Canine Blastomycosis in Wisconsin: A Survey of Small-Animal Veterinary Practices

Jennifer L. Anderson¹, Jordan L. Dieckman¹, Kurt D. Reed² and Jennifer K. Meece¹,*

¹Integrated Research and Development Laboratory, Marshfield Clinic Research Foundation, Marshfield, Wisconsin, USA and ²Department of Pathology and Laboratory Medicine, University of Wisconsin–Madison, Madison, Wisconsin

*To whom correspondence should be addressed. Jennifer K. Meece, Integrated Research and Development Laboratory, Marshfield Clinic Research Foundation, 1000 N Oak Avenue, Marshfield, WI 54449, USA. Tel: +1 715-221-6465; Fax: +715-389-3319; E-mail: meece.jennifer@mcrf.mfldclin.edu

Received 25 April 2014; Accepted 14 June 2014

Abstract
The disease burden and impact of canine blastomycosis in Wisconsin is uncertain. We surveyed small-animal veterinary practices to obtain estimates of disease incidence, determine patient outcomes, and investigate variation in diagnostic and treatment strategies used by veterinarians. Veterinarians representing small-animal practices in Wisconsin were contacted by mail with the option to complete a paper or online questionnaire. Questionnaires were returned from 68 of 443 veterinary practices (15%) that estimated diagnosing 239 cases of canine blastomycosis annually, with an overall mortality of 36%. Annual incidence rates of canine blastomycosis were calculated for 43 individual veterinary clinics and differed significantly between clinics in endemic and nonendemic counties (P = 0.01), with the mean in endemic counties being 204/100,000/yr and nonendemic counties being 72/100,000/yr. Veterinarians reported an increase in canine blastomycosis cases from April through August. A wide variety of methods were used for diagnosis, ranging from clinical signs alone to antigen testing and “in-house” cytology. Of note, fungal culture was used rarely for diagnosis. In addition, veterinarians at these 68 clinics estimated diagnosing 36 cases of feline blastomycosis annually. The incidence of canine blastomycosis is high but quite variable among veterinary practices in Wisconsin. Diagnosis is based frequently on clinical signs exclusively due, in part, to the perceived high cost of laboratory tests. Similarly, the mortality associated with blastomycosis is likely negatively impacted because some dog owners defer therapy due to the cost of antifungal drugs.

Key words: canine blastomycosis, Wisconsin, veterinary, survey, incidence.

Introduction
Blastomycosis is a soilborne fungal disease that is endemic in the United States along the Mississippi and Ohio river valleys, southeastern states, and around the Great Lakes [1]. Infections are most often reported in humans and canines [2–3], but sporadic cases in other mammalian species
have been reported [4–5]. Susceptible hosts are infected by inhalation of *Blastomyces dermatitidis* spores from the environment. Clinical presentation of blastomycosis ranges from mild to severe pulmonary infection, with dissemination to skin, bone, and other tissues.

Although no national surveillance of blastomycosis exists, in endemic areas of the United States, the annual incidence of human blastomycosis is 1–2/100,000 [6]. In Wisconsin, annual incidence rates as high as 68/100,000 are observed in some counties [J. R. Archer, personal communication]. The epidemiology of human blastomycosis has been extensively studied in Wisconsin, where it has been a reportable disease since 1985. In contrast, canine blastomycosis is relatively understudied. A limited number of retrospective reports indicate that annual incidences of canine blastomycosis are 10 to 13 times higher than that of humans [3,7]. In highly endemic areas, canine incidence rates reach 1%–2% annually, and mortality as high as 41% has been reported [8]. Despite these findings, the true incidence and impact of canine blastomycosis in Wisconsin remain unknown. Our goal in this study was to survey practicing veterinarians in Wisconsin to gather information regarding the incidence, clinical presentation, clinical outcome, and seasonality of canine blastomycosis. Additionally, we investigated the variation in diagnostic and treatment strategies for blastomycosis among small-animal veterinary practices.

**Materials and methods**

**Questionnaire design**

A questionnaire was designed to survey veterinarians regarding canine blastomycosis in Wisconsin. The questionnaire consisted of 24 close-ended, ranking, and multiple-choice questions. Questions covered demographic information such as location of clinic, counties served, and estimation of unique canine patients seen annually. In addition, questions regarding canine blastomycosis covered average number of cases diagnosed annually, disease presentation, diagnostic methods, treatment, and patient outcomes. The questionnaire was posted to SurveyMonkey, and a recruitment letter that included a link and access code for participation in the study was composed. Veterinarians had the option to complete a paper or online questionnaire.

