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The welfare of ducks during foie gras production

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Abstract

This review, which focuses on foie gras production from ducks in France, highlights welfare problems that may arise in the final (third) stage of production, when force-feeding occurs and which lasts 12 to 15 days. Welfare problems arising in the first two stages are also considered. The male mulard duck, a non-migratory hybrid between a muscovy drake (*Cairina moschata*) and a female domestic duck (*Anas platyrhynchos*), is used most frequently despite being fearful, nervous and maladapted to force-feeding conditions. During the period of force-feeding mortality is 2 to 6%, higher than in fattening units for meat production. Welfare deteriorates markedly as ducks progress through the three production stages. Posture and gait abnormalities and wing lesions develop, and contact dermatitis is widespread and often severe. Oesophagitis and other injuries are documented. Steatosis and other liver changes are pathological and can limit duck survival. Group housing necessitates the use of crowd-gates to facilitate force-feeding of birds, who show aversive behaviour towards the force-feeder. Cages are small, with a mesh floor without litter or a rest area. Access to open water for bathing or full immersion of the head may be insufficient and make thermoregulation difficult. We conclude that force-feeding causes very poor welfare in ducks and should not be practised. Should foie gras production without force-feeding become possible, duck livers should not reach a weight at which there are pathological effects. Inadequate housing and management conditions should be prevented by establishing limits for the prevalences of contact dermatitis (footpad and digits), breast lesions and gait abnormalities, which should not be exceeded prior to slaughter. Limits should also be established for the prevalence of wing and other body lesions after slaughter.

Keywords
Animal welfare, control of feeding behaviour, foie gras, force-feeding, liver steatosis, mulard duck

Introduction

With increasing societal concern about animal welfare, a number of farm animal production practices have come under scrutiny. One such practice is the force-feeding of ducks and geese for the production of foie gras (fatty liver or hepatic steatosis). In 1998, the Scientific Committee on Animal Health and Animal Welfare (SCAHAW) reported to the European Commission on the welfare aspects of foie gras production in ducks and geese (SCAHAW 1998). They concluded that "force-feeding is detrimental to the welfare of the birds." French researchers, who studied several physiological and behavioural measures during force-feeding and did not find supporting scientific evidence, have objected to this conclusion (Guémené & Guy 2004).

Examination of duck welfare in foie gras production is timely, as there have been recent public calls for the practice to be banned. In January 2016, the individual caging of ducks for foie gras production in France was replaced by group (collective) housing, with at least 3 birds per group (Anon 2015). This review, which focuses on foie gras production in France, highlights the welfare problems that may arise in the final (third) stage of foie gras production, when force-feeding occurs. Where pertinent, welfare problems that may arise in the first two stages are also described.

We focus on research in ducks rather than geese because ducks are used in over 97 % of foie gras production in France (18,600 tons in 2013, Litt & Pé 2015). Most of the foie gras literature is in French. Foie gras producing countries in the European Union are France, Belgium, Bulgaria, Hungary and Spain (Litt & Pé 2015), producing approximately 90% of the world's foie gras. Force-feeding of ducks and geese for foie gras is banned in a large number of European and other countries, but many countries where production is banned continue to import it.

The terms force-feeding and gavage are used interchangeably here. Other terms, such as assisted feeding, cramming and over-feeding, are sometimes used in the literature. The main food used, maize, is usually called corn in North America. In some instances approximate translations are used, because the equivalent English word does not seem to exist (eg 'nervosisme'). The term 'élevage' means rearing or breeding but is also used to describe stages of production (eg starter, grower).

Background information

The male mulard duck, the mulard being a hybrid between a muscovy drake (*Cairina moschata*) and a female domestic duck (*Anas platyrhynchos*) which is a mallard, is used most frequently for force-feeding because it has a good potential for production and is relatively easy to manage when housed individually (Guémené & Guy 2004). The breed of domestic duck/mallard most often used is the Pekin, so this name will be used here unless specified otherwise. In France only male mulards are usually reared for foie gras production (Baéza 2006), while females are killed once they have been identified following hatching. This is because their fatty livers are of poor quality and therefore unsuitable as a product with the appellation "100% foie gras" (Marie-Etancelin *et al* 2015).

The process of foie gras production in France is described in SCAHAW (1998), Guémené and Guy (2004), Rodenburg *et al* (2005) and Guémené *et al* (2007). Briefly, it can be divided into three stages:

1. Starting: Birds are fed *ad libitum* from the time of hatching until 6 to 9 weeks. They are initially kept indoors, usually on straw, and eventually allowed outdoors during the day.

2a. Growing: Birds are feed-restricted for a period of 3 to 5 weeks. This restriction may be in time (hourly feed restriction, when birds are fed *ad-libitum* but for only a short period, once daily) or amount (quantitative feed restriction, when birds are fed a reduced amount of food daily). Birds normally have outdoor access during the day.

2b. Pre-force-feeding: Birds are fed as much as possible for 3 to 10 days. The aim is to dilate the oesophagus and stimulate the digestive secretions necessary for the assimilation of a large amount of food, and start the process of liver steatosis. The liver can weigh up to 180 g by the end of this stage, compared with 80 g with normal feeding. Ducks usually have outdoor access during the day.

3. Force-feeding: From 12 weeks of age and usually for 12 to 15 days, ducks are force-fed increasing amounts of energy-rich food with a high carbohydrate, low protein content and an abnormal amino acid and mineral balance (AVMA 2014). They are force-fed twice daily with a feeding tube powered by a pneumatic or

hydraulic pump; at the beginning each receives 180 to 200 g of maize per meal, increasing to 450 g (1000 g after water is added to make mash) per meal towards the end of the force-feeding stage. Up to 400 individually caged ducks per hour can be force-fed by one person using a pneumatic pump (Guémené & Guy 2004), and even more if a hydraulic dispenser is used. They are kept indoors in cages and in a controlled environment.

Literature Search

In order to find peer-reviewed literature on the force-feeding of ducks, we conducted a search of the following databases: Medline (PubMed, US National Library of Medicine), Google Scholar (Google), Scopus (Elsevier), VetMed Resource (CABI, Centre for Agriculture and Bioscience International) and Web of Science (Thomson Reuters). Each search had the same terms, which were used as subject headings and as keywords. How they were combined varied, depending on the database stipulations. While we focussed on peer-reviewed published research, we also made use of 'grey' literature such as technical reports, and other material that may not have been subjected to editorial control or peer review. The report by SCAHAW (1998) provided background information and served as a useful guide on potential welfare topics to consider. Only publications in English or French were included.

The proceedings from the biennial conferences " Journées de la Recherche sur les Palmipèdes à Foie Gras" were a rich source of information on research covering a wide range of aspects of foie gras production, including welfare. Of the 78 references included in this review, 25 are proceedings from these conferences. This material helped us identify the main researchers in the field and the current research topics. These conferences are supported by a number of organisations, such as the research institutes ITAVI (Institut Technique de l'Aviculture et de l'Elevage des Petits Animaux**)** and INRA (Institut National de la Recherche Agronomique).

