World distribution of camelids

Livestock Pop & Prod

- No
- 400,000 more
- 150,000 400,000
- 50,000 150,000
- 10,000 50,000
- less 10,000
- not available
AFRICA: 16 to 20 millions

ASIA: 12 to 15 millions

Marginal production
0.2% of the world milk production (herbivorous only)

A world population Under estimated
A virtuous animal

A low cholesterol meat

Sobriety, endurance, fidelity, longevity

Milk with medical proprieties

Quality wool and skin
Essential in arid lands

- Well adapted animal to desertification process and scarce natural resources
- Providing high value red and white proteins to population in arid areas
- Providing efficient services in agriculture, environmental friendly transport and leisure
- Emblematic animal, honored and idealized, an animal for prestige and exhibition
- Beauty animal and desert champion
- A biological model
The emerging diseases in camel population

Several unexplained diseases with over mortalities occurred in the last ten years in Mali, Niger, Ethiopia, Sudan, Somalia, Saudi Arabia.....
Emerging diseases in camel population

A mediatc disease on strange mortality in Saudi Arabia

**NEWSFOCUS**

**VETERINARY MEDICINE**

**Camel Scientists Ask: What’s Sinking the Ships of the Desert?**

A wave of deaths among Saudi Arabian camels is the latest reason for a surge in research into these rugged, unusual, and highly valuable animals. When more than 2000 camels perished in Saudi Arabia this year, the mysterious diseases caused a nationwide panic. Investigations were launched and camel “beauty contests” suspended. And when evidence mounted that the killer was not an infectious disease but rather a toxic substance in the animals’ food, a government council demanded sanitized conditions.
Camel Pathology

- Little is known about the pathogens that circulate in camel populations and how these pathogens interact with the camel.
- Very few diagnostic tests are validated for use in camels, and it is not fully understood how they respond to vaccines.
- Role of camels in the human disease ‘Middle East Respiratory Syndrome (MERS)’ and questions about the validity of antibody tests for MERS in camels have highlighted the need to better understand disease dynamics in these creatures.
The specific constraints for diseases control in camel

Camel herd mobility
Desert margins
Absence of systematic vaccination
Low specific competencies in veterinary services
Traditional knowledge based on symptoms not on diseases

Specific metabolism (hyperthermia, mineral metabolism)
Specific pharmacological aspect
Specific immunological aspect
Coarse symptomatology
New Challenge in camel pathology

- Dromedary camels known to be resistant to most diseases
- Increase demand in camel products favors the creation of suburban zones of camel breeding units
- Sedentarization allows emergence of new pathogens in camel population

- Establishment of the list of camel diseases
- Improve diagnostic capacity for camel diseases
- Establish specific guidelines for trade in camels and camel products.
The diseases of Camelids were listed and divided into three groups:

1) Significant diseases;
2) Diseases for which Camelids are potential pathogen carriers;
3) Minor or non-significant diseases.

For each disease, the available antigen detection methods and serological tests were added, followed by recommendations for diagnostic and prevention.

The list of diseases were developed for the Dromedary Camel, the Bactrian Camel and the New World Camelids (Llama and Alpaca).
Meetings of the AHG on Diseases of Camelids

- **2008**: listing diseases by category (significant, potential carrier, minor)
- **2010**: list update and identification of diseases of priority for each species.
- **2011**: Workshop in Teramo, laboratory network for MENA region and specific projects
- **2014**: Special issue on MERS CoV and Brucellosis.
PRIORITY VIRAL DISEASES OF CAMELIDAE

- Camel Pox (Dromedary and Bactrian camels)
- Rabies (all species)
- FMD (Bactrian camels only)
Camelpox

- Camelpox occurs in almost every country in which camel husbandry is practised apart from the introduced dromedary camel in Australia and tylopods (llama and related species) in South America.
- Camelpox virus is an Orthopoxvirus, the most closely related to variola virus, the aetiological agent for smallpox.
- The camelpox virus is very host specific and does not infect other animal species, including cattle, sheep and goats.
- Field reports of mild skin lesions in humans associated with camel pox have been made in the past. Human camelpox has been recently described in India, underlining that camelpox may be of public health concern. More investigations needed for confirmation.
Camel pox prevention

