An investigation of the presence of *Escherichia coli* O149:K91:F4 on pig farms in southern Ontario and the use of antimicrobials and risk factors associated with the presence of this serogroup

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Abstract — Prevalence, causative factors, treatment, and preventative measures for O149:K91:F4 *Escherichia coli* infection of postweaning pigs was determined by using a cross-sectional study including 70 farms in Ontario. Surveys were distributed and samples cultured bacteriologically, resulting in 30% of farms testing positive to *E. coli* O149:K91:F4. Possible causative factors, such as housing or nutrition, were not significantly different between positive and negative farms. Use of injectable antibiotics ($P = 0.05$) and zinc oxide ($P = 0.003$) was higher on *E. coli* O149:K91:K88 (F4)-positive farms. A higher level of biosecurity and the presence of other diseases may be associated with an increased risk of isolating *E. coli* O149:K91:F4 from weanling pigs.

Introduction

Postweaning diarrhea and mortality caused by F4 (K88) *Escherichia coli* is an important disease problem in Ontario. The provincial veterinary diagnostic laboratory records reveal an increase in the isolation of enterotoxigenic *E. coli* (ETEC), beginning in the fall of 1997. The total number of swine enteric submissions to the Animal Health Laboratory (AHL) has remained constant at approximately 23% of total swine submissions over the past 10 y. However, in that period, the total number of F4 *E. coli*-positive isolates from piglets increased from 20% of the total enteric submissions in 1996–1997 to 42% in 1997–1998 (1), 36% in 2002, and 51% in 2003 (2). The O149:K91:F4 ETEC bacteria have been the predominant serogroup associated with postweaning diarrhea in pigs, worldwide (3–5). In a case-control study performed in southern Ontario, this serogroup was the most common *E. coli* to be isolated in pure cultures from pigs with postweaning *E. coli* diarrhea (PWECD) (6). Moreover, serotypes O139:K82 and O138:K81 were also demonstrated in some PWECD cases. Although the disease appears to be common in Ontario, the true prevalence of the disease is unknown.

Causes of postweaning diarrhea are often various and complex, and the simple presence of enteric pathogens is not always sufficient to produce clinical disease. Therefore, in the case of PWECD, it is also necessary to consider other physiological, environmental, and dietary effects that may sometimes be as important as the ETEC bacteria themselves (7). Several factors have been hypothesized to be associated with postweaning colibacillosis, including dietary changes, multisourcing early weaning, continuous flow of pigs through the facilities, and sanitation (8–10). Often, a single, obvious risk factor responsible for triggering *E. coli* outbreaks is not found.

The use of antimicrobials in the creep feed and starter rations have been a significant component of most PWECD control...
programs (11). Treatment of PWECD is usually based on oral antibiotics, preferentially through water (11,12) or injection of individual pigs (3,5,12). There are reports that more antimicrobials are used on farms with PWECD than on those without the problem (6), increasing the risk of resistance among O149:K91:F4 bacteria (3,13). Zinc oxide is another antimicrobial widely used to control postweaning colibacillosis when used at an inclusion level to provide up to 2500 to 3100 ppm zinc (3,12,14,15). Some other preventive measures used on farms with PWECD are acidifiers, probiotics, and sanitizers in water (3). The use of these products reflects an increased production and labor cost.

The objectives of this study were to determine the prevalence of O149:K91:F4 E. coli; to investigate management, housing, and nutrition factors associated with this specific O149:K91:F4 E. coli serogroup; and to describe the use of antibiotics and other preventive measures for PWECD in nursery barns of southern Ontario.

