

Health and management of hobby pigs: a review

Gezondheid en het houden van hobbyvarkens: een overzicht

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A BSTRACT

Miniature pigs, like the Vietnamese pot-bellied pig and the Kunekune, are the most popular hobby pig breeds. Despite their popularity, the knowledge of their health and management is still scarce. They have an exemplary sense of smell and hearing, possess good adaptability and are easy to handle. A well-ventilated shelter space with an area for recreation, and incorporation of straw for manipulation prevents boredom. Drinking water must be provided at all times. Restricted feeding ones or twice a day is preferred to prevent obesity. Unexpected aggressive behavior may occur and lead to abandonment of pet pigs. Overgrowth of claws, mange and sunburns are common skin problems. Diarrhea due to *Escherichia coli* is a common problem in piglets. Neutering is recommended to prevent aggressive behavior and pungent smell in males and to avoid the risk of neoplasms. It is preferably done at a young age to avoid surgical complications. Prophylaxis against erysipelas and parasites are recommended biannually. Other periodical health care practices include tusk and hoof trimming.

SAMENVATTING

Miniatuurvarkens, zoals het Vietnamese hangbuikvarken en de Kunekune, zijn de bekendste hobbyvarkensrassen. Ondanks hun populariteit is de kennis van hun gezondheid en management schaars. Ze hebben een uitstekend reukvermogen en gehoor, beschikken over een goed aanpassingsvermogen en zijn doorgaans gemakkelijk te hanteren. Ze gedijen goed in de thermoneutrale zone. Een goed geventileerde schuilplaats met een recreatiegebied en het opnemen van stro voor manipulatie voorkomen verveling. Drinkwater moet te allen tijde worden verstrekt. Beperkte voeding één of tweemaal daags is optimaal om overgewicht te voorkomen. Agressie kan optreden en is een van de redenen waarom eigenaars het varken niet langer wensen aan te houden. Schurft en zonnebrand zijn de meest voorkomende huidproblemen. Diarree door *Escherichia coli* kan voor problemen zorgen bij biggen. Castratie wordt aanbevolen om agressief gedrag, het verspreiden van een penetrante geur en het risico op neoplasmata te vermijden. Het wordt bij voorkeur op jonge leeftijd uitgevoerd om chirurgische complicaties te voorkomen. Er wordt aanbevolen om profylaxe tegen vlekziekte en endoparasieten twee keer per jaar uit te voeren. Andere maatregelen zijn onder meer het periodiek inkorten van de slagtanden en het bekappen van de klauwen.

INTRODUCTION

Following the introduction of the Vietnamese pot-bellied pigs into the United States in 1986, their popularity increased steadily over the years, reaching a peak between 1991 and 1995 with about 35,000 regis-

tered and 200,000 unregistered pigs by 2002 (Blaney, personal communication) (Munday and Stedman, 2002; Sipos et al., 2007). Although pigs are not usually kept as pets, they can be a good companion to humans as they are intelligent, clean, extremely social and affectionate, and once trained properly, they are

safe to be in the presence of children and the elderly (Braun and Casteel, 1993; Carr and Wilbers, 2008; Swindle and Smith, 2015). Having a mini pig as a pet is quite a commitment as they can live up to 15-25 years of age (Holtz, 2010; Swindle and Smith, 2015).

The aim of the present paper was to review the background and breeds of miniature pigs, the housing and nutritional requirements and the overall management with emphasis on health and behavior.

EUROPEAN UNION (EU) REGULATIONS ON HOBBY PIG KEEPING

A hobby pig keeper can raise up to three pigs. If the hobby pig keeper intends to expand his farm by breeding the pigs, then it is mandatory to have a business register, to identify the pigs and have transport documents. Prior to trading, all pet pigs must be examined and certified by a licenced veterinarian to rule out notifiable diseases (2014/178/EU). In addition, this certificate must be registered (council directive 2008/71/EC) and the documents maintained for five years. All hobby pig keepers must register with Animal Health Care Flanders (Dierengezondheidszorg Vlaanderen, DGZ), without authorization by the Federal Agency for the Safety of the Food Chain (FASFC). In that case, breeding and slaughter for human consumption are forbidden. Commercial pig keepers are not authorized to keep hobby pigs. Many mini pig owners living in the urban areas have no practical knowledge of pig keeping, nor is there awareness among them regarding economically important diseases or those that are zoonotic in nature. Hence, for epidemiological reasons, pet pigs are considered similar to commercial pigs and the statutory provisions differentiate mini pigs from the other pets (Wismans, 1999; Sipos et al., 2007). The owners must notify the FASFC if there has been an accidental contact with feral pigs, following which epidemiological investigation takes place to confirm or exclude disease transmission.

BEHAVIOR

Miniature pigs though smaller in size and docile in nature (Braun and Casteel, 1993; McAnulty et al., 2011), have evolved like the domestic pigs and are part of the Suidae family showing similar behavioral characteristics under natural conditions. Grazing and browsing are the prominent foraging behaviors reported in free-ranging pigs. Exploration and rooting are behavioral necessities starting already early in life, even in the absence of stimulus (Bollen and Ritskes-Hoitinga, 2007; Studnitz et al., 2007).

