1. Title and running head of the paper :

**Biosecurity measures applied in the United Arab Emirates: a comparative study between livestock and wildlife sectors**

**Biosecurity measures applied in UAE farms**

2. Full names and affiliations for all authors :

1st author: **Chaber Anne-Lise**1,2

1 Research Unit of Epidemiology and Risk Analysis Applied to Veterinary (UREAR - Ulg), Fundamental and Applied Research for Animals & Health (FARAH), Faculty of Veterinary Medicine, University of Liege, 4000, Liege, Belgium.

2 Wildlife Consultant L.L.C

Al Ain, United Arab Emirates

Last author: **Saegerman Claude**1

1Research Unit of Epidemiology and Risk Analysis Applied to Veterinary (UREAR - Ulg), Fundamental and Applied Research for Animals & Health (FARAH), Faculty of Veterinary Medicine, University of Liege, 4000, Liege, Belgium.

3. Full mailing and e-mail address and telephone of the author to whom correspondence and proofs should be sent

alchaber@hotmail.com

Tel: 00971 5 61 25 05 96

**Abstract**

In 2013, the livestock population in the UAE exceeded 4.3 million heads with sheep and goats accounting for 90% of this. The overall number of captive wild ungulates (gazelle types) is difficult to assess as there is no registration system in place or enforced in the UAE with regard to the possession of wildlife. Those animal collections, mainly owned by high-ranking families, are therefore not registered and kept far from public viewing. Nonetheless, some collections are housing more than 30 000 ungulates in one location.

The primary objective of this study was to describe the biosecurity measures currently applied in UAE ungulate facilities for different wildlife and livestock sectors. A secondary objective was to use the output from this biosecurity survey to investigate which sector could be categorized into risk groups for disease introduction and spread.

Between October 2014 and May 2015, biosecurity questionnaire data were collected in the Emirates of Abu Dhabi, Dubai, Ras Al Khaimah, Fujeirah, Ajman, Umm al Quwain and Sharjah from 14 wildlife collections, 30 livestock farms and 15 mixed (wildlife and livestock farms). These investigations through questionnaires allowed us to quantify and assess statistically biosecurity practices and levels for both livestock and wildlife sectors.

In both sectors, biosecurity measures could be improved and only a few facilities had high biosecurity scores. The group of small un-registered farms (Ezba) represented the highest risk of disease transmission to other animals due to their lack of biosecurity awareness.

**Keywords:** Biosecurity; Wildlife; Collection; Livestock; Farms; UAE.

**Introduction**

The concept of biosecurity has recently taken great importance in veterinary medicine. Biosecurity can be defined as the implementation of measures that reduce the risk of introduction and spread of disease agents. It requires a set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population (OIE, 2010). Biosecurity greatly relies on the respect of the “Five Bs”: bio-exclusion (to limit the risk of introduction), bio-compartmentation (to limit the spread of the pathogen within the same facility, e.g. by isolating excreting animals), bio-containment (to limit the spread of the disease agent outside the facility), bio-contamination (to prevent the risk of human bio-contamination) and bio-prevention (to prevent any environmental bio-contamination and persistence of the pathogen) (Saegerman et al., 2012).

This Five B concept can also be simplified into all measures related to the prevention of introduction of disease into a herd (i.e. external biosecurity) and all measures to prevent the spread of a disease within a herd (i.e. internal biosecurity) (OIE, 2010).

It is becoming increasingly evident that there is a need to re-orientate farmers and veterinarians towards preventive rather than curative medicine (Saegerman *et al*., 2009). The implementation of biosecurity measures is an important way to contribute towards such re-orientation.

The implementation of biosecurity measures in the management of facilities holding wild ungulates and/or domestic livestock in the UAE has not been studied so far. This study aims to determine if biosecurity measures are implemented in the UAE and if so, which types of farms/animal collections are pro-actively working towards prevention of disease transmission within and between farms.

