USE OF TEMPERATURE SENSITIVE MICROCHIP TRANSPONDERS TO MONITOR BODY TEMPERATURE AND PYREXIA IN THOROUGHBRED FOALS

BY

JOHN DUNCAN GREWAR

A DISSERTATION SUBMITTED TO THE FACULTY OF VETERINARY SCIENCE OF THE UNIVERSITY OF PRETORIA IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MAGISTER SCIENTIAE (VETERINARY SCIENCE)

DATE SUBMITTED: JULY 2009

Dedicated to my wife

Marli

A. ACKNOWLEDGMENTS

B. ABBREVIATIONS

AHS	African Horse Sickness
AHSV	African Horse Sickness Virus
BTV	Bluetongue Virus
cAMP	Cyclic Adenosine Monophosphate
CFT	Complement Fixation Test
COX	Cyclooxygenase
CRC	Cyclic Redundancy Check
dsRNA	Double Stranded Ribonucleic Acid
EE	Equine Encephalosis
EEV	Equine Encephalosis Virus
EHDV	Epizootic Haemorrhagic Disease Virus
EHV	Equine Herpes Virus
EI	Equine Influenza
HA	Haemagglutinin
IFA	Indirect Fluorescent Antibody
IL	Interleukin
INF	Interferon
ISO	International Organization for Standardization
LPS	Lipopolysaccharide
NA	Neuramidase
NO	Nitric Oxide
OVLT	Organ Vasculosum Laminae Terminalis
PDA	Personal Digital Assistant
PG	Prostaglandin
RDA	Rugged Digital Assistant
RF	Radio Frequency
SeM	Antiphagocytic M Protein
TLR	Toll-like Receptor
TNF	Tumour Necrosis Factor
Vap A	Virulence Associated Protein A

C. TABLE OF CONTENTS

D.   List of Figures

E.   List of Tables

F.   List of Appendix Tables

G.   Summary

Use of temperature sensitive microchip transponders to monitor body temperature and pyrexia in
Thoroughbred foals

By

JOHN DUNCAN GREWAR

Supervisor: Prof. AJ Guthrie

Co-supervisor: Prof PN Thompson

Department: Production Animal Studies

Degree: MSc

The aim of this study was to evaluate temperature data collected from Thoroughbred foals between birth and shortly after weaning. It provides a valuable survey with epidemiological conclusions providing insight into the temperature trends and pyretic occurrences of Thoroughbred foals during this age period.

Temperature data were collected using telemetry from temperature sensitive microchips implanted into newborn foals. The system of inputting and storing temperature data was completely electronic and this study evaluated this system. It was found that this system was stable and allowed the evaluation of large amounts of frequently acquired data with little human intervention.

The data obtained resulted in the valuable evaluation of age associated body temperature trends within the foals as well as providing an indication of the extent and epidemiology of pyrexia within the study cohort. The system of evaluating temperatures based both on the individual day value as well as on each individual foals prior series of temperatures shows that the use of these two criteria can be utilised simultaneously. The study provides basic information which future researchers using similar systems can use to objectively set criteria for pyrexia. An outbreak of equine encephalosis also occurred during the study period and this provided much needed prospective epidemiological information for such an outbreak, something which has not previously been documented.

Keywords: pyrexia, Thoroughbred, foal, microchip, scan, Equine Encephalosis, core temperature trend

Chapter 1.   Introduction

A foal's good health is critical in terms of the livelihood and success of the foal, its owner and breeder. Pyrexia plays an important role in disease and is often an initial sign of disease. It is for this reason, as well as the fact that temperature data are routinely collected by both veterinarians and non-veterinarians on Thoroughbred horse farms, that it should be used as a management and diagnostic tool for the horse industry.

There have been many studies which have used telemetric methods to obtain temperature data, but none can be found which evaluate these data for reasons of identifying pyrexia and for evaluating general body temperature trends over an extended period of time. The use of a passive monitoring system of foal temperature allows multiple temperature data to be stored and evaluated with minimum human intervention creating a more stable and low risk data input environment.

An improved knowledge of the normal body temperature characteristics as well as the pyretic characteristics of Thoroughbred foals may assist clinicians and horse owners alike to make informed decisions regarding body temperature evaluation.

Chapter 2.   Literature Review

2.1.   Thermoregulation

2.1.1.   Introduction

Thermoregulation is an important regulatory process of the body which ensures the basal temperature of the body falls within a narrow range. Responses that play a role in thermoregulation include autonomic, somatic, endocrine and behavioural changes[18]. These responses either increase body temperature or lower body temperature depending on which is required to stabilise the basal body temperature.

The following mechanisms are crucial in the thermoregulation of the body: In the presence of a cold environment shivering, hunger and increased voluntary activity increase heat production while cutaneous vasoconstriction, curling up and pilo-erection decrease heat loss. In the presence of a hot environment cutaneous vasodilation, sweating and an increased respiratory rate increase heat loss while anorexia and apathy decrease heat production[18].

Blood flow plays an important role as an internal thermoregulatory mechanism due to the fact that it dissipates heat by convention and the body can regulate the flow of blood to specific areas. A good example of this is the peripheral vasoconstriction and vasodilation in cold and warm conditions respectively. Environmental temperature, solar radiation, humidity and wind speed play a role in heat balance of foals as these animals live outside from an early age[22].

In young children the regulation of temperature is less precise than that of adults and their temperature remains about 0.5°C above that of the adult mean temperature[18]. Similar results have been found in equine studies at 30 days postpartum[42].

The mean temperature of a foal rises both at dawn and at dusk over the first 30 days of life[42]. Foal rectal temperature ranges from between 37.2°C and 38.9 °C during the first 4 days of life[31,41]. In comparison to healthy foals it is more difficult for compromised foals to raise their body temperatures immediately after birth to normal temperatures[39]. This is ascribed to compromised foals not being able to increase their metabolic rate[39]. Sick/premature foals temperatures fluctuate much more than healthy foals due to compromised thermoregulatory effectivity[39].

2.1.2. Circadian Rhythm

Horses maintained in a natural photoperiod and also under experimental permanent light conditions show definite signs of a circadian rhythm[43]. The ascent of temperature starts to rise from its lowest point (nadir) at the beginning of the light phase of the day and reaches its highest point 14 hours later, during the dark stage of the day[43]. A rhythmic pattern of temperature in foals emerges within 10 days after birth and is complete by the first month of life[42].

2.1.3. Thermoneutral Zone

The thermoneutral zone is the environmental temperature zone in which the basal metabolic rate of the animal is maintained at its lowest[22]. This can also be described as the range of temperatures within which the horse does not need to expend or gain energy to maintain its body temperature. This range has been described as falling between 5 and $25^{\circ}C$[36]. This zone is species, breed, climate and coat type dependant[22] and this is clearly seen in the animal kingdom by the type of animal found in the different temperature extremes of the world.

2.1.4. Conclusion

Foals do have thermoregulatory mechanisms in place once they are born and if they are healthy at birth these mechanisms should function to keep their bodies within a normal body temperature range. Disease affects this range and sick foals can have difficulty thermoregulating. The mean temperature of the foal rises within the first 30 days of life, but under normal conditions remains within the normal range. Any pyrexia which is found in neonatal foals will most likely be the result of a pathological insult due to disease.

2.2. The Physiology of Fever

2.2.1. Introduction

Heat is produced in the body by muscle exertion, assimilation of food and all processes linked to the basal metabolic rate of the body. The loss of heat is due to radiation, conduction and evaporation from within (respiratory tract) and without the body (skin). Normal body function requires a core body temperature that remains within a narrow range[18].

Fever, its origins and role in disease, has been studied and reviewed by numerous authors. Fever is part of the acute-phase response to disease and is one of the highly conserved aspects of this response. The acute phase

response is a systemic reaction induced most often by a localised disease[13]. Opinions regarding the fever pathways and its role in disease have changed over the years. It is possible that fever is the only clinical sign of disease and this may occur in diseases such as equine encephalosis (EE), equine rhinopneumonitis and equine piroplasmosis.

Fever is part of the host's defence mechanism against bacterial, viral, physical and chemical insult. It causes discomfort for the host but is required in the healing response. The process of fever is regulated by pro-fever and anti-fever regulators in the periphery of the body as well as in the brain. Regulated feedback mechanisms exist to prevent fever from becoming exaggerated during infectious systemic infections[4].

Fever and hyperthermia should be understood to be two different entities. Hyperthermia is the increase in body temperature due to increases in the ambient temperature, while fever is the increase in body temperature irrespective of the ambient temperature and is due to a regulated response of the host's protective mechanisms[4].

It has been shown that clinical fever in humans does exhibit specific patterns. Examples of these fever patterns are sustained, relapsing, biphasic and remittent fevers[56]. An example of this occurs in viral diseases and abscesses which give rise to intermittent fevers with wide fluctuations. In man, fever patterns have been abandoned as diagnostic signs and cannot be grouped according to a specific infectious process as newer medical and better diagnostic procedures exist[4]. In the equine field, animals are often treated on the most likely cause of a disease, as diagnostics, although available, are often not cost effective. If a fever pattern can be linked to specific disease processes in horses, it would still be of benefit in this species.

2.2.2. Cytokines are endogenous pyrogens

Cytokines are small non-structural proteins that are produced during or after diseased states. They are classified into pro-inflammatory and anti-inflammatory categories. Receptors for cytokines are expressed on most cells, which account for their activities in numerous biological and pathological states[14].

It is generally accepted that the pyrogenic pathway begins with the stimulation of monocytes and macrophages by noxious substances[4,14]. The relevant substances specifically associated with infectious diseases in foals would therefore be associated with viruses (whole organisms, HA (haemagglutinin), dsRNA (double stranded Ribonucleic Acid)) and bacteria. Stimulating substances in gram negative bacteria include whole organisms, LPS (lipopolysaccharide) and peptidoglycans. Exo/endotoxins, polysaccharides, lipotechoic acid and peptidoglycans are the monocytes/macrophage stimulating substances of gram positive bacteria[4].

Monocytes and macrophages then release inflammatory cytokines (endogenous pyrogens), with the principle cytokines being tumour necrosis factor (TNF) and interleukins (IL-1,2,6,8,12)[4,13]. These cytokines are transported to the preoptic-anterior hypothalamic area, specifically the organ vasculosum laminae terminalis (OVLT) where they function to stimulate the release of prostaglandin (PGE-2), which is thought to be the final fever mediator[4]. As neither cytokines nor microbial products cross the blood brain barrier to induce fever they rather stimulate the release of endothelial cyclooxygenase (COX-2), which induces the PG pathways[14]. The one common linkage between all fever producing substances is the production of PGE-2[14].

A wide variety of micro-organisms and microbial substances can initiate fever without making use of the cytokine pathways. The receptors to the cytokines are found on the endothelium of the OVLT and these domains are unrelated amongst different cytokines[14]. Toll-Like Receptors (TLR) are found on the OVLT endothelium and they also mediate cellular signalling[19,57]. The cellular signal stimulated by IL-1 is very similar to the signal stimulated by Toll receptors[19]. It is now believed that LPS can directly stimulate TLR-4 and gram positive substances can stimulate TLR-2[14] and thus provide a mechanism to induce fever without the use of a cytokine pathway.

PGE-2 then stimulates the release of cAMP (cyclic Adenosine monophosphate) which acts as a neurotransmitter and triggers the hypothalamus to increase the temperature set-point of the body[32,33]. Efferent neurons are stimulated by the hypothalamus via sympathetic nerves. The efferent neurons promote vasoconstriction and an increase in core body temperature[14]. There is a major interplay and interaction between the cytokines of the body and the regulatory role they play, in both stimulating and inhibiting certain functions of the body.

2.2.3.   The role of fever in disease

Although moderate fever is beneficial in the body's defence against infection, excessively high fever may be maladaptive and cause pathological changes in the body[30]. Fever helps the immune system to function optimally and inhibits the growth of certain pathogens[24].

2.2.3.1. Fever induced immune benefits

The immune benefits of fever include: increased neutrophil and macrophage motility; improved phagocytosis; increased antibody production; improved T-helper cell function and increased destruction of intracellular bacteria[3].

2.2.3.2. Fever induced behavioural traits

Humans are well aware of the body aches and pains associated with a fever reaction and these behavioural traits remain similar throughout the world when a human has fever. Research has been done on the causes of

the behavioural changes in animals and has also tried to pinpoint specific causes for specific behavioural changes. The functions affected during the fever period include a decrease in grooming/cleaning behaviour, anorexia, depression and a decrease in social activity.

The maintenance of fever is a highly energy expending exercise for the animal and maintaining a 2-3°C increase above basal body temperature results in an increase of 20% and more of the animals energy consumption[30]. It is for this reason that the normal behaviour and function of the animal changes to allow the body to expend this energy and thus the depression, anorexia and other behavioural traits associated with fever are a series of coordinated actions used to enhance the healing capacity of the body[24].

It has been found that specific cytokines are responsible for specific components of sickness behaviour and that the role of these cytokines is dependent on the presence and levels of others[12]. An example is Interleukin 1ß which is responsible for the anorexia caused by fever[29,45], while IL-6 may only be behaviourally active in the presence of other pro-inflammatory cytokines[12]. Although the raised set point of the hypothalamus induces efferent responses, the animal itself shows behavioural changes, like curling up and seeking warm environments to increase the body temperature[24].

Chapter 3.   Materials and Methods

3.1.   Experimental Design

This project was a prospective study of body temperature within a Thoroughbred foal crop from shortly after birth until after weaning on a large stud in the Western Cape Province of South Africa.

3.2.   Method and Apparatus for the Sensing and Transmitting of Body Temperature

3.2.1.   Bio-Thermo® microchips – format and basic function

3.2.1.1. Introduction

A number of transponder devices which measure the temperature of an animal as well as giving the identification of that specific transponder and therefore animal have been described[11,17,20,59,60]. These studies have found that this method of temperature reading has its advantages and has been put to use in both large and small animal applications.

Temperature measuring devices are traditionally called thermistors. Thermistors have semiconductors incorporated in them which are specifically aligned to create a p-n junction which only allows electric current to flow in one direction[51], creating a unique electronic environment used for many applications - one being temperature measurement. Temperature is a function of the voltage across a p-n junction that has a known resistance and current. A thermistor powered by a known current through p-n junctions of known resistance results in a measurable voltage which is proportional to the temperature of the thermistor[61]. Traditionally there are disadvantages with this system, as the device cost is high due to intense assembly and calibration. Their energy requirements are also high when a temperature output result is required. The transmission format of these systems also made use of unique scanners which are programmed to accept unique signals from the said transponder. The microchips that Destron Fearing™ have developed address all these disadvantages. Their Lifechip® microchips with Bio-Thermo® technology have automated calibration when they are made and can be detected by the common scanner types according to ISO standard 11785 and the transponders are passive transponders meaning they gain power from the scanner and therefore don't require a constant power source like a battery[7]. For the sake of simplification the Destron Fearing™ Lifechip® with Bio-Thermo® technology will be referred to as the Bio-Thermo® microchip.

3.2.1.2. Chip format

The Bio-Thermo® microchip is in the format of a FDX-B chip, which transmits both chip identification data and temperature data. The FDX-B chip signal is transmitted at 134.2 kHz[7].

3.2.1.3. Data Sequence

The FDX-B microchips emit their signal in a data sequence which is according to ISO standard 11785. This standard is widely used and well known in telemetric identification. The data sequence includes a header of 11 bits, an Identification Code of 72 bits, a CRC field of 18 bits and a trailer field of 27 bits. The total string is therefore 128 bits. The temperature data is included in the trailer field and consists of 8 data bits and 1 control bit. The remaining part of the trailer field includes 8 error checking bits[7].

3.2.1.4. Data transmission

The Bio-Thermo® transponder uses an auto transmission format which transmits the identification and temperature data continuously. The format of this transmission allows for other readers to read the identification information based on the fact that the transmission is ISO 11785 compliant. If the reader used can only read identification data and not the temperature data it can still function for identification purposes. The temperature data is still sent in the string but in these cases is not decoded[7].

3.2.2. Scanning the microchip

When the scanner is activated it transmits a RF field to the transponder. The energy of this RF field is used to power up the integrated circuit within the transponder. All the components within the transponder are then reset. The transponder then emits a RF field back to the scanner, included within are the identification and temperature data. Once the scanner has emitted its RF signal it enters read mode and picks up the information transmitted from the transponder. If it is then successful in decoding the read information it stores and displays the identification and the temperature (if it is enabled to display temperature). Should the scanner not decode the information it will either continue scanning based on whether the user is pushing the search key, or it will display "No ID Read". If the user does not push the search button either after a successful scan or an unsuccessful scan, the power automatically goes off[7].

3.2.3. Making use of a RDA to assimilate temperature data

A RDA is a Rugged Digital Assistant, which is similar to a standard Personal Digital Assistant (PDA) except for the fact that it is built for the outdoor environment. It communicates with a host computer directly either via a serial communication cable or via Bluetooth or Infrared technology. The RDA's used in this project were Aceeca™ produced Meazura™ Palm based computers. They are reported to be both dust and waterproof. The advantage of the RDA is that it can communicate via a serial cable with other devices as well and in this case with the Identipet™ Reader used to scan the Bio-Thermo® microchips. The scanner can send identification and temperature information to the Meazura™ computer via this serial link.

A database program developed in Satellite Forms™ (Thacker Network Technologies Inc.) was used to then assimilate these data and store them into a Palm based database program. When the RDA is connected to the host computer, the database developed in Satellite Forms™ is linked to a Microsoft® Access 2003 (©Microsoft Corporation) database and data is thus stored on the host computer. The Microsoft® Access Office 2003 (©Microsoft Corporation) database was programmed specifically to store and evaluate these data and write a report based on the temperatures for that day/evaluation. Hereafter the Microsoft® Access Office 2003 (©Microsoft Corporation) database is referred to as the "Access database" and the Satellite Forms™ (Thacker Network Technologies Inc.) database will be referred to as the "Palm database". For a more detailed description of the computer programs developed for the project please see Appendix 4.

3.3. Foal Selection and Handling

The experimental animals were foals born on the Arc-en-Ciel Thoroughbred Stud in the 2007 foaling season. Since the project is intimately associated with the farm and its management, all consideration was given to the farm management regarding any practical arrangements of the study. The foaling occurred from August to December 2007. A total of 127 foals were microchipped and enrolled in the study.

Based on the management principles on the farm, foals were born in the bottom stables (see Appendix 1) on the farm. The only exception to this was when mares foaled earlier than expected and then the foaling occurred within the paddock the mare was in. The closer mares were to foaling the closer they were brought to the bottom stables and the imminently expecting mares were stabled in the days leading to foaling. It was due to this that very few mares did not foal within the stables.

When possible, all foaling was assisted by the farm manager Mr. Carey. The only exceptions were when the mare foaled so quickly that he could not be present or when foaling occurred within the paddocks. All foals were given rectal enemas by farm management to help remove the meconium. During difficult foaling Dr. Antrobus,

the stud veterinarian (or if unavailable another equine veterinarian within the vicinity) was called immediately and Mr. Carey provided basic health care post-foaling.

Foals were microchipped inside their stable of birth on the morning after their birth. No foals were microchipped prior to their receiving colostrum. The microchipping technique used is described below (see 3.4).

Table 3-1: Summary of the number of foals born per month during 2007

Month	Number of foals born per month (with percentage of total)
August	22 (17.3%)
September	27 (21.3%)
October	58 (45.6%)
November	19 (15.0%)
December	1 (0.8%)

The first foals were born at the beginning of August and the most foals born in a month occurred during October (n=58). Healthy foals remained within the immediate vicinity of the bottom stables and later (generally within a week) were moved to surrounding paddocks. Sick foals were kept in the foaling barn vicinity for as long as was necessary. Throughout the year sick foals were taken to the bottom stables or top stables depending on which was closer. This was to separate them from other foals and provide health care. At a later stage foals were separated into their sexes and put in the paddocks higher up in the farm (see Appendix 1), namely the Kloof paddocks and Mandy's and Pearl's paddocks.

Weaning of foals began in March of 2008. The weaning dates of 99 of the 127 foals were recorded. Of the 28 unknown dates, 24 were due to foals removed from the trial prior to weaning. Two foals' dams died prior to weaning and they were hand reared until they were weaned, however their weaning dates were not recorded. Two other foals weaning dates were not recorded. The earliest weaning date was the 25th March 2008 when 18 foals were weaned. This also accounted for the largest single weaning cohort. The final weaning date was the 5 June 2008 where the final 10 foals were weaned. The mean age of foals at weaning was 28 weeks old. The youngest foal to be weaned was 18 weeks old and the oldest was 42 weeks old at weaning.

The first foal vaccinations were administered between 7-11 months of age at a mean age of 8.5 months. The vaccines administered are preventative against African horse sickness (AHS), equine influenza (EI), tetanus and botulism. Although a strangles vaccine was used on the farm in specific cases it was never administered to any foals. AHS multivalent vaccine (Onderstepoort Biological Products Ltd.) bottle 2 (Batch numbers #208/#210) was the first vaccine to be administered. It was administered between the 2nd and the 10th of June 2008. Proteq Flu TE (Batch number L234420) (Merial Animal Health Ltd.) and Botulism (Batch number #481) (Onderstepoort Biological Products) was then administered between the 23rd June and the 1st July 2008. AHS bottle 1 (#174) was then administered between the 7th and 15th July 2008. The Proteq Flu TE and Botulism boosters (same

batch numbers as previously) were administered between the 28th and 29th July. Since the project was terminated on the 31st July 2008 no further information on vaccination was provided or required.

Standard hoof care was performed by the farm farrier on a monthly basis and in cases of foot problems the farrier attended to the foals on a weekly basis. Foals were dewormed monthly and if ticks were observed they are treated with an acaracide.

Foals were not handled during the temperature scanning unless when they were difficult to scan and needed to be restrained. This was done in younger preweaned foals by leading the dam to the pole fence on the side of the paddock and trapping the foal between its dam and the fence and then scanning it. Although every effort was made to scan all foals in the mornings there were those that could not be approached or caught to be scanned. This was especially true of older foals which had been weaned.

3.3.1. Mares

A standard vaccination protocol of AHS, botulism, tetanus and EI was administered to mares on the farm.

3.4. Foal Microchipping Procedure

The microchipping of Thoroughbred foals in South Africa is done on contract for the National Horseracing Authority and this procedure was performed with regard to the requirements of this institution.

All microchipping was undertaken by a registered veterinarian and were performed according to a set procedure identical to that of the Equine Research Centre's procedure which has been used for the last 8 years during which time they have microchipped approximately 30000 foals. The procedure entails shaving a site on the left dorso-lateral side of the neck mid crest of the foal. The site is disinfected with a hibitane and alcohol soaked swab. The applicator is inserted perpendicularly into the neck, with the applicator needle inserted up to its hub. The microchip is then injected into the nuchal ligament and the applicator is removed. The periphery of the site is then coated with Shoo-fly® fly repellent ointment (Kyron Laboratories (Pty) Ltd.) to prevent the attraction of flies to the site and the site itself is smeared with Dermadine Antiseptic Ointment (Medpro Pharmaceutica (Pty) Ltd.). Immediately after insertion all microchips are scanned to ensure they were not been damaged on insertion and the scanned microchip number is checked against the factory recorded microchip number on the applicator packaging.

