Chapter 9: Poultry

The animal care guidelines in this chapter are for the 3 major domesticated poultry species in the United States: chickens (both egg-type and meat-type), turkeys, and ducks.

FACILITIES AND ENVIRONMENT

The physical environment afforded by a poultry research or teaching facility should not put birds at undue risk of injury or expose them to conditions that would be likely to cause unnecessary distress or disease (Davis and Dean, 1968; Berg and Halverson, 1985; Tauson, 1985; Bell and Weaver, 2002; Appleby et al., 2004). The facility should be maintained in such a way as to allow the birds to keep themselves clean and free from predators and parasites, prevent bird escape and entrapment, and avoid unnecessary accumulation of bird waste.

Environmental conditions are known to have major implications on the health, performance, and welfare of poultry (Dawkins et al., 2004; Estévez, 2007). Air quality and the thermal environment should be maintained by ventilation, cooling, and heating to provide birds with the right environmental conditions for their age and time of the year.

Welfare of the caretaker, in addition to bird well-being, deserves consideration in evaluation of housing systems (Whyte, 1993) and should receive attention during remodeling and development of future designs and concepts.

Bird exposure to high levels of ammonia causes irritation of the mucous membranes of the respiratory tract and eyes, increasing susceptibility to respiratory diseases (Kristensen and Wathes, 2000). Birds detect and avoid atmospheric ammonia at or below 25 ppm (Kristensen et al., 2000). According to the National Institute for Occupational Safety and Health (**NIOSH**), the recommended exposure limits for humans should be no greater than 25 ppm for an 8-h day; for short-term exposure of 15 min, the threshold is 35 ppm (Agency for Toxic Substances and Disease Registry, 2004). Ideally, ammonia exposure for birds should be less than 25 ppm and should not exceed 50 ppm (Miles et al., 2004).

Design of all housing systems should facilitate cleaning of the house and equipment as well as the inspection of birds. Cages with multiple decks should allow for cleaning of equipment and inspection of birds without handling them, yet the birds should be easily accessible. Adequate lighting should be available for examination of all birds, and a movable platform or other system should be provided for examination of higher level decks, if those cannot be readily seen by attendants standing on the floor. Feeding and watering equipment also should be accessible for easy maintenance.

Advantages and Disadvantages of Conventional and Alternative Housing Systems

Although there are a variety of systems that can be used for housing poultry, including conventional and furnished cages, aviaries, littered floor systems, and free range, no housing system is perfect, with each system having its own health and welfare advantages and disadvantages. For a colored schematic of the welfare risks of different housing systems for egg-laying strains of chickens, see Table 7.7 of the LayWel report (LayWel, 2006b).

Research into alternative housing systems has been extensive in recent years (Appleby et al., 2004; Vits et al., 2005; Guesdon et al., 2006; Nicol et al., 2006; Zimmerman et al., 2006) including furnished cages, aviaries, and free-range systems as alternatives to conventional cages for egg-laying strains of chickens. Conventional cages lack nests, perches, and dust baths to meet the behavioral needs of hens, but conventionally caged hens have less cannibalism and pecking because of smaller group sizes (Appleby and Hughes, 1991; Abrahamsson and Tauson, 1995) leading to a reduced trend in mortality compared with hens in non-cage systems (Flock et al., 2005; Laywell, 2006b; Tauson et al., 2006; Arbona et al., 2009; Black and Christensen, 2009; Fossum et al., 2009; Glata and Hinch, 2009). Because conventional cages lack perches and do not have access to litter, poor foot health and keel bone deviations and deformities are not as problematic in cages as they are in non-cage systems or furnished cages (Tauson et al., 2006); however, because of lack of exercise, conventionally caged hens are susceptible to osteoporosis (Whitehead and Fleming, 2000; Jendral et al., 2008). Moreover, free-range birds are able to express behaviors such as freedom of movement, running, short-distance flying, and the scratching of soil, and have the opportunity to be exposed to a variety of environmental stimuli (Appleby and Hughes, 1991). They are also leaner with more muscle mass and plumage than caged birds (Hughes and Dun, 1986). However, ranged birds are more susceptible to problems caused by inclement weather and have increased risks of bacterial disease, parasites, cannibalism (Fossum et al., 2009) due to larger group sizes (Appleby et al., 1992), predators (Darre, 2003), environmental contaminants such as dioxin (Schoeters and Hoogenboom, 2006; Kijlstra et al., 2007), and increased frequency of old bone fractures (Gregory et al., 1990). No housing or management system is likely to be ideal in all respects. Therefore, ethically acceptable levels of welfare can exist in a variety of housing systems (Duncan, 1978).

Alternative Housing

Furnished Cages for Egg-Laying Strains of Chickens. Furnished cages are available to house large (~60 hens), medium (15 to 30 hens), and small (up to 15 hens) group sizes. The European Commission (1999) offers standards for furnished cages that include perching space for all hens and a nest and dust bath area, with minimum available space per hen of 750 cm^2 per bird. Appleby (2004) suggests that group sizes of 8 hens or more in furnished cages should have 800 cm^2/hen and that smaller groups of 3 or less should have 900 cm^2/hen, plus an area with litter. In these systems, claw-shortening devices are helpful to maintain short claws, and perches can help to increase leg strength (Hughes and Appleby, 1989; Jendral et al., 2008). Problems observed in this type of housing include increased keel bone deformities associated with high perch use (Vits et al., 2005; Tauson et al., 2006) and should be monitored.

Aviaries or Multi-Tier Systems for Egg-Laying Strains of Chickens. Aviaries, designed to use vertical space, consist of a ground floor plus one or more tiers consisting of perforated or slatted floors or platforms with manure belts underneath (Appleby et al., 2004; LayWel, 2006a; RSPCA, 2008b). Providing a littered area allows for dust bathing and reduces the incidence of cannibalism and feather pecking. The scratch area also allows the hens to keep their claws trimmed. The litter should cover enough area to allow for proper mixing of manure and avoid excessive manure and moisture accumulation. The depth of the litter should be sufficient to prevent hens from coming in contact with the floor. Likewise, the depth of the litter should not be so deep that it encourages the laying of eggs on the floor. Opening and closing the littered areas for specified periods can be used as a management tool to prevent the laying of floor eggs. The European Commission (1999) recommends that the littered areas cover at least 30% of the useable floor area of the house (including the floor area of tiers). The recommended floor space per hen for aviaries (Table 9-9) excludes nest space. Only the floor area and the tiers can be counted as usable space when calculating stocking density for hens in aviaries.

Hens housed in aviaries have a high incidence of bone fractures during the laying cycle because of crash landings or failing to jump gaps effectively (Broom, 1990; Gregory et al., 1990; Nicol et al., 2006). Each tier should allow hens to safely access other vertical tiers, including the littered floor. For example, a ramp can be used to allow birds to move from the littered floor area to the first raised tier. If ramps are used, they should be designed to prevent droppings from falling on the birds below. Hens should have access to the entire littered floor area, including the area under the raised tiers. Raised tiers need a system for frequent removal of manure. To reduce the incidence of hen injury, including broken bones, the highest tier (measured from the littered floor to the underside of the manure belt of the highest tier) should not exceed 2 m (6.5 ft).

Vertical distance between tiers, which also includes the floor to the first tier, is recommended to be between 0.5 and 1.0 m (1.6 and 3.3 ft). Measurements may be taken from the top of the littered floor or slat area to the underside of the manure belt. When adjacent tiers are staggered to allow for diagonal access to tiers of different heights, the hen's angle of descent (measured horizontally from the top tier) should not exceed 45°. The horizontal distance between tiers should not be more than 0.8 m (2.6 ft). Where design discourages horizontal movement between different tiers, there should be a minimum distance between tiers of 2 m (6.6 ft). For flock sizes that exceed 3,000 hens in a room, no more than 2 raised tiers above the floor are recommended. Smaller flock sizes of 3,000 or less can have up to 3 raised tiers in a room (RSPCA, 2008b).

Birds that are to be housed in aviaries as adults should be reared as pullets in similar aviaries to facilitate adaptation to perches and nests. Typically, day-old chicks are housed in a central tier the first 10 d of age and then about half of the pullets can be distributed to the lower tier to provide more space as they age. In this manner, the pullets quickly find the feed and water and are provided proper brooding temperatures during the early stages of growth. By 15 to 21 d of age, pullets are given full access to the aviary. Ramps are provided to allow pullets easy access to all levels of the aviary. Perch space per pullet is recommended to be 8 cm (3.1 in)/pullet during the first 10 wk of age and 11 cm (4.3 in)/pullet after 10 wk of age. Welfare standards for pullet aviaries are still in the investigational stage.

Outdoor Access or Free Range

Poultry may also be raised with access to the outdoors. Poultry raised under an organic protocol require outdoor access (USDA Agricultural Marketing Service, 2001), which can be a range or a semi-enclosed yard often referred to as a veranda or winter garden. During inclement weather or for health-related reasons, birds should remain indoors or in shelters until such conditions are improved.

A range is an outside fenced area. Fence height and fencing material should be of appropriate mesh size to retain domesticated poultry and prevent predator entry. A permanent fence can be extended underground to a minimum depth of 0.25 m (0.82 ft) to prevent ground predator entry. The fence can be surrounded by an electric wire 25 to 45 cm (10 to 18 in) above the ground and 0.6 to 1.0 m (2 to 3 ft) away from the primary fence (Scanes et al., 2004). Overhead fine netting, as used for game birds, can be used to protect domestic poultry from wild avian predators and minimize disease transmission from wild species to domesticated poultry. Ranges should be free of debris such as large rocks and fallen trees, environmental contaminants, and be designed to prevent muddy areas, to avoid injuries and foot problems, and to promote overall bird health. Vegetation should be used for ranges or sections of the range where soil erosion is problematic. Range rotation is one tool for minimizing the threat of a disease outbreak and to provide opportunity for land to recover from bird activity. A covered veranda provides shade and is connected to the house and is made available to the hens during the daylight hours. The floor of the veranda can be solid and may be covered with litter. To minimize the probability of cannibalism, natural light or high-intensity artificial light can be used during early stages of rearing to facilitate the transition of birds from indoor to outdoor lighting conditions.

Free-ranged birds without access to a permanent building should have covered shelters that provide shade, protection from inclement weather, litter, food, and water. The sheltered area should provide space to allow all ranged birds to rest together without risk of heat stress. Mobile shelters should be moved on a regular basis or managed to minimize the probability of a disease outbreak or muddy conditions. Elevated perches designed for poultry can be provided on the range or inside the indoor shelter. See perch section under husbandry for more details.

All range, veranda, or any other type of outdoor access should be managed so that birds are protected from potential predators. Weather permitting, birds should be given access to the outside as soon as they have full feather coverage to encourage ranging behavior. Vegetation such as small bushes, crops such as corn, or cover panels (Cornetto and Estévez, 2001a; Leone and Estévez, 2008) that provide a sense of protection in the outdoor area can be used to encourage the use of the range (Hegelund et al., 2005).

When indoor birds are allowed free access to the outdoors, they should have appropriately sized openings (popholes) of sufficient number to facilitate bird exit from and entrance into the building; alternatively, the doors of the house can be opened to allow birds freedom of movement. The size of each pophole should allow for easy passage of a bird to and from the outside. The number of popholes provided should allow birds to comfortably access the outside or inside without significant congregation of birds on either side of the pophole. A roof can be placed over a pophole to provide protection and baffles installed to reduce entry of wind into the house. Slats can also be used to prevent the formation of muddy areas around the popholes (LayWel, 2006a).

For whole house configuration without individual pens, popholes should be evenly distributed down the entire length of the building to prevent birds from blocking the access in and out of the building. On windy days, it may be wise to open popholes only on the leeward side, so providing more than the minimum number of popholes is advisable.

