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Assessment of Biosecurity Measures for West Nile Virus at Algiers and Blida Equestrian Clubs

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Dedication

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Abstract

Biosecurity remains one of the most critical components in disease prevention within equine management. This study investigates the specific biosecurity protocols utilized by participating equine clubs in Algeria, with a particular emphasis on measures aimed at mitigating the transmission of vector-borne diseases, such as the West Nile virus. The objective of this research is to identify areas where biosecurity practices fall short in Algerian equine clubs. Five equine clubs participated in this study, the investigation covered multiple categories of biosecurity risk, including general facilities, housing materials, resident horse movement, introduction of new horses, vaccination protocols, personnel movement on and off the premises, pest control measures, infection control practices, sick animal management, and isolation procedures. A survey was conducted utilising a questionnaire across five equine clubs located in the cities of Blida and Algiers. The survey inquired about the biosecurity measures implemented in the aforementioned categories. The responses were analysed using a biosecurity calculator developed by the University of Guelph, resulting in an overall biosecurity score for each club. The results indicated that all five clubs achieved scores suggesting the need for significant improvements in their biosecurity measures. This study underscores the necessity for enhanced biosecurity protocols to mitigate disease risks effectively. To the best of our knowledge, this study is the first of its kind to be conducted in Algeria, providing new insights into this area of research.

Keywords : Biosecurity, West Nile Fever, Equine, Algeria, Equestrian club.

Résumé

La biosécurité reste l'une des composantes les plus critiques de la prévention des maladies dans la gestion des équidés. Cette étude examine les protocoles de biosécurité spécifiques utilisés par les clubs équins participants en Algérie, en mettant particulièrement l'accent sur les mesures visant à atténuer la transmission des maladies à transmission vectorielle, telles que le virus du Nil occidental. L'objectif de cette recherche est d'identifier les domaines dans lesquels les pratiques de biosécurité sont insuffisantes dans les clubs équestres algériens. Cinq clubs équins ont participé à cette étude, qui a porté sur plusieurs catégories de risques en matière de biosécurité, notamment les installations générales, les matériaux de logement, les déplacements des chevaux résidents, l'introduction de nouveaux chevaux, les protocoles de vaccination, les déplacements du personnel à l'intérieur et à l'extérieur des locaux, les mesures de lutte contre les nuisibles, les pratiques de lutte contre les infections, la gestion des animaux malades et les procédures d'isolement. Une enquête a été menée à l'aide d'un questionnaire dans cinq clubs équins situés dans les villes de Blida et d'Alger. L'enquête portait sur les mesures de biosécurité mises en œuvre dans les catégories susmentionnées. Les réponses ont été analysées à l'aide d'un calculateur de biosécurité développé par l'Université de Guelph, ce qui a permis d'obtenir une note globale de biosécurité pour chaque club. Les résultats indiquent que les cinq clubs ont obtenu des scores suggérant la nécessité d'améliorer de manière significative leurs mesures de biosécurité. Cette étude souligne la nécessité d'améliorer les protocoles de biosécurité pour atténuer efficacement les risques de maladie. À notre connaissance, cette étude est la première de ce type à être menée en Algérie, apportant de nouvelles perspectives dans ce domaine de recherche.

Mots-clés : Biosécurité, Fièvre du Nil occidental, Equidés, Algérie, Club équestre.

الملخص

يظل الأمن البيولوجي أحد أهم مكونات الوقاية من الأمراض في إدارة الخيول. تبحث هذه الدراسة في بروتوكولات الأمن البيولوجي المحددة التي تستخدمها نوادي الخيول المشاركة في الجزائر، مع التركيز بشكل خاص على التدابير التي تهدف إلى التخفيف من انتقال الأمراض المنقولة بالنواقل، مثل فيروس غرب النيل. الهدف من هذا البحث هو تحديد المجالات التي تقصر فيها ممارسات الأمن الحيوي في نوادي الخيول الجزائرية. شارك في هذه الدراسة خمسة نوادٍ للخيول، وشمل التحقيق فئات متعددة من مخاطر الأمن البيولوجي، بما في ذلك المرافق العامة، ومواد الإيواء، وحركة الخيول المقيمة، وإدخال خيول جديدة، وبروتوكولات التطعيم، وحركة العاملين داخل وخارج المباني، وتدابير مكافحة الآفات، وممارسات مكافحة العدوى، وإدارة الحيوانات المريضة، وإجراءات العزل. تم إجراء مسح باستخدام استبيان عبر خمسة نوادي للخيول في مدينتي البليدة والجزائر العاصمة. استفسر الاستبيان عن تدابير الأمن الحيوي المطبقة في الفئات المذكورة أعلاه. تم تحليل الردود باستخدام حاسبة الأمن الحيوي التي طورتها جامعة جيلف، مما أدى إلى الحصول على درجة إجمالية للأمن الحيوي لكل نادٍ. أشارت النتائج إلى أن جميع الأندية الخمسة حصلت على درجات تشير إلى الحاجة إلى تحسينات كبيرة في تدابير الأمن البيولوجي الخاصة بها. تؤكد هذه الدراسة على ضرورة تعزيز بروتوكولات الأمن البيولوجي للتخفيف من مخاطر الأمراض بشكل فعال. وعلى حد علمنا، فإن هذه الدراسة هي الأولى من نوعها التي تُجرى في الجزائر، مما يوفر رؤى جديدة في هذا المجال البحثي.

الكلمات المفتاحية : الأمن البيولوجي، حمى غرب النيل، الخيول، الجزائر، نادي الفروسية.

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List of abbreviations

AAEP	American Association of Equine Practitioners
C&D	Cleaning and Disinfection
EI	Equine Influenza
EIA	Equine Infectious Anaemia
EHV	Equine Herpes virus
ELISA	Enzyme Linked Immunosorbent Assay
FEI	Fédération Équestre Internationale
PPE	Personal Protective Equipment
PRNT	Plaque Reduction Neutralization Technique
RNA	Ribonucleic Acid
WAHIS	Word Animal Health Information System
WND	West Nile Disease
WNV	West Nile virus
WOAH	World Organisation for Animal Health

INTRODUCTION

Introduction

In order to safeguard your horse(s) from infectious diseases, it's crucial to understand the factors that contribute to disease occurrence. These factors are collectively known as the disease triad and involve three key components (1).

The Host (Susceptible Horse): The host refers to the horse's susceptibility to disease. Factors such as overall health, immune system strength, and genetic predisposition play a role in determining how vulnerable a horse is to infections (2).

The Agent (Pathogen): The agent represents the disease-causing microorganisms, which can include bacteria, viruses, fungi, or parasites. These pathogens are responsible for initiating and propagating infections (3).

The Environment (Contact Opportunity): The environment provides the setting for the host and agent to interact. It includes factors like hygiene, exposure to contaminated surfaces and proximity to other animals. When the host and agent come into contact within this environment, disease transmission can occur (4).

By understanding this disease triad, horse owners and caretakers can take proactive measures that aim to minimize disease risk and promote equine health (5).

The mitigation of disease carries a multitude of benefits for both animal welfare and the broader equine industry. By proactively reducing the negative impacts of disease, we enhance animal health by preventing outcomes such as decreased physiological function, permanent disability, or mortality. Further, this helps safeguard public health through minimizing the transmission of zoonotic diseases. Disease prevention also brings economic advantages, directly reducing costs associated with treatment. Finally, safeguarding the health status of horse's populations is essential for maintaining international trade relationships and horse mobility (1).

Infectious diseases pose significant challenges for horses, affecting their health, economic viability, and overall well-being. As horses serve as working animals and companions, safeguarding their health is crucial. Biosecurity measures play a vital role in minimizing the spread of infectious diseases within the horse population (6).

Biosecurity is a comprehensive set of practices designed to minimize the introduction, spread, and release of pathogens and pests in animal and plant populations. It encompasses three main strategies: bio-exclusion, which focuses on preventing harmful organisms from entering a specific area; bio-management, which aims to control the spread of already established pathogens and pests within a population; and bio-containment, which seeks to limit the release of harmful organisms from a specific area to protect other populations or the environment. By implementing these measures, biosecurity safeguards the health and well-being of animals, plants, and ecosystems, and also protects human health by preventing the spread of zoonotic diseases that can jump from animals to humans (1).

Equine infectious diseases are a significant concern for horse owners and the entire equine industry. These outbreaks can lead to financial losses, animal welfare issues, and even pose a risk to public health as illustrated by the following examples:

Australia's equine industry faced an unprecedented challenge in August 2007 with the nation's first outbreak of equine influenza. While successfully eradicated within five months, the episode left a significant mark, impacting over 70,000 horses across a vast 280,000 square kilometres and incurring government expenditures exceeding A$350 million (7).

In 2002, the United States reported over 15,257 cases of West Nile virus infection in horses, spanning 43 states, with the majority of cases concentrated in the central region. North Dakota reported over 569 horse cases, with a mortality rate of 22%. The total financial burden shouldered by the state was roughly US$1.9 million. Horse owners incurred costs of approximately US$1.5 million (8).

During the CES Valencia Spring Tour 2021, a total of 752 horses participated. However, the event was terminated and the premises were subjected to a lockdown as a consequence of an outbreak of equine herpesvirus-1 (EHV-1) (9).

The disruption to the horse industry caused by such outbreaks is multifaceted. Restrictions on horse movement designed to contain disease spread, result in the cancellation of events and competitions. Furthermore, the urgent need for widespread vaccination campaigns incurs substantial financial costs for both individual horse owners and governing bodies (8).

In Algeria, human cases of West Nile disease (WND) have been documented since 1994, including meningoencephalitis in Tinerkouk and a fatal neuroinvasive case in Jijel in 2012.

Serosurveys in Algiers detected anti-WNV IgG antibodies, while cases were also reported in Timimoune and Guelma in subsequent years. Although equine cases were not reported, seroprevalence studies indicated virus circulation (10).

The aforementioned examples, coupled with the persistent threat posed by emerging diseases, highlights the necessity for enhanced biosecurity measures. This study seeks to identify deficiencies in the implementation of biosecurity management systems, with the objective of minimizing interactions between pathogens and hosts, thereby mitigating the incidence of diseases.

BIBLIOGRAPHICAL PART

CHAPTER I

1 West Nile Virus

1.1 Introduction

West Nile virus (WNV) is a mosquito-borne neurotropic Flavivirus native to Africa, Europe, the Middle East and Western Asia that primarily cycles between mosquitoes and birds. It can infect a wide range of vertebrate animals, including mammals, among which humans and horses were found to be the most susceptible (11).

The virus was initially isolated in 1937 from a febrile patient in the West Nile Province of Uganda. Early observations suggested that the virus posed limited risk to humans, causing primarily mild or asymptomatic infections. Nonetheless, subsequent research has demonstrated the virus's capacity to induce significant morbidity and mortality across various animal species (12) .

Since 1937, sporadic and major outbreaks, mainly in humans, but also in horses, have been reported during the 1960's in Africa, the middle East and Europe . WNV re-emerged as an important pathogen for humans and horses, as frequent outbreaks with increased proportion of neurological disease cases have been reported (13). Outbreaks of West Nile virus equine encephalomyelitis were reported in Egypt (1963), Morocco, and Israel. Human epidemics of West Nile virus meningoencephalitis occurred in Algeria (1994), Romania (1996), and Tunisia (1997) (14).

1.2 West Nile Algeria

In Algeria, human meningoencephalitis cases due to West Nile disease (WND) were reported in 1994 in Tinerkouk (southwest Sahara). In autumn 2012, a fatal WNV neuroinvasive infection occurred in Jijel (coastal east). A retrospective serosurvey that same year in Algiers and surrounding areas detected specific anti-WNV IgG in the local human population (10). Although at the time it only showed the local circulation of the virus.

In 2010, a study collected 164 human sera from patients in the Algiers district and nearby areas, testing for anti-WNV IgG using ELISA and confirming results with plaque reduction neutralization technique (PRNT). The results showed that 9.8% were positive for anti-WNV IgG, with 6.7% having specific neutralizing antibodies confirmed by PRNT, providing serological evidence of WNV circulation in Algiers and its surrounding areas (15).

