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Welfare of ducks in European duck husbandry systems

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European duck meat production is based on the use of Pekin, Muscovy and Mule duck genotypes that vary in their behavioural and physiological characteristics. Furthermore, large differences exist in their housing and management conditions. The aim of this review is to discuss the welfare of these different genotypes in typical husbandry systems, focusing on ducks kept for meat production. Firstly, factors that can affect duck welfare, such as stocking density and group size, access to straw, an outdoor run, or open water, are described. Secondly, welfare problems such as feather pecking, fear and stress, and health problems are assessed. Thirdly, the various systems used in Europe are described for these aspects. Giving ducks access to straw, an outdoor run, or open water increases the behavioural opportunities of the ducks (foraging, preening, bathing, and swimming), but can also lead to poor

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hygiene and increased health- and food safety risks. Therefore, practical solutions that allow expression of natural behaviour, but do not lead to hygiene or health problems have to be found and some practical suggestions are provided.

Keywords: duck welfare; duck behaviour; duck health; genotypes; housing systems; design criteria; performance criteria

Introduction

In European duck production systems Pekin, Muscovy and Mule ducks are reared for meat and foie-gras production. Large differences exist in housing and management (Raud and Faure, 1994), as husbandry systems range from closed lightproof houses to free-range production systems. Each duck genotype has its own specific behavioural requirements and associated welfare problems if these requirements are not met. It would be valuable to be able to assess duck welfare in these different systems and to address specific welfare problems within each system.

To come to such a welfare assessment framework, first design- and performance criteria must be defined (Anonymous, 2001). Design criteria can be related to the design of the housing system, for instance stocking density, access to an outdoor run, and provision of straw. Performance criteria can be related to the welfare performance of the animals in the system, for instance incidence of feather pecking or fear and stress reactions.

The aim of this review was to discuss the welfare of these different genotypes in the various systems, focusing on ducks kept for meat production. Firstly, aspects that can affect duck welfare are described, such as stocking density and group size, access to straw, an outdoor run or open water. Secondly, welfare problems, such as feather pecking, fear and stress, and leg problems are discussed. Finally, the various systems used in Europe are described in relation to these aspects.

Origin of Pekin, Muscovy and mule ducks

The domestic or common duck and the Muscovy duck are the two most common species of farmed ducks reared throughout the world. All breeds of common duck originate from domestication of the mallard duck (*Anas platyrhynchos*) and they are present principally on the Asian market as well as in Europe and the USA. A number of breeds of common ducks have been selected for meat or egg production such as the Rouen, the Aylesbury and the Khaki Campbell (Ashton and Ashton 2001), but the Pekin duck is currently the most popular common duck in commercial meat production. The Muscovy duck (*Cairina moschata*) is a roosting duck originating from the tropical regions of Central and South America. This species has supplanted the common duck in several countries of Europe, especially in France. Cross breeding between the two species involving the Muscovy drake and the common female has resulted in a hybrid called the mule duck, which is reared for the production of "foie gras", but also kept for meat production (Raud and Faure, 1994). The intercross is a sterile hybrid because of the difference in chromosome sizes and number between the two parents. In Muscovy ducks, feather pecking and cannibalism are an important welfare problem (Bilsing *et al.*, 1992; Knierim *et al.*, 2002). In Pekin and mule ducks, fear reactions are a concern (Faure *et al.*, 2003). Supply of open water is an issue in all three types of duck.

Biological characteristics of wild ducks

PEKIN DUCKS

The biological characteristics of the Pekin ducks were described in brief by The Council of Europe in the recommendations concerning domestic ducks (1999a). All breeds of domestic or common ducks are descended from the wild mallard and have been domesticated for about 2000 years. Under wild conditions, the mallard is largely aquatic. Mallards are omnivorous, feeding for example on seeds, plants, insects and worms (Reiter, 1997). They feed by foraging on land or by dabbling the beak along water, which is then expelled through lamellae on each side of the beak, straining out suspended planktonic organisms. In deeper water, Pekin ducks may ‘up-end’ or even dive. Mallards fly, swim and walk efficiently. Ducks spend considerable time performing complex preening behaviours. Ducks carry out a variety of shaking movements to remove water. Cleaning movements are used to remove foreign bodies and an elaborate sequence is carried out to distribute oil on the feathers from the uropygial gland. This is necessary for waterproofing and heat regulation. The structure of the feathers is what makes them waterproof, and not so much the oil film on them; the oil is important to keep the feather structure flexible (Bierschenk, 1991; Bezzel, 1977). Preening is often followed by a short period of sleeping, and the sequence of feeding, bathing, preening and sleeping may be repeated a number of times during the day (Reiter, 1997). Important elements of bathing are the immersion of the head and wings, and shaking the water over the body. Domestic ducks have retained many anti-predator responses such as freezing, alarm-calling, attempts to take off or run rapidly away from danger, and vigorous struggling if caught. Such behavioural responses may be associated with, or replaced by, emergency physiological responses. Human approach and contact often elicit such responses (The Council of Europe, 1999a).