**Recruitment**

Identification and targeted recruitment of veterinary clinics in Wisconsin were pursued through Marshfield Labs, a clinical testing laboratory serving approximately 3000 veterinary practices throughout Wisconsin and the upper Midwest. Large animal–only practices and commercial facilities with contracted veterinarians (including farms, genetics companies, and animal shelters) were excluded from the study. Veterinary clinics were classified as located in an endemic or nonendemic county based on reported human cases [9]. Counties were defined as endemic if they reported 10 or more human cases from 2000 to 2006 and included Brown, Forest, Jefferson, Kenosha, Lincoln, Marathon, Marinette, Menominee, Milwaukee, Oconto, Oneida, Outagamie, Portage, Racine, Sawyer, Shawano, Vilas, Washburn, Waukesha, Waupaca, and Wood counties. Classification of Wisconsin veterinary practices served by Marshfield Labs resulted in 226 clinics located by address of the sole or main branch in endemic counties. We randomly selected another 226 veterinary clinics throughout the state with addresses in nonendemic counties. These 452 veterinary practices were invited by mail to participate in the study. Recruitment letters were sent to each veterinary clinic on 20 June 2012, inviting a single veterinarian at each practice to participate on behalf of the practice. In the case of branch practices, the head office or main branch location was chosen for recruitment. Three weeks after initial contact, a reminder e-mail was sent or a phone call was made to nonresponding clinics. Surveys were accepted through 9 August 2012.

**Case mapping**

Human case counts of blastomycosis, per county, for 2011 and 2012 were obtained from the Wisconsin Department of Health Services [S. Gibbons-Burgener, personal communication]. A map of reported human and estimated canine blastomycosis cases was created in a geographic information system environment using ArcMap V10.1 (ESRI, Redland, CA, USA). Shapefiles for Wisconsin county boundaries were obtained from the Wisconsin Department of Natural Resources [10].

**Incidence calculations**

The estimated annual incidence rate of canine blastomycosis per veterinary practice was calculated if practices provided both the number of annual cases and unique canine patients seen annually. A *t* test was used to assess statistical difference between the average annual incidence rates for veterinary practices located in endemic and nonendemic counties.

**Diagnostic, clinical, and treatment information**

Frequency tables were constructed for all items on the questionnaire where the response options were “very useful,
useful, or not useful” and “always use, sometimes use, or never use.” Other results were analyzed either by totaling or averaging all veterinarian responses. Calculations of standard deviation (SDs) and 95% confidence intervals (CIs) were performed using Excel 2010 (Microsoft, Redmond, WA, USA).

Results

Clinic demographics and incidence calculations
Nine surveys were returned with no forwarding address. Sixty-eight questionnaires were returned from the remaining 443 veterinary practices, yielding a 15% response rate. Participating clinics were located in 33 Wisconsin counties and reported serving veterinary patients from 45 of 72 Wisconsin counties (Fig. 1). Forty-one clinics (60%) were located in endemic counties, with 27 (40%) located in nonendemic counties. Most responses were received from veterinarians in Waukesha, Dane, and Outagamie counties, with 10, 6, and 5 clinics responding, respectively. Four endemic counties—Forest, Menominee, Shawano, and Vilas—had no respondents. Eighteen clinics reported diagnosing no cases of canine blastomycosis; the other 50 clinics estimated diagnosing a combined total of 48 cases annually using clinical signs alone and 191 cases using diagnostic tests. Clinics in Oneida County had the most cases, with four clinics estimating 57 cases annually. Veterinarians in endemic counties diagnosed 206 cases of blastomycosis, with 33 being diagnosed by veterinarians in nonendemic counties (Supplementary Table 1). Annual incidence rates of canine blastomycosis were calculated for 43 individual veterinary clinics and ranged from 0 to 601/100,000/yr (Supplementary Table 1). The annual incidence rate differed significantly between clinics in endemic and nonendemic counties (two-tailed t test, P = 0.01), with the mean being 204/100,000/yr (SD = 173) in endemic counties and 72/100,000/yr (SD = 140) in nonendemic counties. Mapping of estimated canine blastomycosis cases at the 68 responding clinics as compared with human blastomycosis cases reported to the Wisconsin Division of Public Health in 2011 and 2012 are shown in Figure 1.

Diagnostic and clinical information
Eighteen veterinarian respondents reported diagnosing no cases of canine blastomycosis and were therefore excluded...
Table 1. Rankings by veterinarians on the usefulness of history/demographics and diagnostic tests and treatments for canine blastomycosis.

