Abstract

Purpose To determine the significance of Aspergillus and Fusarium spp., as identified by culture, on clinical outcome in equine keratomycosis.

Methods Retrospective analysis of 66 horses (66 eyes) evaluated at the NCSU-VH diagnosed with keratomycosis from which Aspergillus or Fusarium spp. were cultured. Horses were classified into those who improved with medical management alone or those who required surgical intervention to improve. Horses who underwent surgery were divided into globe-sparing procedures or enucleation. Effects of bacterial co-infection, previous topical steroid or antifungal use, and time of year on fungal genus and outcome were evaluated.

Results Aspergillus spp. was cultured from 41 eyes (63%), while 24 eyes (37%) cultured Fusarium spp. One horse cultured both species and was not included in further evaluation. From the horses that cultured Aspergillus spp., 28 eyes (68%) required surgical intervention to control the infection: 21 (75%) of these eyes maintained globe integrity, while 7 eyes (25%) were enucleated. Of those horses with Fusarium spp., 14 eyes (58%) required surgical intervention: 11 (79%) of these eyes maintained globe integrity, while 3 eyes (21%) were enucleated. Genus of fungus cultured was not significantly associated with the need for surgical intervention nor was it significantly associated with the necessity of globe-sparing surgery versus enucleation. Additionally, bacterial co-infection, previous steroidal or antifungal use, and time of year did not affect outcome or type of fungal species cultured.

Conclusion Equine keratomycosis from Fusarium spp. compared to keratomycosis from Aspergillus spp. is not associated with a different clinical outcome.

Key Words: Aspergillus spp., cornea, equine, fungal culture, Fusarium spp., keratomycosis

INTRODUCTION

Fungal keratitis is a common, often difficult to manage cause of equine corneal disease and accounts for up to one-third of all inflammatory keratopathies.1-3 Horses are believed to be more susceptible than other domestic animals to corneal injury based on their environment and laterally placed and prominent globe that has a highly exposed corneal surface.3,4 Additionally, the horse may have altered corneal immunoprotection that impacts corneal susceptibility to fungal keratitis.3,6 Fungal infection develops following initial corneal epithelial damage with subsequent exposure to the environmental fungi or opportunistic infection by normal ocular microflora.3 The species of environmental fungus causing the infection varies based on geographic location.3,7 A robust inflammatory response and protease overproduction secondary to the presence of fungal organisms and infiltrating immune cells occur creating corneal stromal defects, which may progress to corneal perforation.1

Fungal organisms known to cause keratomycosis include Aspergillus, Fusarium, Candida, Cylindrocarpon, Curvularia, Penicillium, and Mucor spp.1,2,8-12 with Aspergillus spp. and Fusarium spp. most frequently identified in both human and equine keratomycosis.1,6,13,14 Both are filamentous fungi and are considered opportunistic infections7,9 with Aspergillus spp. identified in the conjunctival flora of 95% of normal horses and Fusarium spp. occurring as a common soil saprophyte and plant pathogen.11-15

In human keratomycosis, filamentous fungal infections are more likely to require surgical intervention than those
caused by yeast. It has been suggested that disease severity in horses may be impacted by the specific organism involved, as one fungal organism may be more clinically aggressive than another. Some studies suggest that *Aspergillus* spp. cause less progressive clinical signs than those produced by *Fusarium* spp. while others propose a more severe clinical progression of *Aspergillus* spp. compared to *Fusarium, Penicillium*, or *Microsporum* spp. However, it remains unknown if this affects their outcome. The purpose of this study is to compare clinical outcomes associated with *Aspergillus* spp. and *Fusarium* spp. keratomycosis in horses. A second aim of the study was to determine whether concurrent bacterial keratitis or previous topical steroid or topical and/or oral antifungal administration influences these results.

