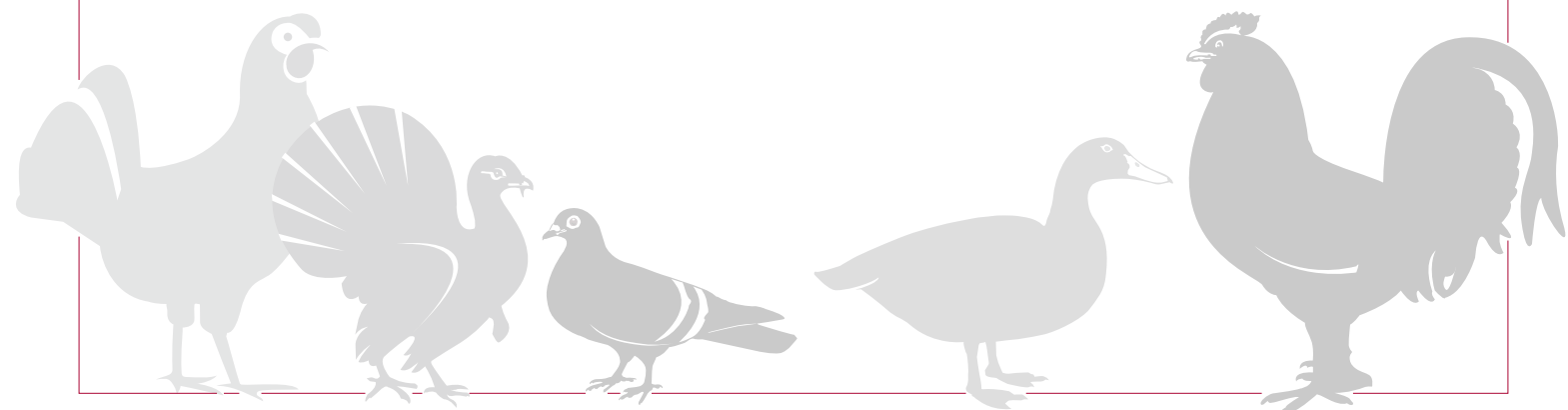


Poultry housing and management in developing countries



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POULTRY HOUSING

Improvements to poultry housing systems in developing countries have focused on providing an environment that satisfies the birds' thermal requirements. Newly hatched birds have a poor ability to control body temperature, and require some form of supplementary heating, particularly in the first few days after hatch. Many developing countries are located in tropical areas where minimal heating is required. Indeed, the emphasis in these countries – particularly for meat chickens – is on keeping the birds cool.

Production systems

International poultry breeding and feed companies operate in many developing countries and have established large-scale commercial farms in a significant number of them. The housing and equipment used make it possible to exert considerable control over the climate provided to the birds, but such houses are expensive to build and operate, and require a large turnover of birds to make them viable. Owing to the lower construction and running costs, medium- and small-scale commercial housing is popular in developing countries. By far the most prevalent poultry farming system in many developing countries is the small-scale scavenging system, which usually involves only very basic (if any) shelter for housing birds.

Large-scale commercial farms: Commercial houses in developing countries are clear-span structures with litter on the floor for meat birds or cages for laying hens. The commercial chicken meat industry in some developing countries is vertically integrated, with single companies owning feed mills, breeder farms, hatcheries and processing plants. Arrangements typically involve agreements in which the farmer or landowner provides the housing, equipment and labour, while the company provides the chicks, feed, medication, transport and supervision.

For controlled-environment housing of layers, multi-tier cage systems are common. Most large-scale commercial farms use controlled-environment systems to provide the ideal thermal environment for the birds (Glatz and Bolla, 2004). Birds' performance in controlled-environment sheds is generally superior to that in naturally ventilated houses, as the conditions can be maintained in the birds' thermal comfort zone. Achieving the ideal environment for birds depends on appropriate management of the poultry house.

Modern houses are fully automated, with fans linked to sensors to maintain the required environment. Some commercial operators use computerized systems for the remote checking and changing of settings in houses. Forced-air furnaces and radiant heating are the main methods of providing heat to young chicks.

Medium-scale commercial: In developing countries, most medium-scale commercial layer and chicken meat houses rely on natural airflow through the shed for ventilation (Daghir, 2001). Where required, meat birds and layers are given radiant heating early in their lives, to maintain body temperature. Laying hens may be kept in commercial wire cages in open sheds, or in sheds with wire sides to exclude wild birds, scavenging poultry and predators.

Small-scale commercial (improved genotype stock and supplementary feeding): Houses of various shapes and dimensions are typically constructed using local building materials consisting of timber or mud bricks and bamboo. These small-scale commercial facilities may have several rooms or compartments where chicks are brooded, pullets are reared and layers are housed in a floor-based system or in cages. Meat birds are often kept in single-age groups of 50 to 100 chickens within the house. The house can



Sector 1 large-scale broiler operations



Photo Credit: Olaf Thiene



Photo Credit: I. Aini

Sector 2 medium-scale layer and broiler operations



Photo Credit: Karma Nidup



Photo Credit: Karma Nidup

Sector 3 small-scale commercial houses

be used as night shelter for birds that forage under free-range conditions or that are confined to an outdoor pen during the day.

Small-scale semi-scavenging system using indigenous birds: When provided, shelters are made from various materials, including wood and leaf material from local trees or shrubs. Birds in the household flock are typically housed overnight in the shelter, and are let out in the morning to forage during the day (Ahlers et al.,

2009). If no special structure is provided, the birds sometimes shelter overnight under the farmer's house or even inside the house with the family. Where provided, the usually rudimentary house comprises posts, a thatch or scrap iron roof, and thatch or scrap wire netting walls. Feeders, perches, drinkers and nest boxes made from local materials are sometimes provided, and special shelters of a wide variety of designs and constructions are sometimes used to house broody hens with their chicks.



Photo Credit: Vengsavanh Phimphachanhvongsod



Photo Credit: Vengsavanh Phimphachanhvongsod

Sector 4 small-scale, semi-scavenging poultry production

Ventilation management

All poultry houses need some form of ventilation to ensure an adequate supply of oxygen, while removing carbon dioxide, other waste gases and dust. In commercial operations, minimum ventilation is often practised in colder climates, but not generally in tropical ones (Glatz and Bolla, 2004).

In large-scale automated operations, correct air distribution can be achieved using a negative pressure ventilation system. When chicks are very young, or in colder climates, the air from the inlets should be directed towards the roof, to mix with the warm air there and circulate throughout the shed. With older birds and in warmer temperatures, the incoming air is directed down towards the birds, and helps to keep them cool. Evaporative cooling pads can be placed in the air inlets to keep birds cool in hot weather. Tunnel ventilation is the most effective ventilation system for large houses in hot weather.

