
Christine L. Cain, DVM, DACVD; Daniel O. Morris, DVM, MPH, DACVD; Shelley C. Rankin, PhD

**Objective**—To define clinical differences between coagulase-positive and coagulase-negative *Staphylococcus schleiferi* infections in dogs and to identify risk factors for the isolation of oxacillin-resistant *S schleiferi*.

**Design**—Retrospective case series.

**Animals**—225 dogs (yielding 225 *S schleiferi* isolates).

**Procedures**—Information obtained from affected dogs’ medical records included isolate body site source, antimicrobial treatments, and primary disease. For each dog, the *S schleiferi* isolate was characterized and antimicrobial susceptibility data were recorded. Risk factors for infection based on coagulase status and for *S schleiferi* oxacillin resistance were investigated.

**Results**—Allergic dermatitis was the most common underlying disease (111/225 dogs). Ears (102 [45%]) and skin (95 [42%]) were sources of most of the 225 isolates. Isolate coagulase status was not significantly associated with any patient-level factors. Of the 225 isolates, 129 (57%) were oxacillin resistant. Coagulase-negative isolates were more likely to be oxacillin resistant than were coagulase-positive isolates (odds ratio [OR], 1.8; 95% confidence interval [CI], 1.1 to 3.0). Administration of penicillin-based or first-generation cephalosporins (OR, 3.0; 95% CI, 1.8 to 5.9) and third-generation cephalosporins (OR, 3.7; 95% CI, 1.1 to 12.3) within 30 days prior to culture were risk factors for oxacillin resistance.

**Conclusions and Clinical Relevance**—Results suggested that coagulase-negative and coagulase-positive *S schleiferi* are potential pathogens in dogs and are often oxacillin resistant. Recent patient treatments with penicillin or cephalosporins were risk factors for oxacillin resistance. In clinical cases, full speciation of all *Staphylococcus* isolates should be performed and microbial treatments should be selected on the basis of results of susceptibility testing. (J Am Vet Med Assoc 2011;239:1566–1573)

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*Staphylococcus schleiferi* was first identified as a coagulase-negative staphylococcus in 1988. A coagulase-positive subtype of *S schleiferi* (identified by use of a tube test) was subsequently isolated from the external ear canals of dogs with otitis externa in 1990. Since that time, *S schleiferi* has been classified as 2 separate subspecies on the basis of coagulase production: *S schleiferi* subsp schleiferi (coagulase positive) and *S schleiferi* subsp coagulans (coagulase negative).

Coagulase-negative *S schleiferi* has been reported to be a normal component of human preaxillary flora, although it has been implicated in nosocomial infections (particularly infections associated with surgical sites and following pacemaker implantation), osteomyelitis, endocarditis, and brain empyema. In many instances, infections have been identified in patients receiving concurrent immunosuppressive medications and in patients with underlying neoplasia. To date, only 2 reports of coagulase-positive *S schleiferi* infection of humans have been published: the first was a case of infection of a cutaneous wound in 1993, and the second was a case of endocarditis in a liver transplant patient in 2007. Virulence factors potentially associated with the promotion of nosocomial *S schleiferi* infections include production of a fibronectin-binding protein, a protein-enhancing bacterial adhesion, and biofilm production. In dogs, both coagulase-positive and coagulase-negative *S schleiferi* isolates have been predominantly associated with superficial infections of the skin and external ear canals, although both have also been isolated from the external ear can-
nals of healthy dogs. When isolated from dogs with pyoderma, an association between recurrent pyoderma and previous or concurrent antimicrobial treatment is common. Staphylococcus schleiferi has a high rate of oxacillin (methylcillin) resistance, especially compared with Staphylococcus pseudintermedius. Oxacillin resistance in Staphylococcus aureus is mediated by an acquired PBP (PBP2a), which is encoded by the mecA gene carried on the mobile staphylococcal cassette chromosome mec (SCCmec) element. Oxacillin-resistant S schleiferi isolates also carry the mecA gene and express PBP2a. Staphylococcal isolates that have mecA-mediated oxacillin resistance are considered to have in vivo resistance to all β-lactam drugs, including potentiated penicillins, cephalosporins, and carbapenems. Methicillin and oxacillin are members of a class of antimicrobial drugs known as the semisynthetic, penicillinase-resistant penicillins. Owing to its superior stability in vitro, oxacillin is now used by most veterinary microbiology laboratories as the surrogate for testing the susceptibility of bacteria to this entire class of antimicrobials. The high rate of oxacillin resistance in S schleiferi isolates from veterinary patients is of concern because of the potential for transfer of the mecA gene to other staphylococci of medical importance to humans and other animals. A recent study also revealed a more clonal relationship in a population of oxacillin-resistant S schleiferi isolates, compared with that among oxacillin-susceptible isolates. Such results may suggest that several ecologically successful strains of S schleiferi, irrespective of coagulase status, have acquired the gene that mediates oxacillin resistance and proliferated within the canine population.