The welfare issues we have identified are organised under six main headings: mortality, physical health, general behaviour, force-feeding, housing and other.

Mortality

Limited mortality figures are available for ducks during the two-week force-feeding period (Servière *et al* 2011) and it is difficult to find a reasonable baseline for comparison, such as the mortality rate of non force-fed mulard ducks. SCAHAW (1998) concluded that mortality during the force-feeding period was typically 2 to 4%. In 2006 the French national average mortality of force-fed birds was 2.4% (Laborde *et al* 2010) and in 2013 it was 2.2% (Litt & Pé 2015).

In an experimental study exploring the effects of group size and stocking density on a number of production measures during force-feeding, average mortality was 5.6% (range 1.4-13.9) (Mirabito *et al* 2002a). The highest mortality was seen in the largest group (9 birds) with the highest stocking density (1000 cm^2 per bird). These data compare unfavourably with mortality rates of muscovy ducks in fattening units for meat production, where in the two weeks before slaughter the mortality rate was 0.2% (SCAHAW 1998).

Physical health

The health of birds can be assessed using a wide range of variables including gross body anatomy, posture, walking ability (gait), face, body and plumage condition, presence of bone fractures, presence and severity of skin lesions as well as mortality (Jones & Dawkins 2010a; Liste *et al* 2012; Makagon *et al* 2015; Saraiva *et al* 2016). There are few such studies in force-fed ducks (but see Litt *et al* 2015 a, c).

Gait means walking ability, and is often recorded as an on-farm measure of welfare in poultry raised for meat (Bradshaw *et al* 2002, Makagon *et al* 2015). Impaired gait can cause poor welfare because of its association with pain (Saraiva *et al* 2016), and is economically important as ducks with moderate to severe walking problems are often culled from the flock (Makagon *et al* 2015). A number of gait score systems have been developed for use in ducks (Jones and Dawkins 2010a; O'Driscoll & Broom 2011; Liste et al 2012; Makagon *et al* 2015; Saraiva *et al* 2016). They need to be standardised so that meaningful comparisons between studies can be made.

When birds are kept in restrictive environments where they cannot move freely, recognising mobility problems becomes difficult. Anecdotal observations by SCAHAW (1998) suggest that abnormalities in posture and gait in fattened ducks occur to the extent that some die from becoming immobile and unable to access water. The legs of force-fed birds are pushed outwards, so that they cannot be held vertically when the bird is standing or walking. SCAHAW concluded that this is caused by the hypertrophy of the liver, which pushes the legs laterally and causes difficulty in standing and impairment of their natural gait.

Recently Litt *et al* described the development (2015a) and application (2015c) of an evaluation grid ('grille d'évaluation') to assess the physical condition of mulard ducks. A subjective scoring system with three or four degrees of severity for each measure was used. The grid was applied to 63 groups of ducks on 44 different commercial farms at the end of each of the three main stages of production. Birds in the force-fed group were evaluated after slaughter in an abattoir. Four main physical abnormalities were noted at all stages: dermatitis of the footpad, toe (digit) and hock (hock burn), and damage to the breast area. Breast abnormalities included loss of feathering and lesions (blisters, ulceration and the formation of crusts). Ventral feathering loss was more commonly noted during the growth stage while breast lesions were noted after slaughter. Footpad and toe dermatitis lesions appeared very early and very frequently in the production process. Wing lesions were noted at the end of force-feeding; 88% of lesions probably occurred at the stages of collection, transport to the abattoir and shackling. Other body injuries, such as scratches to the dorsal part of the body, pseudo-crop injury (lacking a defined crop, the mulard has an oesophageal out-pouching called the pseudo-crop) and joint abnormalities, were also noted after slaughter. Litt et al (2015c) concluded that the most useful measures were the presence and severity of dermatitis of the footpad and digits, the condition of the breast, back injuries (eg scratches or haematomas) and injuries to the pseudo-crop. Overall, the prevalence of lesions varied greatly between farms and groups of birds, and associations with fixed factors such as starter density and season were not sufficient to explain this variability.

Comparisons between Litt et al's (2015c) evaluation grid and other studies in ducks reared for meat should be made with caution. Force-fed ducks are housed and managed very differently, and are fattened for much longer. What is clear is that the welfare of force-fed ducks, as assessed by general physical condition, deteriorated significantly as they progressed through the three production stages.

In a survey of Pekin ducks commercially reared for meat in the UK, the physical and plumage condition of the ducks was recorded at two ages, 23 and 41 days (Jones & Dawkins 2010a). The birds' condition deteriorated between 23 and 41 days, but this was not marked. At slaughter, the incidence of moderate and severe footpad dermatitis lesions was 10% and 3%, 32% of ducks had calloused toes and 11% had pink hocks. In other commercial trials evaluating open water sources for farmed ducks over 43 days, contact dermatitis lesions were mild and general condition good (O'Driscoll & Broom 2011; Liste *et al* 2012). In contrast, Litt *et al* (2015b) found that by 14 weeks of age, the end of force-feeding, all the duck foot samples had moderate to severe macroscopic signs of epidermal ulceration. Pododermatitis was common, and developed early in the birds' lifetime. Biija *et al* (2013) studied ducks during the period prior to force-feeding, when they were allowed outdoor access either onto a meadow with scattered trees or onto woodland. At 9 and 11 weeks of age both groups (especially the one with woodland access) had developed moderate to severe pododermatitis.

An increase in enteric flora load and in faecal streptococci, causing gastro-intestinal upset and diarrhoea, has been noted at the beginning of force-feeding. Enteric flora overgrowth and infections can exacerbate any existing contact dermatitis and cause death in force-fed birds (Laborde *et al* 2010).

Contact dermatitis is an umbrella term that includes footpad and toe dermatitis (also known as pododermatitis or foot burn), hock burns and breast blisters and burns in poultry (Shepherd & Fairchild 2010; Hepworth *et al* 2011). It is a condition which causes pain and disability (Haslam *et al* 2007; Saraiva *et al* 2016), leading to poor welfare and significant economic loss. Animal welfare audits often include contact dermatitis as an indicator of housing conditions and bird welfare (Haslam *et al* 2007; Hepworth *et al* 2011; Saraiva et al 2016); this may be useful for foie gras ducks too.

Reports of post-mortem examinations of ducks that die during or at the end of force-feeding are sparse in the published scientific literature. There is little information on injuries, disease incidence and nature, causes of death, the incidence of secondary oesophageal infections (such as Candidiasis, a yeast infection caused by *Candida albicans*) or on other complications that may arise. SCAHAW (1998) reported that secondary infections with *C.albicans* was present in up to 6% of birds.

