THE FINANCIAL CONSEQUENCES OF THE PREVENTION AND CONTROL MEASURES ON CONTAGIOUS EQUINE METRITIS IN THE NETHERLANDS

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The financial consequences of the prevention and control measures on Contagious Equine Metritis in the Netherlands

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PREFACE

This minor thesis is part of my Master program in Animal Sciences. There were several reasons for me to choose a topic a little outside the regular program. One of them was that I liked to broaden my knowledge on economics. Another was that I started horse back riding when I was eight years old, and since then it has always been a big hobby. So I didn't want to let a chance to contribute something to this sector go by. In the end gathering information about regulations and numbers in the Dutch horse sector turned out to be quite a challenge. Things may not have turned out the way I expected, but nevertheless I learned a great deal. I learned about economics, doing analyses, writing a report and most importantly, about myself.

I would like to thank Joyce Parlevliet from Utrecht University, for commissioning this topic and providing as much information as possible. Also I would like to thank Hendrik Jan Roest from the CVI, Thomas Dijkstra from the GD and Marijn Graf from the PVE for answering any questions I had. Thanks to my friends and family for their support and special thanks go out to Monique Mourits. Even though I sometimes had a difficult time explaining myself on paper, she always challenged me to think further, stimulated me to go on and helped me when it was necessary.

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SUMMARY

Contagious Equine Metritis (CEM) is a contagious bacterial infection of the genitals in horses. The infection is caused by the bacterium *Taylorella Equigenitalis.* Stallions are only carriers of this bacterium; they do not develop clinical signs of the disease. In mares the infection can lead to temporary infertility. Even though this usually only lasts a few weeks, the result often is that the mare will not conceive at all during that breeding season. This of course results in the missed income for the mare holder of the sales of a foal the next year. In the Netherlands the prevalence of CEM in the total population is estimated at 2 – 3 %. Prevention of CEM in mares is done at the level of stallion holdings that are certified by the Board for Cattle, Meat and Eggs (PVE). Part of this certification is that stallions at these holdings have to be tested for CEM every year before the breeding season starts. Testing of stallions is done by taking a swab of the genitals. The testing method used at national level is Polymerase Chain Reaction (PCR). The international Golden Standard test is the bacteriologic culture test. When a stallion is found positive, it has to be treated and it is not allowed to sell the semen of this stallion. Testing, treatment and missed income from not selling semen during this time are the most important economic consequences of CEM for a stallion holder. The objective of this thesis was to estimate the total economic consequences of current prevention measures as well as control measures against CEM. With the use of the partial budgeting method and Monte Carlo simulation with the program @RISK for Excel, four scenarios were analyzed. 1. The additional yearly costs of certification and testing for CEM for a certified stallion holding. 2. The economic consequences of a detection of CEM at a certified stallion holding. 3. Three alternative measures: i) the use of PCR testing instead of bacteriologic culture, ii) the use of a different treatment method and iii) an advancement in the test moment. 4. Consequences of no testing for CEM in the Netherlands at the national level.

Information on numbers in the Dutch horse sector was difficult to obtain. Therefore several assumptions were made for the benefit of the analyses. Results show that the costs for certification and testing of stallions are only one third of one stud fee. This is relatively low. However, when calculating the costs of a detection of CEM in a stallion the mean costs for the stallion holding are € 29,307, which is 35% of the total income from one stallion in one breeding season. The third scenario showed a clear decrease in costs with the use of the PCR method and the advancement of the test moment. And while the new treatment method is a little more expensive than the current one, the chance of recurring positive stallions in the next breeding season is expected to decrease sufficiently. This will contribute to a decrease in costs then. The conclusion here is therefore that it is economically beneficial to adopt all three alternatives. Without testing at all in the Netherlands the question was what would happen to the prevalence in stallions and the number of infected mares. In the Netherlands the prevalence in stallions is estimated at 2% and the infection rate in mares as well. Given the results of the analysis, the question is whether testing stallions on CEM is economically reasonable. The prevalence of the population is not expected to increase much therefore the economic consequences of testing made at present seem open to discussion.

SAMENVATTING

Besmettelijke baarmoederontsteking in paarden (CEM) is een besmettelijke infectie van de genitaliën van het paard. De infectie wordt veroorzaakt door de bacterie Taylorella Equigenitalis. Hengsten zijn slechts drager van deze bacterie en vertonen geen klinische symptomen. Bij merries kan CEM leiden tot tijdelijke onvruchtbaarheid. Ook al is deze onvruchtbaarheid vaak tijdelijk, namelijk een aantal weken, het resultaat is vaak dat de merrie niet drachtig wordt gedurende dat dekseizoen. Op deze manier loopt de merriehouder het volgende jaar inkomen mis omdat geen veulen verkocht kan worden. In Nederland wordt de prevalentie van CEM in de hele populatie geschat op 2 – 3%. Preventie van CEM in merries wordt uitgevoerd op het niveau van hengstenhouders die zijn gecertificeerd door de Productschappen voor Vee, Vlees en Eieren (PVE). Een onderdeel van deze certificatie is dat hengstenhouders verplicht zijn jaarlijks hun hengsten te testen op CEM voor het dekseizoen begint. Het testen op CEM wordt gedaan door een monster te nemen van de genitaliën. De testmethode die gebruikt wordt voor testen op nationaal niveau is de Polymerase Chain Reaction (PCR). De internationale Gouden Standaard test is de bacteriologische cultuur kweek. Wanneer een hengst positief wordt bevonden moet deze behandeld worden en daarnaast is het verboden het sperma van de betreffende hengst te verkopen. Het testen, de behandeling en het gemiste inkomen van de verkoop van sperma zijn de belangrijkste economische consequenties van CEM voor een hengstenhouder. Het doel van deze thesis was een schatting te geven van alle economische consequenties van de huidige preventie maatregelen evenals de maatregelen ter controle van CEM. Hiervoor is de methode van partial budgeting gebruikt en Monte Carlo simulaties met het programma @RISK voor Excel. Vier scenario's zijn geanalyseerd; 1. De extra jaarlijkse kosten voor certificatie en het testen op CEM voor een gecertificeerde hengstenhouder. 2. De economische consequenties van de detectie van CEM in een hengst voor een gecertificeerde hengstenhouder. 3. Drie alternatieve maatregelen: i) het gebruik van de PCR methode in plaats van de bacteriologische cultuur kweek, ii) de toepassing van een nieuwe behandelmethode en iii) het verplaatsen van het testmoment naar eerder in het jaar. 4. De gevolgen die het afschaffen van het testen op nationaal niveau zou hebben in Nederland.

Informatie over getallen in de Nederlandse paardenhouderij was moeilijk te verkrijgen. Daarom zijn voor deze analyses verschillende aannames gedaan. Het eerste resultaat was dat de kosten voor certificering en testen van hengsten slechts een derde van het gemiddelde dekgeld bedragen, wat relatief weinig is. Echter wanneer een hengst positief wordt getest op CEM bedragen de kosten voor de hengstenhouder € 29,307. Dit is 35% van wat een hengst opbrengt tijdens een dekseizoen. Analyse van het derde scenario gaf duidelijk een afname in kosten weer bij het gebruik van de PCR methode en het vervroegen van het testmoment. Hoewel de nieuwe behandelmethode iets duurder is dan degene die nu gebruikt wordt, is de kans op terugkerend positieve hengsten in het volgende dekseizoen wel lager. Dit zorgt dan voor een afname in de kosten. Daarom is hier de conclusie dat het economisch gezien beter is om al deze drie alternatieven aan te nemen. Als het testen op CEM in Nederland zou worden afgeschaft, wat voor gevolgen heeft dit dan op de prevalentie in de totale populatie. Op dit moment wordt de prevalentie in

hengsten op gecertificeerde hengstenhouderijen geschat op 2% evenals de infectie ratio in merries. De resultaten van de analyse van het vierde scenario roepen de vraag op of het testen van hengsten op CEM economisch wel haalbaar is. Wanneer helemaal niet getest wordt is de verwachting dat de prevalentie van CEM niet veel toe zal nemen in de populatie, daarom roepen de kosten die op dit moment gemaakt worden op tot een discussie over de huidige maatregelen tegen CEM in Nederland.