Recently, it was reported that the 2 subspecies of S schleiferi may not be biologically distinct as defined by genotype but, rather, may represent variable coagulase production within a single bacterial species. Therefore, the primary objective of the retrospective case series reported here was to define clinical differences between coagulase-positive and coagulase-negative S schleiferi infections in dogs in an attempt to provide evidence to further support or refute a biological difference between S schleiferi isolates on the basis of coagulase status. A secondary objective was to identify clinical risk factors that may increase the odds of isolating an oxacillin-resistant strain of S schleiferi from an infected dog.

Materials and Methods

Case selection—Medical records of dogs that were evaluated at the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania between January 2003 and April 2009 were searched to identify patients for which clinical isolates were identified as S schleiferi. Missing or inaccessible medical records and medical records of noncanine patients with clinical isolates of S schleiferi were excluded from analysis. Isolates were obtained from clinical specimens via aerobic bacterial culture by use of standard laboratory protocols for the isolation of bacteria and were identified as S schleiferi by use of a conventional biochemical identification system, as described by the manufacturer. This system consists of 20 biochemical tests, including tests for α-lactose, D-trehalose, pyridoxylidyl arylamidase, and urease. The minimal inhibitory concentrations of various antimicrobials (amoxicillin-clavulanic acid, ampicillin, ceftazidime, ceftriaxone, cephalexin, gentamicin, imipenem, oxacillin, penicillin, rifampin, tetracycline, TMS, and vancomycin) were tested via broth microdilution for each isolate by use of the same test plate. Susceptibilities to enrofloxacin and marbofloxacin were determined via Kirby-Bauer disk diffusion because these drugs were not available on the preconfigured commercial test panel. All assays were performed and results were interpreted by use of the Clinical Laboratory Standards Institute guidelines. A tube coagulase test was performed with rabbit plasma and EDTA for 212 of the 229 (94%) isolates.

Medical record review—All records were reviewed by a single author (CLC). For each dog with an S schleiferi infection, information regarding signalment was recorded, including breed, sex (sexually intact male or female, neutered male, or spayed female), and age (in years). The body site source for each S schleiferi isolate was coded as follows: 0 = unknown body site, 1 = ear (external ear or tympanic bulla), 2 = skin, 3 = urogenital tract (eg, urine, bladder mucosa, and semen), 4 = respiratory tract (isolates obtained via endotracheal or transtracheal wash), 5 = eye (conjunctiva or other ocular structure), and 6 = other (body cavity, CSF, or joint fluid). Isolates were further characterized as the cause of superficial infections of the skin, ear, or eye or as deep infections of the urogenital tract, respiratory tract, or other deep sites (eg, joints and body cavities). Inpatient or outpatient status was recorded for each dog as well as the admission date for each patient and the date of specimen submission for bacterial culture. Nosocomial infections were defined as those for which S schleiferi was obtained via culture of a sample submitted to the microbiology laboratory > 48 hours after hospital admission and for which signs of infection at the cultured site upon hospital admission were not noted in the dogs' medical records. Coagulase status for each S schleiferi isolate was recorded, when available.

For each dog, previous antimicrobial treatments were recorded for each of the following antimicrobial classes or groups: penicillins (eg, amoxicillin, ampicillin, and ticarcillin), potentiated penicillins (eg, amoxicillin-clavulanic acid and ampicillin-sulbactam), or first- or second-generation cephalosporins (eg, cephalexin, cefadroxil, cefazolin, and cefoxitin); third-generation cephalosporins (eg, cefpodoxime, cefovecin, cefotaxime, and ceftriaxime); macrolides or lincosamides; fluoroquinolones; sulfanomides or potentiated sulfonamides; chloramphenicol; tetracycline; aminoglycosides; and other (silver sulfadiazine, polymyxin B, mupirocin, and bacitracin). Antimicrobial exposure was divided into 3 temporal periods: ≤ 30 days prior to submission of a specimen for bacterial culture, > 30 days but < 6 months prior to submission of a specimen for bacterial culture, and ≥ 6 months prior to submission of a specimen for bacterial culture. Route of administration was recorded, and antimicrobial treatment was coded as follows: 0 = no treatment or prior or concurrent antimicrobial treatment.
Each dog’s primary underlying disease was recorded when this information was available. If the diagnosis was tentative, this was recorded as an unknown primary disease. Underlying diseases were coded as follows: 0 = unknown primary disease, 1 = allergic dermatitis (flea allergy dermatitis, atopic dermatitis, or cutaneous adverse reaction to food), 2 = endocrinopathy (diabetes mellitus, hypothyroidism, hyperadrenocorticism, or other), 3 = autoimmune disease (immune-mediated blood dyscrasia, immune-mediated polyarthropathy, immune-mediated dermatosis, or other), 4 = neoplasia, and 5 = other (other systemic disease or wound). Use of immunosuppressive medications within 30 days before submission of a specimen for bacterial culture was also investigated.