**MATERIALS AND METHODS**

Medical records from equine cases presented to the North Carolina State University Veterinary Hospital (NCSU-VH) from January 2004 to December 2013 with a diagnosis of keratomycosis and a positive corneal culture for *Aspergillus* spp. or *Fusarium* spp. were selected for review. Inclusion criteria for further review included a follow-up time of at least 1 month from discharge from NCSU-VH. This was documented through re-evaluation at NCSU-VH or by communication with the referring veterinarian or owner.

Information collected from each record included signalment (age, sex, breed); eye affected; season during which the horse was presented; ophthalmic examination findings and clinical diagnosis at NCSU-VH; cytologic results (if available), aerobic bacterial culture, and fungal culture results; medical therapy instituted by the referring veterinarian or owner prior to presentation at NCSU-VH; medical therapy initiated at NCSU-VH; type of surgical procedure; and when it was performed in relation to when the horse was admitted, if applicable.

A complete ophthalmic examination was performed on all horses. Prior to sedation, a brief neuro-opthalmic examination was performed including a menace response, a dazzle reflex, and direct and indirect pupillary light reflexes performed with a 3.5 v finoff transilluminator (Heine Ophthalmic, Herrsching, Germany). Horses then received from 5 to 20 mcg/kg detomidine hydrochloride 10 mg/mL (Pfizer Animal Health, New York, NY), based on temperament, intravenously for the examination. Subcutaneous auriculopalpebral and supraorbital nerve blocks using lidocaine hydrochloride 2% (0.5–1 mL; Vedco Inc, Saint Joseph, MO) were performed on all horses. Sedated examination included corneal fluorescein staining (Akorn, Lake Forest, IL), tonometry (Tonopen, Reichart Technologies, Depew, NY) following topical application of 0.5% proparacaine hydrochloride ophthalmic solution (0.1 mL; Akorn), and slit-lamp biomicroscopy (SL-15; Kowa American Corp, Torrance, CA). Pupils were dilated with 1% tropicamide ophthalmic solution (0.1 mL; Bausch and Lomb Inc, Bridgewater, NJ), and indirect fundic examination was performed with a binocular indirect headset (Keeler Instruments Inc, Broomall, PA) and a 14D or 20D indirect lens (Volk Optical, Mentor, OH).

Samples for cytology and culture were collected by lightly scraping the corneal surface over the lesion with the back of a Bard-Parker #15 scalpel blade (Becton Dickinson and Co., Franklin Lakes, NJ) at a 45 degree angle. Cyto logical samples were transferred directly to a slide and stained with Diff-Quik stain (Fisher Scientific, Kalamazoo, MI) after collection, then examined by ophthalmology residents and board-certified ophthalmologists. If the cytologic diagnosis was questionable, the sample was reviewed by a clinical pathologist. Samples for aerobic bacterial culture were plated directly on Columbia blood agar and thioglycollate broth (Remel, Lenexa, KS), cultured at 36 degrees Celsius, and examined every 24 hours for 3 days. Samples for fungal cultures were plated directly on Sabouraud Dextrose media and Corn Agar Meal or Potato Dextrose agar (Remel, Lenexa, KS), and incubated at 36 degrees Celsius for a minimum of 21 days. Cultures were conducted at the NCSU Clinical Microbiology Laboratory and were reviewed by a clinical microbiologist.

Horses were first categorized based on fungal culture results (*Aspergillus* spp. or *Fusarium* spp.). Then, horses were further divided based on outcome results. Outcomes were classified by the type of treatment received (medical or surgical and type of surgical treatment) that lead to disease resolution. Medical cases were those who only received medical treatment (topical, subconjunctival, oral, or parenteral antifungal, antibacterial, and anti-inflammatory agents). Resolution for these cases was defined as the ability to maintain a visual, comfortable globe for at least one month following discontinuation of all medications.

If a lamellar keratectomy (with or without a supporting graft of conjunctiva or amnion), penetrating keratoplasty (performed with equine frozen cornea and with or without a supporting graft of conjunctiva), or enucleation had been performed in addition to medical therapy, the cases were considered surgical. Horses that were enucleated were then analyzed separately from horses receiving a globe-sparing procedure (lamellar keratectomy, penetrating keratoplasty). Resolution for cases receiving a lamellar keratectomy or penetrating keratoplasty was defined as the ability to completely discontinue all medications 8–12 weeks after the surgical procedure and maintain a visual, comfortable globe through remaining documented rechecks or communication with the owner or referring veterinarian. For cases that were enucleated, the end point of therapy was at the time of eye removal.

