Clinical and research searching on the wild side: exploring the veterinary literature

Kristine M. Alpi, MLS, MPH, AHIP; Elizabeth Stringer, DVM; Ryan S. DeVoe, DVM, MSpVM, Dipl. ACZM, Dipl. ABVP (Avian); Michael Stoskopf, DVM, PhD, Dipl, ACZM

See end of article for authors' affiliations.

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Zoological medicine furthers the health and well-being of captive and free-ranging wild animals. Effective information retrieval of the zoological medicine literature demands searching multiple databases, conference proceedings, and organization websites using a wide variety of keywords and controlled vocabulary. Veterinarians, residents, students, and the librarians who serve them must have patience for multiple search iterations to capture the majority of the available knowledge. The complexities of thorough literature searches are more difficult for nondomestic animal clinical cases and research reviews as demonstrated by three search requests involving poisonous snakes, a gorilla, and spiders. Expanding and better disseminating the knowledgebase of zoological medicine will make veterinary searching easier.

INTRODUCTION

Setting

The William Rand Kenan, Jr. Library of Veterinary Medicine, located at the College of Veterinary Medicine (CVM), is a branch of the North Carolina State University (NCSU) Libraries. The library provides literature search support, publication advice, and information literacy educational outreach to the students, residents, faculty, and staff of the Veterinary Teaching Hospital at NCSU. The CVM offers a three-year residency program in zoological medicine [1], the primary objective of which is to assure the clinical competency of residents in zoological medicine and to prepare them for the successful completion of all steps of the certification process leading to diplomate status in the American College of Zoological Medicine (ACZM) [2].

According to the mission statement of ACZM [2], the discipline of zoological medicine integrates principles of ecology, conservation, and veterinary medicine and applies them to wild animals in natural and artificial environments (e.g., zoos and aquariums) to further the health and well-being of captive and free-ranging wild animals. As zoo and wildlife veterinarians, teachers, researchers, government officials, and administrators of other relevant programs, ACZM diplomates foster high-quality medical care for nondomestic animals and participate in discovering new knowledge in zoological medicine and disseminating this knowledge to the veterinary profession and public. This effort to create and share knowledge supports the secondary objective of NCSU's CVM residency program, which focuses on exposing the resident to the fundamentals of clinical research. In line with this objective, residents are required to prepare seven papers for publication, which can include case reports, but at least one paper must be a prospective research report. The residency program also requires formal presentation of cases and/or research at appropriate scientific meetings.

The three cases discussed in this paper were prompted by this emphasis on authoring cases and research reports. These three cases as a group provide an introduction to the complexities of searching in veterinary medicine in general and searching for information on nondomesticated species in particular. Several databases provide core support for literature searching in zoological medicine (Table 1). While some of the clinical problems addressed in zoological medicine will be familiar to human medical expert searchers, the variety of databases, the need to search for particular species, and the international nature of the literature all add to the complexity of animal health searches. Due to this complexity, more time will likely be required to retrieve relevant articles. In many cases, the small amount of relevant literature means that the searcher will use or share all the literature found, rather than focus on evaluating the validity of the articles to narrow the output further. Often, limiting to certain study designs or publication types is not necessary, unless there is a great deal of literature on a topic.

Conference proceedings are very important in veterinary medicine. Many papers never transition from the conference presentation level to journal article publication. While the publication rate in veterinary medicine is not known, there is no reason to suggest that it would be higher than the weighted mean full publication rate of 44.5% (95% confidence interval 43.9–45.1) identified in a 2007 systematic review of conference proceedings and their conversion into published journal articles [3]. All of the databases in Table 1, with the exception of PubMed, include some conference proceedings, and some databases, such as BIOSIS Previews, focus intensively on reports and references to meetings [4]. Expert consultation is also extremely important in fields with scarce literature. The primary professional organization of these veterinarians in the United States is the American Association of Zoo Veterinarians (AAZV) [5], but there are organizations for many different countries and for different animals, such as the British Veterinary Zoological Society and the Association of

Table 1
Selected databases in zoological medicine

Database name	Coverage	System/subscription	Indexing
BIOSIS Previews	1926–present	Subscription-based access*	BIOSIS authority file
Centre for Agricultural Bioscience (CAB) Abstracts	1973–present	Subscription-based access*	CAB thesaurus descriptors and CABICODES
CAB Abstracts Archive	1910–1972	Subscription-based access*	Same as above
PrimateLit	1940–present	Free online <http://primatelit.library.wisc.edu>, cooperative project of the Wisconsin and Washington Primate Research Centers and the Libraries of the University of Wisconsin–Madison, supported by the National Center for Research Resources, National Institutes of Health (grant RR13511)	Hierarchical list of index terms
PubMed (MEDLINE)	1950–present	Free online <http://www.pubmed.gov>	Medical Subject Headings
Web of Science	1900–present	Subscription-based access*	Author-supplied keywords where available
Zoological Record	1864–present	Subscription-based access*	Controlled terms and modifiers

* Available from several search system vendors.