3.5. Pyretic Event

Pyrexia determination was based on a scanned temperature greater than 39.9°C and/or a temperature which was greater than 1.96 standard deviations above the baseline mean temperature for each specific foal, as determined in the Access database. The Access database program had integrated queries which isolated the daily temperatures of the foals and after examining them determined if the specific temperature of the foal on that specific day was considered as pyretic. This was done either by identifying temperatures for the day which were greater than 39.9˚C (from now referred to as a "Value Pyrexia") or determining if the temperature was significantly higher than that foals previous 7 readings (including that current scan). The latter method (hereafter referred to as the "Statistical" method) was based on the probability of a normal temperature falling more than 1.96 standard deviations away from the mean of the previous 7 scans. If a temperature fulfilled either or both of these criteria it was labelled as pyretic.

The standardised score of a data value is the "distance" in standard deviation units away from that data's mean. For normally distributed data 95% of all observations are found within 1.96 standard deviations on either side (positive and negative) of the mean value. This said, in a normal distribution curve, 2.5% of values will fall outside of the +1.96 standard deviation value. The standardised score was determined by the equation $z = (x - \mu)/\sigma$ where x was the raw score to be standardized (in this case current foal temperature), σ was the standard deviation of the foal's temperature series over a maximum of 7 readings including the current reading and μ was the mean temperature of the foal's temperature series over a maximum of 7 readings including the current reading.

Pyretic episodes and pyretic scans are also differentiated. Pyretic scans were all scans fulfilling the pyretic criteria described above while a pyretic episode could account for more than 1 pyretic scan. This would occur if there were one or more pyretic scans within 7 days of a previous pyretic scan for the same foal. Together these scans would be included as a pyretic episode. This was done assuming the aetiology of a pyretic episode was likely to be the related to other pyrexia within this time period. An exception was made during the EEV outbreak for 1 foal (Discover Diamonds 2007 Foal 985140000313018) where the pyretic scans of the 2nd, 11th and 16th of April 2008 were included as 1 pyretic episode.

A standard protocol was followed on each pyretic foal and this included a clinical examination of the foal and the collection of a standard set of samples from the foal.

3.5.1. Clinical Examination

Where possible a basic clinical examination was carried out on the same day as the pyretic event as well as for every day of pyrexia and for 1 day following the return to a normal body temperature. The clinical examination evaluated specific bodily function and the outcomes were inputted into the RDA and uploaded into the Access database. There were occurrences where foals were treated with anti-pyretic drugs after the initial temperature scan but before the clinical examination could be performed. In these cases temperature data were not recorded.

3.5.1.1. General Examination

The body temperature of the foal, both rectal and microchip, was obtained using a digital thermometer and the microchip scanner. The pulse and respiratory rates were auscultated and a subjective evaluation of the foal's habitus (alertness/attitude) was inputted. A habitus score of 0 indicated the foal was moribund, 1 indicated severe depression with anorexia, 2 being mildly depressed with a small interest in food, 3 indicating normal behaviour and 4 indicating hyperexcitability. The habitus scores were modified from those used by Zambelli in the assessment of canine patients with babesiosis[58].

3.5.1.2. Neurological System

Ataxia was subjectively scored from 1 to 4 with 1 being mildly off balance and stumbling to a 4 in which the foal was recumbent with an inability to stand.

3.5.1.3. Gastrointestinal System

Diarrhoea presence was established and quantified (0 to 4) with 1 consisting of mild signs of increased frequency/volume of faeces and 4 consisting of vast quantities of faeces frequently passed and causing secondary systemic signs, like dehydration. Borborygmus was also subjectively determined and ranked 1 to 4 with 3 being normal gut sounds with a frequency of approximately 1 episode per minute. A score of 1 indicated a severe lack of gut sound, a score of 2 indicated a mild lack of gut sound while a score of 4 indicated a high intensity of continual gut sound.

3.5.1.4. Respiratory System

Nasopharyngeal discharge was evaluated and scored 0 to 4 with 4 being copious amounts of discharge causing discomfort and irritation. It was also noted if it was either unilateral or bilateral. Coughing and sneezing were noted and scored 1 to 4 based again on frequency and effort. Thoracic auscultation was performed listening for wheezes, crackles or other abnormal lung sounds. This was noted and the lung sounds scored 0 to 4. Severity

was based on harshness and frequency of sounds. Any signs of dyspnoea were noted and scored similarly with an increase in respiratory rate and effort scored from 0 to 4. Ocular discharge was noted and scored 1 to 4 based on the criteria used for nasopharyngeal discharge. An oversight was made when the Palm database was created in that the lymphoid system evaluation was omitted. This was only discovered some time into the project and for the sake of continuity was then omitted from all clinical examinations. These data may have played a significant role in the diagnosis of strangles as an aetiology of pyrexia.

3.5.2. Foal sampling during pyretic episodes

Foals were sampled at every pyretic episode. The only samples that were collected were blood samples from the jugular vein. Foals were restrained by 1 or 2 of the farm workers. The workers stood on the left side of the foal and the foal's tail was held at the base and forward pressure was exerted on it towards the head, while the workers left arm was held under the foal's mandible and his left hand grasped the foal's right ear. This allowed for full control of the foal and blood was sampled from the right side of the foal.

Serum samples were collected by jugular venipuncture into vacuum tubes without anticoagulant (Serum SST Vacutainer®- Becton Dickinson). Samples were then stored at 4˚C in a standard refrigerator and were sent to the Equine Research Centre at regular intervals for centrifugation and storage. Serum samples were also collected from all pyretic foals as close to 14 days as possible post pyrexia and these were used to evaluate rising antibody titre to specific diseases if required.

Blood samples for viral isolations were also collected by jugular venipuncture into heparinised (Vacutainer® 102 I.U. LH - Becton Dickenson) vacuum tubes and stored at 4˚C in a standard refrigerator. The other blood sample taken was 1 EDTA sample (Whole Blood K2E 10.8 mg Vacutainer®– Becton Dickinson)

3.5.3. Routine foal sampling

Serum samples were collected from foals on a monthly basis based on foal age. This was a routine procedure and the technique used was the same as the described technique for pyretic event sampling. All samples were taken using a new Precision Glide Vacutainer® Sterile 21 Gauge Needle (Becton Dickinson) which was fitted into a shoulder for stability.

3.6. Outlier Microchips

There were distinct differences between the spread and central tendencies of temperature data between different foals. To try to identify potential outlier microchips which had excessive variability the following method was applied.

On calculation of the co-efficient of variation (CV) for each individual foal's temperature data using the formula $CV\% = (\sigma/\mu \times 100)$, it was found that only 3/127 (see Table 3-2) foals had values greater than 3. This value provides an indication of the variability in temperature readings over the spectrum of readings for these foals. An attempt to show whether these 3 microchips were variable from the first reading was not conclusive (see Table 3-3). In this evaluation temperature readings were grouped into thirds based on when during the each individual foals study the temperature was measured. Foal 985140000285207's microchip readings had an increase in variability over the study period with the range and central spread of temperature also increasing as time progressed. Foal 985140000372407 and foal 985140000373036 both had standard deviations of the grouped temperature readings which decreased as time progressed. It must be said however that only foal 985140000373036's final 3rd temperature measurements bore any resemblance to the mean standard deviation of the rest of the study group.

Table 3-2: Outlier microchips based on co-efficient of variation criteria

Foal ID	Total Scans	Mean	Min	Max	Range	Std Dev	CV%
985140000285207	172	36.4˚C	32.1˚C	39.5˚C	7.4˚C	1.7˚C	4.74
985140000372407	184	36.6˚C	31.3˚C	39.6˚C	8.3˚C	1.4˚C	3.83
985140000373036	157	36.9˚C	34.2˚C	39.2˚C	5.0˚C	1.2˚C	3.33

Table 3-3: Outlier microchips - variability within different periods of reading

Foal ID	Total Scans	Initial 3rd readings		Middle 3rd Readings		Final 3rd readings	
		Range	StdDev	Range	StdDev	Range	StdDev
985140000285207	172	4.2˚C	0.9˚C	5.8˚C	1.2˚C	6.4˚C	1.4˚C
985140000372407	184	8.2˚C	1.4˚C	7˚C	1.3˚C	6.7˚C	1˚C
985140000373036	157	3.7˚C	1.1˚C	4.8˚C	1˚C	3.8˚C	0.7˚C

These 3 outlier microchips with all their associated readings were, unless otherwise indicated, excluded from further analyses.

3.7. Farm Environmental Aspects

3.7.1. Movement of Water

There were multiple dams on the farm containing water originating from the natural run-off from the western slopes of the Lemietberg Mountains on the eastern border of the farm. Water from the 2 large dams on the top farm flowed to the water pump and filter as indicated on the map in Appendix 2. Water was then pumped from there and with the aid of gravity flowed down the farm through to the paddocks. All paddocks were irrigated via pop up sprinklers on a timing system.

3.7.2. Movement of Feed

All feed, consisting of concentrate and lucerne, was stored in a large store as indicated in Appendix 3. Feed was loaded twice daily, in the morning and in the afternoon onto a flatbed trailer and was taken to the paddocks via the route indicated. The trailer seldom entered the paddocks, unless the paddock was used as a thoroughfare. The feed was either thrown or carried into the paddocks by the workers. The lucerne/hay was placed on the ground while the concentrate mix was placed in mobile feed bins, one bin per horse. Feed was also partially stored in 2 small stores near both stable blocks and these blocks were fed independently from the paddock system.

3.7.3. Animal populations associated with the farm

Other than the horses there were other animal populations on the farm. Part of the top farm was hired out to a cattle farmer who ran a herd of beef cattle on the land. There was also a wild animal paddock on the slopes of the mountain on the eastern border of the farm. The 2 main dams on the top farm were situated in this large paddock. Zebra, eland and springbuck were present in this paddock throughout the course of the project. There were also wild pigs which roamed free on the farm and their presence could be seen in the horse paddocks due to the damage they caused while rooting. Fallow deer were also intermittently seen on the farm. There was a variety of birdlife on the farm with a large presence of duck and geese species. There was also a 10 house broiler farm 1.3 km NE from the main gates of the farm. This farm did not border immediately on Arc-en-Ciel.

Chapter 4.   General Results and Discussion

The results pertaining to the specific sections and topics can be found within those topics' chapters. This section reports results and discussion which are not associated with specific sections but are still pertinent to the project as a whole.

4.1.   Pyretic Events

The results pertaining to pyretic events are also found in Chapter 5 and this section deals more with the results regarding pyretic events and the differences regarding the two pyretic criteria, viz. Value pyrexia and Statistical pyrexia. Outlying foals as described above are also excluded in the following section. Only 1 pyretic episode, which contained only a single pyretic event, occurred within the 3 outlier foals during the course of the study.

4.1.1.   Pyretic Categories

Table 4-1: Pyretic categories count data – Statistical and Value criteria

Pyretic Event Count	Statistical Pyrexia Count		Value Pyrexia Count		Both Statistical and Value Pyrexia Count	
168	Count	% of Total	Count	% of Total	Count	% of Total
	40	23.8%	120	71.4%	8	4.8%

Table 4-1 shows the comparison in numbers of statistical to value pyretic events. There were 40 statistical pyretic events and 120 value pyretic events, with only 8 fulfilling both criteria. The criteria we chose for statistical pyretic events made use of a standardised score cut-off of 1.96 units which ensured that the likelihood of false positive pyrexia's was low. Considering the statistical vs. value pyretic event counts as shown in Table 4-1 we considered retrospectively improving this ratio. One method to attain this would be to increase the number of statistical pyretic events by changing the cut-off of the standardised score for temperature events. The mean standardised score of all the value pyretic events was 1.18 units. Changing the statistical pyrexia criteria to this standardised score cut-off increased the percentage of temperature readings being labelled as statistically pyretic from 40 to 1527, which would increase the false positive rate of pyrexia and decrease the false negative rate. The re-evaluated data is summarised in Table 4-2.

Table 4-2: Pyretic categories using 1.18 as a z-value cut-off for statistical pyrexia's

Pyretic Event Count	Statistical Pyrexia Count		Value Pyrexia Count		Both Statistical and Value Pyrexia Count	
1655	1527	92.3%	58	3.5%	70	4.2%

Since roughly half of the value pyretic events would have a standardised score of >1.18 the number of value pyretic events and the number of both category pyretic events tended to converge with 58 and 70 in each group respectively. However the number of statistical pyretic events increased by 1487 events to a total of 1527 events. This is a large change and would require more evaluation due to the fact that each foal on average would have then had 13-14 separate pyretic events within the year or more likely would have had on average more pyretic events within each pyretic episode. In order therefore for statistical pyrexia to identify all value pyrexia's the standardised score cut-off would have to be even further lowered which would in turn result in a still greater number of false positive statistical pyrexia's. This re-evaluation can only therefore be considered theoretically and a standardised score cut-off of 1.96 units was used in further evaluation of the temperature data.

4.1.2. Pyretic Temperature

Table 4-3: Pyretic events – Pyretic temperature central tendencies

Pyretic Event Count	Mean	Median	Minimum	Maximum	Range
168	40.05°C	40.2 °C	37.2°C	41.5°C	4.3°C

Table 4-3 gives an indication of the central tendency of the pyretic temperature, which was that temperature which was flagged as being pyretic based on either the value or the statistical category.

4.1.3. Series Temperatures of Pyretic Events

Table 4-4: Pyretic events – Temperature series count data (NA = Not Applicable)

Count in series	Total Pyretic Events		Statistical Pyretic Events	
1	3	1.8%	NA	NA
2	1	0.6%	0	0%
3	11	6.5%	0	0%
4	14	8.3%	0	0%
5	21	12.5%	0	0%
6	72	42.9%	17	35.4%
7	41	24.4%	26	54.2%
8	5	3.0%	5	10.4%

Series temperatures are those temperatures that were used to calculate the mean temperature which was then used in the calculation of the standardised score for each individual foals daily temperature scan. Table 4-4 provides information on the number of readings within the pyretic event series'. The proposed and ideal scan period is 7 days. This was not possible in all cases as some foals could not be scanned due to their handling or due to their unavailability. Scanning was also not performed on weekends, public holidays and on days where rainy weather prevented scanning. It was due to this that within the pyretic cases the most frequent number of scans in a pyretic series, irrespective of category of pyrexia, is 6 scans. This corresponds with the series count

of all temperature scans throughout the project where the mode was 6 scans (n= 4845, 32.3%). What is of interest here that the statistical pyretic events had a minimum of 6 or greater scans within the series. This confirms that an increased number of temperature readings within a temperature series decreased the standard deviation of that series, creating a more likely scenario for statistical pyrexia. Eight scans in a series occurred due to the very occasional temperature scan occurring over a weekend. Supporting the above information is the fact that all 5 of the pyretic occurrences of 8 scans in the temperature series were statistical pyretic events. The information provided by Table 4-4 above also has an impact on the use of a decreased standardised score to predict Statistical pyrexia (see 4.1.1). It shows that another way of improving the statistical pyrexia frequency would be to increase the number of readings per temperature series.

4.1.4. Conclusion

In order for a system which identifies pyrexia based on both value criteria as well as series criteria to be effective, as many readings as possible must be made within the defined temperature series period (this is improved by making every effort to input data at every opportunity), those readings must be consistent i.e. have a small standard deviation (this will be affected by inherent microchip variability – see 4.3) and the choice of the normalised score cut-off (in our case 1.96) must make biological sense. Our method of identifying statistical pyretic occurrences was chosen to limit the number of false positive pyrexia's while still allowing for pyrexia identification below body temperatures of 40°C. It was also chosen for its simplicity which allowed it to be included in an automated query to identify pyrexia in MS Access™. There are methods of statistical process control which use a variety of criteria to identify variability within data over and above the expected biological variability. The data set produced by this project may be used in future studies to evaluate these methods.

4.2. Clinical Examinations

In total 143 clinical examinations were performed during the course of the year. Details of the clinical variables may be found in section 0.

Table 4-5: Central tendencies of clinical examination variables obtained from foals during pyretic episodes

Clinical Category Evaluated		Count	Mean	Min	Max	Range	Median	Mode
Temperature (˚C)	Rectal	125	39.63	36.3	41.5	5.2	39.7	40.2
	Scanned	132	40.16	37.5	42.3	4.8	40.3	-
Circulatory System	Heart Rate	143	78	20	180	160	70	60
Respiratory System	Respiratory Rate	143	36	10	150	140	30	30

Table 4-6: Clinical examination data obtained from foals during pyretic episodes - Multiple systems

Clinical Category Evaluated		Sub-category	Sub -category percentage	Count
Mucous Membranes	Colour	Pink	73%	105
		Pale Pink	3%	3
		Congested	24%	34
	Capillary Refill Time (seconds)	1	25%	36
		2	68%	97
		3	7%	10
Dehydration	0%	-	94%	135
	5%	-	6%	8
Gastrointestinal System	Diarrhoea	Present	12%	17
		Absent	88%	126
		1	18%	3
		2	35%	6
		3	47%	8
	Borborygmi	0	2%	3
		1	6%	8
		2	37%	53
		3	50%	71
		4	6%	8
Habitus		1	6%	9
		2	34%	48
		3	49%	70
		4	11%	15
Ocular Discharge		Present	18%	26
		Absent	82%	117
		1	88%	23
		2	8%	2
		3	4%	1
Ataxia		Present	0%	0
		Absent	100%	143

Table 4-7: Clinical examination data obtained from foals during pyretic episodes - Respiratory system

Clinical Category Evaluated	Sub-category		Sub -category percentage	Count
Respiratory System	Nasal Discharge	Yes	56%	80
		No	44%	63
		Unilateral	9%	7
		Bilateral	91%	73
		1	56%	45
		2	35%	28
		3	9%	7
	Coughing	Yes	4%	6
		No	96%	137
		1	83%	5
		2	17%	1
	Sneezing	Yes	1%	2
		No	99%	141
		1	100%	2
	Lung Sounds	Present	25%	36
		Absent	75%	107
		1	86%	31
		2	11%	4
		3	3%	1
	Dyspnoea	Present	28%	40
		Absent	72%	103
		1	63%	25
		2	30%	12
		3	7%	3

The normal respiratory rate of an adult horse is between 10-14 breaths per minute at rest. There were 3/143 clinical examinations where the respiratory rate was >100 breaths/min and 2 of these were associated with the foal 985140000375757, and were during this foal's one and only pyretic episode, during which the foal died. This pyretic episode and consequent death of the foal were associated with lower respiratory tract disease based on the post mortem performed by Dr. J. Antrobus. In his experience it was deemed most likely to be a *Rhodococcus equi* infection.

Nasal discharge was one of the more frequent abnormal clinical signs seen within the foal crop, not only amongst the clinical examinations (56% of all clinical examinations presented with some form of nasal discharge) but also subjectively when walking through the foal paddocks when scanning them in the mornings. The aetiologies of nasal discharge in foals include: Viral Diseases – Equine Herpes Virus, Equine Influenza; Bacterial Infection – Strangles and Lower Respiratory Tract Disease. Common infectious causes of nasal discharge in younger horses not specifically evaluated in this project are Adenovirus infections and Rhinovirus

infections, both of which may lead to febrile reactions but may be very mild and uneventful clinical episodes. This may be the cause of the high number of nasal discharges seen in the foals even though they did not present with pyretic episodes.

Of the clinical examinations 25% (n=36) had abnormal lung sounds present on thoracic auscultation, with the majority of these being a mild 1 severity (86%), 11% (n=4) being a moderate 2 severity and 1 case being a more severe 3. Of the examinations, 28% (n=40) had dyspnoea present, with the majority being 1 severity (63%), 30% being 2 severity and 7% being 3 severity.

Similar to the incidence of nasal discharge over the period of interest, many foals were observed having diarrhoea while temperature scanning was being performed in the mornings. Most of these cases did not present with any pyrexia based on the project criteria. Therefore although only 17% of clinical examinations had diarrhoea, the total incidence for diarrhoea would have been distinctly higher on the farm. Of the 17 cases 35 % and 47% had a severity of 2 and 3 respectively while only 18% (n=3) had a severity of 1.

Of foals with pyrexia, 60% still had a habitus of 3 or greater. Only 9 foals (6%) had a habitus of 1 and 34% (n=48) had a habitus of 2. This confirms the subjective observation that the foals which had pyretic events seldom showed signs of illness/discomfort.

4.3.   Microchip evaluation

One important outcome of the study was to evaluate the temperature sensitive microchips and identify any shortcomings using data from the general scanning sessions as well as data obtained during clinical examinations which compares rectal temperature with microchip temperature.

Two microchips ceased to work after insertion (2/127 ≈1.5%) and these foals were removed from the study due to this. These microchips had worked for 36 and 75 scans over a period of 53 and 140 days respectively. Based on the evaluation for outlier microchips, 3/127 (2.3%) provided data which was variable beyond the allowed value based on the CV%. In total therefore 5/127 (4%) microchips were not able to provide complete temperature data for the study. This value does not take into consideration those microchips which may have ceased to work or provide excessively variable data after their associated foals had been removed from the trial for reasons previously mentioned.

