INTRODUCTION

The one-humped camel is widely distributed in the Horn of Africa, North African countries, the Arab peninsula and some countries of Asia. In Jordan, the population of dromedary camels is around 18,000. Bedouins use them as a means of transportation in the desert; they can also be used for tourism or reared for production of meat, milk, hair or hide (16).

Lung infections, especially pneumonia, are major diseases of domestic animals. Outbreaks occur in camel, cattle, buffaloes and small ruminants in various countries (13, 25, 26). Pneumonia may be caused by bacteria, mycoplasmas, viruses, parasites and fungi (5, 25).

Rearing systems, stress factors, climatic changes, unhygienic conditions, sudden changes in feed and a low level herd health status were stated as predisposing factors to bacterial and viral pneumonia. In camels, pneumonia outbreaks are usually observed during the change from the dry to the rainy season (5, 17, 19, 25, 27). Only few studies were found in the available literature on pathological and bacteriological affections of pneumonic lungs in camels. Most of the studies on camels were about parasitic infections (7, 12, 22). In Jordan, only one study on camel diseases was available (6). Therefore, the objective of this work was to study the etiology (bacterial) as well as histopathological findings of pneumonia in camels in the northern part of Jordan.

MATERIALS AND METHODS

From July 2000 to February 2001 (summer and winter), 284 lungs of slaughtered camels (6 months to 10 years of age) from northern Jordan were examined. Pneumonia prevalence was 10.2%. Pathological lesions of pneumonic lungs showed the presence of chronic proliferative bronchopneumonia, chronic pleuropneumonia and interstitial pneumonia. Lung abscesses were also recorded. Chronic proliferative bronchopneumonia (20.69%) and chronic pleuropneumonia (6.9%) were more frequent in older camels (about 10 years of age), while interstitial pneumonia (58.6%) and lung abscesses (10.34%) were more frequent in young camels (6 months to 4 years of age). Mannheimia haemolytica and Pseudomonas aeruginosa were the most frequent isolates from cases of chronic proliferative bronchopneumonia and chronic pleuropneumonia, while Escherichia coli and Klebsiella spp. were the most frequent isolates from cases of interstitial pneumonia. Staphylococcus aureus, Actinomyces pyogenes and hemolytic streptococci were the most frequent isolates from lung abscess cases. A total of 75 bacterial isolates were collected from the 29 pneumonic lungs. The most frequent were E. coli (26.66%), Klebsiella spp. (14.66%), Pseudomonas aeruginosa (12%), Staphylococcus aureus (10.66%), Mannheimia haemolytica (6.66%) and Actinomyces pyogenes (6.66%). Klebsiella ozaenae was the most frequent among the Klebsiella species identified.

Key words
Camelus dromedarius - Pneumonia - Gram-positive bacteria - Gram-negative bacteria - Histopathology - Jordan.

Summary
In general, literature about camel pneumonia is scarce. In this study, 284 lungs of slaughtered camels (6 months to 10 years of age) from northern Jordan were examined. Pneumonia prevalence was 10.2%. Pathological lesions of pneumonic lungs showed the presence of chronic proliferative bronchopneumonia, chronic pleuropneumonia and interstitial pneumonia. Lung abscesses were also recorded. Chronic proliferative bronchopneumonia (20.69%) and chronic pleuropneumonia (6.9%) were more frequent in older camels (about 10 years of age), while interstitial pneumonia (58.6%) and lung abscesses (10.34%) were more frequent in young camels (6 months to 4 years of age). Mannheimia haemolytica and Pseudomonas aeruginosa were the most frequent isolates from cases of chronic proliferative bronchopneumonia and chronic pleuropneumonia, while Escherichia coli and Klebsiella spp. were the most frequent isolates from cases of interstitial pneumonia. Staphylococcus aureus, Actinomyces pyogenes and hemolytic streptococci were the most frequent isolates from lung abscess cases. A total of 75 bacterial isolates were collected from the 29 pneumonic lungs. The most frequent were E. coli (26.66%), Klebsiella spp. (14.66%), Pseudomonas aeruginosa (12%), Staphylococcus aureus (10.66%), Mannheimia haemolytica (6.66%) and Actinomyces pyogenes (6.66%). Klebsiella ozaenae was the most frequent among the Klebsiella species identified.