**Data analysis**

For all nonparametric data comparisons (i.e., gender, breed), a Pearson’s chi-squared test was used. Differences were considered significant at $P \leq 0.05$. Results and


Table 1. Outcome of eyes in 65 horses

<table>
<thead>
<tr>
<th>Time of presentation</th>
<th>Resolved with medical management</th>
<th>Resolved with surgical management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combination of topical, oral, +/- subconjunctival n (%)</td>
<td>Ocular sparing n (%)</td>
</tr>
<tr>
<td>Fall 24 (36%)</td>
<td>10 (44%)</td>
<td>10 (44%)</td>
</tr>
<tr>
<td>Winter 10 (15%)</td>
<td>3 (30%)</td>
<td>5 (50%)</td>
</tr>
<tr>
<td>Spring 16 (24%)</td>
<td>4 (25%)</td>
<td>9 (56%)</td>
</tr>
<tr>
<td>Summer 16 (24%)</td>
<td>6 (38%)</td>
<td>8 (50%)</td>
</tr>
</tbody>
</table>

**A. Outcome based on time of presentation**

**B. Outcome based on culture results**

**Culture results (n)**

- Aspergillus spp. (41) 13 (32%)
- Fusarium spp. (24) 10 (42%)
- Fusarium spp. + Co-infection (Bacterial and Fungal) (10) 4 (40%)

**C. Outcome based on prior treatment**

- Previous topical therapy (n)
  - Corticosteroid (6) 3 (50%)
  - Antifungal (20) 3 (15%)

- Antifungal (20) 13 (65%) 4 (20%)

*Sixty-six horses were part of the initial inclusion criteria and time of year data analysis. One horse was not included in further data analysis regarding medical and surgical management as this horse cultured both Aspergillus spp. and Fusarium spp.

The ten horses in this group were also included in the culture results data for Aspergillus spp. or Fusarium spp.

**RESULTS**

**Study population**

Sixty-six horses met the initial inclusion criteria. The mean age of affected horses was 12.5 years ± 6 years (range 3 years to 30 years). Twenty horses were mares, forty-four were geldings, and two were stallions. The most common breeds were Quarter horse (15/66 [22%]) and Thoroughbred (14/66 [21%]) with other breeds affected including Saddlebred (7/66 [11%]); Warmblood (6/66 [9%]); Appaloosa (5/66 [7.5%]); Arabian (5/66 [7.5%]); Paint (2/66 [3%]); Welsh Pony (2/66 [3%]); Walking horse (2/66 [3%]); and Andalusian, Hanoverian, Morgan, Selle Francias, and Connemara Pony (1/66 [1.5%] each).

Breed was not recorded for 3 of 66 (4.5%) ponies. The remaining isolates included Selle Francias, and Connemara Pony (1/66 [1.5%] each). Of the horses that cultured Aspergillus spp., 7 of 41 (17%) also cultured aerobic bacteria.

Outcome results based on fungal culture are listed in Table 1B. The number of Aspergillus horses responsive to medical management alone was 13 of 41 (32%), while the other 28 of 41 (68%) required surgical intervention. Of those horses that required surgical intervention, 21 of 28 (75%) received a globe-sparing surgery, while 7 of 28 (25%) underwent enucleation. Out of those horses that were enucleated, 3 of 7 (43%) had undergone a globe-sparing surgery first. Among the different Aspergillus isolates cultured, eyes that cultured an unknown Aspergillus species were more likely than the other isolates to be enucleated (P = 0.01).