Administrations of corticosteroids or nonsteroidal immunosuppressive medications (cytotoxic agents [including azathioprine and anti-neoplastic drugs] or cyclosporine) were noted separately. Route of administration was recorded, and treatment with exogenous immunosuppressive agents was noted as follows: 0 = no treatment or prior or concurrent immunosuppressant treatment unknown, 1 = systemic administration (oral or parenteral), 2 = topical administration (cutaneous, otic, or ophthalmic), and 3 = both topical and systemic administrations.

When available, any results of previous cultures that yielded *Staphylococcal* spp and the species isolated at that time were recorded. Results were coded as follows: 0 = no or unknown *Staphylococcus* spp cultured previously, 1 = *Staphylococcus pseudintermedius*, 2 = *S aureus*, 3 = coagulase-negative *Staphylococcus* spp, 4 = unspecified coagulase-positive non-*S aureus* staphylococci, and 5 = *S schleiferi*. All reported *Staphylococcus intermedius* isolates were reclassified as *S pseudintermedius*. Recently, molecular techniques have revealed that *S pseudintermedius*, not *S intermedius*, is the major disease-causing species in dogs.23 Oxacillin susceptibility results provided by the biochemical identification system were noted for each of the *S schleiferi* isolates. If any previous oxacillin-resistant staphylococcal isolate was cultured from a sample from a patient, this was also recorded.

**Statistical analysis**—Cell count tables and allied tests were used in the cross tabulation of categorical variables of major interest. The strength of association of dichotomous outcomes with categorical predictors (risk factors) was expressed in terms of the OR with the 95% CI, and a value of $P < 0.05$ was considered significant. When necessary, an adjusted OR was calculated to adjust for all other competing variables that were included in the regression analysis (other antimicrobial classes) and to exclude the more recent use of β-lactam antimicrobials within 30 days prior to sample culture. The Pearson $\chi^2$ test was used when all cell counts exceeded 5, but for tables with smaller counts, the Fisher exact test was used. All statistical analyses were conducted with statistical software.6

**Results**

Dog and *S schleiferi* isolate characteristics—Medical records of 225 dogs from which clinical samples yielded *S schleiferi* isolates between January 2003 and August 2009 were included in the study. A total of 232 medical records were initially identified for review; 7 records were either missing, inaccessible, or incorrectly identified as belonging to a dog and were excluded from the study. The dogs were identified as 1 of 56 breeds or mixed breed. Among the 225 dogs, the most common breeds were Cocker Spaniel (26 [12%]), Labrador Retriever (19 [8%]), English Bulldog (14 [6%]), mixed (12 [5%]), Shih Tzu (11 [5%]), and Golden Retriever (10 [4%]). Most patients were neutered males (104 [46%]) or spayed females (77 [34%]) with fewer numbers of sexually intact males (34 [15%]) or sexually intact females (10 [4%]). Dogs’ ages ranged from 0.5 to 16 years at the time of submission of a sample for bacterial culture (mean, 7.2 years; median, 7 years).

One hundred thirty-five dogs (135 isolates) were evaluated at the hospital from 2003 to 2007, and 90 dogs (90 isolates) were evaluated at the hospital from 2007 to 2009. Among the 225 isolates overall, 117 (52%) were coagulase negative and 95 (42%) were coagulase positive; for 13 (6%) isolates, no coagulase status was recorded in the laboratory report. Among the 135 isolates from 2003 to 2007, 36 (27%) were coagulase positive and 98 (73%) were coagulase negative; for 1 isolate, no coagulase status was recorded. Among the 90 isolates from 2007 to 2009, 59 (66%) were coagulase positive and 19 (21%) were coagulase negative; for 12 isolates, no coagulase status was recorded. In total, 129 of 225 (57%) isolates were oxacillin resistant according to results of the biochemical identification system. With regard to coagulase status, these oxacillin-resistant isolates were distributed as 73 of the 117 (62%) coagulase-negative isolates and 46 of the 95 (48%) coagulase-positive isolates. Oxacillin resistance was significantly ($P < 0.042$) more prevalent in the coagulase-negative group (OR, 1.77; 95% CI, 1.02 to 3.10).