General Behaviour

Mulard ducks are most often used for foie gras production, despite being recognised as particularly fearful, nervous and hyper-reactive – the term 'nervosisme' is used in French. These behaviours become evident at 5 to 7 weeks of age (Guémené *et al* 2002). Birds show panic and flight responses to the approach of humans and are generally described as being 'sensitive to the environment' (Guémené *et al* 2002; Guémené *et al* 2006b; Laborde & Voisin 2013). It seems that the move from individual to group housing has brought the problem of 'nervosisme' in ducks to the fore. Certain behavioural characteristics of mulards are recognised: while ducks are gregarious and sociable towards conspecifics (Guémené *et al* 2006b), making group housing enriching, they are fearful of humans, nervous, and highly reactive to their environment (Laborde & Voisin 2013). Therefore, they are less well able to cope with environmental changes and with the presence of humans. They struggle and try to escape when approached for force-feeding thereby necessitating the use of crowd-gates.

French scientists have established a research project called "CaNervosisme" to address these undesirable characteristics. The project includes a large number of different experiments looking at factors such as the birds' phenotype, genotype, genetic manipulations, provenance, rearing conditions, group size, behavioural and physiological responses and exposure to humans (Guémené *et al* 2002; Faure *et al* 2003; Guémené *et al* 2004; Guémené *et al* 2006b; Arnaud *et al* 2008; Laborde & Voisin 2013). For example, Arnaud *et al* (2008) found that mulards showed greater panic responses and fear of humans, and appeared to be more sensitive to social stress (isolation from other ducks) than the two parent types, evidence of heterosis. A heterosis effect was also found for basal adrenal activity, with mulards having higher basal levels of corticosterone than parental lines.

There are many aspects of husbandry and practice prior to force-feeding that may affect the birds' behaviours during force-feeding, but effects are not clear-cut. Nevertheless, it seems that 'nervosisme' has two main components: fear of humans and fear of the environment. Because foie gras production involves close human contact and sudden environmental changes, it has severe negative effects on the birds' welfare.

Force-feeding

A major objection to the practice of foie gras production is that, unlike other farmed animals, the birds cannot choose what, when and how much they will eat. They cannot show a food preference or feed spontaneously, and are fed considerably more than they would eat voluntarily. They receive this food without having the opportunity to forage in a species-specific manner.

Force-feeding, where the duck is restrained and a rigid tube is inserted into the oesophagus, has the potential to cause injury and pain so the condition of the upper digestive tract is of particular interest. A number of studies have looked for histological evidence of pain at different stages of force-feeding. Servière *et al* (2002) described signs of sub-acute moderate and multifocal oesophagitis, which may be a result of effects of abrasion and distension of the upper digestive tract caused by food boluses. In other experiments, force-fed ducks were compared with pharmacologically-treated control ducks, in which neurogenic inflammation of the upper digestive tract was provoked under anaesthesia by an irritating substance containing mustard oil (Servière *et al* 2002) or hydrochloric acid (HCl) (Servière *et al* 2011). For example, in Servière *et al* (2011) varying concentrations of HCl were applied to different parts of the upper digestive tract and the resulting neurogenic inflammatory response compared with that due to the force-feeding regime.

Neurogenic inflammation describes the local release of inflammatory mediators from afferent neurons upon activation of sensory nerve fibres (Rosa & Fantozzi 2013). These neuropeptides cause an inflammatory response characterized by plasma extravasation, local vasodilatation, leukocyte and platelet adhesion, and mast cell degranulation. By measuring degrees of the extravasation response in both groups, the authors concluded that the mechanical insult to upper digestive tract walls due to the force-feeding regime is moderate compared with chemical nociceptive stimulation with HCl.

One may question whether the above experiments are a good way of evaluating pain caused by force-feeding. The irritating substances may not produce standardized inflammatory responses (and consequent pain) with which force-feeding effects can be compared. Mechanical stimulation, such as excessive distension, may also induce visceral nociception. Detailed post-mortem examination of the upper digestive tract and other body areas may be more informative, as well as behavioural observations. Recording facial and body lesions is particularly relevant, as it seems that the likelihood of injury may increase in group-housed birds because of the need to catch, position and restrain them (Guémené *et al* 2002; Guémené *et al* 2006b).

Effects on the liver

The potential to develop hepatic steatosis depends on the species of waterfowl and also varies with the genotype (Baéza *et al* 2013). Some migratory waterfowl, such as greylag geese *Anser anser,* eat more than their normal amount of food in the days before migration. The muscovy and the mulard duck, however, are non-migratory and do not develop a hypertrophied liver when reared normally. Force-feeding results in an increase in liver size and fat content. By the end of force-feeding, the duck's liver is 7 to 10 times the size of a normal one with an average weight of 550 to 700 g and a fat content of 55.8% (Babilé *et al* 1996; Gabarrou *et al* 1996). This increase in liver weight is accompanied by a substantial overall live-weight gain in the range of 50 to 85%. In comparison, the average weight of a non force-fed drake's liver is 76 g with a fat content of 6.6% (Babilé *et al* 1996).

Steatosis and other changes that occur as a result of general management for foie gras production, in particular force-feeding, are pathological and can limit the ducks' survival potential. The enlarged liver may cause discomfort, compress airsacs (reducing respiratory capacity) and abdominal organs. When liver function is severely compromised, hepatic encephalopathy (central nervous dysfunction due to effects of toxins such as ammonia on the brain) may develop (SCAHAW 1998).

A detailed illustration of the steatosis process is presented in Baéza *et al* (2013). Steatosis results from an increased capacity of hepatic lipogenesis and insufficient capacity to export newly synthesised triglycerides, resulting in their accumulation in hepatocytes. Peripheral tissues cannot take up sufficient circulating lipids, thus favouring their return towards the liver. Hepatocytes hypertrophy due to accumulation of fat and other components (water, minerals, proteins, phospholipids). Lipid synthesis in the liver is maximised when the food is high in starch and low in protein, such as maize. Maize also has high levels of thiamine and biotin, which are necessary for the conversion of sugars to lipids. To reduce the ducks' capacity to make Very Low Density Lipoprotein, which carries lipids away from the hepatocytes to peripheral tissue, the diet is restricted in levels of certain nutrients necessary for their synthesis such as amino acids methionine and choline (Gabarrou *et al* 1996). Force-feeding a high-energy, high carbohydrate diet turns a normal liver into a steatotic one in under two weeks (Gabarrou *et al* 1996).

In an experiment by Babilé *et al* (1996), mulard ducks were force-fed for 10, 13 and 16 days, and at the end of each period were released back into the group. For the first few days they did not eat but drank copiously, and lost a lot of weight in the first week. The longer the force-feeding period, the longer it took for ducks to start eating spontaneously again (8 to 15 days). The liver returned to its initial weight after 15 days following the end of force-feeding for groups force-fed for 10 and 13 days, and took 30 days for those force-fed for 16 days. These results give an insight into the degree of insult from which the liver had to recover. Prolonging the force-feeding from 13 to 16 days has a disproportional effect on time to liver weight recovery (an increase from 15 to 30 days), suggesting that 16 days of force-feeding brings the duck close to severe liver dysfunction and failure.