<table>
<thead>
<tr>
<th>Patient History/Demographics</th>
<th>Very useful No. (%)</th>
<th>Useful No. (%)</th>
<th>Not useful No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1 (2)</td>
<td>16 (31)</td>
<td>34 (67)</td>
</tr>
<tr>
<td>Breed</td>
<td>2 (4)</td>
<td>23 (45)</td>
<td>26 (51)</td>
</tr>
<tr>
<td>Recent travel to endemic area</td>
<td>22 (43)</td>
<td>21 (41)</td>
<td>8 (16)</td>
</tr>
<tr>
<td>Proximity of owner’s house to water</td>
<td>14 (27)</td>
<td>24 (47)</td>
<td>13 (25)</td>
</tr>
<tr>
<td>Failed treatment with antibiotics</td>
<td>16 (31)</td>
<td>33 (65)</td>
<td>2 (4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnostic test</th>
<th>Always use No. (%)</th>
<th>Sometimes use No. (%)</th>
<th>Never use No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine antigen</td>
<td>27 (54)</td>
<td>18 (36)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Cytology</td>
<td>17 (35)</td>
<td>31 (63)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Fungal culture</td>
<td>1 (2)</td>
<td>9 (18)</td>
<td>39 (80)</td>
</tr>
<tr>
<td>Clinical signs</td>
<td>26 (52)</td>
<td>22 (44)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Radiographs</td>
<td>25 (50)</td>
<td>24 (48)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Serology</td>
<td>10 (20)</td>
<td>20 (40)</td>
<td>20 (40)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Itraconazole</td>
<td>30 (61)</td>
<td>17 (35)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Amphotericin B</td>
<td>0 (0)</td>
<td>12 (26)</td>
<td>34 (74)</td>
</tr>
<tr>
<td>Glucocorticoids</td>
<td>1 (2)</td>
<td>12 (26)</td>
<td>33 (72)</td>
</tr>
<tr>
<td>Ketoconazole</td>
<td>3 (6)</td>
<td>18 (37)</td>
<td>28 (57)</td>
</tr>
<tr>
<td>Fluconazole</td>
<td>11 (23)</td>
<td>23 (49)</td>
<td>13 (28)</td>
</tr>
</tbody>
</table>

from further data analysis. For the 50 clinics that reported diagnosing cases of canine blastomycosis, partial responses are included in the results presented here. Forty-two veterinary clinics shared data regarding the seasonality of canine blastomycosis. Veterinarians reported diagnosing 8–17 cases of canine blastomycosis per month from September through March, with cases increasing to 22–27 cases per month in April through August. Fever (69%; SD = 36; 95% CI, 59–79), lethargy (69%; SD = 33; 95% CI, 60–78), and anorexia (64%; SD = 35; 95% CI, 54–74) were the most commonly reported clinical signs of canine blastomycosis. When asked to consider demographics and history pertaining to a potential case of canine blastomycosis, 65% of veterinarian respondents said failed treatment with antibiotics was useful and 31% said it was very useful, whereas age and breed of dog were rated as the least useful (Table 1). Veterinarians ranked their use of specific diagnostic tests for canine blastomycosis and reported using a variety of methods (Table 1). Notably, fungal culture was infrequently used, with 80% of respondents reporting they never use it to diagnose blastomycosis. In a separate question, veterinarians representing 35 practices reported the use of direct microscopy performed “in-house” to diagnose blastomycosis, with 12 practices reporting the use of this method for ≥50% of cases. When asked what influences the decision not to send samples to a diagnostic laboratory to test a suspected canine blastomycosis case, 26% of veterinarians reported that cost was always a factor, with 64% reporting that it was sometimes a factor.

### Treatment and patient outcome

The most frequently reported treatment for canine blastomycosis was itraconazole, with 61% of veterinarians reporting that they always use it and 35% reporting that they sometimes use it (Table 1). Sixty-four percent (SD = 25; 95% CI, 57–71) of cases were estimated to be successfully treated. Notably, 13% of dogs diagnosed with blastomycosis were euthanized with no attempt at treatment. In these cases, veterinarians indicated that dog owners cited cost of treatment as the reason an average of 73% (SD = 25; 95% CI, 8) of the time.