Materials and methods
Selection of the farms
This cross-sectional study was part of a larger study known as the Ontario Swine Sentinel Project (16). The Ontario Swine Sentinel Project was established in 2001 and included swine operations representative of the Ontario swine industry in terms of management style and geographical distribution. Initially, swine operations were included by 1 of the following strategies: stratified (sow herd size) random sampling of names from the sampling frame supplied by Ontario Pork and using inclusion criteria of at least 500 finisher pigs marketed per year (51.5%), convenience selection (17.5%), and purposive selection due to geographical location or membership in a multisite production system (31%). Subsequently, these operations were visited in 2002. Operations that dropped out of the study permanently were replaced by conveniently or purposively selected operations. For the present study, 20 farms out of the 100 farms selected for the Sentinel Project were not included, because they were grower-finisher farms. The remaining farms were sampled, providing that nursery pigs were available at the time of the visit. A total of 70 operations were incorporated into this cross-sectional study: 60 farrow-to-finish farms, 4 nurseries that were part of multisite systems, and 6 farrow-to-wean operations.

Survey information
A face-to-face interview was conducted with the person responsible for managing the farm. The number of field staff conducting the interview was limited to 3 to ensure consistency and to limit variation in interview style. These people met to discuss the purpose of each question and to ensure that the survey was presented in the same manner on each farm. The team met regularly to discuss any further concerns throughout the project. Information on diarrheal prevalence, management, and mortality were collected on each farm visit throughout the survey. Information on history of diagnosis of E. coli and mortality due to PWECD during outbreaks was obtained from the farm manager or from records, when these were available. A disease outbreak was defined as the development of mild to severe diarrhea (from pasty to watery) as evaluated by the farm manager, and an increase in average mortality. In addition, samples from the farm sent to the laboratory had to culture positive to enterotoxigenic E. coli. Information on farm hygiene, nursery management, nursery facilities, and feed management was recorded. The presence of diarrhea and coughing in the nurseries was evaluated. Definitions of variables included in the survey are listed in Table 1.

Information on the use of in-feed antibiotics in creep, 1st, and 2nd nursery feed; the use of antimicrobials in water or as an injectable for the treatment of PWECD, or both; and the use of high levels of zinc oxide and other preventive measures were recorded in the survey. Feed tags were another source of information of antimicrobial use that was collected to verify the data provided in the survey.

Bacteriology
Rectal swabs of 5 weaned pigs were collected from each of the farms visited to determine the presence of O149:K91:F4 E. coli. The presence of E. coli O139:K82 and O138:K81 were determined in a subset of 53 farms out of the 70 farms tested. The samples were taken from pigs within 1 to 4 wk postweaning that showed clinical signs of diarrhea. In herds where no diarrhea was present, pigs were sampled in a random manner from the same age group. These samples were cultured on blood agar plates (the same day as the samples were collected) and incubated for 24 h. Three to 5 hemolytic colonies with E. coli morphology were subcultured on blood agar and incubated for 24 h. The slide agglutination tests for F4 and O149:K91 antigens were performed for each of the isolates by using standard techniques (17). Just 1 of the isolates per positive pig was stored for further analysis. A farm was considered positive for E. coli if at least 1 of the rectal swabs was positive in the agglutination test.

Statistical analysis
The simple association between positive and negative herds and risk factors were determined by using chi-square and Fisher's exact test for qualitative variables and Student's t-test for quantitative variables. Fisher's exact test was used in cases where expected values in the 2 × 2 table were < 5 in at least 1 of the cells. Odds ratios (OR) of qualitative variables were calculated with 95% confidence intervals. Quantitative variables were presented as means and standard deviation (±). A value of P < 0.05 was considered significant; P values between 0.06 and 0.1 were considered numerically reportable as potential trends. Risk factors related to the case and control classification (P < 0.2) were reexamined in a multivariate model by using logistic regression. Models were built using stepwise backwards elimination. Models were evaluated based on the Pearson chi-square goodness-of-fit test, and the Bayesian Information Criteria (BIC) and Akaike's Information Criteria (AIC) values. The predictive ability of the model was evaluated based on the Receiver Operating Characteristic (ROC) curve and the classification statistics. Statistical analysis was completed in software (Intercooled Stata 8 for XP, 2003; Stata Corporation, College Station, Texas, USA).
Table 1. Description of the variables evaluated in a survey of a cross-sectional study investigating the presentation of E. coli O149:K91:F4 in pigs and risk factors associated with this pathogen in 70 nurseries in Ontario in 2002