Bénard *et al* (1998, 2006) examined the effects of force-feeding on liver function, morphology and pathology. Group-housed ducks were force-fed for 2 weeks and then received normal *ad-libitum* feeding for 4 weeks. This cycle was performed three times, with force-fed birds compared with a control group fed *ad-libitum* throughout. Blood samples were taken at the end of every force-feeding or free-feeding cycle from the test birds and at the same time from controls. A bromosulphophthalein (BSP) clearance test, a measure of the liver's ability to detoxify, was also performed. Birds were killed after 2, 6, 8, 12, 14 and 18 weeks and their livers examined.

While the weight of the non force-fed birds did not change significantly, the test ducks put on weight (1.5 to 2 kg), but lost it during the 4-week non force-feeding period (1.4 to 2.3 kg). Gross hepatomegaly was noted in force-fed birds and concentrations of liver enzymes lipase, alanine aminotransferase and aspartate aminotransferase rose significantly at the end of each force-feeding period. After 4 weeks of normal feeding they returned to levels similar to those of the control group.

After 2 weeks of force-feeding, hepatocytes in control birds had an average diameter of 7-10 µm whereas signs of steatosis were obvious in force-fed birds: hepatocyte diameter was 35-40 µm and the cell was full of fat vacuoles. After 3 cycles of force-feeding the liver structure was similar, but 4 weeks later most of the liver cells had an average diameter similar to that of controls, and were no longer full of fat. BSP clearance, as measured graphically by the area under the curve, was reduced in force-fed birds at 2 and 8 weeks compared with controls, while it returned to normal after periods of free-feeding as well as after the third force-feeding cycle. The elimination half-life ($T_{1/2}$) of BSP was greatly prolonged at the end of each force-feeding period but returned to normal (values same as controls) after 4 weeks of free-feeding.

The authors concluded that since animals were able to withstand three consecutive cycles of force-feeding with four-week intervals of normal feeding, and that no pathology was found after these rest periods, force-feeding does not induce diet-related pathological changes since the steatosis was reversible. Consequently, animal welfare is not adversely affected. However, we argue that survival after a problem does not mean that the problem was of no significance. While steatosis was reversible in the studies described above, its reversibility does not mean that the liver changes were not pathological. The reduction in the liver's ability to detoxify at the end of the force-feeding period, as indicated by a slower BSP clearance, longer BSP half-life and raised liver enzymes, is clear evidence of clinical pathology. These and various other data show that the steatosis obtained by force-feeding induces an impairment of hepatic function (SCAHAW 1998). In Babilé *et al* (1996), liver weight after 16 days of force-feeding took 30 days to reduce to normal, and in other studies the mortality of ducks increased when the force-feeding period was prolonged beyond 15 days (SCAHAW 1998).

There are other points in the articles by Bénard *et al* (1998, 2006) that deserve attention. Force-feeding was performed on ducks housed in groups on the floor, by one person seated on a stool within their pen. This force-feeding is not typical of current practice (Litt 2010), taking much longer, about 30 seconds. The birds were closely examined twice daily throughout the study; force-fed birds were kept on wire mesh floors and developed signs of tibio-tarsal arthritis as well as skin calluses on their feet. These lesions disappeared when they were returned to straw litter for free-feeding. After an initial 3-day period of agitation they showed increasingly longer periods of rest between each force-feeding, as well as an increase in wing flapping; the authors do not explain these behavioural changes. Agitation and wing flapping may be due to pain or fear, increasingly longer periods of rest due to pain, lethargy or abdominal discomfort. Hypertrophied livers can cause discomfort in a number of other species and this may also occur in ducks (SCAHAW 1998). There is no mention of access to water troughs for head immersion and wet preening, and despite close examination twice daily, the state of the ducks' face, eyes and nostrils are not

described. The results of this study do not support the authors' conclusion that force-feeding did not cause suffering.
We suggest that additional physiological measures could be used in the assessment of liver function in force-fed ducks such as bile acids, ammonia, urea nitrogen, gamma glutamyltransferase, uric acid and coagulation factors in the blood and ketones in the blood or urine (Harr 2005). These measures are commonly used in other species. In addition, because maize is not a balanced diet for ducks other abnormalities may be present, such as hormone imbalances or altered calcium to phosphate ratios leading to bone pathology (SCAHAW 1998), so these should be measured too.

Effects on behaviour

Compared with physical and physiological effects, there is an even greater lack of published data on the behavioural responses to force-feeding both during the procedure itself and at other times, eg immediately beforehand when the ducks anticipate a potentially unpleasant experience, and afterwards when they have to digest a large amount of food. When behavioural responses are described, their interpretation and significance from a welfare perspective is often lacking or incomplete (Bénard *et al* 1998, 2006).
The gag or pharyngeal reflex is a reflex contraction of the back of the throat, evoked by touching the roof of the mouth, the back of the tongue or the back of the throat. There is a contraction of both sides of the posterior oral and pharyngeal musculature, and humans report that this is an unpleasant experience (Shriprasad & Shilpashree 2012). The reflex helps to prevent material from entering the throat, except as part of normal swallowing, and protects against choking and aspiration. There is controversy as to whether the reflex is present in ducks; we agree with SCAHAW (1998) that it probably is. Unlike some birds such as pelicans and storks, mulard ducks consume food by dabbling and sieving and do not swallow large food items. There is no reason why the pharyngeal reflex would be absent in these ducks. Initially, force-feeding stimulates this reflex but after a certain time it stops. The adaptation time required for the gag reflex to be extinguished, and how this affects the duck, are not known.
Carrière *et al* (2006) compared the behaviour of force-fed mulards (during the hour after the second, twelfth and twenty-fourth meal) with controls that were kept in the same conditions but not handled or force-fed. Test birds were force-fed twice daily for 13 days (the amount fed and whether it increased day by day are not specified) while control ducks had *ad-libitum* access to food, which was provided every morning at the same time as the test ducks were force-fed. The behaviour of the control ducks was video-recorded the day after the recording of the test ducks.
Force-fed ducks spent more time lying down, and walked less frequently and for a shorter time than control ducks. The authors explain these results by the negative effects of the duck's weight gain on posture and movement. We argue that this has consequences for the duck's welfare. Excess weight can reduce the animal's mobility in a number of ways including pressure from an enlarged abdomen, reduced respiratory capability and joint pain. As with broilers (Bradshaw et al 2002; Weeks 2014), lack of mobility is likely to lead to further consequences that reduce welfare such as poor muscle strength, skeletal defects, skin lesions and altered social interactions with conspecifics. Other changes in behaviour in test birds included spending less time with their head at rest, reduced grooming and preening, and spreading their wings and shaking their tail less often. Self-grooming, preening and wing-stretching are all behaviours generally associated with good welfare in birds

(Rodenburg *et al* 2005). The time spent performing these behaviours was reduced in force-fed compared with control birds and decreased over time. Force-fed birds shook their heads more than controls, especially after the first force-fed meal but also after subsequent meals. The authors suggest that this may be a reaction to handling by the force-feeder, or to the introduction of a large amount of food into the oesophagus. Head-shaking normally indicates an aversive event and also occurs when birds are deprived of access to open water (Rodenburg *et al* 2005). It may also be evidence of stimulation of the gag reflex.