Figure 1 below illustrates a method described by Bland et al. which assesses agreement between two different methods of obtaining data of one clinical variable[2]. In this case we assessed the rectal temperature against the microchip temperature obtained during clinical examinations. The method briefly described consists of evaluating

the 95% confidence interval of the expected differences between the 2 measurements for each individual clinical instance using the mean and standard deviations of the differences between the measurement methods. In this case it was found that an expected difference between rectal and microchip temperature can range between 0.43 and -1.48˚C with a mean of -0.53˚C. This is a clinically unacceptable range and this means that based on the data collected rectal and microchip temperatures cannot be used interchangeably. Figure 2 also shows this difference where it can be seen that the large majority of microchip readings falling above the line of perfect agreement. A more intensive study would be required to confirm these findings with a larger sample size with temperatures taken in clinically normal horses and not only, as in our study, pyretic horses.
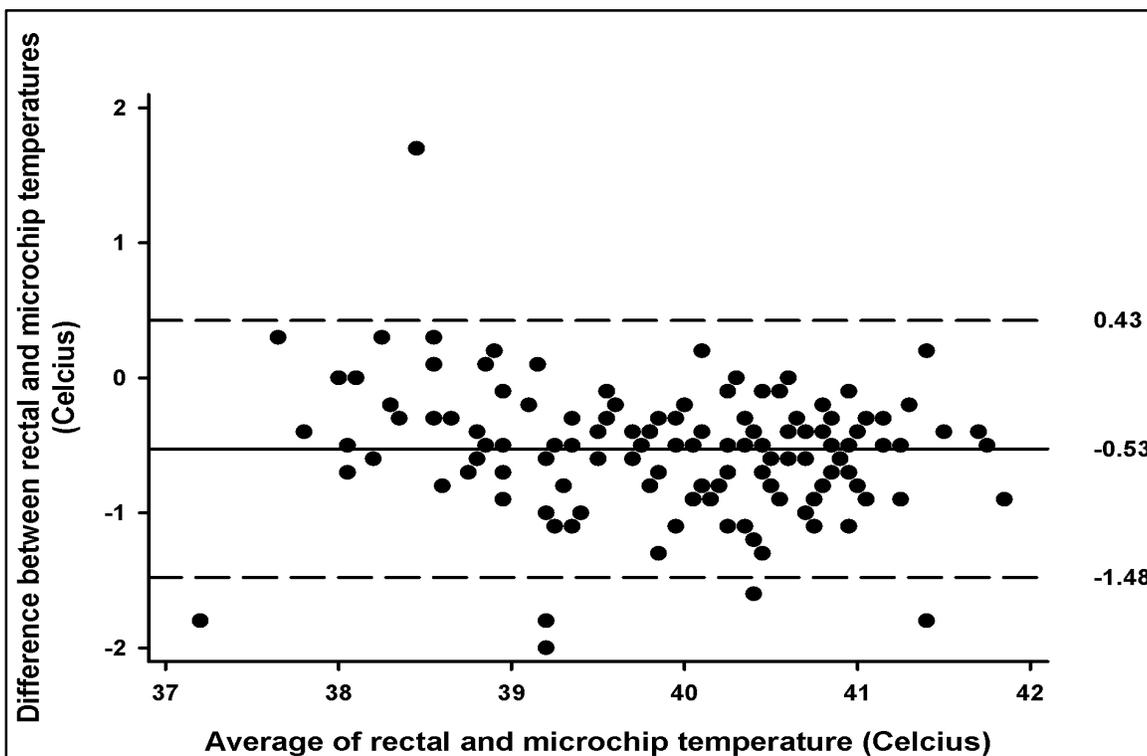
Figure 1: Agreement of rectal temperature to microchip scanned temperatures collected during clinical examinations
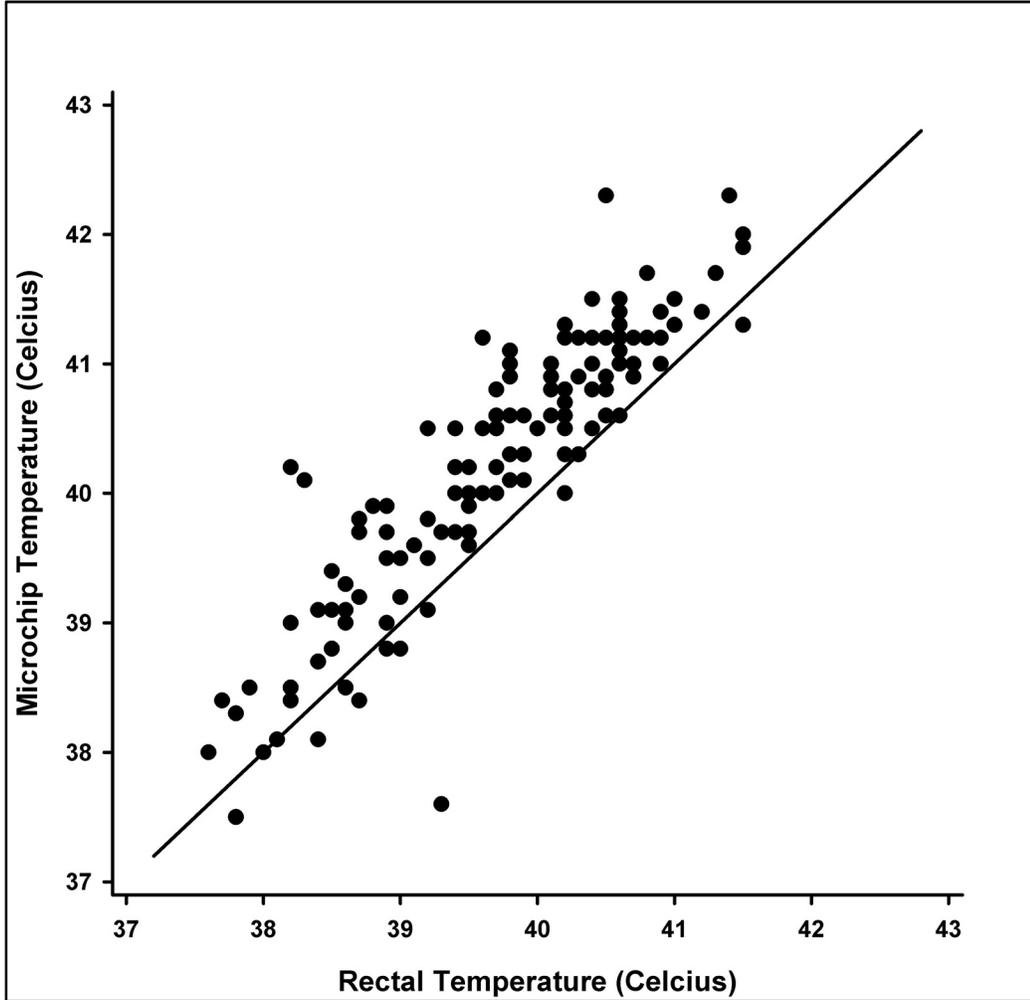
Figure 2: Scatter plot of microchip vs. rectal temperatures collected during clinical examinations
        Diagonal line shows perfect agreement

4.4.   Foal Death

A total of 13 foals died or were euthanased on the farm during the course of the project. This excludes any foals that returned home and may have died or were euthanased there. No information was available for these foals.

Four foals were euthanased. The reason for 1 of these was unknown (985140000370421); 1 was due to a broken leg (985140000315941); 1 due to a fractured back (985140000319183) and 1 shortly after birth due to dysmaturity (985140000254089) with a poor prognosis.

The 9 dead foals included 2 foals for unknown reasons (985140000262070 and 985140000317495). One foal's cause of death could not be established even after post mortem (985140000316549). Foal 985140000306338

had a severe extensive peritonitis with fibrinous exudate in the abdominal cavity. Foal 985140000375757 died of suspected *Rhodococcus equi* infection based on the clinical signs of dyspnoea and post mortem signs of extensive lung abscessation. Three foals died of suspected *Lawsonia intracellularis* infection (985140000370803, 985140000372805 and 985140000312819). Foal 985140000315882 died post-operatively after surgical correction of a unilateral guttural pouch tympany.

4.5.   Wellington Environmental Conditions

Environmental variables of daily minimum temperature, maximum temperature and daily rainfall were obtained from the South African Weather Service. Conditions were measured at the Weather Service's Wellington station ([0021879 8] (-33.6510; 19.0060) 176 m altitude).

Table 4-8: Environmental weather conditions – Wellington 2007/2008

Month	Minimum Temperature		Maximum Temperature		Total Rainfall (mm)
	Minimum	Mean	Maximum	Mean	
August 2007	5.9°C	8.75°C	26.5°C	17.72°C	113.8
September 2007	6°C	9.67°C	30.7°C	20.57°C	37.1
October 2007	5.4°C	13.48°C	36°C	26.21°C	18.3
November 2007	9°C	13.47°C	34°C	26.58°C	49.2
December 2007	10.5°C	17.86°C	38.6°C	31.34°C	45.1
January 2008	15°C	18.34°C	42°C	33.91°C	18.6
February 2008	13.4°C	17.92°C	40.2°C	32.84°C	64.3
March 2008	12.5°C	16.95°C	40.2°C	32.92°C	0.0
April 2008	7.9°C	14.05°C	38°C	29.18°C	8.0
May 2008	10°C	13.35°C	33.3°C	24.50°C	108.2
June 2008	7°C	10.19°C	27.5°C	20.79°C	153.8
July 2008	5°C	7.39°C	25°C	18.39°C	220.3
TOTAL	5°C	13.44°C	42°C	26.23°C	836.7

Chapter 5. Body temperature trends of Thoroughbred foals from birth to post-weaning

5.1. Introduction

Many studies have measured specific physiological variables during specific life stages, with core body temperature being a common variable incorporated into the analyses. With regard to the temperature characteristics the purposes of these studies include understanding the effects of hormones on body temperature, understanding of the circadian rhythm and evaluation of temperature data associated with specific reproductive periods of mammal life. These studies have used various methods to measure core body temperature, and these range from using digital thermometer probes for rectal[1,41,42,44] or blood temperature[37], telemetry[5,10,11,16,38] and combinations of methods to evaluate the differences between them[20,21]. These studies incorporated very specific time periods and in those studies that measured temperatures in newborn mammals none could be found that continued monitoring post 35 days beyond birth. To our knowledge no study has monitored core body temperature from birth to post weaning in foals, or any other mammal for that matter. No study could be found that specifically focused on pyrexia and the epidemiological aspects associated with it in foals from birth to post-weaning.

The aim of our study was to evaluate body temperatures of foals using a telemetric Bio-Thermo® microchip from birth to post weaning and identifying foals as being pyretic on a specific day using criteria based on the point value of the temperature reading and also based on previous readings of each foal.

5.2. Materials and Methods

A total of 127 Thoroughbred foals were microchipped with temperature sensitive Bio-Thermo® microchips manufactured by Destron Fearing™ as soon as possible after birth. Microchipping was performed as prescribed by the Equine Research Centre, University of Pretoria, and was identical to the procedure routinely used for the annual microchipping of Thoroughbred foals throughout South Africa. This briefly involves preparing a disinfected site on the lower third of the neck just below the crest and inserting the microchips with the aid of an applicator into the nuchal ligament of the foal. The temperature sensitive microchips were developed to monitor animal temperatures in a multitude of species. A more detailed description of these microchips and their temperature sensing function can be found in Chapter 3.2 above. Once a temperature had successfully been scanned the scanner emitted a signal and the foal identification appeared on the scanner display screen accompanied by the foal's temperature.

Scanning of foal temperatures was performed on the weekday mornings between 6 August 2007 and 31 July 2008. Most readings were taken between 6AM and 9AM (n=14734 98.1%), with the majority of readings taken between 7AM and 8AM (n=9258 61.64%). Foals were scanned in their respective locations where they were standing the previous night. See Appendix 1 below for a basic map of the farm.

A total of 42 enrolled foals did left the study before 31 July 2008. Removal from the study was due to: handling (38.1% n=16), death (30.9% n=13), left farm (26.3% n=11) and microchips ceasing to work (4.8% n=2). A total of 85 foals were still part of the study at its point of completion on 31 July 2008. All data evaluated from this point excludes the 3 outlier foals described within paragraph 0 above of this dissertation. It also excludes temperature scans which occurred after 12h00 on the day of scanning (n=3).

Data was analysed using NCSS (2004 Kaysville UT, USA) and STATA 10.1 (StataCorp College Station, TX, USA). A significance level of $\alpha = 0.05$ was used. Effects of sex, season and coat colour on risk of pyrexia were evaluated using Fishers exact test. Foal body temperature was plotted against age over 3 age periods which were selected based on their distinctly different trends. Within each of the age periods a mixed-effect multiple linear regression model was used to estimate the effect of age, minimum daily environmental temperature, sex and coat colour on foal body temperature, with foal modelled as a random effect. In this model all pyretic temperatures as well as temperatures within 2 days of pyrexia were excluded. Unless indicated, all other results include pyretic events and temperature readings found within 2 days of pyrexia.

5.3. Results

5.3.1. General data summary

Table 5-1: Pyretic episode and pyretic event scan types for all pyrexia's

Foals Scanned in Period	Total Scans	Pyretic Scans		Pyretic Scan Type			Pyretic Episode Type		
		Total	Pyretic Episodes	Value Pyrexia	Statistical Pyrexia	Both Categories of Pyrexia	Value Pyretic Episode	Statistical Pyretic Episode	Both Category Pyrexia
124	14504	168	111	120 (71.4%)	40 (23.8%)	8 (4.7%)	65 (58.6%)	38 (34.2%)	8 (7.2%)

Table 5-1 is the summary of data of the foals from which statistical analyses were performed. Of all scans, 1.16% (n=168) resulted in pyrexia and a total of 111 pyretic episodes were encountered. Value pyretic occurrences accounted for 58.6% of pyretic episodes and 71.4% of pyretic scans.

Table 5-2: Number of pyretic events within pyretic episodes

Number of Pyretic events within a Pyretic episode	Occurrences	Percentage
1	79	71.2%
2	17	15.3%
3	7	6.3%
4	6	5.4%
5	2	1.8%

Table 5-3: Duration (in days) of pyretic episodes

Duration of Pyretic episode (days)	Occurrences	Percentage
1	79	71.2%
2	13	11.8%
3	6	5.4%
4	5	4.5%
5	3	2.7%
6	1	0.9%
7	2	1.8%
8	1	0.9%
15	1	0.9%

Table 5-2 summarises the number of pyretic scans constituting the pyretic episodes while Table 5-3 summarises the duration of pyretic episodes. This was calculated by determining the number of days between the first and the final pyrexia within the episode.

Table 5-4: Number of pyretic episodes per individual foal

Pyretic Episodes per foal	Occurrences	Percentage
0	50	40.3%
1	44	35.5%
2	24	19.4%
3	5	4%
4	1	0.8%

Table 5-4 summarises the number of pyretic episodes per individual foal. A total of 74 individual foals (59.7%) had at least 1 pyretic episode while 40.3% (n=50) of foals did not experience a pyretic episode.

Table 5-5: Central tendency and spread of foal temperatures associated and not associated with pyrexia

Group	Count	Mean	StdDev	Median	Mode	Range
All temperatures	14504	37.97˚C	0.845˚C	37.9˚C	37.6˚C	7.4˚C
Pyrexia associated scans	422	39.21˚C	1.076˚C	39.3˚C	40.1˚C	5.5˚C
Non-Pyrexia associated scans	14082	37.94˚C	0.808˚C	37.9˚C	37.6˚C	5.8˚C

The central tendency of all foal temperatures is summarised in Table 5-5 with grouping that includes and then excludes temperature scans read within and including a 2 day period before and a 2 day period after any

pyrexia. There was a significant difference between the means of the pyrexia associated scans and the non-pyrexia associated scans (p<0.001).

5.3.2.   Sex Associated Data

Table 5-6: Sex distribution of pyretic foals

Sex	Total Count in Group	Count of foals with pyrexia	Percentage
Colt	59	29	49.15%
Filly	65	45	69.2%

Table 5-6 tabulates the number of foals with pyretic episodes by sex. The relative risk of developing pyrexia at least once within 1 year of age was 1.41 (95% CI: 1.04 - 1.91 p=0.028) times greater in fillies than it was in colts.

5.3.3.   Seasonal Data

Table 5-7: Seasonally categorised temperature data with associated pyretic episodes

Season	Temperatures Scanned	Pyretic Episodes		Mean foal body temperature (˚C)
		Count	%	
Winter (June, July, August)	2755	5	4.5%	37.66
Spring (Sept, Oct, Nov)	3380	16	14.4%	38.70
Summer (Dec, Jan, Feb)	4058	25	22.5%	37.84
Autumn (Mar, Apr, May)	4311	65	58.6%	37.74

Table 5-7 summarises the number of pyretic episodes in different seasons and Figure 3 summarises the mean foal body temperature during the seasons of the year. Table 5-7 also indicates the number of pyretic episodes within each season. Autumn had significantly more pyretic episodes than any other season (p<0.001) with more than double that of summer and this season accounted for more than half the total pyretic episodes (58.6%) and the relative risk of foals developing pyrexia in autumn compared to all other seasons was significantly greater (p<0.0001). The individual seasonal relative risks are illustrated with Table 5-8.
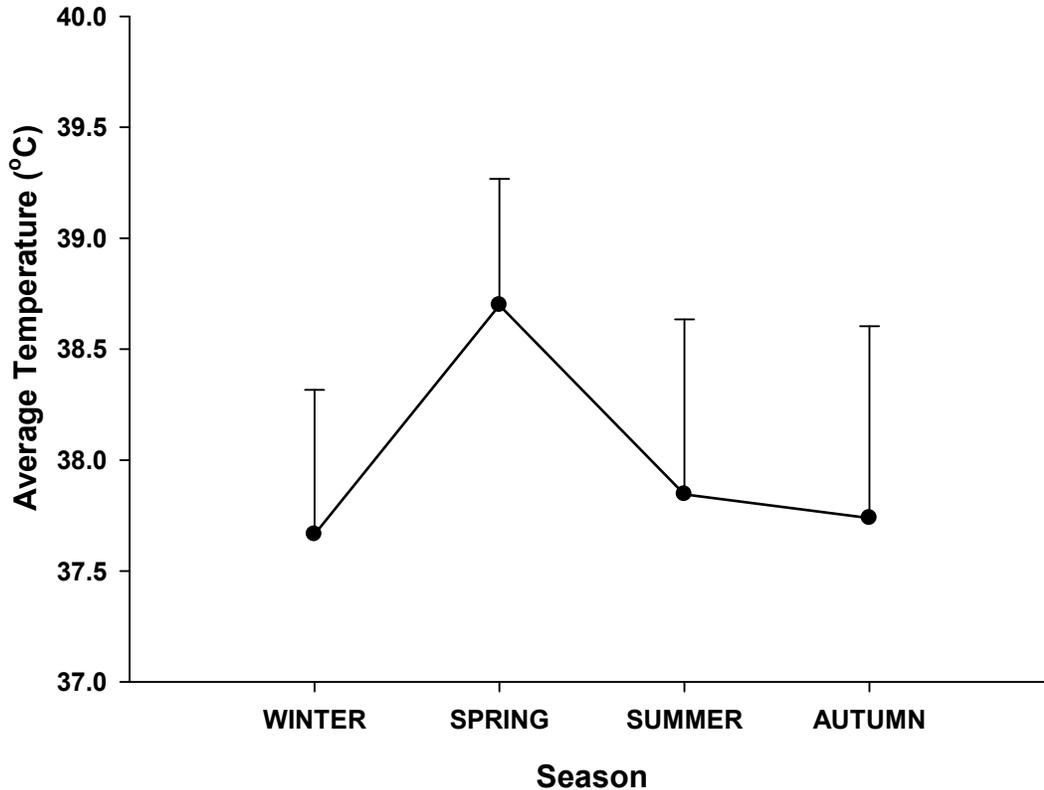
Figure 3: Mean and standard deviations of foal temperature during different seasons

Table 5-8: The relative risk of developing pyrexia within different seasons

Season Comparison	Relative Risk	95% Conf. Interval	p value
Autumn vs. Spring	3.19 times	1.85 – 5.5	<0.0001
Autumn vs. Summer	2.45 times	1.55 – 3.88	<0.0001
Autumn vs. Winter	8.32 times	3.36 – 20.64	<0.0001

5.3.4.　　Coat Colour Associated Data

Table 5-9: Coat colour distribution of pyretic episodes

Coat colour	Total in Group	Count of unique foal occurrences of pyrexia	Percentage
Bay	108	65	60.2%
Chestnut	15	9	60%
Grey	1	0	0%

There was no association between the coat colour of the foal and the risk of having a pyretic episode (p=0.64).

5.3.5. Spatial Data

The layout of Arc-en-Ciel is provided in Appendix 1. Towards the middle of the study fillies and colts were separated and grouped in specific paddocks. There was no significant association found between the location of the foals and pyretic episodes (p>0.2). Figure 4 below gives an indication of which paddocks averaged the highest foal body temperatures on the farm. This graph excludes 197 readings of foals that did not have a location assigned to them when the scanning took place. This was due to the decision to monitor the location of the scan 26 days after the project started (4 August 2007). It also excludes the location "Small Camp Bottom" which only had 1 scan associated with it. That individual reading was 39.9°C.
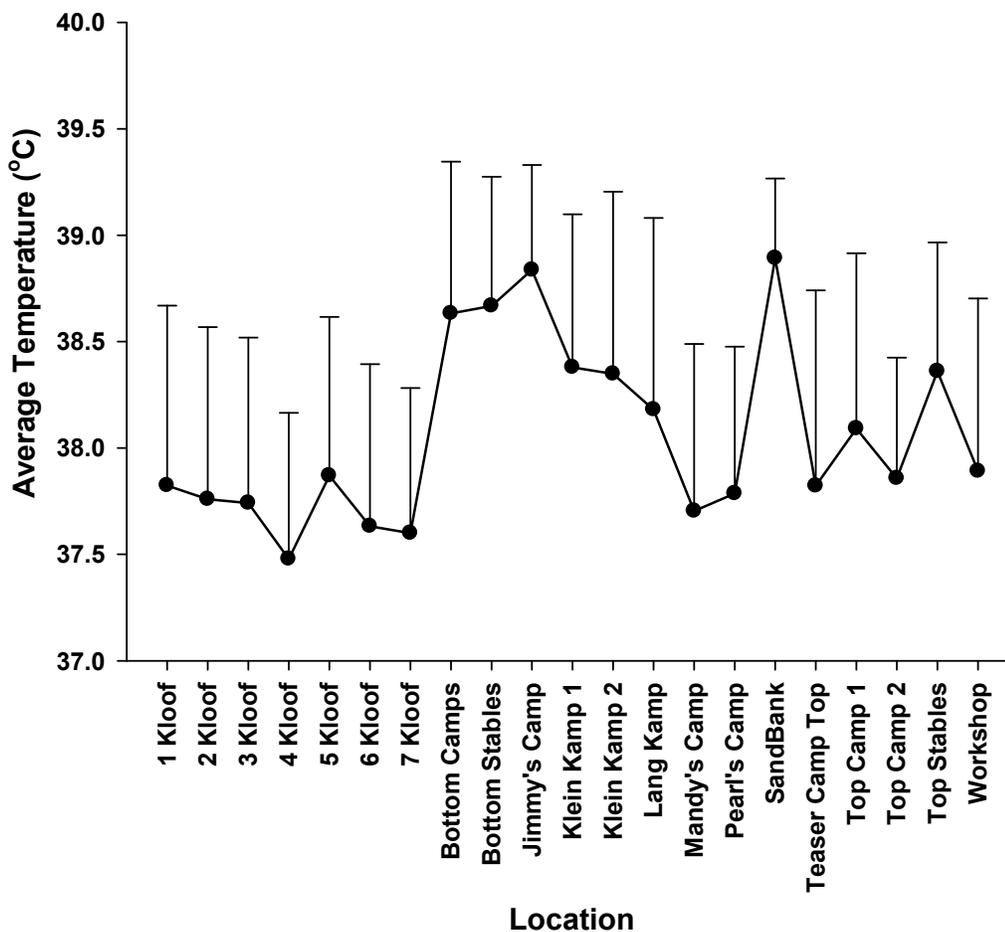
Figure 4: Means and standard deviations of foal temperatures in each different paddock