Egg-Laying Strains of Chickens. The approximate age that egg-laying strains of chickens are allowed access to the range is about 12 wk of age. Before 12 wk of age, they are brooded in confinement. To allow for range rotation, provide each hen with 4 m^2 (43 ft^2) of outdoor access (European Union, 2001). Shade should be evenly distributed in the outdoor area and provided at a minimum of 8 m^2 (86 ft^2) per 1,000 hens (RSPCA, 2008b).

Meat-Type Chickens. Fast-growing strains of broilers should have access to a minimum of 1 m^2 (10.8 ft^2) of outdoor access, whereas slower growing strains (e.g., French Label Rouge) require 2 m^2 (21.6 ft^2) of outdoor access (Fanatico, 2006).

Turkeys. The age that turkeys are given access to outdoors may vary from 5 to 12 wk depending on weather conditions and predator risk, with 8 wk being the most common age. A flock can gradually be transitioned to range by moving one-third of the flock the first morning and then moving the remainder of the flock a day or two later (Scanes et al., 2004). The following formula can be used to calculate the minimum amount of shelter (m^2) recommended: area, $m^2 = [(n \times 0.3)W]/D$, where n is the number of birds in the flock, W is the expected average weight (in kg) at depopulation, and D is the maximum stocking density in kg/m^2 (RSPCA, 2007). Growing turkeys are allowed a minimum space allocation of 6 m^2 (65 ft^2)/bird of free range (Parkhurst and Mountney, 1988).

Ducks. Information for porches or winter gardens for ducks is not available. When growing ducks are first introduced to the range, they need to be shown the location of the feeders, drinkers, and shelters. The outdoor feeders and drinkers should be surrounded by slatted or solid flooring to prevent the ground in the immediate area from becoming muddy. Free-ranged growing ducks are allowed a minimum of 2.5 m^2 (27 ft^2)/bird when reared on well-maintained ranges with ground cover. If the vegetation is poor, then a minimum of 4 m^2 (43 ft^2)/growing duck should be provided. If ponds are available, they should be well maintained so as to avoid stagnant water containing decaying vegetation. Botulism in ducks can be a problem when pond water is not well aerated or not filtered to remove plant debris (RSPCA, 2006). Developing breeders may be raised outdoors on well-drained soil (preferably sand) with open shelter. A minimum of 1,290 cm^2 (200 in^2) of shelter area/bird is recommended for developing breeders.

FEED AND WATER

Feed

Circular or linear troughs can be used to supply feed. Feed troughs can be located either inside or outside the area where the birds are housed. If feed troughs are located outside the area where the birds are housed (as is the case for most adult cages), then only one side of the trough is available to the birds. Unless the feeder is mounted on a wall, feeders located in the area where the birds are housed generally provide bird access to both sides of the trough. Minimum feeder space recommendations for egg-laying strains of chickens, meat-type chickens, turkeys, and Pekin ducks are shown in Tables 9-1, 9-2, 9-3, and 9-4, respectively. Depending on species, specifications are for birds housed in multiple-bird pens and cages, individual cages, or aviaries. Feeder space allocation is presented in the tables as linear trough space per bird when both sides of the trough are available. If only one side of the trough is available, then the amount of feeder space per bird must be doubled.

Because meat-type chickens, ducks, and turkeys have been bred for rapid growth to market age, excessive body weight (**BW**) gain of broiler breeders, duck breeders, and male turkey breeder stocks is a problem unless energy intake is controlled beginning early in life. Because breeders are allocated limited feed to allow for a gradual increase in BW each week, birds are hungry as indicated by motivational test (Savory et al., 1993), stereotypic pecking on nonnutritive objects, and excessive drinking of water. Stress is also apparent in feed-restricted broiler breeders between 8 and 16 wk of age (Hocking et al., 1993). Feed restriction of breeders allows for controlled BW gain, reduces skeletal problems, increases activity, and improves livability, fertility, immune function, egg production, and disease resistance. Evidence to date indicates that the welfare of breeders is better if they are feed restricted (DEFRA, 2002).

Feed should be allocated and BW routinely monitored to maintain the recommended BW for the particular stock and age. Rations may be either a fixed amount of feed allotted daily or under various alternate-day feeding schemes. Alternate-day feed restriction as opposed to limited feed each day allows more-timid birds access to feed, resulting in better flock uniformity (Bell and Weaver, 2002). Inhibition of feeding by subordinate birds is likely if feeder space is limited (Cunningham and van Tienhoven, 1984). Therefore, procedures that require restricted feeding should have enough feeder space so that all birds can eat concurrently. It may also be helpful to use low-density diets and to provide birds with environmental enrichment such as devices that they can manipulate to obtain small amounts of food to fulfill their feeding behavior.

Table 9-1. Minimum feeder space (linear trough space/bird) for egg-laying strains of chickens in floor pens, aviaries, or cages[1,2]

	White Leghorns				Mini Leghorns				Medium-weight breeds			
	Female		Male		Female		Male		Female		Male	
Type of housing and age (wk)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)
Pen[3]												
0 to 6[3]	1.27	0.50	1.65	0.65	1.15	0.45	1.50	0.59	1.40	0.55	1.82	0.72
6 to 18	2.54	1.00	3.30	1.30	1.91	0.75	2.48	0.98	2.92	1.15	3.80	1.50
>18[4]	5.08	2.00	6.61	2.60	3.81	1.50	4.96	1.95	5.84	2.30	7.60	3.00
Cage and aviary												
0 to 3[3]	0.51	0.20	0.64	0.25	0.46	0.18	0.57	0.23	0.56	0.22	0.70	0.28
3 to 6	1.00	0.40	1.27	0.50	0.92	0.36	1.15	0.45	1.12	0.44	1.40	0.55
6 to 12	1.53	0.60	2.03	0.80	1.15	0.45	1.53	0.60	1.76	0.69	2.34	0.92
12 to 18	2.54	1.00	3.30	1.30	1.91	0.75	2.48	0.98	2.92	1.15	3.80	1.50
18 to 22	3.81	1.50	4.95	1.95	2.86	1.13	3.72	1.47	4.38	1.73	5.70	2.25
>22	5.08	2.00	6.61	2.60	3.81	1.50	4.96	1.95	5.84	2.30	7.60	3.00

[1]Feed should be allocated and body weight routinely monitored to maintain the recommended body weight for the particular stock and age. Specifications for feeder space for single bird cages are the same as multiple bird cages.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of feeder space/bird. Perimeter space for round feeders is obtained by multiplying linear trough space by 0.8.

[3]During the first week, supplementary feed should be placed on some type of temporary feeders (such as egg flats) on the floor.

[4]Feeder space for White Leghorn and medium-weight breeders is the same as commercial layers except for pens in which 5.35 cm (2.1 in) and 6.16 cm (2.42 in), respectively, is provided to mature breeders after 18 wk of age. Male and female breeders are housed together for natural mating.

Table 9-2. Minimum feeder space for meat-type chickens[1]

		Linear trough space/bird[2]	
Bird type and body weight, kg (lb)	Approximate age, d	(cm)	(in)
Commercial broilers on 100% litter or multiple bird cages			
<1.53 (<3.3)	0 to 28	1.9	0.75
1.5 to 3.3 (3.3 to 7.2)	29 to 65	2.5	1.00
>3.3 (>7.2)	>66	3.2	1.25
Broiler breeder females or mixed ratio of 1 male to 10 females on 100% litter			
<0.3[3] (<0.7)	0 to 21	3.8	1.5
0.3 to 0.6 (0.7 to 1.3)	22 to 42	5.1	2.0
0.6 to 0.9 (1.3 to 2.0)	43 to 63	6.4	2.5
0.9 to 1.2 (2.0 to 2.6)	64 to 84	7.6	3.0
1.2 to 1.5 (2.6 to 3.3)	85 to 105	8.9	3.5
1.5 to 1.8 (3.3 to 4.0)	106 to 126	10.2	4.0
1.8 to 2.1 (4.0 to 4.6)	127 to 140	11.4	4.5
>2.1 (>4.6)	>141	12.7	5.0
Broiler breeder males only on 100% litter			
<0.3[3] (<0.7)	0 to 14	3.8	1.5
0.3 to 0.6 (0.7 to 1.3)	15 to 28	5.1	2.0
0.6 to 0.9 (1.3 to 2.0)	29 to 43	6.4	2.5
0.9 to 1.2 (2.0 to 2.6)	44 to 61	7.6	3.0
1.2 to 1.5 (2.6 to 3.3)	62 to 77	8.9	3.5
1.5 to 1.8 (3.3 to 4.0)	78 to 92	10.2	4.0
1.8 to 2.1 (4.0 to 4.6)	93 to 104	11.4	4.5
2.1 to 2.4 (4.6 to 5.3)	105 to 120	12.7	5.0
2.4 to 2.7 (5.3 to 6.0)	121 to 138	14.0	5.5
2.7 to 3.0 (6.0 to 7.2)	139 to 149	15.3	6.0
3.0 to 3.3 (6.1 to 7.2)	150 to 161	16.5	6.5
>3.3 (>7.2)	>162	17.9	7.0

[1]Feed should be allocated and body weight routinely monitored to maintain the recommended body weight for a particular stock and age.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of feeder space/bird. Perimeter space for round feeders is obtained by multiplying linear trough space by 0.8.

[3]Provide 1 accessory feeder tray/75 chicks the first week of age.

Although adult broiler breeders are housed together for mating, they are fed separately to control BW gains. If both sexes have access to the same feeder, the more aggressive males will consume more than their share of feed. The female feeder is fitted with a 4.3-cm (1.7 in) grill sufficiently wide to allow feeding, whereas the male trough is fitted with a 5.1-cm (2.0 in) grill. In this manner, the installation of narrow grills over the female feeder may prevent males with larger heads from consuming the hen's feed. However, some genetic lines of male breeders have smaller heads allowing them access to the female feeder, which not only deprives the hens of proper nutrient intake, but may lead to excessive BW gains for those males eating the hen's feed. University research uses a multitude of genetic lines in their studies; therefore, a one-size restriction grill does not exist to meet the head size of all breeds of meat-type chickens. To rectify this situation, small plastic pegs that are 6.3 cm (2.5 in) in length (Noz-Bonz) are inserted through the nares of genetic lines of male broiler breeders known to have small heads at 20 to 21 wk of age to minimize male access to female feeders (Wilson, 1995a,b). The behavior of males with Noz-Bonz inserted did not appear to be affected, with resumption of foraging activities immediately post-insertion (Millman et al., 2000). Use of breeds or genetic lines that do not require Noz-Bonz is highly encouraged.

Ducks experience difficulty consuming mash because the mash, as it becomes moist, may cake on their mouth parts. Therefore, it is recommended that all feeds for ducks be provided in pelleted form. Pellets no larger than 0.40 cm (5/32 in) in diameter and approximately 0.80 cm (5/16 in) in length should be fed to ducklings less than 2 wk of age. Pellets 0.48 cm (3/16 in) in diameter are suitable for ducks over 2 wk of age.

Water

Recommendations for watering space vary widely, depending on species, type of bird (Siegel, 1974), bird density, and whether water intake is restricted. Minimum watering space recommendations for egg-laying

Table 9-3. Minimum feeder space for turkeys[1]

Bird type and age (wk)	Linear trough space/bird[2] (cm)	(in)
Commercial turkeys		
0 to 12[3]	1.9	0.75
12 to 22	3.8	1.50
Turkey breeder females[4]		
6 to 16 (physical feed restriction)	7.6	3.00
6 to 16 (full fed or ad libitum consumption of a low protein or energy diet)	3.8	1.50
16 to 29 (physical feed restriction)	12.7	5.00
16 to 29 (full fed or ad libitum consumption of a low protein or energy diet)	6.4	2.50
>29 (full fed)	7.6	3.00
Turkey breeder males (feed restricted)[4]		
>16 (physical feed restriction)	35.6	14.00
>16 (ad libitum consumption of low protein or energy diets)	10.0	4.00

[1]Feed should be allocated and body weight routinely monitored to maintain the recommended body weight for a particular stock and age.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of feeder space/bird. Perimeter space for round feeders is obtained by multiplying linear trough space by 0.8.