A more recent report on the World Animal Health Information System (WAHIS) in September 2023 shows West Nile Virus circulation in Algeria. The outbreak, starting September 17, 2023, affected domestic Equidae in Biskra, Batna, and El Oued, with six confirmed cases out of 21 susceptible. Diagnostic testing using IgM-capture ELISA confirmed the virus, and vector control measures were implemented, resolving the event by November 2, 2023 (16).

1.3 Virus structure and biology

West Nile virus (WNV) is a single-stranded RNA virus belonging to the Flaviviridae family and the Flavivirus genus. Notably, it is a member of the Japanese encephalitis antigenic complex. This complex encompasses a diverse group of viruses including Alfuy, Cacipacore, Japanese encephalitis, Koulango, Kunjin, Murray Valley encephalitis, St. Louis encephalitis, Rocio, Stratford, Usutu, Yaounde, and WNV itself (17).

WNV, similar to other flaviviruses, has a single-stranded RNA genome with positive polarity [ssRNA(+)] that is about 11 kilobases (kb) long (18). This RNA genome is encapsulated by an enveloped icosahedral nucleocapsid. Mature virions are spherical in shape and have a diameter of approximately 50 nanometres (figure 1). The viral genome contains a single open reading frame (ORF) that is translated into a polyprotein, which is subsequently cleaved by host and viral proteases (19).

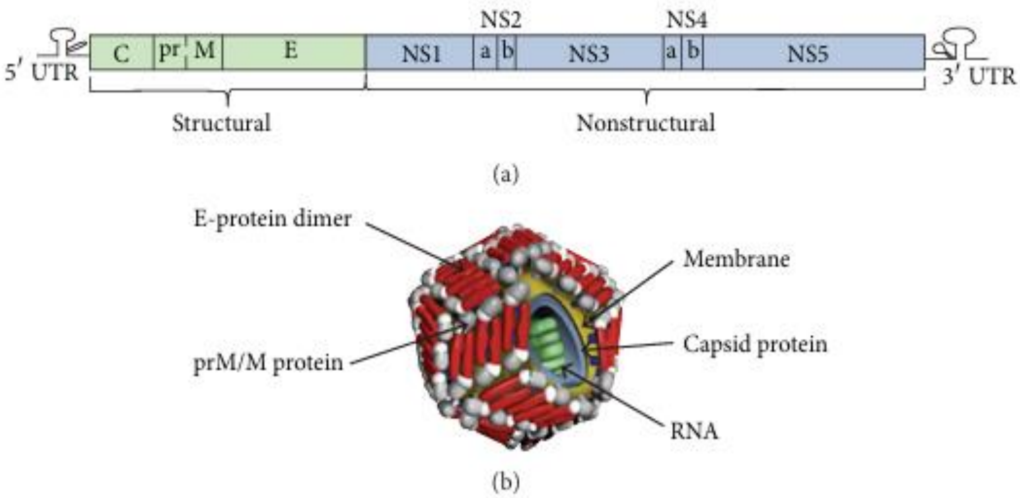

Figure 1 : WNV genome organization and virion composition: (a) the viral genome is represented with one ORF encoding 3 structural and 7 non-structural proteins. The 5’ and 3’ UTRs are indicated. Structural proteins are coloured green, whereas non-structural proteins are blue. (b) Structure of WNV virion *(*20*)*.

The cleavage of the polyprotein results in both structural and non-structural proteins (See Figure 1). Among the structural proteins are the capsid (c), pre-membrane (prM), and envelope (E) proteins. Additionally, there are seven non-structural proteins: NS1, NS2A, NS3, NS4B, and NS5. All of these proteins play essential roles in genome replication (See Table 1) (12).

Table 1 : Main functions of West Nile virus structural and non-structural proteins.

Protein	Function
C	Formation of nucleocapsid core; Participation into virion assembly
prM	Prevention of early-fusion between envelope and host membranes
E	Attachment, entry and fusion
NS1	Viral RNA synthesis; Replication complex formation; Immunomodulator
NS2A	Involved in viral replication and assembly
NS2B	Co-factor of NS3 protease
NS3	Viral protease
NS4A	Co-factor for the ATPase activity of NS3-helicase
NS4B	Inhibition of host interferon responses to West Nile virus
NS5	RNA-dependent RNA polymerase

C, Capsid protein; prM, Pre-membrane protein; E, Envelope protein; NS1, Non-structural protein 1; NS2A, Non-structural protein 2A; NS2B, Non-structural protein 2B; NS3, Non-structural protein 3; NS4A, Non-structural protein 4A; NS4B, Non-structural(21).

1.4 WNV Transmission Cycle and Epidemiology

The WNV life cycle involves virus reservoirs (primarily birds that can be asymptomatic carriers), mosquito vectors (where the virus replicates), as well as final or incidental hosts (Figure 2) (12). WNV is transmitted to naïve hosts by the bite of a mosquito primarily contaminated following a blood meal on an infected bird, after the extrinsic incubation period, that is, the time lapse between the blood meal and the presence of the virus in the mosquito's saliva (a minimum of 5–9 days post infection in *Culex pipiens* mosquitoes) (11).

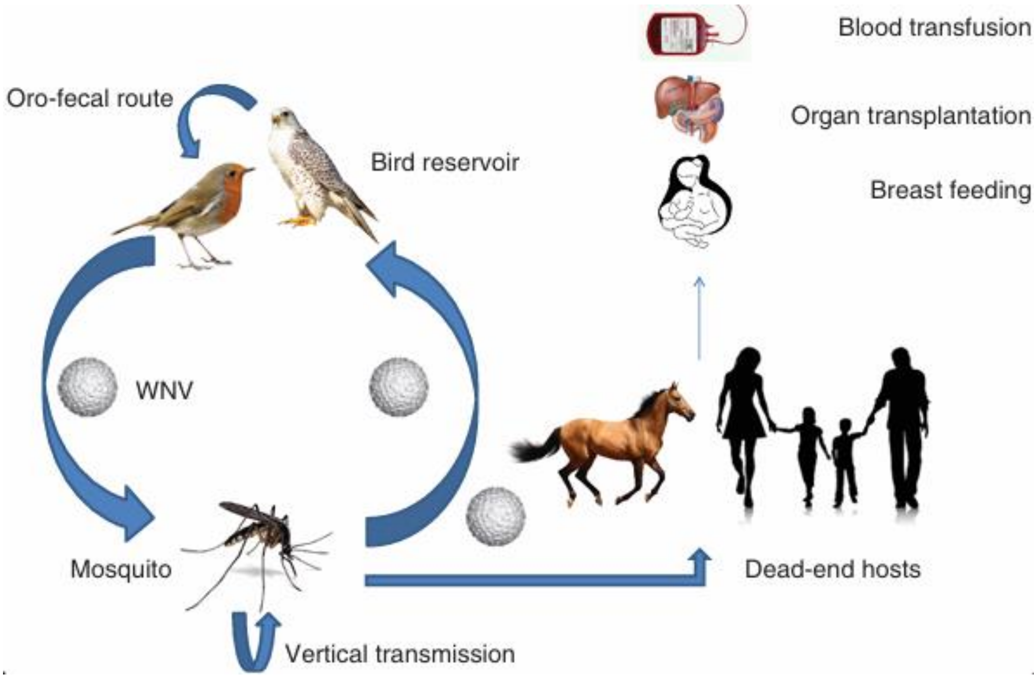

Figure 2 : WNV transmission (11).

When virus circulation between reservoir birds and vectors is intense, humans and horses can get incidentally infected by bridge vectors (e.g. mosquitoes feeding both on birds and mammals). Humans and horses are dead-end hosts for WNV as they do not develop viraemia high and long enough to infect naive mosquitoes. Human-to-human transmission can be observed through blood transfusion, organ transplantation and breast feeding upon recent infection of donors or mothers respectively (11).

1.5 Vectors

Culex mosquitoes serve as the primary vectors for West Nile Virus (WNV) transmission, though other genera may demonstrate competence as well. Specific vector species exhibit geographic variation. In Europe and Africa, the principal vectors include *C. pipiens, C. univittatus,* and *C. antennatus,* while species within the *C. vishnui* complex fulfil this role in India. In Australia, Kunjin virus, a related flavivirus, is primarily transmitted by *C. annulirostris.* Notably, North America demonstrates a wider range of potential WNV vectors with 59 distinct mosquito species documented, but fewer than 10 are considered major contributors to transmission (22).

The outcome of the interaction between mosquito and WNV is largely dependent on the specific combination of the mosquito species, mosquito origin, WNV lineage and WNV strain. For a virus exposed mosquito to become infectious, the virus has to overcome various barriers within the mosquito body: the peritrophic membrane, the midgut barrier and the salivary gland barrier. The midgut and salivary gland barriers are both further divided into an infection and an escape barrier. These barriers can limit virus infection both mechanically and through a range of antiviral immune responses, thereby determining the vector competence of the mosquito to transmit a certain arbovirus (23).

1.6 Reservoir

The primary reservoirs for WNV are wild birds, which serve as natural reservoirs and amplifiers of the virus (24). The capacity of different avian species to amplify WNV depends on the intensity and duration of their viraemia. Species within the orders Passeriformes, Charadriiformes, Falconiformes, and Strigiformes generally demonstrate high enough levels of viraemia to infect mosquitoes (11). The significance of bird species as amplifying hosts is determined by several factors: (i) susceptibility to infection; (ii) duration of viremia at levels sufficient to infect mosquitoes; (iii) density of naïve individuals, influenced by population density and infection rates; (iv) attractiveness to mosquito vectors, and (v) mortality rates of infected individuals. (25).

2 Implications for horses

Horses most likely become infected with WNV in the same manner as humans, for example, by the bite of infectious mosquitoes. In regions where WNV is prevalent, it is crucial to protect horses from mosquito bites as much as possible to mitigate the risks of infection (26). This preventive measure is especially important considering that equine diseases, are significant causes of morbidity and mortality in horses. These diseases not only have direct health impacts but also lead to substantial economic costs and broader implications due to the loss of animals that generate income (6).

2.1 Clinical implication of WNV

WNV can have significant clinical implications for horses. While human WNV infections frequently remain asymptomatic or present with mild disease, horses exhibit a higher predisposition for severe neurological complications (27). Approximately 10% of infected horses develop neurological disorders affecting the central nervous system, particularly the spinal cord, brainstem, and cerebellum. This manifests as a range of symptoms including ataxia, limb paralysis, muscle tremors, behavioural changes, and facial nerve deficits. Mortality rates in horses with clinical WNV disease are substantial, reaching up to 38%. Treatment protocols prioritize mitigating CNS inflammation, preventing self-inflicted injuries, and providing comprehensive supportive care (13).

2.2 Economic implications of WNV

In the United States (US), it has been responsible for substantial socio economic losses, both in the equine industry and in the human health sector, since its emergence in 1999 (28). Furthermore, in 2002, West Nile virus infection affected over 15,257 horses across 43 states in the United States, with the highest concentration of cases observed in the central region. North Dakota reported over 569 horse cases, with a mortality rate of 22%. The total financial burden shouldered by the state was roughly US$1.9 million. Horse owners incurred costs of approximately US$1.5 million. The sector of the North Dakota horse industry mainly affected by WNV occurrence was the leisure industry which is a source of substantial income to the state (8).

2.3 Importance of biosecurity in disease prevention

Infectious disease in horses continues to rank as one of the major challenges to the equine industry, leading to disease (and potentially death), financial costs, welfare concerns and potential risks to human health. The need for preventive measures will always be an important management process against the backdrop of ongoing or rapidly spreading regional or global concerns and emerging or re-emerging diseases (6).

The impacts of infectious disease in horses are significant and can be devastating. Disease can range from mild disease to death, from sporadic cases to extensive disease outbreaks. Even mild disease can result in chronic or permanent damage and impaired function. Farms and facilities with poor biosecurity may become a significant risk to the rest of the industry (29).