**Material and Methods**

Farms’ selection.

Data were collected from all seven emirates where farms holding domestic or wild ungulates were willing to complete the questionnaire. To encourage transparency and willingness to share information, respondents were guaranteed anonymity. As most of the wildlife collections are not officially referenced, the questionnaire was given opportunistically during the 2014 Sharjah Conference on Biodiversity Conservation in the Arabian Peninsula and completed on the spot by animals’ collection representatives (manager, veterinarian or owner). Questionnaires were completed during visits to randomly selected farms after being translated into Arabic, and explained if necessary. Visits to farms, industrial or familial, permitted the inclusion of small un-registered farms (locally called Ezba) in this study. Any facilities holding ungulates could participate to the study. All answers were treated confidentially.

Questionnaire

The questionnaire was designed to collect basic information on farms typology, biosecurity awareness, disease prevention measures implemented, and proximity to other farms. The questionnaire consisted of 12 questions and was intentionally short to increase the response rate. As much as possible closed questions with multiple choices were used in order to ensure consistency in the information gathered. The questionnaire (in Arabic or English) can be obtained upon request.

**2.3. Data processing**

Data were encoded numerically to assist analysis, entered into a database worksheet program (Microsoft Excel, 2010) and recorded into categorical data (nominal or ordinal level) for further analysis.

**2.4 Data analysis**

2.4.1 Biosecurity Scoring

A binary biosecurity scoring system was created following Van Steenwinkel method (Van Steenwinkel et al. 2011) (value of 1 for biosecurity measure present and value of 0 for biosecurity measures absent). The variables were indicators aiming at covering internal and external biosecurity measures.

Internal biosecurity was assessed via the following questions: Is the farm representative aware of the notion of biosecurity and can he define it? Is the food stored in a closed container or building? Is a pest control plan in place? Are sick animals isolated?

The external actions recorded included: Is the wheel bath filled? Are new animals coming to the collection? Are incoming animals quarantined? Is there a disease-screening program in place?

Presence or absence of buffer zone, fencing system as well as the distance to other farms were also noted.

2.4.2. Analysis

Groups were defined as livestock (farms holding domestic ungulates such as sheep, goats cows and camels), wildlife collection (with at least one wild ungulate species) and both where wild and domestic species were in the same location. Encoded data were summed up per group and each variable tested for significance with a Fisher Exact Test. A p-value of 0.05 was considered as significant. The variables that had a p-value less than 0.05 were aggregated by scoring (i.e. score is the sum of the seven biosecurity measures that were present) and each score (count variable) was analysed, in first instance, by a Poisson regression model and finally using a negative binomial regression due to extra-binomial variability (Dohoo et al., 2010). In addition, the 7 significant variables in univariate analysis were also entered into a Classification And Regression Tree (CART) analysis model in order to identify significant exploratory variables (Saegerman et al., 2011). A CART analysis is a non-linear and non-parametric model that is fitted by binary recursive partitioning of multidimensional covariate space (Breiman et al. 1984). Using Salford Predictive Modeler software (Salford Systems, San Diego, CA, USA), the analysis successively splits the dataset into increasingly homogeneous subsets until it is stratified to meet specified criteria. The Gini index was used as the splitting method, and 10-fold cross-validation was used to test the predictive capacity of the obtained trees. CART performs cross validation by growing maximal trees on subsets of data then calculating error rates based on unused portions of the data set. To accomplish this, CART divides the data set into 10 randomly selected and roughly equal parts, with each “part” containing a similar distribution of data from the populations of interest (i.e., livestock farms, wildlife collections and both livestock farms and wildlife collection). CART then uses the first 9 parts of the data, constructs the largest possible tree, and uses the remaining 1/10 of the data to obtain initial estimates of the error rate of the selected sub-tree. The process is repeated using different combinations of the remaining 9 sub-sets of data and a different 1/10 data sub-set to test the resulting tree. This process is repeated until each 1/10 sub-set of the data has been used as to test a tree that was grown using a 9/10 data sub set. The results of the 10 mini-tests are then combined to calculate error rates for trees of each possible size; these error rates are applied to prune the tree grown using the entire data set. The consequence of this process is a set of fairly reliable estimates of the independent predictive accuracy of the tree, even when some of the data for independent variables are incomplete and/or comparatively small. For each node in a CART generated tree, the “primary splitter” is the variable that best splits the node, maximizing the purity of the resulting nodes. Further details about CART are presented in previously published articles (e.g., Porter et al., 2011; Saegerman et al., 2011, 2014 and 2015).