MUSCOVY DUCKS AND MULE DUCKS

The Council of Europe also briefly described the biology of Muscovy ducks and mule ducks (1999b). The Muscovy duck originated in South America. It was domesticated by the Colombian and Peruvian Indians and then introduced to the Old World by the Spanish and the Portuguese in the 16th century. Under natural conditions, the Muscovy duck is a tropical bird and lives in marshy forests, but its robustness and hardiness have enabled it to adapt to different climates and habitats. Muscovy ducks are sexually dimorphic, the male being much bigger than the female. Aggressive and sexual displays are simple and not well differentiated. Muscovy ducks, especially the males, are more aggressive than mallard ducks. Muscovy ducks are not noisy birds, in comparison to Pekin ducks. Vocalisation is primarily in the form of hissing. Muscovy ducks are omnivorous, feeding for example on plants, worms, insects, fish, amphibians and reptiles. They feed by dabbling in water, foraging on land and up-ending. Muscovy ducks perch, fly, swim and walk efficiently. Muscovy ducks also dive efficiently and hunt for insects (Knierim, personal communication).

Their preening behaviour is comparable to that of Mallard ducks, as is their diurnal rhythm of activity and anti-predator responses. Male Muscovy ducks and the mule hybrids fight frequently using their claws, wings and beaks, particularly for chasing off intruders. The mule duck shows little sexual dimorphism and is able to flourish in cooler conditions than pure strains of Muscovy duck (The Council of Europe, 1999b).

Design criteria

STOCKING DENSITY AND GROUP SIZE

Stocking density and group size can affect performance and welfare of ducks, although results are inconsistent. De Buisonjé (2001) showed in Pekin ducks that production, feather damage, and product quality were negatively affected at a stocking density of 8 birds/m², compared with stocking densities of 5, 6, and 7 birds/m². Stocking density was manipulated by increasing the group size and maintaining the space allowance per group (group size 225-360 birds). Baéza *et al.* (2003) studied the effect of stocking density on behaviour, welfare, performance, and carcass quality in Muscovy ducks. They compared stocking densities of 7, 9, and 11 male ducks/m² and found that the stocking density of 9 birds/m² gave the best results for all criteria mentioned previously. Group size was equal for the three groups (29 birds), and much smaller than the group sizes used in practice. Hence, mainly in large groups, as used by De Buisonjé (2001), negative effects of high stocking densities can be found. Stocking density can also affect feather pecking in Muscovy ducks (Bilsing *et al.*, 1992), as high stocking densities (11.6 birds/m²) led to serious injuries, whereas no feather pecking was observed in ducks kept at a lower density (6.3 birds/m²). In *Table 1*, stocking densities are given for the different types of duck husbandry systems in France, Germany, the United Kingdom (DEFRA, 2000), and The Netherlands. This table was composed during a workshop on duck welfare held in Wageningen, The Netherlands in 2004 and was based on the information supplied by the participants. It should be noted that in the conventional system for Muscovy ducks in France, the stocking density of 52 kg/m² is only theoretical, since it corresponds with the final body weight of both males and females at slaughter. Sexes are kept separately, but in the same house. The female birds are taken out at 10 weeks of age, so that the complete house is available to the males until they are slaughtered at 12 weeks of age. A similar system for keeping Muscovy ducks is used in Germany.

High stocking densities can lead to welfare problems in poultry, but the effect of stocking density is strongly influenced by the quality of the management on the farm. It

Table 1 Typical stocking rates and densities of ducks, according to genotype, rearing system and country.