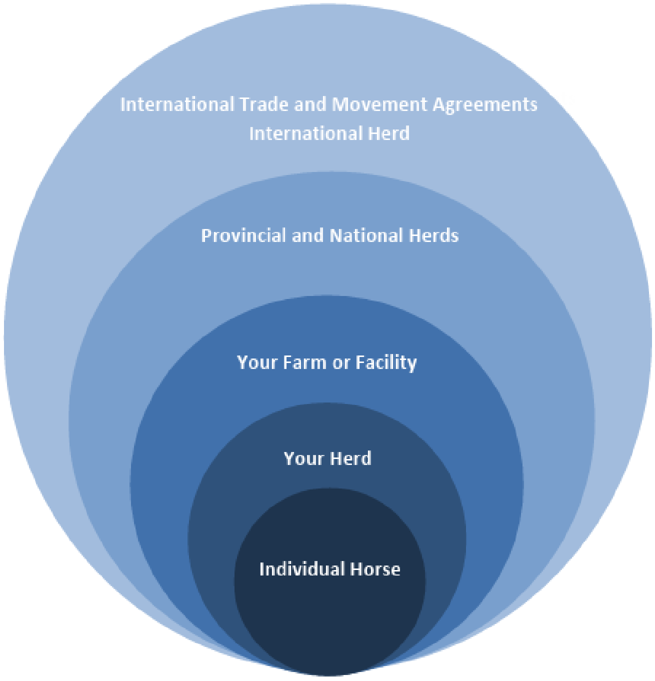

Figure 3 : This diagram illustrates the relationship of an individual horse to the national and international horse industry. It emphasizes the impact that disease left uncontrolled from an individual horse can have on the horse industry *(29)*.

Robust biosecurity protocols are essential for equine facilities to maintain horse health. Adhering to veterinary guidelines for international movements and maintaining hygiene and vaccination practices prevent disease spread. These measures protect horses from health threats, reducing disease-related issues and ensuring their well-being (30). It lowers the direct costs of treating diseases and the indirect costs incurred by the equine industry through disease control measures, decreased event attendance, and revenue losses. Ultimately, a robust biosecurity plan protects equine health reputation, ensuring continued access to export markets and international horse movement (Figure 3) (29).

3 Challenges and potential barriers to equine biosecurity

The equine industry presents unique biosecurity challenges due to diverse housing arrangements and high mobility of horses**.** A survey of British horse owners found that 59% travelled with their horses within a single day, highlighting this movement frequency (31). In another study, 330 horses undertook 1754 movements to various locations over a seven-month period (32). This dynamic network of horse contacts contrasts with livestock farms, where closed herds are standard biosecurity practice. Unfortunately, for many equestrian businesses, particularly competition venues and riding schools, closed herds are impractical due to their reliance on external client and horse traffic (33).

CHAPTER II

4 BIOSECURITY

4.1 Introduction

Livestock herds are susceptible to devastating outbreaks of both endemic and exotic contagious diseases. Diverse transmission routes of infectious agents between farms include animal transport, human movement and contaminated vehicles and equipment. Additionally, aerosols, wildlife, and insect vectors can also contribute to the spread of infections. The frequency and patterns of contact via these transmission routes are critical determinants of disease introduction risk. Understanding these dynamics is essential for both epidemiological investigation of disease outbreaks and the design of effective preventative measures (34).

Biosecurity encompasses a range of hygiene and management measures, designed to reduce the introduction of infectious agents and to control their spread within populations or facilities (35).

Biosecurity measures predominantly address non-specific disease threats rather than targeting specific pathogens. As such, biosecurity is considered good everyday practice to avoid significant impacts when disease incursions occur (33).

Biosecurity standards are generally based on disease risk assessments (the assessment of risk and potential consequences of pathogen exposure or transmission), they are designed to anticipate and address risks before they occur (36).

A biosecurity plan addresses the risk associated with diseases and pests by focusing on three actions, firstly it focuses on preventing the introduction of pathogens on the facilities (bioexclusion)(36), Examples of bioexclusion measures implemented on equestrian premises include; quarantine of new arrivals or returning resident equids, infection control precautions for visitors and avoidance of contact with other animals (33). Secondly, preventing the spread of pathogens among animals on the facility (bio-management)(36) for example, isolation of equids suspected or confirmed as having a contagious disease (33), and lastly prevent the spread of pathogens between animal farms or from animal farms to other animal populations (36).

4.2 Principles of disease prevention and control in equestrian establishments

4.3 General concepts of infection control

Four broad approaches form the foundation of infection prevention and control. Decreasing exposure and susceptibility to disease, increasing resistance to disease and treatment with medication to control an diseases (29).

4.3.1 Decrease exposure to pathogen

This includes implementing separation strategies to minimize pathogen transmission, such as isolating individuals suspected of infectious diseases. Personnel should wear personal protective equipment (PPE) to minimise transmitting pathogens to susceptible animals (37).

4.3.2 Decrease susceptibility to disease

To mitigate disease susceptibility , a focus on achieving optimal health status is essential. The nutritional status significantly influences the susceptibility and pathogenesis of infectious diseases in several ways. For example, protein deficiency and malnutrition increase the susceptibility to infections, and facilitate the pathogenesis of diseases (38).

4.3.3 Increase resistance to disease

Vaccination is the primary method used to improve resistance to certain infectious diseases. While vaccination does not offer complete prevention, it is essential for controlling infectious diseases. Since exposure is often inevitable, vaccination plays a crucial role in reducing the severity of clinical symptoms and enhancing resistance in both individual horses and horse populations (39).

4.3.4 Treatment with medications to control an infectious disease

There are many different medications that can be used to help manage infectious disease, thus decreasing the chances of it spreading to other horses. The medications most commonly used to control bacterial infections are antibiotics (29).

5 Prevention and control of disease on equine establishments

5.1 Measures for newly arriving horses

The introduction of new equids presents a potential biosecurity threat through the introduction of infectious diseases. To mitigate this risk, bioexclusion measures are implemented for new arrivals. These measures typically include a pre-entry inspection for clinical signs of disease, a quarantine period upon arrival, daily temperature monitoring during quarantine, and verification of current vaccination status (33).

5.2 Quarantine

Quarantine is an important aspect of implementing bio security measures. Ideally, there should be a separate facility used for any horse that has left the premises for showing or breeding and not just for sick or new horses (39). Failures in compliance with quarantine requirements can also be contributing factor in spreading infections as in case of 2007 outbreak of equine influenza in Australia (40).

5.3 Measures for visitors

Humans play a significant role in the transmission of pathogens, particularly through fomite transmission, for example via hands, clothing or equipment (33). Visitor management is crucial for balancing the potential risks they introduce with the necessity of their presence (Figure 4). While some areas, like isolation units, might benefit from restricted access altogether, other situations may require visitor limitations. To achieve this, designated visiting hours and mandatory check-in procedures can be implemented. Visitors can be asked to wear clean clothing, wash their hands before contact with the horses on the premises, or step on a disinfectant footmat before entering the stabling area (37).

Figure 4: Visitor interacting with a horse (Mulenga, 2024).

5.4 Animal Feed, Water and Bedding

Animal feed, water, and bedding materials can significantly impact disease transmission within a farm environment. Water poses a high risk for indirect transmission of several diseases. One biosecurity strategy involves preventing animals from accessing natural waters (41). Another critical aspect is managing contaminated feed, which can occur due to improper storage in humid climates, leading to fungal growth and toxin production. Similarly, unsanitary bedding materials can harbour disease-causing organisms. Therefore, implementing a biosecurity plan necessitates regular quality checks of feed and bedding materials prior to use. Furthermore, routine testing of water sources is crucial as they are susceptible to contamination by faecal matter or urine, potentially exposing animals to a range of pathogens. Consistent monitoring of these elements is essential for maintaining animal health and preventing disease outbreaks at the farm level (40).

5.5 Movement within the Farm Premises

Movement of owners, employees, visitors, veterinarians and services is daily occurrences for a farm operation, which increases the risk of introduction and spread of diseases. Measures can be developed and implemented to reduce these risks. The access to farm premises should be restricted by establishing distinct zones with varying levels of protection (40).

Strict biosecurity protocols govern farm vehicle and equipment use. Dedicated parking areas exist for employee and family vehicles, while designated wash-down zones ensure proper cleaning and disinfection for incoming and outgoing vehicles, equipment, and livestock transports. Sharing equipment is discouraged, and farm-specific tools are sanitized between uses (42).

5.6 Disposal of Manure

Although, manure serves as a useful source of plant nutrients, soil enhancement and energy if properly utilized, it represents a major source of environmental pollution if mismanaged. It may contain pathogenic microorganisms, which are transmissible through water and can cause potentially fatal diseases or death (43).

When it is disposed in fields without any pretreatment, it poses an opportunity for human contact and risk of transmission of pathogen, posing biosecurity threat. Biosecurity measures include manure management plan to address collection, storage, handling and disposal (40).

5.7 Pests, and wildlife control

Vermin control is critical, especially for disease agents transmitted through fomites. Simple control measures, such as securing feed storage areas from unwanted wildlife (Figure 5), removing brush and wildlife habitats, instituting rodent control measures, and eliminating areas of standing water, will contribute significantly to the reduction of disease transmission risks on the event premises (44).

Figure 5: (Left) Feed containers ,(Right) top view of the green feed containers not properly closed (Mulenga, 2024).

Wildlife can also serve as a source of pathogens for domestic animals, for example, faeces of the opossum may contain the infective form of *Sarcocystis neurona*, which is the causative agent for equine protozoal myeloencephalitis (EPM). West Nile virus is spread via mosquito bites, equine infectious anemia (EIA) is spread by tabanid flies, flies have been shown to carry Salmonella, and certain insects are proposed vectors for the spread of vesicular stomatitis virus. For this reason, pest management should be incorporated into a comprehensive infection control program (37).

The infection control measures vary depending on the geographic area and the wildlife species involved, which involve cutting grass and vegetation around the farm premises, monitoring rubbish dumps and debris piles, managing feed spills and food sources to discourage pests and wildlife. Secured entry points to animal housing, pens and barns; prevent pest, pets and wildlife access (40).

5.8 Isolation

Isolation is the process of separating animals that are ill, suspected to be ill, or of an unknown or lesser health status from healthy animals. The period of separation ends when animals have recovered, or been determined to be healthy, or aligned with the health status of the herd. Separation includes measures to prevent direct contact (nose to nose) and indirect contact (shared equipment) between isolated animals and the remainder of the herd (29).

The importance of preventing shared air space for isolation facilities to effectively control disease varies depending on the pathogen of concern. For example, maintaining a separate air space is unlikely to be required for control of pathogens spread only by oral or direct transmission but is a key consideration for pathogens capable of airborne transmission such as equine influenza (EI) virus and equine herpes virus (EHV) (33).

5.9 Vaccination

Vaccination is an important component for prevention of many infectious diseases. The availability of safe and effective vaccines has had a profound impact on equine health (37). However, while important, vaccination should not be the cornerstone of an infection control programme. Rather, vaccination should be used to reduce the risk of disease when measures to reduce the risk of exposure are ineffective or impractical (6).

5.10 Cleaning and Disinfection

Cleaning and disinfection (C&D) procedures are fundamental for pathogen inactivation, to prevent the spread of the disease Cleaning represents one of the most important steps in the C&D process. It removes over 90% of micro-organisms when properly performed and improves the disinfection efficacy (45).

Cleaning vehicles and equipment that enter or leave a site to remove all visible dirt is crucial. This process eliminates most contaminants, and following disinfection, when properly applied, will inactivate any pathogens present on the pre-cleaned materials (46). This will help prevent indirect transmission of pathogens (47).

6 Risk Factors for West Nile Virus Transmission in Equestrian Clubs

Ecological variables (including weather and climate conditions) affect mosquito-borne viruses; considerably, the main factors that can pose a risk are abundance of mosquito vectors and their vertebrate hosts, intense summer precipitations or floods, summer temperatures and drought, and presence of appropriate habitats for example wetlands, small water pools (Figure 6), or humid building basements (48).

Figure 6 : Stagnant water can be breeding ground for mosquitoes (Mulenga, 2024).

Thus, preventing horse exposure to infected mosquitoes remains essential to avoid risk of infection (Figure 7). Stabling, particularly at night in insect proof stabling may form an inexpensive, safe and effective means of preventing infection. The effectiveness of stabling in non-insect proof stabling is less clear, but probably depends on specific local environmental factors such as the local species of mosquito, the availability of other hosts for mosquitoes to feed on and the mosquito and horse population densities. Normal stabling could be enhanced by the use of insecticides within stables and topical insect repellents but the efficacy of such measures has not been fully evaluated (13).