[3]During the first week, supplementary feed should be placed on some type of temporary feeders (such as egg flats) on the floor so as to double feeder space.

[4]Feeder space during earlier ages is the same as commercial or market turkeys.

strains of chickens, meat-type chickens, turkeys, and Pekin ducks are shown in Tables 9-5, 9-6, 9-7, and 9-8, respectively. Depending on type of poultry, specifications are for multiple-bird pens and cages, individual cages, or aviaries. These recommendations assume moderate ambient temperatures.

Newly hatched birds may have difficulty initially obtaining water unless they can find the waterers easily. Similar difficulties may occur when older birds are moved to a new environment, especially if the type of watering device differs from that used previously by the birds. Watering cups that require birds to press a lever or other releasing mechanism involve operant conditioning. Because individuals may fail to operate the releasing mechanism by spontaneous trial and error, shaping of the behavior may be required. Thus, it may be necessary to press the individual bird's beak or bill to the trigger to facilitate finding the water source. Watering cups may need to be filled manually for several days (or weeks in some cases) until the birds have learned the process. Water pressure must be regulated carefully with some automatic devices and watering cups. In such cases, pressure regulators and pressure meters should be located close to the levels at which water is being delivered. Manufacturer recommendations should be used initially and adjusted if necessary to obtain optimal results. Automatic watering devices require frequent inspection to avoid malfunctions that can result in flooding or stoppage. Waterers should be examined at least once per day to ensure they are in good working condition.

The height of drinkers should be adjusted to meet bird size. Birds accessing nipple drinkers should raise their heads up while standing to activate the trigger pins (Bell and Weaver, 2002). As a general guide, the bottom of the water trough should be approximately even with the back of the bird (Parkhurst and Mountney, 1988).

Poultry ordinarily should have continuous access to clean drinking water. However, with some restricted

Table 9-4. Minimum feeder space for Pekin ducks[1,2]

Bird type and age (wk)	Linear trough space/bird[3] (cm)	(in)
Growing ducks		
1[4]	0.9	0.35
2	1.0	0.40
3	1.3	0.50
4	1.5	0.60
5	1.7	0.65
6	1.8	0.70
7	1.9	0.75
Developing breeders (feed restricted)[5]		
7 to 28	10.2	4.0
Breeders		
>28	2.0	0.8

[1]Feed should be allocated and body weight routinely monitored to maintain the recommended body weight for a particular strain and age.

[2]Feeder space allocations may be slightly excessive for smaller breeds of ducks.

[3]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of feeder space/bird. Perimeter space for round feeders is obtained by multiplying linear trough space by 0.8.

[4]During the first week, supplementary feed should be placed on some type of temporary feeders (such as egg flats) on the floor.

[5]Feeder space during earlier ages is the same as for growing ducks.

Table 9-5. Minimum drinker space for egg-laying strains of chickens in floor pens, aviaries, or cages[1]

	Linear trough space/bird[2]				Cups or nipples	
	Females		Males		Females	Males
Bird type and age (wk)	(cm)	(in)	(cm)	(in)	(maximum no. birds/device)	
White Leghorns						
0 to 6[3]	0.75	0.30	1.00	0.40	20	15
6 to 18	1.00	0.40	1.25	0.50	15	11
>18	1.25	0.50	1.65	0.65	12	9
Mini Leghorns						
0 to 6[3]	0.68	0.27	0.90	0.36	22	17
6 to 18	0.75	0.30	0.94	0.38	19	14
>18	0.94	0.38	1.24	0.49	15	11
Medium-weight breeds						
0 to 6[3]	0.83	0.33	1.10	0.44	18	14
6 to 18	1.15	0.46	1.44	0.58	14	9
>18	1.44	0.58	1.90	0.75	10	8

[1]Egg laying strains of chickens should have continuous access to clean drinking water. Drinker space for layer breeder parent stock is the same as the commercial table egg-producing hen. Specifications for drinker space for single bird cages are the same as for multiple bird cages.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of drinker space/bird. Perimeter space for round drinkers is obtained by multiplying linear trough space by 0.8.

[3]Provide one 3.78-L [1-gal] or four 0.95-L [1-qt] chick drinkers/100 chicks during the first week of age.

Table 9-6. Minimum drinker space for meat-type chickens[1]

	Linear trough space/bird[2]		Cups	Nipples
Bird type and age (wk)	(cm)	(in)	(maximum no. birds/device)	
Commercial broilers				
0 to 4[3]	0.5	0.2	28	10
4 to 8	1.3	0.5	28	10
Broiler breeders				
0 to 8[3]	1.3	0.5	28	10
9 to 16	1.5	0.6	28	10
16 to 23	2.5	1.0	28	10
>23	5.0	2.0	28	10

[1]With the exception of feed restriction used with broiler breeders, meat-type chickens ordinarily should have continuous access to clean drinking water.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of drinker space/bird. Perimeter space for round drinkers is obtained by multiplying linear trough space by 0.8. A 40 in circumference hanging drinker would provide 0.4 in/broiler.

[3]Provide 2 satellite supplemental drinkers/100 chicks or one 3.78 L [1 gal] or four 0.95 L [1 qt] chick drinkers/100 chicks during the first wk of age.

feeding programs, overconsumption of water may occur, leading to overly wet droppings that can hamper health and performance of poultry due to poor litter quality. This situation can be controlled by restricting excessive water intake, usually by limiting water availability to certain times of the day, in accordance with accepted management programs that consider the amount of time that feed is available and also environmental temperature conditions. There is little effect on welfare indicators of breeders with limited access to water compared with breeders consuming water ad libitum (Hocking et al., 1993). Water should be provided each day and also made available during the time that feed is being consumed. Adequate drinker space is needed to prevent undue competition at the drinkers when the water is turned back on. Water may also be shut off temporarily in preparation for the administration of vaccines or medications in the water.

Most conventional poultry drinkers may be used for ducks, except for cup drinkers that are smaller in diameter than the width of the duck's bill. Nipple drinkers support slightly poorer duck performance during hot weather than do trough waterers. Ducks can grow, feather, and reproduce normally without access to water for swimming or wading, but weight gain may be improved slightly during summer months if such water is provided (Dean, 1967). If ducks are provided water for swimming or some other wet environment, they should also have access to a clean and dry place; otherwise, they are unable to preen their feathers and down properly, and the protection normally provided by this waterproof, insulated layer may be lost.

HUSBANDRY

Social Environment

All poultry species are highly social and should be maintained in groups when possible. However, certain social environments can be stressful to poultry and should be avoided. For example, repeated movement of individuals from one socially organized flock to another may induce stress in those individuals that are moved (Gross and Siegel, 1985). Human interactions with chickens can also contribute, either favorably or unfavorably, to the social environment of the animal (Gross and Siegel, 1982; Jones, 1994). A calm, friendly interaction between known animal caretakers and the birds will result in reduced stress and better performance compared with abrupt, careless interactions. Human–poultry interactions are discussed in more detail in the chapter on environmental enrichment.

Chickens, turkeys, and ducks are likely to panic when sudden changes occur in their environment (e.g., a wild bird flying overhead or loud noises to which the birds are not habituated). When birds are kept in group housing, this panic reaction may result in birds trampling each other and piling up against barriers or in corners with resulting injury and mortality. Husbandry

Table 9-7. Minimum drinker space for turkeys[1]

	Linear trough space[2]		Cups	Nipples
Bird type and age (wk)	(cm)	(in)	(maximum no. birds/device)	
Commercial females				
0 to 16.5[3]	1.27	0.50	28	10
Commercial males				
0 to 8[3]	1.27	0.50	30	20
8 to 16	1.91	0.75	25	10
16 to 20	2.54	1.00	20	10
Breeder females[4]				
8 to >54	1.91	0.75		
>30 restricted	2.54	1.00		
Breeder males[4]				
8 to >54	1.91	0.75		
>25 restricted	2.54	1.00		

[1]With the exception of feed restriction used with turkey breeders, turkeys ordinarily should have continuous access to clean drinking water.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of drinker space/bird. Perimeter space for round drinkers is obtained by multiplying linear trough space by 0.8.

[3]Provide satellite drinkers during the first week of age.

[4]Drinker space during earlier ages is the same as market or commercial turkeys.

methods should be used to prevent death loss caused by smothering. Such sudden changes should be prevented to the extent possible. Alternatively, young birds, which are less reactive to such stimuli, can be habituated to conditions that are likely to be encountered and could cause panic responses later in life.

Chickens. Excessive fighting and mounting (Millman et al., 2000) may occur in groups of mature males residing in floor pens. If such abuse is likely to be encountered, as when aggressive stocks are used, late adolescent or mature males should be placed in environments where those behaviors are not possible or are less injurious; for example, in individual cages, in multiple-bird cages with moderate density (Craig and Polley, 1977), or in mixed-sex flocks with appropriate sex ratios. The proportion of mature males in sexually mature flocks should be low enough to prevent injury to females from excessive mounting. Male to female ratios for breeding purposes can be variable in regard to different breeds and strains of chickens. The optimal ratio in most breeder flocks is 1 male to 12 to 15 females for egg-type strains and 1 male to 9 to 11 females for meat-type chickens. Some environmental enrichment techniques can be used to control aggression and over-mating in poultry (Estévez, 1999; Cornetto et al., 2002).

Recent research has shown that social dynamics in layers and chickens raised for meat are complex and increments in group size or density do not necessarily result in a linear increase in aggression or reduced welfare and performance (Estévez et al., 1997; 2003; 2007). Intermediate group sizes of around 30 birds were found to be more problematic than smaller (15) or larger (60 to 120) groups of layers in floor pens (Keeling et al., 2003). Chickens kept for meat production can be safely maintained in large groups of several hundreds or thousands of birds with no increased aggression or behavioral problems, as long as sufficient feeding and drinking space is provided to prevent competition for resources (Estévez et al., 1997). The welfare of broiler chickens tends to be affected more by environmental conditions (Dawkins et al., 2004) than by group size or density effects, as long as density is maintained within a reasonable range (Estévez, 2007).

Turkeys. Tom turkeys are prone to excessive aggression as they become older. Early beak trimming reduces the likelihood of injuries from fighting among toms. Breeder toms are housed separately from breeder hens using artificial insemination to produce fertile hatching eggs.

Ducks. Ducks, being very sociable animals, do not perform well in isolation. Therefore, it is imperative that individually caged ducks have some means of social interaction such as a wire partition between adjacent cages so that they can see and touch each other. For sexually mature breeder ducks, injury to females resulting from excessive mounting by drakes may be exacerbated in the presence of other stressful conditions such as lameness associated with foot pad trauma caused by improper flooring (discussed later in this chapter). For Pekin breeders, the ratio of males to females should not exceed 1:5 and may require periodic adjustment throughout the breeding cycle because of higher mortality rates for females than for males.

Table 9-8. Minimum drinker space for Pekin ducks[1]

	Linear trough space[2]		Cups[3]	Nipples
Bird type and age (wk)	(cm)	(in)	(maximum no. birds/device)	
Growing				
0 to 7[4]	1.91	0.75	10	15
Breeders[5]				
7 to >52	2.54	1.00	12	18

[1]With the exception of feed restriction used with duck breeders, ducks ordinarily should have continuous access to clean drinking water.

