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FAO ANIMAL PRODUCTION AND HEALTH

manual

SMALL-SCALE POULTRY PRODUCTION

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Foreword

Keeping poultry makes a substantial contribution to household food security throughout the developing world. It helps diversify incomes and provides quality food, energy, fertilizer and a renewable asset in over 80 percent of rural households.

Small-scale producers are however constrained by poor access to markets, goods and services; they have weak institutions and lack skills, knowledge and appropriate technologies. The result is that both production and productivity remain well below potential and losses and wastage can be high. However, adapted breeds, local feed resources and appropriate vaccines are available, along with proven technologies that can substantially improve productivity and income generation.

FAO recognizes the important contribution that poultry can make to poverty alleviation and has programmes that focus on small-scale, low-input, family based poultry production. These programmes target the more vulnerable households especially those affected by natural disasters, HIV Aids and conflict. This manual provides a comprehensive and valuable technical guide for those in government service or aid agencies, wishing to embark on projects that exploit the potential of small-scale poultry production to improve the livelihoods of the rural poor. All aspects of small-scale poultry production are discussed in this book including feeding and nutrition, housing, general husbandry and flock health. Regional differences in production practices are described.

FAO acknowledges and commends the effort that the authors have put into making such a comprehensive and valuable reference for those involved in poultry production in the developing world. The views expressed are, however, those of the authors and do not necessarily reflect those of FAO. Members of the International Network for Family Poultry Development (INFPD) have been involved in producing and reviewing this document and their contribution is also gratefully acknowledged. A major aim of the INFPD is to bring together and disseminate technical information that supports small-scale poultry producers throughout the world.

Chapter 1
Introduction

The socio-economic Importance of Family Poultry

Family poultry is defined as small-scale poultry keeping by households using family labour and, wherever possible, locally available feed resources. The poultry may range freely in the household compound and find much of their own food, getting supplementary amounts from the householder. Participants at a 1989 workshop in Ile-Ife, Nigeria, defined rural poultry as a flock of less than 100 birds, of unimproved or improved breed, raised in either extensive or intensive farming systems. Labour is not salaried, but drawn from the family household (Sonaiya 1990b). Family poultry was additionally clarified as "small flocks managed by individual farm families in order to obtain food security, income and gainful employment for women and children" (Branckaert, as cited in Sonaiya, 1990c). Family poultry is quite distinct from medium to large-scale commercial poultry farming.

Family poultry is rarely the sole means of livelihood for the family but is one of a number of integrated and complementary farming activities contributing to the overall well-being of the household. Poultry provide a major income-generating activity from the sale of birds and eggs. Occasional consumption provides a valuable source of protein in the diet. Poultry also play an important socio-cultural role in many societies. Poultry keeping uses family labour, and women (who often own as well as look after the family flock) are major beneficiaries. Women often have an important role in the development of family poultry production as extension workers and in vaccination programmes.

For smallholder farmers in developing countries (especially in low income, food-deficient countries [LIFDC]), family poultry represents one of the few opportunities for saving, investment and security against risk. In some of these countries, family poultry accounts for approximately 90 percent of the total poultry production (Branckaert, 1999). In Bangladesh for example, family poultry represents more than 80 percent of the total poultry production, and 90 percent of the 18 million rural households keep poultry. Landless families in Bangladesh form 20 percent of the population (Fattah, 1999, citing the Bangladesh Bureau of Statistics, 1998) and they keep between five and seven chickens per household. In LIFDC countries, family poultry-produced meat and eggs are estimated to contribute 20 to 30 percent of the total animal protein supply (Alam, 1997, and Branckaert, 1999), taking second place to milk products (38 percent), which are mostly imported. Similarly, in Nigeria, family poultry represents approximately 94 percent of total poultry keeping, and accounts for nearly four percent of the total estimated value of the livestock resources in the country. Family poultry represents 83 percent of the estimated 82 million adult chickens in Nigeria. In Ethiopia, rural poultry accounts for 99 percent of the national total production of poultry meat and eggs (Tadelle *et al.*, 2000).

Poultry are the smallest livestock investment a village household can make. Yet the poverty-stricken farmer needs credit assistance even to manage this first investment step on the ladder out of poverty. Poultry keeping is traditionally the role of women in many developing countries. Female-headed households represent 20 to 30 percent of all rural households in Bangladesh (Saleque, 1999), and women are more disadvantaged in terms of options for income generation. In sub-Saharan Africa, 85 percent of all households keep poultry, with women owning 70 percent of the poultry. (Guéye, 1998 and Branckaert, 1999, citing World Poultry 14).

Income generation is the primary goal of family poultry keeping. Eggs can provide a regular, albeit small, income while the sale of live birds provides a more flexible source of cash as required. For example, in the Dominican Republic, family poultry contributes 13 percent of the income from animal production (Rauen *et al.*, 1990). The importance of poultry to rural households is illustrated by the example below from the United Republic of Tanzania (see Table 1.1). Assuming an indigenous hen lays 30 eggs per year, of which 50 percent are consumed and the remainder have a hatchability of 80 percent, then each hen will produce 12 chicks per year.

Assuming six survive to maturity (with 50 percent mortality), and assuming that three pullets and three are cockerels, the output from one hen projected over five years would total 120 kg of meat and 195 (6.8 kg) eggs.

Table 1.1 Projected output from a single initial hen (United Republic of Tanzania)

Time (months)	Nº of hatching eggs	Nº of cockerels	Nº of pullets	Nº of cocks	Nº of hens	Nº of culls
0	-	-	1	-	-	-
8	-	-	-	-	1	-
20	15	3	3	-	-	1
28	-	-	-	3	3	-
40	45	9	9	-	-	6
48	-	-	-	9	9	-
60	135	27	27	-	-	18
Total	195	39	40	12	13	25

Source: Kabatange and Katule, 1989.

A study on income generation in transmigrant farming systems in East Kalimantan, Indonesia (see Table 1.2), showed that family poultry accounted for about 53 percent of the total income, and was used for food, school fees and unexpected expenses such as medicines (Ramm *et al.*, 1984).

Flock composition is heavily biased towards chickens in Africa and South Asia, with more ducks in East Asia and South America. Flock size ranges from 5 – 100 in Africa, 10 – 30 in South America and 5 – 20 in Asia. Flock size is related to the poultry farming objectives of:

- home consumption only;
- home consumption and cultural reasons;
- income and home consumption; and
- income only.

(See Table 1.3.)

In Bangladesh (Jensen, 1999), the average production rate per local hen of 50 eggs/year was regarded by some as low productivity. However, if it is considered that 50 eggs per hen per year represents four hatches from four clutches of eggs laid, incubated and hatched by the mother hen, and the outcome is 30 saleable chicken reared per year (assuming no eggs sold or eaten, 80 percent hatchability and 25 percent rearing mortality), then it is a remarkably high productivity.

PRODUCTION SYSTEMS

Family poultry are kept under a wide range of conditions, which can be classified into one of four broad production systems (Bessei, 1987):

- free-range extensive;
- backyard extensive;
- semi-intensive; and
- intensive.

Indicative production levels for the different systems are summarized in Table 1.4.

Table 1.2 Annual budget for a family farm with 0.4 ha irrigated paddy, 0.1 ha vegetable garden, 100 ducks and two buffaloes in Indonesia

	Unit	Rupees
Annual expenses		
Crops		1 198 000
Animals:		
- Buffaloes		
- Ducks		1 147 200
Subtotal		2 345 200
Annual revenue		
Crops:		
- Maize	240 kg	96 000
- Rice	4 000 kg	2 000 000
- Cassava	600 kg	60 000
- Peanut	60 kg	60 000
- Soybean	60 kg	30 000
- Mixed garden		150 000
Subtotal Crops		2 396 000
Animals:		
- Buffaloes - meat	150 kg	300 000
- draft	30 days	180 000
Subtotal Buffaloes		480 000
- Ducks - eggs	13 140 eggs	5 256 000
Subtotal Animals		5 736 000
Annual net return to family labour from crops		1 198 000 (20.7%)
Annual net return to family labour from livestock		
- Buffaloes		480 000 (8.3%)
- Ducks		4 108 800 (71.0%)
Total return to family labour from agriculture		5 786 800 (100%)

Source: Setioko, 1997.

Table 1.3 Flock size and poultry farming objectives in Nigeria

Objectives	Flock size	% of sample
Home consumption only	1-10	30
Home consumption and cultural reasons	1-10	
Income and home consumption	11-30	44
Income only	>50	10.5

Source: Sonaiya, 1990a.

Free-Range Extensive Systems

In Africa, Asia and Latin America, 80 percent of farmers keep poultry in the first two extensive systems. Under free-range conditions, the birds are not confined and can scavenge for food over a wide area. Rudimentary shelters may be provided, and these may or may not be used. The birds may roost outside, usually in trees, and nest in the bush. The flock contains birds of different species and varying ages.