**Results**

Seven variables linked to biosecurity measures were found to be statistically different in each sector (i.e. awareness of biosecurity, pest control plan, isolation of sick animals, disease-screening program, fencing system, buffer zone and distance to other farm for at least 500 meters). In addition, the calculation of odds ratio permitted us to identify farms holding only livestock with a value less than 1 for these seven biosecurity measures present in comparison with collections holding wild ungulates. Results are summarized in table 1.

Biosecurity scores were significantly lower in farms holding only livestock (mean=0.80; S.D.=1.73) in comparison with collections holding wild ungulates (mean=4.29; S.D.=1.20) (negative binomial regression; p-value < 0.001). However no significant difference was observed in scores between farms with both livestock and wild ungulates (mean=4.07; S.D.=1.79) in comparison with collections holding wild ungulates. In addition, unlike the livestock farms, wildlife collections biosecurity scores describe a normal distribution defining a Gaussian curve (Shapiro test, p-value=0.39).

CART analysis revealed that “presence of a disease-screening program”, “presence of a perimeter fence” and “distance to other farms” were the 3 main predictors of divergence between the three groups (Table 2; Figure 1).

**Discussion**

Few farms obtained an overall high biosecurity level. Distribution of scores in the livestock sector is skewed towards 0 with few professional farms reaching the highest scores. The farms implementing biosecurity measures were registered as commercial farms breeding sheep and goats intensively, with herds of more than 3000 heads. Most of the sheep and goats are bred in Abu Dhabi, respectively 85% and 65% of the country flock (United Arab Emirates National Bureau of Statistics, 2014), where herd *Brucella* seroprevalence is of 55.1% (Mohammed et al., 2013). Some diseases are known to be endemic and/or epizootic in the country such as: Contagious Caprine Pleuropneumonia (Chaber et al., 2014), Foot and Mouth Disease (Lignereux and Al Kharusi, 2013), Q Fever (Chaber et al., 2012), Lumpy Skin Disease (Tuppurainen and Oura, 2012), Bovine Tuberculosis (Wernery et al., 2007). Other diseases seem to be directly related to international animal trade (livestock or wildlife), such as Crimean Congo haemorrhagic fever (Rodriguez et al., 1997) and Rift Valley Fever (Boshra et al. 2015). In this environment, it is essential and understandable that professional farms holding large herds apply the strictest biosecurity measures as a breach in those measures may have catastrophic economic consequences. In the UAE, the livestock population grew from 0.4 million in 1970 (Thomson et al., 2000) to 4.3 million registered heads today (United Arab Emirates National Bureau of Statistics, 2014). The expansion of this industry has major ecological and epidemiological consequences that have a national impact on disease security. On one hand, livestock industry has a very limited effect on the gross national product with agriculture representing 0.8% of the GDP and disease security is costly, from agricultural advisory services to veterinary research and investigation laboratories to veterinary field services. On the other hand, relying on importation for major food products is a national risk in case of conflicts in the region. Control of the major livestock diseases is a necessary step in improving livestock productivity on a national scale.

