases Act, No. 35 of 1984
iii The Foodstuffs, Cosmetics and Disinfectants Act, Act No. 54 of 1972

Caries in Dogs (and some other species)

Dr Mareli van de Wetering & Prof Gerhard Steenkamp

Dental caries, commonly referred to as cavities, is an uncommon but important oral health problem in dogs. It is often overlooked during routine oral examinations and can have serious implications if not detected early.

Unlike humans, dogs are less prone to developing caries. This is largely due to several anatomical and physiological differences. The saliva of dogs is more alkaline, which helps to neutralize the acids formed during the fermentation of carbohydrates (Hale, 2009, Ramsden, 2023). Additionally, their teeth are more conical in shape with less occlusal surface contact and wider interdental spacing (Hale, 2009). Finally, most canine diets tend to be lower in highly fermentable carbohydrates, reducing the substrate available for acid-producing bacteria.

While both periodontal disease and caries involve dental plaque biofilms, their pathogenesis differs significantly. Caries are the result of demineralization or decalcification of the inorganic portion (enamel and dentin) of the tooth by acids which are produced during the process of bacterial fermentation of carbohydrates in the mouth. Once the enamel and dentin are compromised, bacteria gain access to the organic portion of the tooth—the pulp—which contains blood vessels and nerves. This invasion results in pulpitis and, eventually, pulp necrosis, sometimes accompanied by periapical pathology.

The body may attempt to protect the pulp by depositing tertiary dentin in response to carious insult. However, if the rate of bacterial degradation outpaces this protective mechanism, the pulp becomes exposed (Ramsden, 2023).

Clinically, caries should be suspected if a periodontal explorer "catches" or sticks in a discoloured or softened area of the tooth (Hale, 2009). Healthy enamel is too hard to be penetrated by pressing with the tip of a periodontal explorer on the tooth surface (Hale, 2009). In early stages, lesions may appear as chalky white spots—referred to as incipient lesions—indicative of enamel demineralization (Ramsden, 2023). The tooth most commonly affected in dogs is the maxillary first molar (Fig. 1), particularly on its occlusal surface (Hale, 2009).

Figure 1: Caries affecting the 1st and 2nd molar teeth in the right maxilla of this dog

If a lesion is suspected, intraoral dental radiographs are essential to assess the extent and severity of the damage (Fig. 2).

Figure 2: Radiograph of the left mandibular 1st molar tooth of a dog. The caudal cusp has been destroyed by caries and the pulp is exposed. Pulpitis is present as there are two apical lesions present at both root apices

Treatment options depend on the stage of the lesion. In early or moderate cases, restorative treatment by a veterinary dental specialist may be possible. Unfortunately, most cases are identified only after significant tooth destruction has occurred, leaving extraction as the only viable option. Prevention is key. Regular professional dental cleanings and the application of dental sealants during these procedures can help reduce the risk of caries. At home, daily tooth brushing and limiting the intake of fermentable carbohydrates in the dog's diet are critical components of oral hygiene.

Figure 3: Three interproximal caries lesions in the incisor teeth of a chimpanzee in the process of being restored. The blue gel is a weak acid gel used to clean the dentinal walls before a final restoration is placed

Caries have never been described in the cat. The anatomy of feline teeth and cat diets seems to have a preventative effect. Other species where caries occur commonly are the Primates (Fig. 3), especially when they are on a diet high in fermentable sugars like fruits and candy bars.

« BACK TO CONTENTS

Figure 4: Caries-like lesion in the left molar of an Indian elephant

Infundibular necrosis of maxillary cheek teeth in horses may well be seen as a form of caries. Lastly, the authors have also seen similar lesions to infundibular necrosis (if not caries) affecting elephants (Fig. 4).

Treatment of all these species is based on the extent of the destruction. Small superficial lesions may be treated as for dogs.

Lesions penetrating the pulp where the tooth structure is still reserved may have root canal therapy with restorations or even a crown. Teeth with severe structural damage should be extracted. V

HALE, F. A. 2009. Dental caries in the dog. *The Canadian Veterinary Journal,* 50**,** 1301.

RAMSDEN, S. 2023. Causes and prevention of caries (cavities) in dogs. *The Veterinary Nurse,* 14**,** 130-133.

Influential Life Coaching

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B.Sc. B.V.Sc.

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I hope this article finds you and your families well and safe!!!