Management of aggression in pet pigs

Mini pigs may show aggression towards unfamiliar people and environment, which is usually noticed

around the time of social maturity (six months to three years). Irrespective of the age of weaning, sex, neutering status and incorporation of enrichment material, aggressive behavior is more common in pigs than in other domestic animals (Tynes et al., 2007). Neglecting such behavior can result in them showing dominance aggression towards familiar people as well. These issues are treated in a similar way as dog aggression. Introducing them to a leash or harness at a very early age and teaching them simple commands using food lure while they are being fed, petted and walked will avoid conflicts. Young pigs can be trained faster (two to three weeks), while in adults, training may take two to three months' time (Holtz, 2010; Swindle and Smith, 2015). Pigs raised as single pets are more likely to show aggression, as isolation may lead to stress and behavioral changes (Ruis et al., 2001; Kanitz et al., 2004). Pigs housed in individual pens require visual, auditory and olfactory contact with other pigs to avoid social deprivation (Smith and Swindle, 2006).

Isolation and boredom may lead to vacuum chewing with an empty mouth and under unfavorable housing conditions, a frustrated pig might bite and destroy inanimate objects like fences and food bowls. Among all, cannibalism involving mutilation of the ears and tail leads to serious bacterial infections. Continuous massage of the anal region with the snout can cause serious injury, inflammation and may even lead to death (Holtz, 2010).

Incorporating fresh wood logs in the pens improves the exploratory behavior of pigs and reduces the incidence of tail and ear biting (Telkanranta et al., 2014). High-duration tail movements are an indicator of positive emotions whereas, high frequency ear movements are a sign of decreased welfare (Ruis et al., 2018).

Interspecies aggression can occur when a dog and a pig are left unsupervised. Although the two species communicate differently, the risk of aggression is lower with a combination of a non-predatory and non-aggressive breed of dog, such as a Labrador, and a mini pig of similar size. In spite of careful consideration and acceptance by a dog, a pig is likely to show dominance post maturity, but with a gentle dog serious fights are unlikely. Another possible target for pet pigs are children, as pigs are intimidated by them (Tynes, 1997).

Restraint and handling of pet pigs

A visit to the veterinarian may be very stressful and chaotic especially with an untrained and aggressive pet. Forceful approach may provoke fear and distrust leading to struggle and vocalization as pigs squeal when they are anxious or kept confined. Extreme stress and panic may lead to circulatory collapse because of their relatively small sized hearts (Bollen and Ritskes-Hoitinga, 2007; Zimmerman et al., 2012). Small piglets (5-20 kg) can be lifted or tucked

up under the arm. With the aid of boards, heavy and uncooperative boars can be approached from the sides but with caution, as they can inflict serious injuries with their tusks (Tynes, 1998; Holtz, 2010). The examiner can kneel on the floor and restrain the pig by placing it in between the examiners legs. Snout snares are not well accepted by pet owners. There is a risk of fracture or luxation when held by the hind limbs (Fubini and Ducharme, 2016). Pigs relish back scratching and belly stroking, and use of a hammock-like sling is well tolerated by mini pigs (Swindle, 2007).

Gentle handling builds trust and develops a human animal bonding. Introducing them to toys of various sizes, shapes and colors will not only enrich their environment but also improves the habit of exploration and reduces the fear for new stimuli. Enrichment objects reduce the biting behavior of pigs (Van de Perre et al., 2011). Conditioning them to a harness and leash at an early stage will ensure easy handling even when they are fully grown. Habituating them for short walks and car rides can make their visit to the veterinary clinic less stressful (Zimmerman et al., 2012). Although pigs in general are afraid of humans (especially the Vietnamese pot-bellied pigs), they are easy to train and socialize with positive reinforcement. They must be taught to obey commands in return for small food rewards, such as carrots, cookies, dog biscuits and candy (Lorensten, 2014; Swindle and Smith, 2015).

MINIATURE PIG BREEDS

The idea of having a pig as a pet animal started when the Vietnamese pot-bellied pig (VPB), other-

wise called Chinese house pig, gained popularity after being kept as a show animal in zoological parks in Canada in the mid-1980's. The New Zealand Kunekune, which has gained popularity in the United Kingdom, are friendly pigs and are crossed with the Vietnamese to make an ideal household pet (Duncanson, 2013). The small stature of the VPB pig (birth weight 0.4 – 0.6 kg and weight at six months 17-28 kg) made them an ideal indoor pet. The majority of the miniature pigs weigh about 12-45 kg around the time of sexual maturity in contrast to the domestic pigs that weigh about 100 kg (McAnulty et al., 2011; Swindle and Smith, 2015) (Table 1).

At least 45 different breeds of miniature pigs have been reported worldwide. Miniature pig breeds are a subspecies of the domestic pig (*Sus scrofa*) and are either commercially raised for research studies or bred naturally to be raised as pets (Ilha et al., 2010; McAnulty et al., 2011). The Yucatan, a Mexican feral pig and the Ossabaw of Spanish heritage are the only two naturally occurring mini pigs used in biomedical research (Swindle and Smith, 2015).