The majority of the investigated farms, called locally “Ezba”, were not officially registered and managed by families with the help of poorly qualified workers. “Ezba” can be found in small numbers in isolated secluded desert areas or in hundreds aggregated in designated areas much closer to other type of animal holding facilities. One “Ezba” is generally overseeing 50 to 200 small ruminants and were implementing few to no biosecurity measures. Animals are transported to local markets for sale during festivities and religious events. This group represents a very high risk of spreading diseases to any other farms in their vicinity.

Most of the wildlife collections are owned by high-ranking families and managed by qualified professionals who are aware of the importance of biosecurity. Few wildlife collections indicated the number and species of wild ungulates held in their facility as those questions could be politically sensitive.

Seven biosecurity variables were significantly different (Fischer exact test, p-value<0.05) between the wildlife and livestock sectors.

Internal biosecurity measures were generally better enforced in the wildlife sector as representatives of wildlife collections were more conscious and better able to define biosecurity than livestock farmers. This is linked to staff education levels and ultimately to salaries offered in this sector. Sick animals were isolated only in 16% of the livestock farms and in 58% of the wildlife collections. Isolation of sick animals requires competent staff to identify sickness and ability to seclude potentially contagious animals. Farm design and space allocations can be an obstacle in small-scale farms. In addition, pest control plans were rarely implemented in “Ezba”, not only hampering livestock health safety in their farms but also any adjacent farms as cat, dog, raven and rodent populations are likely to travel from farm to farm and disseminate contaminated material (Sumner and Buck Jr, 2007).

External biosecurity measures were also more thoroughly followed in wildlife collections than on livestock farms. Indeed, disease screening of incoming animals was performed by 86% of the collections holding wildlife versus 13% of the livestock sector, as the livestock sectors surveyed were largely unregistered and therefore not falling into groups screened by governmental agencies. It is interesting to note that animal health authorities focus their pathogen screening on *Brucella* and foot-and-mouth disease only. Livestock are mainly traded within the country or with adjacent countries harbouring similar epidemiological situations and might not expose the UAE herd to new diseases, while wildlife is being brought from all over the world and might thus be the source of new and emerging diseases. In addition, the list of diseases screened and methods employed in wildlife collections remained at the discretion of the veterinarian or collection managers.

Pathogen introduction is also prevented via a proper fencing system, presence of wide buffer zones and farm-to-farm distances. The perimeter fence was only a single fence for 93 % of the surveyed farms, but a double fence or a wall for up to 76% of the wildlife collections. This is largely explained by the nature of the wildlife collections, which are mainly private collections surrounding palaces and therefore benefit from the security measures set to protect goods and people. In addition 27 % of the wildlife collections had a buffer zone that was not the case for the livestock sector. Similarly and linked to the social rank of the owner, the farm-to-farm distance was less than 500 meters for 98% of the livestock farms surveyed against 37.9% of the collections holding wild ungulates.

Nevertheless, both wildlife and livestock sectors had poor scores regarding some internal and external biosecurity indicators. New animals were coming to all the facilities and quarantine was rarely properly enforced. Even if quarantine enclosures are present in the facilities, they are not used to avoid contact with the already established animal collections.

Wheel dips, when present, were also filled and used in only 17% and 10% of the livestock and wildlife farms respectively. Although wheel dip is a requirement of all farms that have to be registered by the Abu Dhabi Food Control Authority, wheel dips are actually not at all effective in preventing entry of pathogens. Firstly, wheels that rotate at high speed at a high temperature over generally dry surfaces (particularly so in the UAE) do not provide a good habitat for pathogens. Secondly, if the wheels have solid material like dung in their grooves the wheel bath will not remove it and the disinfectant would not reach any pathogens lodged in it. Thirdly, pathogens in vehicles are most likely to be present in the loading space and in the cab of the vehicle, where contaminated animals or materials and contaminated footwear provide a rich potential source of pathogens. Washing and disinfection of vehicles is nevertheless important in some intensive livestock farming operations where vehicles from outside are excluded altogether from entry by having delivery and loading points on the periphery of the farm.