Genotype	System	Country	Stocking rate (birds/m²)	Stocking density (kg/m²) [1]	Source
Muscovy	Conventional	Germany	9 (no litter)	35	
			5 (litter)	19	
		France	13	52	
Muscovy	Free range	France	9	28	
Mule	Rearing	France	4	16	
Mule	Force feeding	France	10	60	
Pekin	Conventional	Germany	6	20	
		United Kingdom	7 (litter)	22	DEFRA,
			8 (no litter)	25	2000
		Netherlands	8	25	
		France	15	46	
Pekin	Free range	France	8	35	
Pekin	Organic	United Kingdom	0.25-0.50[2]	21	DEFRA, 2000
		Germany	6	20	

[1]Stocking density means the maximum density at the end of the fattening period
[2]2,500 ducks per hectare, but 5,000 ducks per hectare on well grassed outdoor runs

was found in broilers that housing conditions, such as litter quality, had a larger effect on welfare than stocking density per se (Dawkins *et al.*, 2004). If climate (temperature and humidity), ammonia levels, and litter quality are monitored closely and adapted if necessary, many problems can be avoided.

Group size can also affect duck welfare, as larger groups are more nervous and panic reactions can lead to serious damage and increased mortality (Guy, personal communication).

SLATTED FLOORS VERSUS STRAW-BASED SYSTEMS

In the Council of Europe Recommendations (1999a; 1999b) both concerning Pekin and Muscovy ducks, it is stated that the floor must be covered with an appropriate bedding material. To improve hygiene and reduce risk of pathological problems, such as parasites, ducks can be kept on slatted floors made out of wood, metal or plastic materials instead of on straw. Providing birds with slatted floors can, however, lead to problems related to environmental impoverishment, difficulty in balancing, slipping and falling, and skin irritation. Microclimate control (humidity, ammonia) plays a significant role in the appearance of balancing problems, because damp and poorly maintained litter has the same undesirable effects (Raud and Faure, 1994). In systems with slatted floors beak trimming is often used to reduce the damage caused by feather pecking. According to the Council of Europe Recommendation (1999a) beak trimming is not allowed in Pekin ducks, whereas in Muscovy and Mule ducks beak trimming is tolerated if it is done according to specific guidelines. In Pekin ducks, Leipoldt (1992) studied the effect of different floor covers on feather pecking. He compared a 100% slatted floor with a 50% slatted floor in combination with 50% with straw, and a floor with 100% litter (straw, wood shavings, sawdust or chopped straw). Feather pecking was mainly performed on the slatted floor. Consequently, levels of feather pecking were lower if the area of slatted floor was smaller. Birds seem to direct their foraging behaviour at the straw, instead of other ducks, if available (Leipoldt, 1992; Ruis *et al.*, 2003a). On the slatted floor, birds spent much time lying. On mixed floor types, they preferred straw for walking. In Germany and France, Muscovy ducks are mainly kept on slatted floors. In Germany, the United Kingdom, and The Netherlands, Pekin duck systems use mainly straw, although in Germany Pekin ducks are sometimes kept on slatted floors. In some cases partly slatted floors are used, for instance in association with water supply areas.

LIGHTING

According to Barber *et al.* (2004), rearing birds at low light intensities can result in improved performance and help to minimise problems with feather pecking and aggression, but they state that it can lead to other problems, such as lameness, impaired visual development and increased fearfulness. Low light intensities may also lead to visual sensory deprivation of the birds. When light intensity preferences of Pekin ducklings were studied at two and at six weeks of age (<1, 6, 20, and 200 lux), ducklings showed a preference for the brightest light environment (200 lux) at both ages (Barber *et al.*, 2004). Locomotion and pecking at the environment was more frequent in the higher light intensities at two weeks, whereas at six weeks preening and feeding where also more commonly observed in the higher light intensities than at <1 lux. Resting, standing and drinking at six weeks occurred more in 6 lux than in <1 lux. De Buisonjé (2001) studied the effects of two different light sources (incandescent- and high frequency fluorescent lighting) on performance, feather pecking, and external quality in Pekin ducks, but found no effect of light source on these traits. Sostak (1999) studied the physiological aspects of light and temperature under husbandry conditions in ducks. She recommended that ducks should be reared in constant surroundings of 14-16 hours of light, followed by a dawning period of at least 25 minutes and a low light intensity to allow adaptation of the eyes. Providing dim light during the night, can help to prevent panic reactions (Pingel, personal communication). In *Table 2*, the lighting schedules and intensities used for the different genotypes and countries are listed. This table was composed during a workshop on duck welfare held in Wageningen, The Netherlands in 2004 and was based on the information supplied by the participants. In general, shorter light periods are used in Muscovy ducks, than in Pekin ducks. In some systems, daylight may enter the house, so light intensities will vary strongly. In the United Kingdom, it is recommended to provide heterogeneous light intensities inside the house. A higher light intensity over the feeders and drinkers may help the birds find food and water.