- Life-long immunity follows after natural infection
- Different strains of camel pox virus may show some variation in their virulence. However, no major differences from the vaccine strain have so far been demonstrated.
- Prevention of Camel Pox has been successfully conducted using vaccinia virus in several countries.
- Live, attenuated vaccine provides protection against the disease for many years. Inactivated vaccine provides protection for 1 year only.
Rabies in camels

- Rabies of camels has been observed in many African and Asian countries, Morocco, Mauritania, Oman and the U. A. E.
- Rabies-like diseases with hindquarter paresis have been reported in Somali dromedaries.
- Two forms of rabies have been described in the dromedary: the "raging fury" and the "silent fury". The latter form is seldom seen in camels.
- An incubation period of 3 weeks to 6 months followed by symptoms in cases of the "raging fury": restlessness, aggression, biting and snapping, self-mutilation, hypersalivation and muscle tremor. This excitative state is followed by the paralytic phase, the rabid dromedaries lie on their sides and flail with their limbs. Prior to death, the dromedary attempts to yawn continuously.
Rabies diagnosis and Prevention

Presence of Negri bodies can be confirmed by immunofluorescence. In all of the rabid dromedaries examined, massive numbers of rabies virus particles of varying sizes were seen in the brain.

Active immunisation is possible with inactivated vaccines. The data show that one cattle dose of inactivated rabies vaccine induces good but short-term serological conversion in dromedary camels. Therefore a booster dose of vaccine is necessary 6 to 8 months after primary vaccination.
Foot and Mouth Disease

- Foot and mouth disease (FMD) is caused by a virus of the genus Aphthovirus, family Picornaviridae. There are seven serotypes of FMD virus.

- Foot-and-mouth disease (FMD) is an acute infectious disease, which causes fever, followed by the development of vesicles in the mouth and on the feet.

- Dromedaries are not susceptible to infection with FMDV while Bactrian camels seem to be of a similar cattle susceptibility to FMD.

- Prevention of FMD in Bactrian camels in endemic area can be conducted through vaccination using homologous strain inactivated vaccine at recommended cattle dose.
Diseases for which camelids are potential pathogen carriers

- MERS CoV
- Rift Valley fever (Dromedary camels)
- Bovine Viral Diarrhoea (New World camelids)
- Orbiviruses (BT, AHS, EHD)
MERS CoV

- **Novel disease in humans - first reported April 2012**
  - 635 confirmed cases with 193 deaths
  - 17 countries including traveler cases outside Middle East
  - Most secondary human cases appear to be acquired from other humans (nosocomial)

- **Epidemiological data point towards an animal reservoir of MERS-CoV**
  - Camels likely to be the natural host of MERS CoV
  - Some primary cases have reported contact with camels
  - Evidence of Subclinical infection in human in contact with camels
  - Limited human-to-human transmission,
  - Serology surveys suggests widespread exposure of camels to MERS CoV or a similar virus in Africa and ME
Smaller number of MERS CoV infections reported in camels (mild or subclinical).

PCR positive results from camels in some countries; virus isolated.

Camel serology positive to MERS CoV in 11 countries. Study suggests antibodies from camels detected as far back as 1992 but probably much longer.

Dromedary camels may play a role as reservoir carrier of the virus.

OIE declared MERS CoV as a notifiable disease in camels (23/05/14 Oman).
Rift Valley Fever

- Rift Valley Fever is an infectious zoonotic disease affecting sheep, goats, and cattle.
- First discovered in Kenya in 1931, it is characterized by a short incubation period, fever, hepatitis, high morbidity in lambs less than one week of age, and high abortion rates.
- The disease is caused by the Rift Valley Fever (RVF) virus, a member of the genus Phlebovirus in the family Bunyaviridae and the disease is transmitted by mosquitoes.
- Limited to Africa in earlier years, it causes enormous waste of livestock, especially in wet conditions. In 2001 Rift Valley Fever also occurred in Saudi Arabia and the Yemen.
Rift Valley Fever

During the epidemic of Rift Valley fever (RVF) that occurred in Egypt and other areas of North Africa in 1977, the virus was isolated from various species of domestic animal and rats (Rattus rattus frugivorus) as well as man. The highest number of RVF virus isolates were obtained from sheep; only one isolate was recovered from each of the other species tested, viz. cow, camel, goat, horse, and rat. RVF virus was reisolated from both camel and horse sera, apparently for the first time.