Most intensive farms for foie gras production have air ventilation systems to keep ambient temperatures relatively low, in an attempt to reduce thermal stress in the birds. Nevertheless, the force-fed ducks spent a lot of time panting and this increased with time. After the twelfth meal 5 out of 9 ducks panted, and after the last all panted in the hour after force-feeding. This behaviour was not evident in the control ducks at any time. Force-feeding disrupted the test birds' thermal homeostasis, causing them to spend a proportion of their time budget panting, while control birds fed *ad-libitum* remained in thermal homeostasis and did not pant. These behavioural changes indicate poorer welfare in the test birds, which worsened over time. Panting to aid evaporative cooling is part of the thermoregulatory response to the ingestion of large amounts of high-energy food, as is immersion of the face and, by wet preening, the body in water (Rodenburg *et al* 2005). The birds had access to water but it is not clear whether it was to water troughs, showers, baths or nipple drinkers; it seems that water was only available for drinking. This study was limited to studying birds for one hour after each force-feeding and did not consider the effect of handling of test birds, separate from the effect of force-feeding, as controls were not handled prior to feeding.

Ducks' behavioural responses to force-feeding were also examined by Faure *et al* (1998, 2001). In the first experiment (Faure *et al* 1998), the hypothesis was that if force-feeding caused aversion, the ducks would not spontaneously leave their rearing pen or go into the test pen where they were force-fed. Force-fed birds showed aversion to entering the test pen, compared with controls (not force-fed). However, there were some methodological issues with this experiment (eg birds were fed just once daily).

In the second experiment (Faure *et al* 2001), the flight distances of ducks from the force-feeder and from an unknown observer were measured in ducks housed in individual cages. Flight distance was the distance between the person and the duck's cage, at the time when the duck withdrew its head as the person approached it. Tests were performed several hours after the force-fed meal on days 3, 7, 9 and 11. Initially the flight distances were similar, but on days 7 and 9 ducks avoided the unknown person more than the force-feeder and their avoidance of the force-feeder decreased during the force-feeding period. The authors concluded that there was no evidence of an aversion to the force-feeder. This is a poorly controlled experiment with alternative explanations for the results and it does not demonstrate that force-feeding is not aversive to ducks. It is well known to those who force-feed ducks that the birds show initial avoidance and struggling but reduce this over time, presumably because they learn that they are less likely to be caused pain if they do. There is the confounding effect of greater familiarity of the force-feeder compared with the unknown observer, and the choice of flight distance as a measure of aversion is problematic (eg duck movements in an individual cage are limited). Repeating this experiment using two persons of equal familiarity, with one doing the force-feeding and the other not, as well as using measures other than flight distance, is indicated.

Effects on physiology

A number of studies have examined the effects of force-feeding and its different components (handling, intubation) on various physiological indicators of acute and chronic stress in mulard ducks (Guémené *et al* 2001; Mirabito *et al* 2002c; Guémené *et al* 2006a; Flament *et al* 2012; Mohammed *et al* 2014). Some have shown no effects of force-feeding on blood corticosterone levels or ACTH sensitivity (eg Guémené *et al* 2001; Flament *et al* 2012), while others have had different results. For example, Mirabito *et al* (2002c) found that force-feeding caused significant increases in blood corticosterone in some ducks on some days and Mohammed *et al* (2014) noted that blood corticosterone levels of force-fed ducks rose while those of controls did not. In humans (Legler *et al* 1982) and animals (Broom & Johnson 2000) plasma glucocorticoid concentrations are not consistently related to eating.
The experimental design of studies needs to be improved, and the methodology clearly established, before the usefulness of corticosterone as a measure of acute or chronic stress in force-fed ducks can be determined.

Effects on thermoregulation

Force-fed ducks are susceptible to thermal stress, which causes panting in order to disperse the extra heat generated from digestion. They may spend large amounts of time, standing or lying down, performing this behaviour (Carrière *et al* 2006). Thermal stress makes the duck prone to discomfort, reduces food digestibility and increases mortality. Nutritional supplements containing electrolytes and anti-oxidants have been developed to mitigate these effects (Mathiaud *et al* 2013). Immersion in water is another homeostatic mechanism for thermoregulation in birds, but if sufficient water for immersion is not available, heat stress becomes a greater risk (Rodenburg *et al* 2005).

Alternatives to force-feeding

Researchers and farmers are keen to find a way of producing foie gras without the need to force-feed. The main methods are summarised in Guy *et al* (2007). One approach is to stimulate the birds to over-eat voluntarily to a degree that is sufficient to cause hepatic steatosis. Spontaneous over-eating leading to liver steatosis can be stimulated in geese by manipulating day length (because photoperiod is a major environmental factor controlling migration and the pre-migratory fattening process) and feeding regimes (Fernandez *et al* 2013; Guy *et al* 2013; Bonnefont *et al* 2015; Fernandez *et al* 2015). However this response is not seen in ducks, the variability in the response is high, the production cycle is long (up to 31 weeks), the liver produced is less liked by some consumers (Fernandez *et al* 2015) and there are negative effects on the environment (Brachet *et al* 2015). Life Cycle Analysis (LCA) examines a product's complete life cycle from raw materials to final disposal of the product (Williams 2009). Brachet *et al* (2015) used LCA to estimate potential impacts on the environment, and found that non force-fed geese had a greater impact due to a longer production time and higher food consumption while achieving lower liver weights. EU Regulations 1538/91 and 543/2008 state that in order to be called foie gras, the minimum liver weight must be 300 grams net in ducks and 400 grams net in geese. These weights cannot be achieved without force-feeding but if they were reduced, it may be possible to produce a fatty liver that is still acceptable to consumers without force-feeding. A maximum liver weight should be specified, in order to prevent the accumulation of toxic substances and other adverse effects on welfare due to liver malfunction.