The Wuzhistan miniature pig is one among the four indigenous Chinese breeds (Wuzhistan, Xiang, Diannan small-ear and Tibetan miniature breeds), which can withstand hot environmental conditions. The indigenous pigs breeds of Vietnam are genetically diverse from the European gene pool. They can adapt to extreme climatic conditions (Huyen et al., 2005). In Table 2, the general characteristics of six indigenous pig breeds in Vietnam are depicted (Dang et al., 2010). The Vietnamese miniature pigs have therefore been cross-bred with the commercial farm pigs in Europe to attain certain breeds and lines namely the Göttingen miniature pig, the Berlin miniature pig,

Table 1. General description of miniature pig breeds.

Breed	Average birth weight (g)	Weight at sexual maturity (kg)	Average adult weight after one year (kg)	Coat color
Vietnamese pot-bellied pig	400-600	15-20	50-60	Black or black with white marking
Kunukune	800-900	-	50-80	Hairy black, red and white, ginger, brown, black, gold-tip, cream and also tri-colored
Göttingen	450	10-14	30-45	White non pigmented
Sinclair S-1	590	16-22	55-70	Black, red, white and roan
Juliana or painted miniatures	-	-	6-20	Red, red and black, red and white, white and black, black, silver, silver and white
African Pygmy or Guinea Hogs	-	-	10-20	Hairy red
Miniature Yucatan	500-900	20-30	70-80	Slate grey to black
Micro Yucatan	600-700	14-20	55-70	Slate grey to black
Wuzhistan	1000	12-14	25	Black with white abdomen and flank area
Hanford	730	20-40	80-95	White hair coat
Panepinto	500-800	-	25-30	Dark grey or black
Munich	600-900	-	60-100	White, black, red, dark brown or spotted
Clawn	500	-	40	White, rarely black and spotted

the Munich miniature pig and the Bergstrasser Knirps (Sipos and Kaltenegger, 2004).

The Sinclair or otherwise the Minnesota or Hormel mini pig from the United States has a complex genetic background and is used to develop other mini pigs like the Göttingen, Nebraska and mini pig of the Czech Republic. The Göttingen mini pig was developed in 1961 at Georg-August-University in Göttingen, Germany by crossing the Minnesota Mini pig (for small size and docile behavior) with the Vietnamese pot-bellied pig (for fertility) and the German Landrace (for the white phenotype) and it carries the characteristics of the three (Rozkot et al., 2015). The Juliana or painted miniature is the smallest of all the mini pigs with a light boned body and are extremely playful. The Pitman-Moore and its derivative, the Hanford minipig, the Minisib minipig from Serbia and Ohmini and Clown of Japanese origin are a few other miniature breeds (Bollen et al., 2010; Holtz, 2010). The Hanford (25 to 40 kg) and the Gottingen (10 to 14 kg) are the largest and smallest miniature pigs, respectively.

The Ossabaw, Banna, Ohmini, Pitman-Moore, Chinese Dwarf, Meishan, Panepinto and Vietnamese pot-bellied-pig are available in limited markets (Swindle and Smith, 2015).

HOUSING

Pet pigs should never be raised with production animals and ideally be housed at least 500 meters away from commercial pig farms to prevent the risk of spread of diseases. A full grown adult mini pig weighing 50-80 kg requires a minimum floor space of 0.55 to 0.65 sq. m per pig. In Table 3, the floor space requirements for pet pigs housed outdoors are shown (Duncanson, 2013). Rarely, owners keep their pet pig indoors (Duncanson, 2013). Besides these dimensions, pigs require a space for excretion, recreation and exercise (Figure 1).

Proper ventilation is essential, as they are sensitive to extreme temperatures due to the lack of sweat glands and scanty hair. In warmer months, when more noxious gases are released, a fan can be used. The air velocity must not exceed 0.2–0.3 m /s for adults and 0.1 m /s for piglets (Bollen et al., 2010). The pens must be fitted with an insulated, non-slippery flooring, and sufficient quantities of straw or hay keeps them comfortable to tolerate temperatures as low as 10°C (Mul et al., 2010). Incorporating enrichment material like hanging objects and some extra straw will keep them occupied with their manipulative activities like root-

Table 2. General description of Vietnamese miniature pigs.

Breed	Age at sexual maturity (months)	Average Litter size	Adult weight after one year (kg)	Coat characteristics	Coat Color
“I” or Vietnamese pot-bellied	1-2	8-11	50-60	Short and sparse	Black
Mong Cai	2	10-14	75-80	Thin hair	White
Muong Khuong	6-7	5	90	Thin and soft	Black or black with white spots
Soc	6-9	6-10	50-55	Thick skin, Long hair	Black
Meo	8-9	6-7	100	Long black hair	Yellow skin
Co	2 -3	6-7	30-35	Black and white hair	Mixed black and white

Table 3. Space requirements for pet pigs housed outdoors

Pig weight (kg)	Sleeping Space/ Shelter Space (sq. m)	Running meter for hand feeding per pig
Weaning to 35	1	0.25
35 - 60	1.5	0.3
More than 60	2	0.4

Table 4. Feed and water requirements of miniature pigs.