Fusarium spp. was cultured from 24 of 65 (37%) eyes. Speciation was performed in one isolate, which grew Fusarium oxysporum (1/24 [4%]). The remaining isolates were unspeciated (23/24 [96%]). Of the horses that cultured Fusarium spp., 3 of 24 (13%) also cultured aerobic bacteria. The number of Fusarium horses responsive to medical management alone was 10 of 24 (42%), while 14 of 24 (58%) required surgical intervention. Of those horses that required surgical intervention, 11 of 14 (79%) received a globe-sparing surgery, while 3 of 14 (21%) underwent enucleation. There was no significant difference in the number of eyes culturing Aspergillus spp. or Fusarium spp.

**Aspergillus** spp. was cultured from 41 of 65 (63%) eyes. The most common species of Aspergillus cultured was Aspergillus fumigatus, 26 of 41 (63%), with Aspergillus niger cultured from 3 of 41 (7%) and Aspergillus glaucus from 1 of 41 (2%) of eyes. One horse cultured both Aspergillus fumigatus and Aspergillus terreus, 1 of 41 (2%). The remaining Aspergillus isolates (10/41) were not speciated. Of the horses that cultured Aspergillus spp., 7 of 41 (17%) also cultured aerobic bacteria.

**Culture and cytology**

One horse was not included in further statistical analysis as the eye cultured both Aspergillus spp. and Fusarium spp. The eye cultured both Aspergillus and Fusarium species presented in the fall; however, there was no significant association between time of occurrence and species of fungus isolated (P = 0.4) or clinical outcome (P = 0.5).
Fusarium spp. that resolved with medical therapy or surgical management \((P = 0.4)\) or type of surgery performed \((P = 0.7)\).

Positive aerobic bacterial culture results were found in 10 of 65 (15%) horses, with five of those horses culturing more than one bacterial isolate. *Staphylococcus* spp. was the most common bacteria isolated (5/10 [50%]), followed by *Streptococcus* spp. (3/10 [30%]) and *Bacillus* spp. (3/10 [30%]). *Klebsiella* spp., *Escherichia coli*, *Corynebacterium* spp., and *Rhodococcus* spp. were each cultured in one eye (1/10 [10%] each). The number of horses with mixed bacterial and fungal infections that resolved with medical management was 4 of 10 (40%) compared to 6 of 10 (60%) that required surgery. There was no significant difference in medical versus surgical management \((P = 0.7)\) or type of surgery performed \((P = 0.3)\) among horses with mixed bacterial or fungal infections compared to horses with fungal infections only.

Cytology results were documented in the medical record of 51 of 65 (78%) horses. Of those, fungal hyphae were identified in 40 of 51 (78%) samples. Fungal species was not discernable from cytology examination. Bacteria (cocci) alone were documented in 3 of 51 (6%), and both fungal hyphae and cocci were identified in 4 of 51 (8%) samples. Of the 40 positive fungal cytology samples, 23 of 40 (58%) were later cultured by the NCSU Clinical Microbiology Laboratory as *Aspergillus* spp. and 17 of 40 (43%) were cultured as Fusarium spp.

**Medical therapy prior to referral**

The number of horses who received topical steroids prior to presentation at NCSU-VH was 6 of 65 (9%). Five horses received dexamethasone (0.1%) combined with neomycin and polymyxin B sulfate (5/6 [83%]). Type of topical steroid used by one horse is unknown (1/6 [17%]). All 6 horses that received steroids cultured an *Aspergillus* spp. (6/6 [100%]). The number of horses who previously received steroids and improved with medical management was 3 of 6 (50%), while the other 3 of 6 (50%) required globe-sparing surgery (Table 1C). No eyes that had previously received steroids were enucleated. There was no significant difference in number of eyes requiring medical versus surgical management \((P = 0.4)\) or type of surgery performed \((P = 0.5)\) among horses that received steroids and horses that did not.