Primate Veterinarians. Knowing these organizations is important for tracking down conference abstracts that may not be indexed by the major databases and for finding other subject experts outside of one's existing network.

Search terms in animal medicine

Given the international nature of the zoological medicine community, it is essential in natural language topic searching to use both British and American English spellings, as well as synonyms, free-text, truncation, abbreviations, and other options to broaden a search. However, for searching for a species or family of animals, controlled vocabulary can be most useful for retrieving all relevant papers. When searching for a broader subject such as an organism at the family level or higher (e.g., *Canidae*) or a class of diseases (e.g., neoplastic disease), controlled terminology is particularly useful. PubMed's taxonomic trees in Medical Subject Headings (MeSH) are not complete, but there is a ''Veterinary'' subset to narrow inquiries to those that are veterinary in nature. This approach and other ways to limit to animal species and groups in PubMed are outlined in a brochure by the Veterinary Medical Libraries Section [6].

Because many case report events are rarities, searching the historical literature can be critical. Zoological Record offers coverage from the late-1800s, but early twentieth century conferences, book chapters, and journal articles can be identified in the Centre for Agricultural Bioscience (CAB) Abstracts Archive and Web of Science. The many additional specific databases for veterinary searching include Animal Behavior Abstracts, Fish & Fisheries Worldwide, and Wildlife & Ecology Studies Worldwide, though these were not explored for any of the cases discussed in the current paper.

The cases

Snakes, gorillas, and spiders are the animals covered by the three cases. The snake and spider cases focus on procedures, while the gorilla case primarily considers treatment and prognosis, a situation very similar to a human medicine case. Each case is outlined below, followed by searching details, and concluded with examination of the literature. (Note: Case descriptions are intentionally brief, as the cases and research projects are being written up for publication by the veterinarian authors.)

CASE 1: NEUTRALIZING THE VENOM DISTRIBUTION OF POISONOUS SNAKES

To safely study behavioral biology in poisonous snakes, some researchers and zoological parks have de-venomized the snakes through surgical procedures [7]. The first case is prompted by the quest for an alternative and reversible procedure for use in repressing venom excretion in poisonous snakes. The current project description from the requesting faculty member and his student (italics added to emphasize key concepts) is:

> We are looking at the suitability of using dental glasionomer compounds to *oblate the venom canal* in the fangs of venomous snakes as a substitute for the invasive *surgical removal of the venom glands* in studies that require *de-venomized* snakes. In addition to being less invasive (reducing anesthesia time and needed post surgical recovery time to normal physiology), we hypothesize that the normal *shedding of fangs* will make the *procedure predictably reversible*.
>
> Steps in the study: (1) we are doing scanning electron microscopy of the inside of the fang to determine any microstructure available to impact bonding of the polymer; (2) we are going to use microscopically guided mass spectroscopy techniques to determine the surface composition of the venom canal to assess how that might affect polymer binding and selection; and (3) we are going to develop the *surgical canal oblation technique*, which will require good anesthesia, preparation of the fang and venom canal, and filling techniques under microsurgical visualization.

If the technique is successful, researchers would be able to spare other animals from the very invasive extirpation methods currently considered necessary. Success would also open the opportunity for using the technique in other species that would never be able to be studied by the permanent surgical removal of their