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total inventory</td>
<td>Average number of pigs in the nursery</td>
</tr>
<tr>
<td>Total space per pig (ft&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Area of the pen divided by the number of pigs per pen</td>
</tr>
<tr>
<td>Weaning age (high and low range)</td>
<td>Average age of the pig at weaning and the range of low and high average weaning age</td>
</tr>
<tr>
<td>Form of the 1st and 2nd nursery feed</td>
<td>Mash, crumble, pelleted, or liquid</td>
</tr>
<tr>
<td>Biosecurity</td>
<td>Did the farm have shower-in facility, provide coveralls and boot dips, require a downtime of at least 24 h before visiting the farm? Did personnel have contact with other pigs? Were cats, dogs, rodents, birds present in the barn or were other animals species present on the farm (horses, cattle, chickens, goats, and/or sheep)?</td>
</tr>
<tr>
<td>Cleaning procedures</td>
<td>Did the farm use detergent before disinfection, use a disinfectant in the nursery; or disinfect the water?</td>
</tr>
<tr>
<td>Sources per pen in the nursery</td>
<td>Did pens house pigs from 1 litter or &gt; 1 litter, &gt; 1 farrowing room, or &gt; 1 sow farm?</td>
</tr>
<tr>
<td>Sources per room in the nursery</td>
<td>Did rooms house pigs from 1 farrowing room, &gt; 1 farrowing room, or &gt; 1 sow farm?</td>
</tr>
<tr>
<td>Full access feed vs limited feed</td>
<td>Were pigs in the nursery given access to feed all day or were they fed several times per day?</td>
</tr>
<tr>
<td>Continuous flow vs all-in/all out</td>
<td>Was the room or barn emptied completely before receiving a new batch of pigs?</td>
</tr>
<tr>
<td>Use of creep feed</td>
<td>Were pigs offered creep feed in the farrowing room, and at which age was the creep first offered?</td>
</tr>
<tr>
<td>Feed mixed in the farm</td>
<td>Were the 1st and 2nd nursery feeds home-mixed or was the farm using a purchased complete feed?</td>
</tr>
<tr>
<td>Condition of diarrhea and coughing</td>
<td>Were the pigs exhibiting diarrhea and/or coughing at the time of the farm visit?</td>
</tr>
<tr>
<td>Previously diagnosed with E. coli</td>
<td>Were the pigs on farm diagnosed with postweaning E. coli diarrhea in the previous 3 y?</td>
</tr>
<tr>
<td>PRRS&lt;sup&gt;+&lt;/sup&gt; vaccination status</td>
<td>Were nursery pigs and/or sows vaccinated against PRRS virus?</td>
</tr>
</tbody>
</table>

<sup>+</sup> PRRS = Porcine reproductive and respiratory syndrome

Results

Twenty-one of the 70 (30%) farms were positive for O149:K91:F4 E. coli; 17 farrow-to-finish farms (24.3%), 3 multisite nurseries (4.3%), and 1 farrow-to-wean farm (1.4%). Thirty-nine of 350 (11.1%) pigs tested were positive for O149:K91:F4 E. coli.

Positive farms reported more sporadic severe diarrhea problems than did negative farms (P = 0.002). During farm visits, diarrhea in newly weaned pigs tended to be seen more commonly on positive farms than on negative farms (65% vs 42.5%) (P = 0.09); in older weanling pigs, diarrhea was also more common on positive than on negative farms (60% vs 32.6%) (P = 0.03). There were no differences in the average mortality between positive and negative farms when diarrhea problems were not present. During a diarrhea outbreak, the nursery mortality was higher on positive farms (5.2%, s = 0.8%) than on negative farms (2.3%, s = 0.2%) (P < 0.001) for a batch of pigs. Some positive farms reported nursery mortalities as high as 15%.