5.3.6. Age Associated Data

The mean age of the foals 1st pyretic episode was at 119 days old (median 136 days old). The youngest pyretic foal was 5 days old and the oldest at first pyrexia was 253 days old. Since some foals failed to complete the study it is important to note that the mean age of the foals on their last scan was 235 days (median 278 days, mode 283 days). The minimum age of removal from the trial was 4 days old and the maximum age of a foal in the trial was 364 days old. A total of 27 foals (21.6%) were removed from the trial prior to the mean and median age in days of 1st pyrexia.
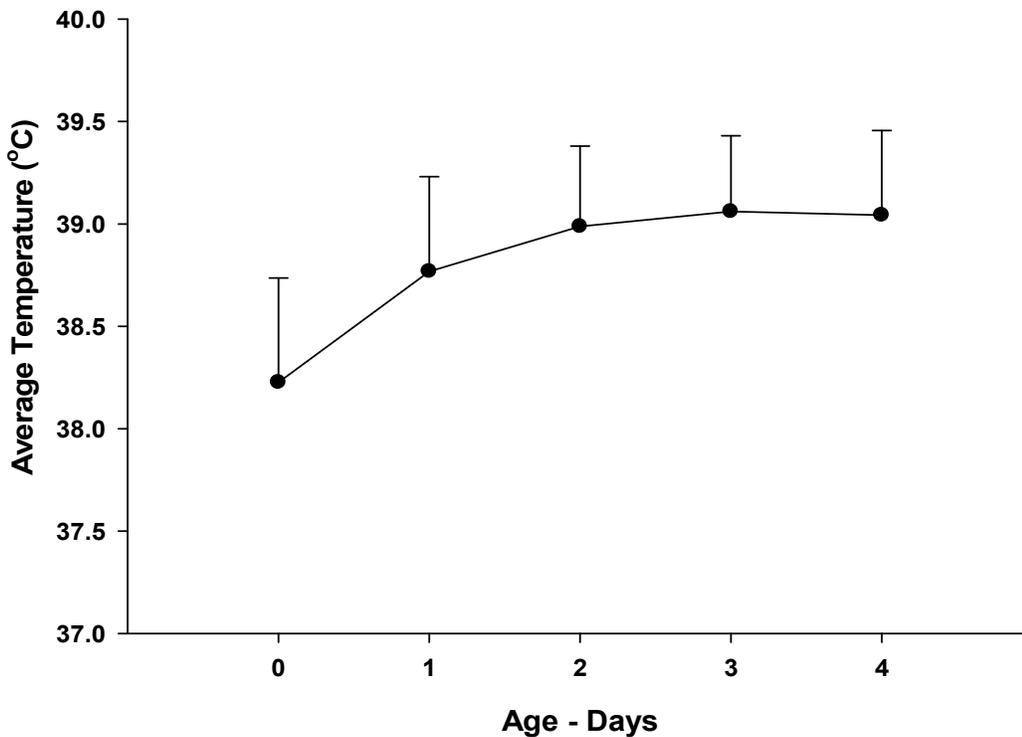
Figure 5: Means and standard deviations of foal temperatures during the first four days of life
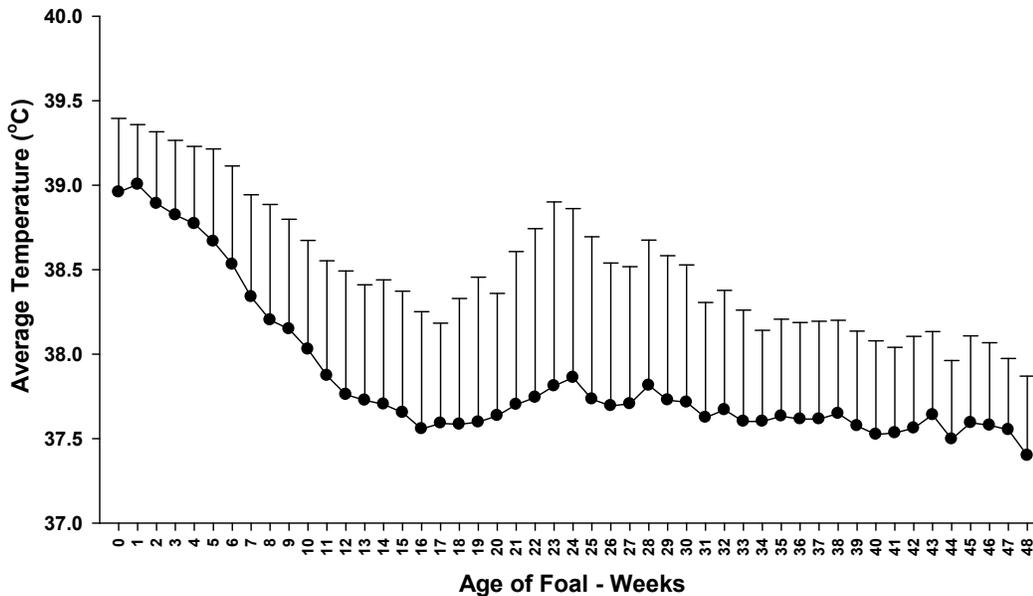
Figure 6: Means and standard deviations of foal temperatures from birth to 48 weeks of age

Figure 5 and Figure 6 give an indication of the mean foal temperatures during the entire study period with Figure 5 specifically illustrating the increase in temperature from day 0 (mean of 38.22˚C) through day 4 (mean of 39.04˚C).

5.3.7. Multivariable Analysis

Three distinct age group categories were evaluated during which distinctly different body temperature trends were seen.

Table 5-10: Effect of age, mean environmental temperature, sex and coat colour on body temperature in foals 0-3 days old

Predictor	Level	*b*	SE of *b*	95% Confidence Interval	p - Value
Age (0 days old = Reference)	1 day	0.533	0.083	0.371,0.696	<0.001
	2 days	0.755	0.083	0.592,0.918	<0.001
	3 days	0.794	0.084	0.630,0.957	<0.001
Sex (Filly = Reference)	Colt	-0.015	0.065	-0.142,0.112	0.815
Coat Colour (Bay = Reference)	Chestnut	0.133	0.097	-0.056,0.323	0.167
	Grey	-0.138	0.420	-0.961,0.685	0.742
Minimum Environmental Temperature		0.017	0.008	0.002,0.033	0.028
Intercept		38.026	0.128	37.774,38.278	0

Table 5-11: Effect of age, mean environmental temperature, sex and coat colour on body temperature in foals 4-118 days old

Predictor	Level	*b*	SE of *b*	95% Confidence Interval	p- Value
Age (days old)		-0.015	0.0002	-0.016,-0.015	<0.001
Sex (Filly = Reference)	Colt	0.033	0.057	-0.078,0.144	0.558
Coat Colour (Bay = Reference)	Chestnut	0.012	0.088	-0.161,0.185	0.894
	Grey	0.355	0.314	-0.261,0.970	0.259
Minimum Environmental Temperature		0.013	0.002	0.009,0.018	<0.001
Intercept		38.952	0.051	38.853,39.052	0

Table 5-12: Effect of age, mean environmental temperature, sex and coat colour on body temperature in foals 119-342 days old

Predictor	Level	*b*	SE of *b*	95% Confidence Interval	p- Value
Age (days old)		0.002	0.0002	0.002,0.003	<0.001
Sex (Filly = Reference)	Colt	0.047	0.073	-0.097,0.191	0.523
Coat Colour (Bay = Reference)	Chestnut	-0.116	0.119	-0.351,0.119	0.333
	Grey	-0.008	0.359	-0.712,0.697	0.983
Minimum Environmental Temperature		0.037	0.002	0.032,0.041	<0.001
Intercept		36.621	0.087	36.450,36.793	0

The multivariable analysis summarised in Table 5-10 through Table 5-12 indicates that there is a significant association between age of foal and body temperature. During the first 3 days of life there is a significant increase in body temperature between zero days old and 1,2 or 3 days old respectively.(p<0.001). There was also a significant increase in body temperature between one day and two day old foals (p<0.001). From four days old to 118 days old there was a mild but significant decrease in temperature as age increased (p<0.001) while from 119 days old through to 342 days old there was a very mild but significant increase in body temperature as age progressed (p<0.001). Throughout the analysis there was a very mild but significant increase in body temperature associated with an increase in the minimum daily environmental temperature.

5.4.   Discussion

To date, there are no published reports on the temperature trends of foals from birth to post-weaning. The present study is novel due to its duration, the non-invasive technique used to measure temperature and the electronic data collection and input system used.

As no information was available reporting the number of pyretic episodes expected during such a study, an estimate was made of 1 pyretic episode per foal over the study period. This estimate was relatively accurate as

we had 111 pyretic episodes out of the total of 124 horses within the trial period (excluding the 3 horses removed from analysis due to microchip precision discrepancies). Each foal therefore had an average of 0.9 pyretic episodes within the trial period. However 50/124 foals did not have a single pyretic episode and therefore there were an average of 1.5 pyretic episodes per foal in foals that had pyrexia.

The distinct difference between the value pyretic events versus the statistical pyretic events is due to the combination of the requirements of the latter. The reason for this is that a high number of compact (relatively low series standard deviation) pre-reading scans are required for statistical pyrexia to be evident and also the set value of the standardised score cut-off has a direct influence on the likelihood of statistical pyrexia. This is discussed in more detail within Chapter 4.

An unexpected finding was the high percentage of pyretic episodes that consisted of a single pyretic event and which lasted only 1 day. A possible cause for this is the fact that no interference was made with regard to treatment of trial animals and when pyretic events were identified the farm management was notified. There were a documented 29 treatments of pyretic episodes with anti-inflammatory drugs and it is realistic that more than these were performed. This may thus account for the high percentage of single pyretic events within pyretic episodes.

The significant difference between pyretic associated scans and non-associated scans is biologically expected. This association was still found to be significant (p<0.001) even after the actual pyretic scan was removed from the associated pyretic scans. This shows that the temperatures two days on either side of pyrexia are significantly higher than normal.

The risk of fillies developing pyrexia based on our pyretic criteria was significantly greater than in colts. The reason for this difference between colts and fillies is not certain. No literature could be found that specifically deals with the risk of specific sexes of mammals developing pyrexia.

The significance of the relative risk of foals developing pyrexia, based on our criteria, in autumn compared to other months was due to pyrexia associated with an equine encephalosis outbreak within the foal cohort. A total of 37 of 44 pyretic episodes over 3 weeks in March/April were due to equine encephalosis based on viral isolation results (see Chapter 6 for more information).

The 6 paddocks with the highest mean foal temperature were all located on the lower regions of the farm (see Appendix 1). This is also where the younger foals were kept so the increased temperature means in the younger foals may have influenced this as they remained in the bottom farm until they were close to weaning later on in the year. This would make sense as the "Workshop" paddock, which is geographically associated with the lower

farm, was treated as a paddock for older foals like the top farm paddocks, and the mean temperature of the foals in the "Workshop" paddock was less than the foals in the other bottom farm paddocks.

The age vs. mean body temperature graphs show distinct patterns. The core temperatures of sheep and their lambs from prepartum through partus to 5 weeks post partus have been measured. Immediately after birth the lamb core temperature fell up to 4.5°C but then increased and exceeded maternal temperatures within 24 hours of birth[16]. Although our study did not include prepartum measurements of temperature, we believe the increase in temperature over the first 3-4 days of life in the foals is due to the low starting point due to the sudden environmental change following partus and then, as suggested by Symonds et al. the high metabolic rate associated with the immediate post-partum period[48]. The increasing temperature seen in lambs shortly after birth is not only associated with changes in the metabolic rate but thermoregulatory mechanisms (both non-shivering as in brown fat activation as well as shivering and vasoconstriction) exist to recover the temperature post-partum[8,35]. Although the mentioned studies were associated with lambs, it makes biological sense that foals would follow similar trends based on similar high levels of neonatal maturity.

Our proposed reason for the decreasing mean temperature from day 4 to day 118 is that it shows a stabilising of body temperature within foals to mature levels. Why the drop is gradual and over 114 days may be due to the decreasing metabolic rate of the foals from the initial peak post partum to a mature basal metabolic rate. Foals attain 46, 67 and 80% of mature weight at 6, 12 and 18 months respectively, and the early growth in foals is rapid as they gain 110kg during the first 90 days, 75 kg in the second 90 days and then 60 and 45 kg in the following 90 day periods respectively[25,52]. It follows therefore that although the growth rates are positive during the first 18 months the rate of growth decreases from the initial high level. We postulate therefore that as the growth rate decreases, the metabolic rate also decreases from the high level attained post partum. This possibly then leads to a decreasing core temperature which is not sudden due to the fact that the metabolic rate is still relatively high. From day 118 to approximately 48 weeks of age the mean temperature flattened significantly although there was still a significant but mild increase in daily body temperature mean. We postulate that this section correlates to the normal adult temperature patterns of Thoroughbred horses.

In the mixed effects multiple regression analysis the ambient daily minimum temperature was significantly associated with the daily foal mean temperatures in all 3 age group sections of interest. Within the first 3 days of life an increase in 1°C in the environmental minimum temperatures was associated with a 0.017°C increase in foal mean body temperature taking the age association into consideration. This is compared to a 0.013°C increase in the 4-118 day section and then a 0.037°C increase in the >118 day cohort. The definitions and temperature levels within equine thermal neutral zones has been reviewed[36]. The general estimate of the equine thermal neutral zone is found to be between 5 and 25°C and up to 30°C based on definition. The daily minimum temperatures of the environment based on the South African Weather Service throughout the trial fell between 5 and 26.5°C and only 2 days had daily minimums of greater than or equal to 25°C. It may take 4 - 8 weeks for

lambs to regulate their body temperatures in patterns similar to that of adults[16,42]. This indicates therefore that although thermoregulatory processes may be evident in foals and other mammals which have a high level of maturity at birth, the ambient temperature still has an influence on mean body temperature irrespective of thermoregulatory processes.

5.5. Conclusion

The actual temperature means described must be used with caution due to the poor agreement between these and rectal temperature means (see 4.3 above). This said the data presented are significant in terms of patterns of foal temperature and pyrexia from birth to post-weaning, and a greater understanding of these patterns is attained. The use of microchips to attain temperature data allowed the collection of such a vast quantity of data over an extended period of time from a large sample cohort. This methodology may thus be useful in future to monitor various other biological variables from large sample cohorts.

Chapter 6.   Epidemiology of an Equine Encephalosis outbreak in Thoroughbred foals on a stud farm in the Western Cape Province, South Africa

6.1.   Introduction

Equine encephalosis (EE) is a vector transmitted disease of equines transmitted by *Culicoides* midges[40] causing clinical signs which include inappetence, fever, mucous membrane congestion and icterus. The disease has a mild to sub-clinical mainifestation[9] although in some cases the clinical signs may be similar to those seen in some cases of African horse sickness (AHS)[27].   The viraemia is short-lived and horses do not act as carriers of the virus[15]. The mortality rate is less than 5%[27].

Although the first historical description of EE in South Africa was in 1967[15], it is speculated that when Theiler described what he called Equine Ephemeral Fever[49] he was describing a case of EE[23]. Seven different serotypes of equine encephalosis virus (EEV) have been identified in southern Africa, and are assigned as numerical isolates, viz. serotype 1 (Bryanston), serotype 2 (Cascara), serotype 3 (Gamil), serotype 4 (Kaalplaas), serotype 5 (Kyalami), serotype 6 (Potchefstroom) and serotype 7 (E21/20)[26]. The EEV is very similar in morphology, cytopathology and clinical manifestation to African horse sickness virus (AHSV), but genomic probe techniques in a study by Viljoen et al. found that EEV is more closely related to bluetongue (BTV) and epizootic hemorrhagic disease virus (EHDV) than it is to AHSV[15,54]. Phylogenetic analysis has also revealed that BTV is more closely related to AHSV compared to the relationship between EEV and AHSV[47].

EEV is transmitted by a number of different species of *Culicoides* midges and there are EEV vector competent populations of these midges circulating in the Western Cape Province[40,50,53]. South Africa has a high prevalence of circulating EEV antibody and it has been shown that all 7 serotypes of EEV have been prevalent within the Western Cape Province[26,28,40].

To date no prospective study of the clinical manifestations of EE under field conditions has been published. This study provides prospective data on the pyrexia and clinical manifestation of EE in Thoroughbred foals during an outbreak of EE.

6.2.   Materials and Methods

6.2.1.   Data Collection

Data collection included a total of 9556 temperature scans from the initial scan on 6th August 2007 up to and including scans on the 30 April 2008. The total temperature scans during the infection period of 15 March 2008 to 30 April 2008 included 2526 scans from 93 foals. Twenty-eight foals had been withdrawn from the trial prior to the outbreak due to various reasons while 6 foals were removed during the outbreak. Two of these 6 were removed due to impossibility of handling, 1 was sold and taken from the farm and 3 died: 1 from suspected *Lawsonia* induced diarrhoea, 1 was euthanased due to a fractured leg and 1 died for unknown reasons, even after an extensive post mortem was performed. In this case EE was excluded as a cause of death.

Scanning data was collected in the paddocks of the foals. Effort was made to collect the data prior to feeding, and temperature scanning began at approximately 7:00 am every morning and it took between an hour and an hour and a half to complete the group of foals.

6.2.2.   Sample Collection

Serum samples were collected from foals on a monthly basis based on foal age. Samples were collected by jugular venipuncture into vacuum tubes without anticoagulant. Samples were stored at 4°C in a standard refrigerator and were sent to the Equine Research Centre (University of Pretoria) at regular intervals for centrifugation and storage.

Blood samples for viral isolation were taken during the then suspected outbreak period from 28 March 2008 to 18 April 2008. These samples were collected by jugular venipuncture into heparinised (Becton Dickenson Vacutainer™ 102 I.U. LH) vacuum tubes and stored at 4°C in a standard refrigerator.

6.2.3.   Virological Methods

Virus isolation was performed as described by Quan et al.[47]. Heparinised blood samples were centrifuged at 440g for 10-15 minutes; the buffy coat harvested and stored at -80°C. The processed buffy coat was thawed and then inoculated onto a confluent monolayer of BHK-21 cells in 25 cm^3 tissue culture flasks. The cell cultures were then observed daily for any cytopathic effects (CPE). Blood cells were washed off after 3 days and the medium replaced. Cultures showing no CPE after 10 -14 days were passaged by inoculating a freshly prepared BHK-21 monolayer with 0.2-0.5 ml of the culture. Cultures showing no CPE after 3 passages were defined as negative for EEV. The cells and supernatant were harvested from cultures showing 100% CPE of the monolayer

or where the monolayer had detached from the flask surface due to degeneration. This was then identified as EEV by a group specific antigen capture ELISA which tests for EEV antigen[9].

The serotype of the EEV from the heparin samples was determined by a type specific plaque inhibition neutralization test after the technique described by Porterfield[46] and modified as described by Quan et al.[47] in which electrical insulating fish-spine beads filled with type specific antiserum were used to indicate homologous virus-antibody neutralization of viral inoculated Vero cells.

6.2.4.   Serological Methods

Group specific ELISA's were performed on serum samples collected from foals as part of the monthly routine collections during the post outbreak months of May, June and July. These ELISA's were performed on the principles described for AHS antibody detection by Maree et al.[34]. Due to the prolonged period between sample collection and centrifugation and storage, many samples had haemolysed, so samples from each horse collected in the post April period were evaluated macroscopically and the most viable were chosen for testing. A minimum of 1 and a maximum of 2 samples per individual foal were chosen from the post 30 April 2008 samples. This testing was to evaluate whether foals had been exposed to EEV after the expected maternal antibody levels had waned. Although any titre over 10 is considered positive we treated cases with a titre of less than 25 with suspicion. May samples which tested positive and were greater than 20 were seen as cases due to the possibility of rising titre levels existing due to the close temporal association with the EEV outbreak in March/April.

Based on the results seen these ELISA assays provided impetus to further test all pre and post-outbreak samples using a type specific serum neutralizing assay described by Howell et al.[26]. The pre-outbreak samples were selected from foal samples collected between 1 January 2008 and 15 March 2008. Again a minimum of 1 sample per foal in the study was evaluated with a maximum of 2 samples per foal evaluated. Post outbreak samples were the same samples as used for the ELISA assay.

6.2.5.   Case Definition

Equine encephalosis cases that occurred in 2008 during the March and April period of the study were identified by one or both of the following two criteria: 1. positive EEV isolation results from whole blood samples collected during foal pyrexia that occurred during the outbreak and 2. Seroconversion results to EEV using ELISA and SNT assays.

The second case type made use of sera which were routinely taken from foals on a monthly basis. Both ELISA and SNT results were evaluated and cases were defined as positive by any post outbreak antibody titre greater than 10 in the case of the ELISA results and in the case of the SNT any seroconversion to EEV antibody based on a fourfold titre increase between serum samples collected prior to the 15th March 2008 and samples collected after the 30th April 2008.

6.2.6.   Statistical Methods

Data were evaluated using Chi-squared tests of association using NCSS (2004 Kaysville UT, USA) software. An α value of < 0.05 was considered significant.

6.3.   Results

Table 6-1: Viral isolation and serotyping results of samples collected from pyretic foals during the EE outbreak

Outbreak pyretic episodes	Outbreak pyretic episodes adequately sampled for viral isolation	Viral Isolation		c-ELISA		Plaque Inhibition Test		
		Virus Recovered		EEV Positive		Serotype 4		
		Yes	No	Yes	No	Yes	No	% Serotype 4
53	44	37	7	37	7	37	0	100%

Of the viral isolations performed 84% (n=37) were positive to EEV and all 37 positive samples were typed as Serotype 4 EEV.

Table 6-2: ELISA results of post EE outbreak samples

ELISA Case result	Number of Foals	Percentage
Positive	59	63%
Negative	9	10%
Low/Alternating Titres	22	24%
Not Tested	3	3%

The group specific ELISA results showed that 63% (n=59) of foals showed a positive titre to EEV with 10% (n=9) showing a negative result from samples tested between 1 May 2008 and 31 July 2008. A relatively high percentage (24%) produced inconclusive results, which along with the high positive exposure rate, prompted a complete set of pre and post outbreak seroconversion testing using the type specific serum neutralising assay.

Table 6-3: SNT results – Seroconversion over the EE outbreak period

SNT Case result	Number of Foals	Percentage
Positive	84	90%
Negative	0	0%
Possible Exposure	6	6%
Not Tested	3	3%

The SNT results showed an extremely high percentage of foals (93% n=84) seroconverting to EEV over the outbreak period from 15 March to 30 April 2008. All positive results were shown to be serotype 4 EEV which was the same serotype found in the outbreak viral samples.

Based on results from all 3 types of assays performed viz. viral isolation and typing, group specific ELISA's and type specific SNT's a total of 87/93 foals (94%) seroconverted or were viral isolation positive to EEV serotype 4 over the mid March to end of April 2008 period. Of the 6 EEV case negative foals 1 foal had a definite positive ELISA result, however it is excluded from the 87 positive foals above based on inconclusive SNT results. Although this foal did have a pyretic episode within the outbreak it was not tested using viral isolation methods. All of the remaining 5 foals which were not conclusively positive to EEV based on any of the 3 assays used were also not conclusively negative based on the SNT assay, and all these foals showed results which either indicated a mixed serotype infection to EEV or showed a likelihood of possible but not certain exposure to EEV serotype 4. It is due to this fact that the 94% incidence of EEV exposure following maternal antibodies is if anything still a conservative estimate and it is likely that the incidence was greater than this.

Inconsistencies within the test results did occur. Three foals which had tested positive using viral isolation methods were later found to have negative titres on their ELISA assays on their post outbreak serum. All 3 were however found to have positively seroconverted to EEV type 4 based on the SNT results. It is due to this fact that these foals are included as cases in the EEV infection investigation. Six foals tested negative for EEV using the aforementioned viral isolation methods and then were positive based on the SNT results. In this scenario it is a possibility that they became infected with EE after their initial pyretic episode and that episode was not due to EEV. Alternatively the viral isolations of these foals may have provided false negative results.