CONTENTS

LIST OF ABBREVIATIONS

BvHH	Dutch Board of Stallion Holders (Bond van Hengsten Houders)
CEM	Contagious Equine Metritis
CVI	Central Veterinary Institute
GD	Animal Health Service (Gezondheidsdienst voor Dieren)
HBLB	Horserace Betting Levy Board
OIE	World Organization for Animal Health
PCR	Polymerase Chain Reaction
PVE	Board for Cattle, Meat and Eggs (Productschappen Vee, Vlees en Eieren)

1. INTRODUCTION

Contagious Equine Metritis (CEM) is a highly contagious genital infection of horses which was first described in 1977 (Eaglesome and Garcia 1979). It is caused by the bacterium *Taylorella Equigenitalis*. Transmission of *T. Equigenitalis* occurs through the venereal route by natural intercourse or artificial insemination. Infected materials such as hands or instruments also pose a risk of spreading the disease further (Timoney 1996; Agriculture 2005). After exposure to *T. Equigenitalis* stallions do not develop clinical signs; they are merely carriers of the bacterium. (Timoney, 1996). Clinical signs in mares can vary from obvious disease symptoms to sub clinical infections. The most important clinical signs are metritis and temporary infertility which usually lasts a few weeks, long-term effects on reproduction have not been reported.

In the Netherlands the prevalence of CEM in the total population is estimated at 1–2% (CVI 2008). CEM is categorized as a notifiable disease (former list B) and is therefore subject of stringent import regulations by all the major horse-breeding countries. In the Netherlands it is not mandatory to report individual cases of the disease to the Dutch animal health authority (CVI 2008; PVE 2008). However, stallion holdings that are certified by the Board of Cattle and Meat (PVE) are obliged to test the semen of their stallions every year for the presence of *T. Equigenitalis* and to take control measure in case the test returns positive. When a stallion is found to be positive for *T. Equigenitalis*, its semen cannot be used for insemination until the stallion is tested negatively again. Treatment of CEM in stallions is relatively easy but requires time and money. Therefore, a loss of income due to the presence of *T. Equigenitalis* mainly occurs when semen cannot be sold for insemination and in addition to this the stallion holder can suffer image damage, resulting in a loss of potential clients.

An overview of the total costs on prevention and control of CEM in the Netherlands does not exist yet. The analysis described in this thesis aims to provide a first insight into these costs. The main focus of the analysis is on the stallion holdings within the breeding segment in the Netherlands. Due to the use of artificial insemination mares are less likely to spread the disease (i.e. infect the stallion). Moreover, because the stallions from stallion holdings certified by the PVE are tested for the presence of *T. Equigenitalis* on a yearly basis, information on the presence of CEM is available for this segment.

1.1 Thesis outline

The objective of this thesis is to get an overview on the disease, transmission and treatment of *T. Equigenitalis* plus the prevention and control of CEM in the Netherlands. This is done by means of literature study and elicitation of expert knowledge. Furthermore a description of the involved organizations is given to understand the complexity of the CEM problem in the Netherlands. With this information the total economic consequences of prevention measures as well as control measures for CEM are estimated at the level of the stallion holding. In addition to this, alternatives are analyzed; I) the development of a different treatment method, II) the use of an alternative swab testing method and III) an advancement of the test moment. All these alternatives can contribute to a change in costs.

2. CONTAGIOUS EQUINE METRITIS

Contagious Equine Metritis (CEM) is a sexually transmissible disease in mares. The causative agent of this bacterial disease is *Taylorella Equigenitalis*, a Gram-negative bacterium (Parlevliet, Bleumink-Pluym et al. 1997). The first report of CEM was in 1977, when an unknown disease was found among the Thoroughbred breeding population in Ireland and the United Kingdom (Platt and Taylor 1982). Since then, various measures have been implemented to eradicate the disease from the horse population. At present, the disease is endemic in Europe, while North America claims to be free from CEM (Matsuda and Moore 2004; Samper and Tibary 2006).

2.1 Symptoms

After exposure to *T. Equigenitalis* only mares develop clinical signs of CEM. Stallions do not develop clinical symptoms of the disease; they are merely carriers of the bacterium (Timoney 1996). Clinical signs in mares can vary from obvious disease symptoms to sub clinical infections. Only the reproductive tract is affected by *T. Equigenitalis*, there is no evidence of systemic illness in infected mares (Timoney 1996).

There are three general degrees of infection in mares (Agriculture 2005; DEFRA 2009):

- Acute: active inflammation of the uterus causes an obvious, thick, milky, muciod vulvar discharge 10 to 14 days after breeding.
- Chronic: milder uterine inflammation causes less obvious vulvar discharge, and infection may be more difficult to eliminate.
- Carrier: the bacteria are established in the reproductive tract, though there are no obvious symptoms. The mare is still infectious and can remain a carrier for several months or longer.

Most mares will fail to conceive following primary infection with *T. Equigenitalis*, however, this infertility is reversible and only lasts a few weeks in most cases (Timoney 1996). No long-term effects on fertility have been reported (Samper, Pycock et al. 2007). When a mare fails to conceive the loss for the mare holder will be that there will be no foal to sell the next year while the stud fee is already paid. When this is the case a certified stallion holder is obliged to return half of that stud fee to the mare holder. Losses therefore occur on both sides.

2.2 Transmission

Transmission of *T. Equigenitalis* occurs through the venereal route, by natural intercourse or artificial insemination. Infected materials such as hands or instruments (e.g. vaginal specula, examination sleeves, insemination equipment) also

pose a risk of spreading the disease further, for the disease is highly contagious (Timoney 1996; Agriculture 2005). Therefore, it is important to follow several hygienic measures to prevent the spread of CEM when breeding with horses. Some hygienic measures have been conducted by the Horserace Betting Levy Board (HBLB) in a Code of Practice for CEM. (HBLB 2008). In Section 2.5 these guidelines will be explained further.

2.3 Treatment

The conventional and international treatment to eliminate *T. Equigenitalis* consists of washing the genitalia of the horse with 2% chlorhexidine. This is applied to both mares and stallions. After this, the genitalia should be packed with an antibiotic ointment, such as 0.2% enrofloxacin (Baytril). The treatment should last for 3 consecutive days. (Timoney 1996; Boersma, Duikeren et al. 2003; Agriculture 2005) Currently a new treatment is being tested in the Netherlands. With this treatment the genitalia are washed only for one day first with shampoo and then with chlorhexidine followed by cefquinome ointment (Cobactan LC). Hereafter Cobactan 4.5% is injected intravenous for 3 consecutive days (Parlevliet 2009).

Attempts have been made to produce a vaccine against CEM but these were unsuccessful as the killed bacteria inoculating vaccine did not prevent an infection by *T. Equigenitalis* after a subsequent uterine challenge (Timoney 1996; Samper, Pycock et al. 2007).

2.4 Prevalence

The United States, Canada and the United Kingdom claimed to have a CEM free status in 2008. Strict measures have been taken here to prevent the introduction of CEM, based on the international regulations of the OIE. Furthermore, rules for the import of semen and horses have been implemented regarding CEM (OIE 2007). The reason for a rather strict policy in the US, Canada and the UK is the Thoroughbred population in these countries. These are horses used for racing and therefore of more value than non-Thoroughbreds. Other than that, Thoroughbreds exhibit more severe symptoms when infected with CEM than warm blood horses (Roest, 2008). In addition to this no artificial insemination is used when breeding Thoroughbreds, which makes the risk of spreading CEM among this type of horses larger. Nevertheless, a case of CEM is sometimes detected within these countries when a horse is imported from an European country (OIE 2008).

In the Netherlands figures on prevalence, which is the total number of cases of the disease in a population at a given time, are not easy to obtain. The Central Veterinary Institute (CVI) estimates the prevalence of CEM in the horse population in

the Netherlands at 1% - 2%, and the Animal Health Service (GD) gives an estimate of 2% - 3% in breeding stallions (CVI 2008; GD 2008).

When a stallion is found positive for the presence of *T. Equigenitalis* it is not clear how many mares will get infected with CEM when they are bred with this stallion or artificially inseminated with the infected semen. According to the United States this infection rate is 40% (Agriculture 2009) while another study shows that there is no significant prevalence of clinical symptoms in mares when bred with semen that is contaminated with *T. Equigenitalis* (Parlevliet, Bleumink-Pluym et al. 1997).