Backyard Extensive Systems

Poultry are housed at night but allowed free-range during the day. They are usually fed a handful of grain in the morning and evening to supplement scavenging.

Semi-Intensive Systems

These are a combination of the extensive and intensive systems where birds are confined to a certain area with access to shelter. They are commonly found in urban and peri-urban as well as rural situations. In the "**run**" system, the birds are confined in an enclosed area outside during the day and housed at night. Feed and water are available in the house to avoid wastage by rain, wind and wild animals.

In the European system of free-range poultry keeping, there are two other types of housing. The first of these is the "**ark**" system, where the poultry are confined overnight (for security against predators) in a building mounted on two rails or skids (usually wooden), which enable it to be moved from place to place with draught power. A typical size is 2 × 2.5 m to hold about 40 birds.

The second type of housing is the "**fold**" unit, with a space allowance (stock density) for adult birds of typically 3 to 4 birds per square metre (birds/m^2), both inside and (at least this) outside. The fold unit is usually small enough to be moved by one person. Neither of these two systems is commonly found in developing countries.

Intensive Systems

These systems are used by medium to large-scale commercial enterprises, and are also used at the household level. Birds are fully confined either in houses or cages. Capital outlay is higher and the birds are totally dependent on their owners for all their requirements; production however is higher. There are three types of intensive systems:

- **Deep litter system**: birds are fully confined (with floor space allowance of 3 to 4 birds/m^2 within a house, but can move around freely. The floor is covered with a **deep litter** (a 5 to 10 cm deep layer) of grain husks (maize or rice), straw, wood shavings or a similarly absorbent (but non-toxic) material. The fully enclosed system protects the birds from thieves and predators and is suitable for specially selected commercial breeds of egg or meat-producing poultry (layers, breeder flocks and broilers).
- **Slatted floor system**: wire or wooden slatted floors are used instead of deep litter, which allow stocking rates to be increased to five birds/m^2 of floor space. Birds have reduced contact with faeces and are allowed some freedom of movement.
- **Battery cage system**: this is usually used for laying birds, which are kept throughout their productive life in cages. There is a high initial capital investment, and the system is mostly confined to large-scale commercial egg layer operations.

Intensive systems of rearing indigenous chickens commercially is uncommon, a notable rare exception being in Malaysia, where the industry developed in response to the heavy demand for indigenous chickens in urban areas (Supramaniam, 1988). However, this accounts for only two in every 100 000 (0.002 percent) of that country's indigenous chicken.

Table 1.4 Production and reproduction per hen per year under the different management systems

Production system	Nº of eggs per hen/year	Nº of year-old chickens	Nº of eggs for consumption and sale
Scavenging (free-range)	20-30	2-3	0
Improved scavenging[1/]	40-60	4-8	10-20
Semi-intensive	100	10-12	30-50
Intensive (deep litter)	160-180	25-30	50-60
Intensive (cages)	180-220	-	180-220

[1/] improved shelter and Newcastle Disease vaccination

Source: Bessei, 1987.

The above management systems frequently overlap. Thus free-range is sometimes coupled with feed supplementation, backyard with night confinement but without feeding, and poultry cages in confined spaces (Branckaert and Guèye, 1999).

Conclusions

Over the last decade, the consumption of poultry products in developing countries has grown by 5.8 percent per annum, faster than that of human population growth, and has created a great increase in demand. Family poultry has the potential to satisfy at least part of this demand through increased productivity and reduced wastage and losses, yet still represent essentially low-input production systems. If production from family poultry is to remain sustainable, it must continue to emphasize the use of family labour, adapted breeds and better management of stock health and local feed resources. This does not exclude the introduction of appropriate new technologies, which need not be sophisticated. However, technologies involving substantially increased inputs, particularly if they are expensive (such as imported concentrate feeds or genetic material) should be avoided. This is not to say that such technologies do not have a place in the large-scale commercial sector, where their use is largely determined by economic considerations.

Development initiatives in the past have emphasized genetic improvement, usually through the introduction of exotic genes, arguing that improved feed would have no effect on indigenous birds of low genetic potential. There is a growing awareness of the need to balance the rate of genetic improvement with improvement in feed availability, health care and management. There is also an increased recognition of the potential of indigenous breeds and their role in converting locally available feed resources into sustainable production.

This manual aims to provide those involved with poultry development in developing countries with a practical guide and insight into the potential of family poultry to improve rural livelihoods and to meet the increasing demand for poultry products.

Chapter 2
Species and Breeds

Different Poultry Species and Breeds

All species of poultry are used by rural smallholders throughout the world. The most important species in the tropics are: chickens, guinea fowl, ducks (including Muscovy ducks), pigeons, turkeys and geese. Local strains are used, but most species are not indigenous. The guinea fowl (*Numididae)* originated in West Africa; the Muscovy duck (*Cairina moschata*) in South America; pigeons *(Columba livea*) in Europe; turkeys *(Meleagrididae)* in Latin America; pheasants (*Phasianidae*) in Asia; the common duck *(Anas)* in Europe; and geese (*Anser*) in Asia.

Flock composition is determined by the objectives of the poultry enterprise (see Chapter 1). In Nigeria for example, the preference is for the smooth-feathered, multicoloured native chickens or Muscovy ducks. Multicoloured feathers serve as camouflage for scavenging birds against predators, including birds of prey, which can more easily see solid colours (especially white). Foundation stock is usually obtained from the market as grower pullets and young cockerels. A hen to cock ratio of about 5:1 is common. Both sexes are retained for 150 to 300 days, for the purposes of culling, selling, home consumption and gifts, most of which require adult birds.

In the last 50 years, there has been a great advance in the development of hybrid breeds for intensive commercial poultry production. This trend is most noticeable in chickens, turkeys and ducks. The new hybrids (those of chickens in particular) are widely distributed and are present in every country in the tropics, even in the most remote villages. The hybrids have been carefully selected and specialised solely for the production of either meat or eggs. These end-product-specialised hybrid strains are unsuitable for breeding purposes, especially for mixing with local village scavenger stock, as they have very low mothering ability and broodiness.

For the smallholder, keeping hybrids means considerable changes are required in management. These changes are expensive for the following reasons:

- All replacement day-old chicks must be purchased.
- Hatchery chicks require artificial brooding and special starting feed.
- Hybrids require higher quality balanced feed for optimum meat and egg production.
- Hybrids require more careful veterinary hygiene and disease management.
- Egg-laying hybrid hens require supplementary artificial light (a steadily increasing day-length up to 17 hours of total light per day) for optimum (profitable) egg production.

The meat and eggs from intensively raised hybrid stock are considered by many traditional consumers to have less flavour, and the meat to have too soft a texture. Consumers will thus often pay a higher price for village-produced poultry meat and eggs. Thus for rural family poultry keepers, it is more appropriate to maintain and improve local birds to meet this demand.

Chickens

Chickens originated in Southeast Asia and were introduced to the rest of the world by sailors and traders. Nowadays, indigenous village chickens are the result of centuries of cross-breeding with exotic breeds and random breeding within the flock. As a result, it is not possible to standardize the characteristics and productive performance of indigenous chickens.

There is no comprehensive list of the breeds and varieties of chickens used by rural smallholders, but there is considerable information on some indigenous populations from various regions. Most of this is based on feather colour and other easily measured body features (genetic traits), but more detailed data are becoming available. Examples of local chickens from different parts of the tropics are given in Tables 2.1 to 2.3 below. These evaluations were usually carried out under intensive management conditions in research stations, as the objective was to evaluate the local birds' productivity. More recently, data on the performance of local chickens under extensive management have become available, which makes it possible to compare performance under extensive and intensive systems (see Table 2.3).

Table 2.1 Performance of local breeds in South Asia (intensively housed)

Traits	Desi	Naked Neck	Aseel	Kadak-anath	Black Bengal
12 wk live wt (g)	544	629	640	NA	433
Age at 1st egg (d)	208	NA	219	NA	200
Eggs/hen/year	116	104	100	80	NA
Egg wt (g)	46	45	51	39	49
Fertility (%)	81	80	55	90	86
Hatchability (%)	55	61	45	61	68

Source: Acharya and Kumar, 1984. *Desi* means “local” (as in Bangladeshi)

Characteristics such as adult body weight and egg weight vary considerably among indigenous chicken populations, although reproductive traits, such as the number of laying seasons per year, the number of eggs per clutch and hatchability are more consistent. *Desi* hens in Bangladesh range from 190 to 200 days of age at first egg (an easy measure of age-at-sexual-maturity), and they lay 10 to 15 eggs per season in 3 to 4 clutches (3 to 4 times) per year, with a hatchability of 84 to 87 percent (percent of eggs set) (Haque , 1999).