Figure 7 : Uncovered windows pose a risk for entry of insects (Mulenga, 2024).

Furthermore vaccination proves to be an important aspect in infection prevention. In a 2003 Saskatchewan study, vaccination demonstrated a remarkable 96% efficacy during a natural outbreak. Vaccinated equids were 23 times less likely to develop clinical signs compared to unvaccinated animals, and this association held true even for WNV-exposed and infected individuals. Furthermore, unvaccinated premises were more likely to experience clinical cases, highlighting the herd-level protection offered by vaccination. These findings suggest that WNV vaccination is a highly effective preventive measure against clinical West Nile virus disease (49).

EXPERIMENTAL PART

7 Experimental part

7.1 Introduction

Given the threat that infectious diseases pose in equestrian clubs, it is crucial to implement effective biosecurity measures to protect both animals and humans. This study examines biosecurity implementation within equine clubs, focusing on identifying deficiencies in current practices that contribute to the spread of infectious diseases among horses. The study investigates the specific biosecurity protocols utilized by participating farms, with a particular emphasis on measures aimed at mitigating the transmission of vector-borne diseases like West Nile fever. By analysing these practices, the study aims to identify areas where biosecurity protocols fall short. Through a comprehensive understanding of current risk factors, this thesis seeks to establish a foundation for the development of biosecurity recommendations. These recommendations will be formulated to address identified deficiencies and enhance biosecurity protocols within equine clubs. Ultimately, this thesis strives to contribute to the improvement of horse health by promoting more effective disease prevention strategies across member farms.

7.2 Materials and methods

7.2.1 Selection of participating equestrian clubs

A random cross-sectional survey was carried out on 5 Algerian equestrian clubs located within the cities of Algiers and Blida.

8 Ethical Statement:

Authorizations were obtained from the Inspection Vétérinaire de la Wilaya d'Alger and the Direction des Services Agricoles de la Wilaya de Blida prior to conducting our study on horses from the equestrian clubs of Algiers and Blida. These authorizations were sought to ensure compliance with ethical standards and regulatory requirements concerning the welfare and participation of animals in our research.

8.1.1 Data collection

Data were collected from equestrian clubs using two adapted questionnaires. The first questionnaire was based on the Equine Biosecurity Risk Calculator developed by the university of Guelph, while the second was adapted from the research titled "Equine Biosecurity and Biocontainment Practices on U.S. Equine Operations.'' (50). The secondary questionnaire, comprising a subset of questions similar to those in the main questionnaire, was used to cross-validate the responses obtained from the first one. The questionnaire was administered in a face-to-face format by an interviewer, the response were recorded using google forms. Additionally, a thorough tour of the equestrian clubs was conducted to gather more detailed information about each club.

Reports on the occurrence of West Nile Virus in Algeria were collected using data from the World Animal Health Information System (WAHIS) database.

8.1.2 Biosecurity assessment criteria

Biosecurity assessment was conducted using the Equine Biosecurity Risk Calculator developed by University of Guelph. This calculator employs a questionnaire format encompassing ten distinct categories. These categories include ;

- general facilities,
- housing materials,
- resident horse movement,
- introduction of new horses,
- vaccination protocols,
- personnel movement on and off the premises,
- pest control measures,
- infection control practices,
- sick animal management, and
- isolation procedures.

Based on participant responses to each category, a color-coded grading system is applied. Green denotes satisfactory biosecurity measures, indicating recommended practices are in place. Yellow signifies areas requiring improvement, prompting participants to consider implementing additional biosecurity protocols. Conversely, red signifies a critical risk area, urging participants to immediately halt current practices and re-evaluate biosecurity measures to mitigate disease transmission risks.

Following the individual category assessments, the calculator generates an overall biosecurity score. This score adheres to the same color-coded grading system (green, yellow, red) to provide a comprehensive evaluation of the farm's overall biosecurity posture (51).

8.1.3 Data analysis and statistical processing

Data was collected and analysed using google forms. Google forms allowed us to create survey forms and automatically compile the responses into a structured dataset. Additionally, the built-in analytical tools provided graphical representation of the data facilitating easy interpretation of the results.

RESULTS

9 Results

9.1 Characteristics of participating equestrian clubs.

This study was carried out on 5 equestrian clubs, designated as Club 1 through Club 5 to ensure anonymity. Three of the clubs were public, operated by the state, while the remaining two were privately owned. All clubs possessed a sizeable horse population, exceeding 30 horses each. Additionally, each establishment housed horses for more than four individual owners

Further characterization revealed distinct specializations within the clubs. Clubs 1, 2, and 4 housed horses primarily dedicated to professional and amateur competitions. These clubs additionally had breeding mares and foals within their herds. In contrast, Club 3 exclusively catered to amateur competition horses, potentially indicating a less complex biosecurity environment. Finally, Club 5, while offering amateur competition opportunities, also had breeding mares and foals, suggesting a blend of the characteristics observed in the other clubs.

9.1.1 Club-Specific Results

9.1.2 Club1

The survey on Club1's compliance with equine biosecurity standards across ten categories, the overall score indicated areas for improvement, reflected by a yellow colour code. A breakdown of the individual categories revealed a mixed performance.

Club1 achieved a green score, signifying satisfactory compliance, in only two categories: housing materials and new horse acquisition. The club receives approximately 7-9 new horses annually from sources that adhere to stringent health regulations or those with comparable requirements. Housing for these horses utilizes concrete floors and painted concrete block walls (figure 8).

Figure 8: Floors and walls of stalls on club 1 (Mulenga, 2024).

Several categories received yellow scores, including general facility upkeep, resident horse movement within the facility, vaccination protocols, personnel traffic flow, pest control measures, infection control practices, sick animal management, and isolation procedures. While Club1 vaccinates horses for tetanus, rabies, and influenza, West Nile Virus vaccinations were not administered. Additionally, attics within the facility were accessible to various animals like cats, pigeons, rats, and mice. Floor bags were also found to be accessible to pests (Figures 8 & 9)

Figure 9: Attic, hay storage area at club 1 (Mulenga, 2024).

Figure 10: Opening on the roof of the attic(Left), feathers showing birds have access to the attic(Right) at club 1(Mulenga, 2024).

The survey results indicated critical non-compliance in two categories concerning horse movement and human traffic. Club1 received a red score in these areas. Notably, the club lacks procedures to verify the health status of horses that come into contact with resident horses after leaving the facility. Furthermore, the facility receives a high volume of human traffic, with 36-50 people entering and exiting weekly (Figure 11).

Figure 11: Weekly visitors at club1 (Mulenga, 2024).

The response from second questionnaire showed the club lacked procedures to control disease transmission among visitor. Additionally, no designated isolation zones or protocols were established to manage potentially contagious horses. Additionally, no designated isolation zones or protocols were established to manage potentially contagious horses. On a positive note, the club adhered to a commendable practice of refilling water containers with fresh water daily. Manure is left to accumulate then transported off the premises or it spread where horses are not kept (Figure 12).

Figure 12: Manure being transported off premises at club 1 (Mulenga, 2024).

The figure below shows the summary of the results at club 1 (Figure 13).

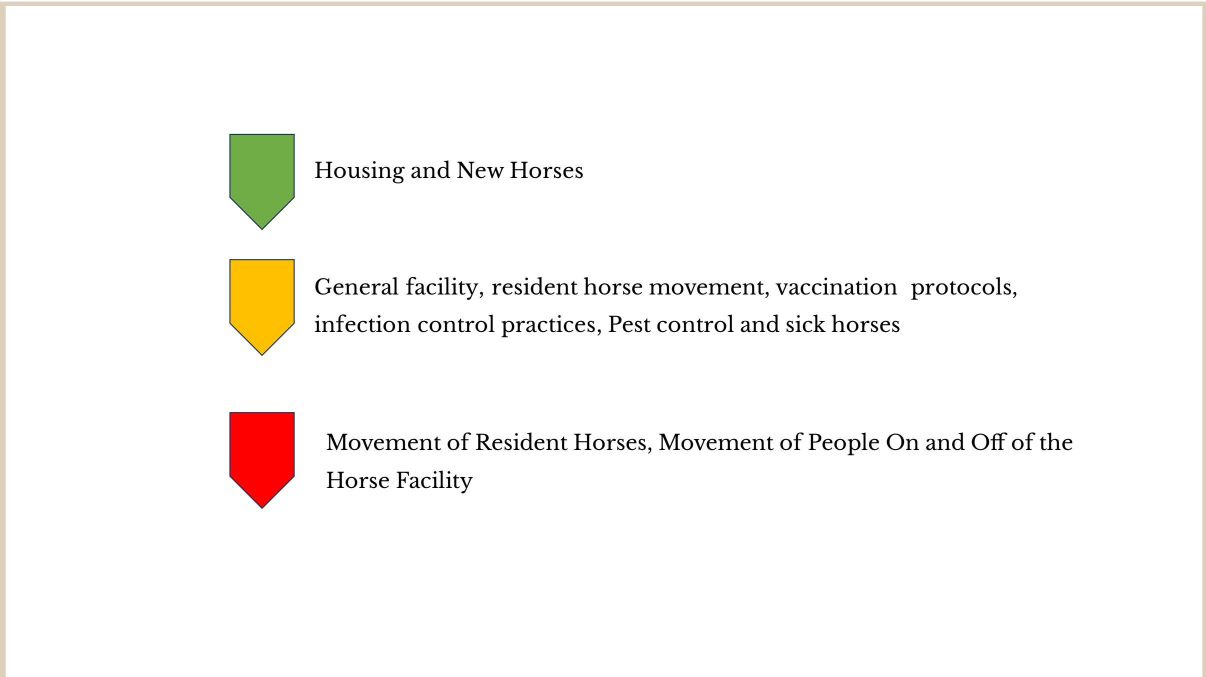

Figure 13: Club 1 biosecurity score.

9.1.3 Club2

Similar to Club 1, Club 2 received an overall biosecurity score of yellow, indicating areas for improvement. However, Club 2 achieved green scores in four specific categories: housing materials, movement of resident horses, introduction of new horses, and management of sick horses. Concrete floors and painted concrete walls were utilised by the club. During the past year, resident horses primarily participated in competitions (seven total) held between October and May. These events involved shared equipment, cleaning tools, food, water, and washing areas. Accidental nose-to-nose contact also occurred during transportation.

Club 2 received an average of more than ten horses annually. These horses originated from establishments with biosecurity measures comparable to their own. Horses were also acquired from importers, followed by a mandatory quarantine period before integration with the resident population. Verification of health certificates ensured proper vaccinations (tetanus, rabies, and influenza) for incoming horses.

Additionally, the club implemented a protocol for contacting the veterinarian if a horse's temperature exceeded 39 degrees Celsius. Finally, handwashing was emphasized during wound treatment procedures.

However the club received a score yellow in the rest of the categories. These categories include general facility, vaccination and deworming, movement of people on and off the facility, pest control, infection control and isolation category. The club had over 36 horses which were grouped by owner, with individual stalls for each animal (figure 13).

Figure 14 : Individual stalls at club2 (Mulenga, 2024).

Group interaction occurred only during training sessions. Vaccination protocols included rabies, tetanus, and equine influenza for all horses. Equine herpesvirus vaccination was administered solely to horses traveling internationally. The club also kept Vaccination records. While a new syringe accompanied each injection for most medications, antibiotics involved reusing the needle and syringe on the same horse for multiple doses. Sharps disposal followed proper protocol with designated plastic bins (Figure 14).

Figure 15: Plastic sack bin at club 2 (Mulenga, 2024).

Deworming practices lacked a standardized schedule, occurring upon parasite detection or at owner discretion. Public access to the club was significant, exceeding 300 visitors a week, particularly during competitions. Club members underwent registration upon arrival, while visitors did not.

Pest control efforts included maintaining short grass, utilizing fly spray, and frequent manure removal. Additionally, feed containers remained securely closed. Handwashing solely relied on water, with no soap provided. Furthermore, neither personnel nor horse owners received training in infection control procedures. Equipment was shared among all horses. Manure management varied, with practices including off-site transport, spreading on horse-occupied land, accumulation, or even sale (Figure 16). In addition to horses other animal species were present at the club (Figure 15).