2.5 Preventive measures

2.5.1 Hygiene

The first measure to prevent the introduction or spread of CEM on an enterprise is working with strict hygienic measures. In the United Kingdom a Code of Practice is developed to provide guidelines on hygiene (HBLB 2008). When using a phantom mare to collect semen, it is important to cover it with plastic and change the plastic after the collection of semen between each stallion. Also when collecting semen the employees must wear gloves and change those after handling each stallion (GD 2008; HBLB 2008). When a stallion is infected with *T. equigenitalis* and is treated, the sponge that is used for washing should be thrown away after washing, to prevent further spread on the enterprise (HBLB 2008; Parlevliet 2008).

2.5.2 Screening

Before the breeding season starts, swabs must be taken of all breeding stallions at the stallion holdings that are certified by the PVE. Certification of stallion holdings will be explained further in Chapter 3. The guidelines for taking these swabs are conducted by the Animal Health Service (GD 2008). Testing the swabs for presence of *T. equigenitalis* on stallion holdings with an EU certificate or testing of horses for export occurs at the Central Veterinary Institute, by means of bacteriologic culture (Roest 2008). Testing stallions of stallion holdings with a national certification takes place at the Animal Health Service (GD), using the PCR method (GD 2008). The PCR method is not the Golden Standard as used by the World Organisation for Animal Health (OIE), the bacteriologic culture method is (Parlevliet 2008). Therefore, when a stallion is found to be positive by PCR, a new swab of the stallion has to be tested by means of bacteriologic culture to validate the result of the PCR (GD 2008). Treatment of the stallion against *T. equigenitalis* begins immediately after this new swab is taken. Seven days after treatment a new swab is tested by means of bacteriologic culture. A schematic overview of the testing procedure along with its time frame is given in figure 1. In the past the deadline of delivering the swabs from stallions to the GD was

before March 31st. Starting in 2009 this date has been advanced to March 15th to ensure a minimal loss of income for the stallion holder due to treatment of the stallion when a stallion is found to be positive (GD 2009).

2.5.2 Taylorella Asinigenitalis

On epidemiological level it has been found that besides *T. Equigenitalis* another species of Taylorella exists, namely *Taylorella asinigenitalis* (OIE 2007). The precise effects of this species are so far uncertain, although it is suspected that this species does not give rise to clinical symptoms to the degree that *T. Equigenitalis* does. For this reason testing methods have been developed to separate *T. Equigenitalis* from *T. asinigenitalis* to ensure that an infection with *T. asinigenitalis* is not labeled as a case of CEM.

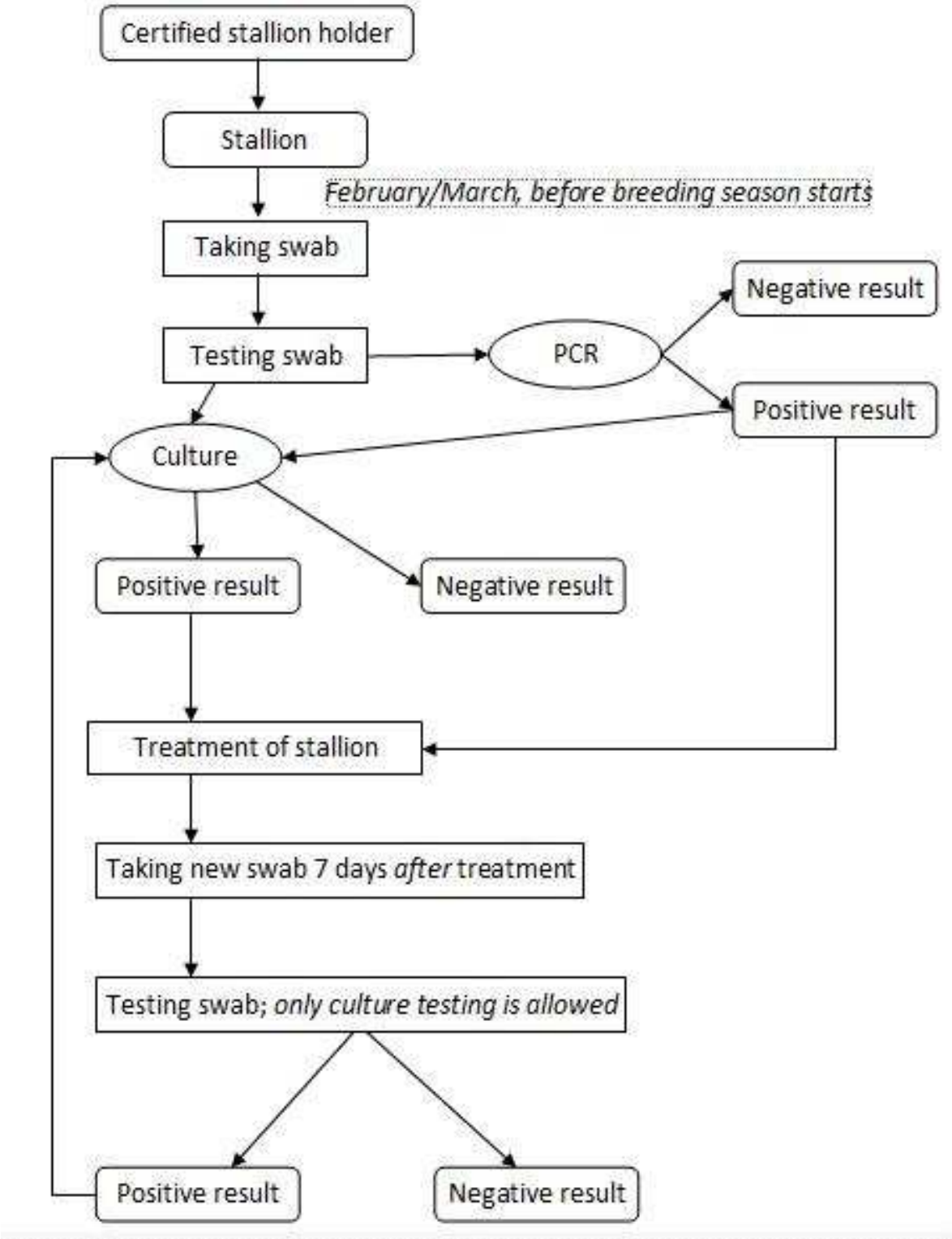

Figure 1: Schematic overview testing scheme for CEM

3. POSITION OF THE CEM ISSUE WITHIN THE DUTCH HORSE SECTOR

3.1 Breeding segment

The Dutch horse sector is very complex, and its breeding segment is no exception to this. Other sectors in the Netherlands have an elaborate Identification and Registration system so that every animal and its location is known. But only a minority of the horses and pony's are officially registered, which makes it difficult to estimate the total number and gather other information. In the Netherlands it is estimated that there are between 400.000 and 600.000 horses and ponies. The *professional* breeding segment is estimated to contain 12.000 horses of this total. Application of prevention and control measures for CEM occurs only at stallion holdings, so within the breeding segment of the horse sector. Within the Netherlands, we can distinguish the following branches in the breeding segment (Rijksen and Visser-Riedstra 2005; Schuring 2005):

- Stallion holdings: when the major part of the turnover is from the use of one or more stallions used for breeding by means of A.I. or mating.
- Mare holders: when the major part of the turnover is from the use of mares for breeding.
- Semen collecting stations: the collection and sale of semen is the most important aspect of this kind of enterprise.
- Embryo transfer centers: when the major part of the turnover is from embryo transfer and offering carrier mares for rent.
- Stud farms: when an enterprise is a combination of a mare holder and a stallion holder it is called a stud farm.

There are only 70 professional mare holders and 125 stallion holders certified by the PVE (Schuring 2005). In total it is estimated that there are between 700 and 800 stallion holdings in the Netherlands, but this number includes recreational stallion holdings as well (PVE 2008; Schuring 2005). It appears that the certified stallion holdings are only a small proportion of the total number, yet these stallion holdings have the most influence on the breeding of good Dutch sport horses.