Table 2.2 Local chicken breeds of Ethiopia

Traits	Tukur	Melata	Kei	Gebsima	Netch
24 wk body wt (g)	960	1000	940	950	1180
Age at 1st egg (d)	173	204	166	230	217
Eggs/bird.yr	64	82	54	58	64
Egg wt (g)	44	49	45	44	47
Fertility (%)	56	60	57	53	56
Hatchability (%)	42	42	44	39	39

Source: Shanawany & Banerjee, 1991 as cited in Forssido, 1986; Australian Agricultural Consultancy and Management Company, 1984; Beker and Banerjee, 1990.

Indigenous village birds in Ethiopia attain sexual maturity at an average age of seven months (214 days). The hen lays about 36 eggs per year in three clutches of 12 to 13 eggs in about 16 days. If the hen incubates her eggs for three weeks and then rears the chicks for twelve weeks, then each reproductive cycle lasts for 17 weeks. Three cycles then make one year. These are very efficient, productive and essential traits for survival.

Guinea fowl

Guinea fowl are native to West Africa but are now found in many parts of the tropics, and are kept in large numbers under intensive systems in France, Italy, the former Soviet Union and Hungary. In India, guinea fowl are raised in parts of the Punjab (Shingari *et al.*, 1994), Uttar Pradesh, Assam and Madhya Pradesh, usually in flocks of a few hundred birds. Guinea fowl are seasonal breeders, laying eggs only during the rainy season, under free-range conditions. They are very timid, roosting in trees at night, and although great walkers, they fly very little.

Guinea fowl thrive in both cool and hot conditions, and their potential to increase meat and particularly egg production in developing countries deserves better recognition. The first egg is normally laid at about 18 weeks of age, and unlike many indigenous birds (which produce a single clutch a year), guinea hens lay continuously until adverse weather sets in. In West Africa, laying is largely confined to the rainy season. Guinea hens under free-range conditions can lay up to 60 eggs per season, while well-managed birds under intensive management can lay up to 200 eggs per year. The guinea hen "goes broody" (sits on eggs in the nest) after laying, but this can be overcome by removing most of the eggs. A clutch of 15 to 20 eggs is common, and the incubation period for guinea fowl is 27 days. Domesticated guinea fowl under extensive or semi-intensive management in Nigeria were reported to lay 60 to 100 eggs with a fertility rate of 40 to 60 percent.

Table 2.3 Performance of local chicken breeds under scavenging and intensive management systems

System	Country	Breed	Body Wt (g)	Egg Nº	Egg Wt (g)
Scavenging					
Africa	Burundi	Local	1 500	75	40
	Mali	Local	1 170	35	34
	United Rep.Tanzania	Local	1 200	70	41
Asia	Indonesia	Kampung	2 000	35	-
	Malaysia	Kampung	1 430	55	39
	Bangladesh	Local	1 140	40	37
	Thailand	Thai	1 400	40	48
	Thailand	Betong	1 900	18	45
	Thailand	Samae	2 300	70	-
Latin America	Dom. Rep.	Local	1 500	100	38
	Bolivia	Local	1 500	100	-
Intensive					
Africa	Egypt	Fayoumi	1 354	150	43
	Egypt	Dandarawi	-	140	45
	Egypt	Baladi	1 330	151	40
	Nigeria	Local	1 500	125	36
	United Rep. Tanzania	Local	1 652	109	46
	Uganda	Local	1 500	40	50
	Zambia	Local	1 500	35	52
Asia	Bangladesh	Desi	1 300	45	35
	India	Kadakanath	1 125	80	40
	Indonesia	Ayam Nunukan	2 000	150	48
	Indonesia	Ayam Kampung	1 350	104	45

Sources: Compiled from Horst, 1989; Katule, 1991; Horst *et al.*, 1996; Haque, 1999.

Domesticated guinea fowl are of three principal varieties: Pearl, White and Lavender. The Pearl is by far the most common. It has purplish-grey feathers regularly dotted or "pearled" with white. The White guinea fowl has pure white feathers while the Lavender has light grey feathers dotted with white. The male and female guinea fowl differ so little in appearance (feather colour and body weight [1.4 to 1.6 kg]) that the inexperienced farmer may unknowingly keep all males or all females as "breeding" stock. Sex can be distinguished at eight weeks or more by a difference in their voice cry.

Domesticated guinea hens lay more eggs under intensive management. French Galor guinea hens can produce 170 eggs in a 36-week laying period. For example, from a setting of 155 eggs, a fertility rate of 88 percent and hatchability of 70 to 75 percent, it is possible to obtain 115 guinea keets (chicks) per hen. In deep litter or confined range conditions, a 24-week laying period can produce 50 to 75 guinea keets per hen.

Table 2.4 Reproduction and egg characteristics of guinea fowl varieties

Traits	Variety		
	Pearl	Lavender	White
Age at 1st egg (d)	196	217	294
Eggs/hen/year	51	38	43
Egg wt (g)	38	37	36
Laying (d/yr)	155	114	92
Fertility (%)	53	50	0.0
Hatchability (%)	87	81	0.0

Source: Ayorinde, 1987 and Ayorinde *et al.,* 1984.

Ducks

Ducks have several advantages over other poultry species, in particular their disease tolerance. They are hardy, excellent foragers and easy to herd, particularly in wetlands where they tend to flock together. In Asia, most duck production is closely associated with wetland rice farming, particularly in the humid and subtropics. An added advantage is that ducks normally lay most of their eggs within the three hours after sunrise (compared with five hours for chickens). This makes it possible for ducks to freely range in the rice fields by day, while being confined by night. A disadvantage of ducks (relative to other poultry), when kept in confinement and fed balanced rations, is their high feed wastage, due to the shovel-shape of their bill. This makes their use of feed less efficient and thus their meat and eggs more expensive than those of chickens (Farrell, 1986). Duck feathers and feather down can also make an important contribution to income.

Different breeds of ducks are usually grouped into three classes: meat or general purpose; egg production; and ornamental.

Ornamental ducks are rarely found in the family poultry sector. Meat breeds include the Pekin, Muscovy, Rouen and Aylesbury. Egg breeds include the brown Tsaiya of Taiwan Province of China, the Patero Grade of the Philippines, the Indian Runner of Malaysia and the Khaki Campbell of England. All these laying breed ducks originate from the green-headed Mallard *(Anas platyrhynchos platyrhynchos).* The average egg production of the egg breeds is approximately 70 percent (hen.day basis). The Indian Runner, Khaki Campbell, Pekin and Muscovy are the most important breeds in rural poultry.

The Indian Runner

This is a very active breed, native to Asia, and ideal for free-range. It is a very good egg layer and needs less water than most other breeds, requiring only a basin in which it can immerse its beak up to the nostrils. It is the most graceful and elegant of all ducks on land with its upright carriage and slim body. It stands at an angle of about 80° to the ground but when startled can be almost perpendicular.

The Khaki Campbell

Originally bred in England, this breed is derived from three breeds: the wild Mallard, the Rouen and the Indian Runner. The female has an overall khaki colour, and the male has a bronze-green head. The female is best known for her prolific egg laying ability, with an average of 90 percent (on a hen/day basis) with an average 73 gram egg weight.

The Pekin

Originally bred in China, this attractive meat breed is favoured by commercial producers throughout the world. It is large and meaty with an upright stance and a broad round head. It has white to lemon-yellow plumage and a yellow skin. It is hardy, a reasonable layer, and grows rapidly. Although timid, it is docile and easily confined by low fences. It is well suited to both large, specialized duck farms and smallholdings. Pekin ducks are the major meat duck breed in Thailand, Malaysia, Philippines, the Democratic People’s Republic of Korea and China.

The Muscovy

This is not genetically a duck or a goose, but is more similar to the goose *(Anseridae).* It eats grass, as do geese, and has a similarly long egg incubation period of 36 days (compared with that of ducks - 28 days). It is popular in areas where there is little wetland rice production, since it does not require swimming water. The female Muscovy is an excellent brooding mother. It is often used as a foster brooder-mother for other species such as ducks, chickens and guinea fowls. It is a poor layer, producing only 30 to 40 eggs per year under extensive management. The male Muscovy can become very large (4.5 to 5.5 kg) while the female is smaller (2.3 to 2.8 kg). The feather colouring is usually a combination of black and white, ranging from mostly black to mostly white. The male has characteristic red fleshy outcrops around the eyes called *caruncles*. The Muscovy is the predominant waterfowl in Africa and Latin America, as it thrives well under free-range conditions. Numbers are increasing in parts of Asia where lean, red meat is popular (Hahn *et al.,* 1995). When mated with breeds of domestic ducks, they produce infertile hybrid offspring ("mule" ducks). These mule ducks are a major source of duck meat in Taiwan Province of China. A three-way cross-system is used for white mule duck production. Firstly, Pekin drakes are crossed with white Tsaiya ducks to produce a cross-bred female line called the Kaiya duck. These are then crossed with large white Muscovy drakes, usually by artificial insemination. The resulting progeny is a mule duck, which is sterile but grows rapidly. It has good carcass composition with more meat and less fat than the Pekin. These three-way crosses have the added advantages of the high egg production of the Tsaiya, the high growth rate of the Pekin and the good carcass quality and meat texture of the Muscovy. Their white feathers are more valuable as down than those of darker-feathered ducks.