Figure 16: Presence of other animal species at the club at club 2 (Mulenga, 2024).

Figure 17: Manure pile at club 2 (Mulenga, 2024).

Cleaning routines involved daily stall cleaning, with paddocks neglected. Transport vehicles received cleaning only after completing all daily trips. The cleaning process involved sweeping followed by washing with soap, water, and bleach. Isolation protocols for horses suspected of contagious diseases were informal. Isolated horses were placed in areas preventing contact with healthy animals. Handwashing and disinfection were implemented by personnel handling isolated horses. Additionally, equipment used on isolated horses was either separated or disinfected before use on healthy animals. The figure shows the summary of the colour coded score at Club 2 (Figure 18).

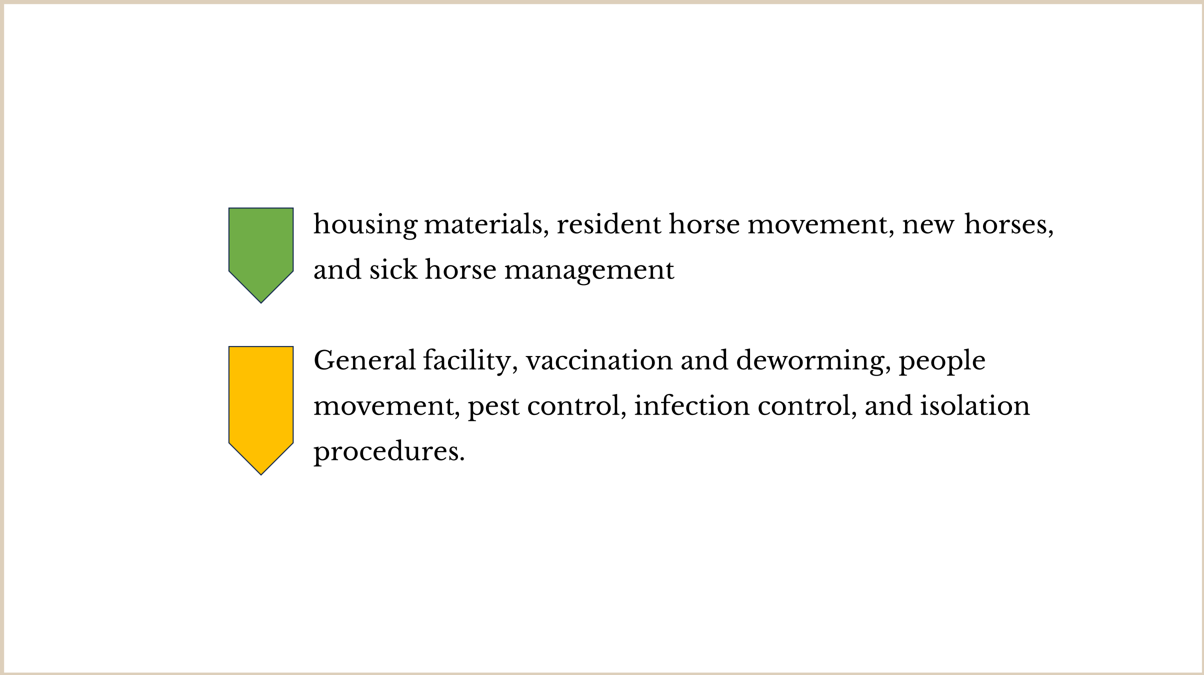

Figure 18: Club 2 biosecurity score.

9.1.4 Club3

Club 3 received an overall score of yellow, consistent with the previously mentioned clubs. It achieved a green score only in the housing materials category, where the floors were made of concrete, and the walls were lime-painted cement bricks. In contrast, the club scored red in two categories: new horses and the movement of people on and off the facility. More than ten new horses visit the club annually, coming from other domestic establishments with similar health statuses. However, the club does not practice isolation for new arrivals nor require any health tests.

Additionally, the club receives over 100 visitors, excluding owners, each week without any registration requirements. All other categories, including general facility, movement of resident horses, vaccination and deworming, pest control, infection control, sick horses, and isolation, received a yellow score.

The club has over eight owners and more than 50 horses, primarily used for amateur competitions. These horses are kept in separate stalls, with potential nose-to-nose contact during training sessions (Figure 17).

Figure 19: Horses kept in individual stalls at club 3 (Mulenga, 2024).

They are grouped based on the frequency of movements in and out of the club. Over the past year, horses from this club travelled to other domestic establishments with similar health statuses, with approximately 15 horses transported monthly. During these trips, horses came into contact with others whose health statuses were unknown, sharing water and tools like brushes.

Vaccinations against influenza, rabies, and tetanus are administered, with records maintained in a register. Injections are given with new needles and syringes, and sharp objects are disposed of in plastic bins. Deworming occurs regularly, typically in autumn and spring. Pest control measures include frequent manure removal, anti-insect blankets, and cutting overgrown grass. However, feed is stored in containers that are not closed, allowing access to other animals like birds (Figure 19). Other stalls had visible points of entry for pest (Figure 18).

Figure 20: Possible points of entry for pests at club 3 (Mulenga, 2024).

Figure 21: Feed storage at club 3 (Mulenga, 2024)

Personnel and horse owners lack training in infection control practices. The club uses only water and soap for handwashing, and horses share water and equipment such as blankets and brushes. Manure accumulates before being transported out, and stalls are cleaned daily (Figure 20).

Figure 22: Manure left to accumulate at club 3 (Mulenga, 2024).

The club lacks disinfectants for disease outbreaks, and transport vehicles are cleaned only at the end of the day, using a process of manure removal, sweeping, and washing with soap and water.

A veterinarian examines the horses each morning, and personnel are instructed to call the veterinarian if a horse shows signs of nasal discharge or a high temperature. While treating wounds, personnel do not use disposable gloves but wash their hands before and after the procedure. In cases of suspected contagious diseases, the club has an informal protocol for isolating affected horses, with all personnel having access to the isolation area. Figure below summarises the colour coded biosecurity score at club 3 (Figure 23).

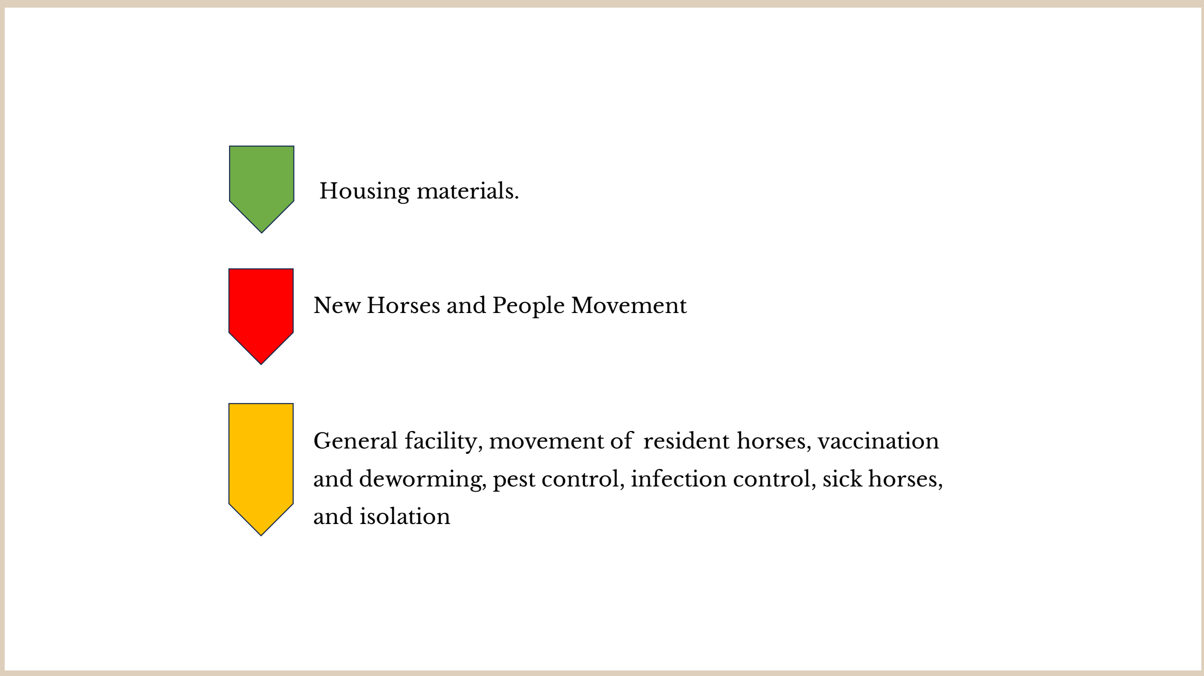

Figure 23: Club 3 biosecurity score.

9.1.5 Club4

The club received an overall score of yellow, similar to all other clubs. However, it scored red in the general facility and movement of people on and off the premises category. The club comprises about 20 horse owners and over 50 horses, which are used for professional competitions and breeding. These horses frequently travel to nine racetracks across the country, and they are grouped according to their owners, with potential nose-to-nose contact during races held every Saturday.

The club earned a green score in the housing material, new horses, and isolation categories. The floors are made of concrete, and most walls are painted with lime. Annually, the club receives more than 10 new horses that travel to establishments within the country adhering to similar health regulations. New arrivals are placed in separate stalls, while horses from other countries are quarantined for 20 days and must present a health certificate from the originating racetrack's veterinarian. Each stable at the club has its own veterinarian. Suspected cases of contagious diseases prompt immediate isolation and veterinary consultation.

The club has written protocols for separating and disinfecting personnel and equipment before contact with healthy horses. In the isolation stable, an empty stall is left between two adjacent horses. In the last five years, the club experienced an influenza outbreak, after which corrective measures were taken, preventing further outbreaks.

Other categories, including the movement of resident horses, vaccination and deworming, pest control, infection control, sick horses, received yellow scores. In the past year, the club's horses travelled to domestic establishments with similar health statuses and once to Tunisia. Approximately 40 horses are transported in and out of the club annually, with potential nose-to-nose contact and shared equipment usage. The health status of encountered horses remains unknown.

The club vaccinates against influenza, rabies, and tetanus, although vaccinations are not obligatory, and records are not maintained. New needles and syringes are used for injections, and sharp objects are disposed of in bin bags. Deworming is infrequent and conducted only upon an owner's request. Insect control measures include using insecticide strips, frequent manure removal, and cutting overgrown grass. However, feed is stored in sack bags (Figure 21).

Figure 24: Feed storage bags at club 4 (Mulenga, 2014).

Personnel and horse owners lack training in infection control practices. While horses in the same stable share equipment such as blankets and brushes, they do not share water (Figure 22).

Figure 25: Individual drinking points at club 4 (Mulenga, 2024).

Manure is transported out, and the main accommodation area is cleaned daily. Transport vehicles are disinfected after use with water and bleach, involving manure removal, sweeping, and washing with soap and water. Horses are regularly examined by a veterinarian, who is notified of nasal discharge and high temperatures, followed by antibiotic treatment for a few days. Personnel do not wear gloves when treating wounds. The summary of the colour code score for club 4 is shown below (Figure 26).