Housing

Individual and group housing

Until recently, most production systems placed ducks in individual cages during the force-feeding period. The cages prevent the ducks from avoiding the force-feeding. The main advantages to the producer are that the ducks can be force-fed rapidly one after the other, without the feeder having to catch them, and that "they always remain in the right position" (Guémené & Guy 2004). Individual cages are small and greatly restrict the bird's movements; they do not allow the bird to turn around, stretch and flap its wings, stretch to its full height or length or show more than a minimal behavioural repertoire. The degree of restriction increases as the bird grows rapidly and fattens.

As of January 2016, the individual caging of ducks for foie gras production is illegal in France (Anon 2015). Ducks have to be housed in groups of at least 3 birds although cage dimensions and bird density are not specified. This bylaw refers to the Council of Europe (1999) recommendations for muscovy ducks (*Cairina moschata*) and hybrids of muscovy and domestic ducks (*Anas platyrhynchos*), which state in more detail what the birds should be able to do when housed together.

Factors that affect welfare in group housing include group size, stocking density, type of flooring, provision of litter or bedding material, access to water for drinking, and the provision of water for bathing or at least full immersion of the head (Mirabito *et al* 2002a, b, c; Mirabito 2006). Management of the air space and ventilation, maintaining cleanliness and controlling disease, and ensuring homogeneity of groups are also important. Potential undesirable effects of group housing include increased aggression between birds, difficulty in maintaining cleanliness (especially in larger groups), competition at water sources, and difficulties in catching birds causing repeated stress (Guémené *et al* 2002; 2006a).

Previous work on group housing has examined the effects of floor space and group size on production, behaviour and blood corticosterone (Mirabito *et al* 2002a, b, c). In general, the best production results were obtained when ducks had 2000 cm^2 of floor area each, and larger groups (9 ducks) had higher mortality and poorer cleanliness (Mirabito *et al* 2002a). However, birds kept at the highest stocking density in the smallest group had more humeral lesions at slaughter, perhaps a reflection of reduced activity and subsequent bone weakness. Surface area per bird was the main factor that influenced behaviour, with birds kept at 1000 cm^2 each moving less and stretching their wings less frequently than birds kept at a density of 1500 or 2000 cm^2 (Mirabito *et al* 2002b).

The effects of group size (3, 6 or 9 ducks) and surface area per bird (1000, 1500 and 2000 cm^2) on blood corticosterone before and after force-feeding and on the HPA axis were explored, and compared with birds housed individually (Mirabito *et al* 2002c). Effects of different housing conditions on blood levels of corticosterone were not clear-cut, and were difficult to interpret. Increases were noted for ducks housed individually after the 1st and 11th meal, findings which are not in agreement with those of Guémené *et al* (2001). There was no evidence of abnormalities in sensitivity or

reactivity of the HPA axis, except for some unusual results obtained for the group of 6 ducks kept at 1500 cm^2 stocking density.
Between 2007 and 2009, trials of group versus individual housing of ducks were performed by Litt (2010). The focus was largely on production outcomes rather than on welfare. While birds were fed the same amount, group-housed birds had smaller livers, force-feeding took longer and more water was required for cleaning. There was a small increase in breast tissue (‘magret’), also noted by Mirabito *et al* (2002a).

Cage design in group housing

More recent models of group cages have been modified, particularly with regard to containment (restraint using one or more crowd-gates, ‘peigne de contention’) of birds when force-fed and the work conditions of force-feeders. The restraining containment method aims to make force-feeding easier by bringing birds to the front of the cage and immobilising them. A back wall pushes the birds forwards. As they collect at the front, the front vertical grid wall descends backwards over them and prevents them from escaping or moving the body. Group-housed birds may be susceptible to injury resulting from getting caught in the cage’s containment mechanism, or from being restrained for a long time as the force-feeder works up one row of cages and back down the other before releasing the mechanism. Because birds immobilised by the crowd-gates may be facing any direction, the force-feeder must be able to insert the feeding tube from any angle (Cepso 2013). This can increase the risk of injury, especially if the bird struggles and resists or if others get in the way. It is more difficult and takes longer for the force-feeder to carry out their task, especially with larger groups (Mirabito *et al* 2002a; Litt 2010). The force-feeder is unable to develop a steady rhythm, working their way uninterrupted along a row of cages as is possible with individual caging.
A brochure by the agricultural group Centre d’Etudes des Palmipèdes du Sud Ouest Cepso Chambagri (Cepso 2013) illustrates 12 different types of cages available, and provides a summary table which compares the cage systems with regard to density, minimum floor space per bird and other parameters. Recommended cage floor surface area is 4000 cm^2 for 3 ducks, 5000 cm^2 for 4 and at least 1200 cm^2 surface area per bird (the equivalent of 2 size A4 sheets of paper) for 5 ducks or more. The cage should be tall enough for the bird to stretch fully to its vertical height and there is usually no roof. Ten of the systems have a movable back wall, and all but one have a front vertical grid wall that can move back and down to immobilise the birds. Based on available published studies, the choice of cage floor surface area per bird seems to be a compromise between economics and duck comfort (1000-1200 cm^2 or 1500-2000 cm^2). Most cages are small, with a surface area of 1200 cm^2 to 1300 cm^2 per bird.

Flooring and provision of litter or bedding

Force-fed ducks are usually kept on a mesh floor (‘caillebotis’) made of some type of steel (galvanised or stainless) and less commonly of plastic. As force-feeding progresses, they become more inactive and rest on this firm bare surface as litter or bedding is not provided. Contact dermatitis is common and develops early during the production process (Litt *et al* 2015c). It is already of moderate to marked severity when birds are ready for force-feeding (end of stage 2b). Lesions may improve, worsen (Litt *et al* 2015b) or stay the same (Litt *et al* 2015a, c) during force-feeding. Bénard *et al* (2006) noted that force-fed birds kept on wire mesh floors developed signs of tibio-tarsal arthritis as well as skin calluses on their feet. These lesions disappeared when birds were returned to straw litter for free-feeding.

Many environmental factors have been associated with the development of contact dermatitis in chickens kept for meat production. Why it occurs in some flocks and not in others is not fully understood. A major contributing factor, particularly at the onset, is the type of litter, or ground quality if litter is not provided. Damage occurs to the skin surfaces that have prolonged contact with litter, usually starting with the footpad and toes, then the rear surface of the hock and, when severe, the breast area. While high moisture litter is sufficient to cause the condition, litter depth, ammonia levels, climatic conditions, condensation, ventilation, stocking density, rearing system, leg weakness, overweight and inactivity, ground quality and diet (such as levels of methionine, choline and certain vitamins) are also recognised as causative factors (Haslam *et al* 2007; Bassett 2009; Shepherd & Fairchild 2010; Hepworth *et al* 2011; Saraiva *et al* 2016).