Table 2.5 Duck breeds and their traits

Breed	Feather Colour	Body weight (kg)		Egg colour
		Drake	Duck	
Pekin	White	4.1	3.6	White / Blue green
Muscovy	Black/White	4.5	3.0	White / Green cream
Indian Runner	White	2.0	1.8	White / Creamy white
Khaki Campbell	Brown/Khaki	2.0	1.8	White
Mallard	"	1.4	1.1	Blue green / Mottled

Source: Hahn *et.al.*, 1995

In most tropical countries, there are local duck breeds that have been selected to suit local conditions. They may not perform as well as improved breeds, but they do have the ability to survive and produce well under local extensive and semi-intensive systems. Setioko (1997) described three Indonesian ducks: Tegal, Alabio and Bali. Improved genotypes have been introduced and have either been crossed with local ducks or remained reasonably pure. There was some concern about the ability of the improved genotypes to survive under traditional farming systems. Trials conducted in the Mekong River Delta by The Bin (1996) found that hybrid ducks raised for **meat** in rice fields were more profitable than the local ducks, even though they consumed more feed and cost more to buy initially. However, when raised for **egg** production in rice fields and on canals, the hybrids did not perform as well as the local ducks.

Geese

Geese are less important in family poultry production, except in China, where mainly local breeds are kept, except for a few European breeds such as the Toulouse and White Roman, imported for cross-breeding purposes. The great variety in breed size of geese permits their use under various management conditions. At the less intensive levels of production preferred by most family producers, smaller-sized birds (weighing approximately 4 kg, such as the Lingxhian or Zie breeds in China) are easier to manage. Geese are high in the broodiness trait, and have a consequent low egg production of 30 to 40 hatching eggs (in three to five laying cycles) per year. At the other extreme are breeds of high fertility (and egg number), which are smaller and are selected specifically for use in breeding flocks for their lack of broodiness. Breeds such as the Zie may lay 70 to 100 eggs annually. The importance of the wide gene pool variety in China is significant for the Asian region in particular and for the world in general.

Pigeons

Pigeons are scavengers (not fed any supplementary feed) in most countries, living on the roofs of houses and treated as "pets" that do not need to be fed. They appear to prefer homestead compounds to fields. In some countries, they are eaten only for ritual purposes. They normally lay two eggs in a clutch, and the young birds (squabs) hatch after 16 to 17 days. The growing squabs are fed by their mothers on *crop milk*, produced in the mother's crop (first stomach). This enables young squabs to grow very rapidly. They reach maturity in three to five months at a body weight of 200 to 300 g for males, and 150 g for females. Adult pigeons are monogamous for life.

Local pigeons are specific to different regions in the tropics. Africa has five breeds, within which Chad has three local breeds. Asia and the Pacific have five breeds, with local breeds found specific even to the Cook Islands. Latin America and the Caribbean islands have only one breed. Europe has six breeds, two of which come from Belgium.

Turkeys

These birds are native to Latin America. The breeds kept by rural producers in the tropics usually have black feathers, as distinct from the white-feathered breeds that are raised intensively. Where there are no geese and ostriches, they are the largest birds in the farming system. Body weight ranges from 7 to 8 kg in males and from 4 to 5 kg in hens. They have good meat conformation, produce about 90 eggs per year and have medium to good hatchability. They are more susceptible to disease than either chicken or ducks.

Chapter 3
Feed Resources

INTRODUCTION

A regular supply of low-cost feed, over and above maintenance requirements, is essential for improved productivity in the three farming systems used in family poultry production:

- free-range – poultry roost in trees at night;
- backyard – poultry are confined at night; and
- semi-intensive – poultry are enclosed during the day in a very limited scavenger resource base.

When feed resources are inadequate, a few birds in production are better than more birds just maintained, but without enough food for production.

Extensive Systems

Farmers attempt to balance stock numbers according to the scavenging feed resources available in the environment in each season. Under the free-range and backyard systems, feed supplies during the dry season are usually inadequate for any production above flock-maintenance level. When vegetation is dry and fibrous, the scavenging resources should be supplemented with sources of minerals, vitamins, protein and energy. Under most traditional village systems, a grain supplement of about 35 g per hen per day is given.

There have been various approaches to utilising a wider base of feed resources for the flock. One is the use of poultry species apart from chicken. Waterfowl, especially ducks, may be distributed throughout the wetland rural areas, where they can feed on such resources as snails and aquatic plants in ponds and lagoons. Another approach is the integration of poultry with the production of rice, vegetables, fish and other livestock. An example is the combination of chicken with cattle, as practised by the Fulani of Nigeria, where the chickens feed on the ticks on the cattle as well as on the maggots growing in the cattle dung. Chickens raised in the cattle kraal (compound) weighed an average of 500 g more than those in the same neighbourhood but outside the kraal (Atteh and Ologbenla, 1993).

Semi-Intensive System

Under the semi-intensive system, all the nutrients required by the birds must be provided in the feed, usually in the form of a balanced feed purchased from a feed mill. As these are often expensive and difficult to obtain, smallholders use either unconventional feedstuffs or “dilute” the commercial feed by supplementing it with grain by-products (which supply energy and some protein). A well-balanced feed however is difficult to achieve, as grains and plant protein sources (the by-products of a few oil seeds) are becoming increasingly unavailable for livestock, and premixed trace minerals and vitamins are usually too expensive for smallholders. Phosphorus and calcium can be obtained from ashed (burnt and crushed) bones; and calcium from snail shells, fresh or seawater shellfish shells, or limestone deposits. Salt to supply sodium can come from evaporated seawater or land-based rock salt deposits. These mineral sources are rarely used. Feed provided for birds kept under this system is therefore of a much poorer quality (unbalanced by dilution with crop by-products) than under either the extensive or fully intensive system.

AVAILABLE FEED RESOURCES

The size and productivity of the village flock ultimately depend on the human population and its household waste and crop residues, and on the availability of other scavengable feed resources. There is a clear relationship between egg production and nutrient intake. This is demonstrated in

Bangladesh, where fewer eggs are laid in the rainy season from August to September, but when snails are available in January and February, production increases (ter Horst, 1986). A list of feed resources available to smallholders was compiled from surveys undertaken in Nigeria (Sonaiya, 1995). These feedstuffs were mostly by-products of home food processing and agro-industries, and were similar to those found in other tropical countries.

The Scavengable Feed Resources Base (SFRB) include:

- household cooking waste;
- cereal and cereal by-products;
- roots and tubers;
- oilseeds;
- trees, shrubs (including *Leucaena, Calliandra* and *Sasbenia)* and fruits;
- animal proteins;
- aquatic plants (*Lemna, Azolla* and *Ipomoea aquatica*); and,
- commercially prepared feed.

These resources are described in greater detail in the following section.

The Scavengeable Feed Resource Base

Gunaratne *et al.* (1993; 1994), Roberts and Senaratne (1992), Roberts *et al.* (1994) and Roberts (1999) have researched and classified the feed resources available for scavenging poultry in Southeast Asia, which they named the Scavengeable Feed Resource Base (SFRB). The SFRB was defined as the total amount of food products available to all scavenging animals in a given area. It depends on the number of households, the types of food crops grown and their crop cultivating and crop processing methods, as well as on the climatic conditions that determine the rate of decomposition of the food products. Seasonal fluctuations in the SFRB occur due to periods of fallow or flooding, cultivation, harvesting and processing. The SFRB includes termites, snails, worms, insects, grain from sowing, harvesting by-products, seeds, grass, fodder tree leaves, water-plants and non-traditional feed materials. The SFRB can only be harvested by scavenging animals, of which poultry are the most versatile, although this varies with species. Several types of poultry scavenging together can make more effective use of this resource.

Keeping poultry under the free-range and backyard systems depends to a large degree on the quality of the feed available from scavenging. Therefore it is essential to know what feed resources are available. For example: a flock of 12 young growing chickens with five productive hens have access to an SFRB of 450 g (dry weight) containing nine percent protein and 2 300 kcal of metabolizable energy (ME)/kg. This supports about 22 percent daily egg production, with about three eggs/clutch, assuming 80 percent of the SFRB was utilized.

Methods of estimating SFRB

The value of the SFRB can be estimated by weighing the amount of daily food product/household waste generated by each family as parameter “H”, which is then divided by the proportion of food product/household waste found in the crop of the scavenging bird (assessed visually) as parameter “p” (Roberts, 1999). This is then multiplied by the percentage of households that keep chickens (parameter “c”):

SFRB = H/p(c)

For example, an SFRB measured using the above method in Southeast Asia ranged from 300 to 600 g on a Dry Matter (DM) basis, containing eight to ten percent of vegetable protein and 8.8 to 10.4 megajoules (MJ) of metabolisable energy (ME) per kg (2 100-2 500 kilocalories [kcal] ME per kg) (Prawirokusumo, 1988; Gunaratne *et al.*, 1993 and 1994). The amount of protein and ME in the SFRB was determined by analysis of the crop content. In Sri Lanka, the annual SFRB available to each family was calculated to contain 23 kg of Crude Protein (CP) and 1959 MJ of ME (468 mega [M] cal of ME) (Gunaratne *et al.,* 1993).