The 225 isolates were derived from 170 (76%) outpatient sample submissions and 55 (24%) samples from hospital inpatients. Most of the isolates were collected from cutaneous (102/225 [45%]) or otic (93/225 [42%]) sources, with smaller numbers from the urogenital tract, respiratory tract, or other body sites (Table 1). There were no statistical associations between the coagulase status of *S schleiferi* isolated or oxacillin resistance of the isolates and other systemic disease (6 [19%]). There were no significant associations between the coagulase status of *S schleiferi* isolated or oxacillin resistance of the isolates and primary disease status (all $P > 0.08$) or treatment with immunomodulatory drugs (corticosteroids; $P = 0.823$) or cytotoxic agents or cyclosporine ($P = 0.328$).

Infections of 4 dogs were considered nosocomial by use of the study definition. Three isolates were
from skin sites, and 1 was from the respiratory tract. Two isolates were coagulase negative, 1 was coagulase positive, and 1 was of unknown coagulase status. One of these patients was receiving nonsteroidal immunosuppressive medications. One of the 4 isolates was oxacillin resistant. Of the 4 dogs, 3 had a systemic disease or wound and 1 had a combination of neoplasia and nonneoplastic systemic disease. There was no statistical association between nosocomial infection and isolate coagulase status.

Antimicrobial susceptibility—Antimicrobial susceptibility data were obtained for the 225 isolates and were assessed on the basis of isolates that were oxacillin resistant (n = 129) or those that were oxacillin susceptible (96; Table 3). Of the oxacillin-susceptible isolates, ≥80% were susceptible to each of the tested antimicrobials, with the exception of erythromycin (70/96 [73%] of isolates were susceptible). Of the oxacillin-resistant isolates, >50% were susceptible to most non-β-lactam antimicrobials, with the exceptions of gentamicin (39/129 [30%] isolates were susceptible) and the fluoroquinolones (enrofloxacin [41/123 [33%] isolates were susceptible] and marbofloxacin [35/123 [28%] isolates were susceptible]). Antimicrobial susceptibility results for enrofloxacin and marbofloxacin were available for 95 of the 96 oxacillin-susceptible isolates and for 125 and 123 of the 129 oxacillin-resistant isolates, respectively.

Antimicrobial treatment, by class and duration of treatment, was investigated as a risk factor for acquisition of an oxacillin-resistant S schleiferi strain. Eighty-one of 95 (85%) dogs with cutaneous S schleiferi infections were treated systemically with 1 or more antimicrobials within a 6-month period preceding culture of the isolate investigated in the present study; 55 of 102 (54%) of dogs with otic S schleiferi

Table 1—Number (%) and coagulase status of Staphylococcus schleiferi isolates by body site sources in 225 dogs.

<table>
<thead>
<tr>
<th>Body site source</th>
<th>Total No. (%) of S schleiferi isolates (n = 225)*</th>
<th>No. (%) of coagulase-negative isolates (n = 117)</th>
<th>No. (%) of coagulase-positive isolates (n = 95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>External ear or tympanic bulla†</td>
<td>102 (45)</td>
<td>60 (51)</td>
<td>42 (41)</td>
</tr>
<tr>
<td>Skin‡</td>
<td>95 (42)</td>
<td>48 (41)</td>
<td>47 (43)</td>
</tr>
<tr>
<td>Respiratory tract†</td>
<td>8 (4)</td>
<td>5 (4)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Urogenital tract‡</td>
<td>8 (4)</td>
<td>3 (3)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Eye†</td>
<td>2 (&lt;1)</td>
<td>0 (0)</td>
<td>2 (&lt;1)</td>
</tr>
<tr>
<td>Other†</td>
<td>9 (4)</td>
<td>1 (&lt;1)</td>
<td>8 (8)</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (&lt;1)</td>
<td>0 (0)</td>
<td>1 (&lt;1)</td>
</tr>
</tbody>
</table>

The distribution of coagulase-negative and coagulase-positive isolates by body site source (superficial vs deep) did not differ significantly (P = 0.236).

*Number includes isolates of unknown coagulase status. †Superficial body sites. ‡Deep body sites.