### Feline blastomycosis incidence

Sixteen veterinarians from clinics in 10 Wisconsin counties reported diagnosing a combined total of 36 cases of feline blastomycosis annually. Included in this was one veterinary practice estimating that 10 cases of feline blastomycosis were diagnosed annually at their clinic in Oneida County.
Discussion

In order to investigate the burden and impact of canine blastomycosis in Wisconsin, we surveyed 68 small-animal veterinary practices located in 33 counties representing both endemic and nonendemic areas based on human cases reported to the Wisconsin Department of Health Services. Our goal was to obtain a better understanding of the incidence and outcomes of canine infections and determine how diagnosis and treatment strategies might vary across practices.

A total of 239 cases of blastomycosis were reported from the 68 practices surveyed. In contrast, in neighboring Minnesota where canine blastomycosis is a reportable disease, 962 cases were reported from 1999 to 2012, averaging 69 cases annually [11]. The estimated cases of canine blastomycosis in Wisconsin obtained in this study from a small portion of Wisconsin veterinary practices greatly exceed the levels currently reported statewide in Minnesota.

Mapping of human cases by county of residence and canine cases by location of veterinary clinic showed overlapping areas of endemicity in both hosts. Bayfield and Washington counties were an exception to this. Although not classified as endemic by the definition described earlier, the veterinary practices surveyed in this study showed high annual incidence rates of canine blastomycosis. This could be explained by the fact that these counties border endemic counties and could draw canine patients that reside elsewhere.

Analysis of the seasonal incidence of canine blastomycosis showed that cases peaked from April through August. Previous reports of the seasonality of canine blastomycosis in Wisconsin are somewhat varied. Archer et al. [12] reported that most cases were diagnosed in May through September, with a second peak in November and December. Baumgardner [3] also noted an increase in canine cases from late spring through early fall, but reported few cases in November and December, with resurgence in January. Consistent among these studies and the survey data presented here is the peak that overlaps the summer months. This is in stark contrast with the seasonal occurrence of human cases, which peaks in fall and winter [13–14]. Other researchers [15] have also observed this difference in seasonality between host species, which could be explained by varying host factors such as behavior and incubation period. Further investigation of this seasonal phenomenon over time seems justified and may reveal predictive value to forecast seasons in which blastomycosis infection rates may be especially high in one or both host species.

Veterinarians reported using a variety of tests including cytology, radiographs, clinical signs, and urine antigen to diagnose a suspected case of canine blastomycosis. Importantly, 80% of veterinarians reported that fungal culture is never used as a diagnostic test. This may be due to the slow result turnaround time inherent in culture-based testing (1–3 weeks), as well as the associated costs. This is unfortunate from a research and epidemiological perspective because limited availability of Blastomyces isolates from dogs is a significant roadblock to a better understanding of the population genetics, ecology, and evolutionary biology of this pathogen.

Veterinarians reported diagnosing a significant percentage of cases using direct microscopy performed in-house. This has the advantages of being inexpensive, providing rapid results, and possibly having high diagnostic accuracy when performed by experienced veterinarians and technicians. We did not inquire about ongoing training and proficiency testing for practices that use microscopy as a primary diagnostic modality. This should be investigated further as a potential opportunity to improve diagnostic accuracy, especially in geographic areas where the infection rate is low and veterinarians and/or laboratory technologists encounter cases of blastomycosis infrequently.

The mortality rate of canine blastomycosis in this study averaged 36%, including dogs that died of the disease naturally and those that were euthanized either prior to or following treatment. This is consistent with previous reports [8]. It is clear from the data obtained in this survey that the cost of testing and treatment is a significant factor affecting mortality rates.

An unexpected finding of this study was the large number of feline blastomycosis cases (n = 36) reported. Feline blastomycosis is infrequently reported in the literature [4,16], and veterinarians in Wisconsin seem to diagnose feline blastomycosis more than would be expected based on published data. We plan to pursue future studies on this topic.

A limitation of this study is the relatively low response rate. Furthermore, veterinarians responding to the survey may not be entirely representative of the state of Wisconsin. Despite this, the high number of cases of canine blastomycosis reportedly diagnosed by the veterinarian respondents in this study is an important finding and underscores the need to have accurate and cost-effective laboratory diagnostic tests available to veterinary practitioners. Moreover, this study reinforces previous observations of variation in seasonal incidence of blastomycosis in human and canine hosts [3,15].

Acknowledgments

This work was supported by the Marshfield Clinic Research Foundation and funded through philanthropic contributions to the summer student internship program. We thank Maria Sundaram for critical review of this manuscript.
Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

Supplementary material

Supplementary material is available at Medical Mycology online (http://www.mmy.oxfordjournals.org/).

References