In a case study conducted in Sri Lanka, collections of daily waste from 34 households were made on 14 occasions (Gunaratne *et al*., 1993). The collections were weighed, examined and analysed for approximate composition, calcium and phosphorus. Fifteen scavenging hens were collected late in the morning and slaughtered and their crop and gizzard contents examined and weighed.

The results indicated that the fresh weight of food product/household waste per household averaged 460 ±210 g per day and consisted of:

- 26 percent cooked rice;
- 30 percent coconut residue;
- 8 percent broken rice; and
- 36 percent other (vegetable trimmings, egg shells, bread, dried fish and scraps).

The crop contents are shown below after Table 3.1.

Table 3.1 Calculated values of SFRB for family flocks in different countries of Southeast Asia

Country	SFRB as kg DM/year	Source
Indonesia	475	Kingston and Creswell, 1982
Thailand	390	Janviriyasopak *et al.*, 1989
Sri Lanka	195	Gunaratne *et al.*, 1993
Sri Lanka	197	Gunaratne *et al.*, 1994

Source: Gunaratne *et al.*, 1993.

The crop contents comprised:

- 72 percent household waste;
- 13 percent grass;
- 8 percent animal matter (earthworms, snails, ants and flies); and
- 7 percent paddy rice.

For composition details of crop contents and food/products household waste, see Table 3.2 below.

Each family flock had access to the food product/household waste from two households, so that on average the amount available to the household flock was 550 g of Dry Matter per day. Daily egg production ranged from 11 to 57 percent, with an average of 30 percent. This did not vary significantly over the 12 months of the study. Chicken body weight at 20 days ranged from 41 to 100 g, and at 70 days from 142 to 492 g. Mortality up to 70 days was 65 percent. Losses were attributed to predators, particularly dogs, cats, mongooses, crows and other birds of prey. More than 90 percent of the hen’s day was spent scavenging over a radius of 110 to 175 m. Cattle and goat pens were favourite scavenging areas.

Table 3.2 Average composition of major feed components and crop content of scavenging hens in Sri Lanka

Component	DM	CP	EE	CF	Ash	Ca	P
	Percent					mg/g	
Food product /household waste	43.2	10.3	7.2	2.2	1.4	0.8	4.0
Coconut residue	24.1	6.9	38.1	8.9	1.1	1.1	6.0
Broken rice	89.9	9.0	1.3	1.5	3.2	0.5	1.4
Crop content	34.4	9.4	9.2	5.4	16.0	0.8	0.9

Source: Gunaratne *et al.*, 1993 and 1994

Factors affecting the SFRB

Among the factors determining the size of the SFRB are: climate; number of households; number and type of livestock owned; crops grown; and the religion of the household. This was clearly illustrated in a Sri Lankan study (Gunaratne *et al.*, 1994), where results showed that the total biomass of the scavenging population was proportional to the SFRB. If the available SFRB is exceeded, then production falls (birds die and hens lay fewer eggs). If there is a surplus SFRB (such as a good harvest or fewer birds due to disease or stock sale), then production increases (more chicks and growers survive and more eggs are laid). Hence the SFRB available in a community determines the production potential of the poultry. If the SFRB is known, other factors affecting production can be identified and the benefits of providing additional inputs assessed.

Table 3.3 Amount of household waste, calculated SFRB and average flock biomass

Location - Village name	Month	House waste DM (g)	SFRB DM (g)	SFRB CP (g)	Flock biomass CP (g)
Galgamuwa I	March	143	260	20	91
Galgamuwa I	Sept	267	834	78	75
Galgamuwa II	March	543	639	63	83
Galgamuwa II	Sept	549	603	49	36
Ibbagamuwa	June	414	575	56	57
Ibbagamuwa	August	307	365	43	48

Source: Gunaratne *et al.*, 1994

The maximum productive size of the village flock depends on the SFRB. To keep the flock size in balance with the available SFRB, it is necessary to set fewer eggs for incubation, cull unproductive birds and sell stock as soon as they are saleable. Production capacity should also be adjusted to match the seasonal variations in the SFRB. For example, during harvest time, when the SFRB is increased, extra chicks and growers may be reared, but at the end of the dry season birds may need to be culled, sold or consumed. Supplementing the available SFRB with other feed resources can improve the overall quality of the nutrition of the flock and reduce chick mortality. This may then result in more and larger growers, and the expanded flock could then exceed the SFRB. If this happens, then production will fall again until the balance is restored. Feed supplements are only beneficial if they result in increased off-take rather than increased flock size.

FEED INGREDIENTS

The on-line and CD-ROM versions of the FAO searchable database *Feeds and Feeding* provide a full resource on this topic for all types of livestock, including poultry. The following descriptions may supplement the above source.

Cereals and cereal by-products

Examples of grains for supplementing scavenging poultry include millet, sorghum, maize, and rice in the form of whole and broken grains.

Amounts supplied are inadequate when using the surveyed estimate of 35 g supplement grain/bird.day (Obi and Sonaiya, 1995). This and the tannin content of sorghum have led to a search for alternative grains and the evaluation of agro-industrial by-products.

Dehulled rice grain

This can be used with vegetable and animal protein supplements for all types of poultry. Rough or paddy rice, off-coloured rice and broken rice have been used up to 20 to 30 percent in poultry rations. Rice bran has a moderate quality protein of 10 to 14 percent, approximately 10.4 MJ of

ME/kg (2 500 kcal of ME/kg), and about 11 percent Crude Fibre (CF). It is rich in phosphorus and B vitamins. Because of its high oil content (14 to 18 percent) it easily goes rancid. For this reason it should make up no more than 25 percent of the ration. This also applies to rice polishings. Rice bran usually includes rice polishings, but is often adulterated with rice hulls/husks, which are very high in fibre and silicon, and have a low nutritive value. Nevertheless, rice bran is still an important feed resource.

Maize starch residue (MSR)

This is a by-product of the extraction of starch from fermented, wet-milled maize, which is used as a breakfast cereal in West Africa. It usually has more than 16 percent Crude Protein, although the amount varies according to the maize variety and processing method.

By-products from local breweries and other local industries

Brewer's grain and yeast have become common ingredients for poultry rations, but the process of drying the wet by-product can be very expensive.

Legumes and legume by-products

Non-traditional legumes, such as boiled jack bean (*Canavalia ensiformis*) and sword bean (*Canavalia gladiata*), have been shown to be acceptable to laying hens, although they should not form more than ten percent of the ration because the sword bean is of low nutritive value (Udedibie, 1991). Winged bean (*Phosphocarpus tetragonolobus*) contains approximately 40 percent Crude Protein and 14 percent oil, and its overall nutritive value is very similar to that of soybean and groundnut cake for broiler meat chicken (Smith *et al.*, 1984). Winged bean leaf foliage is also acceptable to laying hens. Unless the plant is grown with stake supports, the yield is very low, which makes its cultivation on a large scale less economical. However it is suitable as a feed and fodder crop for smallholder poultry.

Soybean (Glycine max)

This crop is being grown increasingly for human consumption. If the cotyledons (fleshy beans) are used for human food, the testa (bean-seed coat) is given to poultry. Raw soybeans heat-treated by boiling for 30 minutes and then fed to scavenging birds in amounts of up to 35 percent of the ration resulted in satisfactory performance in broilers and laying hens. In pullets and layers fed raw soybeans with no heat treatment as 12 percent of the ration, there was a significant reduction in body weight at 20 weeks, as well as a delay of four days in the onset of sexual maturity (as measured by age at the 50 percent egg production). The heat treatment destroys a trypsin (a digestive enzyme present in the intestine of poultry) inhibitor, which, if left intact, prevents digestion of raw soybean.

Cowpea (Vigna unguiculata)

This legume crop is grown solely for human consumption in Africa. Its by-products, especially the testa (seed coat), are used as a feed for small ruminants and have also been fed to poultry (Sonaiya, 1995). The testa represents about six percent of the weight of the whole cowpea, but is usually discarded (in West Africa) when the cotyledons are made into a puree for a locally popular fried cake. With its crude protein content of 17 percent, its apparent metabolizable energy (AME) value of 4.2 MJ of AME/kg (1005 kcal AME/kg) and its mineral profile (44 g ash/kg; 9.0 mg Ca/g; 0.9 mg P/g), cowpea testa should be a good feed resource, but the presence of tannin (53 mg/g) and trypsin inhibitor (12.4 units/mg) limits its utilization. Cowpea testa should not make up more than ten percent of the total feed of a poultry ration.