Prior to presentation at NCSU-VH, 20 of 65 (31%) cases received antifungal therapy (all received topical and two cases received both topical and oral antifungal medications). These medications included topical voriconazole \((n = 5)\), miconazole \((n = 13)\), natamycin \((n = 1)\), or itraconazole \((n = 1)\), and oral fluconazole \((n = 2)\). Of those horses that previously received antifungal therapy, 11 of 20 (55%) cultured an *Aspergillus* spp., while 9 of 20 (45%) cultured a *Fusarium* spp. Horses that previously received antifungal therapy were significantly more likely to have surgical treatment \((17/20 [85%]) at NCSU-VH compared to medical therapy \((3/20 [15%]) \((P = 0.01)\). Three of these surgical cases were enucleated \((3/20 [15%])\) (Table 1C).

**Medical therapy at NCSU-VH**

Topical, oral, and subconjunctival medications initiated at NCSU-VH, their frequencies and how commonly they were used are listed in Table 2. The combination of medications used and the frequency at which they were administered were at the discretion of the attending veterinary ophthalmologist and were specific for the condition of each individual horse at presentation.

### Table 2. Medical management received at NCSU-VH

<table>
<thead>
<tr>
<th>Medication</th>
<th>Route</th>
<th>Purpose</th>
<th>Dose</th>
<th>Frequency</th>
<th>Number of horses receiving ((n = 65))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voriconazole 1% Ophthalmic Preparation</td>
<td>Topical</td>
<td>Antifungal</td>
<td>0.1 mL (1 mg)</td>
<td>4–12 times daily</td>
<td>53</td>
</tr>
<tr>
<td>Natamycin 5% Ophthalmic Suspension</td>
<td>Topical</td>
<td>Antifungal</td>
<td>0.1 mL (5 mg)</td>
<td>4–12 times daily</td>
<td>23</td>
</tr>
<tr>
<td>Miconazole 1% Ophthalmic Solution</td>
<td>Topical</td>
<td>Antifungal</td>
<td>0.1 mL (1 mg)</td>
<td>4–12 times daily</td>
<td>9</td>
</tr>
<tr>
<td>Fluconazole</td>
<td>Oral</td>
<td>Antifungal</td>
<td>5 mg/kg</td>
<td>1 time daily</td>
<td>44</td>
</tr>
<tr>
<td>Amphoterpinic B</td>
<td>Subconjunctival</td>
<td>Antifungal</td>
<td>62.5ug</td>
<td>Every other day</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3 doses total)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moxifloxacin 0.5% Ophthalmic Solution</td>
<td>Topical</td>
<td>Antibacterial</td>
<td>0.1 mL (0.5 mg)</td>
<td>4–12 times daily</td>
<td>35</td>
</tr>
<tr>
<td>Ciprofloxaclin 0.3% Ophthalmic Solution</td>
<td>Topical</td>
<td>Antibacterial</td>
<td>0.1 mL (0.3 mg)</td>
<td>4–12 times daily</td>
<td>11</td>
</tr>
<tr>
<td>Tobramycin 0.3% Ophthalmic Solution</td>
<td>Topical</td>
<td>Antibacterial</td>
<td>0.1 mL (0.3 mg)</td>
<td>4–12 times daily</td>
<td>11</td>
</tr>
<tr>
<td>Neomycin Polymyxin B Sulfates and</td>
<td>Topical</td>
<td>Antibacterial</td>
<td>0.1 mL</td>
<td>4–12 times daily</td>
<td>4</td>
</tr>
<tr>
<td>Gramicidin Ophthalmic Solution</td>
<td>Topical</td>
<td>Antibacterial</td>
<td>¼ inch strip</td>
<td>4 times daily</td>
<td>1</td>
</tr>
<tr>
<td>Terramycin (oxytetracycline with</td>
<td>Topical</td>
<td>Anticollagenase</td>
<td>0.1 mL</td>
<td>4–12 times daily</td>
<td>13</td>
</tr>
<tr>
<td>polymyxin B sulfates)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autologous Serum</td>
<td>Topical</td>
<td>Anticollagenase</td>
<td>0.1 mL</td>
<td>4–12 times daily</td>
<td>25</td>
</tr>
<tr>
<td>Trimethoprim sulfadiazine</td>
<td>Oral</td>
<td>Antibacterial</td>
<td>15–30 mg/kg</td>
<td>2 times daily</td>
<td>25</td>
</tr>
<tr>
<td>Atropine 1% Ophthalmic Solution</td>
<td>Topical</td>
<td>Mydriatic</td>
<td>0.1 mL (1 mg)</td>
<td>1–4 times daily</td>
<td>61</td>
</tr>
</tbody>
</table>