Council of Europe recommendations (Council of Europe 1999) state that "Where ducks are housed, floors shall be of a suitable design and material and not cause discomfort, distress or injury to the birds. The floor shall include an area sufficient to enable all birds to rest simultaneously and covered with an appropriate bedding material" (article 10, point 6) and "Adequate litter shall be provided and maintained, as far as possible, in a dry, friable state in order to help the birds to keep themselves clean and to enrich the environment" (article 11, point 4). Despite these recommendations, currently the standard group cage lacks an area where ducks can rest together, and there is no bedding material or litter to ensure their comfort and cleanliness or to provide substratum for foraging and exploratory behaviours. The cage is barren and not enriched beyond the provision of water troughs and conspecifics.

Access to water

Ducks spend considerable time performing complex preening behaviours (Rodenburg *et al* 2005). After feeding followed by bathing (an important element being immersion of the head and wings), they carry out a variety of shaking movements to remove water and cleaning movements to remove foreign bodies. An elaborate sequence is then carried out to distribute oil on the feathers from the uropygial gland above the tail. This is necessary for waterproofing and heat regulation. A short period of sleep often follows preening. The sequence of feeding, bathing, preening and sleeping may be repeated a number of times during the day. Council of Europe recommendations (Council of Europe 1999) state that "Access to an outside run and water for bathing is necessary for ducks, as water birds, to fulfill their biological requirements. Where such access is not possible, the ducks must be provided with water facilities sufficient in number and so designed to allow water to cover the head and be taken up by the beak so that the duck can shake water over the body without difficulty. The ducks should be allowed to dip their heads under water" (article 10, point 2).

The provision of a good open water system such as troughs improves eye, nostril and feather condition and reduces disease (Knierim *et al* 2004; Jones *et al* 2009; Jones & Dawkins 2010a, b; O'Driscoll & Broom 2011; O'Driscoll & Broom 2012, Liste et al 2012). Water troughs must be wide enough and deep enough so that ducks can immerse and wet their head fully, and long enough so that there is no competition between ducks for access although it may not be necessary for all birds to bathe simultaneously (Waitt *et al* 2009). The Cepso brochure (Cepso 2013) states that there should be at least 800 mm length of water trough per cage, but it is not clear if this is dependent on group size. In addition, the width and depth dimensions of the troughs are not supplied. While studies state that water troughs are provided for drinking and head immersion, to our knowledge none published so far have examined whether the troughs are actually used for what they are intended, or reported on water cleanliness and duck behaviour at the troughs.

Dimensions are available for troughs used in experimental conditions in British studies of farmed ducks, eg: 950 mm long, 125 mm wide and 80 mm deep (Jones *et al* 2009; Waitt *et al* 2009) or 1600 mm long, 150 mm wide and 100 mm deep (O'Driscoll & Broom 2011, Liste *et al* 2012, 2013). However, ducks in these studies are younger, smaller and lighter than ducks at force-feeding, and the troughs are often placed on the ground rather than attached to cages. Little attention seems to have been paid to water trough dimensions in other studies, or to whether the birds are able to perform immersive behaviour in addition to drinking, or to water cleanliness and trough maintenance. As ducks lack sweat glands, immersion in water as well as panting is a vital homeostatic mechanism for thermoregulation in force-fed birds subjected to a high level of thermal stress due to the ingestion of large amounts of food.

When mulard ducks are kept in individual cages, they have access to water via nipple drinkers (Rodenburg *et al* 2005) or via troughs but, because of the restrictive cage, the type of trough and increasing bird size, they may not be able to immerse their heads fully, spread water over their feathers and self-groom. It is notable that they are unable to keep themselves clean, especially towards the end of force-feeding. Force-feeding with maize mash is messy and it not clear whether group housing results in cleaner birds with improved welfare.

Other welfare issues

The human-animal relationship

In the case of foie gras production, the relationship between the stockman (the force-feeder) and the force-fed ducks has received little attention despite the major impacts stockmanship has on animal welfare (Boivin *et al* 2003; Hemsworth 2007). Perhaps this is because the force-feeder is often only involved in the final stage rather than in the whole production process, and their work is normally restricted to force-feeding and cleaning activities. Concerns have been raised that group housing (obligatory as of January 2016) makes the force-feeder's work harder and take longer (Litt 2010). Workers have to modify their technique and movements, and access to birds is more difficult.

Fear responses in ducks include freezing, alarm calling, agitation, attempts to run away rapidly and vigourous struggling if caught (Ekesbo 2011). There is substantial evidence that negative interactions between humans and animals increase the animals' fear (Boivin *et al* 2003; Hemsworth 2007); fearful animals are more difficult to handle. Mulards show fear of humans (Arnaud *et al* 2008), and when force-fed they pull back ('movement de recul') (Laborde & Voisin 2013). Difficulties in catching and restraining birds for force-feeding led to the development of a containment system using a crowd-gate, which reduces the birds' ability to struggle, resist or escape. The need for containment strongly indicates that ducks find the force-feeding procedure aversive.

Domestic animals usually develop a relationship with the person looking after them, especially if that person provides food and other positive resources such as bedding, and activities such as talking, petting and grooming. Containment may make force-feeding quicker and easier, but has a negative impact on the stockperson-animal relationship. If ducks were being offered appropriate food and did not find the procedure painful, frightening or otherwise aversive, there would be no need for containment. Instead, they would move voluntarily towards the force-feeder and stay still while being fed because food is a necessary and desirable resource supplied by the feeder. Habituation is defined as a decrease in responding resulting from repeated stimulation (Shettleworth 2010), providing that it is not due to sensory adaptation or motor fatigue. Habituation to an extremely unpleasant stimulus is less likely than to a slight one, and is also unlikely if the stimulus remains biologically relevant (Shettleworth 2010). Habituation to force-feeding is unlikely to occur.

Control over the environment and motivation

A major objection to the practice of foie gras production is that the birds cannot chose what, when and how much they will eat. They cannot show a food preference or feed spontaneously. They are the only farmed species that is not able to feed by expressing normal feeding behaviour, and are fed considerably more than they would eat voluntarily. They receive this food without having the possibility to forage in a species-specific manner ie by pecking, nibbling and swallowing and, if there is access to open water, dabbling, sieving and up-ending.

Motivated behaviours have two phases: an 'appetitive' phase in which the animals search or prepare for the opportunity to perform a 'consummatory' phase (Mason & Burns 2011). In the case of food, their expression is vital to the animal's survival so both phases are driven by strong motivations, and emotions appear to be important in their control. Being unable to satisfy these strong motivations leads to frustration (Mason & Burns 2011).

An important concept in relation to understanding animal welfare is the control which an individual has over its environment (Broom 1991). Welfare is poorer when the individual lacks control and is affected by the consequences (Broom 2008). Birds in foie gras production cannot control their own feeding nor can they control the amount and nature of their contact with humans. This lack of control leads to very poor welfare.