Table 2 Recommended lighting schedules and light intensities per genotype, age, and country.

Breed	Country	Age	Light schedule	Light intensity (lux)
Muscovy	Germany	1-7 d	23L:1D	60-80 lux
		8-21 d	16L:8D	30 lux
		22-84 d	15L:9D	20 lux
Muscovy	France	1-7 d	24L	60-80 lux
		8-14 d	20L:4D	30 lux
		15-21 d	16L:8D	30 lux
		22-84 d	14L:10D	< 5 lux
Pekin	France	1-7 d	24L	60-80 lux
		8-14 d	20L:4D	30 lux
		15-21 d	16L:8D	30 lux
		22-45 d	12L:12D	10 lux
Pekin	United Kingdom		18L:6D	10 lux brooder pens
			or	Varying light
			23L :1D	levels in house
Pekin	Germany	1-7 d	24L:0D	20 lux
		8-14 d	20L:4D	15 lux
		15-48 d	16L:8D	10 lux
Pekin	Netherlands		18L:6D	30 lux
				2 lux in dark

ACCESS TO AN OUTDOOR RUN

In a number of production systems, ducks have access to an outdoor run. Reiter *et al.* (1997) studied the effect of access to an outdoor run and a bath in Pekin, Muscovy and mule ducks. They found that birds showed more foraging behaviour in the grass and more preening in groups with outdoor run compared with groups without outdoor run. Birds with an outdoor run also spent less time sitting. The presence of a bath did not influence behaviour in this study. Feather growth in Muscovy ducks was improved by access to the outdoor run, but was not affected by access to the bath. In Pekin ducks, live body weight was higher in groups which had access to an outdoor run with a bath and live body weight of Muscovy ducks and mule ducks was higher in groups with an outdoor run. Robin *et al.* (2002) compared the performance of mule ducks that had access to either a barren or a grassy outdoor run. Surprisingly, they found better performances for the ducks with a barren outdoor run, presumably because the birds with a grassy outdoor run had a lower feed intake. Outdoor runs are used in the United Kingdom (free range: 2500-5000 birds/ha; 2-4 m^2/duckling), Germany (organic production), and France (Label Rouge: 2 m^2/duckling). Furthermore, the ducks kept for foie gras production in France generally have access to an outdoor run from 5 to approximately 12 weeks of age (3 to 5 m^2/duckling), *i.e.* until transfer to cage housing for the force feeding period. In the Netherlands it is prohibited to keep ducks in a free-range system for environmental reasons, as farmers have had to reduce nitrogen leaching and emission of ammonia.

OPEN WATER FOR DRINKING, BATHING, AND SWIMMING

Supplying ducks with open water allows them to use water for several water-directed activities or behaviours such as dabbling, head-dipping, bathing and swimming. On the other hand, it can also lead to hygiene problems, spoilage of clean water and an increased volume of manure production. The Council of Europe recommends that ducks should be able to cover their head with water and to spread water over their feathers (1999a; 1999b). When Pekin ducks were given the choice between different kinds of drinkers, they preferred the bell drinker over the nipple drinker and the trough over the bell drinker (Cooper *et al.*, 2002). Nipple drinkers were used only for drinking and some wet-preening activities, whereas bell drinkers and troughs were also used for other water-directed activities, including dabbling, and head dipping. When ducks had to cross a barrier to get access to each of these drinkers, the number of visits to each type of drinker decreased. However, ducks were willing to cross a higher barrier, to get to a trough (195 mm) than to a bell drinker (135 mm) and only crossed the lowest barrier to get to a nipple drinker (75 mm; Cooper *et al.*, 2002). Ruis *et al.* (2003b) also studied drinker-preferences of Pekin ducks. They compared nipple drinkers, troughs, shallow open water and deep open water, and found the highest preference for shallow and deep water and a lower preference for a trough. Access to open water led to an increase in preening behaviour, compared with nipple drinkers, but not compared with a trough. Deprivation of open water resulted in a decrease in preening, but only in ducks that previously had access to deep or shallow water. At slaughter, plumage of the ducks with deep and shallow water was clean, whereas the feathers of the other birds were at least slightly dirty. Ducks with deep water had a higher growth rate but also a higher feed conversion (less efficient) than birds with only nipple drinkers. The trough used in the study by Ruis *et al.* (2003b) was covered with a grid so that the ducks could not move onto the water. An open trough may have led to different results. Bulheller *et al.* (2004) compared access to a water gutter with access to a bell drinker with a wide or narrow rim in Muscovy ducks. They found that birds with access to a gutter spent more time preening and had a better plumage condition than birds with access to a bell drinker. Also the area around the eyes is much cleaner if access to open water is given so that the ducks can dip their heads into them (Knierim *et al.*, 2004).