Table 2
Sample searches for each case

Case	Keyword strategy	Databases	Results
Disabling snake venom glands (final search 2/24/09)	(venom* or poison*) and (remov* or extirpat* or ablat* or excis* or surg* or operat* or venemoid or ligat* or regenerat* or tying or tied or ductectom*) and (snakes or rattlesnake* or crotalid*) [In PubMed used surgery or surgical, instead of surg*]	■ Web of Science, BIOSIS Previews and Zoological Record ■ PubMed ■ CAB Abstracts and CAB Abstracts Archive	■ 199 papers: 11 relevant (some duplicates) ■ PubMed: 319 results, 1 relevant ■ 207 papers: 5 relevant and from veterinary journals not covered by the other databases
Uterine adenocarcinoma in a gorilla (final search 9/30/2008)	■ PubMed: (Gorilla gorilla OR gorilla OR Pan paniscus OR chimpanzee OR Pan troglodytes OR Pongo pygmaeus OR orangutan) AND (adenocarcinoma OR Genital Neoplasms, Female)	■ PubMed	■ PubMed: 42 papers, of which only 3 were deemed relevant by the resident
	■ PrimateLit: (cervix or uterine or uterus) AND (adenocarcinoma* or carcinoma* or neoplasms or cancer* or tumor* or tumour* or neoplasia) —later limited to Pongidae in the Taxonomic Category	■ PrimateLit: very different search, variety of cancer terms	■ PrimateLit: 104 results, from which 21 items were sent for review and 8 were relevant; when limited to Pongidae, 16 results
Anesthesia in spiders (final search 1/29/09)	(Arthropods or arachnid* or spider* or tarantula*) and (anesthe* or anaesthe* or isofluorane or isofluran* or Aerrane or Ethane or Forane or Forene or CO2 or carbon dioxide)	Web of Science, BIOSIS Previews, and Zoological Record	209 results

venom glands. A literature search was needed to see whether less invasive techniques were in use.

Understanding the medical concepts

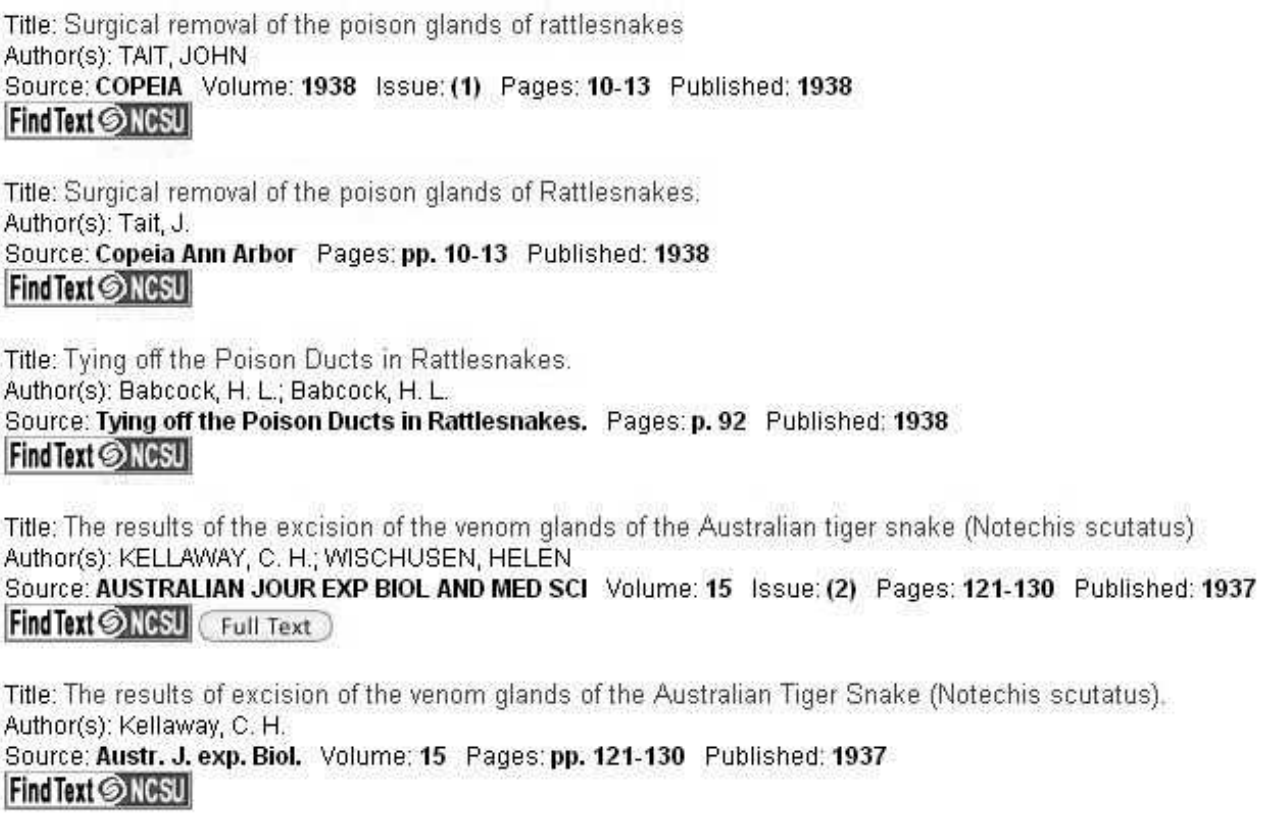
The anatomy of the venom production system in poisonous snakes is an important starting point. The labels used in two online images [8, 9] show some of the diverse terms used to describe the anatomy. The venom distribution system begins with the venom or poison glands, moving on to the venom-conducting tube or duct through which the venom travels into the venom canal in the fang. The terms ''venom'' and ''poison'' are often used interchangeably. There are different types of venom, but that distinction was not important to this search. Discussion of the literature with the faculty member revealed that the snakes of interest for the current project were native crotalids (rattlesnakes and others of the pit viper group) and not those of the families of snakes that produce neurotoxic venom (e.g., cobras, coral snakes). There is also a term for de-venomized snakes: a *venomoid* is a formerly venomous snake whose venom glands or ducts have been removed or destroyed to make it ''harmless.''