The animal feed was stored in a closed container or building in 30% of the livestock farms and in 51.7 % of the wildlife collections. Food in the open attracts and will increase the presence of potentially harmful pests, such as insects, rodents, and wild birds that can act as pathogen vectors.

Although free roaming wildlife is often seen as the source of contagious diseases, human activities and disrespect of biosecurity measures are enhancing disease transmission and thus should be the central pillar of actions regarding disease control and prevention. The ‘Five Bs’ of biosecurity measures have to be addressed specifically as the disrespect of only one might render null and void all efforts to control disease and will thus jeopardize the entire farm or national security. In addition implementation of biosecurity programs helps in preventing the introduction of all pathogens and are not limited to specific pathogens.

Zoonotic disease might also be transmitted from humans to animals and the government has identified tuberculosis as an important disease with 179 reported positive TB cases (55 goats, 51 sheep, 71 camels) in 2010 by Abu Dhabi Food Control Authority. Serious losses of valuable wildlife as well as economic losses on livestock farms due to abattoir condemnations have been recorded as a result of infection of animals with human tuberculosis by workers or visitors. Although locally circulating TB strains remain unknown, national measures are in place to prevent transmission of human tuberculosis caused by *Mycobacterium tuberculosis* to wildlife or livestock. UAE ministerial decree No 28 of 2010 and Federal Law No 7 of 2008 state that all newcomers found to have active or old pulmonary TB in a chest X-ray will be denied a fitness certificate and thus UAE resident visa. After initial entry, all workers legally employed are tested every 3 years upon renewal of their visa.

It is commonly assumed by veterinarians in the country that atmospheric conditions in such an arid climate with temperature reaching up to 50°C under the shade during summer time reduces disease burden, especially infection through environmental contamination. Although it is true that UV and heat are not favorable to the survival of most bacteria and viruses, re-contamination of the environment is problematic at animal reservoirs; or when asymptomatic shedders have not been cleared. In addition, some bacteria have the ability to sporulate such as *Coxiella burnetti* and can thus persist in the environment for up to 5 months (Welsh et al., 1958).

**Conclusion**

Before any drastic measures are taken in the country to control animal infectious diseases, such as culling of animals that tested positive for specific diseases, it seems important to define and implement biosecurity measures from the local farms to the national level. Education on the importance of understanding and respecting biosecurity measures should be encouraged for all stakeholders involved in animal health.

**List of tables and figure**

**Table 1:** Description of farms holding animals in wildlife collections, livestock farms and farms with both wildlife and livestock animals regarding to biosecurity measures

**Table 2:** Relative importance of the different biosecurity measures (splitters) obtained after classification and regression tree (CART) analysis (maximum relative importance = 100)

**Figure 1:** Classification and regression tree analysis for main biosecurity measures applied in three types of farms (wildlife collections [class 1; in black], livestock farms [class 2; in grey] and farms with both wildlife and livestock animals [class 3; in white])

**References**

Breiman, I., Friedman, J.H., Olsen, R.A., Stone, C.J., 1984: Classification and regression trees. Wadsworth International Group Belmont, Monterey, Calif., U.S.A., pp. 358.

Chaber, A., Lignereux, L., Al Qassimi, M., Saegerman, C., Manso-Silván, L., Dupuy, V., Thiaucourt, F., 2014. Fatal transmission of contagious caprine pleuropneumonia to an Arabian oryx (Oryx leucoryx). Vet. Microbiol. 173, 156–159.

Chaber, A.-L., Lloyd, C., O’Donovan, D., McKeown, S., Wernery, U., Bailey, T., 2012. A Serologic Survey for Coxiella burnetii in Semi-wild Ungulates in the Emirate of Dubai, United Arab Emirates. J. Wildl. Dis. 48, 220–222.

Dohoo, I., Martin, W., Stryhn, H., 2010. Veterinary Epidemiological Research. 2nd Edtn. AVC Inc Charlottet. Prince Edw. Isl. Can.