Tunnel ventilation: These systems are popular in hot climates. Exhaust fans are placed at one end of the house or in the middle of the shed, and air is drawn through the length of the house, removing heat, moisture and dust. Evaporative cooling pads are located at the air inlets. The energy released during evaporation reduces the air temperature, and the resulting airflow creates a cooling effect, which can reduce the shed temperature by 10 °C or more, depending on humidity. Maximum evaporation is achieved when water pumps are set to provide enough pad moisture to ensure optimum water evaporation. If too much water is added to the pads, it is likely to lead to higher relative humidity and temperatures in the shed.

Fogging systems: Fogging systems are sometimes used to reduce the shed temperature. Fogging works best in dry climates, and usually involves several rows of high-pressure nozzles that release a fine mist throughout the house. The cooling effect is significantly increased by airflow from the use of fans within the shed.

Natural ventilation is common in medium- and small-scale operations and in areas where the climatic conditions are similar to the temperatures required by birds. Ventilation is usually provided by prevailing breezes. Natural ventilation works best in poultry sheds where the long axis runs east to west, to avoid heating of the sidewalls by the sun during the morning and afternoon.

POULTRY MANAGEMENT

The aim of management is to provide the conditions that ensure optimum performance of the birds (Bell and Weaver, 2001). Given reasonable conditions, broody hens are very successful at hatching their chicks, but good hatchability using artificial incubation (both large and small) relies on careful management of temperature, humidity, ventilation, position and egg turning. During incubation, the egg loses water vapour through its shell. The rate of water loss depends on both the shell structure and the humidity of the air surrounding the egg. The quality of the hatch also depends on the age and health of the breeder flock, and on the evenness and cleanliness of the eggs set.

Factors involved in poultry management

Poultry management involves monitoring poultry health; ensuring that the poultry house is maintained with appropriate brooding, rearing, growing and laying conditions; and ensuring that recommended vaccinations are given and appropriate feeding programmes are used. In developing countries, it is often difficult to achieve optimum performance from birds, owing to less-than-optimal housing conditions and lack of quality feed, vaccines and trained staff.

Breed effects

Owing to their superior production, commercial hybrids of high genetic merit are often used in developing countries, but are not well-suited to tropical environments (see website on Poultry genetics and breeding in developing countries). These birds are sensitive to changes in the diet and to high ambient temperature, and require skilled stockpersons to manage them. Indigenous poultry can cope better with the harsh conditions often prevailing in developing countries, and good management will improve their performance. This can be achieved by using good housing, protecting the birds from predators, and providing them with the environmental conditions that allow them to achieve maximum profitability.

Temperature effects

Farmers need to compensate for undesirable climatic conditions by manipulating control systems or modifying the house to ensure that the welfare and environmental needs of the birds are satisfied. Environmental extremes (heat and cold stress, excessive or inadequate ventilation, poor air quality) can be managed if the design of the poultry house is appropriate for the conditions. Birds require adequate space, sufficient feed to meet their nutritional requirements, and an adequate supply of good-quality



Tunnel-ventilated broiler house: exterior and interior views

water. Use of a stringent quarantine programme to prevent disease is an essential element of good management, and farmers must be able to recognize disease and treat it as soon as possible. A suitable vaccination and medication programme is essential in commercial operations.

Effects of nutrition

Managers need to ensure that the diets provided to birds in commercial operations meet the nutrient requirements of each age group and strain of chickens (see website on Poultry feed availability and nutrition in developing countries). Smallholder systems in developing countries typically place less emphasis on achieving maximum production, and more on maximizing profitability by using diets comprised mainly of local feedstuff ingredients, rather than imported feeds. Key management practices by farmers who mix their own feed include ensuring that micro-ingredients are kept cool, mouldy ingredients are not used, and storage facilities are weather- and rodent-proof.

Importance of good hygiene

An essential management task is to maintain clean sheds, surroundings and equipment. A clean shed improves health and limits parasites, dust and microbial contamination, while clean shed surroundings reduce vermin and fly loads. This is important not only for litter and manure management but also for biosecurity. Removal of residual feed from feeders is an important practice critical to the health of the flock. Another important management task is to sanitize sheds to minimize the risk of disease to incoming flocks of birds. Maintaining high flock health status is essential, and routine vaccination programmes for a number of diseases are typically in place, particularly in larger-scale operations. Some vaccinations are carried out at the hatchery, but it is essential that a proper vaccination schedule be established and that vaccination protocols be complied with.

Litter materials and management

Broiler litter is the material used as bedding in poultry houses to absorb faecal waste from birds and to make the floor of the house easy to manage. Common litter materials are wood shavings, chopped straw, sawdust, shredded paper and rice hulls, and a wide range of other materials are used in different regions around the world. Litter should be light, friable, non-compressible, absorbent, quick to dry, of low thermal conductivity and – very important – cheap. After use, the litter comprises poultry manure, the original litter material, feathers and spilled feed. The litter quality in a shed is determined by the type of diet, the temperature and the humidity. The recommended depth for litter is between 10 and 20 cm. Sawdust can result in high dust levels and respiratory problems. Dust particles in the litter capable of causing health problems in the birds are derived from dried faeces, feathers, skin and litter; their adverse effects arise because they carry or incorporate bacteria, fungi and gases.

Management of lighting

Poultry have seasonal and daily biological rhythms, both of which are mediated by light, particularly day length. For day length to exert its controlling effect, there needs to be a dark phase (night) when light levels should be less than 0.5 lux. Day length and

light intensity during the breeder bird's life have an important role in development of the reproductive system. The difference in day lengths and light intensities between the rearing and the laying phases is the principal factor responsible for controlling and stimulating ovarian and testicular development (Lewis and Morris, 2006). The response to increases in day length and lighting intensity depends on the body weight profile during rearing, which in turn depend on the nutritional regime. The effects of light are predominantly on the rate of sexual maturation and egg production.

The two types of artificial lighting commonly provided are incandescent and fluorescent. Incandescent globes are cheaper to install, but have lower light efficiency and a shorter life. Fluorescent lights are three to four times as efficient and last about ten times as long, but have variable performance in cold weather. The colour of the light rays has an effect on chickens' productivity. For example, green and blue lights improve growth, and lower age at sexual maturity, while red, orange and yellow lights increase age at sexual maturity, and red and orange lights stimulate egg production. Birds are calmer in blue light, so blue lights are recommended for use during depopulation in commercial operations.