Body weight (in kg)	Feed requirement (g/day)	Body weight (in kg)	Water requirement Normal range (in liters/per pig/day)
5	255	Weaners	2-4
10	425	15-25	3-5
20	715	25-45	5-7
50	1.425	45-65	4-9
80	2.025	> 65	9-12
		Dry sow/ Boars	7-17
		Lactating Sows	14-30

Table 5. Analgesics used in miniature pig practice.

Drug class	Drug	Dose	Route	Interval
Opiate	Buprenorphine	5-20 µg/ kg	IM	6-12 hours
	Butorphanol	0.1-0.3 mg/ kg	IM, SC	4-6 hours
NSAID	Ketoprofen	3 mg/ kg	SC	24 hours
	Meloxicam	0.1-0.2 mg/ kg	SC	24 hours
Local	Bupivacaine Lidocaine		Local infiltration	

ing and chewing and can also spare them from boredom (Fraser et al., 1991; Council Directive 2008/120/EC). They can show destructive behavior due to boredom. Studies have shown better behavioral responses and also a reduction in postweaning diarrhea and tail biting incidences when the pens were enriched (Munsterhjelm et al., 2009).

Fly problems are encountered when pigs are housed under unsanitary conditions. Flies and mosquitoes may contribute to the spread of pathogens, such as porcine reproductive and respiratory syndrome (PRRS) virus and *Streptococcus suis* over short distances. Blood-sucking insects can be potential vectors for e.g. African swine fever (ASF) virus. The use of insecticide sprays in the premises and proper sanitary measures can help control flies. For pigs that are constantly housed outdoors, strict biosecurity measures must be followed. Based on the Royal decree of 18 June 2014 containing measures for the prevention of notifiable porcine diseases, the provision of double fencing is mandatory to avoid direct contact with feral pigs. A boundary fence that is 2.5 meters high and 0.5 meters deep prevent pigs and other animals like feral cats and wild boars from leaving or entering the premises (Jackson and Cockcroft, 2007; Commission Implementing Decision 2014/178/EU).

NUTRITIONAL REQUIREMENTS

Mini pigs are omnivorous like their domestic counterpart. A restricted low-energy diet with a metabolic energy of 9.5 MJ/ kg (2275 kcal/ kg) comprising of mashed meal and roughages (grass, hay, silage and



Figure 1. Knor, a seven-year-old, castrated, male hobby pig (from private collection).

tubers) suffices the daily nutritional requirements of a mini pig (Bollen et al., 2010) (Table 4). A combination diet with standard pellets or meal containing ground cereals, enriched with protein (milk products, soya bean meal or fish meal), vitamins, minerals and amino acids can be mixed with water to make a mash. Pigs that are maintained on a commercial fixed formula diet need to be fed at least once a day. (Holtz, 2010; Mul et al., 2010). Dividing the ration into twice or thrice a day keeps them engaged. Pigs are generally fed at the rate of 0.2 to 2.5 kg feed per day for pigs within the weight range of 5-55 kg (National Research Council, 1998; Swindle and Smith, 2015). Inclusion of green fodder, sugar beet pulp and bran provides a low energy maintenance ration with a high

fiber content (14%). However, high fiber diet in excess of 15% may result in prolonged gastric emptying and intestinal transit time.

The nutrient requirements of male Göttingen miniature pigs are higher than those of females. Both males and females can become obese following ad libitum feed intake, but females generally gain more weight with thicker relative back fat layers (Bollen et al., 2005). Restricted feeding is recommended for miniature swine as they don't restrain feed intake. This may result in obesity, which is common in hobby pigs. It is a serious health problem. It compromises the overall health of the animal and increases the susceptibility to a variety of conditions like cardiovascular problems (atherosclerosis), arthritis and kidney failure. Excess facial fat and fat depots around the eye may hinder vision (Tynes, 1999). In extremely obese miniature pigs, more pronounced oxyhemoglobin desaturation takes place during sleep with both central and obstructive sleep apneas (Lonergan et al., 1998). This results in snoring and disturbed sleep with frequent arousal to regain oxygen saturation. In order to maintain the small stature, some owners feed their pets lower than the minimum daily requirement, which creates a constant feeling of hunger, in turn leading to aggression.

The Royal decree of 15 May 2003 concerning the protection of pigs in pig farms prohibits swill feeding (feeding of kitchen waste) as it can pose a risk of spread of diseases like African swine fever (ASF) and foot and mouth disease (FMD).

Water requirement for pigs weighing between 20 and 90 kg is 2.5 liters for every kilogram of feed provided (Swindle, 2007). The water consumption by pigs when given a restricted diet and when fed ad libitum is 3.7 liters and 2.5 liters per kilogram of feed consumed, respectively (Cumby, 1986). The amount of water intake is further determined by the climate and the temperature of the drinking water. Fresh cool water is preferred on warmer days, while in winter, pigs do not consume adequate quantities if the water is cold (Vajrabukka et al., 1981). The daily water requirements of pigs is given in Table 4 (Hill and Sainsbury, 1995). Water deficits may cause urinary tract infections (cystitis), salt poisoning and lead to vices like urine drinking (Hill and Sainsbury, 1995; Swindle, 2007; Duncanson, 2013).

Pigs must be allowed to root and find their food rather than feeding them from a bowl. They constantly alternate between the feed and water containers resulting in spillage. This can be prevented by removing the water at the time of feeding or to place a tray below to contain the spillage.