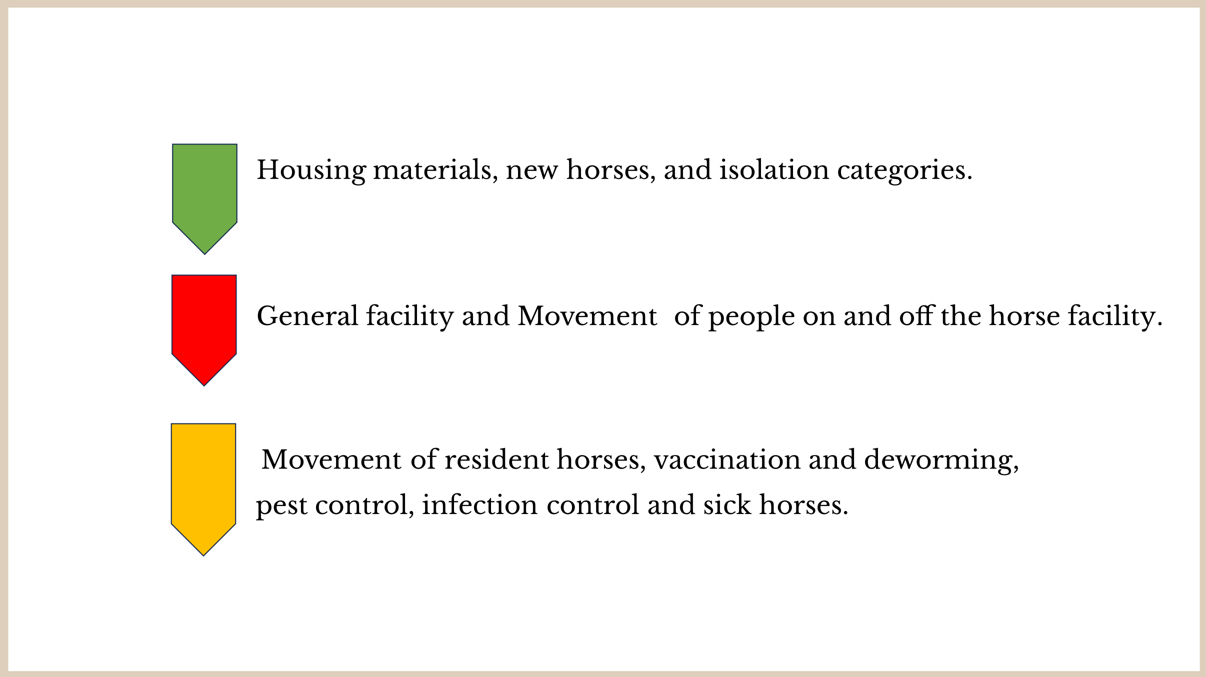

Figure 26: Club 4 biosecurity score.

9.1.6 Club5

Club 5 also had an overall score of yellow, similar to all the other clubs. It received a red score in two categories: general facility and movement of people on and off the horse facility. The club has 35 horse owners with a total of 70 horses, used for amateur competitions and breeding. Horses are grouped by personality or by the frequency of their movements in and out of the club. They come into contact with each other three times a week, with the possibility of nose-to-nose contact (Figure 23).

Figure 27: Horses grouped together at club 5 (Mulenga, 2024).

The club receives more than 50 visitors, excluding horse owners, each week without any registration requirements. It scored green in the categories of housing materials, new horses, pest control, and sick horses. The floors are made of concrete, and the walls are cemented brick painted with lime.

The club receives about 150 horses annually, depending on whether they host competitions. In a normal year, the horses travel to other domestic establishments with similar health regulations and to establishments without strict health regulations, including international auctions. New horses are placed in an ordinary stable for a set period. The club requires new arrivals to have health certificates, vaccination records, and health examinations. Daily observations are conducted for symptoms such as diarrhoea, coughs, and nasal discharges.

Insect control measures include insecticide strips, spraying insecticides on horses and the environment, frequent manure removal, fly traps, and removal of overgrown grass. Feed is stored in closed containers, preventing access by other animals like birds.

Veterinarians regularly examine the horses and are called if nasal discharge or high temperature is observed. Personnel sometimes use disposable gloves when treating wounds.

The categories of movement of resident horses, vaccination and deworming, infection control, and isolation received yellow scores. The club's horses travelled to Tunisia in November 2022 and January 2023. Over the past 12 months, the horses travelled to domestic establishments with health statuses similar to the club's. On average, 11-15 horses are transported in and out of the club each month, depending on the number of competitions. The health status of horses that club horses come into contact with is unknown, and they share equipment and have nose-to-nose contact.

The club vaccinates against influenza, rabies, and tetanus, keeping detailed vaccination records. New needles and syringes are used for each injection. Sharp objects are disposed of in plastic bins, bin bags, and sometimes left on the ground. The club collaborates with a veterinarian to develop a deworming plan, administering deworming treatments annually.

Horse owners and personnel lack training in infection control practices. Horse owners and personnel primarily use soap and water for hand disinfection. Horses share equipment like blankets and brushes but do not share water. Manure is allowed to accumulate before being transported out, and sometimes spread on areas where horses are not kept. The main residing areas are cleaned daily. Transport vehicles are cleaned after every use by removing manure, sweeping, and washing with bleach and water (Figure 24).

Figure 28 : Transport vehicles used by the club 5 (Mulenga, 2024).

The club has an informal protocol for isolating horses suspected of having contagious diseases, placing them in stalls without adjacent horses. It has written protocols for disinfecting personnel and equipment before and after contact with healthy horses. The club has never experienced a disease outbreak and lacks corrective measures for such an event. Summary of the results in shown below (figure 29)

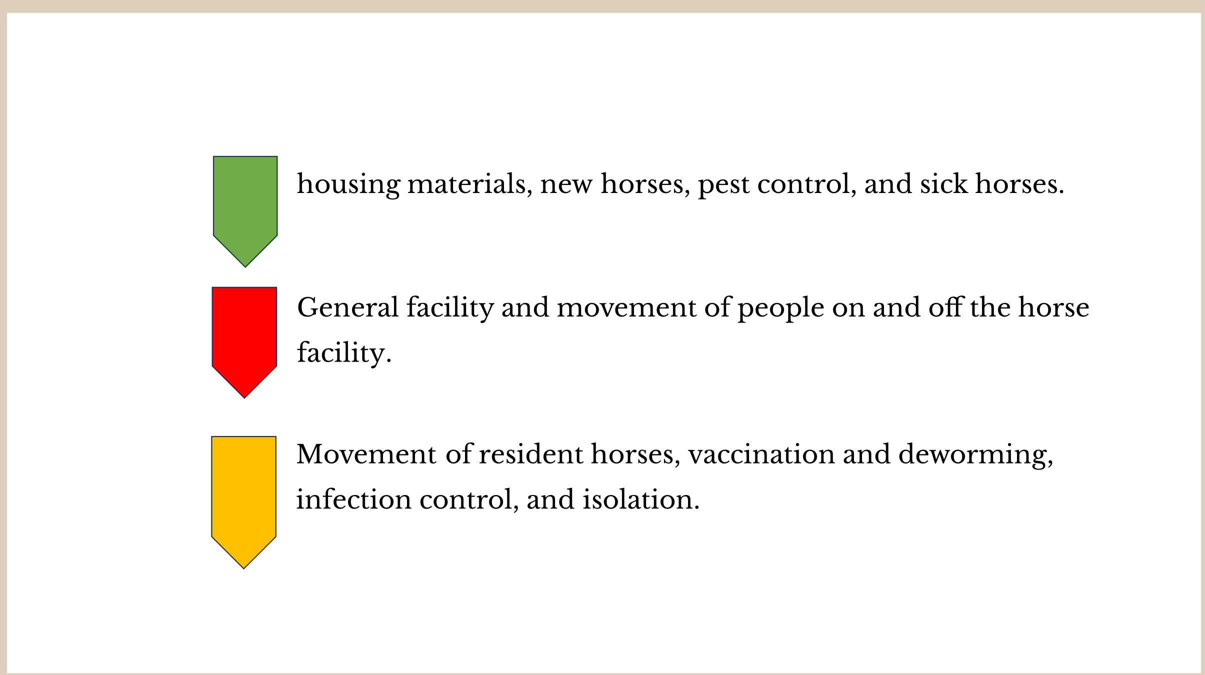

Figure 29: Colour coded biosecurity score at club 5.

9.2 WAHIS results

9.2.1 General Information

The report on the West Nile Fever outbreak in Algeria, provided by the World Animal Health Information System (WAHIS), details an event starting on September 17, 2023. This outbreak was noted as a recurrence of a previously eradicated disease, with the last occurrence recorded on September 6, 2022. The event was confirmed on September 24, 2023, and was resolved by November 2, 2023.

9.2.2 Epidemiology

The source of the infection remains unknown or inconclusive. Quantitative data summary reveals that the outbreak affected domestic Equidae (horses, donkeys, etc.), with a total of 21 susceptible animals and 6 confirmed cases, but no deaths were reported.

9.2.3 Diagnostic Details

Diagnostic testing employed the capture enzyme-linked immunosorbent assay (IgM-capture ELISA), conducted by the Laboratoire Central Vétérinaire. The testing, performed between September 24 and October 10, 2023, confirmed the presence of the West Nile Virus in five sampled outbreaks.

9.2.4 Control Measures

Control measures primarily focused on the control of vectors and were applied at the event level. No additional control measures differing from the event level were implemented.

The region that were concerned with the outbreak include:

- El Hadjab**:** Located in Biskra, from September 17 to October 16, 2023, with one case in domestic Equidae.
- Barika**:** Located in Batna, from September 17 to October 16, 2023, with one case in domestic Equidae.
- Doucen**:** Located in Biskra, from September 18 to October 17, 2023, with one case in domestic Equidae.
- Sidi Amrane**:** Located in El Oued, from October 5 to November 2, 2023, with one case in domestic Equidae.
- Djamaa**:** Located in El Oued, from October 5 to November 2, 2023, with two cases in domestic Equidae.

DISCUSSION

10 Discussion

To the best of our knowledge, this is the first study of its kind conducted in Algeria. This research aims to provide a comprehensive insights into the biosecurity practices within Algerian equestrian clubs. Our investigation encompasses various dimensions of disease prevention, management, and control specific to equine facilities, thereby contributing valuable data to the field of veterinary epidemiology and biosecurity.

Facilities housing a large number of horses are at an elevated risk for disease transmission within the equine population, particularly if the animals are susceptible (51). The equestrian clubs examined in this study maintain a substantial number of horses that reside on the premises for the majority of their time, hosting over 40 horses. This high concentration of resident horses may present significant challenges in the implementation of effective biosecurity measures. Some diseases are transmitted through direct contact with nasal secretions or lymph node discharge from infected horses or by exposure to fomites, highly concentrated or populations are at greater risk of contracting such diseases (39).

All the clubs included in this study utilize concrete flooring in their horse stalls, which is advantageous due to its ease of cleaning and disinfection. In contrast, dirt floors cannot be thoroughly cleaned, if the soil becomes contaminated, it must be removed and replaced to mitigate the risk of disease exposure. Nonporous surfaces, such as concrete, are ideal as they can be washed and disinfected between uses or in the event of a disease outbreak. As with flooring, stall wall surfaces that are difficult to clean and disinfect can harbour infectious pathogens. Porous materials such as untreated wood and unsealed concrete are very difficult to clean completely (51).

The movement of resident horses within the clubs varied, with some clubs, such as Club 2, exhibiting controlled interactions primarily during training sessions, while others allowed more frequent and less regulated contact.

This category performed poorly due to the lack of proper biosecurity measures in place. When horses leave the premises, a total of 4 clubs reported their horses came into contact with other horses and frequently shared equipment.

This is a significant concern because all the clubs reported having no knowledge of the health status of the horses their animals encounter off-premises. However, club1 noted that during events, veterinarians examine all participating horses. To reduce the risk of disease transmission among horses, the Fédération équestre internationale (FEI) recommends that personnel wash and sanitize their hands, change disposable gloves, before contacting different horses and direct contact between horses should be minimized. Common water troughs should be avoided; instead, individual water and feed buckets should be used. Additionally, equipment such as halters, leads, rugs, tack, and buckets should be assigned to a single horse, with a recommended recognition system for each item.

In the past 12 months, the horses from Clubs 4 and 5 have travelled out of the country (horses from Club 4 travelled to Tunisia, while those from Club 5 travelled to both Tunisia and Italy), which carries inherent risks, particularly the potential introduction of diseases into the local horse population. This is highlighted by the findings in a study which identified 54 disease events linked to international horse movements, of which only seven were contained in post-arrival quarantine (52). The remaining events led to the introduction of pathogens into importing countries, with 81% resulting from non-compliance with world organisation for animal health (WOAH) recommendations. Subclinical infections pose a significant challenge, as 88% of regulated movements introducing diseases involved horses that appeared healthy at import. This highlights the importance of effective biosecurity and management practices within resident equine populations to mitigate the spread of diseases to local horses (52).