3.2 General tasks of the organizations involved

For a certified stallion holder the most important organizations involved are the Animal Health Center, or *"Gezondheidsdienst voor Dieren"* (GD), the Central Veterinary Institute (CVI) and the Board for Cattle, Meat and Eggs or *"Productschappen Vee, Vlees en Eieren"* (PVE). In figure 2 a schematic overview of these organizations and their role in the CEM testing process is given. The GD is a

market-oriented organization primarily focused on the improvement of animal health and safety of animal products. (GD 2009, website). The Central Veterinary Institute contributes to the health protection of animals and humans in the Netherlands by undertaking research on and recommending about animal diseases (CVI 2009, website). The PVE is the organization that is responsible for the policy making regarding different agricultural sectors in the Netherlands, including the horse sector. Certification of stallion holdings is done by the PVE as described in 3.4.

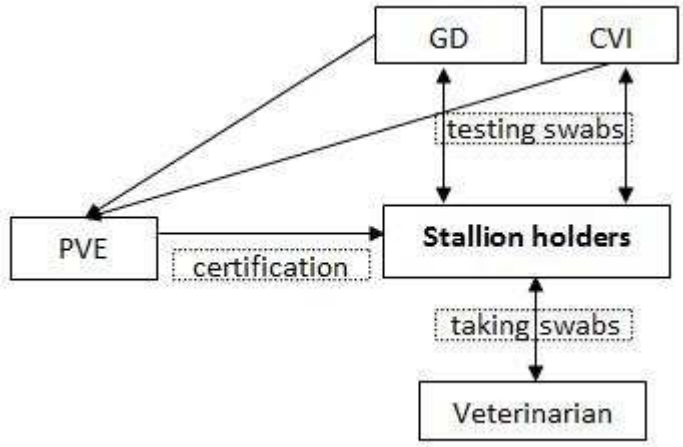

Figure 2: Schematic overview of the most important organizations regarding CEM in the Netherlands

3.3 Role of organizations regarding swab testing

As can be seen in figure 2, swab testing can be done at either the GD or the CVI. The testing of samples of stallions from certified stallion holdings, only for the Dutch breeding market, occurs at the GD by means of PCR. The CVI is the organization that is accredited by the OIE as one of the reference laboratories that can test swabs for export. Therefore the swabs of both mares and stallions that will be exported are tested there by bacteriologic culture, as well as swabs from stallions of EU certified stallion holdings (Roest 2008). The results of these tests are reported back to the stallion holder and to the PVE.

3.4 Certification of stallion holdings

Legislation on the national level regarding CEM appears to be based on the legislation of the OIE. This is not the case in the Netherlands, for CEM is a former B-list disease and therefore the Netherlands can implement different regulations (PVE 2008). Chapter 12.2 of the OIE Terrestial Animal Health Code shows that it is mandatory to report a case of CEM is when this occurs in a CEM-free country due to international trade. The Netherlands is a country where CEM is already present therefore it is not an issue if CEM is introduced and a case of CEM does not have to be reported. However, to prevent the spread of CEM some measures have been

implemented of which the certification of stallion holdings and therefore testing stallions on the presence of *T. Equigenitalis* is the most important one. Testing of stallions is done to prevent the spread of CEM in *mares*.

3.4.1 Certification at national level

For stallion holdings the PVE has developed a certificate which indicates that the stallion holding complies with certain regulations set by the PVE. The certification of stallion holdings is voluntary. A stallion holding has to meet several requirements before the certificate can be obtained, the most important ones are:

- Sufficient education and working experience of the stallion holder and the staff;
- No other animals on the enterprise;
- Requirements regarding housing of the horses;
- Requirements regarding the collection, storage and distribution of semen;
- The presence of wet and dry laboratories to test the semen etc.;
- Decent administration;
- Good quality of the semen;
- A veterinarian that is bounded to the stallion holding;
- Testing of swabs for the presence of *T. Equigenitalis*.

Testing of the swabs is done every year before the breeding season starts. Stallion holders can choose whether to test the swab at the CVI (by culture) or the GD (by PCR). In the regulations of the PVE it is stated that a positive CEM test will result in a destruction of the semen of the concerned stallion until a subsequent swab is tested negative for the presence of *T. Equigenitalis*. This is the most important loss of income for the stallion holder, because income is generated from the sales of semen.

3.4.2 Export

Regulations for CEM regarding export are very strict. Every horse that is exported to either an EU country or outside the EU is tested for the presence of *T. Equigenitalis*. This happens at the CVI. Also stallion holdings that want to obtain the EU certificate need to let their stallions be tested every year for the presence of by the CVI. Currently there are 24 stallion holdings certified by the EU. This might seem like a small fragment but these enterprises are larger than average and therefore they contribute a significant part to horse breeding in the Netherlands. Even though this is the case, the exporting part of the sector will not be considered further in this analysis.

4. SUMMARY OF ECONOMIC CONSEQUENCES

The economic consequences of CEM control for certified stallion holders can be categorized as follows:

Structural costs:

- Costs to be paid to the PVE to be certified
- Costs for preventive tests by either PCR or bacteriologic culture

In case of a positive test result:

- Costs of treatment
- Costs of another swab test after treatment
- Loss of income
- Image damage

In case of a negative test result but a positive stallion (SE <100%) or a positive stallion at a non certified stallion holding:

- A compensation payment for mare holders. According to the regulations of the Dutch Board of Stallion Holders or "*Bond van Hengstenhouders"* (BvHH) a stallion holder is obliged to return half of the stud fee when a mare is found not to be pregnant at the end of the breeding season, which is at the beginning of September. Since a risk of CEM is temporary infertility in mares, these might be significant costs.
- Loss of image

5. MATERIAL AND METHODS

5.1 Background information

The first step in estimating the economic consequences of prevention and control of CEM in the Netherlands was to get a clear overview of the disease and its transmission. This was done by literature research. From the literature it became clear that there are two different ways of swab testing for the presence of *T. Equigenitalis*, namely PCR testing and bacteriologic culture. To fully comprehend the epidemiological and bacterial aspects of both procedures of testing there has been personal communication with experts from both the GD as well as the CVI.

Several organizations are involved in the registration and prevention of CEM, as described in Chapter 3. The process of certification of the stallion holdings was clarified through the regulations of the PVE, which are available on the internet. Also, the contact person from the PVE on certification was approached fur further questions. Practical issues regarding hygiene measures at the stallion holding were not often mentioned in literature or other reports. A visit to a stallion holding gave more insight on this topic. Also the image damage that a stallion holder can suffer when CEM is introduced on the holding became more evident after this visit. Information on figures of the Dutch horse breeding sector was barely available. A report from the Animal Sciences Group provided some figures that were useful; this report was written in 2005. According to the 'Sectorraad Paarden' other information sources are not available at the moment. Therefore most of the figures on the breeding sector used in this analysis originate from the above referred report.
From all this the main findings are described in Chapters 2 and 3.

5.2 Method

To estimate the economic consequences of prevention and control of CEM the economic method of partial budgeting will be used. Partial budgeting is a planning and decision making tool used by farm managers to compare the costs and benefits that will be the result of a particular change. If the proposed analysis concerns a simple economic comparison of disease control measures on a farm, and the outcome does not involve a specific time pattern nor a high degree of uncertainty, then partial budget is the method of choice (Huirne and Dijkhuizen 1997). All aspects of farm profit that are not altered by the proposed change can be ignored. Different from a total budget, which includes all revenues and expenses for the entire farm, the partial budget evaluates whether or not the proposed change would be more profitable than the current situation. The analysis of the economic consequences of CEM fits the description of partial budgeting and is therefore a logical method to use.

When calculating a partial budget the following four categories of revenues and costs must be considered (Huirne and Dijkhuizen 1997):

- (1) Additional returns – a list of items of returns from the alternate plan that will not be received from the base plan
- (2) Reduced costs – a list of items of returns from the base plan that will be avoided with the alternate plan
- (3) Reduced returns – a list of items of returns from the base plan that will not be received from the alternate plan
- (4) Additional costs – a list of items of costs of the alternate plan that are not required with the base plan

Once these aspects have been determined it is possible to calculate a net effect. This is done by comparing the sum of (1) the additional returns and (2) the reduced costs with the sum of (3) the reduced returns and (4) the additional costs. When the sum of (1) and (2) is larger than the sum of (3) and (4) the proposed change will be economically beneficial and it should be adopted.

Four scenarios will be analyzed as is described in paragraph 5.4. For each scenario it is necessary to know the four categories of economic consequences related to partial budgeting. At first the whole segment of preventive and control measures will be analyzed. After this the focus will be on the damage that the detection of CEM at a stallion holding can cause. Several alternative measures will be considered and at last the situation where there is no testing for CEM in the Netherlands at all.