[2]Linear trough space is when both sides of the trough are available. If only one side of the trough is available, double the amount of drinker space/bird. Perimeter space for round drinkers is obtained by multiplying linear trough space by 0.8.

[3]Swish-type cups are 7.6 cm (3 in) in diameter and 2.54 cm (1 in) deep.

[4]Provide satellite drinkers during the first week of age.

[5]Drinker space during earlier ages is the same as for growing ducks.

Table 9-9. Minimum floor area per bird for egg-laying strains of chickens in floor pens, cages, or aviaries[1]

Type of housing and age (wk)	White Leghorns				Mini Leghorns				Medium-weight breeds			
	Female		Male		Female		Male		Female		Male	
	(cm^2)	(in^2)	(cm^2)	(in^2)	(cm^2)	(in^2)	(cm^2)	(in^2)	(cm^2)	(in^2)	(cm^2)	(in^2)
Pen[2]												
0 to 6	464	72	606	94	418	65	545	85	510	79	667	103
6 to 18	929	144	1,206	187	697	108	905	140	1,068	166	1,387	215
>18 Litter[3]	1,625	252	2,116	328	1,219	189	1,587	246	1,869	290	2,433	377
>18 S&L, W&L[3]	1,393	216	1,812	281	1,045	162	1,359	211	1,602	248	2,084	323
>18 All-S, All W	1,161	180	1,509	234	871	135	1,132	176	1,335	207	1,735	269
Cage[4]												
0 to 3	97	15	129	20	87	14	116	18	107	17	142	22
3 to 6	155	24	200	31	140	22	180	28	171	26	220	34
6 to 12	232	36	303	47	174	27	227	35	267	41	348	54
12 to 18	310	48	400	62	233	36	300	47	357	55	460	71
18 to 22	387	60	503	78	290	45	377	59	445	69	578	90
>22	464	72	606	94	348	54	455	71	534	83	697	108
Aviary[5]												
>22									1,155	173		

[1]A chicken should have sufficient freedom of movement to be able to turn around, get up, lie down and groom itself.

[2]Kinds of flooring: S&L, W&L = >50% slats (S) or wire (W) and <50% litter (L); All-S, All-W = all slats or all wire.

[3]Floor area for breeders is the same as commercial layers up to 18 wk of age. After 18 wk of age, provide 1,858 cm^2 (288 in^2) and 2,137 cm^2 (331 in^2) for litter pens and 1,625 cm^2 (252 in^2) and 1,869 cm^2 (290 in^2), respectively, for S&L or W&L to White Leghorn and medium weight breeders, respectively.

[4]A bird within a cage should be able to stand comfortably without hitting its head on the top of the cage. The cage door should be wide enough to allow for the easy removal of the bird.

[5]Space allocation when based on floor area only is 855 cm^2 (132 in^2).

Floor Area and Space Utilization

Chickens, turkeys, broilers, and ducks should have sufficient freedom of movement to be able to turn around, get up, lie down, and groom themselves (Brambell, 1965). Use of floor area by birds within groups follows a diurnal pattern and is influenced by the dimensions and design of the facilities. Birds may huddle together for shared warmth or spread out for heat dissipation. They generally use less area during resting and grooming than during more active periods and will often seek the protection offered by the walls of the enclosure (Newberry and Hall, 1990; Cornetto and Estévez, 2001b). Recommendations for minimum floor area for multiple-bird pens and cages as well as individually housed birds are presented for layer-type chickens, broiler-type chickens, turkeys, and ducks in Tables 9-9, 9-10, 9-11, and 9-12, respectively.

Floor space allowances for layer-type chickens in conventional cages are based on extensive research. In a survey of experiments involving density effects (mostly White Leghorn hens), Adams and Craig (1985) made multiple comparisons within specific categories for several production traits and for livability. Their survey indicated that livability and hen-housed egg production were reduced significantly when areas of 387 cm^2 (60 in^2) and 310 cm^2 (48 in^2) were compared with 516 cm^2 (80 in^2), amounting to reductions of 2.8 and 5.3% in livability and 7.8 and 15.8 eggs per hen housed, respectively.

Decreases in livability and other measures of well-being were also associated with high density. Craig et al. (1986a,b) found that livability and egg mass were significantly lower with 310 cm^2 (48 in^2) than with 464 cm^2 (72 in^2); Okpokho et al. (1987) and Craig and Milliken (1989) found livability was lower at 348 cm^2 (54 in^2) than at 464 cm^2 (72 in^2) and 580 cm^2 (90 in^2); and Craig and Milliken (1989) found lower hen-day rate of lay and egg mass per hen at the highest density. In the same studies, however, no differences in survival and egg production measures were detected between the 2 lower densities. From data on plasma corticosterone concentrations, Mashaly et al. (1984) concluded that more than 387 cm^2 (60 in^2) of space per hen should be provided; Craig et al. (1986a,b) found that plasma corticosterone concentrations were greater at 310 cm^2 (48 in^2) than at 464 cm^2 (72 in^2). Similarly, feather condition was worse (Craig et al., 1986a,b) and fearfulness was greater when estimated at 40 wk of age or older (Okpokho et al., 1987; Craig and Milliken, 1989). Using data on egg production, mortality, and serum corticosterone concentrations, Roush et al. (1989) concluded that 3 hens, rather than 4, should be kept in cages of 1,549 cm^2 (240 in^2) area; that is, within the goals and

Table 9-10. Minimum floor area for meat-type chickens in pens or cages[1]

Bird type, flooring, and body weight, kg (lb)	Approximate age (d)	Floor area/bird (cm²)	Floor area/bird (in²)
Commercial broilers on 100% litter or multiple bird cages[2]			
<0.3 (<0.7)	0 to 13	248	38
0.3 to 0.6 (0.7 to 1.3)	14 to 18	342	53
0.6 to 0.9 (1.3 to 2.0)	19 to 24	432	67
0.9 to 1.2 (2.0 to 2.6)	25 to 27	516	80
1.2 to 1.5 (2.6 to 3.3)	28 to 31	606	94
1.5 to 1.8 (3.3 to 4.0)	32 to 35	703	109
1.8 to 2.1 (4.0 to 4.6)	36 to 39	780	121
2.1 to 2.4 (4.6 to 5.3)	40 to 43	871	135
2.4 to 2.7 (5.3 to 6.0)	44 to 48	948	147
2.7 to 3.3 (6.0 to 7.2)	49 to 57	1,019	158
>3.3 (>7.2)	>58	1,097	170
Broiler breeder females or mixed ratio of 1 male to 10 females on 100% litter			
<0.3 (<0.7)	0 to 21	320	50
0.3 to 0.6 (0.7 to 1.3)	22 to 42	690	107
0.6 to 0.9 (1.3 to 2.0)	43 to 63	870	135
0.9 to 1.2 (2.0 to 2.6)	64 to 84	1,058	164
1.2 to 1.5 (2.6 to 3.3)	85 to 105	1,238	192
1.5 to 1.8 (3.3 to 4.0)	106 to 126	1,426	221
1.8 to 2.1 (4.0 to 4.6)	127 to 140	1,612	250
2.1 to 2.4 (4.6 to 5.3)	141 to 150	1,740	270
2.4 to 2.7[3] (5.3 to 5.6)	151 to 160	1,860	288
Individually caged adult broiler breeder female[2]			
>2.4 (>5.3)	>151	1,161	180
Broiler breeder males only on 100% litter in multiple bird pens			
<0.3 (<0.7)	0 to 14	320	50
0.3 to 0.6 (0.7 to 1.3)	15 to 28	690	107
0.6 to 0.9 (1.3 to 2.0)	29 to 43	870	135
0.9 to 1.2 (2.0 to 2.6)	44 to 61	1,058	164
1.2 to 1.5 (2.6 to 3.3)	62 to 77	1,238	192
1.5 to 1.8 (3.3 to 4.0)	78 to 92	1,426	221
1.8 to 2.1 (4.0 to 4.6)	93 to 104	1,612	250
2.1 to 2.4 (4.6 to 5.3)	105 to 120	1,740	270
2.4 to 2.7 (5.3 to 6.0)	121 to 138	1,860	288
2.7 to 3.0 (6.0 to 7.2)	139 to 149	1,974	306
3.0 to 3.3 (6.1 to 7.2)	150 to 161	2,090	324
>3.3 (>7.2)	>162	2,195	340
Individually caged adult broiler breeder male[2]			
>3.3 (>7.2)	>162	1,393	216

[1]A chicken should have sufficient freedom of movement to be able to turn around, get up, lie down, and groom itself.

[2]All birds in cages should be able to stand comfortably without hitting their heads on the top of the cages. The cage door should be wide enough to allow for the easy removal of the bird.

[3]Provide this amount of floor area/bird during the egg-laying phase when birds are housed on two-thirds slats and one-third litter or in multiple bird mating cages. Provide 2,787 cm^2 (432 in^2)/ bird on 100% litter during egg laying.

constraints employed, hens should have 516 cm^2 (80 in^2) rather than 387 cm^2 (60 in^2) area. Using operant determination for laying hens' preference for cage size, Faure (1986) indicated that a stocking density of 400 cm^2 (62 in^2) was sufficient most of the time, although hens would work to obtain more space (up to 6,000 cm^2 or 930 in^2) up to 25% of the day.

Modification of commercial cages from those currently in wide usage for chickens may improve the health and welfare of birds (Tauson, 1995). Thus, cage height should allow birds to stand comfortably without hitting their heads on the top of the cages. Studies have indicated at least 40 cm (15.7 in) over 65% of the cage area and not less than 35 cm (13.8 in) at any point is desirable (Harner and Wilson, 1985; Nicol, 1987). Taller cages may be necessary for larger breeds. Cage floors with a slope of no more than 9° in shallow, reversed cages may result in better foot health (Tauson, 1981).

Table 9-11. Minimum floor area for turkeys in pens or cages[1]

	Floor area/bird		
Bird type, flooring, and body weight, kg (lb)	(cm^2)	(in^2)	(ft^2)
Commercial turkeys on 100% litter or multiple/individual bird cages[2,3]			
<0.3 (<0.7)	257	40	0.3
0.3 to 2.0 (0.7 to 4.4)	580	90	0.6
2.0 to 3.0 (4.4 to 6.6)	807	125	0.9
3.0 to 6.0 (6.6 to 13.2)	1,419	220	1.5
6.0 to 8.0 (13.2 to 17.6)	1,871	290	2.0
8.0 to 12.0 (17.6 to 26.4)	2,741	425	3.0
12.0 to 16.0 (26.4 to 35.2)	3,548	550	3.8
16.0 to 20.0 (35.2 to 44.1)	3,866	600	4.2
Turkey breeder females on 100% litter in multiple bird pens			
<8.0 (<17.6)	2,786	432	3.0
8.0 to 12.0 (17.6 to 26.4)	3,715	576	4.0
>12.0[4] (>26.4)	4,644	720	5.0
Turkey breeder males on 100% litter in multiple bird pens			
<12.0 (<26.4)	3,715	576	4.0
12.0 to 17.0 (26.4 to 37.4)	4,644	720	5.0
>17.0 (>37.4)	5,573	864	6.0
Individually caged turkey breeder females with a solid littered floor[3]			
<12 (<26.4)	2,696	418	2.9
>12 (>26.4)	4,644	720	5.0
Individually caged turkey breeder males with a solid littered floor[3]			
<20 (<44.0)	4,644	720	5.0
>20 (>44.0)	8,359	1,296	9.0

[1]A turkey should have sufficient freedom of movement to be able to turn around, get up, lie down, and groom itself.
[2]Thin-stranded wire flooring not recommended after 3 kg of BW. Other cage flooring types such as hog wire (welded wire) or PVC piping may be appropriate for short-term housing of older and heavier birds.
[3]An individual bird within a cage should be able to stand comfortably without hitting its head on the top of the cage. The cage door should be wide enough to allow for the easy removal of the bird.
[4]Does not include space for nests or broody pens.