Clubs such as Club 3 and Club 5 introduced numerous new horses annually without stringent isolation or health status verification. Our findings show that of the five clubs that participated in the research, four clubs reported having no specific protocols for handling new horses upon their arrival (figure 28).

The introduction of new horses presented a significant biosecurity challenge, leading to potential biosecurity breaches. Without proper isolation or quarantine measures, disease control and prevention prove to be a significant challenge (5)

For the vaccination category clubs that participated in this research all administered vaccinations for equine influenza, rabies, and tetanus. However, none of these clubs vaccinated against a range of other diseases, including West Nile virus, strangles and equine herpesvirus, among others.

This poses a substantial risk in the event of a severe outbreak of diseases, such as West Nile fever, strangles and equine herpesvirus for which most clubs are not vaccinating. The recent WAHIS reports of West Nile circulation in Algeria highlights the need for vigilance and should not be overlooked. Vaccination has been proven to be effective in disease control and prevention, as evidenced by a study comparing the clinical outcomes and virology of equine influenza in unvaccinated horses versus those vaccinated shortly before exposure to the virus. In the unvaccinated subgroup, all horses contracted equine influenza with severe symptoms and required extensive treatment. Conversely, in the vaccinated group, only 48.2% showed milder symptoms and had a shorter disease duration, demonstrating significant vaccine protection (53). However, it is important to note that the decision to vaccinate must be made by the state, represented by the Direction des Services Vétérinaires (Ministry of Agriculture and Rural Development). Additionally, all vaccines must receive marketing authorization before veterinarians can administer them to horses in the field. This process ensures the safety and efficacy of the vaccines used (54).

The daily movement of owners, employees, visitors, veterinarians, and service providers in a farm operation elevates the risk of disease introduction and spread (40). To mitigate these risks, specific measures should be developed and implemented. Access to farm premises should be restricted by establishing distinct zones with varying levels of protection, clearly defined by boundaries and appropriate signage. Controlling the movement of people into, out of, and between these designated zones can be achieved through the use of controlled access points (55).

It was observed that all the clubs had a substantial number of weekly visitors and lacked strict measures for visitor management. Three clubs reported to have more than 50 weekly visitors at the club. None of the clubs required any form of registration or imposed restrictions on visitors. Implementing a check-in requirement for visitors at the horse facility can ensure that only authorized individuals enter the premises, thereby enforcing the disease control plan. Additionally, maintaining visitor logs allows for traceability in the event of a disease outbreak at the facility.

The presence of people, their equipment, and vehicles poses a significant risk of transporting pathogenic agents to the horses. The higher the number of visitors to a facility, the greater the risk of disease introduction, particularly if these individuals do not take precautions to mitigate this risk. Restrict vehicles to designated parking areas and designated routes without animal access to limit risk of disease introduction and spread. Outside supply trucks and non-essential vehicles should not be permitted in the equid stabling area (44).

In the context of pest control, contamination of feed and water by pests is another potential route of infection for equids. Intact bags should provide a layer of protection against possible contamination by faecal contamination by mice, rats, domestic and wild birds, livestock, dogs, cats, and other wildlife (50).

The five equine clubs examined in this research have adopted different strategies to manage pests, with varying levels of success and compliance. Effective pest control is crucial for maintaining the health and well-being of horses in equine facilities, as pests can transmit diseases, cause stress, and contaminate feed and water sources (29).

Clubs that received yellow scores (Clubs 1, 2, 3, and 4) faced issues such as pests having access to feed storage areas and improper feed storage. Despite some positive practices like frequent manure removal, use of fly sprays, and maintaining short grass, the presence of unsealed feed containers and accessible areas for pests highlighted the need for improvement.

Club 5, which scored green, exemplified good pest control practices by using insecticide strips, regular manure removal, fly traps, and securely storing feed. To enhance pest control across all clubs, it is recommended to seal access points, use sealed feed containers, implement strict manure management schedules, regularly apply insecticides, and limit visitor access to reduce the risk of pest introduction. By adopting these measures, equine clubs can improve their pest control strategies, ensuring better health and biosecurity for their facilities.

The infection control practices across the five equine clubs exhibit significant challenges and areas for improvement. A common issue is the lack of training for personnel and horse owners, leading to inconsistent infection control measures. Handwashing practices are inadequate, often missing soap, which is crucial for preventing the spread of infections (56). Equipment sharing among horses without proper disinfection and the unrestricted access of animals like pigeons, rats, cats, and dogs increase the risk of disease transmission (50).

Specifically, Club 1, despite having protocols for contacting a veterinarian when a horse's temperature exceeds 39 degrees Celsius, lacks designated isolation zones and allows unrestricted access to various animals, potentially facilitating the spread of infections.

Contact between equids and other animals species presents at the club may pose significant risk for disease transmission, a few diseases are transmitted to equids via other animal species. For example, the parasite that causes equine protozoal myeloencephalitis is acquired from the faeces of opossums. Awareness of contact between equids and other animal species can lead to a more timely response to a disease outbreak (50).

Club 2 implements quarantine measures for new horses and maintains vaccination records, yet its handwashing procedures are minimal, and there is no soap provision, compounded by significant public access without proper infection control protocols. Club 3 has an informal protocol for isolating horses with suspected contagious diseases but frequently shares water and equipment among horses without adequate disinfection, alongside infrequent cleaning of transport vehicles. Club 4 has written disinfection protocols and a history of effective responses to outbreaks, such as influenza, but the movement of horses and their interactions at various racetracks present ongoing risks, exacerbated by the lack of infection control training. Club 5 also lacks comprehensive infection control training and relies on basic soap and water for hand hygiene, while equipment sharing and inconsistent manure management further undermine its infection control efforts. The biosecurity calculator recommends that clubs should implement formal training programs, ensure enhanced hand hygiene with soap or sanitizers, develop and enforce formal isolation protocols, and establish regular disinfection schedules for equipment and facilities. These measures will significantly enhance infection control and safeguard both equine and human health.

The management of sick horses across the five equine clubs reveals varying levels of effectiveness and numerous areas for improvement. Club 1 lacks designated isolation zones for sick horses, and its informal protocols fail to ensure consistent isolation of potentially contagious animals. Club 2 performs relatively well with green scores for managing sick horses, implementing protocols for contacting veterinarians and isolating new arrivals. However, its reliance on informal isolation and the frequent public access present risks. Club 3 has an informal protocol for isolating horses with suspected contagious diseases but faces issues with sharing equipment among horses. Club 4 maintains written protocols for separating and disinfecting personnel and equipment before contact with healthy horses, but its high volume of horse travel and interaction with other horses pose a constant threat to maintaining a disease-free environment. Club 5 similarly relies on basic protocols, such as using soap and water for handwashing and informal isolation procedures, which are insufficient given the high traffic of horses and people through the facility. All potentially sick equids should be isolated, anything that touches an infected equid, and its secretions or excretions has the potential to transmit pathogens to other equids. Pathogens can be indirectly transmitted to other equids on equipment, tack, hands, footwear, or clothes (44).

The examination of isolation protocols across the five equine clubs highlights a spectrum of practices, revealing strengths and significant gaps in biosecurity measures. Club 1, despite having individual stalls, lacks designated isolation zones. Furthermore, measures to prevent interaction between resident horses and other animal species were absent. This unrestricted access exposed the horses to potential disease vectors, including pigeons, rats, cats, and dogs (United States Department of Agriculture, 2006). Club 2 performs marginally better, achieving a green score in some areas. They enforce quarantine for new arrivals and maintain isolation for suspected cases, yet the high public access and informal practices still pose biosecurity risks. Club 3 also received a yellow score overall, reflecting inconsistencies. While they separate infected horses, the lack of formal isolation protocols for new horses and minimal health testing undermine their efforts. Club 4, however, stands out with its green score in isolation. They implement stringent protocols, including quarantine for international arrivals and immediate isolation of sick horses, supported by thorough disinfection procedures. This club's practices have proven effective, evidenced by their successful containment of an influenza outbreak. Lastly, Club 5 shares the general trend of yellow scores, maintaining basic isolation practices but lacking formalized procedures. Their informal methods and shared equipment increase the risk of disease spread, emphasizing the need for more rigorous protocols and training. Overall, while some clubs show commendable practices, a uniform implementation of comprehensive isolation protocols is essential for enhanced biosecurity across all facilities. The biosecurity calculator tool emphasizes that isolation is crucial for preventing the spread of contagious infectious diseases among horses in a facility. Educating personnel and horse owners on proper procedures for handling sick or infected horses is essential. Effective communication and a detailed isolation plan help prevent cross-contamination. Without isolation, the risk of disease spread increases significantly, potentially leading to widespread outbreaks. Ideally, sick horses should be housed in separate barns or paddocks, and protocols for human movement should be in place to further minimize risk. Written protocols, developed in consultation with a veterinarian, ensure everyone understands and follows the necessary procedures. In case of an outbreak, collaborating with a veterinarian to review and improve prevention strategies is vital.

The world animal health information system recent reports of the recurrence of West Nile Fever necessitates sustained attention and enhanced vector control measures to mitigate the risk of future outbreaks. The diverse geographical locations of these outbreaks suggest a potentially widespread presence of the virus, thereby requiring coordinated regional efforts in disease management. Strengthening continuous monitoring and early detection systems is imperative for the timely identification and containment of new cases. Implementing and expanding effective vector control strategies will be crucial in reducing the risk of transmission. Additionally, raising awareness among farmers and veterinary professionals regarding the symptoms of West Nile Fever and preventive measures is essential for comprehensive disease management and prevention.

CONCLUSION AND RECOMMENDATIONS

11 Recommendations

Based on our findings, the following recommendations are proposed to improve biosecurity in equine clubs.

Implement Strict Quarantine Measures: Introduce stringent quarantine protocols for new and returning horses. Ensure that new arrivals are isolated and monitored for a sufficient period before integrating them into the general population. This will help prevent the introduction of pathogens from external sources.

Enhance Vaccination Programs: Expand vaccination programs to include diseases such as West Nile virus, strangles and equine herpesvirus. Consistent and comprehensive vaccination will significantly reduce the risk of outbreaks.

Improve Infection Control Training: Conduct regular training sessions for staff and horse owners on infection control practices. Emphasize the importance of hand hygiene, proper use of personal protective equipment, and disinfection of equipment and facilities. Ensuring all personnel are well-trained can significantly reduce the risk of disease transmission.

Strengthen Pest Control Measures: Implement comprehensive pest control strategies, including sealing access points, using insecticide strips, regular manure removal, and secure storage of feed. Controlling pests will help reduce the risk of vector-borne diseases such as West Nile virus.

Develop and Enforce Isolation Protocols: Establish formal protocols for isolating sick horses. Ensure designated isolation zones are available and used consistently. This will help contain any outbreaks and prevent the spread of infectious diseases within the facility

Monitor and Report Health Status: Implement a system for regular health monitoring of all horses, including daily temperature checks and observation for signs of disease. Maintain accurate health records and ensure that any signs of infectious disease are promptly reported and managed.

Promote Individual Equipment Use: Assign individual equipment such as halters, leads, rugs, and feed buckets to each horse to prevent cross-contamination. Avoid the use of common water troughs and instead use individual water buckets for each horse.

Limit Visitor Access: Restrict visitor access to equine facilities and ensure that any necessary visitors follow strict biosecurity protocols. This includes washing and sanitizing hands, wearing protective clothing, and avoiding direct contact with horses

Promote the use of personal protective equipment (PPE): This will significantly reduce the risk of transmitting pathogens between humans and horses.

Mosquito Control and Habitat Management: Eliminate Stagnant Water, regularly check and eliminate stagnant water sources where mosquitoes can breed, such as small water pools, humid building basements, and any other water-holding containers.

Stabling Practices: Utilize insect-proof stabling, especially at night, to prevent mosquitoes from accessing horses. This can be an effective, safe, and inexpensive way to reduce infection risk.

Implementing these measures will help reduce infectious disease risks, ensuring better health and safety for horses and humans.

12 Conclusion

This pioneering study on biosecurity protocols within equine clubs in Algeria not only reveals significant gaps in current practices, particularly in mitigating the transmission of vector-borne diseases such as the West Nile virus, but also emphasizes the distinctive biosecurity challenges encountered by the Algerian equine industry, laying the groundwork for further studies.