Bacteriological and Pathological Study on Pneumonia in the One-Humped Camel (Camelus dromedarius) in Jordan

Y.H. Al-Tarazi1

1. Department of Basic Veterinary Medical Sciences, Faculty of Veterinary Medicine, Jordan University of Science and Technology, PO Box 3030, Irbid, Jordan Tel: +962 2 720 10 00; Fax: +962 2 709 51 23; E-mail: tarazi@just.edu jo
Bacteriological Isolates of Pneumonia in One-Humped Camels

Histopathological changes showed chronic proliferative bronchopneumonia in six lungs and chronic pleuropneumonia in two lungs (Table I). The chronic proliferative bronchopneumonia was characterized by a “hepatized” texture of the affected tissue and a mosaic appearance (Figure 1). Under a microscope, the lesions were characterized by severe monocellular infiltration and fibrous proliferation. The alveoli were either filled with inflammatory cells or totally damaged with giant cell formation (Figure 2). The bronchi were filled with inflammatory cells and congested blood vessels. In chronic pleuropneumonia, there was also expansion and congestion of the pleura and caudal lobe (phringe-extensions) and infiltration of inflammatory cells (macrophages and polymorphs) (Figure 3). In only one lung, pleuritis was diagnosed with pulmonary edema, which was characterized by dilated lymph vessels, congestion of blood vessels, moderate infiltration of inflammatory cells with proteinaceous materials and thickening of the alveolar wall. Interstitial pneumonia was observed in 17 lungs and was characterized by thickening of alveolar wall and presence of inflammatory cells in moderate numbers (Figure 4). Lung abscesses were found in three lungs and were characterized by the presence of several abscesses (1-2 cm in diameter) close to each other and filled with cheese-like viscid pus.

### RESULTS

#### Histopathological pictures

Out of 284 lungs examined, 29 (10.2%) lungs had gross lesions. These lesions were found in lungs of various camel age groups. The chronic proliferative bronchopneumonia and chronic pleuropneumonia were observed more frequently in older animals, while interstitial pneumonia and lung abscesses were more common in younger animals (Table I).

<table>
<thead>
<tr>
<th>Type of Lung Lesion</th>
<th>Prevalence of Lung Lesions (%)</th>
<th>Animal Age</th>
<th>Most Frequent Bacterial Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic proliferative bronchopneumonia</td>
<td>6 (20.69)</td>
<td>1-10 years</td>
<td>Pasteurella haemolytica, Pseudomonas aeruginosa, E. coli, Klebsiella spp.</td>
</tr>
<tr>
<td>Chronic pleuropneumonia</td>
<td>2 (6.9)</td>
<td>10 years</td>
<td>Pasteurella haemolytica, Pseudomonas aeruginosa</td>
</tr>
<tr>
<td>Pleuritis with pulmonary edema</td>
<td>1 (3.45)</td>
<td>2 years</td>
<td>Staphylococcus aureus</td>
</tr>
<tr>
<td>Interstitial pneumonia</td>
<td>17 (58.6)</td>
<td>6 months to 4 years</td>
<td>E. coli, Klebsiella spp., Pseudomonas aeruginosa, Staphylococcus spp.</td>
</tr>
<tr>
<td>Lung abscess</td>
<td>3 (10.34)</td>
<td>1-2 years</td>
<td>Staphylococcus spp., hemolytic streptococci, Actinomyces pyogenes, E. coli</td>
</tr>
</tbody>
</table>

**Figure 1:** Chronic proliferative bronchopneumonia of a ten-year-old camel. The affected part shown is the caudal lobe of the lung. Notice the mosaic appearance, the fibrosis on the right side and the phringses.