Common medications used are listed. Flunixin meglumine was administered parenterally or orally in all cases at 1 mg/kg and continued at a tapering frequency per clinician’s discretion. Omeprazole or ranitidine was administered at standard gastroprotective dosages.
DISCUSSION

The main objective of this study was to compare clinical outcomes in cases of keratomycosis among horses culturing Aspergillus spp. or Fusarium spp. More horses that cultured Aspergillus spp. required surgical intervention (68%) than those who cultured Fusarium spp. (58%); however, this difference was not statistically significant. A similar finding has been reported in a retrospective study comparing various fungal species isolated with treatment performed in cases of equine fungal keratitis in the mid-Atlantic region. Another retrospective study evaluating the management of equine ulcerative keratitis found horses receiving both medical and surgical intervention cultured Aspergillus spp. more frequently than those treated with medical therapy only. While both Aspergillus spp. and Fusarium spp. are common fungal organisms, Aspergillus spp. was more prevalent in this study, as has been noted in other retrospective evaluations. This may explain why Aspergillus spp. may have been perceived as a more aggressive pathogen in past studies.

Any surgical intervention regardless of type performed is suggestive of more aggressive disease. Indications for surgical management of equine fungal keratitis include nonresponsiveness or progression of a lesion despite appropriate medical therapy or presentation of a deep ulceration or descemetocele formation. In a study by Andrew et al., evaluating 39 horses with fungal keratitis, vision was maintained in 100% of cases following medical therapy and in only 84% following surgical treatment. Of note, more than half of the horses in our study received surgical intervention, which may speak to the aggressive nature of keratomycosis in general. It must also be considered the inevitable role that finances play in the ability to pursue either aggressive, long-term medical therapy, or surgical intervention.

Horses in which enucleation was performed underwent an additional, separate analysis from the other surgical procedures. No statistically significant difference was found for type of surgical procedure performed (globe-sparing or enucleation) between horses culturing Fusarium spp. or Aspergillus spp. in our study. This is in contrast to past reports that suggest a greater likelihood of loss of vision/globe with Aspergillus spp. Results of the current study suggest that the possibility of a worse clinical outcome should be based on clinical signs and progression of disease, as opposed to species of fungal organism involved.

Concurrent bacterial infection did not have a significant effect on the type of fungus cultured, therapy instituted, or type of surgery performed in this study. Bacteria and fungus are often thought to have a synergistic effect and a more harmful outcome on corneal integrity. This lack of effect could be due to low number of positive bacterial cultures in our horses. Only, 10 of 65 (15%) horses had a positive aerobic bacterial culture, while previous studies have shown a 30–50% concurrent bacterial keratitis rate in horses with keratomycosis. One reason for low bacterial culture results could relate to the various, previous antibacterial therapies received by our study population, with 89% of horses treated with either a topical and/or systemic antibacterial agent prior to presentation to NCSU-VH. Additionally, it is known that filamentous fungi such as Penicillium and Aspergillus can produce metabolites with antimicrobial properties, which may have influenced our results.

The most common corneal bacterial isolates were gram-positive and included Streptococcus, Staphylococcus, and Bacillus which is consistent with previous studies. Another study from Sauer et al. documented Pseudomonas spp. as one of the most common bacterial pathogens isolated in cases of ulcerative keratitis. No cases in our study were infected with a Pseudomonas spp., although our study population was not inclusive of all ulcerative keratitis cases. Larger case numbers and greater organism diversity are needed to draw conclusions on the severity of the infections related to mixed populations of bacterial and fungal organisms.