The lack of standardized terminology for the various procedures to remove, separate, or otherwise disable venom delivery beyond de-venomization points to the need for creative keyword searching and truncation. Removal in its various forms—extirpation (provided by the requestor to describe a known item [10]), ablation, excision, surgery, operations, and -ectomies of the anatomical pieces—were all part of the initial strategy. When thinking about reversible procedures, it helped to think of the literature about reversible vasectomies and tubal ligation and use terms like ''ligat*,'' ''tying'' or ''tied,'' or ''regeneration.'' Some terms were not readily apparent before beginning the search but were discovered during exploration of the literature; for example, the term ''venomductectomy'' appeared in the search results [11]. ''Snake'' was not truncated in the ultimate search, as that stemming increased the results by almost 700 items—mostly irrelevant papers on snakebites. A sample search used to simultaneously search BIOSIS Previews, Web of Science, and Zoological Record appears in Table 2. As a point of comparison, the same strategy retrieved 319 results in PubMed, of which most were about snakebites or other uses of the venom; only one was relevant [12], and it was already identified by the previous search. Of note, PubMed does not index the herpetological journals in which the most relevant papers were published, making it less relevant for this case. CAB Abstracts and CAB Abstracts Archive—which are excellent veterinary databases with journal, book chapter, and conference proceedings coverage—also yielded relevant items for this search [13–17]; three of these [15–17] were unique to CAB.

Exploring the literature

Searching ligation-related keywords using BIOSIS Previews, Web of Science, and Zoological Record retrieved a reference by Babcock on ligating the poison duct, a strategy that might be considered reversible [18]. It was listed as a book from 1938, but the source was listed as Copeia Ann Arbor. Upon physical examination of the print journal volume, this item turned out to be a letter to the editor of the journal *Copeia* commenting on the article by Tait [10]. Citation quality of older material was inconsistent. Figure 1 provides examples of the sample material from different databases. The subject term for the Babcock paper was ''Ligature of duct of venom gland of snakes''; however, no other articles were indexed with this term. A 1937 article by Kellaway and Wischusen [19] about the possible survival of ducts and gland tissue after certain pieces were removed was found in BIOSIS and Zoological Record and used the modifiers ''Effect of Extirpation of poison glands of snakes'' and ''Effect of extirpation of venom glands'' in the same record, showing the lack of

Figure 1
Sample material from different databases



consistency in indexing in this older literature. This article reports a prospective study of thirty snakes, followed for nearly two and a half years. Some phrases from the abstract provided additional terms to revise the search: ''There was no evidence of regeneration of glands by proliferation from duct tissue, nor any hypertrophy of the supralabial mucus glands.'' Neither of the two papers citing this paper was relevant to the question. The search retrieved other relevant papers [20–22], but using only English-language keywords kept the search from identifying an 1894 French paper [23], which was referenced by de Langlada and Belluomini [13]. Although other papers related to snake digestion and anatomy were informative, the literature search established the need for further work and publication on procedures and outcomes of de-venomization.

One avenue not searched initially was the conference proceedings of the AAZV and the Association of Reptilian and Amphibian Veterinarians. The librarian was not aware that the AAZV conferences were indexed only by PrimateLit and not the rest of the database group noted in Table 1, which otherwise provides good coverage of meeting papers. A search of those collective proceedings on CD-ROM [24] for ''venom'' and then for ''fang/s'' produced only one relevant abstract by Funk on venomoid surgeries in snakes from 2001 [25]. A search on ''venomoid and (surgery or surgeries or surgical)'' in a combined search of BIOSIS Previews, Web of Science, and Zoological Record retrieved two additional papers [7, 26] not previously seen in the searches, one of which was presented at the 1975 American Association of Zoological Parks and Aquariums conference [26].