Last month, we looked at being brutally honest in reflection and communication that's both truthful and kind, direct yet considerate. This month, we will discuss priorities. Busy workdays and home days, seemingly never-ending responsibilities, and DIY projects, as well as overflowing calendars with webinars, Zoom meetings and phone calls.I commonly hear from professionals who struggle to keep up. Long to-do lists can be exhausting or lead to burnout. Scheduling downtime and self-care is also a challenge when deadlines and responsibilities loom.

Here are eight tips on how to better manage time to **increase efficiency and reduce procrastination**:

A. MANAGE YOUR TO-DO LIST

Somehow, the more we work, the longer our to-do lists get, making us feel frustrated and defeated. It can be difficult to keep track of everything. Stay organised and accountable by making a list of everything you need to get done. Once your list is written, consider what needs the most attention, how much time each task may take, and which items can wait. Prioritise a few to focus on immediately. Do not be frustrated by the lower-priority tasks, but remind yourself that you will soon be available for them.

B. LEARN TO SAY NO

That is the best gift I have ever given myself!!!! Be kind to yourself. Looking at your list, are there items that overextend you? Are there any tasks you can ask someone else to help with?

It is noble to want to do it all, but if your health or the completion of another task could be jeopardised, consider passing. My father taught me to work smarter and not necessarily harder all the time. Consider it.

C. MAKE AND KEEP "APPOINTMENTS" WITH YOURSELF

Yes, you can! You have prioritised the to-do list, and it is time to get to work. Schedule your day as if each task has its own appointment.

If you know you have a few meetings or other appointments during the day, plan the tasks around those. Maintaining structure reduces distractions and procrastination. This is a skill I have gotten better at – it is impressive!

D. SHORT PERIOD FOCUS BURSTS

Avoid working on a single task for several hours at a time – it tends to ruin momentum. Furthermore, starting a task and not stopping until it is finished may encourage procrastination. Think about the effort it takes for certain tasks and whether you can spread them out over a few days. Within your "appointments," try to work in brief, regular intervals of attention. For example, if you plan to work for two hours on a task, set a timer for intervals of 20 minutes at a time and focus on that project only during the intervals. After the 20 minutes are up, consider a brief break, no longer than 5 minutes. Done this with many people, including my daughter and me.

After your break, set the timer for another interval of 20 minutes. Repeat until your 2-hour appointment is over. I used this strategy as a student very effectively.

E. MAKE YOUR BREAKS COUNT

The purpose of brief and longer breaks that take you away from work for a moment is to help you maintain energy and focus while working. Eat lunch away from your desk, go for a walk, check your personal email, or practice a 10-minute mindfulness meditation. When you leave work/study/home office at the end of the day, leave it all there until you return.

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

The SAVA Stress Management Hotline is there to assist members who are experiencing personal problems by offering access to professional counselling/advice.

The hotline can assist with referrals or simply offer much needed emotional support when anxiety, depression, anger, grief, lonelinessand fear are at their highest.

The following SAVA members are available on the SAVA stress management hotline. If required, they will refer you to professionals.

Ken Pettey	082 882 7356	ken.pettey@gmail.com
Aileen Pypers	072 599 8737	aileen.vet@gmail.com
Willem Schultheiss	082 323 7019	schultheisswillem@gmail.com
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Day 1
09:00 Sponsors welcome
09:15 Approach to Elbow Dysplasia
09:55 A few "must knows" in veterinary ophthalmology
10:35 TEA
11:05 Approach to Hip Dysplasia
11:45 Ocular neoplasia Part 1
12:25 Approach to Cruciate Ligament Disease
13:05 LUNCH
14:05 Approach to Patella Luxation
14:45 Ocular neoplasia Part 2
15:25 TEA
15:40 Corneal Ulcers and the management options.

Day 2
8:30 Sponsors welcome
8:45 Acute onset blindness and your DD list
9:25 GDV
10:05 TEA
10:35 ADAMTS17 gene and its effect on the eye
11:35 Intestinal surgery techniques and tips
12:15 Diagnostic and treatment modalities used in veterinary ophthalmology
12:55 LUNCH
13:55 Basic skin surgery techniques and tips
14:35 Some fun facts about vision in wildlife
15:15 TEA
15:30 Approach to Spinal Cases