RVF Severe disease in Camels of West Africa during 2010 outbreak in Mauritania, Senegal.
AHS, Bluetongue & EHD

- BTV & EHDV infections involve domestic and wild ruminants. Caused by orbiviruses, and there are 24 serotypes of BTV and 9 of EHDV and AHS.
- Insect-borne viral infection inapparent in the vast majority of infected animals but causes fatal disease in a proportion of infected sheep, deer and wild ruminants.
- Although cattle and camels rarely show clinical signs, they are important in the epidemiology of the disease due to the prolonged viraemia in the absence of clinical disease.
- Because of high percentage of seropositive dromedary camels, Camelids are suspected to play a role as a carrier reservoir in sub-Saharan Africa.
- Zebras and camels may be infected by AHSV without showing signs of disease.
Bluetongue, AHS & EHD in camel

**BTV Serology prevalence**
- Egypt 14.3%
- Iran 6%
- Yemen 13%
- Sudan 17%
- Morocco 15 to 65%

**EHD Serology prevalence unknown**

**AHS reported between 5 to 23% in Egypt and Sudan**
BVD in Camels

- Camels can be infected subclinically. The percentage of seropositive to BVD: 1.7% in Egypt (1998), UAE: 9.2% - 3.6% (1990). In 552 camels tested was 0.5% in racing camels and 6.4% in breeding camels (2002).

- Egypt 1998: the prevalence of neutralizing antibodies to BVD virus was 52.5% in camels. The positive sera were titrated against BVD virus (BVDV) strains NADL and Oregon C24V; the latter is closely related to border disease (BD) virus.
VIRAL DISEASES IN CAMELIDS

- Camel Pox is the only one specific disease of camels that occurs in almost every country in which camel husbandry is practiced.
- The real impact of other significant viral diseases in camelids (FMD, rabies, BVD) is still controversial.
- Role of camelids as potential carriers for vector borne diseases should be investigated (susceptibility to different strains/serotypes, viraemia duration).
# Viral Diseases in Camelids

## A) Viral diseases of camelids

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Species</th>
<th>Identification of the agent</th>
<th>Serological tests</th>
<th>Recommendations for diagnosis</th>
<th>Vaccines</th>
<th>Recommendations for vaccines / control of the disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camelpox (see Chapter 2.9.2. of the OIE Terrestrial Manual 2012)</td>
<td>Dromedary and Bactrian camels</td>
<td>TEM, virus isolation, IHC, PCR and qPCR</td>
<td>ELISA VNT</td>
<td>None</td>
<td>Several vaccines available (killed and attenuated)</td>
<td>Only homologous strains should be used for vaccine production. A global strategy for the eradication of the disease should be initiated.</td>
</tr>
<tr>
<td>Rabies (see Chapter 2.1.13. of the OIE Terrestrial Manual 2012)</td>
<td>All species</td>
<td>FAT, PCR and IHC</td>
<td>VNT</td>
<td>An ELISA need to be developed and validated for camels</td>
<td>No vaccination protocol developed for camels. Vaccination with cattle dose was used.</td>
<td>Vaccination protocols (taking into account duration of antibodies) with available vaccines need to be developed in camels.</td>
</tr>
</tbody>
</table>
# Viral Diseases in Camelids