REPRODUCTION

Sows are polytocous with an estrous cycle of 21 days (range 17-24 days). During the estrous period of two days (1-5 days), they display nervousness and

increased activity along with prominent swelling and reddening of the vulva. This is followed by ovulation 30-36 hours after the onset of estrous. Miniature pigs reach sexual maturity by 4-6 months of age. Owners who intend to breed their pigs can either follow pen mating, hand mating or artificial insemination (AI). The pig is considered to be pregnant on failure to return to estrous 18-24 days following mating or AI. The gestation length ranging from 111-114 days is generally slightly shorter than the gestation length of commercial pigs. Litter size is 4-8 piglets, depending on the breed (Laber et al., 2002; Swindle, 2007). Pet pigs are often weaned at 7-8 weeks of age. By that time, the piglets have reached a sufficient size. For comparison, under natural conditions, weaning takes place at approximately twelve weeks and is a gradual process.

NEONATAL CARE AND MANAGEMENT

Knowledge of neonatal piglet care can prevent serious conditions like hypothermia and hypoglycemia. As piglets are unable to regulate their body temperature in the nest area, an artificial heating source using light bulbs or heating pads should be provided. Piglets move away from the light source if the temperature is above the ambient temperature (33°C to 35°C). The first 24 hours of life is critical for the absorption of immunoglobulins from colostrum. Orphan piglets are either introduced to a foster sow, or cow colostrum can be substituted to acquire nonspecific immunity (Braun and Casteel, 1993). Homemade or commercial milk replacers, given 4-6 times a day, can satisfy the high energy and nutrient requirements of newborn piglets. Iron should be supplemented to piglets raised indoors. This is not needed for piglets that are raised outdoors and have access to soil (Braun and Casteel, 1993; Jackson and Cockcroft, 2007).

HOBBY PIG MEDICINE

Pigs in general are sturdy animals, yet mini pigs are likely to share the same diseases as domestic pigs. They may succumb to illness when exposed to other diseased animals, under unsanitary conditions and/or when the immune system is compromised as a consequence of malnourishment.

Skin problems

Mange

Mite *Sarcoptes scabiei* var. *suis* causes severe pruritus (itching) of the affected areas like the ears, snout, rump, flank and abdomen. Flaky skin, dryness and alopecia are common in mange-affected pigs. Constant rubbing may lead to oozing of serum, giving

the animal a greasy appearance. Diagnosis is made by microscopic examination of the yellowish-brown wax in and around the ears. Pet pigs recover well with two doses of Inj. Ivermectin (two weeks interval) at the rate of 300 μ g/ kg body weight given subcutaneously (Carr and Wilbers, 2008; Zimmerman et al., 2012). Additionally, medicated shampoo baths and isolation till they are mange-free is recommended.

Pediculosis

Lice (*Hematopinus suis*) infestation results in skin damage due to excessive itching and rubbing, and anemia due to blood sucking. Swine lice are known to transmit erysipelas and swine pox virus. Insecticides for external use or Ivermectin may be used to treat affected animals (Zimmerman et al., 2012).

Ticks Infestation

Both hard (ixodid) and soft (argasid) ticks infest pigs. The importance of ticks is their ability to transmit pathogens. The tick species *Ornithodoros erraticus* is a reservoir of African Swine fever virus (Braks et al., 2017).

Sunburn

Light-colored pigs are more prone to sunburns when exposed to hot weather. The ultraviolet rays can cause dryness, scaling, necrosis of skin. Affected pigs may experience muscle twitching and pain. Application of sunscreen lotion, provision of water for wallowing and shade will protect them from sunburns and heat strokes. Pigs prefer to coat their bodies with mud. This does not only keep their bodies cool but also helps to protect their skin from sunburn (Hill and Sainsbury, 1995; Carr and Wilbers, 2008).

Dippity pig syndrome

Bleeding back or dippity pig syndrome is an acute skin condition affecting 3-10-month-old pigs. Although the exact cause is not known, a number of factors, like stress, sunburns, dehydration, climate changes affecting the body temperature, change from routine activities or even a visit to the veterinarian, can inflict areas of weeping blisters on the body. It is a self-limiting condition; however, medication (application of lidocaine gel) to alleviate the pain and palliative treatment are recommended for the acute necrotizing cellulitis (Tynes, 1998; Carr and Wilbers, 2008).

Blown coat syndrome

Blown coat syndrome is a condition in pot-bellied pigs, in which alopecia with complete baldness is noticed for a few weeks. It mostly occurs following

pregnancy or illness (Tynes, 1999).

Other skin diseases

Flaky skin may also result from deficiency of essential amino acids and is managed by supplementation of cod liver oil (10 ml/ 50 kg) with a mild shampoo bath (Carr and Wilbers, 2008). Bacterial infection caused by *Staphylococcus hyicus* may cause exudative epidermitis, giving the skin a greasy appearance.