All these scenarios will be analyzed using a Monte Carlo simulation in the stochastic program module @Risk 5.0 for Excel to show possible outcomes in a Microsoft Excel spreadsheet. Of this simulation ten thousand iterations will be done to improve the accuracy of the analysis. Also, a sensitivity analysis of the influence of the different variables (as described in Section 5.3.1) will be done.

5.3 Input

5.3.1 Definition average stallion holding

Stallion holdings in the Netherlands differ significantly from each other e.g. in size, numbers of services, price per service. To estimate the economic consequences, it is necessary to have an overview of the characteristics of the ‘average’ stallion holding in the Netherlands. The certification costs by the PVE and the estimated average figures of a Dutch stallion holding are presented in table 1 and 2.

Table 1: Certification costs [1]

	Costs
Certification of stallion holding by the PVE	
- Natural insemination	
Basic costs	€ 100
Per stallion	€ 100
- Artificial insemination	
Basic costs	€ 255
Per stallion	€ 102
- Artificial insemination, EU accredited	
Basic costs	€ 205
Per stallion	€ 51

[1] PVE 2007

Table 2: Average stallion holding in the Netherlands

	Most likely value	**Minimum**	**Maximum**	**Average value**
Number of stallions [2]	3	1	11	4
Stud fee [2]	€ 776	€ 350	€ 1200	€ 776
Number of inseminations per stallion per year [2]	82	15	300	107
Breeding season [3]	March 1st – August 15th (168 days)			
Income from inseminations per stallion per day	€ 379	€ 32	€ 2,143	€ 494

[2] Schuring 2005

[3] Bond van Hengstenhouders 2008

From table 2 it becomes clear that a stallion holding has 4 stallions on average, with a most likely of 3 stallion and a minimum of one stallion per stallion holding and a maximum of 11. Each stallion provides semen to perform 82 inseminations per year. Here the minimum is 15, while the maximum is 300. It was decided to base the analysis on an average stallion holding with artificial insemination, because natural insemination is not often used in the Netherlands anymore (Schuring 2005). Costs for certification of the stallion holding are on a yearly basis, it is the fee that has to be paid when a stallion holder desires to be certified by the PVE. An average of these costs will be used in the analysis, as illustrated in table 2. Here the costs of certification are contributed only to CEM, for certification is the most important measure taken against CEM in the Netherlands. In section 3.4.1 the most important measures regarding certification are described.

The income from inseminations per day is calculated as follows:
82 inseminations per breeding season x average stud fees of € 776 = € 63.632 (per stallion per breeding season).

Per day this means € 63.632 / 168 days = € 379. This means that every day that the semen of a stallion of which the swab has a positive result on the test for CEM cannot be sold, will cost the stallion holder € 379.

The minimum is calculated on the basis of the minimum stud fee of € 350 and the minimal number of inseminations per stallion per year, which is 15. The maximum missed income is calculated in the same way. The assumption is made that the demand for semen in the Netherlands is evenly distributed over the whole breeding season.

Due to the differences between stallion holdings the analyses account for the variation in the variables;

I) number of stallions (Poisson distribution)

II) stud fees (Pert distribution)

III) inseminations per stallion per breeding day (Pert distribution).

The assumption is made that these variables are not correlated with each other, for no evidence is found that they do (personal communication; BvHH, 2009).

5.3.2 Preventive measures

In Section 2.6 an overview figure of the whole testing scheme of CEM is given. From this figure it becomes clear that several preventive measures result in financial consequences. The costs that are related to these measures in the Netherlands are given in table 3, as well as the number of days until the results of the swab tests are known.

Table 3: Costs related to prevention measures

Measure	**Costs**
Costs for accreditation per year by the PVE [1]	
- Basic costs	€ 230
- Per stallion	€ 77
Taking of swab by veterinarian [2]	
- Visiting fee	€ 20
- Transport of swab to GD	€ 10
Total	**€ 30**
Swab testing [3]	
- PCR method	€ 43
- Culture	€ 58
- Basic costs[4]	€ 9
Days until test results are known	
- Culture	7
- PCR	2

[1] PVE 2007

[2] Dr. Joyce Parlevliet, UU, 2009

[3] GD 2008

[4] Costs of CEM swab pack from the GD in 2009

The costs for accreditation per year by the PVE are the average costs for accreditation on non EU level and for accreditation on EU level. This means for the basic costs an average of € 255 and € 205, which is € 230. Per stallion the costs are € 77, the average of € 102 and € 51 (see table 1). The total costs of taking the swab by a veterinarian are based on the sum of the fee for swab taking (€ 20) and the costs to transport the swab to the GD (€ 10). The costs for swab testing are the fees that the GD charges a stallion holder per swab. Days until the results are known are the number of days it takes to test the swabs with the different methods. When the result of the swab testing is positive the stallion has to be treated and after 7 days another swab has to be taken to determine whether the treatment has been effective. Costs of treatment of CEM are given in table 4.

Table 4: Treatment costs [1]

Treatment method	**Costs**
Conventional method	
- Domosedan® to sedate the stallion	€ 20
- Costs of washing stallion by veterinarian for 3 days	€ 105
- Costs of washing substance Hibiscrub®	€ 13
- Antibiotic ointment Baytril®	€ 19
Total	**€ 157**
New method	
- Domosedan® to sedate the stallion	€ 20
- Costs of washing stallion by veterinarian once	€ 35
- Three injections with Cobactan	€ 137
Total	**€ 192**

[1] Dr. Joyce Parlevliet, UU, 2009

The two treatments are described in Section 2.3. Treatment costs are based on prices that have been provided by a veterinarian (Parlevliet 2008). The conventional method is the one as given in the literature of Timoney (1996) while the new method is the one that is being tested now in the Netherlands.

5.4 Scenarios

Four scenarios will be analyzed to estimate the costs for prevention of CEM as well as the financial consequences for a stallion holder when CEM is present.

1. The additional yearly costs of certification and testing for CEM for a certified stallion holding. The base scenario will be a stallion holding without certification.
2. The economic consequences of an detection of CEM at a certified stallion holding, compared to a certified stallion holding where no CEM is present.
3. There are alternative measures for the prevention and control of CEM. Among these there are the following alternatives:
   I) the use of PCR instead of bacteriologic culture as a swab test
   II) the use of a different treatment method
   III) an advancement in the test moment.
   All these three alternatives will be analyzed using the second scenario of a detection of CEM at a certified stallion holding as the base scenario.
4. No testing for CEM in the Netherlands at the national level, only testing of horses and semen that is destined for export.

In all the analyses only the direct costs are considered, no indirect costs such as image loss.

5.4.1 Prevention of CEM

The analysis will be done for certified stallion holdings in the Netherlands. Prevention costs here include the costs for certification and the costs for testing swabs. First, the costs of prevention and control measures for an average stallion holding and the range in these costs are analyzed. The situation where there is no prevention or control of CEM and there is no CEM present at the enterprise will be the base situation. An enterprise with prevention and control measures as described in Section 2.5 and where also no CEM is present will be the alternate situation. This makes it possible to analyze the economic consequences of only the preventive and control measures for CEM. The table below shows the costs and returns of certification and testing for CEM for a certified stallion holding.

Table 5: Preventive measures

Additional returns	**Reduced returns**
Reduced costs	**Additional costs**
	- Certification costs - Taking swab by veterinarian - Swab testing by bacteriologic culture

5.4.2 Detection of CEM

The next step is to estimate the economic consequences of a detection of CEM. Within this partial comparison, the base scenario is reflected by an enterprise with preventive and control measures and without CEM. The alternate scenario is an enterprise with the same measures, but despite of them, with a positive test for the presence of CEM. Table 6 shows the different costs and returns that occur with a detection of CEM at a certified stallion holding.

Table 6: A detection of CEM

Additional returns	**Reduced returns**
	- Insemination income
Reduced costs	**Additional costs**
	- Taking of swab by veterinarian - Treatment - Swab testing by bacteriologic culture

The base scenario also considers a certified stallion holding; therefore the taking of the swab by a veterinarian is included here again, for it occurs twice. Because when a stallion is tested positive another swab has to be taken after treatment and tested by means of bacteriologic culture to ensure that the stallion is free of *T. Equigenitalis*. The assumption for this scenario is that after treatment the stallion will be free of *T. Equigenitalis*.