<table>
<thead>
<tr>
<th>Disease</th>
<th>Camel Type</th>
<th>Diagnosis Method</th>
<th>Validation</th>
<th>Vaccination Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVF</td>
<td>Dromedary camels</td>
<td>Virus isolation and qPCR</td>
<td>Validation of an IgM ELISA would be necessary</td>
<td>No vaccination protocol developed for camelids. Vaccination with cattle dose was used.</td>
</tr>
<tr>
<td>BVD</td>
<td>New world camelids&lt;br&gt;More investigation on Dromedary and Bactrian camels</td>
<td>Virus isolation, PCR, IHC and ELISA</td>
<td>1. Validation of serological tests in milk&lt;br&gt;2. Susceptibility for Dromedaries and Bactrian camels should be assessed</td>
<td>No vaccination protocol developed for camelids. Inactivated vaccine with sheep and goat dose is used.</td>
</tr>
<tr>
<td>FMD</td>
<td>Bactrian camels</td>
<td>Virus isolation, PCR, and ELISA</td>
<td>Validation of ELISAs is needed</td>
<td>No vaccination protocol developed for Bactrian camels. Vaccination with cattle dose is used.</td>
</tr>
</tbody>
</table>

Vaccination protocols with inactivated vaccines need to be developed in camelids.

Vaccination protocol with the Clone-13 live attenuated virus vaccine needs to be developed in dromedary camel.
Bacterial diseases in camel

- Significant diseases
  - Brucellosis (abortus and melitensis)
  - Tuberculosis
  - Paratuberculosis
  - Anthrax
  - Caseous lymphadenitis
  - Pasteurellosis
Camel brucellosis

- Brucellosis in camels and other livestock considered the most widespread zoonosis in the world
- Can have a dramatic impact on livelihood and public health
- Increasingly important with the explosion of urban and peri-urban livestock
- Brucellosis in camels seems to display less clinical signs than in other ruminant animals
Brucellosis in camel: Etiology

- Infection in camels is caused by different biotypes of *B. abortus* and *B. melitensis*
- *Brucella melitensis* biotype 3 seems to be the most prevalent
- Isolation of *Brucella* from internal organs (lymph nodes) is relatively easier compared to milk
Brucellosis control strategies

- Lack of clear-cut policies regarding the control of the disease
- Control strategies depend on
  - Level of prevalence (seroprevalence)
  - Production systems (extensive vs intensive)
  - Financial resources
  - Capacity of veterinary services
  - Participation of herders
- Whole herd vaccination in extensive management system using S19 or Rev1 vaccine (dose and route !)
- Public education and sensitization
Respiratory diseases: Pasteurellosis

- May be responsible for considerable loss of production and deaths
- Represents a wide range of pulmonary and septicemic infections
- Associated with Pasteurella Multocida and Mannheimia haemolytica
- Both organisms are frequently isolated from the upper respiratory tract of both sick and apparently healthy animals
- M. haemolytica infections include a wide range of primary and secondary pneumonia (pneumonic pasteurellosis)
- P. multocida is associated with hemorrhagic septicemia in adults and enzootic pneumonia complex in young animals
Development of pasteurellosis

Endogenous organisms

Virulence factors
- Capsule
- Fimbriae
- Endotoxin
- Leukotoxin

Predisposing factors
- Stress
- Climate change
- Herd health status
- Deficient nutrition
- Concomitant infections

Immune status
Pneumonic Pasteurellosis

- **Mannheimia hemolytica** (P. hemolytica biotype A)

- acute febrile respiratory disease with fulminating fibrinopurulent bronchopneumonia and fibrinous pleurisy

- **Disease develops within 10 to 14 days** (cough, dyspnea, mucopurulent nasal and ocular discharges)

- Animals may die as a result of toxemia (young animals 2-3 days) before development of pulmonary lesions
Bacterial lung lesions (pasteurellosis)

Lung with severe congestion
(Credit Al Ani et al. 1998)

Lung with pulmonary emphysema
(Credit Al Ani et al. 1998)
Pyogenic infections: Pseudotuberculosis