Roots and tubers

Cassava (Manihot esculenta)

This is grown in large quantities in Africa, Asia and Latin America, both for human consumption and as a livestock feed. Cassava and its by-products (in the form of leaves, small tubers, pulp, peels, chaff, *gari* [fermented grated tubers], *gari* sievings, whole fermented roots and ensiled cassava meal) are used. The dried chips are high in energy and fibre but low in protein. In regions where cassava is used for human food, the peels are the most useful part of the cassava plant for feeding livestock. Amounts of 20 to 45 percent cassava peel meal (CPM) have been fed to chickens, but its use is limited because of the high content of the poison hydrogen cyanide (HCN), as well as high Crude Fibre, low protein content and dust. There is a considerable range of HCN levels in cassava, according to variety. When cassava completely replaces grains in a ration, there is a consequent reduction in egg weight and a change in egg yolk colour. Whether or not there are negative effects on egg fertility and hatchability is not known. Cassava meal gives good growth in meat chickens, although protein and other nutrients must be carefully balanced. Molasses or sugar may be added to sweeten the bitterness of the cyanide and thus improve palatability. Oilseeds such as full fat soybean can compensate for the high fibre and low protein content and for the dustiness. To remove the cyanide, detoxification methods include ensiling, sun-drying, air-drying, roasting, boiling and soaking. For smallholders, the most practical method is sun-drying (Sonaiya and Omole, 1977). Palm oil can also moderate the effects of cyanide on poultry. Some "sweet" varieties of cassava (which do not contain cyanide) are used in human food preparation, and these are often fed to poultry, particularly ducks.

Sweet potato (Ipomoea batatas)

Dried sweet potato forming up to 35 percent of the ration has been fed successfully to broilers and layers. The tubers are boiled before use, which overcomes any problems with dust or fungal growth from storage.

Oilseeds

Oilseeds in full-oil or partly oil-extracted form are a source of both energy and protein for extensive and intensive poultry systems.

Cotton (Gossypium spp.)

Glanded cotton seed cake (CSC) is a high-demand supplement fed to ruminants, but if available it can be fed in amounts up to 25 percent in the diets of layers and broilers without adversely affecting egg production and growth (Branckaert, 1968). Poultry are tolerant of the gossypol found in CSC, but it can cause an olive discolouration of egg yolks, which consumers do not like. Addition of 0.25 percent ferrous sulphate should be added routinely to laying hen rations containing up to ten percent CSC.

Sesame (Sesamum indicum)

The feed consumption and conversion rates for birds fed various forms of raw unhulled sesame seeds were better than those for birds fed dehulled but whole sesame seeds, confirming the practice of smallholders who use whole sesame seeds as a supplement for scavenging poultry. Sesame seeds should used in amounts between 20 and 35 percent of the ration.

Groundnuts (Arachis hypogaea)

Groundnuts may be used in the oil-extracted cake form to make up 8 to 24 percent of the ration. Mouldy groundnuts may contain toxic substances, the most dangerous of which is aflatoxin.

Coconut (Cocos nucifera)

Coconut meal can be used to form 50 percent of the ration, especially when combined with a high-energy source such as cassava meal. It is low in lysine, isoleucine, leucine and methionine.

Sunflower (Helianthus Annuus)

Sunflower seeds can be fed whole, or the decorticated meal can be used to replace groundnut cake and soybean meal and up to two-thirds of fishmeal. It has the highest sulphur amino acid content of all the major oilseeds.

Oil Palm (Elaeis guineensis)

Most oil palms are processed locally. The by-products are kernels and an aqueous solution of oil, fibre and solids. This solution can be filtered to remove the fibre (which is used as fuel). This leaves an aqueous mixture called palm oil sludge (POS), which supplies feed energy and fatty acids. Sludge processed using chemical solvents should not be used, as the chemical residue may be toxic to the birds. It can be fermented and used in smallholder poultry systems or dried to form up to 40 percent of commercial compound feeds (Hutagalang, 1981). Palm kernels are processed locally into palm kernel oil by heat or cold-water extraction. The residue from heat extraction is similar to ash and of no use in poultry feed, but the residue from water extraction is very nutritious and palatable to birds, and can be used in the same way as groundnut cake. The meal can provide up to 30 percent of the ration. However, the product is low in the sulphur amino acids.

Soybean – see under Legumes and legume by-products

Other oilseeds

Other oilseeds that have been fed to poultry under research conditions include rubber, amaranth, Niger seed (*Nueg*), breadfruit *(Artocarpus altilis)*, locust bean *(Ceratonia siliqua)*, African oil bean, melon, mango and castor oil. Okra seed *(Hibiscus esculentus)* has not yet been evaluated as a protein source for poultry, and although it is lower in protein, it compares favourably with soybean in all other nutrient components. Since okra is widely grown by smallholders and the seeds are kept for planting, it may be a potential source of protein for smallholder poultry.

Bambara groundnut (Voandzeia subterranea)

This is a good source of protein with a high lysine content. As the nut is not widely eaten, the plant is grown mainly as a mulch crop and the foliage is scavenged by poultry.

Trees, shrubs and fruits

Neem leaves

A pilot study was undertaken to test the response of three groups of layers to neem leaves. One group was fed a ration containing ten per cent fresh neem leaves, the second a ration of ten per cent dried neem leaves, and the third none. The group receiving the fresh neem leaves had increased feed intake, daily egg production and egg weight compared with the other two. There appears to be a fat component of fresh neem leaves *(Azadirachta indica)* that enhances egg production and egg weight (Siddiqui *et al.*, 1986).

Coffee pulp

This is high in fibre, but as the essential amino acid content is similar to that of soybean, it can only be used in limited amounts.

Citrus pulp

No more than two percent citrus pulp should be included in the ration to avoid reduction in growth rate and off-colour egg yolks.

Over-ripe bananas and plantains

These are of greater palatability for poultry than green bananas, which contain free or active tannins.

Derinded sugarcane pith and molasses

Sugarcane juice can make up to 25 percent of the poultry ration and molasses up to 30 percent, but it should be noted that over ten percent molasses results in watery faeces. Raw sugar however can be fed at up to 50 percent of the ration without watery faeces. Combining one part molasses with three parts sugar gives good production without the digestive problems. Molasses is often added to rations at low levels of inclusion to make it more palatable, although there may be problems with evenly mixing the liquid, and with fungal toxins in the stored feed, encouraged by the sugar levels.

Table 3.4 Optimum levels of inclusion in poultry rations of some ingredients

Feedstuff	Optimum level in the diet (%)
Banana meal	5-10
Citrus molasses	5-10
Citrus pulp	1-2
Cocoa bean residue	2-7
Cocoa husk	6-15
Cocoa shell	5-15
Coconut meal/cake	5-15
Coffee grounds	3-5
Coffee pulp	3-5
Kapok seed cake	5-10
Leucaena leaf meal	2-5
Oil-palm sludge, dried	10-30
Oil palm sludge, fermented	20-40
Palm kernel meal	10-40
Palm oil	2-8
Rubber seed meal	10-30
Sugar cane molasses	10-30
Raw sugar	40-50
Sugar cane juice	10-25

Source: Hutagalung, 1981

Animal protein

Blood meal

This is recognized as a high crude protein source with an imbalanced, relatively poor amino acid profile. Handling and processing of blood is difficult in low-technology situations. For processing small amounts, one method is to absorb the blood on a vegetable carrier such as citrus meal, brewers grain, palm kernel, ground maize, cob rice or wheat bran, after which the material is spread out for drying on trays heated from below or placed in the sun (Sonaiya, 1989). At the farm level, the blood may be supplied from the slaughter of livestock. Abattoirs and slaughterhouses provide large volumes of blood for making up feeds at the commercial level.

Termites

Farina, *et al.,* (1991) described a technique used to collect termites for scavenging poultry. Briefly, the straw of sorghum, millet and maize are chopped, placed in clay pots or calabashes and moistened. The mouth of the container is placed over a hole in a termite colony under construction. The container is covered with a jute sack to prevent drying out and a heavy stone is placed on it to secure it in position. After three to four weeks, a new colony of termites should be established inside the container. The eggs and larvae are particularly relished by chicks, guinea keets and ducklings, while adult birds also feed on the adult insects. Cattle dung can be used in place of the cereal straw.

Maggots

Alao and Sonaiya (1991) grew maggots on cowpea testa (seed coats) and monitored the chemical composition of the mixture over ten days. Cowpea testa samples were placed in a basket near a pit latrine to attract flies to lay eggs on them. Every two days, a sample was steeped in boiling water to kill the maggots. They were then sun-dried and ground before analysis. Results showed that the Crude Protein content of the mixture doubled by the second day. Soukossi (1992) produced maggots from fibrous vegetable material and poultry droppings. The method was developed for feeding fish, but can easily be adapted for smallholder poultry. A tank with a capacity of one cubic metre is filled with water to about 15 cm from the top. Dried stalks of maize, amaranth, groundnut, soya and other legumes are soaked in the water to which some poultry droppings are added. Flies and other insects are attracted to the soaked material to lay their eggs. After five to seven days, eggs are hatched and larvae are sufficiently developed to be fed to fish. Beyond this period the maggots develop into adult flies. It was observed that up to 50 percent of the eggs laid by flies died if exposed to the sun for several hours. A cover, at least for the hottest hours of the day, is therefore necessary. Similar trials have been carried out in Burkina Faso.