5.4.3 Alternatives

Given the current practice, there is an interest in alternative prevention or control measures that can lead to a change in costs for the stallion holder. Among these, three alternatives are evaluated to estimate their relevance with respect to these costs. The first alternative is the use of the PCR method for the testing of the swabs instead of the bacteriological culture. The second alternative focuses on the use of an alternative treatment method, while the last alternative analyzes the influence of the test moment.

PCR method

The first alternative measure is the use of PCR as the official swab test instead of bacteriologic culture testing. Within this partial comparison, the base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the PCR method is used for testing the swabs. With the PCR method the testing of the swab only takes 2 days, while with culture this is 7 days.

This means that the stallion holder has fewer days of missed income when waiting for the results of the test. In addition to this the PCR test is cheaper than the bacteriologic culture. Table 7 shows the different costs and returns that occur with a detection of CEM at a certified stallion holding.

Table 7: PCR testing instead of bacteriologic culture testing

Additional returns	**Reduced returns**
- Less loss of income due to 2 days testing instead of 7	
Reduced costs	**Additional costs**
- Testing costs	

Treatment

Another alternative measure to possibly reduce costs of CEM is the development of a different treatment method. As mentioned before this method is being used on a trial basis in the Netherlands by Dr. J. Parlevliet (Utrecht University). Within this partial comparison, the base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the new treatment method is used for the infected stallion. In table 8 is described what the difference will be. With this treatment it should be possible to minimize the number of stallions that come back positive the next breeding season. This is not possible to include in the analysis, because the results are not conclusive enough. Therefore only the extra costs of the treatment will be considered.

Table 8: Costs of applying the new treatment

Additional returns	**Reduced returns**
Reduced costs	**Additional costs**
	- More expensive treatment

Test moment

Within this partial comparison, the base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the advanced test moment is applied. The deadline for the testing of swabs used to be at March 31st just before the start of the breeding season. From past experiences, it became clear that stallion holders are quite late with submitting the swabs for testing. This can cause a loss of income, for the semen of a stallion cannot be sold when this

stallion is tested positive for CEM. When the deadline is advanced there will be less days between the start of the breeding season and the results of the testing. Thus, there is a minimal loss of income for the stallion holder due to treatment when a stallion is found to be positive. Starting in 2009 the deadline has been advanced to March 15th.

Table 9: Costs of advancing the test moment

Additional returns	**Reduced returns**
- Less loss of income	
Reduced costs	**Additional costs**

5.5 No testing

5.5.1 Restitution of stud fees

When at the end of the breeding season a mare is not pregnant, this is called gust, the stallion holder is obliged by the regulations of the Dutch Board of Stallion Holders to return half of the stud fee to the mare owner. A stallion with CEM that is not tested is likely to infect the mares that will be inseminated with its semen. Since the most important consequence of CEM in mares is temporary infertility, there is a large risk of these mares being gust at the end of the breeding season. The prevalence's of CEM that are found are 2% (CVI 2008; GD 2008) and infertility due to vaginal discharge at 40% according to the United States Department of Agriculture (Agriculture 2009). These percentages will be used to calculate the minimal and maximal losses for a stallion holder when a positive stallion is not tested and thus not marked as a positive stallion and still used for breeding. The number of mares infected is calculated based on the assumption that 107 inseminations per stallion per breeding season means 107 mares will be inseminated. The number of mares infected is the percentage, 2% or 40%, given of this insemination number. This is a rounded up number, for it is not possible to have half a mare infected. The number of mares infected times half the stud fee gives the final costs.

5.5.1 Break even prevalence

Another consequence of no testing is that the prevalence of CEM in the population is expected to increase. There are costs for the whole sector either way. With testing there are testing and treatment costs and missed income for the stallion holders. Without testing the prevalence of CEM will increase and there is the missed income at the mare holders' side from not selling a foal and at the stallion holder side for restitution of half the stud fee. It is possible to calculate where the break even point of testing vs. no testing exists. For this analysis we assume that when stallions are

tested there will be a healthy foal born the next year. All the numbers necessary for this analysis:

Average number of stallions [2]	4
Number of stallion holdings	125
Total number of stallions	500
Stud fee [2]	€ 776
Restitution fee	€ 388
Number of inseminations	107
Prevention costs stallion holder	€ 926
Foal price [2, 3]	€ 3000
Difference in foal revenues	€ 3000

[2] Schuring 2005

[3] R. Vullers, Diergaerdehof, 2009

Where:

- Total number of stallions = 4 * 125 = 500
- Restitution fee = ½ * € 776 = € 388
- Prevention costs stallion holder: from the results in Section 6.1.
- Difference in foal restitution:

Without CEM	Stallion holdings	= + € 776
	Mare holdings	= - € 776 + € 3000
	Sector	= + € 776 - € 776 + € 3000
		= € 3000
With CEM	Stallion holdings	= + € 776 - € 388
		= € 388
	Mare holdings	= - € 776 + € 388 + € 0
		= - € 388
	Sector	= € 388 - € 388
		= € 0
Difference in foal revenues		= € 3000 - € 0
		= € 3000

Break even prevalence

- Prevention costs sector = 125 * prevention costs stallion holder * 1/3. We assume for this analysis that 1/3 of all prevention costs – of which the major part is certification costs – can be attributed to the prevention of CEM.

- Control costs sector = prevention costs sector * total number of stallions * prevalence in stallions

With testing:

- Restitution costs = infection rate * prevalence in stallions * total number of stallions * number of inseminations * restitution fee
- Foal damage = number of inseminations * prevalence in stallions * total number of stallions * difference in foal revenues
- Damage sector level = prevention costs sector + control costs sector + foal damage
- Fixed factor infection rate = total number of stallions * number of inseminations * infection rate
- Fraction infected mares = damage sector level / fixed factor infection rate
- Break even prevalence = fraction mares / foal damage

By calculating the break even prevalence it can be shown how high the prevalence in the population can get before it is economically better to test.

Without testing:

- Restitution costs = infection rate * total number of stallions * break even prevalence * restitution fee * number of inseminations
- Foal damage = infection rate * break even prevalence * total number of stallions * number of inseminations * difference in foal revenues

A table will be created, with the use of Excel, showing the different break even prevalence's for the prevalence in stallions ranging of 1, 2, 5 and 10% and infection rates in mares of 1, 2, 5, 10, 20, 30 and 40%.

6. RESULTS

6.1 Prevention of CEM

The costs for prevention of CEM in mares by testing stallions between a non certified stallion holding and a stallion holding that is certified by the PVE are compared. This gives the following results for the certified stallion holding:

Table 10: Certification costs at an average stallion holding

	Minimum	Mean	Maximum
Total costs of certification and testing	€ 404	€ 926	€ 2,144

These figures are calculated from the total of certification costs and the total costs of testing the stallions for the presence of CEM. The minimal costs are based on the costs that a stallion holder with 1 stallion has the mean on the average value of four stallions and the maximal costs are based on a stallion holder with 11 stallions.

6.2 Detection of CEM

When estimating the economic consequences of a detection of CEM the base scenario is an enterprise with preventive and control measures and without CEM. The alternate scenario is an enterprise with the same measures, but despite of them, with a positive test for the presence of CEM.

6.2.2 Results

When using the program @Risk for Excel to calculate the total costs of a case of CEM while taking into account the variation in all three variables the mean total costs are € 29,307, as can be seen in table 11. These are the costs when *T. Equigenitalis* is found in only one stallion at an average stallion holding. In the table below the results are presented. The different costs – certification, income from inseminations and missed income – are merely to illustrate how the total costs of prevention and control measures with one case of CEM are build up. With the use of @Risk all three input variables are varied simultaneously. Unlike the results with Excel that were for each variable separately, these are the results of all the variation that is possible in the process of a case of CEM at a stallion holding.

Table 11: Range in total costs with variation in all three variables using @Risk for Excel

	Minimum	Mean	Maximum
Total certification costs (without testing costs)	€ 307	€ 545	€ 1,077
Income from inseminations per stallion per breeding season day	€ 47	€ 494	€ 1,819
Missed income from inseminations (testing by bacteriologic culture)	€ 2,674	€ 28,112	€ 103,675
Total costs of prevention measures and CEM	€ 4,051	**€ 29,307**	€ 104,854

6.2.3 Sensitivity analysis

There are three input variables that can be varied;

I) number of stallions

II) stud fees

III) inseminations per stallion per breeding day.