During the outbreak 3 foals died and of these foals one died of unknown causes. The macroscopic post mortem was negative and no cause of death could be established after histopathology was performed. This foal did not have a pyretic episode and clinical signs associated with EEV were not observed.

It was not possible to associate risk factors such as location on the farm, coat colour and sex with EEV infection due to the fact that no association could be made between pyretic episodes and the risk of EEV infection as well as due to the high infection rate of EEV amongst the foals.

During the period 15 March 2008 to 30 April 2008 53/93 (57%) foals had at least 1 pyretic event based on the pyretic criteria used.

6.4. Discussion

Our study showed a very high rate of infection with subsequent seroconversion to EEV which is similar to the results found in other seroepidemiological studies performed throughout South Africa where seroprevalence was found to be 77%[40] and 84%[28]. The high incidence found in our study using foals indicates that the Thoroughbred population in the Western Cape Province are being infected and are seroconverting if exposed to EEV during the first autumn season after birth.

EE has been described as a mild to subclinical disease[9] and in some cases shows signs similar to AHS[27]. Our study evaluated the pyretic foals which were subsequently found to be EEV positive on isolation and in these foals the only overt clinical sign seen was the pyrexia. The fact that only 43% of foals showed clinical signs of pyrexia in the face of a 94% infection rate confirms the mild to subclinical nature of EE. There were zero mortalities due to EE during the outbreak, and this is similar to the less than 5% mortality rate defined by Coetzer et al[27]. The clinical signs observed during this outbreak appear to be very similar to those reported in the outbreak of EE in Israel in 2008 involving approximately 150 cases with no mortalities[6]. The outbreak of EEV serotype 1 in the Western Cape in 2007 caused 18 deaths[55] and this high mortality rate compared to the mortality rate and subclinical disease rate experienced in our study indicates there may have been other factors involved during that outbreak and it is unlikely that EE was the main determinant in the deaths of those horses.

The maintenance mechanism and vector of EEV plays an important role in determining the distribution of individual serotypes of EEV[26] and Howell et al. in 2002 noted that serotype 2 was then being maintained at low levels while serotype 6 and 7 levels may have be on the ascendancy[26]. The outbreak described concurs with this as we found that EEV serotype 4 was the exclusive isolate from our samples which indicates a shift from previous serotypes in previous years. To further support this statement the outbreak in 2007 in the Western Cape Province was ascribed to EEV serotype 1[55] and Howell et al. suggest that there is a decrease in homologous seroconversion of a specific serotype of EEV following 1 to 2 seasons of that serotype predominating in a specific area[28].

This study has also confirmed that maternal antibody transfer of EEV antibody has little effect on the likelihood of EEV infection, most likely due to the variable maternal antibody serotype[28] as well as waning maternal antibody levels prior to the March/April period, during which the likelihood of infection is high due to the vector associated factors of the disease. Using the maximum SNT antibody titres of each foal prior to the infection period as an

indication of maternal antibody titres, it was found that 62% (n=56) of the 90 foals tested were completely negative for EEV serotype 4 antibody while a further 16% (n=14) had antibody titres less than 20.

Overall, irrespective of the aetiology of pyretic episodes between 15 March 2008 and the 30 April 2008, 87 of 93 foals were found to be positive to, or seroconverted to, EEV serotype 4. Furthermore, 53 of the same 93 foals had a pyretic episode over this period based on the chosen criteria of pyrexia. Even if every pyretic episode observed over the period under scrutiny was due to EEV it was found that there is no significant association between the clinical feature of pyrexia and the risk of infection of EEV serotype 4 (p>0.3). If, for the sake of completeness, all pyretic episodes from the 15 March 2008 right through to the 31 July 2008 were assumed to be due to EEV, still no association between pyrexia and EEV serotype 4 infections could be made (p>0.3). It is thus found that the infection rate of EEV serotype 4 is very high and the use of pyrexia as an indication of infection is not valid as many more cases are sub-clinical than generally believed. In total during the 2008 segment of the project there were 79 pyretic episodes and 53 of these fell within the suspected EEV infection period. It is likely therefore that EEV was the cause of the majority of these pyretic episodes (37/44 pyretic episodes were shown to be due to EEV) but the fact still remains that many foals were infected by EEV but did not show pyrexia as a clinical sign. This study shows that EEV infection is on the whole a sub-clinical infection where, although pyrexia may be an indication of disease, many cases do not exhibit this clinical sign. It also showed the incidence of EEV is extensive and the risk of infection once EEV is found to be prevalent is very high.

Chapter 7.   General Conclusions

This study has shown that a practical system of temperature monitoring is possible using a fully computerised system for the input of frequent body temperatures of horses. Within that system the identification and flagging of pyrexia may be based on user selected criteria. The software is in place but it has been found that the shallow read depth of the temperature sensitive microchip scanners creates difficulties when scanning adult horses whose microchip is further from the skin due to neck growth (Guthrie unpublished data). If the technology development in this field improves to allow a deeper read depth while continuing to emit temperature data, a system like the one undertaken in the study will be of benefit to any equine breeder, trainer or owner. Once the systems and microchips are in place the work does not require a veterinarian or any professional person and can be undertaken by any suitably trained lay person.

The temperature data collected and the possible future use of this system promotes an accurate and relevant early warning system to disease outbreak and may be a functional tool for epidemiological investigations. More study is required to understand the relationship between microchip temperature and the more traditional rectal temperature readings. It is also important to realise that there is a percentage (albeit low) of microchips which may fail to work after a period of time or will give readings which may be deemed too variable to accurately assess. This must be taken into consideration when embarking on studies which use microchips to evaluate not only temperature data but other clinical variables in future.

The temperature trends of Thoroughbred foals from birth to post-weaning have also been described for the first time with data extending over a greater length of time than other studies as well as using a relatively large sample population. These trends showed that there are distinct age associated body temperature trends with an increase in body temperature over the first 3 days of life, a steady decline in temperature from day 4 through day 118 and then a stabilisation of body temperature from day 119 through day 342. It was also found that environmental temperature had a mild but significant influence on foal body temperature.

The data and conclusions arrived at during the prospective study of pyrexia during the EE outbreak is valuable due to the confirmation of the subclinical to mild nature of this vector borne disease. This is especially relevant with the current outbreak and spread of Bluetongue Virus throughout Europe, the outbreak of EE in Israel in 2009 and the AHS control in the Western Cape Province, as these diseases share similar aetiologies and vector borne transmission properties.

Chapter 8.   References

1. Ammons S F, Threlfall W R, Kline R C 1989 Equine body temperature and progesterone fluctuations during estrus and near parturition. *Theriogenology* 31: 1007-1019

2. Bland J M, Altman D G 1986 Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1: 307-310

3. Blatteis C M 2003 Fever: pathological or physiological, injurious or beneficial? *Journal of Thermal Biology* 28: 1-13

4. Blatteis C M 2006 Endotoxic fever: New concepts of its regulation suggest new approaches to its management. *Pharmacology & Therapeutics* 111: 194-223

5. Bu L H, Lephart E D 2005 Effects of dietary phytoestrogens on core body temperature during the estrous cycle and pregnancy. *Brain Research Bulletin* 65: 219-223

6. Chaimovitz, M. 2009 Equine Encephalosis, Israel Online at: http://www.oie.int/wahis/public.php?page=event_summary&reportid=7957 (accessed 2009/05/21)

7. Chan V K, Meija E 2002 Method and apparatus for sensing and transmitting a body characteristic of a host. Patent Number 7015826

8. Clarke L, Buss D S, Juniper D T, Lomax M A, Symonds M E 1997 Adipose tissue development during early postnatal life in ewe-reared lambs. *Experimental physiology* 82: 1015-1027

9. Crafford J E, Guthrie A J, van Vuuren M, Mertens P P, Burroughs J N, Howell P G, Hamblin C 2003 A group-specific, indirect sandwich ELISA for the detection of equine encephalosis virus antigen. *Journal of Virological Methods* 112: 129-135

10. Cross D T, Threlfall W R 1995 Effect of oxytocin and prostaglandin F2[alpha] on body temperature in horse mares. *Journal of Equine Veterinary Science* 15: 421-422

11. Cross D T, Threlfall W R, Kline R C 1991 Telemetric monitoring of body temperature in the horse mare. *Theriogenology* 36: 855-861

12. Dantzer R, Bluthe R M, Gheusi G, Cremona S, Laye S, Parnet P, Kelly K W 1998 Molecular basis of sickness behavior. *Annals of the New York Academy of Sciences* 856: 132-138

13. Dinarello C A 1999 Cytokines as endogenous pyrogens. *Journal of Infectious Diseases* 179: S294-S304

14. Dinarello C A 2004 Infection, fever, and exogenous and endogenous pyrogens: some concepts have changed. *Journal of Endotoxin Research* 10: 201-222

15. Erasmus B J, Adelaar T F, Smit J D, Lecatsas G, Toms T 1970 The isolation and characterization of equine encephalosis virus. *Bulletin de l'Office International des Epizooties* 74: 781-789

16. Faurie A S, Mitchell D, Laburn H P 2004 Peripartum body temperatures in free-ranging ewes (*ovis aries*) and their lambs. *Journal of Thermal Biology* 29: 115-122

17. Gallaher E J, Egner D A, Swen J W 1985 Automated remote temperature measurement in small animals using a telemetry/microcomputer interface. *Computers in Biology and Medicine* 15: 103-110

18. Ganong W F 1991 *Review of Medical Physiology* (15 edn). Appleton & Lange, Connecticut

19. Gay N J, Keith F J 1991 Drosophila Toll and IL-1 Receptor. *Nature* 351: 355-356

20. Green A R, Gates S G, Lawrence L M 2005 Measurement of horse core body temperature. *Journal of Thermal Biology* 30: 370-377

21. Green A R, Gates R S, Lawrence L M, Wheeler E F 2008 Continuous recording reliability analysis of three monitoring systems for horse core body temperature. *Computers and Electronics in Agriculture* 61: 88-95

22. Guthrie A J, Lund R J 1998 Thermoregulation - Base mechanisms and hyperthermia. *Veterinary Clinics of North America: Equine Practice* 14: 45-59

23. Guthrie A J, Pardini A D, Howell P G 2009 Equine encephalosis. *Equine Veterinary Education* Manual 8 (In Press)

24. Hart B L 1991 The behavior of sick animals. *Veterinary Clinics of North America: Small Animal Practice* 21: 225-237

25. Hintz H F, Hintz R L, Van Vleck L D 1979 Growth rate of Thoroughbreds, effect of age of dam, year and month of birth, and sex of foal. *Journal of Animal Science* 48: 480-487

26. Howell P G, Groenewald D, Visage C W, Bosman A M, Coetzer J A W, Guthrie A J 2002 The classification of seven serotypes of equine encephalosis virus and the prevalence of homologous antibody in horses in South Africa. *Onderstepoort Journal of Veterinary Research* 69: 79-93

27. Howell P G, Guthrie A J, Coetzer J A W 2004 Equine Encephalosis. In Coetzer J A W, Tustin R (eds) *Infectious Diseases of Livestock.* Oxford University Press*,* Cape Town: 1247-1251

28. Howell P G, Nurton J P, Nel D, Lourens C W, Guthrie A J 2008 Prevalence of serotype specific antibody to equine encephalosis virus in Thoroughbred yearlings in South Africa (1999-2004). *Onderstepoort Journal of Veterinary Research* 75: 153-161

29. Kent S, Bret-Dibat J L, Kelley K W, Dantzer R 1996 Mechanisms of sickness-induced decreases in food-motivated behavior. *Neuroscience and Biobehavioral Reviews* 20: 171-175

30. Kluger M J, Kozak W, Conn C A, Leon L R, Soszynski D 1998 Role of Fever in Disease. *Annals of the New York Academy of Sciences* 856: 224-233

31. Koterba A M 1990 Physical examination. In Koterba A M, Drummond W M, Kosch P C (eds) *Equine Clinical Neonatology.* Lea & Febiger*,* Philadelphia: 71-83

32. Laburn H P 1974 Prostaglandin E1 and fever. *South African Medical Journal* 0: Suppl 40-1

33. Laburn H P, Rosendorff C, Willies G, Woolf C 1974 Proceedings: A role for noradrenaline and cyclic AMP in prostaglandin E1 Fever. *The Journal of Physiology* 240: 49-50

34. Maree S, Paweska J T 2005 Preparation of recombinant African horse sickness virus VP7 antigen via a simple method and validation of a VP7-based indirect ELISA for the detection of group-specific IgG antibodies in horse sera. *Journal of Virological Methods.* 125: 55-65

35. Mercer J B, Andrews J F, Székely M 1979 Thermoregulatory responses in new-born lambs during the first thirty-six hours of life. *Journal of Thermal Biology* 4: 239-245

36. Morgan K 1998 Thermoneutral zone and critical temperatures of horses. *Journal of Thermal Biology* 23: 59-61

37. Morgan K 1997 Effects of short-term changes in ambient air temperature or altered insulation in horses. *Journal of Thermal Biology* 22: 187-194

38. Ochi M, Sono S, Sei H, Oishi K, Kobayashi H, Morita Y, Ishida N 2003 Sex difference in circadian period of body temperature in Clock mutant mice with Jcl/ICR background. *Neuroscience Letters* 347: 163-166

39. Ousey J C, McArthur A J, Rossdale P D 1997 Thermoregulation in sick foals aged less than one week. *The Veterinary Journal* 153: 185-196

40. Paweska J T, Venter G J 2004 Vector competence of Culicoides species and the seroprevalence of homologous neutralizing antibody in horses for six serotypes of equine encephalosis virus (EEV) in South Africa. *Medical and Veterinary Entomology* 18: 398-407

41. Piccione G, Assenza A, Costa A, Borruso M, Fazio F, Caola G 2005 Monitoring of some physiological parameters during the first 30 days of a foal's life. *Medycyna Weterynaryjna* 61: 1142-1144

42. Piccione G, Caola G, Refinetti R 2002 Maturation of the daily body temperature rhythm in sheep and horse. *Journal of Thermal Biology* 27: 333-336

43. Piccione G, Caola G, Refinetti R 2002 The circadian rhythm of body temperature of the horse. *Biological Rhythm Research* 33: 113-119

44. Piccione G, Caola G, Refinetti R 2005 Temporal relationships of 21 physiological variables in horse and sheep. *Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology* 142: 389-396

45. Plata-Salaman C R 1998 Cytokine-induced anorexia: Behavioral, cellular, and molecular mechanisms. *Annals of the New York Academy of Sciences* 856: 160-170

46. Porterfield J S 1960 A simple plaque-inhibition test for the study of arthropod-borne viruses. *Bulletin of the World Health Organisation* 22: 373-380

47. Quan M, van Vuuren M, Howell P G, Groenewald D, Guthrie A J 2008 Molecular epidemiology of the African horse sickness virus S10 gene. *Journal of General Virology* 89: 1159-1168

48. Symonds M E, Bird J A, Clarke L, Gate J J, Lomax M A 1995 Nutrition, temperature and homeostasis during perinatal development. *Experimental Physiology* 80: 907-940

49. Theiler A 1909 Notes on a fever in horses simulating horse-sickness. *Transvaal Agricultural Journal* 8: 581-586

50. Theodoridis A, Nevill E M, Els H J, Boshoff S T 1979 Viruses isolated from Culicoides midges in South Africa during unsuccessful attempts to isolate bovine ephemeral fever virus. *Onderstepoort Journal of Veterinary Research* 46: 191-198

51. ThinkQuest 2008 The p-n Junction Diode. In Anon. (eds) *Basic Electronics.* ORACLE ThinkQuest, Internet Publication

52. Thompson K N 1995 Skeletal growth rates of weanling and yearling thoroughbred horses. *Journal of Animal Science* 73: 2513-2517

53. Venter G J, Koekemoer J J, Paweska J T 2006 Investigations on outbreaks of African horse sickness in the surveillance zone in South Africa. *Revue Scientifique et Technique* 25: 1097-1109

54. Viljoen G J, Huismans H 1989 The characterization of equine encephalosis virus and the development of genomic probes. *Journal of General Virology* 70: 2007-2015

55. Wolhuter M J 2007 Press Statement: Horse Movement Control - Western Cape Province.

56. Woodward T E 1997 The fever pattern as a diagnostic aid. In Mackowiak P A (eds) *Fever: Basic Mechanisms and Management.* Lippincott-Raven*,* Philadelphia

57. Yang R B, Mark M R, Gray A, Huang A, Xia M H, Zhang M, Goddard A, Wood W I, Gurney A L, Godowski P J 1998 Toll-like receptor-2 mediates lipopolysaccharide-induced cellular signalling. *Nature* 395: 284-288

58. Zambelli A B 2007 A comparison of the effects of packed red blood cell transfusion and Oxyglobin in canine babesiosis. MMedVet(Med), University of Pretoria

59. Zartman D L, Hallford D M, Tierney L A, Hussain M Y 1983 Reproductive characteristics of Holstein heifers fitted with intravaginal temperature transmitters. *Theriogenology* 19: 541-554

60. Zartman D L, Dealba E 1982 Remote temperature sensing of oestrous cycles in cattle. *Animal Reproduction Science* 4: 261-267

61. Zurbuchen J M 2000 Precision Thermistor Thermometry. *Measurement Science Conference Tutorial* 2-6

Appendices

Appendix 1.   Arc-en-Ciel Paddock Locations
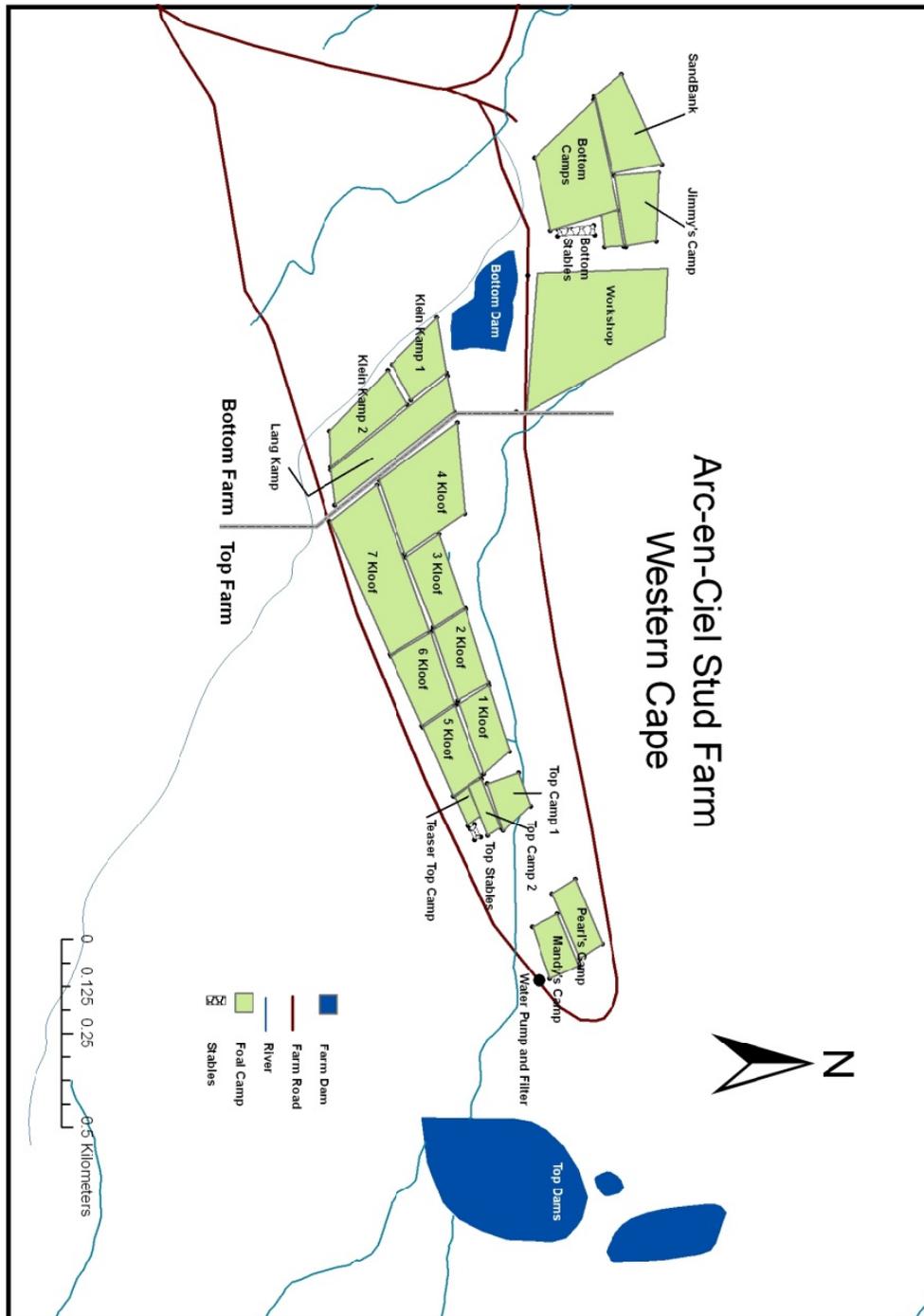
Appendix 2. Movement of Water