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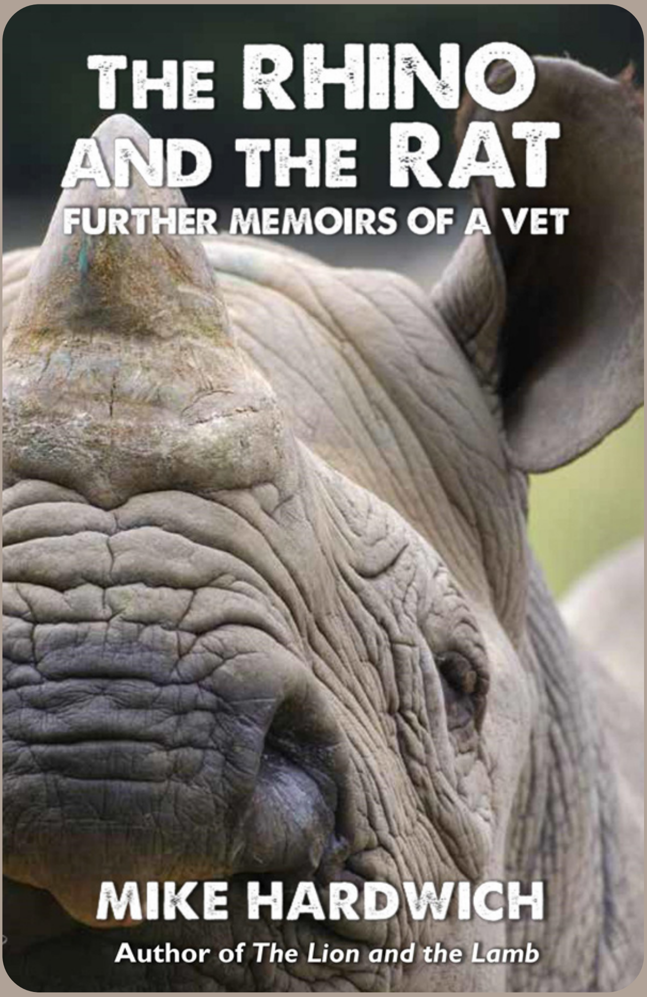
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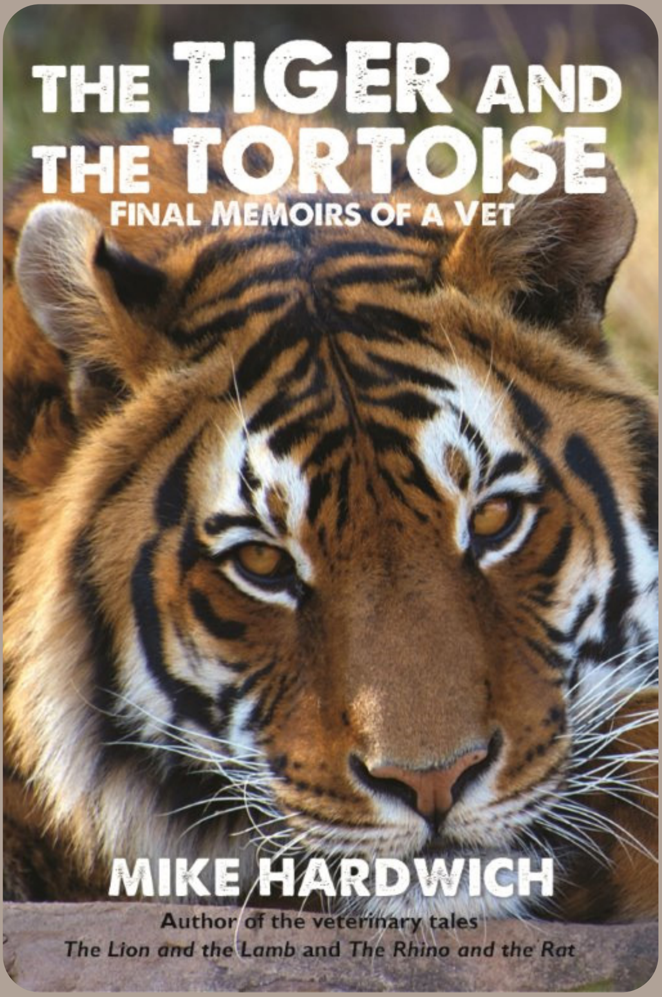
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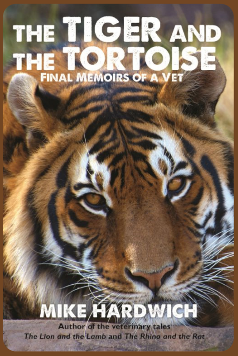
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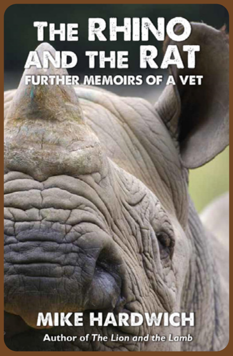
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