Assessing the literature

It was often necessary to retrieve the full text of the items because abstracts are scarce in the older literature and in short case reports, and the indexing was generally too broad to describe an article's content. In this case, when abstracts were available, the faculty member often found they provided enough information to satisfy: The Australian journal article [19] is what one would expect from a tiger snake, in which the venom is near pure neurotoxin, versus the complex venoms of crotalids. It was surprising how little there was in the literature covered by the databases searched for this query. The faculty member suspected that anything else would be hidden in obscure notes or articles in individual zoological institution membership publications or the notes of scientists held in special collections, but from a practical aspect, the search investigated the likely sources of information on the topic and the searches pretty well covered the indexed literature. Turning to colleagues for discussion is typical regardless of the depth of literature.

Figure 2
Medical Subject Headings (MeSH) for great apes

Hominidae
Family of the suborder HAPLORHINI (Anthropoidea) comprising bipedal primate MAMMALS. It includes modern man (HOMO SAPIENS) and the great apes: gorillas (GORILLA GORILLA), chimpanzees (PAN PANISCUS and PAN TROGLODYTES), and orangutans (PONGO PYGMAEUS).Year introduced: 1989*

* National Library of Medicine. Medical Subject Headings: Hominidae [Internet]. Bethesda, MD: The Library; 1989 [cited 10 Mar 2009]. <http://www.ncbi.nlm.nih.gov/sites/entrez?Db=mesh&Cmd=DetailsSearch&Term=%22hominidae%22[MeSH+Terms]>.

The faculty member commented, ''I'm pretty sure after talking with some colleagues that I am going to insist that we try fang filling with various dental polymers for this project.'' This will lead to additional searches to investigate questions raised regarding the properties of individual polymers that have never been tried in this type of application. The literature search was instrumental in guiding the design and direction of the project.

CASE 2: TREATMENT AND PROGNOSIS OF A UTERINE TUMOR IN A GORILLA

The disciplines of human and veterinary medicine are very close indeed, especially in the case of the great apes, and physicians from human medical specialties are often called to consult on great apes cases. A female gorilla at the North Carolina Zoo was initially evaluated by zoo veterinarians for intermittent, irregular vaginal bleeding. Veterinarians at the North Carolina Zoo are adjunct professors at NCSU, partnering to provide the zoological medicine residency program. The clinical investigation occurred over the course of several months, as her condition did not resolve despite treatment. She was anesthetized for examinations, ultrasounds, and various treatments on numerous occasions, culminating several months after the initial presentation in an ovariohysterectomy performed by zoo veterinarians in collaboration with human obstetrical surgeons. At that time, they determined that the tumor present in the removed organs was a primary metastatic uterine adenocarcinoma that was locally invasive.

The team requested a literature review of gorilla reproductive cancer to put this case in the context of previous case reports and discussions of medical management and provide background for future publication of the case. Even the prevalence of this type of cancer in people and the ways it is treated and managed in humans was considered potentially useful by the team, especially long-term prognoses for metastatic uterine adenocarcinoma.

Understanding the medical concepts

Species issues were relevant to this question. While searching for literature on gorillas, it was clear that little literature would be available and that the search might have to concentrate more broadly on the great apes in general. However, the information from all types of nonhuman primates was too broad. The great apes are members of the biological family *Hominidae*, which includes humans, chimpanzees, gorillas, and orangutans. To focus on the great apes, the searcher must exclude humans if searching on the family name. Anthropologists may refer to the family *Pongidae* as the ''great apes,'' but many biologists consider *Hominidae* to include *Pongidae* as the subfamily *Pongidae* or restrict the latter to the orangutans. The PrimateLit database offers *Pongidae* as a taxonomic category including gorillas, chimpanzees, and orangutans, while PubMed's MeSH includes them all under the *Hominidae* grouping, which also includes humans (Figure 2).