The European Charter and the Welfare Quality® project

In 2008 the European Federation of Foie Gras, consisting of all the representatives of foie gras producing countries in the European Union, was signatory to a European Charter on the "breeding of waterfowl for foie gras" (see http://www.eurofoiegras.com/docs/EUROFOIEGRAS_CHARTE_UK.pdf). (The term 'élevage' is not translated accurately here; the Charter is not about breeding but about rearing and fattening, or production). The Charter is derived from the twelve criteria of the Welfare Quality® project and uses the term 'assisted feeding' in the English and 'gavage' in the French version. The Federation claims that "if performed by professionals under regulated conditions, gavage does not cause any suffering to the animals" (see http://www.eurofoiegras.com/en/page/euro-foie-gras_p134/). A support programme called 'Palmi G Confiance' was created in 2014 to help foie gras producers meet the standards of the European Charter with regard to animal welfare and good practice. Researchers are working with the poultry industry to develop a simple welfare assessment method that can be used on a large scale and is largely based on animal measures. Some research is focussed on identifying measures easily taken in the abattoir that are correlated with on-farm measures that are more difficult to collect (Litt *et al* 2015a).

The four welfare principles and 12 criteria proposed by the Welfare Quality® project (Welfare Quality® Consortium 2009) are a development of the Five Freedoms (Brambell 1965). We have made a preliminary attempt at assessing the welfare of ducks in foie gras production using the Welfare Quality® assessment system (Table 1). There are four columns in the Welfare Quality® assessment system. The first lists the four welfare principles, and the second presents the criteria associated with each of these principles. Using the information provided by this review, we have completed the last two columns. In the third column we state whether the criterion is met or not, and in the fourth we give examples of how the criterion is or is not met. We conclude that only three of the 12 criteria and none of the welfare principles are met in current systems of foie gras production.

Table 1 at end of paper

Other stages of foie gras production

While the primary aim of this review has been to highlight the welfare problems in the last stage of foie gras production, welfare problems have also been identified in the first two stages. These include the early, frequent and rapid development of contact dermatitis, fear of humans and high sensitivity to the environment, and lack of access to open water for bathing or at least full immersion of the head. It seems that under commercial conditions water is normally only provided by nipple drinkers, despite ducks being aquatic animals who spend most of their lives close to or on water.

Conclusions and animal welfare implications

Force-fed birds are the only farmed species that is not able to feed by expressing normal feeding behaviour. There is substantial evidence from behavioural observations that force-feeding is aversive, and causes high mortality compared with other duck production systems.

The physical condition of the birds deteriorates as they progress through the stages of foie gras production. Force-feeding an unbalanced diet in large amounts causes significant liver pathology. Hepatic steatosis has the potential to be fatal if force-feeding is prolonged beyond 15 to 16 days. Force-feeding causes oesophagitis and leads to other abnormalities such as gait disturbances, wing lesions, and bone pathology which can result in fractures. Contact dermatitis, a painful skin condition, is widespread, starts in the early stages of production, is present in all stages and can be severe.

Due to their fear of humans, nervousness and sensitivity to the environment, mulard ducks are maladapted to the conditions of foie gras production, especially during force-feeding. When group-housed they keep away from the force-feeder; they have to be rounded up and immobilised with crowd-gates in order to be force-fed. This indicates that ducks regard the experience of being handled and force-fed as a negative one, to be avoided. They are very susceptible to thermal stress due to the large amounts of food force-fed, and this makes them spend a large proportion of their time panting.

Housing provisions are poor, with small, barren group cages and a bare mesh floor; resting places, litter or bedding are not provided despite Council of Europe recommendations. It is not clear whether the troughs supplied on the cages of force-fed ducks are effective for bathing or full head immersion, or enable them to keep their plumage clean and to thermoregulate adequately In the first two stages of production, access to open water suitable for bathing may be lacking; water supplied in the form of nipple drinkers does not allow full immersion of the head.
The European Federation of Foie Gras claims that "if performed by professionals under regulated conditions, gavage does not cause any suffering to the animals." We conclude from this literature review that force-feeding causes very poor welfare in ducks and should not be practised. In the future, the production of foie gras in ducks without the need to force-feed may become possible. In order to prevent the accumulation of toxic substances and other adverse effects on welfare due to liver malfunction, maximum liver weights should be specified and based on scientific studies. To avoid poor welfare associated with inadequate housing and management, birds should be checked before and after slaughter using animal-based welfare outcome indicators. For example, maximum acceptable prevalences of contact dermatitis, posture and walking difficulties, wing fractures and other body lesions could be established.

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Table 1. Principles and criteria that underpin the Welfare Quality® assessment system, and whether they are met by force-feeding of mulard ducks

Welfare principles	Criterion	Is it met?	Example of how criterion is or is not met
Good feeding	Animals should not suffer from prolonged hunger, ie they should have a sufficient & appropriate diet.	No	Duck is fed a diet that is neither appropriate nor sufficient (diet is excessive); it cannot regulate its intake to achieve satiety & homeostasis
	Animals should not suffer from prolonged thirst, ie they should have a sufficient & accessible water supply.	Yes	There may be problems with maintaining cleanliness, ensuring ease of access to water troughs & trough design
Good housing	Animals should have comfort around resting.	No	There is no resting area & no bedding, the floor consists of wire or plastic mesh
	Animals should have thermal comfort, ie they should neither be too hot nor too cold.	No	There is thermal stress due to large amounts of high energy food leading to prolonged panting
	Animals should have enough space to be able to move around freely.	Yes	More behavioural research is necessary to confirm optimal cage size & design & stocking density
Good health	Animals should be free of	No	Injuries due to containment,

	physical injuries.		capture, handling & force-feeding occur
	Animals should be free of disease, ie farmers should maintain high standards of hygiene & care	No	Footpad & hock dermatitis, lesions to breastbone are frequent & often severe; liver steatosis is caused deliberately
	Animals should not suffer pain induced by inappropriate management, handling, slaughter, or surgical procedures (eg castration, dehorning).	No	Containment, capture, handling & force-feeding may be sources of pain; high prevalence of wing lesions caused by handling & transport to abattoir
Appropriate behaviour	Animals should be able to express normal, non-harmful, social behaviours, eg grooming.	Yes	Further research needed on social behaviour in group housing, optimal group size & social behaviours, signs of good welfare
	Animals should be able to express other normal behaviours, ie it should be possible to express species-specific natural behaviours such as foraging.	No	There is no substratum for foraging; further research is necessary on the use of water troughs, preening & grooming behaviours
	Animals should be handled well in all situations, ie	No	Catching, handling & force-feeding do not promote good

	handlers should promote good human-animal relationships.		human-animal relationships; poor handling during transport prior to slaughter causes wing lesions
	Negative emotions such as fear, distress, frustration or apathy should be avoided whereas positive emotions such as security or contentment should be promoted	No	Fear, distress, frustration, pain & other negative emotions are very likely when ducks are subjected to the stages of foie gras production, especially during force-feeding. Problem of nervousness & hyper-reactivity in mulard ducks

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