Lighting programmes for broilers: Lighting programmes for commercial broiler operations vary widely from company to company, and depend on the strain of bird used, the housing type (naturally ventilated versus controlled-environment), the geographical location and the season. Where light can be excluded from sheds, birds are typically reared under low-intensity (5 to 10 lux) lighting, to keep them calm and to prevent feather pecking. During early brooding, 25 lux is used to stimulate feeding.

Lighting programmes for layers and breeders: Light is critical for the onset and maintenance of egg production. Increasing day length (from winter to summer) during the rearing period stimulates the onset of sexual maturity, whereas shortening day length (from summer to winter) has the opposite effect. Early onset of lay may not be beneficial as it may predispose to reproductive problems. Where artificial lighting is possible, a constant day length (of between 12 to 16 hours per day) during the rearing period has been shown to result in a delayed onset of lay, and is the preferred rearing treatment. Shortening day length or too little light will discourage egg production, and must be avoided once the birds are in lay.

Stockpersonship

Farmers and their staff play a critical role in looking after the birds and maximizing productivity. They need to empathize with and care about their birds, and to avoid exposing them to adverse situations that may cause stress (see website on Poultry welfare in developing countries). The people responsible for the care of poultry should be well trained, experienced and dedicated. The first task for poultry staff is to learn how to carry out routine checks on the birds, so they can identify what is normal in the flock and what the signs of trouble are. Good stock attendants minimize the risks to their animals' health and welfare. By doing this, they allow production to reach its potential, while treating the animals with care (Barnett and Glatz, 2004). This is sometimes called "stockpersonship". Staff should be able to identify quickly

any changes in the flock and in the birds' environment, and any physical, chemical or microbiological threats, such as damaged equipment, mouldy feed or infectious disease, and should prevent problems from escalating. The more sophisticated the poultry farming system, the greater the management skills required.

Records

Record keeping and meeting production targets are good management practices that allow the identification and solution of problems. When a problem is identified, the next step is to attempt to fix it. Identifying the cause of and fixing a problem is an important part of the farmer's knowledge base, and is likely to assist in preventing a recurrence of the problem (Barnett *et al.*, 2001). Records kept over time can help identify some of the possible causes of problems. One of the most useful record-keeping documents is a diary, which can be used in combination with record-keeping sheets to record major activities, problems identified, equipment repairs, deviations from equipment settings, and any staff issues.

Records of production, growth, feed, egg weights, mortalities, treatments given, and response to treatments should be maintained to assist investigations of sub-optimal performance. In all production systems, signs of ill health can be detected when poultry reduce their food and water intake; reduce production or

growth; undergo a change in appearance, behaviour or activity level; or have abnormal feather condition or droppings.

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Incubation and hatching

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On village farms, fertile eggs are hatched mainly using broody hens. On semi-commercial and commercial farms, they are hatched artificially in incubators.

Hatching fertile eggs using broody hens

One of the important characteristics of village hens is their capacity for broodiness. The large majority of improved-breed birds have lost this capacity. When broody birds are approached, they make a typical brooding noise and fluff up their feathers. Broody hens prefer to sit on eggs in a dark environment that is protected from predators, and they need a supply of feed and water. When one or more cockerels are present in the flock and have been observed mating regularly with females for a week or more, the eggs will normally be fertile (CTA, 2007).

Quality of fertile eggs

Hatching eggs (stored at 16 to 17 °C) need to have good shell quality. Storing eggs at higher temperatures promotes the development of the embryo. In many developing countries it is difficult for village farmers or breeding centres to store eggs under ideal conditions. Under high temperature conditions, the eggs are likely to "sweat", allowing bacteria to penetrate the shell. Relative humidity should be maintained at approximately 75 percent in the fertile egg holding room. Higher humidity encourages mould growth on eggs.

Pre-warming of fertile eggs

Eggs need to be warmed to room temperature for approximately eight to 12 hours before they are set in the incubator. The purpose of pre-warming is to minimize temperature shock to the embryo and condensation on the shell. It also reduces the variation in hatch time. Good air circulation is essential for an even pre-warming of eggs.

The incubator room

Optimum results can be expected if the temperature in the incubator room is maintained at about 25 °C. However, the tropical climate in many developing countries makes it difficult to maintain good incubator room conditions.

Incubators

In small hatcheries in developing countries, incubators are often small, still-air machines with a capacity of 12 to 240 eggs. The relative humidity must be 55 to 60 percent at set, and increased to 75 percent after day 18. In small incubators, this is normally achieved by placing an extra container of water in the incubator.

The eggs are set in a horizontal position and are turned manually. The source of heat is usually a thermostatically controlled heating element or light bulb or kerosene lamp. Humidity is supplied by water in a container either above or below the eggs, and ventilation is controlled by small air vents. Circulating-air incubators have an electrically driven fan to maintain constant temperature and ventilation of the eggs.

In large-scale operations in developing countries, incubator setting capacity ranges from approximately 10 000 to 100 000 eggs. The equipment used to incubate and hatch chicks is all precisely controlled (Cobb-Vantress, 2008). Optimum temperatures for setters are 37.1 to 38.6 °C, at a relative humidity of 60 to 70 percent. The hatching eggs are set vertically, with the blunt end uppermost in the setter, and are turned mechanically through 90° every hour



Hatching by a broody hen



Kerosene operated incubator in small hatchery

Photo Credit: Olaf Thieme

Photo Credit: Olaf Thieme



Photo Credit: Robert Pym

until about three days prior to hatching. The eggs are then transferred to a hatcher, where they are placed on hatching trays on their sides, with the long axis horizontal, to allow the chick to move freely out of the shell at hatching. Hatcher temperatures are usually slightly lower than those in the setter, to reduce the risk of overheating, and are typically 37 to 38 °C, while relative humidity is usually raised to about 75 to 80 percent. Hatchability should be in the range of 80 to 90 percent for imported hybrid strains, but varies with the breed and the age of the breeder flock.

Egg candling

Candling of chicken eggs on the seventh and eighteenth days of incubation is recommended for small poultry producers and commercial farms. Egg candling (using a torch or bright light in a dark area) detects cracked and infertile eggs and those containing dead embryos or bacterial or fungal rots; these eggs can then be removed from the incubator. Cracked and rotten eggs must not be allowed to remain in the incubator as they can explode and result in infection of the hatching chicks.

Fumigation of incubators

The effectiveness of formaldehyde gas in killing bacterial organisms is based on the concentration of the gas, the exposure time, the temperature and the humidity of the incubator. The chemicals potassium permanganate and formalin are mixed together to release formaldehyde gas. This procedure has proved to be the most effective method of destroying bacterial organisms in the hatchery.