Herd size, which was not normally distributed, did not differ between positive and negative farms (P = 0.52). Nursery inventory on positive farms ranged from 100 to 5800, with a mean of 1165, s = 1335 pigs, whereas that on negative farms ranged from 14 to 8000, with a mean of 931.9, s = 1474.5 pigs.

There were no differences between positive and negative farms in the following parameters: population density measured in square feet (3, s = 1.2 in negative farms vs. 2.8, s = 0.9 in positive farms) (P = 0.56) and average weaning age in d (23, s = 4.7 in negative farms vs. 22.3, s = 4.3 in positive farms) (P = 0.52). No differences (P > 0.2) were found for the following variables: texture of the feed; number of sources of pigs per pen and room in the nursery; full access feed vs limited feed; continuous flow vs all in/all out; retention of weak pigs in the nursery; use and time when creep feed was offered; water supply and nursery porcine reproductive and respiratory syndrome (PRRS) vaccination.

Positive farms (76.2%) were more likely to have been diagnosed previously with E. coli diarrhea than were negative farms (14.3%) (P < 0.001). Positive farms had more older pigs that were coughing at the time of the visit (60%) than did negative farms (30.6%) (P = 0.02), and were more likely to use a PRRS vaccination program for sows (66.6%) than were negative farms (44.9%) (P = 0.09). Positive farms were more likely to provide boots for visitors (50%) than were negative farms (24.5%) (P = 0.04). This variable was not included in the model, because
it was considered to be a biosecurity procedure, possibly implemented on farms as a response to diarrhea outbreaks. Variables with a P value < 0.2 are listed in Table 2. Interaction between a previous diagnosis of *E. coli* and older weanling pigs that were coughing was tested. No interaction was found between these 2 variables. The presence of other animals on the premises was significantly associated with positive farms (P = 0.04), but there was an interaction between the presence of other animals and a previous diagnosis of F4 *E. coli*. It was found that after controlling for the situation where a nursery had been diagnosed previously with F4 *E. coli*, the presence of other animals on the premises was not an important factor. Farms that had been diagnosed previously with *E. coli* were more likely to have other species of animals on the premises compared with those not diagnosed previously with *E. coli* (71.4% vs 36.3%) (P = 0.005).

In addition, the presence of coughing of newly weaned pigs was associated with the presence of coughing in older pigs in the nursery (P < 0.001).

In the final multivariate model, O149:K91:F4 *E. coli*-positive farms were more likely to have been diagnosed previously with postweaning *E. coli* diarrhea, and were more likely to have a coughing problem in the older pigs in the nursery (Table 3).

According to the Pearson goodness of fit, the model fitted properly (P = 0.9). The AIC and BIC values were 0.9 and -188.7, respectively. The predictive ability of the model, using the ROC curve, was 84.36 and the ability of the model to correctly classify -negative farms was 82%.

In addition, positive O149:K91:F4 *E. coli* farms were more likely to use high levels of zinc oxide (2.5 kg/t) than were negative farms (85% vs 45.8%) (P = 0.003) and were more likely to use injectable antibiotics for the treatment of diarrhea than were negative farms (80.9% vs 55.1%) (P = 0.05). The most common injectable antibiotic was trimethoprim with sulfadoxine (42.8% vs 24.9% in negative farms) (P = 0.1).

Injectable tetracyclines were used only in positive farms (9.5%) (P = 0.09). The proportion of farms using antibiotics in 1st nursery feed was 100% and 93% for positive and negative PWECD farms, respectively. The percentage of farms using in-feed antimicrobials in the 2nd nursery feed was 95% and 82% for positive and negative farms, respectively. Moreover, the proportions of positive and negative farms that used acidifiers were 60% and 47.8%, respectively. However, no difference in the use of in-feed antimicrobials or acidifiers (P > 0.2) (to treat and/or prevent PWECD) was found between *E. coli*-positive and -negative farms. Only 1 positive farm reported the use of probiotics, another farm reported the use of egg yolk antibodies.