However, such low slopes may not be desirable in deeper cages, because difficulties are encountered in getting eggs to roll out efficiently (Elson and Overfield, 1976). Horizontal bars across the front of the cage appear to allow egg-laying strains of chickens to feed easily and with reduced probability of entrapment (Tauson, 1985). White Leghorn hens housed in cages with horizontal cage fronts had better feather scores than hens in cages with vertical bars fronts (Anderson and Adams, 1991). The cage door should be wide enough to allow easy removal of the bird.

Caged hens may cease egg production temporarily or birds may undergo a molt if removed from the cages to which they have become accustomed; for example, for cage cleaning. Therefore, hens and roosters may be kept in their cages for 18 mo or longer, as long as air cleanliness is maintained and excreta are disposed of regularly from under the cages. However, the incidence of osteoporosis and weak bones may be higher in hens caged for prolonged periods compared with hens housed in systems where greater freedom of movement is possible (Knowles and Broom, 1990).

The welfare of meat chickens is not compromised at densities of 15 to 17 birds/m^2 (1.4 to 1.6 birds/ft^2) as long as adequate environmental conditions are maintained (Dawkins et al., 2004; Estévez, 2007). However, welfare status for a given density will depend in part on the final BW at which the birds are grown and managed (Estévez, 2007). For example, heavy male broilers raised to 49 d of age at a stocking density of 30 kg of BW/m^2 (~1,053 cm^2/bird or 9.5 birds/m^2) had the lowest incidence of foot-pad lesions, the lowest incidence of scratches on the back and thigh, and had the best market BW compared with higher stocking densities of 35, 40, and 45 kg of BW/m^2 (Dozier et al., 2005). With 35 d-old male broilers grown to a lower BW of 1.8 kg, feed consumption, feed conversion, BW gain, and foot pad lesions were adversely affected with increasing stocking densities (25, 30, 35, and 40 kg of BW/m^2, Dozier et al., 2006). These results on lighter weight broilers suggested that the best bird performance and welfare was achieved at 25 kg of BW/m^2 (~761 cm^2/bird or 13 birds/m^2).

In terms of space use, there is no scientific evidence to suggest that social restriction on use of space occurs in large groups of broilers (Estévez et al., 1997), even in mature broiler breeders (Leone and Estévez, 2008). Although less active than layer strains, meat chickens

Table 9-12. Minimum floor area for Pekin ducks raised in total confinement[1]

	Litter floor[2]		Wire floor	
Bird type and age (wk)	(cm^2)	(in^2)	(cm^2)	(in^2)
Growing ducks in multiple bird pens				
1	232	36	232	36
2	464	72	439	68
3	839	130	651	101
4	1,116	173	974	151
5	1,393	216	1,187	184
6	1,671	259	1,413	219
7	1,858	288	1,625	252
Developing breeders in multiple bird pens[3]				
7 to 28	2,322	360		
Breeders in multiple bird pens				
>28	3,251	504		
Individually caged breeder female or male[4]				
>28	3,715	576		

[1]A duck should have sufficient freedom of movement to be able to turn around, get up, lie down, and groom itself. Space allocations may be slightly excessive for smaller breeds of ducks. The inside and outside areas for ducks in semi-confinement are totaled and equal the space allocations for confined ducks.

[2]Space for drinkers is included. Drinkers are located on a wire-covered section with a cement drain underneath.

[3]Developing breeders may be raised outdoors on well-drained soil (preferably sand) with open shelter. A minimum of 1,290 cm^2 (200 in^2) of shelter area /bird is recommended.

[4]An individual bird within a cage should be able to stand comfortably without hitting its head on the top of the cage. The cage door should be wide enough to allow for the easy removal of the bird. Does not include space for feeder, drinkers, or a hen's nest.

will use more space when available to them (Leone and Estévez, 2007). Studies have also shown that provision of partitions such as cover panels help to maintain a more-even bird distribution in the facility (Cornetto and Estévez, 2001b) and can help to control behavioral problems (Cornetto et al., 2002). Use of space can be improved by providing rectangular rather than square pens for the same available area (E. H. Leone and I. Estévez; personal communication). Although broiler chickens can be maintained in cages, it is best for their health and welfare to use floor pens provided with some type of litter such as wood shavings.

Because of a relative absence of research on well-being indicators for turkeys and ducks, recommendations are based on professional judgment and experience. Generally, area allowances are assumed to be adequate when productivity of the individual birds is optimal and conditions that are likely to produce injury and disease are minimal.

Singly caged birds are frequently used in agricultural research and teaching to establish or demonstrate fundamental principles and techniques. Because within-cage competition for feed and water is absent, feeding and watering spaces are not critical; however, individually caged birds must have ready access to sources of feed and water except during feed-restriction periods for meat-type breeder birds.

Flooring

Poultry may be kept on either solid floors with litter or in cages or pens with raised wire floors of appropriate gauge and mesh dimension. When poultry reside on solid floors, which are more adequate for heavy strains of poultry, litter provides a cushion during motor activity and resting and absorbs water from droppings. The ideal litter can absorb large quantities of water and also release it quickly to promote rapid drying. A dry, dusty litter or a litter that is too wet will have a negative effect on the health, welfare, and performance of poultry. Litter, when sampled away from the drinkers, needs to be moist but not so moist that it forms into a ball when handled. Litter should not emit excessive dust when disturbed. The poultry house should be ventilated to maintain litter in a slightly moist condition. Avoiding excess moisture in the litter improves bird health by reducing dirty foot pads, hock lesions, leg defects, and fecal corticosterone (Dawkins et al., 2004). Some examples of acceptable materials used for litter, depending on local availability, include rice hulls, straw, wood sawdust or shavings, and cane bagasse. Because litter materials differ in their ability to absorb and release water, husbandry practices should be varied to maintain proper litter conditions. Litter being stored for future use should be kept dry to retard mold growth.

When poultry are kept in cages or on raised floors, accumulated droppings should not be permitted to reach the birds. Droppings should be removed at intervals frequent enough to keep ammonia and odors to a minimum.

Ducks. Particular attention should be paid to the type of floor provided in pens or cages for the common duck because the epidermis of the relatively smooth skin on the feet and legs of this species is less cornified than that of domesticated land fowl (Koch, 1973) and, therefore, is more susceptible to injury. Properly designed, nonirritating floor surfaces minimize or prevent injury to the foot pad and hock and minimize subsequent joint infection. Dry litter floors are least irritating to the feet and hock joints of ducks and should be used whenever possible, particularly if ducks are going to be kept for extended periods. Litter floors that are not kept dry present a serious threat to the health of the flock.

Wire floors and cage bottoms of proper design may be used without serious adverse effects if the ducks are not kept on wire for more than 3 mo. Younger ducks and smaller egg-type breeds (e.g., Khaki Campbell) are less susceptible to irritation from wire than are older and larger meat-type breeds (e.g., Pekin). Properly constructed wire floors and cage bottoms should provide a smooth, rigid surface that is free of sags and abrasive spots. The 2.5-cm (1-in) mesh, 12-gauge welded wire is usually satisfactory for ducks of all ages over 3 wk. Mesh size should be reduced to 1.9 cm (0.75 in) for ducklings less than 3 wk of age. Vinyl-coated wire is preferable, but stainless steel or smooth, galvanized wire floors are satisfactory. Slats are not recommended for ducks because leg abnormalities have developed in ducks kept in research pens with slatted floors. Raised plastic flooring is commonly used in commercial duck production and is superior to wire in terms of reducing foot and hock damage.

Irritation to the feet and legs of ducks is reduced greatly if hard flooring such as wire occupies only a portion of the total floor area of a pen. In large floor pens, one-third wire and two-thirds litter is a satisfactory combination, provided that drinking devices are located on the wire-covered section of the pen, which greatly reduces the transport of water from the drinking area to the litter.

Maintenance of litter in a satisfactorily dry condition is considerably more difficult in housing for ducks than for chickens and turkeys. Ducklings drink approximately 20% more water than they need for normal growth (Veltmann and Sharlin, 1981), and, as a result, the moisture content of their droppings is relatively high—approximately 90% (Dean, 1984). To offset this extra water input in duck houses, extra litter and removal of excess water vapor by the ventilation system are essential. Supplemental heat may be necessary to aid in moisture control.

Perches

Egg-laying strains of chickens housed in cage-free systems are highly motivated to use perches at night (Olsson and Keeling, 2002). An entire flock (100%) will utilize perches at night if sufficient roosting space is provided (Appleby et al., 1993; Olsson and Keeling, 2000). Perches allow hens to roost comfortably with a minimum of disturbance and provide the opportunity for hens to seek refuge from aggressive birds so as to avoid cannibalistic pecking (Wechsler and Huber-Eicher, 1998). Perches also minimize bird flightiness (Brake, 1987). Early exposure to perches during rearing encourages adult perching behavior (Faure and Jones, 1982) leading to a lower incidence of floor eggs (Appleby et al., 1983; Brake, 1987). Adult Spanish breeds of chickens housed on a slatted/litter combination floor with perches compared with no perches were less stressed (Campo et al., 2005). However, if perches are not designed properly, they can lead to keel bone deformities (Tauson et al., 2006).

Perches should be designed to allow hens to wrap their toes around the perch and to balance themselves evenly on the perch in a relaxed posture for an extended period of time. The perch should be elevated high enough from the surface floor to allow hens to grasp the perch without trapping their claws between the perch and the floor and to discourage the harboring of mites. The center of the upper surface of the perch should be flat to allow for weight distribution so as to minimize keel deformities and foot problems. Perch edges should be smooth and round. The perch should be made of non-slip material. Ideally, perches should be positioned over slats or wire to prevent manure accumulation under the perches. Perch placement should minimize fecal contamination of birds, drinkers, and feeders below.

Egg-Laying Strains. All hens should be able to roost at the same time; therefore, provide a minimum of 15 cm (6 in) of usable linear perch space per egg-laying strain of chicken. Perforated floors that have perches incorporated into the floor structure and the rail in front of nest boxes can be counted as perch space. A minimum of 20% of the perch space should be elevated above the adjacent floor. Perches also need to be away from the wall at a sufficient distance to allow birds to use the perch. The height of the perch should not exceed 1 m (3.3 ft) above the floor so as to minimize skeletal fractures during bird flight from a perch. Provide enough space to allow a bird to jump down from its perch at an angle no steeper than 45°. Perches should be at least 30 cm (12 in) apart (horizontally) to minimize cannibalistic pecking between birds on parallel roosts.

Meat-Type Chickens. Only about 20% of broilers in a flock will use perches at a single time. Depending on bird size, each broiler requires a perch space of 15 to 20 cm. If colony size is 100 birds and bird size indicates 20 cm of perch space/bird, then provide 400 cm of perch space/100 birds for 20% usage. The width of the perch can range from 4 to 6 cm (1.6 to 2.4 in) with perch heights of 10 to 30 cm (4 to 12 in) depending on bird size (RSPCA, 2008a). Broiler breeder hens prefer a roost with a width of 5 cm (2 in) over narrower roosts of 3.8 cm (1.5 in) and 2.5 cm (1.0 in) (Muiruri et al., 1990). For adult broiler breeders, provide 28 cm (11 in) of elevated roost per bird.

Turkeys. If perches are to be used for turkeys, provide a minimum of 30 cm (12 in) to 40 cm (16 in) of elevated roost per bird. Perch height is dependent on bird size relative to breed, sex, and age of marketing with ranges from 20 to 150 cm (8 to 59 in). Turkeys appear to do well on wooden perches with rounded edges with dimensions of 5 cm (2 in) in height and 7.5 cm (3 in) in width (RSPCA, 2007).