Lignereux, L., Al Kharusi, Y., 2013. Middle East Arabian Oryx Disease Survey Report [WWW Document]. URL https://www.arabianoryx.org/En/Downloads/Forms/AllItems.aspx (accessed 10.25.15).

Mohammed, M.A., Shigidy, M.T., Al juboori Abdulwahab Y, 2013. Sero-Prevalence and Epidemiology of Brucellosis in Camels, Sheep and Goats in Abu Dhabi Emirate. Int. J. Anim. Vet. Adv. 5, 82–86.

OIE, World Organisation for Animal Health, 2010.Terrestrial Animal Health Code. Glossary. OIE, Paris. Also available at: <http://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/2010/en_glossaire.htm>. (accessed on 31 January 2016).

Rodriguez, L.L., Maupin, G.O., Ksiazek, T.G., Rollin, P.E., Khan, A.S., Schwarz, T.F., Lofts, R.S., Smith, J.F., Noor, A.M., Peters, C.J., others, 1997. Molecular investigation of a multisource outbreak of Crimean-Congo hemorrhagic fever in the United Arab Emirates. Am. J. Trop. Med. Hyg. 57, 512–518.

Saegerman, C., Dal Pozzo, F., Humblet, M.-F., 2012. Reducing hazards for humans from animals: emerging and re-emerging zoonoses. Ital. J. Public Health 9.

Saegerman, C., Porter, S., Humblet, M., 2011. The use of modelling to evaluate and adapt strategies for animal disease control. Rev. Sci. Tech.-OIE 30, 555.

Saegerman, C., Alba-Casals, A., García-Bocanegra, I., Dal Pozzo, F., van Galen, G., 2014: Clinical Sentinel Surveillance of Equine West Nile Fever, Spain. Transbound Emerg Dis. 2014 Jun 5. doi: 10.1111/tbed.12243.

Saegerman, C., Speybroeck, N., Dal Pozzo, F., Czaplicki, G., 2015: Clinical indicators of exposure to Coxiella burnetii in dairy herds. Transbound Emerg Dis. 62(1), 46-54.

Sumner, D.A., Buck Jr, F.H., 2007. Exotic pests and diseases: biology and economics for biosecurity. John Wiley & Sons.

Thomson, E., Kaufmann, R. von, Li Pun, H., Treacher, T., Houten, H. van, 2000. Global agenda for livestock research: Proceedings of a consultation on setting livestock research priorities in West Asia and North Africa (WANA) region.

Tuppurainen, E., Oura, C., 2012. Review: lumpy skin disease: an emerging threat to Europe, the Middle East and Asia. Transbound. Emerg. Dis. 59, 40–48.

United Arab Emirates National Bureau of Statistics, 2014. Livestock Statistics 2013 [WWW Document]. URL http://www.uaestatistics.gov.ae/EnglishHome/ReportDetailsEnglish/tabid/121/Default.aspx?ItemId=2377&PTID=104&MenuId=1

Van Steenwinkel, S., Ribbens, S., Ducheyne, E., Goossens, E., Dewulf, J., 2011. Assessing biosecurity practices, movements and densities of poultry sites across Belgium, resulting in different farm risk-groups for infectious disease introduction and spread. Prev. Vet. Med. 98, 259–270.

Wernery, U., Kinne, J., Jahans, K., Vordermeier, H., Esfandiari, J., Greenwald, R., Johnson, B., Ul-Haq, A., Lyashchenko, K., 2007. Tuberculosis outbreak in a dromedary racing herd and rapid serological detection of infected camels. Vet. Microbiol. 122, 108–115.

Zanella, G., Martinelle, L., Guyot, H., Mauroy, A., De Clercq, K., Saegerman, C., 2013: Clinical pattern characterization of cattle naturally infected by BTV-8. Transbound Emerg Dis. 60(3), 231-237.

Figure 1.