The most common in-feed antibiotic used in positive farms was chlorotetracycline (57% in creep feed and 61.9% for 1st and 2nd nursery feeds), similar percentages were used in negative farms. The most common water antibiotic used in positive farms compared with negative farms is summarized in Table 4.
Discussion

This is the 1st prevalence study of the presence of O149:K91:F4 Escherichia coli on pig farms in southern Ontario. The high prevalence (30%) of farms found to be positive for this E. coli serogroup is comparable with the results from studies from other pig producing countries where the prevalence of different pathogenic E. coli serogroups ranges from 35% to 42% (3,5,11) and demonstrates that O149:K91:F4 ETEC is widespread on farms in southern Ontario.

Rectal swabs are commonly used for identification of E. coli implicated in diarrhea in pigs (6,18–20) and when pigs are clinically ill, bacteriological culture commonly yields almost 100% of isolates of O149:K91:F4 E. coli. However, it is much harder to detect F4 E. coli in healthy pigs, because they often carry very low levels of ETEC bacteria. Further detection of ETEC has relied on conventional bacteriological culture, followed by an agglutination test (6,19,20). The limitations of direct plating and agglutination testing are that these procedures may yield false negatives (17). Care was taken in this study to isolate a variety of colonies to avoid missing significant ETEC isolates, but the low sensitivity of this test may have led to an underestimation of the prevalence of this pathogen, especially in cultures from pigs without diarrhea.

It has been reported that E. coli serogroups O138:K81 and O139:K82 may also be involved in postweaning diarrhea problems, especially when these isolates are associated with F4 or F18ac fimbriae (21,22,5,3). However, the presence of genes for F18 fimbriae or for toxins associated with PWECD (STa, STb, LT) were not determined in this study, and the number of O139:K82 and O138:K81 isolates was too small to draw any conclusions regarding the importance of these 2 serogroups with or without O149:K91:F4 E. coli on the production of diarrhea in weaned pigs. Further studies need to clarify the importance of these 2 serogroups in PWECD problems.

The 1st report of PWECD as an emerging disease in Ontario corresponded to a time when the pig industry was rapidly changing from mostly farrow-to-finish to segregated-early-weaning (SEW) operations. The 1st cases of PWECD were often traced back to off-site nurseries where pigs had been weaned at young ages (1). This study indicates that PWECD is not restricted to SEW systems. Unfortunately, there were only 4 SEW facilities that had pigs available at the moment of the visit and the small sample size may not be representative of the population of SEW in Ontario, so a comparison between farrow-to-finish and SEW was not possible. However, all 4 of the SEW farms were positive for E. coli O149:K91:F4. Therefore, we assume that the overall prevalence of E. coli O149:K91:F4 would have been even higher if more SEW units had been tested, but diarrhea problems associated with this pathogen are a concern for conventional farrow-to-finish farms as well (3).

The average mortality rates due to E. coli obtained in this study were slightly lower than those reported in a case-control study performed in southern Ontario in 1999 (9). However, in agreement with a previous study, some of the positive farms reported mortality rates as high as 15% during PWECD episodes (9). In addition, previous reports state that the problem occurred mainly in the 1st wk after weaning (23). However, in agreement with some other studies (3,9), a high incidence of PWECD associated with E. coli O149:K91:F4 occurred 2 to 3 wk following weaning, and, in some cases, even later, possibly as late as following transfer of pigs to the grower units. Economical losses caused by E. coli O149:K91:F4 have also been attributed to drug use. In this study, E. coli O149:K91:F4-positive farms used more injectable antibiotics than did negative farms. The combination of trimethoprim and sulfadoxine was the most common injectable antibiotic used on farms with PWECD — similar proportions were used on E. coli-positive farms in 1999 (6). Moreover, compared with the findings of Amezgua et al (6), the use of neomycin in water was higher in the current study, but the use of apramycin was less than on the farms studied previously. Chlortetracycline was widely used as an in-feed antibiotic on many farms. Since the ban on carbadox, the use of in-feed chlortetracycline has increased (6). Resistance to trimethoprim/sulfadoxine, neomycin, and chlortetracycline (antimicrobials used for the treatment of E. coli) is high among pig populations (3,6,10,24–26). It is known that an antimicrobial continuously used in a nursery facility exerts a tremendous selective pressure; as a consequence, categories of antimicrobials have already lost or are on the point of losing their activity against porcine E. coli (13). Antimicrobial susceptibility trends should be monitored to guide clinical judgment on antibiotic use.