Nests

Hens place a high value on accessing nests, and their motivation for use increases greatly as the time of oviposition approaches (Cooper and Albentosa, 2003). Hens without prior exposure to nests also show strong motivation to use nests for egg laying (Cooper and Appleby, 1995; 1997). Nests facilitate egg collection and minimize the risk of cloacal cannibalism. Because eggs laid in nests are cleaner and more sanitary, every effort should be made to avoid floor eggs. Use of electrical hot wire near walls outside of the nests may discourage the laying of floor eggs, as may a bright light that eliminates shadows when directed toward the corner.

Pullets intended for systems with nests should be reared with access to raised areas and perches from an early age to become adept at moving up and down in space. Pullets allowed to access perches during rearing are less likely to lay eggs on the floor during the laying period (Appleby et al., 1983; Brake, 1987). Birds should be transferred to the layer house before sexual maturity to allow for sufficient time for exploration of the house and to find the nests before onset of lay.

Nests should be dark inside. Lights in nest boxes should be avoided because of increased risk of cannibalism. Nests should be constructed and maintained to protect hens from external parasites and disease organisms. Nests should be closed to bird access at night and re-opened before lay early in the morning. Nests should be regularly inspected and cleaned as necessary to ensure that there is no manure accumulation.

Nests should be provided with a suitable floor substrate (e.g., turf pads or wood shavings) that encourages nesting behavior. Nests with wire floors or plastic-coated wire floors alone should be avoided. The provision of loose litter material in nests can be useful for training hens to use nests.

For individual nest boxes with a single opening, provide a minimum of 1 nest box per 5 birds. Nest size for hens of egg-laying strains, which includes table-egg producers and layer breeders, can be 30 cm wide by 30 cm deep by 36 cm high (12 × 12 × 14 in). Nests for broiler breeders are slightly larger than those for egg-laying strains of chickens with recommendations of 36 cm wide by 30 cm deep by 36 cm high (14 × 12 × 14 in). Turkey breeders require a nest size of 51 cm wide by 61 cm deep by 61 cm high (20 × 24 × 24 in), whereas duck breeders are provided a nest size of 36 cm wide by 45 cm deep and 30 cm high (14 × 18 × 12 in). For colony nests, provide a minimum of 0.8 m^2 (9 ft^2) of nest space per 100 chickens (egg-laying strains). Use of colony nests with duck breeders is not recommended because of increased incidence of floor eggs, egg breakage, and egg eating compared with individual nests. Hotter climates may require more nest space.

Brooding Temperatures and Ventilation

Because thermoregulatory mechanisms are poorly developed in young chicks, poults, and ducklings, higher environmental temperatures are required during the brooding period. Requirements of young birds may be met by a variety of brooding environments (e.g., floor pen housing with hovers or radiant heaters distributed in localized areas, battery brooders, and cage or pen units in heated rooms).

Ventilation is ordinarily gradually increased over the first few weeks of the brooding period. Whether ventilation is by a mechanical system or involves natural airflow, drafts should be avoided, and streams of air that impinge upon portions of pens or groups of cages should be minimized. In relatively open brooding facilities, as in houses having windows for ventilation and with chicks kept in floor pens, draft shields may prove beneficial up to 10 d after hatching.

Young birds may huddle together or cluster when sleeping but are likely to disperse when awake. Within limits, birds can maintain appropriate body temperatures by moving away from or toward sources of heat when that is possible and by seeking or avoiding contact with other individuals. Extreme huddling of young birds directly under the source of heat, especially during waking hours, usually indicates a need for more supplemental heat; dispersal associated with panting indicates that the environment is too warm.

With brooding systems that allow birds to move toward or away from heat sources, the temperature surrounding the brooding area should be at least 20 to 25°C (68 to 77°F) during the first few weeks but not be so high as to cause the young birds to pant or show other signs of hyperthermy. When the entire room is heated and chicks are not free to move to cooler areas, the minimum temperatures that are recommended below may be too high. Thus, during the first week after hatching, a lower temperature (e.g., a few degrees below 32°C) may reduce the lethargy and nonresponsiveness that is otherwise likely to be seen.

Areas with minimum temperatures that are adequate for comfort and prevent chilling should be available to young birds. The following minimum temperatures and weekly decreases are suggested until supplementary heat is no longer needed:

- for chicks, a 32 to 35°C ambient temperature (90 to 95°F) initially, decreasing by 2.5°C (4.5°F) weekly to 20°C (68°F); however, for some well-feathered strains, supplemental heat may be discontinued at 3 wk if room temperature is 22 to 24°C (72 to 75°F);
- for poults, 35 to 38°C (95 to 100°F), decreasing by 3°C (5°F) weekly to 24°C (75°F);
- for ducklings, 26.5 to 29.5°C (80 to 85°F), decreasing by 3.3°C (6°F) weekly to 13°C (54°F). After the brooding period, ducklings are comfortable at environmental temperatures of 18 to 20°C (64 to 68°F).

Ducks. The recommended ventilation rates for chickens and turkeys have also given good results with ducks (Davis and Dean, 1968). Generally, however, lower relative humidity is desirable in duck houses to help offset the higher water content of duck droppings. Proper screening underneath watering equipment in houses with litter floors and the addition of generous amounts of litter are necessary features of the moisture control program. When outside temperature allows, supplemental heat may be used to help to control moisture build-up in duck houses.

Semen Collection and Artificial Insemination

Semen collection and artificial insemination may be used in poultry depending on the species and type of research being conducted. Several good references are available for information and training procedures (Bakst and Wishart, 1995; Bakst and Cecil, 1997). Methods for semen collection and artificial insemination in poultry were developed in the 1930s and put into practice by the turkey industry such that artificial insemination is commonly used in commercial turkey breeding.

Under conditions of artificial insemination, the breeder males and females are usually housed separately. Careful and calm handling of the birds is needed to prevent injury and facilitates the success of the collections. Collection of semen from poultry involves restraining the male by the legs during the process. After stimulating the male by manual massage of the back area toward the tail, the semen is removed by squeezing the upper part of the cloaca (called a "cloacal stroke") and collected into a clean container. The number of cloacal strokes used should be limited to 4 strokes to avoid damage to the cloacal tissues. The semen may be inseminated without dilution or diluted with an extender. Males may be used for semen collection several times a week on alternate days although more than 3 collections per week may result in reduced semen volume and sperm concentration. The males must be acclimated to the handling and the semen collection process. Males may need to go through the procedure 3 to 4 times before they have a good response, but this can vary largely from male to male.

During the insemination process, the hen is gently restrained by the legs or held between the legs of the inseminator. Manual pressure is applied to evert the cloaca and expose the opening to the vagina. Semen is placed into the vaginal opening with an insemination straw, a small syringe (without a needle), or a pipette tip (when accuracy of volume inseminated is of critical importance). Depth of insemination will vary with species. As insemination occurs, the pressure on the cloaca is gradually released. After insemination, the hen should be gently released. If done correctly, the process takes only a few seconds to complete and should cause no pain or discomfort to the hen. Hens should also be acclimated to handling and the insemination process. If females are stressed or nervous, they may expel all or a portion of the semen immediately after the insemination.

A typical insemination schedule that will give the highest level of fertility involves 3 inseminations within the first 10 d at the onset of reproduction, followed by insemination on a weekly basis. In turkey hens, more-frequent inseminations may be necessary to maintain fertility as they become older. Actual insemination schedules will vary depending on the research objectives.

STANDARD AGRICULTURAL PRACTICES

For handling birds and for all practices under this heading, experienced and skilled persons should carry out or train and supervise those who carry out these procedures.

Beak Trimming

Trimming of the tip of the beak is done to minimize injury and death due to aggressive and cannibalistic behavior. Outbreaks of cannibalism among egg-laying strains of chickens, turkeys, and ducks can occur with any housing system, resulting in a serious welfare problem. If the trimmed beak grows back, a second trim may be needed.

An alternative to beak trimming is use of low light intensity in housing systems where light control is feasible. Genetic stock that shows little tendency towards cannibalistic behavior and feather pecking should be used when possible (Hester and Shea-Moore, 2003). Use of enrichments to control cannibalism and feather pecking are discussed in Chapter 4: Environmental Enrichment.

Egg-Strain Chickens. Production, behavior, and physiological measurements of stress and pain as indicated by neural transmission in the trimmed beak are used as criteria to determine well-being in beak-trimmed birds. In addition, the welfare of those hens that are pecked by beak-intact hens has been evaluated. Disadvantages of beak trimming include short-term stress (Davis et al., 2004) as well as short-term, and perhaps long-term, pain following the trimming of the beak (Kuenzel, 2007). Because feeding behavior must adapt to a new beak shape, a bird's efficiency in eating is impaired following a trim. Welfare advantages include decreased mortality; reduced feather pulling, pecking, and cannibalism; better feather condition; less chronic stress; and less fearfulness and nervousness. Welfare advantages are more applicable to the interactive flock, whereas welfare disadvantages are applicable to individual birds whose beaks are trimmed (Hester and Shea-Moore, 2003). Genetic lines differ in their aggressiveness and beak-trimming requirements (Craig, 1992). Genetic selection is effective in reducing or eliminating most feather-pecking and beak-inflicted injuries (Craig and Muir, 1993, 1996; Muir, 1996), and heritability estimates for survival suggest that the prospects for improving livability through genetic selection are good (Ellen et al., 2008). Therefore, when feasible, stocks should be used that require either minimal or no beak trimming. Nevertheless, beak trimming is justified in stocks that otherwise are likely to suffer extensive feather-pecking and cannibalistic losses. Management guides, available from most breeders, indicate methods for beak trimming to reduce these vices. Beak trimming should be carried out when birds are 10 d of age or younger (Hester and Shea-Moore, 2003; Glatz, 2005; Kuenzel, 2007).The amount of beak removed should be 50% or less to avoid neuroma formation and to allow the keratinized tissue to regenerate (Kuenzel, 2007). The length of the upper beak distal from the nostrils that remains following trimming should be 2 to 3 mm (0.08 to 0.12 in). The lower beak should be slightly longer than the upper beak. If a second trim is needed due to regrowth of the beak, it is recommended that it be done before the pullets are 8 wk of age to avoid a decrease in egg production (Andrade and Carson, 1975).

Broiler-Type Chickens. Beak trimming is generally not required in young broilers raised for meat production. For broiler breeders, early beak trim before 10 d of age is generally sufficient to control feather-pecking and cannibalism in breeder stocks.

Turkeys. Beak trimming of turkeys is a standard management practice. Strains of turkeys (Noble et al., 1994) and sexes (Denbow et al., 1984; Cunningham et al., 1992) differ in their requirement for and their response to beak trimming. In strains of turkeys that exhibit a high incidence of beak-inflicted injuries, arc-type beak trimming at hatching is effective in reducing such injuries (Noble et al., 1994). Severe arc-type beak trimming (1.0 mm anterior to the nostrils) increased mortality relative to hot-blade trimming of the upper beak at 11 d of age (Renner et al., 1989). There was no evidence that arc-type beak trimming 1.5 mm from the nostrils at hatching or hot-blade trimming of the upper beak at 11 d of age increased mortality relative to leaving beaks intact (Renner et al., 1989; Noble et al., 1994). Beak trimming (infrared, hot-blade, arc-trim) completed shortly after hatch did not modify performance or behavior in commercial market toms compared with nontrimmed controls and also reduced pecking damage when beak regrowth did not occur (Kassube et al., 2006; Noll and Xin, 2006). Arc-type beak trimming 1.5 mm anterior to the nostrils or hot-blade trimming of the upper beak at 11 d of age is recommended to prevent cannibalism in strains of turkeys that exhibit a high incidence of beak-inflicted injuries.