**Table 1: Description of farms holding animals in wildlife collections, livestock farms and farms with both wildlife and livestock animals regarding to biosecurity measures**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | Animals held | Fischer's exact  |   |  |   |  |
|   | Wild | Domestic | Both | test (p-value)  | Domestic *versus* Wild  | Both *versus* Wild |
| Variables | Score 0 | Score 1 | Score 0 | Score 1 | Score 0 | Score 1 |  | OR (95% CI) | p-value | OR (95% CI) | p-value |
|  Internal biosecurity: |   |   |   |   |   |   |   |   |   |   |   |
| 1) Aware of the notion of biosecurity | 4 | 10 | 24 | 6 | 5 | 10 | 0.001 | 0.10 ( 0.02-0.43) | 0.002 | 0.80 (0.16-3.88) | 0.78 |
| 2) Able to define biosecurity | 10 | 4 | 26 | 4 | 11 | 4 | 0.41 | 0.38 (0.08-1.84) | 0.23 | 0.91 (0.18-4.64) | 0.91 |
| 3) Food stored in a closed container or building | 6 | 8 | 21 | 9 | 8 | 7 | 0.20 | 0.32 (0.09-1.20) | 0.09 | 0.75 (0.17-3.33) | 0.71 |
| 4) Pest control plan in place | 5 | 9 | 27 | 3 | 6 | 9 | < 0.001 | 0.62 (0.01-0.31) | 0.001 | 0.83 (0.19-3.75) | 0.81 |
| 5) Sick animals are isolated | 7 | 7 | 25 | 5 | 5 | 10 | 0.002 | 0.20 (0.05-0.83) | 0.026 | 2.00 (0.45-8.96) | 0.37 |
|   |  |   |   |   |   |   |   |   |  |   |  |
|  External biosecurity: |   |   |   |   |   |   |   |   |  |   |  |
| 6) Rotoluve is filled | 11 | 3 | 27 | 3 | 13 | 2 | 0.55 | 0.41 (0.07-2.34 | 0.31 | 0.56 (0.08-4.01) | 0.57 |
| 7) New animals are coming | 13 | 1 | 30 | 0 | 14 | 1 | 0.24 | 0.15 (0.006-3.86) | 0.25 | 0.93 (0.09-10.07) | 0.95 |
| 8) Incoming animals are quarantined | 10 | 4 | 23 | 7 | 12 | 3 | 0.85 | 0.09 (0.009-0.87) | 0.037 | 0.91 (0.18-4.64) | 0.91 |
| 9) Disease-screening program is in place | 1 | 13 | 26 | 4 | 3 | 12 | <0.001 | 0.02 (0.003-0.13) | <0.001 | 1.00 (0.16-6.08) | 1.00 |
| 10) Presence of a buffer zone | 10 | 4 | 29 | 1 | 11 | 4 | 0.02 | 0.15 (0.03-0.73) | 0.019 | 0.67 (0.15-3.01) | 0.60 |
| 11) Presence of a fencing system | 3 | 11 | 28 | 2 | 4 | 11 | <0.001 | 0.01 (0.001-0.12) | <0.001 | 0.31 (0.03-3.38) | 0.34 |
| 12) Distance to other farm (at least 500 meters) | 8 | 6 | 27 | 3 | 10 | 5 | 0.03 | 0.76 (0.18-3.20) | 0.71 | 0.63 (0.11-3.48) | 0.59 |

**Table 2: Relative importance of the different biosecurity measures (splitters) obtained after classification and regression tree (CART) analysis (maximum relative importance = 100)**

|  |  |
| --- | --- |
| Biosecurity measure | Relative importance |
| Presence of a fencing system | 100 |
| Disease-screening program is in place | 92.68 |
| Pest control plan in place | 47.55 |
| Aware of the notion of biosecurity | 39.46 |
| Sick animals are isolated | 32.44 |
| Distance to other farm (at least 500 meters) | 4.76 |
| Presence of a buffer zone | 0.71 |