Table 2—Primary disease diagnoses for 225 dogs with S schleiferi infections according to isolate coagulase status.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Total No. (%) of S schleiferi isolates (n = 225)*</th>
<th>No. (%) of coagulase-negative isolates (n = 117)</th>
<th>No. (%) of coagulase-positive isolates (n = 95)</th>
<th>P value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>31 (14)</td>
<td>17 (15)</td>
<td>14 (15)</td>
<td>—</td>
</tr>
<tr>
<td>Allergy</td>
<td>111 (49)</td>
<td>58 (50)</td>
<td>53 (52)</td>
<td>0.990</td>
</tr>
<tr>
<td>Endocrinopathy</td>
<td>5 (2)</td>
<td>1 (&lt;1)</td>
<td>4 (4)</td>
<td>0.179</td>
</tr>
<tr>
<td>Autoimmune disease</td>
<td>6 (3)</td>
<td>5 (4)</td>
<td>1 (1)</td>
<td>0.239</td>
</tr>
<tr>
<td>Neoplasia</td>
<td>8 (4)</td>
<td>4 (3)</td>
<td>4 (4)</td>
<td>0.807</td>
</tr>
<tr>
<td>Other (eg, other systemic disease or wound ≤ 2 diseases)</td>
<td>33 (15)</td>
<td>11 (9)</td>
<td>22 (23)</td>
<td>0.224</td>
</tr>
</tbody>
</table>

*Includes isolates of unknown coagulase status. †P values for comparison of isolate coagulase status and primary disease diagnosis; a value of P < 0.05 was considered significant. Most common combination diagnoses included allergy and endocrinopathy (9/31 [29%]) and allergy and other systemic disease (6/31 [19%]). — Not applicable.
infections were treated topically with 1 or more antimicrobials within a 6-month period preceding culture of the isolate investigated in the present study.

Seventy-six of 225 (34%) dogs were treated with penicillins, potentiated penicillins, or first- or second-generation cephalosporins (considered together as a single β-lactam group) within 30 days prior to sample culture. Fifty-four of the 76 (71%) S. schleiferi isolates from these dogs were oxacillin resistant. The use of β-lactam antimicrobials within 30 days prior to sample culture was significantly (P < 0.001) associated with oxacillin resistance in S. schleiferi isolates (OR, 3.0; 95% CI, 1.6 to 5.6).

Eighty-eight of the 225 (39%) dogs were treated with β-lactam antimicrobials within a period of 31 days to < 6 months prior to the sample culture date; 58 of the 88 (66%) S. schleiferi isolates from these dogs were oxacillin resistant. The use of β-lactam antimicrobials between 31 days and < 6 months prior to the sample culture date was also found to be significantly (P = 0.008) associated with oxacillin resistance in S. schleiferi isolates (adjusted OR, 2.2; 95% CI, 1.2 to 4.0). An adjusted OR was calculated here to adjust for all other competing variables that were included in the regression analysis (other antimicrobial classes) and to exclude the more recent use of β-lactam antimicrobials within 30 days prior to sample culture. Seventeen of 225 (8%) dogs were treated with a third-generation cephalosporin within 30 days prior to sample culture; 13 of 17 (76%) S. schleiferi isolates from these dogs were oxacillin resistant. Third-generation cephalosporin use within a 30-day period preceding sample culture was significantly (P = 0.036) associated with isolation of oxacillin-resistant strains (OR, 3.7; 95% CI, 1.1 to 12.3).

Although systemic and topical treatments with fluoroquinolones were not significantly associated with the isolation of oxacillin-resistant strains from skin sites (P = 0.881) or ear sites (P = 0.793), resistance to fluoroquinolones was strongly significantly (P < 0.001) associated with resistance to oxacillin within individual strains (OR, 9.2; 95% CI, 4.9 to 18.1; Table 3). There were no statistical associations between antimicrobial administration and oxacillin resistance when coagulase-negative and coagulase-positive S. schleiferi isolates were analyzed separately.