Movement of Water

Arc-en-Ciel Stud Farm

Water on the farm is controlled by a water pump at the Top Farm and is filtered and sent to the camps via gravitational force to pop-up sprinklers.
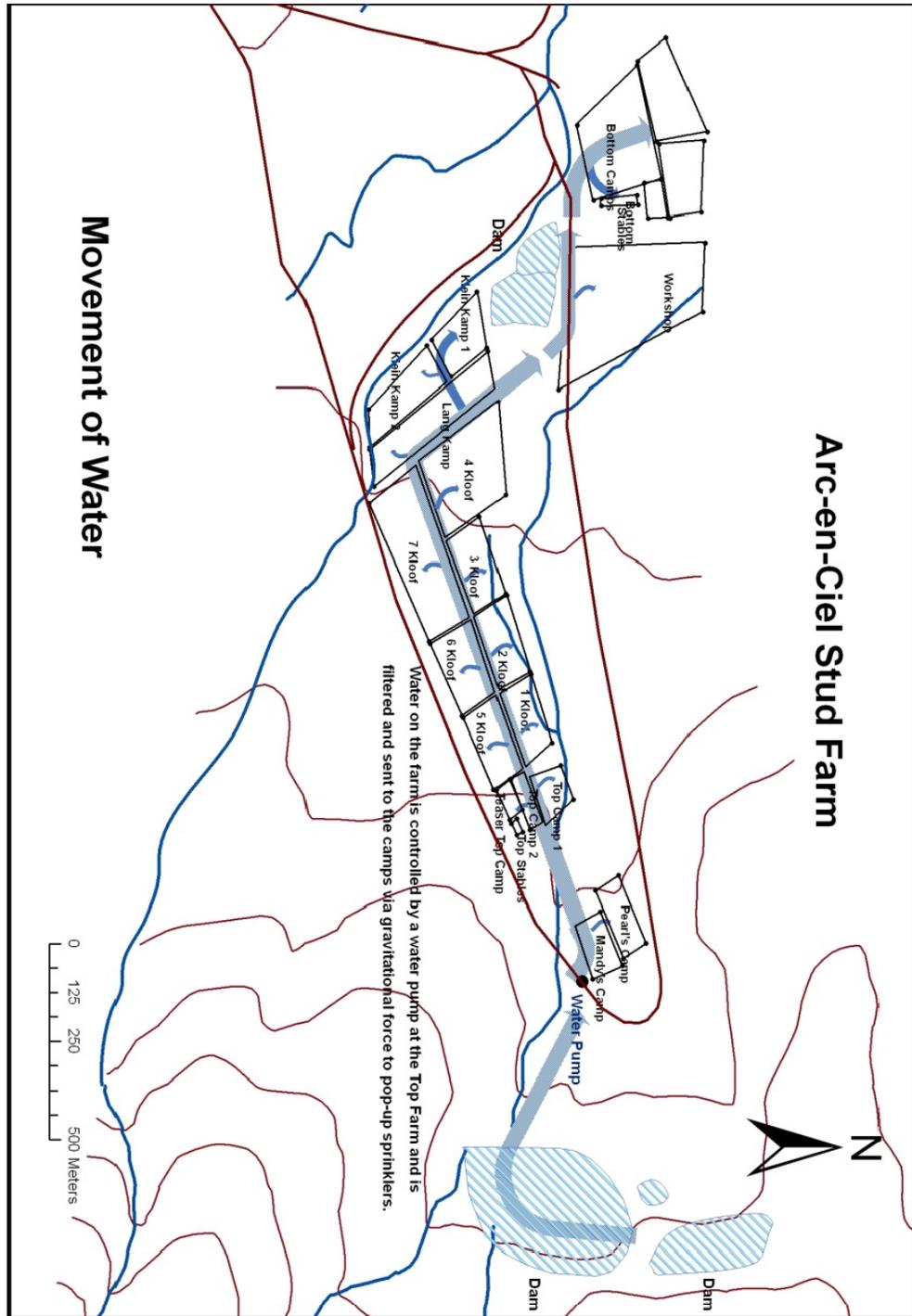
Appendix 3.   Movement of Feed
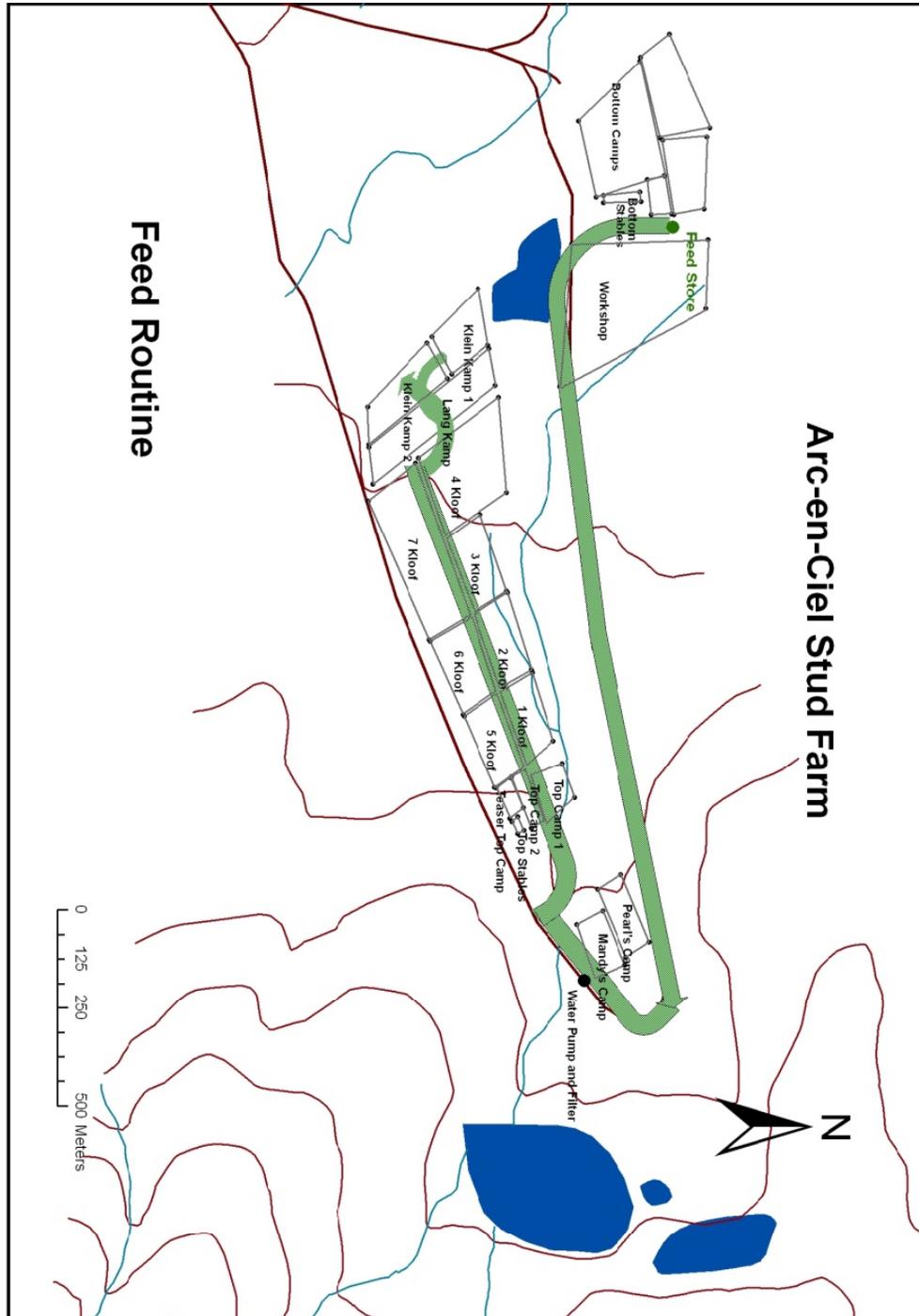
Appendix 4. A description of the computer systems used to upload, assimilate and evaluate temperature data from microchip transponders in Thoroughbred foals

4.1. Introduction

The use of a computer system to input data throughout the project enabled stable and repetitive data to be recorded with confidence. The programs were improved on early on in the project and remained unchanged from then on.

The computer programs allowed input of data onto the Aceeca™ palmtop computer, after which it is uploaded into an MSAccess™ database (from here referred to as the "Access database"), appended into the Access database tables and assimilated to reveal pyretic foals and provide information on sampling procedures.

4.2. Inputting Data onto the Palmtop

4.2.1. Inputting New Foals

Foals were born from the 1st August 2007 until the 4th December 2007. During this time any new foals that were born were microchipped and blood samples were taken on the morning following their birth. The form on the Palmtop associated with new foals was `Frm_New_Foal` (see Appendix 4.8 Figure 13).

The barcode of the microchip was scanned into the `[Foal Microchip]` edit field using scripting (see Appendix 4.8 - 5.2.2) essentially the same as when the foal identification is scanned into the sampling form. This `[Foal Microchip]` field was then the unique identifier of the foal throughout the rest of the project. The `[Dam Name]` and `[Dam Number]` were scanned in with the barcode scanner from the dam's passport details. `[Breed]`, `[Sex]` and `[Colour]` were all inputted via dropdown lists generated from non-linked Satellite Forms™ (from here referred to as "SF") tables (see Appendix Table 10).

`[Birth Date]` and `[Today's Date]` were edit fields. SF has the option to jump to a calendar control when clicking edit fields so that date data may be inserted. This option was chosen here and throughout the SF program for date fields.

The new foal and its associated data was then stored in the underlying SF table `SFTNewFoal` (see Appendix 4.1.7 - 5.3) by clicking on either the "Save and New Foal" button or the "Save and Exit Button". The only difference between these two buttons was that if more than one foal was born it could be scanned in without returning to the menu. The scripting for the "Save and New Foal" button is included (see Appendix 4.8 - 5.3.1).

4.2.2. Inputting Foal Sampling Episodes

Foal sampling occurred on a routine basis, with monthly serum samples being taken, and during pyretic episodes with their associated paired serum sample collections. Sample information was entered into the `Frm_Foal_Sampling` (see Appendix 4.8 Figure 11). The `[Foal ID]`, `[Sample ID]` and `[Thin Smear ID]` were all scanned in via the barcode scanner on the Aceeca palmtop. The scanned text was inserted into the respective fields based on the initial letters in the scanned barcode and was also dependant on the length of the scanned barcode. See Appendix 4.8 - 5.2.2 for the script for the barcode scanning.

The `[Sample reason]` was inputted via a dropdown list based on the non-linked table `LKUPSampleReason` (see Appendix Table 10). The rest of the form consisted of Yes/No boxes indicating which samples were taken.

As in the `Frm_New_Foal` the option existed for saving and then exiting or inputting a new sample. For the scripting see Appendix 4.8 - 5.2.2.

4.2.3. Inputting Daily Foal Temperatures

Foal temperatures were recorded on a daily basis during the week. The form used was `Frm_Foal_Temperature` (see Appendix 4.8 - Figure 12). This form made use of a list box to display the foals in alphabetical order (see Appendix 4.8 - Figure 11). Included in the list box was the field from the `Table_Foal_Information` "Completed" which was by default "False" (see 5.4 - 2.1.3). The list when the form was loaded therefore showed all the foals in the study with "F" (i.e. not scanned) next to their name.

There was a dropdown list in the `Frm_Foal_Temperature` showing locations on the farm where the foals could be situated (see Appendix Table 9) and this dropdown list filtered foals based on their location when last scanned, this information being found in the underlying `Table_Foal_Information` (see Appendix Table 1).

When a foal name was selected by tapping on the palmtop screen, the right 6 digits of the foal's microchip number displayed in the `[Microchip]` field on the form in order to confirm by looking on the temperature scanner that the correct foal was selected.

The temperature was entered into the `[Temperature]` edit field and the script ran when clicking the "DONE" button saved the information into the `Table_Foal_Temperature` (see Appendix Table 2). This button was also linked to the `[Completed]` field in the foal information table, so the "F" beside the foal's name changed to a "T" showing that that foal was completed. An important aspect of the records created when "DONE" was clicked was that a unique record identifier was created by the script `GetSysTime` which returned a number which represented the number of seconds since 12:00 AM on January 1, 1904, and this unique identifier was saved in the RecordID field.

The `Frm_Foal_Temperature` had a button " " which was the search function and clicking it opened the `Search` form (see Appendix 4.8 - Figure 14). This form had a list box of all the foals in the study and showed in which location the foal was last scanned. This was important when foals were moved the previous day by the farmer, after scanning, and it was required to then filter the `Frm_Foal_Temperature` to the previous location to find the right foal. When temperatures were entered for these foals the Location Changed button needed to be clicked and the new location entered. This information was then saved with the pressing of "DONE" as described above and later in the Access database the `Foal Information table` would be updated with that new location (see Appendix 4.8 - 2.2.3).

4.2.4.   Inputting Foal Clinical Examinations

Clinical examinations were performed on every pyretic foal on the day of pyrexia and the day after the pyretic episode. The form used to input the clinical examinations was `Frm_Clinical_Exam` (see Appendix 4.8 - Figure 7 through Appendix 4.8 - Figure 10).

Input of the `[Foal ID]` was as for previous forms using the barcode scanner. This form differed from others as it was a multiple page form. Input in this form was made using dropdown lists with their respective lists coming from non-linked tables in SF (see Appendix Table 10).

The Save/Return button ran a script which saved the data into the underlying table `Table_Foal_Clinical_Exam` (see Appendix Table 6).

4.3. Linking Satellite Forms™ Underlying tables to MSAccess

As described above, input data was saved in the SF tables using scripts which were run when clicking "Save" or "Done" buttons in the respective forms. These tables were functionally Access tables as they were saved in individual databases automatically created by SF when the tables were created in the MobileApplication Designer.

`Hotsync` is the name of the computer operation which describes how and when data is transferred between the Palmtop and the main computer and vice versa. Data in this project was transferred over a direct data cable. There are standard applications that are run and updated on each `Hotsync` operation, but, as in the case of this project, specific commands can be given which enables data to be uploaded from and downloaded to the palmtop. These specific commands are only run when the `Hotsync` operation is run from a specific form in MSAccess™. These forms have a Satellite Forms `Hotsync` control inserted into the form and Visual Basic (VB) coding was written into these controls to run specific commands when a `Hotsync` operation was fired. The project Access database had 2 forms which had this control in it, namely the form used to upload data entered from the palmtop, and the other to download cleared tables and new data from the Access database to the palmtop.

After data entry, the `Uploading form` was opened and a `Hotsync` event was fired. The project specific VB code behind the action is found in Appendix 4.8 - 6.1.

The `Hotsync` code was separated into distinct sections:

- **Defining Names of SF tables**

This section defined simpler or abbreviated names for tables used later in the coding.

- **Describing where these tables were found**

The automatically created SF tables were saved into the directory on the main computer where the application itself was saved. This section of the code indicated where the tables were to be found.

- **Retrieving SF tables from the Palmtop**

In this case the command "`SatForms.GetTableFromPalmPilot`" followed by the required table name was used to retrieve the desired tables.

Therefore once the `Hotsync` event has fired from this form data-filled tables are retrieved from the palmtop.

4.4. Appending Data from SF Tables to Database Tables

This action ran using a button control on the main switchboard of the Access database. The user clicked this button once uploading from the palmtop was complete. On clicking this button two macros ran viz. `Mcr_Append_Data` (see Appendix Table 11) and `Mcr_Routine_Bleed_Append` (see Appendix Table 12).

4.4.1. Mcr_Append_Data

This macro ran the following append and update queries.

- **QRY SFT Foal Clinical Exam Append**

This query (see Appendix 4.8 - 2.1.5) appended data from the SF table saved and uploaded from the palmtop after entering a Foal clinical examination. Data was appended from the SF table to the `Table_Foal_Clinical_Exam`. This table's key field was a combination of the `[FoalID]` and `[ExamDate]` fields, preventing replication of data in this table.

- **QRY SFT Foal Sample Append**

This query (see Appendix 4.8 - 2.1.6) appended data from the SF table saved and uploaded from the palmtop after entering a Foal sampling episode. Data was appended from the SF table to the `[Table_Foal_Sample]`. This table's key field was the `[Sample BarcodeID]` field, preventing replication of data in this table.

- **QRY SFT Foal Temperature Append**

This query (see Appendix 4.8 - 2.1.7) appended data from the SF table saved and uploaded from the palmtop after entering the foal temperature events for a specific day. Data was appended from the SF table to the `Table_Foal_Temperature`, whose key field was the `[RecordID]` field, preventing replication of data in this table.

- **QRY SFT New Foal Append**

This query (see Appendix 4.8 - 2.1.8) appended data from the SF table saved and uploaded from the palmtop after entering newly born foals for a specific day. Data was appended from the SF table to the `Table_Foal_Information`, whose key field was `[Foal ID]` preventing replication of foals in this table.

- **Qry Update DAYDATE**

This update query (see Appendix 4.8 - 2.2.5) updated the `[DayValue]` field and the `[DateValue]` field in the `Table_Foal_Temperature` (see Appendix Table 2). The `[DayValue]` field in each record in this table was only required to be updated once and gave a numerical value between 1 and 7 for the day of the week, starting at Sunday, corresponding to the `[ColDate]` field for that record. The `[DateValue]` field needed continual updating and that field became the difference in days from the current system date to the collection date of the temperature scan record.

These two fields were critical in calculating the standardised score of the temperature scanned of each individual foal.

- **Qry Location Changed Update**

This update query (see Appendix 4.8 - 2.2.3) was used to update the `Table_Foal_Information`. Any foals that had changed location from when they were last scanned had a "Yes" in the Location Changed "Yes/No" field in their temperature data download (see Figure 12: Palm based foal temperature form). These instances were selected for that current system date and those foals' details were changed in the `Foal_Information` table `[Location field]` (see Appendix Table 1) to the new current location.

- **Qry Horse ID Rt Update**

This update query (see Appendix 4.8 - 2.2.4) updated the `[ID Right]` field of the `Table_Foal_Information` to the last 6 digits of the foal identification number in that same table. This query also only needed to run once per foal in the Foal Information table.

4.4.2. Mcr_Routine_Bleed_Append

The function of these queries was to create sampling episodes based on monthly intervals after birth (routine monthly sampling) and based also on paired serum sampling 14 days after a pyretic episode. The update queries ensured that the `[Days to Procedure]` fields in the sampling tables were continually updated to allow a list to be compiled of routine procedures to be completed within 7 day increments (see Appendix 4.8 - 2.4.7; Appendix 4.8 - 2.4.8; Appendix 4.8 - 7.1 and Appendix 4.8 - 7.2)

- **Qry Routine 01 (through 12) Month Append**

These queries (see Appendix 4.8 - 2.1.1 for an example) functioned to continually append any new foal's details into the table `Month_Routine_Procedures` (see Appendix Table 7), along with that foal's relevant monthly sample dates. These queries ran every time the user uploaded data from the palmtop, but data was not replicated in the `Month Routine Procedures` table because that tables' key field, which was the combination of `[Foal Name]`, `[Date of Procedure]` and `[Reason for Procedure]`. It was however only necessary that these queries ran once per foal, adding procedures at 30 day intervals from birth along with the corresponding procedure reason viz. "1 Month Bleed" through "12 Month Bleed".

- **Qry Paired Sample Append**

This query (see Appendix 4.8 - 2.1.2) took information from both the `Foal_Information` table and the `Foal_Sample` table and created an entry in the `Table_Paired_Routine_Procedures` (see Appendix Table 8). Foal details were taken from the `Table_Foal_Information` and the `Foal_Sample` table provided the date of when a sample was taken during a specific foal pyretic episode. Fourteen days were added onto this date which in turn was appended to `[Date of Procedure]` and was later viewed in a report of foals that required paired serum sampling (see Appendix 4.8 - Figure 16).

- **Qry Paired Sample Update**

This query (see Appendix 4.8 - 2.2.2) updated the `[Days to Procedure]` field in the `Table_Paired_Routine_Procedures` for paired serum samples by taking the difference in days between the current system date and the `[Date of Procedure]` field.

- **Qry Routine Month Update**

This query (see Appendix 4.8 - 2.2.1) updated the `[Days to Procedure]` field in the `Table_Month_Routine_Procedures` by inserting the difference in days between the current system date and the `[Date of Procedure]` field.

4.5. Clearing SF Tables and Downloading Data to the Palmtop

Clearing SF tables removed data from the underlying SF tables on the palmtop, allowing new data be added in the fields. Specific data was also downloaded to the palmtop. The coding for the queries which were run to attain this were included in the Visual Basic coding (see Appendix 4.8 - 6.3) during the `Hotsync` operation after data was appended. This coding included the following queries which were run during the `Hotsync` operation performed from the form specifically created to clear and download data to the Palmtop.

4.5.1. Delete Queries

Delete queries were used in this project exclusively to clear linked SF tables in the Access database prior to copying those cleared tables back onto the palmtop. This then created clear tables on the palmtop which were then filled with data when records were saved. An example of the SQL of these queries is Qry SFT Foal Temperature Delete (see Appendix 4.8 - 2.3.1) which cleared the SF Foal Temperature Table (see Appendix Table 9) which then got 'filled' when foals were scanned and temperatures entered the following day.

Other SF tables that were cleared using delete queries were:

- **Qry SFT Foal Information Delete**
- **Qry SFT Location Delete**
- **Qry SFT Foal Clinical Exam Delete**
- **Qry SFT Foal Sample Delete**
- **Qry SFT New Foal Delete**

4.5.2. Download to Palmtop Queries

As mentioned previously, foal information was required on the palmtop to select specific foals, view their microchip numbers and input their temperatures in the `Foal Temperature` form. Other information that was required was the list of possible locations that foals may be in on the farm. Both these sets of information were downloaded to the palmtop during the `Hotsync` operation as described above. The queries used were:

- **Qry SFT Foal Information Append**

This query (see Appendix 4.8 - 2.1.3) appended data from the `Foal_Information` table to the linked `SF_Foal_Information` table which was viewed in the `Foal Temperature` form (see Appendix 4.8 -Figure

12). The data consisted of the `[Foal ID], [Foal Name],` a Yes/No `[Completed]` field which was by default "No" and the `[ID Rt]` field which is the last 6 digits of the foal identification number. Note in the Visual Basic code that the `SF_Foal_Info` table was first cleared of data using a delete query, before the new data was appended to it.

- **Qry Location Dropdown**

This query selected unique values from the `[Location]` field in the `Table_Foal_Temperature` and appended that list to the `SFTLocation` table (see Appendix Table 9), which had previously been cleared using a delete query. This created a table in SF which was used to filter foals in the `Frm_Foal_Temperature` (see Appendix 4.8 - Figure 12) into their specific paddocks and makes finding specific foals less time consuming.

4.6. The Flagging of Pyrexia

Foals were flagged as being pyretic based on either having a temperature above 39.9°C (i.e. Value pyrexia) or having a statistically significant rise in temperature based on the temperatures which that individual foal had had during its previous 6 readings (i.e. Statistical pyrexia).

The following queries ran after the update of the `[DayDate]` field in the `Foal Temperature Table` (see Appendix 4.8 - 2.2.5). Simple access queries like these do not need to be run or viewed to calculate fields. They are generated automatically, so the final query here viz. `Qry Foals Pyretic` could be run and viewed as a report and was updated even though the queries that it depended on are not physically run.

4.6.1. Qry Foal Intermediate DAYDATE

This query (see Appendix 4.8 - 2.4.1) gave each foal's total temperature data summary, with minimum temperature, maximum temperature, mean temperature, total scans and standard deviation of all temperature readings. The only critical field it created is the `[Max of RecordID]` field which returned the maximum record ID of that foal's scans which essentially identified its last scan.

4.6.2. Qry Foal DAYDIFF

The purpose of this query (see Appendix 4.8 - 2.4.2) was to create the field `[DayDiff]`. It took data from the `Foal_Information` table (`[FoalName]`), from the `Qry Foal Intermediate DAYDATE` (`[Max`

RecordID]) and from the `Table_Foal_Temperature` (the last record per foal based on the `[Max of Record ID]`). Using this last record's `[DayValue]`, which determined on what day of the week the last scan for the foal was, it created a `[DayDiff]` field which was either an 8 or a 10. If the foal's `[DayValue]` was 2 (i.e. last scan was on a Monday) `[DateDiff]` equaled 10 otherwise the `[DateDiff]` field was always equal to 8.

This was to ensure that the last seven scans from a foal were taken to establish the mean of these scans. Since scanning was not performed on Saturdays and Sundays, if a foal had been scanned on a Monday last examination of the previous 10 day period would be required to obtain the previous 7 scans. If, however, the last scan was on a Tuesday through Friday, only 8 days would need to elapse to obtain 7 previous scans. (Note that the 7th scan was the last scan of the foal and was included in that foal's temperature summary).

4.6.3. Qry Foal Last 7 Readings

This query (see Appendix 4.8 - 0) then used the `[Foal ID]` and `[DayDiff]` value from the `Qry Foal DAYDIFF` and found all records from the Foal Temperature Table which had `[DateValue]` values less than or equal to the `[DateDiff]` value for each specific foal. This then returned a maximum of 7 records per foal and these correlated to the previous 7 scans of that foal. These last 7 scans were then the temperature series used to evaluate whether the final scan represented a statistical pyretic event.