HATCHED CHICKS

The chicks hatch after 21 days of brooding or incubation. If the eggs have been hatched by a hen, she will immediately take care of the chicks, but will typically remain on the nest until the majority of the eggs have hatched. If the chicks have been hatched in an incubator, they are ready to be taken out of the hatcher when most of them are dry and fluffed up. Chicks will easily dehydrate if left in the hatcher for too long. They have yolk reserves for about three days, but survival rates are increased if they are provided with food and water within 24 hours of hatching. Chicks are normally removed from the hatchers within 24 hours of the first chick hatching. The chicks should be held in an environment that prevents overheating or chilling. Temperatures should be in the range of 30 to 32 °C, and relative humidity in the range of 70 to 75 percent. Adequate ventilation is vital at all times, to provide the chicks with a constant and uniform supply of fresh air.

Vent and feather sexing

Sexing of day-old chickens is not normally practised on village farms, but is an essential procedure in commercial operations with modern hybrids, particularly for layers, where the male chick has no commercial value. Broilers are also often sexed, but the requirement here is less important. There are two fundamentally different approaches to sexing: one identifies the sex of the day-old chick by sex organ-related differences; and the other employs sex-linked genes (Barnett *et al.*, 2001). In the first approach, sexing can be done in any population using one of two methods: i) vent sexing, which relies on visual identification of the sex organs using an endoscope inserted into the chick's vent; and ii) cloa-



Photo Credit: Robert Pym

Large-scale commercial incubator and hatcher



Day-old chicks in 100-bird chick boxes following hatch

cal sexing, where the chick's cloaca is everted and the vestigial copulatory organ can be seen in male chicks. Both of these procedures require extensive training. The second approach involves fixing appropriate sex-linked feathering rate or colour genes in the parental lines (see website on Poultry genetics and breeding in developing countries). In the progeny from such matings, male chicks are either slow-feathering or white, and hatchery staff can readily distinguish them at hatch from their rapid-feathering or coloured-feathered female counterparts.

Culling chicks in the hatchery

Culling is conducted to reduce the potential for transferring disease within flocks, to provide a uniform hatch of chicks for production, and to reduce pain and suffering of sick and deformed chicks.

There are three methods for culling surplus or sick chicks (Barnett *et al.*, 2001):

- Cervical dislocation: The neck of the day-old chick is held against a firm surface (e.g., the edge of a tabletop) and gentle pressure from both thumbs is applied to dislocate it. This method can be used on small farms.
- Gas stunning with carbon dioxide: The chicks are held in a container covered with a lid or plastic. They are initially stunned and then killed with longer exposure. A concentration of 55 percent carbon dioxide in air is required to kill the chicks with two minutes exposure time.
- High-speed macerators: Some larger hatcheries use these to kill unwanted chicks and any live chicks in eggs that have failed to hatch.

Removal of claws and spurs

In commercial operations, it is routine for male breeding birds to have the terminal segment of the inner toe removed, to prevent damage to female birds while mating. This is routinely done at the hatchery, although about 10 percent of chicks may have their claws removed on-farm. It is best to use a beak trimming machine to cut and cauterize the wound, although scissors can also be used. Males may also have their spurs removed, again preferably using a beak trimmer to cut and cauterize the wound (Barnett *et al.*, 2001). Sharp scissors can be used, but the wound is not cauterized, and there is a risk of excessive bleeding. This procedure

is necessary to prevent damage to birds when fighting. In village farms, the sharp points of the claws and spurs can be blunted with abrasive material.

Bird identification

A small percentage of breeding birds require individual identification. Methods used for small numbers of birds include either cutting the skin between the toes (the webbing) with scissors or a scalpel blade, or trimming the digits with sharp scissors or a beak trimming blade (Barnett *et al.*, 2001). For larger numbers of birds number-embossed wing bands or leg bands are necessary. Wing bands are attached to the bird by passing the pin or sharp point through the web of the wing. Leg bands are fastened around the metatarsus above the foot.

Wing-bands can be applied at hatch, but leg-bands can not be applied before about 12 weeks of age, due to rapid increase in the diameter of the leg up until about this age.

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Brooding and management of young chicks

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Hatched chicks should be active, uniform in size and healthy. Although newly hatched chicks can survive on their own body reserves for up to 72 hours, depending on environmental conditions, their survival is increased if they are provided with food and water within 24 hours of hatching. The sooner they are provided with these and a warm area, the higher the rate of survival. Chicks must not be chilled or overheated at any time.

BROODING SYSTEMS

Broody hens

Under natural conditions, the mother hen keeps the chicks warm by allowing them to nestle under her feathers. The chicks follow the broody hen around and learn to forage and drink by watching her behaviour. In small village poultry settings, hens can care for up to 15 chicks. Ideally, chicks should be provided with a commercial ration (Ahlers *et al.*, 2009) or other feed for at least the first two weeks, to improve the survival rate.

Spot brooding

For small flocks of up to 20 chicks, a small enclosure in the poultry house or a confined area can be set up. This can be made from cardboard or timber, with a heat lamp suspended over the enclosure to keep the chicks warm. When the chicks are provided with an ideal temperature, they spread uniformly over the enclosure. When chicks feel cold, they crowd under the heat source. If the pen is too warm, the chicks move away from the heat and pant with their wings spread out (Bell and Weaver, 2001).

For larger flocks of up to 400 chicks, circular enclosures are set up in the poultry house to retain them. These areas are usually made from Masonite or sheet metal, with a gas brooder suspended over them to provide the required temperature (about 35 °C immediately under the brooder). There should be sufficient space for chicks to move away from the heat source. Temperatures in the outer part of the enclosure may be as low as 20 °C.

Commercial layers are often raised in growing cages (of up to 20 chicks/cage) with warm-room brooding, or with a heat source over each cage in tropical climates. As the birds age, the stocking density is reduced by moving chicks to other growing cages.

Whole-house brooding

In large commercial operations, the whole shed is maintained at a temperature of 30 to 32 °C both day and night, using forced-air heaters. This can be achieved only if the shed is completely sealed. As most developing countries are located in the tropics, there is usually no need for whole-house brooding. When this

system is used, the house temperature is lowered by about 2 to 3 °C per week until it reaches ambient temperature, provided this is not below 18 °C.

Chick feeders

At one day old, feed for the chicks can be scattered on paper. After three to four days, the paper can be removed, and chicks provided with feed in shallow feeders on the floor or cages.