When open water was supplied to Pekin ducks, De Buisonjé and Kiezebrink (1999) found high levels of preening and a doubled use of water compared with nipple drinkers. This led to an increase of 100% in waste production and a poor litter quality. When supplied with bell drinkers, ducks showed high levels of feather preening, but used only 25% more water than with nipple drinkers. According to some studies, open water can also impose a danger for ducklings under two weeks of age, because in nature the downy feathers of the chicks are oiled by the mother, making them waterproof. In duck husbandry the mother is absent and the ducklings may cool down rapidly in the water and die (Kosters *et al.*, 1993; Sostak, 1999). However, in another study, Muscovy ducklings performed their own oiling behaviour starting from day one and the experimenter suggested that this behaviour may be stimulated by contact with water (Knierim, personal observation). Knierim studied Muscovy ducklings with access to a water gutter early in life and found no evidence for this risk of cooling down and drowning. The absence of open water can lead to welfare problems. Ducks can start to show abnormal behaviour, such as head shaking and stereotypic feather preening. Without open water they often redirect their foraging behaviour to the straw and their beak, nostrils, and eyes may become dirty as they are unable to clean them if open water is absent (Simantke, 2002). Furthermore, ducks use water for thermoregulation and heat stress can become a problem in systems with an inadequate water supply, especially under high temperatures (Abd El-Latif, 2003). Simantke (2002) suggested some practical solutions to the problems of supplying ducks with open water. The water should be surrounded with plastic slats and the water should be cleaned and re-used, possibly using biofilters. Knierim *et al.* (2004) described equipment for continuous cleaning of the bathing water which provides a satisfactory hygienic quality of the water. However, water loss during the cleaning process was considerable, as well as labour demands and costs. Drinkers should allow immersion of beak and head under water. Open drinkers should be placed as far away from the feeders as possible, to avoid pollution of the water. On the other hand, it is important for a better feed intake to place nipple drinkers near the feeders. To keep the straw dry, all drinkers and feeders should be placed on slats (Simantke, 2002). An outdoor run made of concrete for cleaning was also recommended. Reiter (2003) investigated bathing behaviour of Pekin ducklings with baths or showers. After a short learning phase, the ducklings used the shower in the first week of life and displayed all elements of bathing behaviour from the second week of life onwards with both the shower and the bath. Only slight differences in duration and frequency of behaviours under the shower were found compared with the bath. In the same research group, Benda *et al.* (2004) studied the development of bathing behaviour of Pekin ducks supplied with a shower and found that the ducks developed the main elements of behaviour known from the bath. Percentage of time spent under the shower increased from 3% in week 2 to 6% in week 6. A diurnal rhythm of using the shower developed from week 2 to 4. Head dipping was seen more frequently in the bath than under the shower, but levels of preening and duration of bathing periods were similar. Knierim *et al.* (2004) found that Muscovy ducks did not use showers as described for Pekin ducks. In contrast, mostly the ducks moved away from the shower when it was switched on. In the same experiment, Kuhnt *et al.* (2004) studied the hygienic consequences of providing showers, and shallow or deep open water in Muscovy ducks. Although high values of bacterial contents and some chemical parameters were found in groups with shallow and deep open water, there was no negative effect on health or performance of the ducks. Showers had low bacterial contents and chemical parameters. The showers might be more hygienic than open water but in this study the showers were scarcely used, whereas the open water facilities were frequently visited (Kuhnt *et al.*, 2004).