Exploring the literature

For the purpose of reproductive cancers in gorillas, the search covered various keywords for ''cancer,'' ''tumor,'' ''tumour,'' ''neoplasms,'' ''adenocarcinoma,'' and so on, combined with various reproductive words such as ''uterus,'' ''uterine,'' ''reproduce*,'' ''gynecologic*,'' and terms representing the type of cancer. Unfortunately, many of the reproductive cancers in primates described in the literature were experimentally induced. These nuances can be captured when searching PubMed using MeSH to explode terms such as ''Urogenital Neoplasms'' and exclude terms such as ''Neoplasms, Experimental.'' MeSH also has terms specific to cancers in veterinary medicine such as ''Venereal Tumors, Veterinary'' or the ability to add the ''Veterinary'' subheading to search terms (e.g., ''Uterine Neoplasms/veterinary [Mesh]).''

An initial search of PrimateLit for papers on uterine cancers of any type in any type of nonhuman primate resulted in twenty-one references, but a great deal of this retrieval dealt with nonhuman primate research done on macaques and baboons. Based on a quick glance at the titles, the resident indicated that information more focused on great apes (and hopefully gorillas) would be helpful. Taxonomic searches were performed by limiting to the taxonomic category *Pongidae* from the hierarchical dropdown list, which offers searches by a genus, species, or subspecies (Table 2). Eight references from a variety of primate-specific and general publications were selected by the resident [27–34]. Figure 3 is a sample record from PrimateLit. A search of CAB Abstracts yielded three records that had already been identified in PrimateLit.

To start searching for literature specific to the case, a PubMed search addressing the species:

(Gorilla gorilla OR Pan paniscus [pygmy chimpanzee] OR Pan troglodytes [chimpanzee] OR Pongo pygmaeus [orangutans])

Figure 3
Sample PrimateLit record

Doc Num: 986920
Author: Baeyens MM
Title: Medical problems and treatment of geriatric great apes at the Little Rock Zoo. [Abstract]
Source: CHIMPANZOO CONFERENCE PROCEEDINGS. 1998. 1997. Pgs: 71
Taxonomy: ANTHROPOIDEA / PONGIDAE / PAN / P. TROGLODYTES / PONGO / MALE / FEMALE / GORILLA / G. G. GORILLA / ADULT / OLD ADULT
Biology: AGING
Diseases: ARTHRITIS / OSTEOARTHRITIS / SPONTANEOUS / OBESITY / RENAL FAILURE / NEOPLASIA / CARCINOMA / METASTASIS / STROKE / HIGH CONCENTRATION / HYPERTENSION / MENSTRUAL DISORDERS / TOXEMIA / PREGNANCY DISORDERS / GESTATION PERIOD / PATH REPORT
Anatomy: UTERUS
Chemistry: CHOLESTEROL / STEROIDS / LIPIDS / ENDOGENOUS
Disciplines: VETERINARY MEDICINE
Generalities: ZOO / REVIEW
CPRHeading: COLONY

was combined with a MeSH search for:

(''Venereal Tumors, Veterinary''[Mesh]) OR ''Genital Neoplasms, Female''[Mesh])

Terms in brackets represent common names for each animal, which were used in the search to pick up any new papers not yet indexed. With only five results, the searches were expanded to any adenocarcinoma in great apes regardless of site (thirty-five papers) and any kind of neoplasms in gorillas (thirty-eight papers), then going broader with a keyword search including any type of cancer or reproductive problem in all great apes to check for in-process and not-yet-indexed citations. The librarian forwarded eleven abstracts (nine of which were case reports) selected from the various PubMed great apes and neoplasms searches, of which three were selected by the resident [35–37].

A search of PubMed using Clinical Queries-Prognosis (Narrow) to search for metastatic uterine adenocarcinomas yielded over 300 papers, from which 25 were selected and sent to the resident. She selected 7 papers from 1993–2008 to inform her discussion of prognostic factors [38–44]. For prevalence statistics, the Surveillance, Epidemiology and End Results (SEER) Program data <seer.cancer.gov/faststats/selections.php?series=cancer> were suggested. These data differ by site in the uterus, so the resident could either select Cervix Uteri or Corpus and Uterus, Not Otherwise Specified (NOS), depending on the location of the cancer. The resident deemed this level of exploration sufficient for the initial review.

Assessing the literature

As illustrated by Figure 3, papers often covered a variety of health issues in captive gorilla populations. The proceedings of the AAZV annual conference were a rich source for case reports of reproductive health issues in gorillas and the various diagnostic modalities used in those assessments, although few related to cancers. Eight papers on gorillas were forwarded to the resident for review. Four papers on the few cases of cancer in gorillas that were reported at those meetings [45–48] were deemed useful by the resident, two of these were coauthored by physicians in radiology and obstetrics/gynecology. The other papers, which explored the use of diagnostic technologies and reproductive procedures, were not used. The overarching lack of knowledge about reproductive cancers in gorilla populations should lead to further research.