One by one, the minimal and maximal values for these variables are used in the calculation of the total costs in case of CEM. The other two variables are kept on the *average* value. The three tables below show the ranges in total costs for the variations in these three variables.

Table 12: Range in total costs with variation in number of stallions

	Minimum	Mean	Maximum
Total costs of a case of CEM	€ 28,830	€ 29,352	€ 30,570

Table 13: Range in total costs with variation in stud fees of the stallions

	Minimum	Mean	Maximum
Total costs of a case of CEM	€ 12,706	€ 28,172	€ 43,564

Table 14: Range in total costs with variation in inseminations per stallion per breeding season

	Minimum	Mean	Maximum
Total costs of a case of CEM	€ 3,949	€ 28,172	€ 78,986

6.3 Alternatives

The total costs of a case of CEM in one stallion at an average stallion holding with the use of one of the alternative methods are calculated. With the use of @Risk all three input variables are varied simultaneously.

6.3.1 PCR method

The base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the PCR method is used for testing the swabs. When using the PCR method for testing instead of bacteriologic culture it takes 5 days less to obtain the results. Together with a difference in costs between PCR testing and bacteriologic culture, the results are the following:

Table 15: Decrease in total costs when using PCR

	Minimum	Mean	Maximum
Total decrease in costs	€ 78	€ 3,737	€ 20,528

6.3.2 Treatment

For this alternative the base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the new treatment method is used for the infected stallion. The new treatment method takes as many days as the conventional one; therefore the only difference in costs is an increase in treatment costs, from € 157 to € 192. This gives a total increase in costs of € 35 per infected stallion.

6.3.3 Test moment

Within this partial comparison, the base scenario is reflected by an enterprise with preventive and control measures and with a positive test for the presence of CEM. The alternate scenario is an enterprise in the same situation, only here the earlier test moment of March 15th is applied instead of March 31st. This gave the following results:

Table 16: Decrease in total costs when advancing the test moment

	Minimum	Mean	Maximum
Total decrease in costs	€ 1,114	€ 7,779	€ 33,312

6.4 No testing

6.4.1 Return of stud fees

The minimal and maximal losses for a stallion holding when a positive stallion is not tested and thus not marked as a positive stallion are calculated, of which the results are shown in table 17.

Table 17: No testing; return of stud fees

Percentage	Number of inseminations	Stud fee	Number of mares infected	Costs
2%	15	€ 350	0	€ 0
	107	€ 776	2	€ 776
	300	€ 1200	6	€ 3,600
40%	15	€ 350	6	€ 1,050
	107	€ 776	43	€ 16,684
	300	€ 1200	120	€ 72,000

Calculations of the costs are based on the return of half the stud fee at the end of the breeding season. This means when 2 mares are infected it is twice the half of the stud fee that has to be returned, which is 2 x € 388 = € 776.

6.4.1 Break even prevalence

In table 18 the break even prevalence for different infection rates in mares and prevalence in stallions is shown. What this means is that without testing, the prevalence can increase to the number in the table before it becomes economically better to test again. For example, at present a prevalence of 2% is estimated in stallions. The infection rate in mares in unknown, but evidence is found for 2% as well as 40%. With an infection rate of 2%, the prevalence in stallions can increase to 12%. Should it be expected to increase above this 12% then it is economically better to test for CEM, because those costs of testing will be lower then. If the infection rate is 40%, the prevalence can only increase to 2,5%. This shows that the infection rate in mares has a larger effect on the break even prevalence than the prevalence in stallions.

Table 18: Break even prevalence's

	Possible infection rates						
Prevalence in	1%	2%	5%	10%	20%	30%	40%
stallions 1%	0,12	0,07	0,030	0,020	0,020	0,014	0,013
2%	0,22	0,12	0,060	0,040	0,030	0,027	0,025
5%	0,53	0,29	0,150	0,100	0,070	0,066	0,060
10%	>1	0,57	0,290	0,190	0,150	0,131	0,123

7. DISCUSSION

The objective of this thesis was to give an overview of the prevention and control measures on CEM in the Netherlands. With this information, estimations were made for the total economic consequences of prevention measures as well as control measures for CEM at the level of a stallion holding. In addition to this, three alternatives were evaluated; I) the development of a different treatment method, II) the use of Polymerase Chain Reaction (PCR) as a swab test, and III) an advancement of the test moment.

7.1 Results

The results that are obtained give only a first impression of the costs associated with the prevention and control measures for CEM. Further analyses are necessary to get full insight in these financial consequences. For this analysis several assumptions were made since information was absent on certain figures in the Dutch horse breeding sector. One of these assumptions is that the breeding season in the Netherlands has an even distribution when considering demand for semen of stallions. Presumably the demand will be higher in the first two months of the breeding season (BvHH, 2009; Parlevliet, 2009), which would make the losses for a stallion holding even larger. However, in every other aspect of this analysis the averages of variables are used; therefore it seems reasonable that this is done here as well. Another assumption that is made concerns the three variables – number of stallions, stud fees, and inseminations – that can be varied. This assumption is that these different variables are not correlated with each other. This assumption was first made without any evidence, however later it became clear from personal communications that this assumption holds (BvHH, 2009). Furthermore it is assumed that the costs for certification are only due to CEM, which is not the case in practice as can be seen in Section 3.4.1. Certification is meant for several reasons; for the benefit of the economic analysis this assumption is made. In addition to this it appears as though there are only costs made for certification and no returns, this is not the case because with certification comes improvement of image and therefore an increase in returns for the stallion holder.

7.1.1 Prevention costs

The mean costs for certification and testing swabs for CEM are € 926 per stallion holding when based on an average number of 4 stallions per holding. Costs per stallion are therefore equal to € 232 reflecting that they are relatively low compared to the returns of one stud service of € 776. Missing in the analysis are the additional returns for stallion holdings when they are certified. It is expected that certification

of a stallion holder will exude more trust and an improved image to the mare owners, therefore the demand could be higher when a stallion holder is certified and this would generate extra income.

7.1.2 Detection of CEM

With the program @Risk all three variables were varied simultaneously and the total range in costs is demonstrated. Taking into account all three variation sources, the mean total costs for a stallion holding are € 29,307. Total income of one stallion per breeding season could be 107 * € 776 = € 83,032. This means a loss of income for that breeding season of 35%. A sensitivity analysis was done to calculate the influence that each variable had on the total costs. This shows that the number of stallions does not have much influence on the total costs for a stallion holding when there is a case of CEM. The reason for this is that the assumption is made that only one stallion on the enterprise is infected with CEM and therefore the missed income from selling semen only occurs for one stallion. The variation in stud fees has more effect, for this has a direct influence on missed income from selling semen. This missed income is the largest component of the damage suffered by a stallion holding. Effects are largest when varying the number of inseminations per stallion per breeding season, for this variable also has a large influence on missed income per day from selling semen. To put this amount of € 29,307 in a perspective, it is necessary to consider the total costs for all certified stallion holders. With a prevalence of 2% (CVI, 2008) in the population of stallions at the 125 certified stallion holdings this means that 125 * 4 * 2%) = 10 stallions will be tested positive for CEM each breeding season. The total loss for the affected stallion holders combined will be 10 * € 29,307 = € 293,070. Added to this are the costs for prevention and control, in total 125 * € 926 = € 115,750 which makes the total loss for the stallion holders € 408,820. Therefore, the benefit of the prevention and control of CEM, which occurs at the mare holders, should add up to or exceed this number. Foal prices currently are € 3,000 on average (Schuring, 2005; pers. comm. Diergaerdehof, 2009) but without information on the infection rate it is only possible to calculate this further as done in Section 6.4.1.

Missing in the analysis is the damage that a stallion holding can suffer if there has to be a restitution of the stud fee as mentioned in Section 2.4. These costs are calculated when there would be no testing for CEM, but the infection rate in mares is not known. This ranges from 2% to 40% and would make the analyses done therefore more unstable. When further analyses would be done and the infection rate is known these restitutions should be considered as well to obtain the right figures.