In agreement with a previous study (5), high levels of zinc oxide (> 2.5 kg/t) was another approach used in Ontario, with limited success in preventing PWECD. This may be why, even with the use of zinc oxide, some positive farms were still testing positive to F4 E. coli. Effective therapeutic options other than antimicrobials for the treatment and prevention of PWECD are being developed; however, most of the producers surveyed did not know what a probiotic or a prebiotic was. Just 1 farmer reported the use of probiotics. None of the farms used specific egg-yolk antibody products (27) or vaccinated weaned pigs with any live attenuated or killed autogenous vaccine to prevent the presence of this pathogen (28,29).

In agreement with findings previously reported (9), many factors considered to be risk factors for the presence of E. coli O149:K91:F4 were not significant, which illustrates the complex nature of this pathogen. However, the fact that positive farms had been diagnosed before with E. coli seems to have an important impact. Escherichia coli O149:K91:F4 has been around since the 1980s as the most frequent and persistent ETEC serogroup isolated from weanling pigs with diarrhea problems (30). Positive farms usually experience the problem indefinitely, with sporadic periods of apparent improvement (1,6). This serogroup has several virulence factors that make it more pathogenic than other E. coli (3,5).

More coughing in older pigs was present in positive nurseries at the time of the visit than in negative farms. Often researchers have found a significant correlation between pigs that needed treatment for enteritis and pigs that were treated for pneumonia (31). There are indications that in-utero PRRSV infection induces a state of immuno-suppression in newborn
piglets, paving the way for enhanced secondary infections (32). There are reports of PRRS infection being strongly associated with the increased severity of E. coli infection in weaning pigs (33,34). The actual PRRSV or Mycoplasma hyopneumoniae status was not determined in this study, but the presence of coughing in weanling pigs may indicate that a complicated respiratory disease, such as the porcine respiratory disease complex (PRDC), is involved with the immuno-suppression of weaned pigs, thus enhancing the E. coli problem. The presence of coughing pigs might also be related to poor housing, chilling from drafts, or wide temperature fluctuations that stress the immune mechanism and increase the susceptibility of the pig to this pathogen.

The E. coli O149:K91:F4 serogroup is a serogroup isolated solely from pigs. The presence of other animal species on the premises as a possible risk factor of PWECD may be an indirect effect, signifying a lower level of hygiene and biosecurity and likely indicative of older facilities. This variable was also associated with farms previously diagnosed with PWECD that may reflect that biosecurity, management, and cleaning conditions might not be ideal in farms that are positive. It has been reported that efficacy of biosecurity procedures are confounded by several factors (35). Other studies have found associations between the number of the animal transports, vehicles shared with other farms for animal transport, veterinarians’ or technicians’ vehicles entering the farms, and the presence of other diseases (36,37).

Postweaning E. coli diarrhea caused by O149:K91:F4 is still an economically important disease in nurseries in southern Ontario. The disease is very persistent within the farms and produces high mortality during outbreaks. Farms where E. coli O149:K91:F4 was isolated use more antimicrobials, mainly by injection of individual pigs. The use of other preventive measures, such as zinc oxide, was common on positive farms, but this product did not completely eliminate the bacteria from the pigs on some of the positive farms and its use may increase the cost of production.