Figure 4
BIOSIS Previews super taxa hierarchy for arthropods and arachnids

Organisms [00500]
  Microorganisms [01000]
  Plantae [11000]
  Animalia [33000]
    Invertebrata [34000]
      Arthropoda [75000]
      Crustacea [75100]
      Myriapoda [75200]
      Insecta [75300]
      Chelicerata [75400]
        Arachnida [75402]
        Acarina [75403]
        Merostomata [75404]
        Pycnogonida [75406]

CASE 3: EFFECTIVE ANESTHESIA IN TARANTULAS

A project led by a former zoological medicine resident, now faculty member, compared the use of isoflurane and carbon dioxide as anesthetic agents for Chilean rose haired tarantulas (*Grammostola rosea*). The study compared isoflurane to carbon dioxide because many biologists use carbon dioxide as an anesthetic agent with arthropods. The differences were reported at the 2006 AAZV conference [49]. In preparing this conference paper, the resident was unable to find any studies of isoflurane and included literature on the effects of carbon dioxide anesthesia on various insects.

The faculty member was interested in further exploring how the literature addresses this topic (i.e., in a population of tarantulas): would isoflurane be more effective as an anesthesia agent than carbon dioxide in terms of recovery time and functionality? The requester was interested in literature on the effect of isoflurane or carbon dioxide on spiders and other arthropods, even if not directly compared.

Understanding the medical concepts

Arthropods are organisms having a hard, jointed exoskeleton and paired jointed legs, including spiders (*Arachnida*) and insects (Figure 4). As there would likely be few papers on anesthetic agent use in arthropods, the librarian conducted a broad search, including general words for anesthesia with both British and American spellings, carbon dioxide and a text-word version of its formula (CO2), and multiple variants of isoflurane names in the United States,

Canada, and other countries identified from DrugBank [50]:

(anesthe* or anaesthe* or isofluorane or isofluran* or Aerrane or Ethane or Forane or Forene or CO2 or carbon dioxide)

Species issues were again relevant. Some of the simplest initial word searches for the organisms included a hedge of ''arthropods'' or ''arachnid*,'' ''spider*,'' or ''tarantula*,'' but the librarian quickly realized that taxonomic searching may be useful in improving search efficiency. BIOSIS Previews and Zoological Record allowed taxonomic searching for arthropods, and CAB Abstracts and PubMed offered arthropods as a phylum.

Exploring the literature

BIOSIS Previews, Web of Science, Zoological Record, CAB Abstracts, and PubMed were the targets for these searches. Isoflurane is primarily discussed in the literature as an anesthetic agent, while the literature on carbon dioxide focuses more on side effects, toxicity, and resistance for environmental exposures rather than intentional usage. A sampling of both types of literature was also shared with the researcher [51]. Searching on the abstract and indexing level to see whether isoflurane was the agent used required the librarian to both retrieve and read full text and search full-text databases such as Google Scholar and ScienceDirect. One paper found in Web of Science that looked promising [52] became a key resource after reading its full text. This paper was Reichling and Tabaka's ''Short Communication: A Technique for Individually Identifying Tarantulas Using Passive Integrated Transponders'' from 1991 [52]. The abstract intimated that the procedure for anesthesia might be described: ''A surgical technique for implanting passive integrated transponders into theraphosid spiders is described. An effective procedure for anesthesia was developed.'' The keywords (''PIT tags,'' ''spider marker,'' ''Theraphosidae [family of hairy and large spiders]'') were not helpful, and there were no references for the procedure.

Another step was to find the initial conference paper by the NCSU faculty member to check its indexing coverage. It was then that the librarian discovered this conference was not indexed by CAB Abstracts, Zoological Record, or Web of Science, although the meeting is a tremendously important veterinary resource, so the librarian needed to search on CD-ROM from 1968 to 2008 by keywords. No Boolean operators or truncation was available, although one could also browse by year or article title for known items. The librarian looked at 234 documents with isoflurane in the full text and an additional 63 with carbon dioxide to see if any dealt with arthropods. A catchy-titled 1993 paper, ''Achy Breaky Arachnids'' [53], discussed anesthesia with isoflurane and cites 3 works, one of which dealt with carbon dioxide. The veterinarian on the project already had found these three references: two papers by Cooper from *Journal of Small Animal Practice* and the book, Frye's *Captive Invertebrates: A Guide to their Biology and Husbandry*. Because those involved expected a minimal amount of literature regarding this subject, the researcher felt that all of those located had some value. The main goal was to make sure that no other information was to be found.