FORCE FEEDING

Force feeding is the method used to produce "foie gras" in mule ducks[1]. The force-feeding procedure consists of a period of approximately two weeks at the end of the growing period, during which the birds are force-fed twice a day. They are fed a larger volume of feed than the volume they would eat voluntarily. During this period the ducks are handled intensively and, until now, kept in individual cages. The Scientific Committee on Animal Health and Animal Welfare produced a report on the welfare aspects of foie gras production for the European Commission (SCAHAW, 1998) and concluded that force feeding is detrimental to the welfare of the birds. This conclusion is objected by French researchers who studied several physiological parameters during force feeding and did not find scientific evidence to support the conclusion of the SCAHAW (Guémené and Guy, 2004). The SCAHAW report stated that the liver steatosis obtained by force feeding induced an impairment of hepatic function, as demonstrated from morphometric, biochemical, histological and pharmacological points of view, but that this was completely reversible in the studies carried out (Babilé *et al.*, 1996; Bénard *et al.*, 1996; Bénard *et al.*, 1998). According to the SCAHAW report, the reversibility of steatosis which is reported for many birds which have been force fed does not mean that the changes in the liver are not pathological. The French researchers stated that steatosis in

[1] It was not the aim of this paper to condemn or support the practice of force feeding in mule ducks, but merely to describe it and to list its possible implications for duck welfare.

birds is part of a natural process and that the enlargement of the liver in ducks is indeed a nutritional steatosis but that it does not correspond to a pathological situation. Other aspects that were studied with respect to force feeding are stress physiology, pathology, and behaviour. Guémené *et al.* (2001) found no evidence of acute or chronic stress when measuring the physiological response to manipulation, intubation, and force feeding. Servière *et al.* (2003; 2004) found inflammatory reactions of the pro-ventricle walls (an equivalent of the mammalian stomach) after the first force-fed meal, but not after subsequent meals. Faure *et al.* (2001) have shown that mule ducks exhibited less fear towards the caretaker than to an unknown person during the force feeding period, suggesting that ducks do not learn to treat their regular feeder as an aversive stimulus. The maximum spontaneous feed intake in mule ducks can reach up to 750 g per day (Guy *et al.*, 1997), an amount that is close to the weight of corn delivered by the end of the force feeding period. However, when force feeding is ended, the birds greatly reduce their food intake for several days (SCAHAW, 1998).

Performance criteria

FEATHER PECKING AND CANNIBALISM

Feather pecking and cannibalism can lead to feather damage, injuries and increased mortality in ducks. Feather pecking is mainly a problem in Muscovy ducks, especially when the ducks are kept on slatted floors without litter. In general, the ducks kept in these systems are also fed pelleted feed and water is supplied with nipple- or bell drinkers (Knierim *et al.*, 2002). Beak trimming and reducing the light intensity are measures commonly used to minimise the amount of damage caused by an outbreak of feather pecking and cannibalism, but both measures raise other welfare issues (Raud and Faure, 1994). A more stimulating environment could help to reduce these problems. Muscovy ducks appear to have limited opportunities to express their natural behavioural repertoire, especially with respect to foraging and feeding, feather care, and social behaviour (Knierim *et al.*, 2002). Supplying Muscovies with open water allows them to fulfil their need to forage and feed. Water is also important for feather care. Other possibilities would be to supply ducks with straw or hay, or give them access to an outdoor run (Knierim *et al.*, 2002). Klemm *et al.* (1992) studied the effect of supplying Muscovy ducks with an outdoor run with open water and found that this strongly reduced feather pecking. They recommended that the birds are given access to the outdoor run already during rearing, so that they can learn to use it. Klemm *et al.* (1992) also reported less feather pecking problems in Muscovy ducks when they were kept in mixed groups with Pekin ducks. Bilsing *et al.* (1992) compared groups of Muscovy ducks kept at different stocking densities and found no feather pecking in ducks kept at a low density (6.3 birds/m^2), whereas a high stocking density (11.6 birds/m^2) led to serious injuries. In contrast, Baéza *et al.* (2003) found higher levels of feather pecking at a stocking density of 7 birds/m^2 than at 9 or 11 birds/m^2 at 4 weeks of age. At 8 and at 12 weeks of age, however, the highest level of feather pecking was found at a stocking density of 11 birds/m^2. Desforges (2002) compared beak-trimmed Muscovy ducks reared under standard conditions with non-beak trimmed control birds and with non-beak trimmed ducks reared under favourable conditions (more space, environmental enrichment). She found that the beak-trimmed birds performed better than non-beak trimmed groups whatever the rearing conditions.