Chick drinkers

For village chicks, drinkers can comprise bamboo sections or water bottles. These should be cleaned and refilled daily. Feed and



Older style brooding cages for layer chicks: hot water pipes run along and above the brooder section at the back of the cages; an oil- or gas-fired heater heats the water



Oil or gas-fired hot air brooder units on side of shed for whole-house brooding: the entire brooding area is heated to the required temperature

Photo Credit: Robert Pym

Photo Credit: Robert Pym



Conveyor and pan automated feeding system for young chicks: for the first five days post-hatch every third pan in the line is replaced with scratch trays

water should be within 1.5 m of all chicks. In large flocks, automatic drinkers are typically used. These can be nipple, cup or bell waterers.

Daily management of chicks

Chicks should be checked four times a day, taking note of any abnormal behaviour and ensuring that they are healthy and not heat- or cold-stressed (Barnett and Glatz, 2004). They should be observed to see if they are able to eat and drink successfully from the equipment provided. Any dead chicks should be removed, and litter should be dry.

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Housing and management of breeders

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HOUSING OF BREEDERS IN DEVELOPING COUNTRIES

In village settings, some farmers use bush materials to construct houses for their breeder chickens, which provides some protection. Typically, a village flock comprises ten to 12 layers with one or two cockerels. Natural incubation by broody hens is common, and egg fertility ranges from good to poor, depending on several factors. The decision to construct a house for chickens is often determined by the individual farmer's access to materials, the availability of space within the village, and other social and economic factors. However, the houses built are basically for night shelter, and the breeding birds are left to scavenge for feed during the day, thus they remain prone to predators even though shelters are provided.

In commercial and semi-commercial settings in developing countries, breeders are normally housed in naturally ventilated houses, with some additional lighting provided if electricity is available. The house is usually fitted with nest boxes, feeders and drinkers. Some large-scale operations use automatic feeding and egg collection systems.

BREEDERS IN DEVELOPING COUNTRIES

A number of government, non-governmental and training organizations have developed poultry breeding programmes for producing local chickens in developing countries. Some centres have imported improved commercial strains for crossing with the local chickens to improve the meat and egg production of small-holder poultry flocks. The breeding centres often distribute chicks to farmers for use in their village farm operations. Larger commercial integrated poultry franchises in developing countries normally import fertile eggs from commercial layer or broiler breeder flocks. These eggs are set in large hatcheries, and hatched chicks are either sold in small lots to village farmers or used in commercial or semi-commercial operations to produce chicken meat and eggs for consumers in towns and cities.

The poultry breeding facilities established in developing countries are normally small-scale. Ideally, the breeding flock should comprise females with good egg production, which are mated with active cockerels. A major issue is maintaining a supply of fertile eggs. Young breeder flocks produce fewer fertile eggs than those at peak of lay, and fertility also tends to be lower in eggs produced by older breeders. Hatchability and the uniformity of hatched chicks depend on management of the eggs produced by the breeders. In larger-scale operations, eggs should be collected at least four times a day, handled carefully to prevent breakages, and stored for no longer than seven days in a cool room at 15.5 to 17 °C and relative humidity of 75 percent. Eggs on the floor or

that are dirty should not be set. In small-scale village operations, farmers can clean dirty eggs with abrasive paper and make use of all the eggs that are available.

BREEDER CHICK MANAGEMENT

Chicks that are reared for use in a breeding programme should be kept separate from other birds in other age groups. Cockerels should also be grown separately from females, preferably until five months of age. Generally, however, this approach is not possible in village operations. Most chick rearing in hot-climate developing countries is carried out in naturally ventilated houses. In commercial operations, chicks scratch in the litter, creating uneven litter levels, particularly around feeders and drinkers. Small



Small-scale breeding programme with indigenous breeds



Broiler breeder hens and cocks in a deep-litter naturally ventilated house

Photo Credit: Viengsavath Phimphachanhvongsod

Photo Credit: Robert Pym

birds will not be able to reach the feeders or drinkers if the litter levels are not kept even. In large commercial operations in colder climates, the building should be pre-heated so the floor is warm and the air temperature close to 32 °C when the chicks are placed. If provided, lighting should be continuous for the first 48 hours after the chicks arrive.

Beak trimming is practised where required to prevent injurious pecking in the flock. Males often need re-trimming before they enter the breeding programme, to reduce the risk of pecking damage to the females during mating.

GROWTH AND PRODUCTION

During the rearing and growing period for breeder stock the major objective is to control body weight, particularly to ensure that all the birds reach target weight-for-age uniformly. Body weight targets are achieved by controlling feed allowances. Feed amounts during rearing are based on body weight and maintenance; during lay, egg production and egg weight are also important (Cobb-Vantress, 2008a).

In meat and layer type birds, body weight uniformity is critical during the first six weeks of the breeders' growth. Weekly body weight increase is a good indicator of how successful the brooding has been. High-quality feed of appropriate particle size must be provided to obtain adequate feed intake in the first week. Crop size is a good guide to how well the chicks are consuming feed and water. In developing countries, it is often difficult for breeder farms to meet the body weight standards set for developed countries, owing to poor feed quality and the typically hot environment.

During the period from six to 16 weeks, meat and layer breeders are usually put on a controlled feeding regime to keep their body weight on target. When the birds reach 16 weeks, they are stimulated by providing up to an hour of additional artificial light per day, to promote sexual development. Particularly in layer strain breeder flocks, it is essential that the female parent achieves sufficient body weight between 16 and 20 weeks of age, to maximize peak egg production and achieve consistent egg production throughout lay. Breeder flock egg production can be optimized by appropriate feeding programmes that ensure that the pullets have uniform body weight. It is also important to keep the breeding flock body weight in check after maturity, by handling and weighing birds often and adjusting the feeding levels as required.

Layer breeding stock should be fed daily from hatch to end of lay, whereas for broiler breeders during the rearing phase, skip-a-day feeding is often used because of the relatively severe restriction that is needed to achieve the desired body weight in these much heavier birds. Uniformity and bird welfare suffer if daily feeding is used, as the more timid birds miss out on their daily allowance. On the alternate days, scratch grain is often provided to reduce hunger. During the laying period, from about 21 weeks of age, broiler breeders are typically fed a restricted amount daily. The restriction at this time is considerably less severe than it is during the rearing period. Separate-sex feeding is normally practised during the laying period, with males having no access to females' feed, and vice versa. This has more to do with diet composition than quantity, as males have a far lower calcium requirement than females.

LIGHTING PROGRAMME MANAGEMENT

The onset of lay in layer and broiler breeder hens is critically linked to change in day length: increasing day length stimulates the onset of sexual maturity, while decreasing it has the opposite effect. In developing tropical countries, natural day-light rearing of breeding stock is generally used, and works well, because the variation in natural day length is small. During the rearing period, birds can remain in natural light in all seasons until artificial light stimulus is given, normally at 20 or 21 weeks of age in meat breeders and from 18 weeks in layer breeders. When extending the day length, artificial light is provided at both the beginning and the end of the natural day-light period (Lewis and Morris, 2006).