**Figure 2:** Microscopic appearance of chronic proliferative bronchopneumonia characterized by severe monocellular infiltration; the alveoli are damaged and filled with inflammatory cells (H & E; x 200).
Bacterial isolates

A total of 75 bacterial isolates were collected from the 29 pneumonic lungs cultured. More than one bacterial species were isolated from 24 pneumonic lungs, one species from three lungs and no bacterial growth was obtained from two lungs. The ten apparently healthy lungs examined did not reveal any bacterial growth. There were 47 Gram-negative bacterial isolates that were or could be pathogenic: *Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa*, *Mannheimia haemolytica* (previously *Pasteurella haemolytica*), and *Citrobacter* spp. And there were 20 Gram-positive isolates: *Staphylococcus aureus*, *Staphylococcus* spp., *Actinomyces pyogenes* and hemolytic streptococci. Other bacterial species (eight isolates) were also collected: *Bacillus* spp., *Proteus* spp. and *Enterobacter aerogenes* (Table II). The species of *Klebsiella* were identified and *Klebsiella ozaenae* was the most frequent (Table III). The results showed that *E. coli* and *Klebsiella* spp. were the most frequent isolates from cases of interstitial pneumonia, in addition to *Pseudomonas aeruginosa* and *Staphylococcus* spp. On the other hand, *Mannheimia haemolytica* and *Pseudomonas aeruginosa* were the most frequent isolates from cases of chronic proliferative bronchopneumonia and chronic pleuropneumonia, in addition to *E. coli* and *Klebsiella* spp. From cases of lung abscesses, *Staphylococcus aureus*, other *Staphylococcus* species, hemolytic streptococci, *Actinomyces pyogenes* and *E. coli* were isolated (Table I).

**DISCUSSION**

In this study, pathological examination of 284 slaughtered camel lungs showed occurrence of pneumonia in 29 (10.2%) lungs. This agrees with the results of other studies conducted in Jordan and Egypt, where the infection rates of the lungs examined were 10 and 12%, respectively (6, 18).

The results of this work show that chronic proliferative bronchopneumonia and chronic pleuropneumonia were found mainly in old camels. They were found in six (20.69%) and two (6.9%), respectively, out of 29 pneumonic lungs, from which *Mannheimia haemolytica* (8), *Pseudomonas aeruginosa*, *E. coli* and *Klebsiella* spp. were isolated. In Egypt, it was reported that out of 23 camel lungs examined, only three (13%) showed "hepatization", and *Staphylococcus aureus*, *Streptococcus pyogenes*, *Klebsiella* and *Citrobacter* were isolated (18). In Iraq, another study showed that 56% of 150 camel lungs were pneumonic and *Pasteurella multocida*, *Mannheimia haemolytica*, *E. coli*, *Pseudomonas aeruginosa* and *Actinomyces pyogenes* were isolated (3). In this study, *M. haemolytica*, and *Pseudomonas aeruginosa* were the most prominent in the cultures and they might have been the main cause of chronic bronchopneumonia in camels, while *E. coli* and *Klebsiella* spp. were less prominent and might be considered as secondary invaders.

The results of this study show that interstitial pneumonia was more frequent in young camels than in older ones. It was diagnosed in...
Bacteriological Isolates of Pneumonia in One-Humped Camels

17 (58.6%) of the 29 pneumonic lungs, from which E. coli and Klebsiella spp. were the most predominant isolates mixed with Pseudomonas aeruginosa or Staphylococcus aureus or with other Staphylococcus species. Similarly, these types of pneumonia were reported to occur in free-range animals (12).

In this study, a relatively high number of bacterial isolates (75) were collected from 29 pneumonic lungs, of which 24 revealed more than one bacterial species. The bacterial species isolated and identified from the affected lungs included E. coli, Klebsiella spp., S. aureus, P. aeruginosa, A. pyogenes, M. haemolitica, Streplococcus spp., Citrobacter, E. aerogenes, Proteus and Bacillus. The ten apparently healthy lungs examined and considered as negative control revealed no bacterial growth. These results agree with other studies conducted in Pakistan (4) and Egypt (18), where the authors conclude that the etiology of pneumonia in camels is multifactorial. The results of this study also agree with those reported in Sudan, where S. aureus (34.6%), Klebsiella spp. (26.4%), A. pyogenes (22.4%) and S. pyogenes (16.8%) were isolated from 96 pneumonic lungs among 125 camel examined (20), and those reported in Iraq, where P. multocida, M. haemolitica, E. coli, Pseudomonas aeruginosa and A. pyogenes were isolated in 56% of 150 camel lungs (3).