### Discussion

Most of the S. schleiferi isolates evaluated in the present study were obtained from dogs that were treated as outpatients and were collected from the skin sites or ear canals, as in previous studies. Allergic dermatitis was the most common primary disease of these patients with S. schleiferi infections. This was not surprising given that dogs with allergic dermatitis are predisposed to secondary cutaneous and otic staphylococcal infections. Overrepresented breeds within the study group (Cocker Spaniel, Golden Retriever, Labrador Retriever, Shih Tzu, and English Bulldog) are also commonly affected by allergic skin disease and are frequently examined as outpatients by the clinical dermatology service. Resident or transient commensal bacteria that become opportunistic pathogens as a result of impaired host defense mechanisms, virulence factor expression, and inflammatory skin disease are known causes of staphylococcal pyoderma and otitis externa in dogs. Although coagulase-negative S. schleiferi is considered a normal component of human preaxillary microflora, the true reservoir for S. schleiferi in dogs remains unknown. In a recent study that involved screening for skin carriage of staphylococci in dogs with healthy and inflamed skin, S. schleiferi was significantly more likely to be isolated from dogs with inflamed skin. Furthermore, coagulase-positive S. schleiferi was isolated from 2 of 50 (4%) healthy dogs, whereas coagulase-negative S. schleiferi was not isolated from any of the healthy dogs. These findings suggest that commensal S. schleiferi may occupy a yet unidentified carriage site in dogs, but major conclusions are precluded by the overall small number of S. schleiferi isolates in that previous screening study of staphylococcal carriage in dogs.

Coagulase-negative S. schleiferi has been reported to cause nosocomial infections, especially infections associated with surgical sites and pacemaker implantation in humans. In the present study, only 4 infections in dogs met the definition of nosocomial infection but there was no significant association of nosocomial acquisition with isolate coagulase status or oxacillin resistance. However, the small number of nosocomial infections hinders interpretation of these findings. Unfortunately, the retrospective nature of the present study also makes it difficult to confirm that these infections were truly nosocomial and were not in an incubation phase at the time of hospital admission. It is possible that some of these dogs had clinical signs of infection at the time of hospital admission that were not noted in their medical records.

In humans, an association of coagulase-negative S. schleiferi infections with underlying neoplasia or iatrogenic immunosuppression has been suggested. The data obtained in the present study did not confirm an association between S. schleiferi coagulase status and any primary disease, body site, or immunosuppressive drug treatment in dogs. Coagulase-negative isolates were more common, accounting for 32% of the 225 isolates (42% of the isolates were coagulase positive and 6% of the isolates were unclassified). However, coagulase-positive S. schleiferi isolates were increasingly more common in our hospital from 2007 to 2009, accounting

<table>
<thead>
<tr>
<th>Antimicrobial to which isolates were susceptible</th>
<th>Oxacillin-susceptible isolates (n = 96*)</th>
<th>Oxacillin-resistant isolates (n = 129†)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cefazolin</td>
<td>96 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Amoxicillin-clavulanic acid</td>
<td>96 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Chloramphenicol</td>
<td>87 (91)</td>
<td>110 (85)</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>79 (82)</td>
<td>90 (70)</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>70 (73)</td>
<td>88 (68)</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>80 (83)</td>
<td>39 (30)</td>
</tr>
<tr>
<td>Enrofloxacin</td>
<td>81 (85)</td>
<td>41 (33)</td>
</tr>
<tr>
<td>Marbofloxacin</td>
<td>81 (85)</td>
<td>35 (28)</td>
</tr>
<tr>
<td>Tetracycline</td>
<td>89 (93)</td>
<td>114 (88)</td>
</tr>
<tr>
<td>TMS</td>
<td>96 (100)</td>
<td>127 (98)</td>
</tr>
<tr>
<td>Rifampin</td>
<td>95 (99)</td>
<td>123 (95)</td>
</tr>
</tbody>
</table>

* Data are reported as the number of isolates (%).
† For enrofloxacin and marbofloxacin, n = 85. For enrofloxacin, n = 125; for marbofloxacin, n = 123.

Table 3—Antimicrobial susceptibility of oxacillin-susceptible and oxacillin-resistant S. schleiferi isolates from 225 dogs.
for 27% of isolates from 2003 to 2007 and for 66% of isolates from 2007 to 2009.

**Staphylococcus pseudintermedius** was the most common staphylococcal species isolated previously for those dogs that had results of a prior bacterial culture in their medical record. This was not unexpected given that *S pseudintermedius* has been reported to be the most common resident or transient commensal staphylococcus colonizing healthy dogs and dogs with inflammatory dermatoses.** Staphylococcus pseudintermedius** is also the most frequently isolated pathogen in dogs with pyoderma.** Although many of these isolates were classified in the medical records as *S intermedius*, these isolates likely belonged to the *S pseudintermedius* cluster of the *S intermedius* group on the basis of results of recent studies that have identified *S pseudintermedius* as the major cause of pyoderma in dogs. The isolation of *S schleiferi* following prior identification of *S pseudintermedius* via bacterial culture, especially from dogs with pyoderma, may be associated with recurrent infections or prior or ongoing antimicrobial usage, as has been suggested previously.