Earthworms

Vorster *et al.* (1992) produced earthworms as a source of protein for chicken feed. In an area of 25 m^2, one kg of fresh earthworm biomass was produced daily. This is sufficient to supplement at least 50 chickens with high-quality protein. It must be noted, however, that earthworms (and snails as well) may be important vectors for tapeworms such as *Davainea* and *Raillietina* and also contain a growth inhibitor.

Other animal products

Aquatic animal products containing mineral sources include marine shells from mangrove oysters (*Ostrea tulipa),* mangrove periwinkles *(Tympanostomus fuscatus)* and clams, and shells from land snails. Marine shells are abundantly available in coastal areas. Snails and their shells are harvested from forests, but there is also on-going development of productive snail farms. It is estimated that a box with a capacity of one cubic metre capacity on a snail farm can yield 40 snails each year. Ducks are an important biological control of the semi-aquatic golden snail in the Philippines and Bangladesh. Other marine by-products, such as prawn dust and shrimp heads, supply both minerals and protein.

CONCLUSIONS

There are feed resources available for feeding poultry at all levels of production. Smallholders using the semi-intensive system who make their own feed must base the rations on home-produced feed resources or obtain the ingredients locally. In backyard systems, available resources should be supplemented with appropriate nutrients as necessary. Food products from household waste fed to free-range birds should also be supplemented. Potential substitutes for expensive commercial feeds are cassava, sweet potato, coco yam *(Colocasia esculenta),* arrowroot *(Marantha arundinacea),* coconut residues, coconut oil, palm oil and other non-traditional energy sources. Non-conventional feedstuffs which are good substitutes for fish meal and soybean and groundnut oil meals include earthworm meal, maggot meal, winged bean, pigeon pea, jack bean, *Azolla (A. pinnata, A. caroliniana, A. microphylla)*, leaf meals and leaf protein concentrates.

In different regions, the importance of these feed resources for family poultry depends on their availability in sufficient quantities for farm use, simple preparation and processing methods, knowledge of the potential nutritive values and (for comparison) the price and availability of conventional commercial feeds.

For the family poultry situation with a scavenger flock, free-choice supplements with three containers each containing either protein-rich, energy-rich or mineral-rich feed sources will provide a solution to the problem of balancing nutrient intake for different age-groups. Poultry have an instinctual ability to select exactly what they need in the above food nutrient groups, and will not overeat from any one container. Young growing poultry (under two months of age) should always be fed in a “creep” system, where older stock cannot get access to their feed supply.

Chapter 4
General Management

HOUSING AND RUNS

Under undomesticated conditions, poultry lay eggs in simple nests, perch in trees and spend much of the day scavenging for feed. Chickens spend a large proportion of their time scratching to expose hidden food. Under the backyard and semi-intensive production systems, poultry are usually enclosed at night to discourage thieves and predators, and under intensive production, are totally confined day and night. Some village households keep their few chickens inside the house or even under their bed at night, to discourage theft.

Given a choice of a place to lay their eggs, hens will choose a soft "litter" base, and they prefer an adequately sized (a cube of approximately 30 cm), darkened nest with some privacy. Prior to laying, hens usually investigate a number of possible sites before entering a nest box. They then show nesting behaviour, which includes a special protective nest-seeking voice, after which they sit and finally lay. When they have laid an egg, they announce this with another type of "pride of achievement" call. These calls can also be heard in a battery cage house. If perches are provided, hens will perch most of the time rather than stand on the wire floors, and after dark most birds roost on the perches. Perching is a probable survival characteristic to avoid night predators. The basic requirements for poultry housing are:

- space;
- ventilation;
- light; and
- protection (from weather and predators).

Space: density of birds per unit area

This is the most important basic principle in housing, as the space available determines the number and type of poultry that can be kept. For example, a deep litter house measuring 6 m by 11 m can hold 200 laying hens at a stock density of 3 birds/m^2 (3.6 ft^2/bird). Under the older system of measuring, stock density was measured in ft^2 per bird, which is the inverse of birds per m^2 used in the metric system, incorporating a conversion factor of 0.0929 m^2/ft^2 (for details, see the appendix entitled Abbreviations and Conversions).

Linear space or length of perch per bird is measured in centimetres. The recommended floor and perching space for the three main types of chicken is shown in Table 4.1.

Table 4.1 Requirement of chickens for floor and perch space

Chicken types	Floor Space (birds/m^2)	Floor Space (ft^2/bird)	Perch Space (per bird)
Layer	3	3.6	25 cm (10 in)
Dual Purpose	4	2.7	20 cm (8 in)
Meat	4-5	2.1-2.7	15-20 cm (6-8 in)

Hen groups are comfortable at a stock density of three to four birds per square metre. If more space is allowed, a greater variety of behaviour can be expressed. Less space creates stressed social behaviour, allowing disease vulnerability and cannibalism and leaving weaker birds deprived of feed or perch space. Individual birds need more room for normal behaviour and adequate exercise than the 22 birds/m^2 (0.5 ft^2/bird) density currently used in commercial laying cages. Over recent decades, animal welfare concerns have encouraged research on laying cage structures to make designs better suited to the needs of hens, while retaining cost-effectiveness for production.

Ventilation: air flow

Ventilation is an important factor in housing. A building with open sides is ideal, otherwise cross-ventilation at bird-level should be allowed for in the form of floor level inlets, open in a direction to allow the prevailing wind to blow across the width of the building. An air mass between the side walls of a poultry house resists being moved, even across an open-sided building. The wider the building, the more the resistant it is to air movement. Buildings over 8 m (26 ft) wide have a significantly greater problem because of this inherent property of air to resist movement. It is recommended that buildings relying on natural airflow for ventilation should not exceed 8 m in width.

Heat stress is a significant constraint to successful production and can lead to death. Although birds can withstand several degrees below freezing, they do not tolerate temperatures over 40 °C. This depends on the relative humidity prevailing at the time. Poultry do not possess sweat glands and must cool themselves by panting out water in their breath, which is evaporative cooling. When the humidity is too high, this cooling mechanism does not work very well. Lethal temperatures for most chickens are 46 °C upwards, and severe stress sets in above 40 °C. In temperate regions, the chicken house may be constructed to face the rising morning sun to gain heat. In the tropics however, an east-west orientation of the length of the building helps to minimize exposure to direct sunlight. Building materials such as tin or other metal should be avoided for this reason, although white paint will reflect up to 70 percent of incident solar heat radiation. Ventilation concerns in building alignment may prevail over solar heat control in this aspect, as cross-flow ventilation requires the side of the building to face the prevailing wind.

Ground cover can also reduce reflected heat. Shade should be provided, especially if there is little air movement or if humidity is high. With no shade, or when confined in higher temperatures, poultry become heat stressed and irritable, and may begin to peck at one another. When new pinfeathers are growing (especially on young stock), blood is easily drawn, which can lead to cannibalism. The effects of heat stress are:

- a progressive reduction in feed intake as ambient temperature rises;
- an increase in water consumption in an attempt to lower temperature;
- a progressive reduction in growth rate; and
- disturbances in reproduction (lower egg weight, smaller chicks, reduced sperm concentration and an increased level of abnormal sperm in cocks).

Light: duration and intensity

A well-lit house is essential. A dark house leads to lethargic, inactive, unproductive birds. Light is important for feeding, as poultry identify food by sight. This is especially important for intensively managed day-old chicks, which need very bright 24-hour lighting for their first week of life.

Light is also an important factor in sexual maturity. An increasing light proportion in the day, as naturally occurs from mid-winter to mid-summer, will accelerate sexual maturity in growing pullets, bringing them to lay sooner. If hens are already laying, the increasing light proportion will increase egg production. The opposite effect is also true: as the light proportion of the day decreases (as naturally occurs from mid-summer to mid-winter), then sexual maturity is slowed in growing stock, and egg production is reduced in laying hens. These effects are somewhat reduced towards the equator, as the difference in the daylight proportion of a day changes less and less.

This physiological effect on poultry is important in terms of maintaining egg production in commercial flocks, and requires supplementary lighting programmes. Regular and reliable electricity supply is required for such programmes, otherwise the effect can be made worse by breaks in the light supplementation system. A slow but steady increase maximises the rate of production. However, lighting programmes producing an effective daylight proportion in excess of 17 hours per day can have a worsening effect on egg production. A 24-hour security lighting system can have such an effect on egg production.