WATER MANAGEMENT

Breeding birds in village systems are normally provided with water in open containers. Most commercial operations provide one bell drinker per 80 birds, while nipple drinkers, which are a more hygienic water delivery system, are provided for eight to ten birds per nipple. Chickens normally drink between 1.6 and 2.0 times their daily feed intake at 21 °C, in both *ad libitum* and control fed flocks. At ambient temperatures higher than 30 °C, water consumption increases to more than twice the feed intake. High water consumption may indicate errors in feed formulation or leaking drinker systems.

RELOCATING BIRDS

In village farming systems, breeder birds are often sold and transferred to other village farms. In semi-commercial and commercial operations, the age for transferring stock to other farms is determined mainly by the facilities available, the birds' body weight and the lighting programme. Transfer can be very stressful for the birds, and every effort should be made to ensure that it is carried out smoothly. It is best to transfer males a week earlier than females, so they can adjust to their feeding system. The ratio of males to females is usually kept at about 1:10, and males should be healthy with no obvious skeletal defects.

PRODUCTION PERIOD

In most developing countries, manual nesting systems that allow about four birds per nest are used. Young breeder males are often added to an older flock to overcome the decline in fertility that usually occurs after peak egg production. Older males usually undergo a decline in mating activity and a reduction in sperm quality.

EGG WEIGHTS

There are considerable advantages in weighing a sample of eggs to establish the trend in egg weight. Analysis of this trend provides a useful guide to breeder flock performance, and gives early indication of problems. An egg weight that is too low could be the result of insufficient feed or water intake, high shed temperatures or disease. If egg weight is too high, birds may be overweight or overfed.

EGG HANDLING

On larger breeder farms, eggs are collected two to three times a day and kept in a cool place for three to four days before setting. If held for longer than seven days, they must be stored at 16 to 17 °C.

Maximum hatchability and chick quality can only be achieved when the egg is held under optimum conditions between laying and setting in the incubator (Cobb-Vantress, 2008b). It is normal practice to sanitize hatching eggs prior to setting. Methods commonly used are formaldehyde fumigation, dipping in ammonium solutions, ultraviolet light and ozone. Eggs should be allowed to cool gradually before being placed in the cool room at a relative humidity of 75 percent.

In larger commercial operations, vehicles that maintain a temperature of 16 to 18 °C are used to transport eggs from the breeder farm to the hatchery. Fertile eggs are also maintained under cool conditions when they are transported by air. During

loading, care must be taken to avoid egg breakages when carrying and stacking the egg fillers. Particular care must be taken when transporting eggs on rough roads, which are common in developing countries.

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Housing and management of broilers

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MANAGING THE ENVIRONMENT

The most important aspect of broiler chick management is producing an environment without temperature fluctuations. This is difficult to achieve in village operations, but commercial systems can do so in a number of ways, through whole-house brooding, or partial house brooding to conserve heat and reduce energy costs (Cobb-Vantress, 2008). Correct temperatures are more easily maintained in a small area. Ventilation also needs to be considered, as it distributes heat to the birds and helps maintain good air quality in the brooding area. Chicks are more susceptible to poor air quality than older birds are. High ammonia levels have been shown to reduce the body weight gains of seven-day chicks by 20 percent.

In semi-commercial and large-scale operations, lights are needed along the brooding area above the heat source in the house, to attract chicks to the feed and water. These lights should be used during the first five days after the chicks arrive, after which background lights should be gradually increased, to reach normal lighting by the tenth day.

A well-insulated roof reduces solar heat penetration into the house on warm days, thus decreasing the heat load on the birds. In village settings, many farmers use discarded iron for roofing, but local leaf material made into thatch is preferable (especially in tropical countries), as it insulates the building from extreme heat.

In cold weather, a well-insulated roof reduces heat loss and the energy consumption needed to maintain the correct environment for broiler chicks during the brooding phase. In poorly insulated buildings, an area can be set up inside the shed where temperature fluctuations can be minimized by using curtains and a false ceiling running from eave to eave, to reduce heat loss and make temperature control easier.

STOCKING DENSITY

It is essential that meat birds have adequate room, whether they are housed in small groups on village farms or in larger semi-commercial or commercial sheds. Lack of space can lead to leg problems, injuries and increased mortality (Sainsbury, 1988). As they approach market weight, an approximate maximum stocking density for fully confined birds on deep litter is 30 kg of bird per square metre of floor area.

DRINKER MANAGEMENT

Providing clean, cool water is critical in broiler production. Without adequate water intake, feed consumption will decline and bird growth will be depressed. There are many types of drinkers; in high temperature conditions, drinkers that allow water circula-

tion and cooling are best. In small-scale operations, it is important to keep drinkers topped up, to clean and refill them daily, and to locate them in a cool part of the pen or cage, away from any heat source or the sun's rays.

FEEDING MANAGEMENT

If feeder space is insufficient, growth rates will be reduced and uniformity will be compromised. Feed distribution and the proximity of the feeder to the birds are essential for achieving optimum feed consumption rates. In tropical developing countries, the main factor reducing feed consumption is high temperatures. Feed should be withheld at the hottest time of the day, to prevent heat stress and the resultant mortality. Pan feeders are better than



Large-scale naturally ventilated broiler house

Photo Credit: Robert Pym



Sector 3 small-scale broiler house (Bhutan)

Photo Credit: Karma Nidup

trough feeders, as they allow unrestricted bird movement around the feeder and there is lower incidence of feed spillage and improved feed conversion.

In most commercial operations, automated pan or trough and chain feeders are used, providing 2.5 cm of feeder space per bird. To reduce feed spillage, the lip of the feeder should be level with the bird's back. An issue in developing countries is ensuring continuity of feed supply. This can be achieved by having a rodent-proof storage area for keeping at least five days of feed consumption. Most village farmers in small-scale operations purchase all the feed required for one grow out. This is essential in remote regions, but farmers must store the feed in strong watertight bins, to reduce the risk of rodent attack and of mould and bacterial growth on the feed.

LITTER MANAGEMENT

Litter management is a crucial aspect of environmental management, and is fundamental to bird health and performance and to final carcass quality. If the litter is too hard, birds will develop lesions on the keel bone. If the litter is allowed to get wet, birds will develop foot lesions, and the associated high ammonia levels will cause respiratory problems and also affect the birds' immune system.