Three lungs showed multiple abscesses (1-2 cm in diameter), from which S. aureus, hemolytic streptococci and A. pyogenes were isolated. Such types of abscesses in camel lungs were reported in Iraq, where five camels showed small localized abscesses in the lungs and A. ovis was isolated (3). These results agree with what was mentioned in the literature about causative agents of abscesses (13, 23, 24).

The isolation of M. haemolitica from “hepatized” camel lungs agrees with results from other studies conducted in Jordan (6), Iraq (3) and Sudan (20). In contrast, it differs from reports in Egypt, where no M. haemolitica was isolated from any pathological lesions of six pneumonic lungs (18).

In this study, K. ozaenae, K. pneumoniae, K. oxytoca and K. rhinoscleromatis were isolated from pneumonic lungs of camels, whereas in most previous studies on camel pneumonia Klebsiella is mentioned at the genus level only. Finally, Bacillus, Proteus and E. aerogenes isolates were collected from mixed cultures of pneumonic lungs. Such isolates were previously mentioned by others and are considered less pathogenic (4, 21).

■ CONCLUSION

Camels in Jordan were found to be affected with bacterial pneumonia. Their prevalence rate in the present study was 10.2%. Bacterial pneumonia could be classified into three groups: chronic proliferative bronchopneumonia, chronic pleuropneumonia and interstitial pneumonia. Chronic pneumonia that affected older camels was mainly caused by M. haemolitica and Pseudomonas aeruginosa, whereas interstitial pneumonia that affected young camels was caused by Klebsiella spp. and E. coli. Lung abscesses were caused by pyogenic organisms. The majority of bacterial pneumonia cases had multifactorial causes.

Acknowledgments

The author wishes to thank the Faculty of Scientific Research at Jordan University of Science and Technology (JUST) for funding this research (project No. 14599).

REFERENCES

Les publications concernant la pneumonie chez le dromadaire sont en général rares. Dans cette étude, 284 poumons de dromadaires, abattus entre 6 mois et 10 ans d’âge et provenant du nord de la Jordanie, ont été examinés. La prévalence de la pneumonie a été de 10,2 p. 100. Les lésions pathologiques des poumons atteints de pneumonie ont été classées selon qu’elles indiquaient la présence de la broncho-pneumonie chronique, de la pleuropneumonie chronique ou de la pneumonie interstitielle. Les abcès du poumon ont aussi été enregistrés. La broncho-pneumonie proliférative chronique (20,69 p. 100) et la pneumonie chronique (6,9 p. 100) ont été plus fréquentes chez les dromadaires âgés (10 ans environ), alors que la pneumonie interstitielle (58,6 p. 100) et les abcès du poumon (10,34 p. 100) ont été plus fréquents chez les jeunes dromadaires (âgés de 6 mois à 4 ans). Mannheimia haemolytica et Pseudomonas aeruginosa ont été les espèces les plus fréquemment isolées dans le cas de broncho-pneumonie proliférative chronique et de pleuropneumonie chronique, alors que, dans les cas de pneumonie interstitielle, c’étaient Escherichia coli et Klebsiella spp. qui l’ont été le plus. Dans les cas d’abcès du poumon c’étaient Staphylococcus aureus, Actinomyces pyogenes et des streptocoques hémolytiques qui ont été le plus fréquemment observés. Au total, 75 espèces bactériennes ont été isolées de 29 poumons. Les plus fréquentes ont été E. coli (26,66 p. 100), Klebsiella spp. (14,66 p. 100), Pseudomonas aeruginosa (12 p. 100), Staphylococcus aureus (10,66 p. 100), Mannheimia haemolytica (6,66 p. 100) et Actinomyces pyogenes (6,66 p. 100). L’espèce la plus souvent observée parmi les Klebsiella identifiées a été Klebsiella ozaeae.


**Mots-clés :** Camelus dromedarius - Neumonía - Bacteria gram positiva - Bacteria gram negativa - Histopatología - Jordania.

**Palabras clave:** Camelus dromedarius - Neumonía - Bacteria gram positiva - Bacteria gram negativa - Histopatología - Jordania.

Isolats bactériologiques de la pneumonie chez le dromadaire