- Caseous lymphadenitis: Corynebacterium pseudotuberculosis (and C. pyogenes)
- Reported from several countries in Middle East (Egypt, KSA, UAE, Iran), Asia (India, China, Russia), East Africa (Kenya and Ethiopia) and Australia
- Chronic infection which often affects the lymph nodes at the base of the neck, around the rump and lower part of the mandible
- Abscesses are usually closed, cold and painless
- Erythromycin and penicillin for treatment
### B) Bacterial diseases of camelids

<table>
<thead>
<tr>
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<th>Species</th>
<th>Identification of the agent</th>
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<th>Recommendations for diagnostic</th>
<th>Vaccines</th>
<th>Recommendations for prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthrax (see Chapter 2.1.1. of the OIE Terrestrial Manual 2012)</td>
<td>All species</td>
<td>Immuno-fluorescence, PCR, culture and identification of Bacillus anthracis</td>
<td>None</td>
<td>None</td>
<td>No vaccination protocol developed for camelids. Live vaccine with cattle dose is used</td>
<td>Vaccination protocols with live vaccine need to be developed in camelids.</td>
</tr>
</tbody>
</table>
| Brucellosis (B. melitensis & B. abortus, depends on the environment) (see Chapters 2.4.3. and 2.7.2. of the OIE Terrestrial Manual 2012) | All species                  | Staining methods, culture and PCR                                             | BBAT, CF, FPA, C-ELISA | BBAT, FPA and CF need to be validated (reference samples available) | No vaccination protocol developed for camelids. Live vaccines are used. | 1. Vaccination protocols need to be developed  
2. Challenges should be performed for B. abortus and B. melitensis  
3. Vaccination of all the susceptible species living in the same area |
| Johne’s disease (see Chapter 2.1.11 of the OIE Terrestrial Manual 2012) | All species                  | Culture, Immunochemistry and PCR                                              | I-ELISA, AGID      | Validation of the serological tests | No vaccination protocol developed for camelids. Inactivated vaccine with cattle dose is used | Vaccination protocols with inactivated vaccine need to be developed in camelids.  
   Eradication of positive animals and vaccination |
| Tuberculosis (see Chapter 2.4.7. of the OIE Terrestrial Manual 2012) | New World camelids           | Direct identification, culture and PCR (diagnostic and typing)               | ELISA, TBStatPak MAPIA | Validation of serological test | None                                                                    | Eradication of positive animals |
Although Mange was not included in this list, the Group considered that this disease was of concern for camelids and should therefore be considered by the Biological Standards Commission.

### Significant Parasitic Diseases of Camelids

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Species</th>
<th>Identification of the agent</th>
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<th>Recommendations for diagnostic</th>
<th>Vaccines</th>
<th>Recommendations for prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trypanosomosis</td>
<td>Dromedary and Bactrian</td>
<td>Agent identification, PCR</td>
<td>CATT and I-ELISA (neither ELISA is commercially available)</td>
<td>I-ELISA can be used with anti-camel conjugates</td>
<td>None</td>
<td>1. Systematic control for animal trade</td>
</tr>
<tr>
<td>(see Chapter 2.1.17 of the OIE Terrestrial Manual 2012)</td>
<td>camels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Treatment of positive animal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Need more investigations on drug resistance.</td>
</tr>
</tbody>
</table>
The camel has great economical potential and is anticipated to make a significant contribution to the pastoralists in solving their problem in transportation, food shortage and milk supply. Data relating to camel diseases is scarce, from both a clinical and pathological point of view. OIE AHG listed camel diseases of priority and highlighted need of diagnostic techniques validation and vaccination protocols defined. Epidemiological studies should be designed to study significant diseases based on systematic methods. Greater attention should be given to zoonotic diseases (MERS, brucellosis, RVF).
Summary

- Sampling camel is the biggest threat for laboratory diagnostic confirmation.
- Serologic tests form the basis for surveillance in most countries.
- Molecular diagnostics (rRT-PCR) are rapidly replacing conventional isolation procedures.
- Virus/bacteria isolation is needed to determine the pathogenicity of field isolates.
- Need of camel reference laboratories for diagnosis techniques validation.
Thank you