CHICK PLACEMENT MANAGEMENT

In village settings, it is normal to have multi-age flocks. However, it is best practice to place broiler chicks of the same age and flock source in a single house, and attempt to operate an "all-in, all-out" production system. Chicks must be carefully placed and evenly distributed near feed and water throughout the brooding area. If lights are available, they should initially be set at full intensity in the brooding area, to attract the chicks to the feed source. The first two weeks of a broiler chick's life are critical for its future growth.

UNIFORMITY

In large commercial operations, the average weight and uniformity of a flock are usually determined by taking a random sample of approximately 100 birds and recording their individual weights. Of the 100 birds weighed, the number that is within 10 percent of either side of the average body weight is used to calculate the uniformity, expressed in percentage terms. In a village broiler flock housed in a small enclosure it is important that the farmer

identifies the birds that are underweight, and ensures that they have good access to feed and water.

LIGHTING PROGRAMMES

In most village operations, lighting is not provided, although the amount and intensity of light affect broiler activity. Correct stimulation of activity during the first five to seven days of life is necessary for optimal feed consumption, digestion and immune system development. Reducing the energy required for activity during the middle part of the growing period improves production efficiency. Uniform distribution of light throughout the house is essential. It is recommended that 25 lux at chick height be used during the first week of brooding to encourage early weight gains. For optimum performance, light intensity at floor level should not vary by more than 20 percent. After seven days of age, light intensities should be diminished gradually to 5 to 10 lux.

CATCHING PROCEDURES

Feed should be withdrawn about eight to 12 hours before birds are sent to slaughter (Barnett *et al.*, 2001). The purpose of this is to empty the digestive tract and prevent ingested feed and faecal material from contaminating the carcasses during processing. It is important that farmers know the local or national regulations concerning the recommended time for feed withdrawal prior to slaughter.

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Trough and chain automated system of feeding broilers

Housing and management of layers

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CHICK MANAGEMENT

Modern hybrid layers can be reared successfully in floor and cage brooding systems in developing countries. However, they need more careful management than village chicks, which are better able to cope with temperature fluctuations. Prior to chick arrival, it is important to clean and disinfect the cages or the floor brooding area. The brooders should be set up the day before delivery, at 34 to 36 °C for cage brooding or 35 to 36 °C for floor brooding (Hyline International, 2009). Drinkers need to be full or the drinking system in operation, to encourage birds to drink. If nipple drinkers are used, the water pressure should be reduced so that birds can see the drop of water hanging on the drinker. Feed should be placed on paper if birds are reared in cages. Feeders on the floor should be filled and kept under high light intensity for 20 to 22 hours per day for the first week, to attract the birds.

GROWING PERIOD MANAGEMENT

The first 17 weeks of a pullet's life are critical. Careful management during this period will allow the bird to meet her performance potential (Bell and Weaver, 2001). Although it is not always possible to grow pullets in strict isolation from older birds on village farms, it is recommended on semi-commercial and commercial farms. During the first six weeks, it is important to provide feed at least twice a day. After five weeks, feed consumption and body weights must be checked. It is good practice to weigh 100 pullets a week during the growing period, beginning at five weeks of age. Pullets should be moved to cages or the laying house at 16 weeks of age, before the onset of sexual maturity.

FLOOR SYSTEMS MANAGEMENT

Perches should be provided in the growing and laying house environment. This allows the birds to develop their leg and flight muscles, which is essential for their full utilization of the laying house environment. Perches reduce the social stress of birds interacting on the floor, by providing them with a place to roost and get away from other birds in the flock. It is also desirable that birds have access to the same type of feeder and water system in the growing house as they will have in the laying house, although this is not always possible.

Birds also need to adapt to the presence of humans, and walking through a poultry house regularly will socialize them. In the laying period, the lighting times need to be synchronized with those in the rearing facility. When birds are placed in the laying house they need to be encouraged to explore the nest boxes. Commercial-scale operations can do this with nest lights to train the birds to use the nests.



Rearing layer pullets in multiple-bird wire cages

Photo Credit: Robert Pym

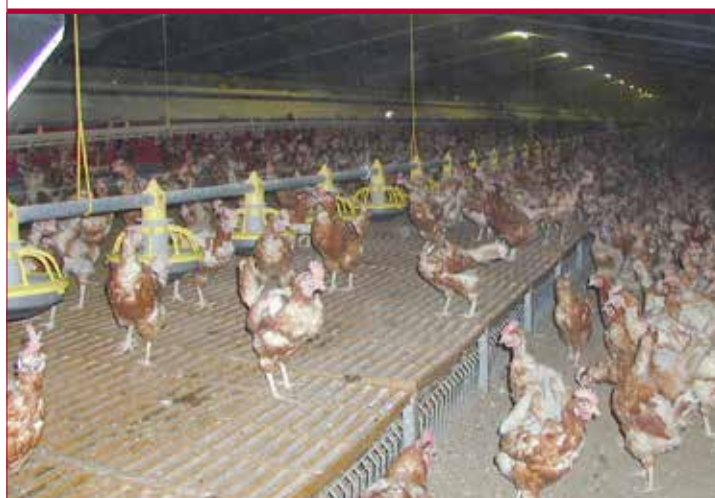


Photo Credit: Phil Glatz



Large-scale modern layer barn (above) and sector 2 layer production unit (Egypt, below)

Photo Credit: Olaf Thieme

LIGHTING PROGRAMME

The egg production of layers is very closely related to the changes in day length to which the pullets are exposed. Egg numbers, size and livability can be markedly influenced by the lighting programme (Lewis and Morris, 2006). An effective lighting programme for houses where outside daylight can be excluded involves giving pullets 20 to 22 hours of light a day at 30 lux in the first week, reducing this to 20 hours at 5 lux in the second week, and then reducing the photoperiod over the following weeks, to reach ten to 12 hours by seven to nine weeks of age.

In open-sided houses, lighting is increased to the longest natural day length from six to 17 weeks of age. It is useful to provide light stimulation when the body weight of commercial hybrids reaches about 1.5 kg. Light can be increased by 15 to 30 minutes per week, until 16 hours of light a day is reached. It is critical that light intensity in housing is increased to 10 to 30 lux. There should be no decrease in day length or light intensity for adult layers. In village poultry production, most birds are exposed to a natural day length, and farmers do not have lighting available to stimulate egg production in village hens.

In developing countries, layers are not generally reared or kept in light-controlled housing.

The onset of sexual maturity or egg production depends on reaching the minimum chronological age and a minimum body weight (usually about 1.5 kg in commercial hybrids), as well as having adequate nutrient intake to support production, and a constant or increasing day length of at least 12 hours.