Ducks. Feather pecking is a behavior that sometimes occurs in ducks and may be controlled either by partial removal of the nail of the upper bill or inhibition of the growth of the nail by heat treatment (Dean, 1982; Gustafson et al., 2007). If not controlled, feather pecking injures the feather follicles of the tail, wings, and back, and the protective feather and down covering breaks down. Tip searing using cautery only (compared with hot-blade trimming with cautery) may be a preferred method of bill trimming in Pekin ducks because of better weight gains following a trim and fewer changes in the morphology of the bill (Gustafson et al., 2007).

For all species of poultry it is critical that the equipment used to trim beaks is maintained in good working condition. Personnel involved in beak trimming should receive species-specific training on proper procedures to use during beak trimming.

Toe Trimming

Because of the size and weight of the birds involved and the sharpness of their toenails, broiler breeder males and market turkeys generally have certain toes trimmed to prevent them from inflicting serious injuries to the hens during natural matings or to their penmates. Toe trimming should be done at 1 d of age using an electrical device that removes and cauterizes the third phalanx of the toes involved. Microwave energy application to the tip of the toe is also used to restrict toenail growth and is conducted using specialized equipment at the hatchery. In chickens, the microwave method did not result in increased stress or fearfulness (Wang et al., 2008). Provision of abrasive strips or hard surfaces in the facility may help to control excessive claw growth and reduce the need for declawing. Trimming toes for the purpose of identification is unjustified and should not be performed.

Egg-Laying Strains of Chickens. Leghorn hatchlings whose claws were trimmed through use of microwave energy experienced increased mortality and reduced feed consumption and BW during the pullet grow-out period. Removal of the claws resulted in a reduced foot spread allowing the toe of some pullets to slip into the wired mesh of the cage floor. The pressure on the web between the toes led to a splitting of the foot epidermis in 24 of the 1,200 pullets whose claws were trimmed (Honaker and Ruszler, 2004). Compton et al. (1981a,b) reported similar results when using a hot blade to reduce claw length and suggested that chick movement about the wired cage was difficult until the toe grew long enough to allow the foot to spread across the wired cage floor. These results suggest that trimming the claws of egg-laying strains of chickens is not recommended.

Broiler Breeder Males. When meat-type males of certain genetic lines are to be used in natural matings, the practice of trimming certain toes (inside toe and dewclaw nail) at 1 d of age can be considered; toe trimming of breeding males may prevent injury to the female during natural mating. However, there is also evidence that toe trimming may impair the mating ability of males (Ouart, 1986). The removal of one nail does not appear to cause chronic pain (Gentle and Hunter, 1988). For those genetic lines with long spurs, the spur bud on the back of the cockerel's leg may be removed at 1 d of age using a heated wire. Use of genetic lines with short, blunt spurs is preferable over spur removal. Most commercially available broiler breeder lines do not need to have their spurs removed.

Turkeys. Toe trimming is a widespread management practice in turkey production. The number of toes trimmed per foot varies from 1 to 3 plus the dewclaw.

Carcass grade of turkeys may or may not be improved by toe trimming (Owings et al., 1972; Proudfoot et al., 1979; Moran, 1985), although rate of early mortality may be increased (Owings et al., 1972; Newberry, 1992). Toe trimming may be justified when excessive injuries are likely to occur, but alternative methods should be considered to prevent bird injury.

Snood Removal

Turkeys have a frontal process called a snood, which is an ornamental appendage for the adult male. The snood can be grasped by other turkeys during fighting and can be torn or damaged. Breaks in the snood skin can be a health concern (e.g., erysipelas) among older turkeys (mature or breeders) or those housed on pasture or on ranges. Data collected from industry showed that snood removal in tom poults reduced the odds of mortality (Carver et al., 2002). To avoid injury and possible infection, the snood can be removed from the newly hatched male poult by clipping or pinching the snood from its base on the head. If removed, the process should occur as soon as possible after hatching (most likely at the hatchery) and no later than 3 wk of age (Berg and Halverson, 1985; Clayton et al., 1985; Parkhurst and Mountney, 1988). Snood removal after 3 wk of age is possible by clipping (Scanes et al., 2004) but not recommended without veterinary advice (Clayton et al., 1985) as the snood will continue to increase in size and vascularization especially in the males (toms).

Partial Comb and Wattle Removal

Removal of part of the comb (dubbing) and wattles of chickens may be needed if birds are kept in cages. Combs and wattles can get caught in wire openings or feeders after significant comb and wattle growth has occurred (Card and Nesheim, 1972; Fairfull et al., 1985). Comb and wattle removal is more commonly performed on cockerels because these structures are larger in males. Dubbing or removal of part of the wattles should only be used as a last resort when equipment or housing conditions cannot be modified to prevent torn or damaged combs or wattles.

To perform successful comb and wattle removal with minimal bleeding and excellent long-term results, surgical scissors, scalpel blade, or electrocautery/radiosurgery electrode (Bennett, 1993; 1994) should be used to remove part of the comb and wattle during the first few days after hatching. To reduce risk of infection between birds, the scissor blades can be disinfected.

Pinioning

Surgical pinioning, which involves amputation of the wing tip from which primary feathers grow, or tendonotomy is used mainly in exhibit birds to render them permanently incapable of flight. Pinioning is not recommended as a means of reducing bird flightiness in chickens, broilers, and ducks used for research and teaching. If flightiness is problematic, the primary feathers of one wing may be clipped.

Induced Molting

In birds, plumage is normally replaced before sexual maturity through a natural molt. Molting also occurs naturally after sexual maturity and is associated with a pause in egg production, which can be lengthy and take place out of synchrony with others in the flock. Inducing synchronized molting is used to rejuvenate laying flocks to extend the productive life of hens for 2 or 3 cycles of production. Molting has become a common procedure for commercial table-egg layers and sometimes for broiler breeders and turkey breeders. In recycled egg-laying strains of chickens, molting decreases the demand for chicks by 47% and thereby reduces the need to process, render, or bury the same percentage of spent hens. Rejuvenation of flocks also prevents the annual euthanasia of one hundred million additional male chicks. Additional advantages of molting include feather rejuvenation, thus improving thermoregulation. After a molt, livability and egg quality are improved during the second cycle of egg production compared with a nonmolt control group (Bell, 2003).

Egg-Strain Chickens. Several procedures used to induce a molt have included short-term (Ruszler, 1998) and long-term feed withdrawal; manipulation of dietary energy, protein levels, and dietary ingredients such as calcium, iodine, sodium, or zinc; and addition of feed additives that influence the neuroendocrine system such as iodinated casein (Kuenzel et al., 2005; Bass et al., 2007). These procedures have been used coupled with a reduction in the daily photoperiod. These methods cause a cessation of egg production along with decreased BW and feather loss. To allow for a return to egg laying, feather regrowth and BW gain are accomplished by feeding a diet designed to meet the nutritional requirements for a nonovulating, feather-growing hen (Bell, 2003).

Until 2000, the most common procedure used to induce a molt was to withdraw feed for 4 to 14 d without water restriction (Yousaf and Chaudhry, 2008). Feed withdrawal for inducement of ovarian arrest is stressful (Alodan and Mashaly, 1999; Kogut et al., 1999; Davis et al., 2000; Kuenzel, 2003) leading to increased mortality during the first 2 wk of the molt (Bell, 2003). Hens are more fearful during a fasted molt compared with before and after a molt (Anderson et al., 2007). Temporary frustration (Duncan and Wood-Gush, 1971) as indicated by a moderate increase in aggression on the first day of feed removal has been noted in molted hens compared with nonmolted full-fed controls (Webster, 2000). Aggression dissipated by the end of the first day, and molting hens showed elevated activity on the second day of fasting as indicated by increased nonnutritive pecking, standing, and head movement. Resting behavior increased by d 3 of fasting, and although nonnutritive pecking decreased from d 2, this pecking, interpreted as a redirection of foraging activity, remained higher than in control hens (Webster, 2000). Resting behavior persisted for the remaining part of the fast (Webster, 2000; Anderson et al., 2004). Similar changes in behavior of hens subjected to a fasting molting regimen have been reported by Simonsen (1979) and Aggrey et al. (1990) with the notation of an additional behavioral repertoire of increased preening on d 8 to 10 post-feed removal, most likely coinciding with the dropping of feathers.

Hens subjected to a fasting molt compared with nonmolted controls demonstrated decreased skeletal integrity (Mazzuco and Hester, 2005a), immunity (Holt, 1992a), helper T cells (CD4+ T cells, Holt, 1992b) and heterophil phagocytic activity (Kogut et al., 1999). In addition, hens subjected to a fasting molt showed an increase in *Salmonella enteriditis* (**SE**) fecal shedding (Holt and Porter 1992a,b; 1993; Holt, 1993; Holt et al., 1994; 1995), the prevalence of SE in organs (Holt et al., 1995), inflammation of the intestines (Holt and Porter, 1992a; Porter and Holt, 1993; Macri et al., 1997), the recurrence of a previous SE infection (Holt and Porter, 1993), and susceptibility to SE infection (Holt, 1993) compared with nonmolting controls. *Salmonella enteriditis* was readily transmitted horizontally among molting birds under simulated field conditions (Holt and Porter, 1992b; Holt, 1995; Holt et al., 1998), whereas in actual field settings, increased environmental *Salmonella* was observed in molted versus nonmolted hens (USDA, 2000; Murase et al., 2001).

As an alternative to fasting, hens subjected to non-feed-removal molting regimens show post-molt performance (egg production, egg weight, feed efficiency, and egg shell quality) not unlike the hens of the fasting molting regimen. Examples of successful non-feed-removal molting methods include the ad libitum feeding of diets high in corn gluten, wheat middlings, corn, or a combination of 71% wheat middlings and 23% corn (Biggs et al., 2003; 2004). *Salmonella* shedding, intestinal inflammation, and internal organ contamination of SE-challenged hens were reduced (Holt et al., 1994; Seo et al., 2001) and bone mineral density improved (Mazzuco and Hester, 2005b; Mazzuco et al., 2005) through the use of non-feed-withdrawal molting programs (wheat middlings or wheat middling/corn combinations) compared with hens of a fasted molt. Environmental presence of *Salmonella* increases during the molt in rooms containing fasting hens, but not in rooms of hens molted through wheat middlings (Murase et al., 2006). *Salmonella* fecal populations did not increase during a non-feed-removal molting program compared with the pre-molt and post-molt periods, with *Salmonella* prevalence being the lowest during the molting period (Li et al., 2007). Biggs et al. (2004) reported no differences in social behavior between fasted hens and hens subjected to a non-feed-removal molting program. These results on increased resistance to *Salmonella* and improved skeletal integrity suggest that non-feed-withdrawal methods of molting should be used rather than the more conventional feed-withdrawal molting regimens. During the non-fast molt, hens should be monitored for health, mortality, and body weight. Water withdrawal or restriction, which can lead to increase mortality especially during hot weather, is not recommended.

Broiler Breeders, Turkey Breeders, and Duck Breeders. Induced molt is occasionally done on parent breeding stock using feed withdrawal methods (Leeson and Summers, 1997). Molting methods for breeder ducks are similar to those used for broiler breeders. Nonfasting methods of inducing a molt have not been reported in breeder stock.

ENVIRONMENTAL ENRICHMENT

Refer to Chapter 4: Environmental Enrichment for information on enrichment of poultry environments.

HANDLING AND TRANSPORT

Refer to Chapter 5: Animal Handling and Transport for information on handling and transportation of poultry.