FEAR AND STRESS

Fear reactions can lead to injuries and even death by suffocation if the animals pile up on top of each other. In Muscovy ducks, claw trimming is used to avoid injuries by the sharp claws when birds pile up in panic reactions or during transport. However, under conditions of lower stocking densities, improved human-animal relationship, provision of a stimulating environment and careful transportation, injuries induced by claws can largely be prevented (Dayen and Fiedler, 1990). Moreover, in the first place abrasion of sharp claws should be provided for by the housing environment. How to achieve this needs further investigation. Claw trimming frequently leads to bleeding or even amputation of toes as it is routinely done with one cut per foot (Knierim, personal communication). Henderson *et al.* (2001) showed that ducks appear to perceive an approaching human as a greater threat than an approaching object (in this case a small vehicle), so fear of man may be a problem. When fear reactions of male Muscovy ducks, Pekin ducks and mule ducks were studied in a tonic immobility test and a fear-of-human test, it was found that Pekin ducks were more fearful than Muscovy ducks and had higher corticosterone levels following exposure to humans (Faure *et al.*, 2003). Their hybrid, the mule duck, was either similar to one parent, intermediate between the two, or showed heterosis (more fearful than the two parents) for fear of humans at 10 weeks of age. The corticosterone response of the mule duck was intermediate between the Pekin duck and the Muscovy duck.

Leg problems

Providing birds with slatted floors can lead to leg problems, as indicated before. If litter is available, however, the quality of the litter is important, because a bad litter quality (wet, dirty) has the same undesirable effects (Raud and Faure, 1994). Knierim *et al.* (2005) studied leg problems in relation to water supply in Muscovy ducks, using about 200 ducks per treatment, and found that foot pad alterations were less severe in ducks that had access to open water. In ducks with access to a shower, the results were not better than in control ducks. There was no difference in gait scores between the experimental groups, but the majority of the birds had a normal gait (80-90%). Dayen and Fiedler (1990) report from their farm visits that in male Muscovy ducks the problem of splay leg or spraddle leg is a considerable one, presumably associated with the high growth rate, low light intensities, and restricted possibilities for locomotion. The problem is more severe on wire floors rather than on plastic or wooden slats. They found that the shape of the skeletal body is changed in spraddle leg ducks and that there are degenerative alterations of the muscles and bones. They also found foot pad dermatitis and injury to a considerable degree in all Muscovy ducks they investigated (Dayen and Fiedler, 1990).

Description of European duck husbandry systems

PEKIN DUCKS

Large differences exist between husbandry systems for Pekin ducks, Muscovy ducks, and mule ducks. Pekin ducks are generally kept on straw, either in a conventional or in an organic system (*Table 3*). *Table 3* was composed during a workshop on duck welfare held in Wageningen, The Netherlands in 2004 and was based on the information supplied by the participants and on the discussions during the workshop. Pekin ducks are kept in flocks of about 3,000 to 13,000 birds. European Pekin duck production is mainly located in Germany, United Kingdom, and The Netherlands. A small proportion of Pekin ducks is kept on organic farms with lower stocking densities and smaller flock sizes than on conventional farms and with access to an outdoor run and open water, although at present access to open water is not always possible and farms are still in a transition period. In

Germany also female mule ducks are used for organic production. The outdoor or organic systems offer more behavioural opportunities than conventional indoor system, but also increased health risks (parasitism, contact with wild birds, rodents, pets, and droppings). The incidence of leg problems is expected to be lower on organic farms, due to the lower stocking density and the outdoor run. No large difference in fearfulness is expected, because both systems use the same type of birds.

Table 3 Characteristics of conventional, free-range and organic systems for Pekin ducks, Muscovy ducks and mule ducks.

	Pekin Conv.	Pekin Organic	Muscovy Conv.	Muscovy Free range	Mule Rearing	Mule Force-feeding
Floor	Straw/ Slatted/ Partly slatted	Straw	Slatted	Slatted	Straw	Cage
Flock size	3,000-13,000	Up to 3,000	3,000-10,000	3,000-10,000	2,500	600
Stocking density	20 kg/m^2	20 kg/m^2	40 kg/m^2	28 kg/m^2	1 kg/m^2	60 kg/m^2
Final BW	3 kg	3 kg	4 kg	3 kg	4 kg	6-7 kg
Drinkers	Nipple/ bell/ trough	Nipple/ bell	Nipple/ bell/ trough	Nipple/ trough	Nipple/ trough	Nipple
Outdoor run	No	Yes	No	Yes	Yes	No
Open water	No	Yes	No	No	No	No
Behavioural opportunities	Less	More	Less	More	More	Less
Health risk	Low	High	Low	High	High	Low
Leg problems	More	Less	More	Less	Less	More
Fear	High	High	Low	Low	High	High
Predation risk	No	Yes	No	Yes	Yes	No
Beak Trimming	No	No	Yes	Yes	No	No
Claw trimming	No	No	Yes	Yes	No	No
Feather pecking	No	No	More	Less	No	No
Force feeding	No	No	No	No	No	Yes