The risk factors identified in this study may not be considered causal factors, since a cross-sectional design was used. However, it seems that a higher level of biosecurity and the presence of other diseases on a farm may be associated with an increased prevalence of E. coli O149:K91:F4.

Acknowledgments

The authors are grateful to the swine producers of Ontario. We thank Dr. Carlton Gyles (Department of Pathobiology, Ontario Veterinary College) for his assistance and for providing the laboratory facilities to isolate the bacteria.

References


31. Christensen G, Sørensen V, Mousing J. Diseases of the respiratory system, comprising 36 chapters and 15 appendices. Although this is the 1st edition of this text, it is probably a natural extrapolation from the *Medical Management of the Elephant*, co-edited by Dr. Mikota in 1994, and the various elephant-oriented chapters found in Dr. Fowler’s *Zoo and Wild Animal Medicine, Current Therapy*, editions 1 to 5. The book’s chapters are well thought out; the first 2 provide an excellent introduction by presenting the evolution and taxonomy of elephants, and a history of elephants in captivity. Sadly, this gives a pessimistic, but probably realistic, view of the future for captive elephants. The next few chapters include behavior, husbandry and nutrition, and are more focussed upon the provision of a satisfactory captive environment. The book then leans towards a veterinary text, with chapters on the restraint and examination of elephants, diagnostic techniques, surgical and medical conditions, and therapeutics. The final chapters cover the different body systems of elephants, including their anatomy, physiology, examination, and diseases. The book concludes with some very useful appendices.

In general, the chapters are thorough, well-written and interesting, and the information is up-to-date. There are many tales of personal experiences, both good and bad, which certainly add to the usefulness of this book, presumably with the hope that such mistakes will not be repeated. The subject matter is broad and will interest a wide audience including veterinarians, biologists, and animal keepers or managers. A few chapters contain useful glossaries that will help anyone not familiar with a particular topic.

Within their introduction, the editors state that they hope this book will begin to fill a void due to the lack of a modern comprehensive text on elephant medicine and surgery. They must be congratulated on doing an excellent job, and at its current price, it is a positive bargain. My only worry is how to keep my copy clean in the elephant house!

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**Book Review**

**Compte rendu de livre**

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**Biology, Medicine, and Surgery of Elephants**


This is an excellent text for anyone working with elephants; indeed, it is a prerequisite! This is hardly surprising, since it has brought together 36 authors with a broad background of elephant experience, many of whom are well-known and well-respected within their particular disciplines. The 2 eminent editors, Drs. Fowler and Mikota, top this off perfectly. Dr. Fowler’s previous works are the backbone of any zoo veterinarian’s library and Dr. Mikota’s elephant-oriented Web site is a wealth of useful information that many a biologist or veterinarian, working with these wonderful creatures, will have explored. Consequently, although my aim was to “browse” this book prior to writing a review, I ended up reading it from cover to cover, thoroughly enjoying it, and learning more than I care to admit.

*Biology, Medicine, and Surgery of Elephants* is 565 pages long, comprising 36 chapters and 15 appendices. Although this is the 1st edition of this text, it is probably a natural extrapolation from the *Medical Management of the Elephant*, co-edited by Dr. Mikota in 1994, and the various elephant-oriented chapters found in Dr. Fowler’s *Zoo and Wild Animal Medicine, Current Therapy*, editions 1 to 5. The book’s chapters are well thought out; the first 2 provide an excellent introduction by presenting the evolution and taxonomy of elephants, and a history of elephants in captivity. Sadly, this gives a pessimistic, but probably realistic, view of the future for captive elephants. The next few chapters include behavior, husbandry and nutrition, and are more focussed upon the provision of a satisfactory captive environment. The book then leans towards a veterinary text, with chapters on the restraint and examination of elephants, diagnostic techniques, surgical and medical conditions, and therapeutics. The final chapters cover the different body systems of elephants, including their anatomy, physiology, examination, and diseases. The book concludes with some very useful appendices.

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