4.6.4. Qry Foal Summary Intermediate

This query (see Appendix 4.8 - 2.4.4) then summarised each foal based on its last maximum 7 scans and gave information regarding the minimum and maximum temperatures, the mean temperature, the standard deviation of the last maximum 7 scans and the count of scans within the last period of evaluation. The aforementioned queries did not account for microchips which were not scanned within the 8/10 day period, but if this was the case the count of the scans then decreased and the summary that this query calculated was based on the decreased number of scans.

4.6.5. Qry Foal Summary Report Last Scan

This query (see Appendix 4.8 - 2.4.5) then took the information from the last scan's summary and worked out the difference in the `[Final temperature]` and the mean of the last scan series and what this percentage difference was. It then determined the standardised score of the last scan based on the mean of the last series of scans and the standard deviation of these scans. If there was however only 1 scan in the series, the standard

deviation would be zero, making this calculation invalid since zero cannot be the denominator of an expression. An "If" statement was therefore included to then make the standardised score equal 0 if the standard deviation of the series was zero.

4.6.6. Qry Foals Pyretic

This was the final flagging query. This query (see Appendix 4.8 - 2.4.6) then flagged any foals in the `Qry Foal Summary Report Last Scan` which either had a final temperature above 39.9˚C or a z-value of >1.96. This query also filtered the last temperature date as the current system date. It therefore evaluated which foals were pyretic based on that day's reading. It was therefore imperative to view this query on the same day as the temperature scanning session. This query was then made into a report which made viewing user friendly.

4.7. Discussion

The use of these computer systems worked extremely well considering the amount of data that were processed on a daily basis by the programs. There were many other queries used in the main Access database to ensure that data had been appended correctly and to evaluate data continuously. The main advantage of the system was the fact that the only devices in the field were the Aceeca Palmtop and the microchip scanner, which allowed for easy data input without writing anything down on paper. The palmtop also served as a search engine for foals, making identification of foals in their specific locations easy.

The main advantage of an automatic system for sample collection dates was that no continual record had to be held on paper or in a calendar to establish when foals must get sampled; the reports for the sampling gave the required information on a weekly basis. The use of barcodes also made the input of sampling data simpler with the foal identification number set as a barcode in the sampling report and the use of barcode labels for sample identification. The scripting of the dates and times of procedures or events was also automatic and saved into the `[ColDate]` fields by the palmtop, allowing the minimum amount of data input by the user ensuring data integrity.

4.8.   Computer Program Tables, Forms, Figures and Scripts

1.   Tables

1.1.   Input Tables

Appendix Table 1: Table Foal Information

Field	Data Type	Data Explanation
ID Table	Autonumber	Index for the table. Not used in any relationships between tables
Foal ID*	Text	Microchip number of the foal. This field is the KEY field. Data as TEXT due to possibility of microchips having characters within the numbers
Dam's Name	Text	Name of foals dam
Dam Number	Text	Passport number of dam if applicable
Breed	Text	Breed of foal (In the projects case always THOROUGHBRED)
Sex	Text	Sex of foal – Male or Female only
Colour	Text	Colour of foal – Bay, Chestnut, Grey or Other
Birth Date	Date/Time	Date of foal birth
Entry Date	Date/Time	Date of entry of foal into MS Access™ Database
In Study	Yes/No	Is foal actively in the study or not - Daily updated field
Reason for Removal	Text	If foal not in study what was the reason for removal
Location	Text	Paddock on farm where foal was in on the last scanned day – Daily updated field
Comments	Memo	Comments on foal
General	Yes/No	Used mainly for database testing
Foal ID Rt	Text	Right 6 digits of the HorseID field – Updated when foal entered into database
Weaned?	Yes/No	Is foal weaned?
Weaning Date	Date/Time	Date of weaning

* denotes the tables unique identifier field

Appendix Table 2: Table Foal Temperature

Field	Data Type	Data Explanation
FoalNo	Text	Foal ID – as in Foal_Information table
RecordID*	Text	Unique Identifier for temperature input
ColTime	Date/Time	Time of temperature input – automatically created by script
ColDate	Date/Time	Date of temperature input - automatically created by script
TempC	Number	Temperature of foal – Degrees celsius
DayValue	Number	Value of day of week of record: 1 – Sun, 2 – Mon, 3 – Tues, 4 – Wed, 5 – Thurs, 6 – Fri, 7 – Sat) Updated field
DateValue	Number	Current date [Date()] less [ColDate] – Daily updated field
Pyrexia?	Yes/No	Was temperature input considered pyrexia – manual daily input based on Qry_Foal_Pyrexia
Comments	Text	Comments on temperature input
Location	Text	Location of foal when temperature was scanned
Location Changed	Yes/No	Was the location different from where foal was previously scanned?

* denotes the tables unique identifier field

Appendix Table 3: Table Location

Field	Data Type	Data Explanation
Location*	Number	Location Name – paddock name (*unique identifier field)
SD	Number	Paddock Centre – South Degrees
SM	Number	Paddock Centre – South Minutes
SS	Number	Paddock Centre – South Seconds
ED	Number	Paddock Centre – East Degrees
EM	Number	Paddock Centre – East Minutes
ES	Number	Paddock Centre – East Seconds
Y	Number	Paddock Centre – Decimal Degrees South
X	Number	Paddock Centre – Decimal Degrees East
BRSD	Number	Paddock South East Corner South Degrees
BLSD	Number	Paddock South West Corner South Degrees
TRSD	Number	Paddock North East Corner South Degrees
TLSD	Number	Paddock North West Corner South Degrees
BRSM	Number	Paddock South East Corner South Minutes
BLSM	Number	Paddock South West Corner South Minutes
TRSM	Number	Paddock North East Corner South Minutes
TLSM	Number	Paddock North West Corner South Minutes
BRSS	Number	Paddock South East Corner South Seconds
BLSS	Number	Paddock South West Corner South Seconds
TRSS	Number	Paddock North East Corner South Seconds
TLSS	Number	Paddock North West Corner South Seconds
BRED	Number	Paddock South East Corner East Degrees
BLED	Number	Paddock South West Corner East Degrees
TRED	Number	Paddock North East Corner East Degrees
TLED	Number	Paddock North West Corner East Degrees
BREM	Number	Paddock South East Corner East Minutes
BLEM	Number	Paddock South West Corner East Minutes
TREM	Number	Paddock North East Corner East Minutes
TLEM	Number	Paddock North West Corner East Minutes
BRES	Number	Paddock South East Corner East Seconds
BLES	Number	Paddock South West Corner East Seconds
TRES	Number	Paddock North East Corner East Seconds
TLES	Number	Paddock North West Corner East Seconds
BRY	Number	Paddock South East Corner– Decimal Degrees South
BLY	Number	Paddock South West Corner – Decimal Degrees South
TRY	Number	Paddock North Eats Corner – Decimal Degrees South
TLY	Number	Paddock North West Corner– Decimal Degrees South
BRX	Number	Paddock South East Corner– Decimal Degrees East
BLX	Number	Paddock South West Corner – Decimal Degrees East
TRX	Number	Paddock North Eats Corner – Decimal Degrees East
TLX	Number	Paddock North West Corner– Decimal Degrees East

Appendix Table 4: Table Vaccination

Field	Data Type	Data Explanation
FoalNo*	Text	Foal ID – as in Foal_Information table
Vacc Date*	Date/Time	Date of vaccination
Vacc Type	Text	Name and number of vaccination

* denotes the tables unique identifier fields

Appendix Table 5: Table Foal Sample

Field	Data Type	Data Explanation
FoalNo	Text	Foal ID – as in Foal_Information table
Sample Col Date	Date/Time	Date of sample collection
Sample BarcodeID*	Text	ID barcode of the sample
NP Swab Virus	Yes/No	Was a nasopharyngeal swab taken for viral culture/isolation?
NP Swab Bacteria	Yes/No	Was a nasopharyngeal swab taken for bacterial culture/isolation?
Heparin Sample	Yes/No	Was a heparin blood sample taken?
Serum Samples	Yes/No	Were serum samples taken?
FNA Abscess	Yes/No	Was a fine needle aspirate sample taken?
MSSmear	Yes/No	Was a thin film blood smear performed on the sample?
MSSampID	Text	Blood smear barcode ID
SampReason	Text	Reason for sampling (Month routine, Paired Sample or Pyretic Event)

* denotes the tables unique identifier field

Appendix Table 6: Table Foal Clinical Examination

Field	Data Type	Data Explanation
FoalNo*	Text	Foal ID – as in Foal_Information table
ExamDate*	Date/Time	Date of clinical examination
TempRect	Number	Rectal temperature
TempChip	Number	Microchip temperature
Pulse	Number	Pulse rate of foal
RespRate	Number	Respiratory rate of foal
MMColour	Text	Mucous membrane colour
MMCRT	Text	Mucous membrane capillary refill time
Hydration	Text	Hydration status of foal (0%-15% Dehydrated)
Habitus	Text	Habitus of foal (1-4)
Ataxia	Text	Severity of ataxia of the foal (0-4)
Diarrhoea	Text	Did the foal have diarrhoea (Yes/No)
DiarrSev	Text	What was the diarrhoea severity (0-4)
BorBor	Text	Borborygmi level of foal (0-4)
NasalDisch	Text	Nasal discharge present (Yes/No)
NDUniBi	Text	Was the nasal discharge unilateral, bilateral or neither?
NDSev	Text	Severity of the nasal discharge (0-4)
Cough	Text	Coughing present (Yes/No)
CoughSev	Text	Severity of the cough (0-4)
Sneeze	Text	Sneezing present (Yes/No)
SneezeSev	Text	Severity of the sneezing (0-4)
LungSnd	Text	Lung sounds (Yes/No)
LungSndSev	Text	Severity of the lung sounds (0-4)
Dyspnoea	Text	Dyspnoea present (Yes/No)
DyspnoeaSev	Text	Severity of the dyspnoea (0-4)
OculDisch	Text	Ocular discharge (Yes/No)
ODSev	Text	Severity of the ocular discharge (0-4)

* denotes the tables unique identifier fields

1.2.　　　　Appended Tables

Appendix Table 7: Table Month Routine Procedures

Field	Data Type	Data Explanation
RoutineID	Autonumber	Index for the table
Foal ID	Text	Foal Microchip as in the Horse_Info table
Dams Name*	Text	Name of Dam/Foal that required routine procedure – from Foal_Information Table
Colour	Text	Colour of foal
Sex	Text	Sex of Foal
Birth Date	Date/Time	Birth date of the foal
Date of Procedure*	Date/Time	Date the procedure must be accomplished
Procedure Reason*	Text	Reason for procedure (1-12 Month Sample)
Days to Procedure	Number	Current date to date of procedure (in days)
Procedure Done	Yes/No	Has the procedure been accomplished?
Comments	Memo	Comments on the procedure

* denotes the tables unique identifier fields

Appendix Table 8: Table Paired Routine Procedures

Field	Data Type	Data Explanation
RoutineID	Autonumber	Index for the table
Foal ID	Text	Foal Microchip as in the Foal_Information table
Dams Name*	Text	Name of Dam/Foal that require routine procedure – from Foal_Information table
Colour	Text	Colour of foal
Sex	Text	Sex of foal
Initial Sample Date*	Date/Time	Sample date at pyrexia
Date of Paired Procedure	Date/Time	Date the procedure must be accomplished
Procedure Reason*	Text	Reason for procedure – always "Paired sample"
Days to Procedure	Number	Current date to date of paired procedure (in days)
Day of Procedure	Date/Time	Day of week that the procedure is scheduled
Procedure Complete	Yes/No	Has the procedure been accomplished?
Comments	Text	Comments on the procedure

* denotes the tables unique identifier fields

Appendix Table 9: Satellite Forms Linked Tables

Table Name	Table Category	Table Purpose
SFTFoalClinical	Upload	Upload all foal clinical examinations entered onto the Palm computer
SFTFoalSample	Upload	Upload all foal sample episodes entered onto the Palm computer
SFTFoalTemp	Upload	Upload foal temperature measurements entered onto the Palm computer
SFTFoalInfo	Download	Download foal information and location to the Palm computer for referencing and searching functions
SFTLocation	Download	Download list of unique location names for the location dropdown list in Palm Application for filtering purposes
SFTNewFoal	Upload	Upload new foal information entered onto the Palm computer

Appendix Table 10: Satellite Forms Non-linked Tables

Table Name	Table Category	Table Purpose
LKUP1_4	Lookup Table	1 to 4 - Severity dropdown lists
LKUPBreed	Lookup Table	Thoroughbred or other dropdown list – New foal information
LKUPColour	Lookup Table	Grey, Chestnut, Bay, Black dropdown list – New foal information
LKUPColourMM	Lookup Table	Pink, Pale, White, Yellow, Congested, Blue ,Red or Other – Clinical examination mucous membrane colour dropdown list
LKUPHydrate	Lookup Table	0%, 5%, 10% or 15% - Dehydration status dropdown list
LKUPMMS	Lookup Table	Mild, Moderate or Severe – Severity dropdown lists
LKUPSampleReason	Lookup Table	Month routine, Pyretic episode or Paired sample – Reason for foal sampling episode
LKUPSex	Lookup Table	Colt or Filly dropdown list – New foal information
LKUPUniBilat	Lookup Table	Unilateral, Bilateral or Neither dropdown list – Foal clinical examination
LKUpYesNo	Lookup Table	Yes/No dropdown list – Foal clinical examination

2.   SQL Queries

2.1.   Append Queries

2.1.1.   Qry Routine 01 Month Append

```
INSERT INTO [Table Month Routine Procedures] ([Dams Name], [Foal ID], [Date of Procedure], Colour, Sex, [Birth Date], [Procedure Reason],
[Days To Procedure])
SELECT Table_Foal_Information.[Dam's Name], Table_Foal_Information.[Foal Id], [Birth Date]+30 AS [Procedure Date],
Table_Foal_Information.Colour, Table_Foal_Information.Sex, Table_Foal_Information.[Birth Date], "1 Month Bleed" AS [Reason For Procedure],
DateDiff("d",Date(),[Procedure Date]) AS [Days To Procedure]
FROM Table_Foal_Information;
```

2.1.2.   Qry Paired Sample Append

```
INSERT INTO [Table_Paired_Routine_Procedures] ([Foal ID], [Dam's Name], Sex, Colour, [Initial Sample Date], [Procedure Reason], [Date of
Paired Procedure])
SELECT [Table_Foal_Sample].[Foal Number], Table_Foal_Information.[Dam's Name], Table_Foal_Information.Sex, Table_Foal_Information.Colour,
[Table_Foal_Sample].[Sample Col Date], [Table_Foal_Sample].SampReason, [Sample Col Date]+14 AS [Date of Paired Procedure]
```

```
FROM Table_Foal_Information INNER JOIN [Table_Foal_Sample] ON Table_Foal_Information.[Foal ID] = [Table_Foal_Sample].[Foal Number]
WHERE ((([Table_Foal_Sample].SampReason)="Pyrexic Episode"));
```

2.1.3.   Qry SFT Foal Info Append

```
INSERT INTO SFTFoalInfo (ID_TABLE, HORSE_ID, DAM_NAME, LOCATION, COMPLETE, HORSE_IDRT)
SELECT Table_Foal_Information.[ID Table], Table_Foal_Information.[Foal ID], Table_Foal_Information.[Dam's Name],
Table_Foal_Information.Location, Table_Foal_Information.Completed, Table_Foal_Information.HORSE_IDRT
FROM Table_Foal_Information
WHERE ((Table_Foal_Information.[In Study])=Yes));
```

2.1.4.   Qry Location Dropdown

```
INSERT INTO SFTLocation (LOCATION)
SELECT DISTINCT Table_Foal_Temperature.LOCATION
FROM Table_Foal_Temperature;
```

2.1.5.   Qry SFT Foal Clinical Exam Append

```
INSERT INTO [Table_Foal_Clinical_Examination] (Foal_ID, ExamDate, TempRect, TempChip, Pulse, RespRate, Hydration, Habitus, Ataxia,
Diarrhoea, DiarrhoeaSev, BorBor, NasalDisch, NDunibi, NDSev, Cough, CoughSev, Sneeze, SneezeSev, LungSnd, LungSndSev, Dyspnoea, DyspSev,
OculDisch, ODSev, MMColour, MMCRT)
SELECT SFTFoalClinical.FOAL_ID, SFTFoalClinical.EXAMDATE, SFTFoalClinical.TEMPRECT, SFTFoalClinical.TEMPCHIP, SFTFoalClinical.PULSE,
SFTFoalClinical.RESPRATE, SFTFoalClinical.HYDRATION, SFTFoalClinical.HABITUS, SFTFoalClinical.ATAXIA, SFTFoalClinical.DIARRHOEA,
SFTFoalClinical.DIARRSEV, SFTFoalClinical.BORBOR, SFTFoalClinical.NASALDISCH, SFTFoalClinical.NDUNIBI, SFTFoalClinical.NDSEV,
SFTFoalClinical.COUGH, SFTFoalClinical.COUGHSEV, SFTFoalClinical.SNEEZE, SFTFoalClinical.SNEEZESEV, SFTFoalClinical.LUNGSND,
SFTFoalClinical.LUNGSNDSEV, SFTFoalClinical.DYSPNOEA, SFTFoalClinical.DYSPSEV, SFTFoalClinical.OCULDISCH, SFTFoalClinical.ODSEV,
SFTFoalClinical.MMCOLOUR, SFTFoalClinical.MMCRT
FROM SFTFoalClinical;
```

2.1.6.   Qry SFT Foal Sample Append

```
INSERT INTO [Table_Foal_Sample] ([Sample BarCode ID], [Foal Number], [Sample Col Date], [NP SWAB VIRUS], [NP SWAB BACTERIA], [Serum
Samples], [Heparin Samples], [FNA Abscess], MSSmear, MSSampID, SampReason)
SELECT SFTFoalSample.BARCODEREF, SFTFoalSample.ID_NUMBER, SFTFoalSample.COLDATE, SFTFoalSample.NP_SWAB_V, SFTFoalSample.NP_SWAB_B,
SFTFoalSample.SERUM, SFTFoalSample.HEPARIN, SFTFoalSample.FNA, SFTFoalSample.THINSMEAR, SFTFoalSample.TSSAMPID, SFTFoalSample.SAMPREASON
FROM SFTFoalSample;
```

2.1.7.   Qry SFT Foal Temperature Append

```
INSERT INTO Table_Foal_Temperature (RECORDID, COLTIME, COLDATE, FOAL_NO, TEMPC, TEMPF, LOCATION, [LOCATION CHANGED], COMMENTS)
SELECT SFTFoalTemp.RECORDID, SFTFoalTemp.COLTIME, SFTFoalTemp.COLDATE, SFTFoalTemp.FOALID, SFTFoalTemp.TEMPC, SFTFoalTemp.LOCATION,
SFTFoalTemp.LOC_CHANGE, SFTFoalTemp.COMMENTS
FROM SFTFoalTemp;
```

2.1.8.   Qry SFT New Foal Append

```
INSERT INTO Table_Foal_Information ([Foal ID], [Dam's Name], [Dam Number], Breed, Sex, Colour, [Birth Date], [Entry Date])
SELECT SFTNewFoal.[FOAL ID], SFTNewFoal.DAM_NAME, SFTNewFoal.DAM_NUMBER, SFTNewFoal.BREED, SFTNewFoal.SEX, SFTNewFoal.COLOUR,
SFTNewFoal.BIRTHDATE, SFTNewFoal.DATE
FROM SFTNewFoal;
```

2.2. Update Queries

2.2.1. Qry Routine Month Update

```
UPDATE [Table_Month_Routine_Procedures] SET [Table_Month_Routine_Procedures].[Days To Procedure] = DateDiff("d",Date(),[Date of
Procedure]);
```

2.2.2. Qry Paired Sample Update

```
UPDATE [Table_Paired_Sample_Dates] SET [Table_Paired_Sample_Dates].[Days To Procedure] = DateDiff("d",Date(),[Date of Paired Procedure]),
[Table_Paired_Sample_Dates].[Day of Procedure] = [Initial Sample Date]+14;
```

2.2.3. Qry Location Changed Update

```
UPDATE Table_Foal_Information INNER JOIN Table_Foal_Temperature ON Table_Foal_Information.[Foal ID] = Table_Foal_Temperature.FOAL_NO SET
Table_Foal_Information.Location = Table_Foal_Temperature.LOCATION
WHERE (((Table_Foal_Temperature.COLDATE)=Date()) AND ((Table_Foal_Temperature.[LOCATION CHANGED])=Yes));
```

2.2.4. Qry Foal ID Rt Update

```
UPDATE Table_Foal_Information SET Table_Foal_Information.HORSE_IDRT = Right ([Foal ID], 6);
```

2.2.5. Qry Update DAYDATE

```
UPDATE Table_Foal_Temperature SET Table_Foal_Temperature.DAYVALUE = Weekday([COLDATE]), Table_Foal_Temperature.DATEVALUE = Date()-
[COLDATE];
```

2.3. Delete Queries

2.3.1. Qry SFT Foal Temperature Delete

```
DELETE SFTFoalTemp.RECORDID, SFTFoalTemp.COLTIME, SFTFoalTemp.COLDATE, SFTFoalTemp.FOALID, SFTFoalTemp.TEMPC, SFTFoalTemp.TEMPF,
SFTFoalTemp.COMMENTS
FROM SFTFoalTemp;
```

2.4. Simple Queries

2.4.1. Qry Foal Intermediate DAYDATE

```
SELECT Table_Foal_Temperature.FOAL_NO, Table_Foal_Information.[Dam's Name], Count(Table_Foal_Temperature.RECORDID) AS CountOfRECORDID,
Min(Table_Foal_Temperature.TEMPC) AS MinOfTEMPC, Max(Table_Foal_Temperature.TEMPC) AS MaxOfTEMPC, Max(Table_Foal_Temperature.RECORDID) AS
MaxOfRECORDID, Avg(Table_Foal_Temperature.TEMPC) AS AvgOfTEMP, StDev(Table_Foal_Temperature.TEMPC) AS StDevOfTEMP
FROM Table_Foal_Information INNER JOIN Table_Foal_Temperature ON Table_Foal_Information.[Foal ID] = Table_Foal_Temperature.FOAL_NO
GROUP BY Table_Foal_Temperature.FOAL_NO, Table_Foal_Information.[Dam's Name];
```

2.4.2. Qry Foal DAYDIFF

```
SELECT Table_Foal_Information.[Dam's Name], Table_Foal_Temperature.FOAL_NO, Table_Foal_Temperature.COLDATE,
Table_Foal_Temperature.DAYVALUE, IIf([DAYVALUE]=2,10,8) AS DAYDIFF
FROM (Table_Foal_Information INNER JOIN Table_Foal_Temperature ON Table_Foal_Information.[Foal ID] = Table_Foal_Temperature.FOAL_NO) INNER
JOIN Qry Foal Intermediate DAYDATE ON Table_Foal_Temperature.RECORDID = Qry Foal Intermediate DAYDATE.MaxOfRECORDID;
```