MUSCOVY DUCKS

Muscovy ducks are kept in conventional or free-range systems on slatted floors, in groups of about 3,000 to 10,000 birds. Muscovy ducks are mainly kept in France and in Germany. In Germany, they are frequently kept in smaller group sizes (multiple small flocks on one farm). In the free-range system, produced in France under 'Label Rouge' conditions, birds are kept at a lower stocking density and group size, and often slower growing genotypes are used. Beak trimming and claw trimming is practised in both systems, to avoid feather damage and wounding of the birds. In the free range system, birds have access to an outdoor run, and are expected to have fewer problems with feather pecking, less leg problems, more behavioural opportunities, but increased health risks compared with the conventional system (*Table 3*).

MULE DUCKS

Male mule ducks are kept for foie gras production. The females are reared under similar conditions as used for conventional Muscovy duck production or they are killed shortly after hatching. In mule duck production, two phases can be distinguished: the rearing period and the force feeding period. During the rearing period the ducks are kept on straw in flocks of about 2,500 birds at relatively low stocking densities with access to an outdoor run. Access to the outdoor run results in increased health- and predation risks, but also offers the birds a wider range of behavioural opportunities. At the end of the rearing period, the birds are feed restricted and fed once a day to train them to consume a large quantity of feed in a short period of time, as will be the case during the force feeding period (Guémené and Guy, 2004). During the last two weeks of the growing period, the ducks are housed individually in cages, resulting in a considerable behavioural restriction, and force-fed twice a day. According to new European regulations that have been adopted, collective rearing will have to supplant individual cages (Council of Europe, 1999b).

Discussion and conclusion

The aim of this review was to discuss the welfare of the different duck genotypes in the various commercial meat production systems. It was found that a large number of factors affect duck welfare. In conventional systems, there are less behavioural opportunities than in free-range or organic systems. On the other hand, health risks are lower in conventional systems and health is a prerequisite for welfare. The housing and management systems used for Pekin ducks, Muscovy ducks, and mule ducks show large differences. In Pekin ducks, supply of a suitable water source is currently the main issue. Supplying birds with showers, bell-drinkers, or troughs on a slatted floor appears to be a good compromise between the possibility of expressing behaviours and health- and hygiene risks. In Muscovy ducks, where slatted flooring is more common, the benefits of housing on straw should be examined. This may result in fewer problems with feather pecking and fewer leg problems. Water provision is also an issue in Muscovy ducks. With regard to the mule ducks kept for foie gras production, there is presently a shift from individual cage housing to group cages, due to legislation. This would allow social interactions and would give the birds more space as a group. There is some concern however, that catching the birds for force feeding may lead to more stress and possibly more aggression in a group cage than in an individual cage.

In discussions and decision making on duck welfare the welfare and health of the farmer and consumer should also be considered. Alternative systems are more difficult to manage than conventional systems, with consequences for detection of welfare problems, workloads and hygiene management. Allowing birds access to straw, an outdoor run, or open water results in increased labour demands and increased risks to human health from dust, ammonia, bacteria and fungi as well as potential threats to food safety. On the other hand, farmers working in free range or organic systems, for instance in organic broiler farming in The Netherlands, are often enthusiastic about their more natural production system (Rodenburg, personal communication).

Animal welfare is a balance between behavioural opportunities and animal health. Giving ducks access to straw, an outdoor run, or open water increases the behavioural opportunities of the ducks (foraging, preening, bathing, and swimming), but may also have negative effects on health and food safety. Perhaps practical solutions can be found, that allow natural behaviour, but do not lead to hygiene or health problems, for example supplying Pekin ducks with a shower, a trough, or a bell drinker on a slatted part of the floor in a straw-based system. Research into duck welfare and assessment of duck welfare in industry is sparse and more work needs to be done to find out what is going on in practice, *e.g.* levels of mortality, incidence of feather pecking, and health problems.

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