Problems of the gastrointestinal tract

Enteritis

Diarrhea is encountered in pigs of all age groups and ranges from yellowish watery diarrhea to hemorrhagic mucoid diarrhea. The morphological and physiological changes during the gut maturation process, the stress associated with transportation or a change in diet may result in diarrhea and dehydration in young and weaned pigs. In adult pigs, diarrhea may result from overfeeding or intake of mouldy feed. Diarrhea associated with *Escherichia coli* and *Clostridium perfringens* type A and C may occur in piglets between 1-14 days of age. Enteritis due to *Salmonella* spp., *Brachyspira* sp. and *Lawsonia* sp. may affect all age groups (Laber, 2002; Thomson and Friendship, 2012; Luppi, 2017). Dogs may be a source of infection for swine dysentery (*Brachyspira* sp. infection) and birds may be carriers of *Salmonella* spp. (Jackson and Cockcroft, 2007).

Endoparasites

Mini pigs contract endoparasites from soil and other pigs or pets that host the parasite resulting in malnutrition. In severe and chronic cases, vomiting, diarrhea, anemia, cough, loss of body condition and bloating may be noticed. Although mini pigs live in semi-secluded homes, routine fecal examination can help in choosing the proper anthelmintic treatment. According to Tynes (1999), hobby pigs do not share parasites with companion animals like dogs and cats. On the contrary, it is possible for mini pigs to contract *Toxoplasma gondii*, a protozoan parasite of cats with zoonotic implications. However, humans acquire infection from pigs only by consumption of tissue cysts, and this is unlikely in the case of pet pigs.

Problems of the respiratory tract

Atrophic rhinitis and pneumonia are commonly encountered in pet pigs (Carr, 2004). Stress, dampness, dust, extreme weather fluctuations and damage to the turbinate may predispose pigs to fatal pneumonia owing to their small sized lung capacity (Tynes, 1998). Sneezing, coughing, mucopurulent discharge, and in extreme cases nasal bleeding and

thumping, are displayed by affected pigs. Vaccination against the target agent is recommended in case of problems.

Problems of the reproductive tract

Scrotal hernia

In pigs, the size of the external inguinal ring is larger in proportion to the size of the animal and larger when compared to other species. This makes them more susceptible to hernias. Commercial pigs are found to be genetically predisposed with high prevalence rates reported for scrotal and inguinal hernias. Unilateral cryptorchidism has been reported in pot-bellied pigs with the testicle retained in the abdomen or the inguinal canal (Ostevik et al., 2012).

Tumors

Intact female pigs are more likely to be affected with uterine, cervical and ovarian tumors and the incidence increases with increasing age (Akermans and Van Beusekom, 1984). Aging nulliparous pet pigs are at greater risk of developing reproductive tract tumors (Harmon et al., 2004). A higher incidence of reproductive tumors in intact female Vietnamese pot-bellied (VPB) pigs followed by intact males has been reported in a retrospective study (Newman and Rohrbach, 2012). In that study, the mean age of pigs with neoplasia was eleven years. From a total of 32 female miniature pet pigs (four months to 19 years of age) that were spayed, twenty had smooth muscle tumor in the uterus whereas, cystic endometrial hyperplasia (CEH) was recorded in 24 of them. Fourteen had concurrent CEH and smooth muscle tumor (Ilha et al., 2010). A case of cervical and uterine leiomyoma and uterine adenocarcinoma with CEH has been reported in a nine-year-old nulliparous VPB sow, that cycled every three weeks (Augustijn et al., 2010). Cystic endometrial hyperplasia associated with uterine leiomyomas has been reported in two VPB pigs (Munday and Stedman, 2002). They were eight and ten years of age, cycling regularly, one being nulliparous and the other having farrowed twice until the age of two. A high incidence of uterine tumors has been reported in pigs aged five and above (Mozzachio et al., 2004). In that study, out of 106 female VPB pigs, 17 had uterine neoplasms consisting of single and multiple leiomyomas, leiomyosarcomas, undifferentiated sarcoma and squamous cell carcinoma. A strong association has been suggested between hormone influence and tumor development in intact female miniature pigs. As cyclic female household pet pigs often never become pregnant, they are predisposed to developing genital tract tumors. In pigs, zearalenone induced hyperestrogenism has resulted in CEH (Chang et al., 1979). During estrous period, there is an increase in the estrogen receptor activity without sufficient serum

estrogen concentrations. Repeated cycling leads to the development of uterine lesions. Inbreeding may be a predisposing factor for changes in uterine pathology (Ilha et al., 2010). Hence, neutering is the only practical measure to prevent constant hormonal stimulation in non-breeding female pigs.

Locomotor problems

In preweaned piglets, polyarthritis affecting more than one joint is associated with bacteria invading the bloodstream through skin wounds, navel or tonsils. Environmental pathogens causing arthritis in piglets below 12 weeks of age include *Trueperella pyogenes*, *Streptococcus dysgalactiae* subsp. *equisimilis*, *Staphylococcus hyicus*, *S. aureus*, and *Haemophilus parasuis* (Zoric et al., 2008). The sow is an important source of infection to piglets. Pathogens like *S. equisimilis* is commonly found in the vaginal microbiota of the sow (Zimmerman et al., 2012). Coliforms are also isolated from affected joints in chronic cases (Zimmerman et al., 2012; Zoric et al. 2016).