An optional lighting technique for promoting increased feed consumption is night lighting. This involves turning the lights on for one hour in the middle of the dark period, to allow the birds to feed.

EGG SIZE MANAGEMENT

Egg size is largely genetically determined, but can be manipulated by lighting and feeding programmes. The larger the body weight at maturity, the larger the hen's eggs will be for her entire life. Egg weight is thus generally a reasonable indicator of body weight, but in general the earlier a flock begins production, the smaller the egg size will be, and the later the onset of egg production, the larger the egg size. Lighting programmes can be manipulated to influence rate of maturity (Bell and Weaver, 2001). A decreasing light pattern continuing past ten weeks of age delays maturity and increases average egg size. Egg size is greatly affected by the intake of energy, total fat, crude protein, methionine and cystine



Modern tier-step layer cages: the cages have automated watering, feeding and egg collection

and linoleic acid. Levels of these nutrients can be increased to improve early egg size, and then gradually reduced to control egg size at later ages.

MOULTING

Many producers practise induced moulting of the whole flock, which does not involve fasting of the birds. Commercial birds perform very well after a rest, particularly in the latter weeks of the moult cycle, when they achieve excellent shell quality and persistency. The optimum age for moulting is usually about 65 weeks.

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Semi-intensive sector 3 type layer production (Afghanistan)

Management and housing of semi-scavenging flocks

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The large majority of families in rural regions of many developing countries own small household flocks of semi-scavenging poultry (mostly chickens), which often make significant contributions to poverty alleviation and household food security (Alders and Pym, 2009). However, the increasing density of human settlements has resulted in a decrease in the scavenging feed resource base (SFRB) in urban and peri-urban areas. This, combined with government action associated with the risks of disease transfer, particularly highly pathogenic avian influenza (HPAI), to humans and commercial poultry, is leading to a steady reduction in the number of peri-urban scavenging flocks of family poultry in many countries, and the large majority of these flocks are now located in rural regions.

Small (five to 30-bird) family-owned flocks, usually of indigenous breed or crossbred birds, are given household food scraps and sometimes small amounts of grain or grain by-products, and spend much of their time during daylight hours scavenging around the house and yard for seeds, insects, snails, earthworms, grass, shoots, fallen fruit, frogs, etc., depending on the local environment and season. Household scraps and supplementary grain typically comprise a significant proportion of the energy intake of these birds, particularly in the dry season (see website on Poultry feed availability and nutrition in developing countries). Birds are not usually provided with water, so have to obtain it from the environment. This can have a marked impact on their health and productivity, particularly in the dry season.



Household flock of scavenging chickens provided with night-time shelter under the human dwelling (Myanmar)

HOUSING

One of the defining features of the semi-scavenging production system is the lack of management compared with most other production systems (Gueye, 2000). The birds are very much on their own, and their productivity is usually quite limited by the typically meagre nutritional inputs they receive. Housing is mostly limited to some form of enclosure for the birds at night, to protect them from predation, theft and environmental exposure, and to provide a site for supplementary feeding. Enclosures also make it possible to catch birds for vaccination, although this is by no means a regular or common practice with semi-scavenging poultry. Birds' night shelters may be a separate structure, under the human dwelling, or even within their owner's home. However, it is not unusual for birds to be provided with no shelter, and to roost in trees at night. Where a separate structure is available, it is usually a simple construction made from local materials.

Indigenous breed birds are seldom reared or housed in confinement, as their productivity (egg and meat production), even under good-quality *ad libitum* feeding, is insufficient to warrant the cost of this level of management. Confinement rearing may be justified for some higher-producing indigenous strains or cross-breeds, where there is a niche market for their eggs or meat. Conversely, improved breed/strain commercial birds cannot perform at their genetic potential under semi-scavenging management conditions, so are not suitable for this form of production. The survival of commercial genotypes (particularly broilers) is severely compromised under scavenging systems.



Semi-scavenging poultry production (Lao PDR)



Poultry house for overnight shelter (Mozambique)



House with woven banana-leaf nests for chickens under the eaves (Philippines)

EGG MANAGEMENT AND REPRODUCTIVE PERFORMANCE

Most rural families keeping small flocks of poultry provide the hens with nests; nests constructed of woven banana leaves or similar materials are very suitable and common in the wet tropics. These are often placed off the ground, to reduce problems with predation. The hen typically lays a clutch of ten to 15 eggs in the nest, and then sits on them. In some cases, the owner might take a number of eggs for eating or sale, but in most communities and cultures the majority of the eggs laid are left in the nest to be hatched by the hen. Most indigenous hens are excellent incubators, and typically ten chicks hatch from a setting of 12 eggs. However, in many cases, fewer than five of these will survive to six weeks of age, owing to predation, disease, malnutrition and climatic exposure.

MANAGEMENT INTERVENTIONS

In many countries, aid projects involving scavenging poultry flocks have demonstrated that it is possible to reduce chick attrition rates dramatically by practising confinement rearing of the chicks with the hen for the first week or two, supplemental feeding of the hen and creep-feeding of the chicks over this period, and regular vaccination of all birds in the flock, including chicks, against Newcastle disease (Henning *et al.*, 2009). These measures allow farming families to rear all surviving chicks to about six weeks, but the birds must also be provided with adequate nutrition from the SFRB or supplementary feeding until they are slaughtered or sold. If the SFRB is inadequate, and supplementary feed is either not available or is too expensive, the family has the option of setting fewer eggs under the hen, and either eating or selling the surplus. This is the most sustainable option in most situations, but may not be readily accepted in all cultures and communities.

Males surplus to requirements for breeding or cock fighting are kept for slaughter. Owing to high levels of chick attrition, this will often apply to only one or two birds per hatch. The large majority of village chicken strains in many developing countries grow slowly, even on relatively high levels of nutrition. Birds are typically slaughtered at about 1.0 to 1.5 kg live-weight at somewhere between 12 and 20 weeks of age. Management of these birds is usually the same as for the rest of the flock, receiving household scraps and small amounts of grain or grain by-products every day to supplement their scavenging. The use of larger-bodied cross-bred birds can have deleterious consequences where feed inputs are restricted, as the growing birds may receive sufficient food to meet only their maintenance requirements. This also applies to larger-bodied laying hens, when egg production can suffer.

One of the major constraints to improving productivity in many regions is the limited availability of suitable prepared feed or feed ingredients for hens and young chicks in the first week or two following hatch. In these regions, considerable efforts are needed



Hen and young chicks kept in cages for the first two weeks post-hatch (Philippines)



Improved chicken housing (Afghanistan)

to identify suitable locally available ingredients and diets that provide the nutrients required by chicks and hens at this stage.

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