SPECIAL CONSIDERATIONS

Genetically Modified Birds

To date, there are no special animal care requirements for transgenic or cloned poultry. Transgenic birds are cared for in the same manner as conventionally domesticated birds unless the genetic manipulation affects basic bird needs. Future transgenic animals may have special requirements (e.g., birds with specific gene insertions) and they should be cared for based on their genotype and phenotype rather than based on the technology that was used to create them.

Surgeries

All intrathoracic and intraabdominal invasive surgeries require anesthesia. Caponization, or removal of the testes, is an invasive surgical procedure that requires anesthesia. See the sections in Chapter 2: Agricultural Animal Health Care that deal with surgery of experimental animals.

Other Bird Species

Gaunt and Oring (1999) and the Canadian Council on Animal Care (1984, 2008) offer recommendations on the care and use of wild birds, pigeons, doves, nondomesticated waterfowl, budgerigars, and quail. Parkhurst and Mountney (1988) provide animal care recommendations for geese, Coturnix quail, Bobwhite quail, chukar partridge, pheasants, guinea fowl, peafowl, pigeons, and swan. The Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes (1997) provides recommendations and minimum standards for the welfare of ostrich and emu. Recommendations from New Zealand (Animal Welfare Advisory Committee, 1998) provide animal care guidelines for ratites. These references are given not as an endorsement but as referral material only.

EUTHANASIA

Appropriate methods of euthanasia and slaughter for poultry are covered in Chapter 2: Agricultural Animal Health Care and by the American Veterinary Medical Association (**AVMA**) *Guidelines on Euthanasia* (AVMA, 2007). For the purpose of euthanasia, the AVMA accepts administration of barbiturates, inhalant anesthetics, carbon dioxide, carbon monoxide, gunshot (free-range birds only), and stunning followed by exsanguination, and conditionally accepts nitrogen and argon gases, cervical dislocation, decapitation, and maceration. Methods of euthanasia should ensure death and be selected to take into account any special requirements of experimental protocols so that useful data are not lost.

Anesthetic agents are generally acceptable, and most avian species can be quickly and humanely killed with an overdose of a barbiturate administered intravenously.

When relatively large numbers are involved, exposure to gas euthanasia agents such as carbon dioxide in enclosed containers may be used. Atmospheres containing a significant amount of carbon dioxide, with or without the presence of oxygen, cause birds to head shake and breathe deeply, but scientific evidence indicates that these behaviors are not associated with distress. These behavioral changes are not caused by irritation of mucosal epithelia in the nares or throat because they occur at carbon dioxide levels considerably below the threshold of trigeminal nerve nociception; that is, 40 to 50% carbon dioxide based on lab study of nerve fiber activity in chickens (McKeegan, 2004). Furthermore, although poultry can detect atmospheres containing significant concentrations of carbon dioxide and may show responses indicative of some degree of aversion, several studies have demonstrated that most chickens and turkeys will voluntarily enter carbon dioxide concentrations as high as 60 to 80% (Raj, 1996; Gerritzen et al., 2000; Webster and Fletcher, 2004; McKeegan et al., 2005; Sandilands et al., 2008). Because poultry can be rendered unconscious with 30% carbon dioxide in air, or less if enough time is allowed, (Webster and Fletcher, 2001; Gerritzen et al., 2004, 2006), and concentrations of carbon dioxide above 50% quickly kill adult birds (Raj and Gregory, 1990, 1994), it is not necessary to measure the carbon dioxide concentration closely when performing euthanasia. However, it is important that the process be observed and carbon dioxide added, if necessary, to ensure that death is attained without undue delay. Although euthanasia of poultry in high concentrations of carbon dioxide (60–80%) is relatively rapid, it also tends to promote vigorous convulsive wing flapping after loss of posture. Although the birds are not conscious when this occurs (Raj et al., 1990), the sight can be disagreeable to human observers. Slower induction of unconsciousness using lower concentrations of carbon dioxide appears to sedate birds and greatly reduces convulsions after loss of posture (Webster and Fletcher, 2001). Newly hatched chicks and poults have a greater tolerance to carbon dioxide so concentrations of 60 to 70% should be used to kill these birds (AVMA, 2007).

Anoxia using argon or nitrogen, or mixtures of these gases with carbon dioxide, has been found to be effective and to produce minimal distress, but residual oxygen should be kept below 2% (Raj, 1993; Raj and Gregory, 1994; Raj and Whittington, 1995; McKeegan et al., 2006). Anoxia causes strong convulsive wing flapping after loss of posture. When employing anoxia, the final gas concentration should be achieved quickly to avoid development of ataxia in conscious birds (Woolley and Gentle, 1988; McKeegan et al., 2006).

It is acceptable for an individual who has been properly trained to use cervical dislocation without stunning or anesthesia when small numbers of birds that are small in size require euthanasia. When enough experienced personnel are available for a given period of time, large numbers of birds can be euthanized via cervical dislocation, as long as operator fatigue is avoided. Cervical dislocation is not recommended with larger poultry such as turkeys and adult ducks or when one individual is required to kill a large number of birds. Following cervical dislocation, the necks of small birds should be checked for dislocation of vertebrae to ensure that the procedure was done correctly. Use of a captive bolt device for euthanizing large birds such as adult ducks and turkeys can be used by a skilled operator provided bolt diameter, mass and velocity, and angle of bolt impact are appropriate (Raj and O'Callaghan, 2001). Restraint of the head without compromising the handler is a major concern with use of captive bolt, so safety and restraint issues need to be considered. Both cervical dislocation and captive bolt killing are followed by severe convulsive wing flapping. A Burdizzo, a flat-edged clamp used for crushing tissue, may be used by trained individuals for the euthanasia of large poultry, particularly turkeys older than 10 wk of age. Birds must be rendered insensible (e.g., stunning or anesthesia) before crushing the cervical vertebral column with a Burdizzo.

Embryonated eggs may be destroyed by chilling or freezing at a temperature of 4°C for 4 h (European Commission, 1997). Decapitation or anesthetic overdose are suitable methods for embryos that have been exposed for experimental purposes. Maceration in a purpose-designed macerator, a mechanical apparatus with rotating blades, is also considered a humane method for killing embryos and surplus neonatal chicks. Chicks are rapidly fragmented by maceration, which results in immediate death (Bandow, 1987; American Association of Avian Pathologists, 2005).

Slaughter

Slaughter of animals entering the human food chain must comply with regulations as outlined in the *Federal Humane Slaughter Act* (Code of Federal Regulations, 1987). The processing area for poultry slaughter should be designed and managed to minimize bird discomfort and distress (Nijdam et al., 2005). The manager or person in charge of the processing area should be competently trained in animal slaughter and is responsible for training all staff to carry out their duties responsibly and humanely.

The holding area for birds to be processed should be adequately ventilated and protected from temperature extremes and adverse weather such as wind, rain, sleet, snow, and hail. Upon arrival, birds should be inspected to ensure that none are injured or suffering from heat or cold stress. Injured birds with signs of severe stress should be humanely killed or slaughtered immediately. If numbers are in excess, the farm manager should be contacted immediately. Birds should be processed as soon as possible once they arrive at the slaughter facility. All birds should be slaughtered within 12 h of feed and water withdrawal. Feed withdrawal minimizes microbial contamination of the carcass by preventing breakage of the gastrointestinal tract (e.g., the crop) during processing. All transport crates and trucks should be inspected to make sure that all of the birds have been removed for processing.

Birds should be handled carefully when removed from crates or, in the case of large turkeys, from livestock trailers. In plants with automated lines, birds should be shackled with a line running at a speed that permits the proper positioning of the birds to prevent injuries such as broken bones or bruising and to minimize discomfort (Gentle and Tilston, 2000) and stress (Kannan et al., 1997; Debut et al., 2005; Bedanova et al., 2007). Shackles should be of proper size to prevent bird escape and discomfort. Both legs should be hung on the shackles. To keep birds in the proper position for stunning, the height of the line should be adequate. Measures should be taken to minimize wing flapping such as use of funnels, breast bars, curtains, low light intensity or blue lights, reduction in noise, running a hand down birds after shackling, and avoiding bends in the line between the shackling area and the stunner. In nonautomated systems, cones (funnels) should be of appropriate size. Birds should not be suspended upside down in cones or shackles for more than 90 s before they are stunned.

Poultry killed using exsanguination should first be stunned using electrical or gas methods. Stunned birds may recover consciousness quickly; therefore, exsanguinations should be accomplished immediately after stunning to avoid recovery from consciousness. Exsanguination itself results in a rapid loss of consciousness if both carotid arteries are completely severed (Gregory and Wotton, 1986, 1988). Considerations involved in electrical stunning are discussed by Gregory and Wilkins (1989), Bilgili (1992), and Raj and Tserveni-Gousi (2000). Electrocution is acceptable if the current travels through the brain and through the heart. Occasionally some birds may not develop ventricular fibrillation after electrocution, so any birds showing signs of recovery should be immediately killed by other means such as by cervical dislocation, decapitation, or gas.

Electrical stunners adjusted for sufficient current (Bilgili, 1999) should render birds immediately insensible before neck cutting, and they should remain insensible during exsanguination. Acceptable stunners include a hand-operated stunner, stunning knife, a dry stunner incorporated into a metal bar or grid that is electrically live, or an electrical water bath. Hand-held electrical stunners may be used for shackled birds or for those birds that are restrained in a cone. The electrodes are applied to either side of the head between the ear and eye. The stunner should be applied to shackled birds until wing flapping stops or until the legs become rigid and extended when using the cone. With respect to use of a water bath for stunning, the water level in the bath should be set so that the heads of all birds make effective contact with the water. Use of an ammeter is recommended to monitor current flow through the water bath while it is loaded with birds. The water bath should be deep enough to prevent water overflow and the electrodes should extend the length of the water bath. Birds exiting the water bath should be regularly checked to ensure that stunning is effective. Characteristics of adequate stunning include rigidly extended legs, rapid and constant body tremors, wings held close to the body, open eyes, and an arched neck with the head directed vertically. If cardiac arrest is induced during stunning, birds become limp with no breathing or reflex of the nictitating membrane. Pupils are dilated and the birds do not respond to a comb pinch. Stunning equipment should be maintained properly (e.g., maintenance of water bath conditions, ground bars, connectors) to ensure an adequate stun.

Gassing birds before exsanguination may be a humane method of rendering birds insensible, but further research is needed to determine if it is a superior method. If birds are gassed before or immediately after removal from transport crates or vehicles, they avoid the stress of shackling (Gentle and Tilston, 2000) and the potential of pre-stun electrical shock. Gas types and concentrations appropriate for stunning poultry are discussed in the previous section on euthanasia.

Post-stun exsanguination should be initiated by making a ventral cut in the neck, wherein at least both carotid arteries or the carotid artery and the jugular vein on one side are severed. Properly stunned birds will not show voluntary behavior such as eye blinking, coordinated head or limb movements, or attempt to escape the shackle or cone during exsanguination. Some involuntary convulsive movement, such as a wing flap, is not unusual as the blood supply to the brain becomes depleted.

In some cases there may be a need for kosher or halal slaughter of birds, which does not allow stunning. For this purpose a very sharp knife with a straight surface that is at least twice the length of the head should be used to cut the arteries, veins, trachea, and esophagus. A poultry scalpel can also be used effectively. An aggressive single stroke cut is most effective. Birds must be permitted to bleed out before further work is conducted. This process should only be performed on birds that are adequately restrained such as by the use of a cone. Birds must be rendered insensitive (i.e., no eyeblink reflex when poked) in less than 30 s.

Following exsanguination, birds must not be breathing when they enter the scalder (USDA, 2008). Birds must be monitored to make sure they are dead before entering the scalding tank. If any bird shows signs of consciousness, they must be removed from the processing line and promptly stunned.

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