2.4.3. Qry Foal Last 7 Readings

```
SELECT Table_Foal_Temperature.FOAL_NO, Table_Foal_Temperature.RECORDID, Table_Foal_Temperature.COLTIME, Table_Foal_Temperature.COLDATE,
Table_Foal_Temperature.TEMPC, Table_Foal_Temperature.TEMPF, Table_Foal_Temperature.DATEVALUE, Qry Foal DAYDIFF.DAYDIFF
FROM Qry Foal DAYDIFF INNER JOIN Table_Foal_Temperature ON Qry Foal DAYDIFF.FOAL_NO = Table_Foal_Temperature.FOAL_NO
WHERE (((Table_Foal_Temperature.DATEVALUE)<=[DAYDIFF]));
```

2.4.4. Qry Foal Summary Intermediate

```
SELECT Qry Foal Last 7 Readings.FOAL_NO, Table_Foal_Information.[Dam's Name], Count(Qry Foal Last 7 Readings.RECORDID) AS CountOfRECORDID,
Min(Qry Foal Last 7 Readings.TEMPC) AS MinOfTEMPC, Max(Qry Foal Last 7 Readings.TEMPC) AS MaxOfTEMPC, Max(Qry Foal Last 7
Readings.RECORDID) AS MaxOfRECORDID, Avg(Qry Foal Last 7 Readings.TEMPC) AS AvgOfTEMP, StDev(Qry Foal Last 7 Readings.TEMPC) AS
StDevOfTEMP
FROM Table_Foal_Information INNER JOIN Qry Foal Last 7 Readings ON Table_Foal_Information.[Foal ID] = Qry Foal Last 7 Readings.FOAL_NO
GROUP BY Qry Foal Last 7 Readings.FOAL_NO, Table_Foal_Information.[Dam's Name];
```

2.4.5. Qry Foal Summary Report Last Scan

```
SELECT Qry Foal Summary Intermediate.FOAL_NO, Table_Foal_Information.[Dam's Name], Qry Foal Summary Intermediate.CountOfRECORDID, Qry Foal
Summary Intermediate.MinOfTEMPC, Qry Foal Summary Intermediate.MaxOfTEMPC, Qry Foal Summary Intermediate.AvgOfTEMP, Qry Foal Summary
Intermediate.StDevOfTEMP, Qry Foal Last 7 Readings.COLDATE, Qry Foal Last 7 Readings.TEMPC, [TEMPC]-[AvgOfTEMP] AS [LAST DIFFERENCE(°C)],
[LAST DIFFERENCE(°C)]/[AvgOfTEMP] AS [LAST DIFFERENCE (%)], IIf([StDevOfTEMP]=0,0,([TEMPC]-[AvgOfTEMP])/[StDevOfTEMP]) AS [Z Value]
FROM (Table_Foal_Information INNER JOIN Qry Foal Last 7 Readings ON Table_Foal_Information.[Foal ID] = Qry Foal Last 7 Readings.FOAL_NO)
INNER JOIN Qry Foal Summary Intermediate ON Qry Foal Last 7 Readings.RECORDID = Qry Foal Summary Intermediate.MaxOfRECORDID;
```

2.4.6. Qry Foals Pyretic

```
SELECT Qry Foal Summary Report Last Scan.FOAL_NO, Qry Foal Summary Report Last Scan.[Dam's Name], Qry Foal Summary Report Last
Scan.COLDATE, Qry Foal Summary Report Last Scan.TEMPC, Qry Foal Summary Report Last Scan.[Z Value], IIf(Qry Foal Summary Report Last
Scan![LAST DIFFERENCE(°C)]>0,Qry Foal Summary Report Last Scan![Z Value],0) AS [Z Value Pos]
FROM Qry Foal Summary Report Last Scan
WHERE (((Qry Foal Summary Report Last Scan.COLDATE)=Date()) AND ((Qry Foal Summary Report Last Scan.TEMPC)>=40)) OR (((IIf([Qry Foal
Summary Report Last Scan]![LAST DIFFERENCE(°C)]>0,[Qry Foal Summary Report Last Scan]![Z Value],0))>1.96));
```

2.4.7. Qry Monthly Samples for Report

```
SELECT [Table_Month_Routine_Procedures].[Foal ID], [Table_Month_Routine_Procedures].[Dams Name], [Table_Month_Routine_Procedures].Colour,
[Table_Month_Routine_Procedures].Sex, [Table_Month_Routine_Procedures].[Date of Procedure], [Table_Month_Routine_Procedures].[Procedure
Reason], [Table_Month_Routine_Procedures].[Days To Procedure], Table_Foal_Information.[ERC Samp EDTA], Table_Foal_Information.Location
FROM [Table_Month_Routine_Procedures] INNER JOIN Table_Foal_Information ON [Table_Month_Routine_Procedures].[Foal ID] =
Table_Foal_Information.[Foal ID]
WHERE ((([Table_Month_Routine_Procedures].[Days To Procedure])<=7) AND (([Table_Month_Routine_Procedures].[Procedure Done])=False) AND
((Table_Foal_Information.[In Study])=True));
```

2.4.8. Qry Paired Samples for Report

```
SELECT [Table_Paired_Sample_Dates].[Foal ID], [Table_Paired_Sample_Dates].[Dam's Name], [Table_Paired_Sample_Dates].Colour,
[Table_Paired_Sample_Dates].Sex, [Table_Paired_Sample_Dates].[Initial Sample Date], [Table_Paired_Sample_Dates].[Date of Paired
Procedure], [Table_Paired_Sample_Dates].[Procedure Reason], [Table_Paired_Sample_Dates].[Days To Procedure],
[Table_Paired_Sample_Dates].[Day of Procedure], [Table_Paired_Sample_Dates].[Procedure Complete], Table_Foal_Information.Location
FROM [Table_Paired_Sample_Dates] INNER JOIN Table_Foal_Information ON [Table_Paired_Sample_Dates].[Foal ID]=Table_Foal_Information.[Foal
ID]
WHERE ((([Table_Paired_Sample_Dates].[Days To Procedure])<8) AND (([Table_Paired_Sample_Dates].[Procedure Complete])=False));
```

3. Forms

3.1. SF Palm Computer Forms

Figure 7: Palm based clinical examination form

Figure 8: Palm based clinical examination form (cont.)

Figure 9: Palm based clinical examination form (cont.)

Figure 10: Palm based clinical examination form (final)

Figure 11: Palm based foal sampling form

Figure 12: Palm based foal temperature form

Figure 13: Palm based new foal form
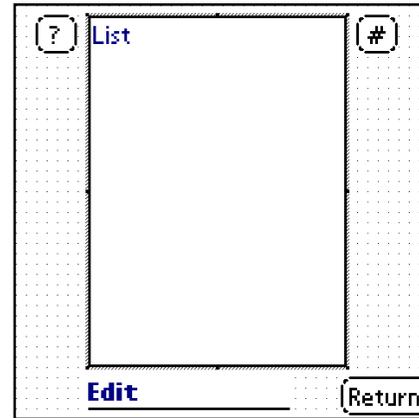
Figure 14: Palm based search form

4. Macros

Appendix Table 11: Append Data Macro

Action	Object	Details
SetWarnings	NO	Disables system warnings to prevent Hotsync disruption
OpenQuery	QrySFTFoalClinicalAppend	Runs append query – Data transfer from SF tables to MSAccess™Tables
OpenQuery	QrySFTFoalSampleAppend	Runs append query – Data transfer from SF tables to MSAccess™Tables
OpenQuery	QrySFTFoalTempAppend	Runs append query – Data transfer from SF tables to MSAccess™Tables
OpenQuery	QrySFTNewFoalAppend	Runs append query – Data transfer from SF tables to MSAccess™Tables
OpenQuery	Qry Update DayDate	Runs update query – Table FoalsMSc – Day of Week value and Days from Date(Now) to COLDATE
OpenQuery	Qry Location Changed Update	Runs update query – Location of foal in Table_Foal_Information updated based on current date location in Table_Foal_Temperature
OpenQuery	Qry Foal ID Rt Update	Runs update query –Right 6 digits of FoalID updated in Table_Foal_Information
SetWarnings	YES	Enables System Warnings

Appendix Table 12: Routine Bleed Append Macro

Action	Object	Details
SetWarnings	NO	Disables System Warnings to prevent USER disruption
OpenQuery	Qry Routine 01 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 02 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 03 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 04 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 05 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 06 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 07 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 08 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 09 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 10 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 11 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Routine 12 Month Append	Runs append query – Data transfer from Table_Foal_Information to Table_Month_Routine_Procedures
OpenQuery	Qry Paired Sample Append	Runs Append Query – Data Transfer from Table_Foal_Information to Table_Paired_Sample _Procedures
OpenQuery	Qry Paired Sample Update	Runs Update Query – Updates Days to Procedure and Day of Procedure in Table_Paired_Sample_Dates
OpenQuery	Qry Routine Month Update	Runs Update Query – Updates Days to Routine Procedure in Table_Month_Routine_Procedures
SetWarnings	YES	Enables System Warnings

5.   Scripts

5.1.   Global Variables

```
Dim RecordNum 'Variable for record number
Dim Buffer
Dim SerialPort
Dim LastBytesAvailable
Dim Location

Dim UserID
```

5.2.   Form Scripts

5.2.1.   Clinical examination form

ONCLICK BTNSAVERETURN

```
Forms().PreviousForm
```

ONCLICK BTNNEXTPAGE

```
Forms("FrmClinical Exam").MoveNextPage
```

ONCLICK BTNPREVPAGE

```
Forms("FrmClinical Exam").MovePreviousPage
```

5.2.2.   Foal sampling form

AFTERLOAD

```
EdMicrochip.SetFocus
```

AFTEROPEN

```
SetTimer (10)

If IDV_IsAceecaUnit() = false then
        msgbox("IDVERIFI scanner functions must NOT be called on non-Aceeca devices or the device will crash!  Scanner selection
disabled on this device.")
EndIf

if not IDV_EnableScanner() = true then
        msgbox("Error enabling scanner!")
else
        ' trap the center button (ASCII 516) to fire the scan
        IDV_SetScanTrigger(1, 516)
endif

edBarcode = ""
```

ONCLICK BTNSAVEANDNEW

```
Tables("tblsampleinput").CreateRecord
Tables("tblsampleinput").MoveLast
Tables("tblsampleinput").Fields("BarCodeRef").Data = EdSampID.Data
Tables("tblsampleinput").Fields("ColDate").Data = SysDateToDate(GetSysDate)
Tables("tblsampleinput").Fields("ID_Number").Data = EDMicrochip
Tables("tblsampleinput").Fields("NP_SWAB_V").Data = chkvirus.Data
Tables("tblsampleinput").Fields("NP_SWAB_B").Data = chkbacteria.Data
Tables("tblsampleinput").Fields("Serum").Data = chkserum.Data
Tables("tblsampleinput").Fields("Heparin").Data = chkheparin.Data
Tables("tblsampleinput").Fields("FNA").Data = chkFNA.Data
Tables("tblsampleinput").Fields("ThinSmear").Data = chkTS.Data
Tables("tblsampleinput").Fields("TSSAMPID").Data = EdTSSampID.Data
Tables("tblsampleinput").Fields("SAMPREASON").Data = DrpSampReason.Data


EdMicrochip = empty
EdSampId = empty
```

ONCLICK BTNSAVEANDEXIT

```
Tables("tblsampleinput").CreateRecord
Tables("tblsampleinput").MoveLast
Tables("tblsampleinput").Fields("BarCodeRef").Data = EdSampID.Data
Tables("tblsampleinput").Fields("ColDate").Data = SysDateToDate(GetSysDate)
Tables("tblsampleinput").Fields("ID_Number").Data = EDMicrochip
Tables("tblsampleinput").Fields("NP_SWAB_V").Data = chkvirus.Data
Tables("tblsampleinput").Fields("NP_SWAB_B").Data = chkbacteria.Data
Tables("tblsampleinput").Fields("Serum").Data = chkserum.Data
Tables("tblsampleinput").Fields("Heparin").Data = chkheparin.Data
Tables("tblsampleinput").Fields("FNA").Data = chkFNA.Data
Tables("tblsampleinput").Fields("ThinSmear").Data = chkTS.Data
Tables("tblsampleinput").Fields("TSSAMPID").Data = EdTSSampID.Data
Tables("tblsampleinput").Fields("SAMPREASON").Data = DrpSampReason.Data


Forms("Main Menu").Show
```

ONKEY

```
dim asckey, virtkey, modkey
GetLastKey(asckey, virtkey, modkey)

'watch for the MzBarcodeReceivedKey=0x1D00 virtual key
'&H1D00 = decimal 7424
if asckey = &H1D00 then
        cmdGetData.execaction                 'get the barcode data
endif

Forms("Main Menu").Show
```

ONCLICK CMDGETDATA

```
dim strTemp, strData, strType

strTemp = IDV_GetScan(5)               'get the scanned barcode

if strTemp = "" then strTemp = "NO READ"

if Right(strTemp, 7) <> "NO READ" then
        if g_BCSType = 2 then
```

```
                        strData = strTemp
                        strType = ""
        else
                        'no barcode type ID
                        strData = strTemp
                        strType = ""
        endif
else
        strType = ""
        strData = "NO READ"
endif

'update the edit controls
edBarcode = strData

if edBarcode <> "NO READ" then
        'play good read tone
        Tone(3800,35)
        Delay(20)
        Tone(3800, 400)
else
        'trouble tone (low frequency razz sound)
        Tone(3800,35)
        Delay(20)
        Tone(400,600)
endif

if Left(EdBarcode,3) = "JDG" then
                    EdSampid.data = edBarcode
        Elseif Left (EdBarcode,1) = "M" then
                    EdTSSampID.data = EdBarcode
        Elseif Left (EdBarcode, 5) = "98514" then
                    EdMicrochip.Data = EdBarcode
        Else

        'trouble tone (low frequency razz sound)
        Tone(3800,35)
        Delay(20)
        Tone(400,600)
EndIf
```

5.2.3.   Foal temperature form

AfterOpen

```
Tables("tblFoalInfo").QuickSort("Foal_Name",True)
```

OnClick CHKDONE

```
Tables("tblfoaltemp").CreateRecord
Tables("tblfoaltemp").MoveLast
Tables("tblfoaltemp").Fields("RecordID").Data = GetSysTime
Tables("tblfoaltemp").Fields("ColDate").Data = SysDateToDate(GetSysDate)
Tables("tblfoaltemp").Fields("ColTime").Data = SysTimeToTime(GetSysTime)
Tables("tblfoaltemp").Fields("FoalID").Data = EdMicrochip.Data
Tables("tblfoaltemp").Fields("TEMPC").Data = EdTemp.Data
Tables("tblfoaltemp").Fields("LOCATION").Data = DrpLocation.Data
Tables("tblfoaltemp").Fields("Loc_Change").Data = ChkYesNo.Data
Tables("tblfoaltemp").Fields("Comments").Data = EdComments.Data
```

```
EdTemp.data = ""
ChkYesNo.data = False
EdComments.data = ""
Forms("Frm_Foal_Sampling").Show
```

5.3. New foal form

5.3.1. OnClick BTNSAVEANDNEW

```
Tables("tblnewfoal").CreateRecord
Tables("tblnewfoal").MoveLast
Tables("tblnewfoal").Fields("Dam_Name").Data = EdDamName.Data
Tables("tblnewfoal").Fields("Dam_Number").Data = EdDamNumber.Data
Tables("tblnewfoal").Fields("Breed").Data = drpbreed.Data
Tables("tblnewfoal").Fields("Sex").Data = drpsex.Data
Tables("tblnewfoal").Fields("Colour").Data = drpColour.Data
Tables("tblnewfoal").Fields("Birthdate").Data = Eddate.Data
Tables("tblnewfoal").Fields("Foal ID").Data = EdFoalID.Data
Tables("tblnewfoal").Fields("Date").Data = EdDateToday.Data


EdFoalID = empty
EdDamName = empty
drpbreed = empty
drpsex = empty
drpcolour = empty
eddate = empty
eddatetoday = empty

RecordNum = Tables("tblnewfoal").Count + 1
edRecord.Data = RecordNum – 1
```

5.3.2. OnClick CmdGetData

```
if Left(EdBarcode,1) <= "9" and Len(EdBarcode)<14 then
                EdDamNumber.data = edBarcode
                Elseif Left(EdBarcode,1) <= "9" and Len(EdBarcode)>14 then
                        EdFoalID.data = EdBarcode
                        Else
                EdDamName.data = EdBarcode
EndIf
```

6.   Visual Basic

6.1.   Uploading Data from the Palmtop

```
Option Compare Database
Const Status_HotSyncStart = 1
Const Status_HotSyncCommandComplete = 3
Const Status_HotSyncEnd = 2

Dim TableFilename_FOALTEMP As String
Dim TableFilename_FOALCLINICAL As String
Dim TableFilename_FOALNEW As String
Dim TableFilename_FOALSAMPLE As String

Dim HotSync_Progress As String
Dim CmdCount As Integer
Dim ReturnVar
_____
Private Sub Form_Load()
    DoCmd.SetWarnings 0

    TableFilename_FOALTEMP = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblfoalTemp.MDB"
    TableFilename_FOALCLINICAL = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblfoalclinical.MDB"
    TableFilename_FOALNEW = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblnewfoal.MDB"
    TableFilename_FOALSAMPLE = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblsampleinput.MDB"

    HotSync_Progress = "Begin"

    SatForms.Enabled = True

End Sub
_____
Private Sub SatForms_HotSyncStatus(ByVal StatusCode As Long, ByVal Param As Long)

If StatusCode = Status_HotSyncEnd Then
    HotSync_Progress = "End"
    Exit Sub
End If

If StatusCode = Status_HotSyncStart Then
    'Move from A - B
    ReturnVar = SatForms.GetTableFromPalmPilot(TableFilename_FOALTEMP, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.GetTableFromPalmPilot(TableFilename_FOALCLINICAL, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.GetTableFromPalmPilot(TableFilename_FOALNEW, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.GetTableFromPalmPilot(TableFilename_FOALSAMPLE, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)

    CmdCount = 1 'Count = 1 - command to transfer 1 file
    HotSync_Progress = "A>B"
End If
If StatusCode = Status_HotSyncCommandComplete Then
    CmdCount = CmdCount - 1
    If CmdCount <> 0 Then GoTo CmdCompleteExit
     If HotSync_Progress = "A>B" Then
          DoCmd.Close acForm, "FrmUploadFromPalm"
        End If
    HotSync_Progress = "B>C"

CmdCompleteExit:
End If
End Sub
```

6.2. Appending Palmtop Data

```
Private Sub AppendPalm_Click()
On Error GoTo Err_Command45_Click

    DoCmd.RunMacro "McrAppendData"
    DoCmd.RunMacro "McrRoutineBleedAppend"
    MsgBox "The Data Has Been Appended", vbDefaultButton1, "Append Data"


Exit_AppendPalm_Click:
    Exit Sub
End Sub
```

6.3. Clearing and Uploading data to the Palmtop

```
Option Compare DatabaseConst Status_HotSyncStart = 1
Const Status_HotSyncCommandComplete = 3
Const Status_HotSyncEnd = 2

Dim TableFilename_FOALTEMP As String
Dim TableFilename_FOALCLINICAL As String
Dim TableFilename_FOALNEW As String
Dim TableFilename_FOALSAMPLE As String
Dim TableFilename_FOALINFO As String
Dim TableFilename_LOCATION As String
Dim HotSync_Progress As String
Dim CmdCount As Integer
Dim ReturnVar
_____
Private Sub Form_Load()

DoCmd.SetWarnings 0

TableFilename_FOALTEMP = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblfoalTemp.MDB"
TableFilename_FOALCLINICAL = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblfoalclinical.MDB"
TableFilename_FOALNEW = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblnewfoal.MDB"
TableFilename_FOALSAMPLE = "C:\Program Files\Satellite Forms 7\Projects\FOALS\tblsampleinput.MDB"
TableFilename_FOALINFO = "C:\Program Files\Satellite Forms 7\Projects\FOALS\Table_Foal_Information.MDB"
TableFilename_LOCATION = "C:\Program Files\Satellite Forms 7\Projects\FOALS\LKUPLOCATION.MDB"


    HotSync_Progress = "Begin"

    SatForms.Enabled = True

 End Sub
_____
Private Sub SatForms_HotSyncStatus(ByVal StatusCode As Long, ByVal Param As Long)

If StatusCode = Status_HotSyncEnd Then
    HotSync_Progress = "End"
    Exit Sub
End If
If StatusCode = Status_HotSyncStart Then
    'Move from A - B
    DoCmd.OpenQuery "QRYSFTFoalClinicalDelete", acViewNormal, acEdit
    DoCmd.OpenQuery "QRYSFTFoalSampleDelete", acViewNormal, acEdit
    DoCmd.OpenQuery "QRYSFTFoalTempDelete", acViewNormal, acEdit
    DoCmd.OpenQuery "QRYSFTNewFoalDelete", acViewNormal, acEdit
```

```
    DoCmd.OpenQuery "Qry SFTFoalInfoDelete", acViewNormal, acEdit
    DoCmd.OpenQuery "Qry SFT Foal Info Append", acViewNormal, acEdit
    DoCmd.OpenQuery "Qry SFTLocationDelete", acViewNormal, acEdit
    DoCmd.OpenQuery "Qry Location Dropdown", acViewNormal, acEdit

    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_FOALTEMP, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_FOALCLINICAL, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_FOALNEW, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_FOALSAMPLE, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_HORSEINFO, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)
    ReturnVar = SatForms.CopyTableToPalmPilot(TableFilename_LOCATION, "SMS0", "Sddi_PalmDB.dll", 0, 1, 0)

CmdCount = 1 'Count = 1 - command to transfer 1 file
    HotSync_Progress = "A>B"
End If

If StatusCode = Status_HotSyncCommandComplete Then
    CmdCount = CmdCount - 1
    If CmdCount <> 0 Then GoTo CmdCompleteExit

        If HotSync_Progress = "A>B" Then
        DoCmd.Close acForm, "frmClearPalmData"
        End If
    HotSync_Progress = "B>C"

CmdCompleteExit:
End If
End Sub _____
```

7. Reports

7.1. Example of Routine Serum Sampling Report

Figure 15: Access database - Routine serum sampling report

7.2. Example of the Paired Serum Sample Report

Paired Serum Sample Procedures to be accomplished between:
15/04/2008 and 22/04/2008

2008/04/17

Brighton Rock	‖‖‖ 985140000373054	1 Kloof
DISCOVER DIAMON	‖‖‖ 985140000313018	3 Kloof
Invitation Only	‖‖‖ 985140000312588	4 Kloof
Jallad's Star	‖‖‖ 985140000308296	7 Kloof
Mazagan	‖‖‖ 985140000373547	2 Kloof
Memphis Blues SNL	‖‖‖ 985140000258936	Mandy's Camp
Splendid Rake	‖‖‖ 985140000320916	Pearls Camp
Stormy Petrel	‖‖‖ 985140000318077	Mandy's Camp
Taking It Deep	‖‖‖ 985140000316973	2 Kloof

Figure 16: Access database - Paired serum sample report