Mycoplasma hyorhinis, *M. hyosynoviae*, *E. rhusiopathiae*, and *S. Choleraesuis* are also associated with infectious arthritis. *M. hyorhinis* causing polyserositis affects pigs mainly below ten weeks of age. Affected animals show lameness and reluctance to move (Neto et al., 2012; Zimmerman et al., 2012).

M. hyosynoviae mainly affects pigs older than ten weeks of age. Infections cause non-suppurative arthritis of the shoulder, hock and elbow joint after 2-3 weeks of exposure. Lameness is noticed in one or more limbs in pigs between 3-5 months of age.

Many factors influence infectious arthritis, including lack of hygiene, genetics and poor nutrition. Wetness, cold floor and improperly bedded flooring may be a risk factor for arthritis in adults. Non-weight bearing is noticed with infections of the third foot commonly termed as bumble foot (Jackson and Cockcroft, 2007).

Septicemia and tail-bite abscessation may spread to bones causing osteomyelitis, ankyloses and muscle wasting. Osteomyelitis results in lameness and pathological fracture of the vertebrae (Zimmerman et al., 2012). Long claws and deformed claws are a common cause of lameness in pot-bellied pigs (Sipos et al., 2007).

DISEASE PREVENTION

Anthelmintics against endoparasites

The most widely used anthelmintic drugs include Benzimidazoles (fenbendazole, flubendazole), Tetrahydropyrimidines (Pyrantel), Avermectins (Ivermectin) and Imidazothiazoles (levamisole hydrochloride). However, fenbendazole is the preferred anthelmintic for the treatment and control of mature and immature

gastrointestinal and respiratory nematodes (*Ascaris suum*, *Oesophagostomum* spp., *Trichuris suis*, *Metastrongylus elongatus*, *Hyostrongylus rubidus* and *Strongyloides ransomi*). Anthelmintic treatment in pet pigs is recommended every 4-6 months and also prior to farrowing (Carr and Wilbers, 2008). Good sanitary measures including periodical removal of bedding (straw), disinfection and drying of pens, along with the proper choice of anthelmintic drug are critical elements in controlling parasite burden.

Immunization

Vaccination of pet pigs usually depend on several factors, like the geographical area they are situated in, their age, possible exposure to other pigs and prior vaccination status. Vaccination against erysipelas is highly recommended starting at twelve weeks of age followed by a booster after 2-4 weeks of initial vaccination and biannual (twice a year) vaccinations thereafter. Depending on whether or not rabies is a threat in the area, mini pigs can be immunized using the dog or horse vaccine as there are no approved products for use in pigs. Rabies vaccination is mandatory in some circumstances, such as travelling to other EU member states, camping, etc.

Vaccinations recommended for breeding pigs

Sow vaccinations can protect piglets from infections occurring early in their lives through maternal immunity transferred through colostrum and milk. Vaccination against *E. coli* or combined vaccination against *E. coli* and clostridial enteritis is given at six and three weeks prior to farrowing. An array of reproductive losses like stillbirths, mummification, embryonic death and infertility are caused by porcine parvovirus (PPV). Vaccination of both sexes against PPV is done prior to breeding using two doses with 4-6 weeks interval, with the second dose given 2-4 weeks before mating. This is followed by biannual vaccination for boars, and for sows, vaccination is always done prior to breeding (Carr and Wilbers, 2008).

OTHER WELFARE PRACTICES

Hoof care

Mini pigs require regular exercise on rough flooring made of concrete or gravel for constant wear and tear of the hoof. White hooves in general are softer than the black and require less frequent trimming as they wear down easily. Annual hoof trimming is adequate except in a few pigs which may require biannual trimming. Hooves must be regularly pared using rasps or trimmers as overgrown hooves are a serious welfare problem (Carr and Wilbers, 2008; Zimmerman et al., 2012).

Tusk trimming

The canine teeth, also called “tusks”, of miniature pigs require proper and regular maintenance for the safety of both the owner and the pigs, as excessive tusk growth can cause facial damage. The tusks of boars grow throughout their lives, whereas for the sows the growth ceases by 1.5 to 2 years of age and are also not as strong as those of a boar. As canine teeth have deep seated roots they are difficult to extract. A Gigli wire or saw is used to trim the tusks at the gum line under minimal restraint and sedation. Constant friction between the canines of the upper and lower jaw may result in sharpening of the edges of the lower tusks. Trimming procedures need to be carried out every 3-6 months for adult males. In castrated males and females, the canine teeth are slow growing and may not require periodical trimming unless otherwise required (Eubanks, 2005; Swindle, 2007).

NEUTERING IN HOBBY PIGS

It is best to neuter all pet pigs both males and females at an early age unless intended for breeding purpose. Early neutering helps to control unpredictable behavior and in case of males, causes a reduction in the size of the preputial diverticulum. This prevents the strong unpleasant odor. Resolution of human directed aggression and undesirable behavior ceases following castration (Ostevik et al., 2012) and ovariohysterectomy (Carr, 2004).

Surgical castration in male pigs

Castration before twelve weeks of age using a prescrotal approach (Zimmerman et al., 2012) similar to the technique used in dogs or a scrotal approach (Ostevik et al., 2012) is recommended for pet pigs. Closure of the external inguinal ring is recommended to prevent herniation (Braun and Casteel, 1993; Ostevik et al., 2012).