Topical steroid use prior to referral to NCSU-VH did not affect the fungal isolate cultured or the treatment type or surgery performed in this study as has similarly been reported by Reed et al. and other retrospective studies. Despite these findings, topical corticosteroids are known to interfere with cellular immunity, corneal re-epithelialization, and wound healing; potentiate enzymatic degradation of the corneal stroma; and delay nonspecific inflammatory responses and vascularization of the cornea. In the presence of corticosteroids, fungal organisms behave more aggressively and antifungal efficacy may be reduced by corticosteroids interacting with fungal organisms to block their activity.

The lack of correlation between prior topical corticosteroid use and management or clinical outcome may relate to the small case numbers in this category (only 6/65 [9%] of horses in this study); however, small numbers are expected as few practitioners feel comfortable prescribing steroids due to their predisposition to infection. As such, greater numbers and additional studies are needed to draw conclusions regarding the use of corticosteroids and the effects on fungal organism cultured and clinical outcomes.

Prior to referral to NCSU-VH, 20 of 65 (31%) of horses received an antifungal agent as part of their medical therapy. Horses that previously received antifungal therapy were more likely to undergo surgical intervention to successfully treat the infection. It is likely that a horse that has been on appropriate antifungal therapy prior to referral and for a longer period of time is considered refractory to medical therapy and less likely to heal without more aggressive intervention. This may motivate the owner and clinician to pursue surgery upon referral.

At least one-third (36%) of the horses in this study and almost half of Fusarium spp. cases presented during the fall months. Climate can significantly affect the prevalence...
of keratomycosis in both equine and human medicine. A study evaluating equine keratomycosis in California cited fall as the most common season for presentation. In Switzerland and Japan, most cases presented between spring and early fall. Henriksen et al., found the lowest number of cases of stromal abscesses during the summer compared to the winter, spring, and fall months, with the authors proposing that the increased humidity and temperature of Florida and the southeastern region in the summer are not suitable for corneal invasion of Aspergillus spp. and Fusarium spp. This may explain why a higher incidence of these infections was noted during the fall months in our study.

Fungal hyphae were identified on cytology in 78% of cases in our study. No comments were provided in the medical record regarding branching of fungal organisms; therefore, no information regarding a possible connection between cytological appearance and culture results was obtained. Cytology has been cited as the most reliable method for identifying primary pathogens in equine keratomycosis but not the specific causative agent. It is recommended to utilize both cytology and culture to increase the likelihood of pathogen identification as has been suggested by past reports.

One limitation to the study reported here includes the method of diagnosis. Fungal culture has been cited as the gold standard for diagnosis of equine fungal keratitis and was used as criteria for inclusion based on the ability to speciate organisms. It is important to recognize fungal culture can take 2–4 weeks to complete, which limits its utility in guiding therapeutic approaches. Based on the severity and depth of the corneal lesion, or in the case of a stromal abscess, samples for culture may be unobtainable as they can cause further harm to the already compromised integrity of the corneal surface. Alternatively, environmental contaminants may give false-positive results. Another modality that may be useful for identifying and speciating fungal organisms involved in keratitis is PCR, as described by Zeiss et al., which allows more rapid detection of fungal organisms and may identify a broader spectrum of fungal organisms.

Other limitations of this study include those inherent in retrospective evaluations, principally the need for a larger population size to further identify the influence of coinciding bacterial infection and previous steroid administration. Additionally, there is expected variability in how cases were managed and how quickly post-ocular signs were noticed that they presented to NCSU-VH. Following admission to NCSU-VH, clinician preference was also a factor in the decision to pursue surgical management, in conjunction with owners’ preferences and financial abilities, which further influenced treatment decision.

In conclusion, in this population of horses studied, aggressiveness of treatment instituted or surgery performed in fungal keratitis was not influenced by fungal isolate cultured. Concurrent bacterial keratitis and steroid usage did not influence results. Previous antifungal therapy influenced surgical intervention and how quickly this was pursued.

REFERENCES