Assessing the literature

The faculty member responded to the initial search results: ''So far the tarantula paper you found is the only thing I've been able to find regarding anesthesia of spiders in the peer-reviewed literature.'' The text quoted below from Reichling and Tabaka provided a helpful comparison of technique and outcome in those tarantulas.

Spiders were immobilized with isoflurane (Iso-thesia_, Abbott Laboratories, North Chicago, Illinois). A cottonball was soaked in the anesthetic agent and placed in a small plastic container away from the spider. The effect of the anesthetic was monitored by leg movement. As the spiders became anesthetized the legs contracted followed by relaxation. Spiders which were not anesthetized during transponder implants accepted food within several hours, suggesting they had not been severely traumatized by the procedure. Anesthetized spiders required 2–3 hours post-surgical recovery time before normal movement was exhibited. [52]

From the librarian perspective, not only did this paper yield technique and outcome information, but also another commercial name for the anesthetic to add to the search. The researcher said that the paper actually provided the most specific description of how isoflurane had been used with spiders making it the ''best'' reference found. All the other papers simply made very general statements about its use.

CONCLUDING REMARKS

Collaborating on searches with veterinarians at various stages of training and careers highlights the differences in approaches to literature searching. The current culture is not one of doing extensive literature searches during the care of a patient and study design, unless the intention of publication is impending. McCord and Croft [54, 55] describe a general tendency among veterinary students to do required literature searches after coming up with a treatment plan as opposed to having the literature truly inform the treatment plan.

Given the complexity of searching across multiple databases—using a wide variety of synonyms, related terms, truncated terms, and subject headings where appropriate—it is not surprising that relying on a cursory search of the free PubMed database is typical. Follow-up questions when sending literature were required to discern actual information needs, changes in information needed, and usefulness and relevance of articles. Even when papers were located, it was

difficult to track them down due to age and obscurity of journals or to decide utility due to lack of full text.

When evidence is scarce, and even when it is not, doctors have an understandable tendency, which begins in medical education and continues for several reasons, to rely on the experience of professional colleagues [56]. The factors identified such as ''To get quick answers'' and ''To monitor their own knowledge'' could be addressed by better searching and greater access to the literature, while the other aspects such as ''To create or sustain camaraderie'' are unique to the collegial interaction.

Having a well-trained and diligent librarian to teach, provide literature searching consults, and even perform a more thorough search of the literature is crucial to finding the scarce literature available. While biological and medical knowledge speed the process, willingness to look up all the unknown pieces about species, procedures, and so on can provide sufficient background knowledge to proceed. Veterinarians who work with a variety of species are also sympathetic to the need to fill in knowledge gaps before proceeding with the literature search. Successful searchers in veterinary situations will have knowledge of and access to a wide range of databases, creativity in coming up with keywords, persistence, and tolerance to review a great number of irrelevant records. Interesting cases like these are part of what make veterinary librarianship such as challenge [57]. A concerted effort by veterinarians and librarians to improve the ease of searching and access to the literature of zoological medicine may be required to change the extent and success of searching for literature about clinical problems in zoological medicine.

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AUTHORS' AFFILIATIONS

Kristine M. Alpi, MLS, MPH, AHIP, kristine_alpi@ncsu.edu, Director, William Rand Kenan, Jr. Library of Veterinary Medicine, NCSU Libraries, North Carolina State University, 4700 Hillsborough Street, Raleigh, NC 27606; **Elizabeth Stringer, DVM,** betsy_stringer@ncsu.edu, Zoological Medicine Resident, North Carolina State University and North Carolina Zoological Park, 4700 Hillsborough Street, Raleigh, NC 27606; **Ryan S. DeVoe, DVM, MSpVM, Dipl. ACZM, Dipl. ABVP (Avian),** ryan.devoe@nczoo.org, Senior Veterinarian, North Carolina Zoological Park, 4401 Zoo Parkway, Asheboro, NC 27205; **Michael Stoskopf, DVM, PhD, Dipl, ACZM,** michael_stoskopf@ncsu.edu, Professor of Aquatics, Wildlife, and Zoologic Medicine and of Molecular and Environmental Toxicology, North Carolina State University, 4700 Hillsborough Street, Raleigh, NC 27606

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