Male mini pigs attain puberty as early as three months of age and if left intact, display sexual behavior (mounting), aggression, urine spraying, and also develops an unpleasant boar odor due to the accumulation of a pungent material in the enlarged preputial diverticulum. The diverticulum has no known function and accumulates urine, semen and smegma. For intact boars above 2-3 years of age, an additional preputial diverticulectomy can reduce the smell and the risk of ascending cystitis infection. For piglets above seven days of age, the directive 2001/93/EC states that castration must be performed under anesthesia with additional prolonged analgesia (Jaggin et al., 2006).

Spaying (ovariohysterectomy or ovariectomy) in female pigs

To ensure patient safety, routine spaying must be performed when pigs are older than two to three months and younger than six years of age (Cypher et al., 2017). Performing ovariohysterectomy (OHE) at six weeks of age in pot-bellied pigs has lesser complications as the uterus is underdeveloped. The fat deposits in the subcutis and broad ligament is highly vascular complicating hemostasis in mature and obese pigs (Braun and Casteel, 1993). Poor survival rate has been observed following OHE in pot-bellied pigs of more than six years of age, especially in those with reproductive lesions like neoplasia, pyometra and cystic endometrial hyperplasia (Cypher et al., 2017). In pot-bellied pigs, hemorrhage is the common complication with OHE and an increase in morbidity and mortality is associated with neoplasia of the reproductive tract. Ovariectomy (OVE) using an electrothermal bipolar vessel sealing (EBVS) device in pet pigs has a better surgical outcome with lesser surgical and anesthetic time. There is reduced tissue handling and perioperative complications. When performed after nine weeks and before the onset of puberty, the cervix remains closed and reduces the risk of ascending infection (Biedrzycki and Brounts, 2013).

Immunocastration

Immunization against gonadotropin releasing hormone (GnRH) for male pigs older than eight weeks of age is an alternative to surgical castration. The first dose of Improvac (containing 200 μ g of GnRH protein conjugate/ ml, Zoetis) given any time after 8-9 weeks of age primes the immune system. The second dose given four weeks after the priming dose stimulates immunity and inhibits testicular function. Pre or early pubertal vaccination (3-5 months old) causes irreversible testicular dysfunction and reduces unwanted sexual behavior (Zamaratskaia et al., 2008; Brunius et al., 2010). There is reduction in unwanted sexual and aggression behavior in males, similar to that observed in surgically castrated pigs following two doses of Improvac (Rydhmer et al., 2010). Effects are noticed one to two weeks following the second injection and lasts for a minimum of eight weeks, with extended effect up to 22 weeks after the completion of the vaccination course (Brewster and Nevel, 2013). Estrogen has a negative effect on feed intake and the reduction of estrogen by Improvac results in increased feed intake in immunocastrated pigs (Bonavera et al., 1994; Zamaratskaia et al., 2008). The effect of immunocastration on females is not clear.

SEDATION AND ANESTHESIA

Injectable anesthetics

Minor surgical procedures like tusk and hoof trimming can be performed with a combination of Xylazine (2.2 - 4.4 mg/kg body weight) and Tiletamine/zolazepam (4.4 mg/kg body weight) given intramuscularly, without further induction of anesthesia. This combination is not suited for patients with cardiovascular and renal problems. Ketamine (11-33 mg/kg, IM or SC) is used for both short- and long-lasting surgeries. It exerts only a mild depressing effect on the cardiovascular system and hence is safe to use in pet pigs.

For long lasting procedures (more than one hour), premedication is followed by tracheal intubation as apnea is common in pigs. A combination of azaperone (premedication) and ketamine (induction general anesthesia) has been recommended by Sipos et al. (2007) for minor surgical procedures, and the same combination has been reported by Augustijn et al. (2010) to perform laparotomy in a VPB pig. Pre-medication with Azaperone at 1-2 mg/kg body weight ensures good sedation and anti-emetic properties but has no analgesic effects. The ketamine (20 mg/kg) and xylazine (2 mg/kg) combination is recommended along with atropine sulphate (0.02 - 0.05 mg/kg) as premedication to avoid fatal arrhythmias caused by xylazine in pigs.

Inhalation anesthetics

For short surgical and diagnostic procedures, inhalation anesthesia with an initial concentration of 4-5% isoflurane followed by 2-3% maintenance dose can be used alone or in combination with sedation for pot-bellied and miniature pigs. Isoflurane offers a low analgesic effect but has a wide margin of safety with rapid and smooth recovery (Bollen et al., 2010; Fubini and Ducharme, 2016). Inhalation anesthesia must be used only at the veterinary practice.

Local anesthetics

Infiltration of local anesthetics ensures analgesia without causing side effects and anorexia. The effects of lidocaine lasts for two hours and that of bupivacaine lasts for four to eight hours (Jackson and Cockcroft, 2007; Bollen et al., 2010).

Pain management

Postoperative pain can be managed for one to three days using either nonsteroidal anti-inflammatory drugs (NSAID) or opiates or a combination of both. The commonly used analgesics are listed in Table 5 (Bollen et al., 2010).

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