Oxacillin resistance was common among *S schleiferi* isolates in the present study, in keeping with the results of several other studies. Coagulase-negative isolates were significantly more likely to be oxacillin resistant, compared with coagulase-positive isolates, which has been previously suggested and is likely the result of acquisition of the mecA gene by lateral dissemination of related *S schleiferi* clones. The administration of β-lactam antimicrobials, such as cephalaxin and amoxicillin-clavulanic acid, to dogs within 30 days and 31 days to < 6 months prior to sample culture and the treatment with third-generation cephalosporins within 30 days prior to sample culture were significantly associated with oxacillin resistance in *S schleiferi* isolates. Administration of a combination of β-lactam and β-lactamase inhibitors or first-, second-, or third-generation cephalosporins increases the risk of nosocomial MRSA infection in humans and β-lactam use within 90 days prior to sample culture has been reported to increase the odds of MRSA infection in dogs. Administration of penicillin derivatives or cephalosporins may effectively eradicate oxacillin-susceptible staphylococcal strains and increase susceptibility to colonization by oxacillin-resistant staphylococci.

Previous fluoroquinolone treatment was not significantly associated with culture of oxacillin-resistant strains in the present study. Fluoroquinolone use has been identified as a risk factor for nosocomial MRSA infections in humans and dogs. Because of a strong correlation between fluoroquinolone and methicillin resistance in MRSA strains, fluoroquinolone use may promote MRSA colonization by eliminating methicillin-susceptible strains. In addition, fluoroquinolones may increase adhesion (mediated by fibronectin-binding protein) of MRSA strains to host cells. There are several possible explanations for the observed lack of association between prior fluoroquinolone treatment and the isolation of oxacillin-resistant *S schleiferi* strains. First, fluoroquinolones may not promote adhesion of *S schleiferi* to host cells by the same mechanism as that for *S aureus*. Second, although the proportions of fluoroquinolone resistance among the oxacillin-resistant *S schleiferi* isolates in the present study (67% of isolates had enrofloxacin resistance and 72% of isolates had marbofloxacin resistance) were significant, they are not as high as the rates of fluoroquinolone resistance among MRSA isolates (rates > 90% are generally reported for human and canine isolates). Fluoroquinolone use may inhibit both oxacillin-susceptible and oxacillin-resistant but fluoroquinolone-susceptible strains of *S schleiferi* and may not as effectively promote colonization by oxacillin-resistant strains as does treatment with β-lactams. It is also possible that the present study was underpowered to detect an association between oxacillin resistance and recent fluoroquinolone administration.

There was a slightly greater number of oxacillin-resistant isolates from patients that had undergone fluoroquinolone treatment (parenteral, topical, or both) within the preceding 6 months (69/129 [53%]), compared with oxacillin-susceptible isolates from patients that had undergone fluoroquinolone treatment within the preceding 6 months (44/96 [46%]). Given a 7% difference between oxacillin-resistant and oxacillin-susceptible isolates from patients with recent fluoroquinolone administration, 1,070 *S schleiferi* isolates at 90% power would be required to detect an association between oxacillin resistance and fluoroquinolone treatment within a 6-month period prior to sample culture.

In the present study, isolates from skin sites were more likely to be oxacillin resistant than were isolates from ear sites. This could be because 85% of patients with cutaneous isolates had received systemic treatment with 1 or more antimicrobials within 6 months prior to sample culture, many of which were penicillins, potentiated penicillins, or cephalosporins. An association between *S schleiferi* and recurrent pyoderma has been previously suggested. It is likely that most dogs with cutaneous infections had recurrent pyoderma, especially since most patients had received antimicrobials within the 6-month period prior to sample culture. The Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania is a tertiary referral facility, and most patients receive antimicrobial treatment prior to referral. Also, clinicians are likely to select cases with recurrent infections, prior antimicrobial treatment, or lack of clinical response to empirical antimicrobial administration to undergo sample collection for culture and antimicrobial susceptibility testing. Among the study dogs, identification of an oxacillin-resistant *Staphylococcus* spp via previous bacterial culture was not significantly associated with oxacillin resistance of the current isolate. However, the number of patients with infections caused by oxacillin-resistant *staphylococci* was likely underestimated because the medical records of few dogs included prior culture results indicating the presence of an oxacillin-resistant isolate and because antimicrobial susceptibility results were not available for every dog for which bacterial culture had been performed previously.