7.1.3 Alternatives

PCR method

The use of the PCR method causes a decrease in total costs. Testing swabs with the PCR method takes 5 days less than with bacteriologic culture. Therefore there is an effect on missed income from selling semen, fewer days waiting on the results means less loss of income. This result could be a reason to adapt the PCR test as the new Golden Standard in the Netherlands. In addition to this, it is found that the sensitivity and specificity of the PCR test are similar as the culture test (CVI presentation, 2008).

Treatment

Even though the new treatment method is more expensive than the conventional one, the re-occurrence of positive stallions in the next breeding season is believed to be less when using this method (Parlevliet, 2009). When more information is known on the effectiveness of this treatment a verdict can be given on whether the higher costs are worth using this new method. Since the treatment only costs € 35 more, the chance for recurring positives only has to decline a little to make it economically beneficial to use this new treatment.

Test moment

The main effect on the total costs when CEM is detected at a stallion holding originates from advancing the test moment. The decrease of costs is largest for this alternative because the number of days that semen of the infected stallion cannot be sold is least. Stallion holders are relatively late when it comes to submitting the swabs for testing. The breeding season starts at the beginning of March, while stallion holders generally submit the swabs at the end of March. When a stallion is found be positive, it has to be treated against CEM and seven days after this treatment another swab has to be taken to confirm that the stallion is indeed negative. During this time, it is not possible to use semen of that particular stallion for insemination (PVE 2005). According to the economic analysis the loss of income due to the fact that it is not possible to use the stallion for insemination is the largest economic consequence. The question arises why stallion holders submit their swabs so late in the breeding season. Possible reasons for this can be that the stallion holder works with a different breeding season that starts later because the demand for semen for insemination of mares starts later in the year. Therefore it does not matter for the stallion holder whether or not the stallion can be used early in the breeding season and the results of the analysis will be an overestimation of the total costs. When the demand for semen is distributed normally over the whole breeding season however, results of the analysis show that submitting the swabs earlier than

the start of the breeding season is beneficial for a stallion holder. Another explanation could be that it is simply not possible to take the swabs earlier in the year. Stallions get moved all the time for inspections and competitions. Only when the breeding season starts they stay at the premises of the stallion holding and a swab can be taken for testing.

7.1.4 No testing

Restitution of stud fees

From table 17 can be seen that the infection rate in mares is the most important factor when it comes to restitution of stud fees without testing. The difference in number of inseminations from 15 to 300 causes an increase of the restitution amount with € 3,600 if the infection rate is 2%. However an infection rate of 40% increases this with € 70,950. Because this is a basic calculation assuming that the return of stud fees is the only consequence when there is no testing, not much can be said from it except that the infection rate in mares is a very important factor.

Break even prevalence

From table 18 the situation in the Netherlands can be deducted because the current prevalence in stallions from certified stallion holdings is estimated at 2% (CVI, 2009). According to Dr. J. Parlevliet the infection rate in mares is also 2%. In the table this gives a prevalence of 12%. Currently there is only testing of stallions on certified stallion holdings and probably not in the rest of the population. Even though the major part of the stallions is not tested, the prevalence of CEM in the total Dutch horse population is estimated at only 1-2% (CVI, 2009). This means that the increase to 12% will probably not occur if testing for CEM at certified stallion holdings would be abolished. The question arises whether testing is then economically better than no testing. However, without solid numbers on the prevalence and infection rate in mares no firm conclusion can be drawn from this.

7.2 Limitations of the analysis due to lack of information

This analysis focused on the PVE-certified average stallion holdings. The question arises whether the most likely values and averages of stallion holdings that were used for the analysis give a realistic idea of the Dutch horse population. When considering all 800 stallion holdings in the Netherlands results might change considerably. As mentioned before prevention measures are mainly taken in this segment of the breeding sector. Moreover information on the prevalence of CEM can only obtained from the testing of certified stallions. Information within the non-certified segment is lacking. Therefore the prevalence of CEM in relation to the rest of the Dutch horse sector is difficult to estimate. According to experts the prevalence

of CEM will be higher in the total sector (CVI 2008; GD 2008) than the prevalence of 2% that is measured in breeding stallions.

Without any information on the CEM prevalence among non-regulated stallion holdings it is hard to make estimations about the efficiency of certification for CEM. Hence, the extent to which the certification results in an additional benefit by a reduction in the prevalence of CEM is unknown. Furthermore, this benefit is mainly for the mare owners, as the damage of CEM in stallions is negligible, for they are merely carriers of *T. Equigenitalis* (Timoney 1996). The consequences of an infection with CEM in mares are not entirely clear. In contrast to the clinical symptoms in mares which are researched extensively, the actual prevalence of clinical symptoms in mares after being bred by an infected stallion is not known. Prevalence's vary from 2% up to 40% (Agriculture 2009; Parlevliet, Bleumink-Pluym et al. 1997). The reason for this difference may be that the exact number of mares that become infected or manifest clinical symptoms is not identified. The actual economic damage of *T. Equigenitalis* is the temporarily infertility of diseased mares. Part of the damage will be recouped from the stallion holders due to the fact that some of the infected mares will be still gust by the end of the breeding season. Due to the large variation in levels of infection within mares and the serious lack of data reflecting the epidemiological consequences of CEM among the Dutch mare holders, it was not possible to include the mare holding segment within the analysis as well. When this information becomes available in the future, a more complete analysis can be made of the total costs of CEM for both stallion holders and mare holders.

7.2.1 Sector level

An estimation of the costs of certification on sector level was not possible. One reason for this is that not all costs for certification can be contributed to prevalence of CEM and therefore an overestimation of the costs would be the result. When certification would be mandatory for all stallion holdings in the Netherlands all stallion holders would have to test for CEM. To justify such a change in regulations, these costs would have to be earned elsewhere; otherwise the sector will lose money. For example the export could increase as a consequence of this. The reason for the Dutch regulations on CEM is that the EU handles regulations, for which the guidelines are provided by the OIE (OIE 2008; PVE 2008). In the Netherlands CEM is not considered a large treat among stallion holders and other parties involved, for the disease is not well known (Anonymous 2008). The reason for this might be that warm blood horses can be bred by the use of AI, while thoroughbred horses are only mated naturally. Natural mating poses a larger risk of spreading CEM for an infected mare can infect a stallion. With the use of AI the infection occurs one-way. Furthermore, in the United Kingdom and the United States thoroughbred are used

for horse racing. There are large economic consequences when these horses cannot be used for breeding, the consequences will probably be larger than with warm blood horses that are only used for dressage and show jumping. The most important question that remains is if the Dutch regulations are coherent with the Dutch horse breeding sector. When testing for CEM will be restricted to only horses that are destined for export or for frozen semen it is questionable what the effects on the total prevalence will be. On the other hand the prevalence of CEM is not something that seems to concern the Dutch horse breeding sector therefore it is probably not at a very high level. At this moment prevention and control only occurs at certified stallion holdings, which is a small fragment of the total sector. No certification and therefore no prevention and control of CEM will probably have a larger effect on the image of the Netherlands concerning CEM than on the actual prevalence of CEM.

8. CONCLUSIONS

Several assumptions were made for the benefit of this analysis. While these assumptions make it possible to get some insight in the financial consequences of the prevention and control of CEM, when more information is available the analysis will be more accurate. The prevention costs for CEM are relatively low for a stallion holder when CEM is not present for they are only one third of the average stud fee. When detected in a breeding stallion, *T. Equigenitalis* can cost the stallion holder rather a lot. These costs could be even higher when the distribution of the demand for semen during the breeding season is not normal like it is assumed in this analysis. The question for further analysis is if the costs for control of CEM are earned back at the side of the mare holders. Looking at the alternatives for testing, the test moment, and treatment it appears that all these three alternatives should be adopted. Even though only the first two methods cause an actual decrease in costs for the stallion holder, the more expensive treatment method could be beneficial in the long run. Of these three alternatives advancing the test moment is the most important one since this has the largest effect on the damage that occurs. The decision of the PVE and GD to advance the test moment two weeks earlier is therefore the right one. Educating stallion holders on the importance of submitting the swabs early in breeding season might also be an action that can be taken. Overall, more information and further analyses are needed to provide a full overview of all the consequences of CEM in the Netherlands. At present it is just as unclear what would happen if all stallion holders are obliged to test for the presence of *T. Equigenitalis* as it is unclear what would happen if none of the Dutch stallion holders would test for it. A major part of this is that the infection rate in mares is not known.

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