The comprehensive survey conducted across five equine clubs in Blida and Algiers indicates a pressing need for improved biosecurity measures. The performance of the five clubs was suboptimal across all assessed categories, with the exception of the housing materials category, which consistently achieved favourable scores across all five clubs.

The biosecurity scores, derived using the Equine Biosecurity Risk Calculator from the University of Guelph, suggest that while some practices meet the recommended standards, many critical areas require substantial improvement. Clubs often failed to implement adequate isolation protocols, feed storage measures and proper management of visitors on the premises. Additionally, most clubs reported that their horses frequently had direct contact with other horses and shared water and cleaning tools when outside their resident premises.

The findings highlight the necessity of adopting more rigorous biosecurity measures and regular monitoring to ensure compliance. Emphasizing education and training for staff and horse owners on the importance of biosecurity can significantly enhance disease prevention efforts. Additionally, integrating systematic vaccination programs and improving infrastructure to manage pest populations and isolate sick animals are essential steps towards mitigating biosecurity risks.

Ultimately, this research highlights the need for a collaborative approach involving all stakeholders in the equine industry to develop and implement robust biosecurity protocols. By addressing the identified deficiencies and enhancing current practices, the health and well-being of horses in Algerian equine clubs can be significantly improved, thereby reducing the risk of infectious disease outbreaks.

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Summary

Introduction

This thesis explores the critical importance of safeguarding horses from infectious diseases by understanding the disease triad, which encompasses the host (the susceptible horse), the agent (pathogen), and the environment (contact opportunity). The host's health, immune system, and genetic predisposition determine its vulnerability, while pathogens like bacteria, viruses, fungi, or parasites cause infections. The environment facilitates the interaction between the host and agent, leading to disease transmission. Effective biosecurity measures, including bio-exclusion, bio-management, and bio-containment, are essential for minimizing the spread of infectious diseases in horses. These measures not only protect animal health and welfare but also prevent economic losses, safeguard public health, and ensure the sustainability of the equine industry. Through examining significant outbreaks, such as the 2007 equine influenza in Australia and the 2002 West Nile virus in the United States, this study highlights the necessity of enhanced biosecurity practices to mitigate the risks and impacts of such diseases. Additionally, the study identifies deficiencies in current biosecurity management systems, aiming to minimize pathogen-host interactions and reduce disease incidence

West Nile Virus

West Nile virus (WNV) is a mosquito-borne neurotropic Flavivirus that primarily cycles between mosquitoes and birds but can infect various vertebrates, including humans and horses. Initially isolated in Uganda in 1937, WNV was considered to pose limited risk to humans, causing mostly mild or asymptomatic infections. However, subsequent outbreaks have demonstrated its potential to cause significant morbidity and mortality. Notable outbreaks in Africa, Europe, and the Middle East have highlighted its re-emergence as a significant pathogen. In Algeria, WNV infections were reported in 1994 and 2012, with recent outbreaks in 2023 affecting domestic equidae. WNV's genome is a single-stranded RNA, encapsulated by an enveloped icosahedral nucleocapsid, translating into a polyprotein that is cleaved into structural and non-structural proteins essential for viral replication. The virus is primarily transmitted by Culex mosquitoes and cycles between birds and mosquitoes, with humans and horses being dead-end hosts. The virus has significant clinical implications, especially for horses, causing severe neurological disorders and economic losses in the equine industry

Biosecurity

Biosecurity measures are essential for managing risks associated with both endemic and exotic contagious diseases in livestock. Various transmission routes, such as animal transport, human movement, and contaminated vehicles, along with aerosols, wildlife, and insect vectors, contribute to the spread of infections. Understanding these transmission dynamics is vital for epidemiological investigations and designing effective preventive measures. A comprehensive biosecurity plan includes three key actions: bioexclusion (preventing pathogen introduction), bio-management (controlling pathogen spread within a facility), and preventing inter-farm transmission.

Key principles for disease prevention and control in equestrian establishments include decreasing pathogen exposure through separation strategies and personal protective equipment, reducing disease susceptibility by maintaining optimal health through proper nutrition and health management, increasing disease resistance through vaccination to control outbreaks and reduce clinical symptoms, and using medications, primarily antibiotics, to manage infections and prevent their spread. Specific biosecurity measures include pre-entry inspections and quarantine for new arrivals, regular quality checks of feed and bedding materials, routine testing of water sources, and isolating any horse that leaves the premises for activities such as showing or breeding.

Furthermore, restricting movement within premises by establishing zones with varying levels of protection, enforcing strict protocols for cleaning and disinfecting vehicles and equipment, discouraging the sharing of tools, and proper manure management to prevent environmental pollution are critical components of an effective biosecurity strategy. Additionally, implementing control measures for vermin, securing feed storage areas from wildlife, and managing visitors through restricted access, designated visiting hours, and mandatory check-in procedures significantly reduce disease transmission risks. Overall, these biosecurity practices are integral to preventing and controlling diseases in equestrian establishments, ensuring the health of both animals and humans through proactive and systematic measures.

Methodology

The study investigates the specific biosecurity protocols utilized by participating clubs, with a particular emphasis on measures aimed at mitigating the transmission of vector-borne diseases like West Nile fever. By analyzing these practices, the study aims to identify areas where biosecurity protocols fall short. Through a comprehensive understanding of current risk factors, this thesis seeks to establish a foundation for the development of biosecurity recommendations. These recommendations will be formulated to address identified deficiencies and enhance biosecurity protocols within equine clubs. Ultimately, this thesis strives to contribute to the improvement of horse health by promoting more effective disease prevention strategies across member farms.

A random cross-sectional survey was carried out on five Algerian equestrian clubs located within the cities of Algiers and Blida. Ethical approvals were obtained from relevant veterinary and agricultural authorities to ensure compliance with standards. Data were collected using two adapted questionnaires: the first based on the Equine Biosecurity Risk Calculator developed by the University of Guelph, and the second adapted from the research titled “Equine Biosecurity and Biocontainment Practices on U.S. Equine Operations.” The questionnaires, administered face-to-face, focused on various biosecurity aspects, including facilities, housing, horse movement, vaccination, personnel movement, pest control, infection control, sick animal management, and isolation procedures.

The assessment employed a color-coded grading system (green, yellow, red) to indicate the adequacy of biosecurity measures. Data were analyzed using Google Forms, providing structured datasets and graphical representations for easier interpretation. The study's findings will inform the development of targeted biosecurity recommendations to enhance disease prevention and promote horse health in Algerian equestrian clubs.

Results

The study meticulously evaluated the biosecurity measures across five equestrian clubs in Algeria, designated as Clubs 1 through 5, ensuring anonymity. These clubs collectively house a significant horse population, each exceeding 30 horses, and are either state-operated or privately owned. Clubs 1, 2, and 4 are primarily dedicated to professional and amateur competitions, maintaining breeding mares and foals within their herds. Club 3 exclusively caters to amateur competitions, suggesting a less complex biosecurity environment, while Club 5 offers a blend of amateur competitions and breeding activities.

The assessment of Club 1 revealed significant gaps in biosecurity, particularly in horse movement and human traffic management, earning it a red score in these categories. The club lacked protocols to verify the health status of horses interacting with resident horses and failed to control disease transmission among the high volume of weekly visitors. Despite adhering to satisfactory standards in housing materials and new horse acquisitions, the absence of West Nile Virus vaccinations and accessible attics to pests highlighted critical vulnerabilities.

Club 2 demonstrated better compliance in areas such as housing materials, horse movement, and management of sick horses, achieving green scores in these categories. However, it fell short in general facility upkeep, pest control, and infection control practices.

Club 3, primarily focused on amateur competitions, received an overall yellow score, with red scores in new horse introduction and human traffic management. The club's lack of isolation practices for new arrivals and minimal infection control training for personnel underscored significant biosecurity risks. The frequent movement of horses without health verifications and shared equipment further exacerbated these vulnerabilities.

Club 4, housing over 50 horses used for professional competitions and breeding, exhibited commendable practices in housing materials and isolation procedures but struggled with pest control and maintaining comprehensive vaccination records. The presence of informal isolation protocols and the lack of infection control training highlighted areas needing substantial improvement.

Club 5, while receiving green scores in several categories, faced challenges in general facility maintenance and managing the high influx of visitors. The club's practices in manure management and the presence of other animal species indicated potential biosecurity threats. The informal protocols for dealing with contagious diseases and the shared use of equipment without proper disinfection underscored the need for enhanced biosecurity measures.

Discussion

This study represents the first comprehensive examination of biosecurity practices within equestrian clubs in Algeria, filling a critical gap in the existing veterinary epidemiology and biosecurity literature. The primary aim is to provide detailed insights into disease prevention, management, and control measures specific to equine facilities. Given the high concentration of resident horses, typically over 40 per club, these facilities face significant challenges in implementing effective biosecurity measures. Disease transmission risks are heightened in such environments, particularly through direct contact with nasal secretions, lymph node discharge, or exposure to contaminated fomites.

All the clubs studied utilize concrete flooring in their horse stalls, which is advantageous for its ease of cleaning and disinfection, unlike dirt floors that are harder to manage if contaminated. However, variations in biosecurity practices were noted, particularly in the management of horse movement within the clubs. Some clubs, such as Club 2, exhibited controlled interactions primarily during training sessions, while others allowed more frequent and less regulated contact. This inconsistency is concerning, especially as four clubs reported that their horses often came into contact with other horses and shared equipment during external activities, without knowledge of the health status of the animals they encountered.

A significant finding of this study is the lack of stringent protocols for the introduction of new horses into the clubs. Only one club implemented specific measures for new arrivals, such as isolation from the general horse population. The absence of proper quarantine or health status verification for new horses poses substantial biosecurity challenges, potentially leading to disease outbreaks.

The study also highlights the need for better visitor management and infection control practices. None of the clubs had strict measures for visitor management, with three clubs reporting more than 50 weekly visitors without any form of registration or restrictions. This lack of control significantly increases the risk of disease introduction and spread. Effective measures such as establishing distinct zones with varying levels of protection, restricting access, and maintaining visitor logs are recommended to enhance biosecurity.

Pest control emerged as another critical area requiring improvement. While some clubs implemented positive practices like frequent manure removal and use of fly sprays, issues such as pests accessing feed storage areas and improper feed storage were common. Club 5 exemplified good pest control practices, but overall, the study recommends sealing access points, using sealed feed containers, and implementing strict manure management schedules across all clubs to improve pest control.

Recommendations and conclusion

Based on the findings, the study proposes several recommendations to enhance biosecurity in equine clubs. Firstly, it is crucial to implement strict quarantine measures for new and returning horses, ensuring they are isolated and monitored before joining the general population to prevent the introduction of external pathogens. Enhanced vaccination programs are recommended, specifically targeting diseases such as West Nile virus, strangles, and equine herpesvirus, to reduce the risk of outbreaks.

Improving infection control training for staff and horse owners is another key recommendation. Regular sessions should emphasize hand hygiene, the proper use of personal protective equipment (PPE), and the disinfection of equipment and facilities. This training can significantly lower the risk of disease transmission. Strengthening pest control measures is also vital. Strategies should include sealing access points, using insecticide strips, regularly removing manure, and securely storing feed to reduce vector-borne diseases like the West Nile virus.

Developing and enforcing isolation protocols for sick horses is essential. Designated isolation zones should be available and consistently used to contain outbreaks and prevent the spread of infectious diseases. Regular health monitoring and accurate record-keeping are recommended, including daily temperature checks and prompt reporting of any disease signs.

Promoting the use of individual equipment for each horse, such as halters, leads, rugs, and feed buckets, will help prevent cross-contamination. Avoiding common water troughs and using individual water buckets for each horse is advised. Limiting visitor access to equine facilities and ensuring visitors adhere to strict biosecurity protocols, such as hand sanitization and wearing protective clothing, will also reduce infection risks.

Overall, these measures aim to improve the health and safety of both horses and humans by reducing infectious disease risks in equine clubs. Implementing these recommendations will foster a more robust biosecurity culture within the Algerian equine industry, significantly enhancing disease prevention efforts.