As previously reported, oxacillin-resistant *S schleiferi* isolates had an overall favorable antimicrobial susceptibility profile (> 50% of isolates were susceptible to ≥ 4 non-β-lactam antimicrobial classes), especially compared with oxacillin-resistant *S aureus* and *S pseudintermedius*. More than 50% of oxacillin-resistant isolates were susceptible to all non-β-lactam antimicrobials other than gentamicin and the fluoroquinolones commonly used in veterinary medicine. Trimethoprim-sulfamethoxazole was
the most effective tested antimicrobial. However, 2 oxacil-
lin-resistant isolates did have in vitro resistance to TMS,
whereas 100% of the S schleiferi isolates in our previous study were susceptible to TMS.

The study reported here had some limitations. As in any retrospective study, the data collection may have been
limited by information available in the medical record, and
some medical records were incomplete or missing. Also,
clinician selection bias likely influenced the selection of
clinical cases to undergo bacterial culture and antimicro-
bial susceptibility testing, and dogs that were presumed
to have an infection with an antimicrobial-resistant organism or that failed to respond to empirical treatment may have been more likely to be selected for investigation via bac-
terial culture. Ideally, the findings of this retrospective case
series should be further substantiated by results of prospec-
tive studies prior to drawing major conclusions about the
clinical behavior of S schleiferi in dogs.

Oxacillin resistance is common in S schleiferi, espe-
cially in isolates from skin sites. Because recent treatment with β-lactam drugs was significantly associated with oxacil-
in resistance in the population of dogs included in this
retrospective study, empirical administration of macrolide,
lincosamide, and potentiated sulfonamide antimicrobials
may be preferable to treatment with potentiated penicillins
or cephalosporins in dogs with treatment-naïve pyoderma.
Concern about selection pressure for oxacillin-resistant staphylococci and other antimicrobial-resistant bacteria may eventually influence standardized antimicrobial usage
guidelines, as proposed in some European countries.29 Al-
though fluoroquinolone administration was not identified
as a risk factor for oxacillin resistance in the present study,
empirical selection of this antimicrobial class is not recom-
manded because of the high rate of fluoroquinolone resis-
tance among oxacillin-resistant S schleiferi isolates and the
established association of fluoroquinolone treatment with
MRSA acquisition.

Results of the present study confirmed that both
coagulase-negative and coagulase-positive S schleiferi are
important pathogens of dogs. Coagulase-negative staphy-
lococci, once regarded as minor pathogens, are of increas-
ing importance as the cause of infections in human and veterinary patients.13 Microbiology laboratories should be
encouraged to fully speciate all Staphylococcus isolates,
regardless of their coagulase status. No major differences
in infections caused by coagulase-negative or coagulase-
positive S schleiferi were identified, but coagulase-negative
S schleiferi isolates were significantly more likely to be ox-
acillin resistant. This finding supports other data suggest-
ing that coagulase-positive and coagulase-negative isolates are not genotypically distinct but represent a single species with variable coagulase production, rather than biologi-
cally distinct S schleiferi subspecies.14

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Evaluation of radiographic, computed tomographic, and cadaveric anatomy of the head of boa constrictors

Tommaso Banzato et al

Objective—To evaluate the radiographic, computed tomographic (CT), and cadaveric anatomy of the head of boa constrictors.


Procedures—Cadavers weighed 3.4 to 5.6 kg and had a body length ranging from 189 to 221 cm. Radiographic and CT images were obtained with a high-detail screen-film combination, and conventional CT was performed with a slice thickness of 1.5 mm. Radiographic images were obtained in ventrodorsal, dorsoventral, and left and right laterolateral recumbency; CT images were obtained with the animals positioned in ventral recumbency directly laying on a plastic support. At the end of the radiographic and CT imaging session, 2 heads were sectioned following a stratigraphic approach; the other 2, carefully maintained in the same position on the plastic support, were moved into a freezer (–20°C) until completely frozen and then sectioned into 3-mm slices, respecting the imaging protocol. The frozen sections were cleaned and then photographed on each side. Anatomic structures were identified and labeled on gross anatomic images and on the corresponding CT or radiographic image with the aid of available literature.

Results—Radiographic and CT images provided high detail for visualization of bony structures; soft tissues were not easily identified on radiographic and CT images.

Conclusions and Clinical Relevance—Results provide an atlas of stratigraphic and cross-sectional gross anatomy and radiographic and CT anatomy of the heads of boa constrictors that might be useful in the interpretation of any imaging modality in this species. (Am J Vet Res 2011;72:1592–1599)