Birds do best in situations where there is plenty of natural light that does not raise the temperature of the house. Natural light is preferable unless regular, reliable and well-distributed artificial light can be provided. It is recommended that the interior of the house be whitewashed to reflect light. The intensity or brightness of the light is also important. Egg production will decrease at light intensities lower than five lux (the "lux" is the metric unit of light intensity and can be measured by a meter similar to that measuring light intake into a camera lens), although meat chicken will keep growing optimally at light intensities as low as two lux (not bright enough to read a newspaper). These intensities are measured at the eye-level of the bird, not near the light source. Unless supplementary lighting is spaced uniformly, there may be areas in the building insufficiently lit to allow optimum growth or egg production. Designs for layout assume that the light bulbs or tubes will be kept clean, as dusty surfaces will reduce light output.

Protection: shelter sheds and buildings

Many factors influence the type and choice of housing to protect poultry from the effects of weather and predators. These include the local climate, the available space, the size of the flock and the management system. In extensive systems, birds must be protected from disease and predators but also be able to forage. Traditional large animal fencing using live plants is not enough protection against predators such as snakes, kites, rats and other vermin.

A simple and effective system to deter predator birds is to tie parallel lines of string across the main scavenging area, the intervals between which measure less than the predator's wingspan; or, alternatively, a fishing net supported on poles can be spread across the side of the run where predator birds could swoop on the scavenging chicks.

Leg traps can be set for large predators. It is not necessary to set traps around all the pens, as predators tend to attack the same pen on the second night. Steel traps can be boiled in walnut hulls or cocoa pods, both to camouflage them and to prevent rust. The traps will be more effective if not touched with bare hands, as most predators have a keen sense of smell. Instead, they should be handled with a stick, rubber gloves or tongs.

Rats, mongooses and snakes are only a problem when the birds are small. Rats often come up through the earth floors, and the first signs of a rat attack may be unusually quiet chicks huddled under the brooder heater or in a corner, or dead chicks with small bloody neck scratches. Snakes will kill chicks if they can get into the brooder house. A treble fishhook in a dead bird can be left as bait: the snake will swallow the hooks as it gulps down the bird and eventually die. Holes around doors and windows through which rats and snakes may enter should be plugged.

Coops or baskets may be used to house mother hens and chicks in order to reduce chick mortality due to predators, thieves and rain. They also allow for separate feed and water supplementation, although the inadequate feed usually provided in coops means that some scavenging remains necessary.

Table 4.2 Predator attack modes and control methods

Predator	Attack mode	Control method
Hawk	Picks up stray birds and weaklings. Attacks birds so that head and toe marks are visible on back. Often plucks birds.	Hunt the hawk and keep chicks away from clear swoop areas.
Rat, mongoose	Usually take more than they eat, and stuff chicks in holes for later consumption.	If allowed, use rat poison.
Snake	Will swallow eggs and chicks	Use fishhooks.
Dog, cat	General destruction	Try to catch them. Cats can control rats but wild cats and dogs are a problem.
Fox, jackal	Will bite off the feathers over the back and between wings, eat the entrails and breast, and carry bird to den.	Roam in the early morning; kill for their young. Trapping is the best control.
Raccoon	Pulls off head and eats crop. Will carry birds off.	May be protected in some countries. A permit to destroy may be required.

HOUSING IN FREE-RANGE SYSTEMS

Overnight shelter which is roomy, clean and airy should be provided under free-range systems. Houses may be either fixed or mobile. If space permits, a mobile chicken house may be appropriate, and to increase egg production, mobile folds or field units for laying birds can be provided. These mobile units can be rotated on the range. Although housing is cheaper and there is less need for balanced rations, the birds are exposed to the sun and prone to parasite infestation.

The stocking density on pasture should be calculated according to the soil type and pasture management system. A night shelter for up to 20 free-range chickens can be attached to any existing structure, such as the farmer's outhouse, kitchen or dwelling. In a deep litter system, there should be a density of at most three to four birds per square metre. In regions where it rains heavily, the floor should be raised with a generous roof overhang, particularly over the entrance. The raised floor can be a solid platform of earth or a raised bamboo platform. The raised bamboo platform has the advantage of providing ventilation under the poultry, which helps cool them in hot weather and keeps them out of flood water in the monsoons.

The walls of the building can be made of mud or bamboo, and the windows and door of bamboo slats. The house can also be free-standing, and may also be suitable for semi-intensive or intensive production systems.

HOUSING IN SEMI-INTENSIVE AND INTENSIVE SYSTEMS

Planning

Complete confinement is only advisable where:

- there is good management;
- reproduction is spread equally over the year;
- land is scarce or inaccessible all year round;
- balanced rations are available;
- a supply of hybrid day-old chicks is available;
- labour is expensive;
- parasite and disease control are readily available; and
- the objective is commercial production.

The reasons for confinement are, in order of priority, to:

- reduce mortality due to predation in chicks under two months of age;

- achieve higher daily gain and better feed conversion in growers; and
- allow better supervision of production in laying hens.

In all confined systems, the location and building design must be carefully considered. The area surrounding the house should be mown or grazed. A good location should meet the following criteria:

- It should be easily accessible.
- There should be a reliable water supply.
- The ground should be well drained.
- It should be at a sufficient distance from residential areas (far enough to protect human health and close enough to provide security for the birds).
- It should be well away from woodland.

Converting existing facilities can provide housing, although planning permission may have to be obtained. An unused outhouse kitchen, for example, can be converted into a poultry house. In all conversions, maximum use should be made of the space available through careful planning:

- A plan of the building should be drawn to scale.
- Use should be made of existing floors and walls, if suitable.
- Space requirements of the birds and manure disposal should be taken into consideration.
- A feasibility study should be carried out, taking into consideration future plans and requirements as well as the economics of converting the building.

Construction

The floor is extremely important. An ideal floor for a deep litter house is well drained and made of concrete, with a layer of heavy gravel or wire mesh embedded in it to keep out rats. This type of floor is usually costly. Wood, bamboo, bricks or large flat stones (according to what is locally available) can be used, but are harder to clean. Clay floors are cheaper, but require the application of a fresh layer of clay either between flock batches or at least annually. In areas where construction materials are cheaper than deep litter, and particularly in humid regions where litter material is not available, raised floors are sometimes used. These are made of wire mesh, expanded metal, wooden slats or split bamboo, to allow the droppings to collect under the house, and should be about one metre above the ground to allow for cleaning and ventilation. Higher floors may result in an unstable building. They are supported by pillars, which are either rot-resistant or have stone or concrete footings, and which are made of such materials as wood, bamboo, oil drums and concrete blocks. Houses with raised floors on posts can be protected against rats with baffles. The baffles can be made of a metal collar, a tin can turned upside-down or a metal band wound around the post, but must fit tightly to deter even the smallest rodent.

The roof and walls of the house can be made of any inexpensive local material, including bamboo slats, sorghum stalks, mud, wooden slats and palm fronds, as long as the structure is made relatively rat-proof. In colder regions, the walls should be thicker or insulated, but in warmer climates thatch can be used, although it should be replaced frequently to minimize parasite and disease problems. The inside of the walls should be as smooth as possible, to prevent tick and mite infestation and to make cleaning easier. Interior length-ways building partitions are not advisable, as they reduce cross-flow ventilation.

The roof should be watertight, and should overhang the walls by one metre if the windows have no shutters. The roof can be made of thatch, sheet metal or tiles. Thatch is usually the cheapest option and provides good insulation. It will probably have to be replaced every three years, or immediately if ticks get into it. It should be interlaced with bamboo or wooden slats to keep predators out. Sheet metal is usually too expensive, and in hot climates must be painted with white or aluminium to reflect sun heat. However, it is easily cleaned which is an important advantage where ticks are a problem. A layer of plastic sheeting sandwiched between bamboo slats is a good seal against rain and vermin. Flattened oil drums can be used at a lower cost. Although usually more expensive than thatch, sun- or oven-baked tiles will last much longer. Because of their weight, the frame for a tiled roof must be stronger than for other materials.

Window design depends on the local climate. Chickens need more ventilation than humans, but should be sheltered from wind, dust and rain. During storms, wood or bamboo hinged shutters or curtains made from feed sacks can cover window openings on the windward side of the house. In humid climates, window design should take as much advantage of the wind direction as possible to reduce the amount of moisture in the house. Window areas are best covered by wire mesh or expanded metal. Wooden slats or bamboo can be used, depending on available funds and materials. However, the thicker the material, the more ventilation will be reduced. Doors should be made of metal, wood or bamboo. The top half of the door could be wire mesh. Doors should be sufficiently strong to withstand being opened and closed many times a year.

Gabled roofs reduce solar heat loading when compared with flat or lean-to roofs. The pitch or “angle of rise” on a gabled roof is important for many reasons. Traditional village thatched gabled roofs are usually constructed using bush timber, and at a steeply pitched angle (greater than 42° from the horizontal), which helps the roof to withstand stormy winds. Shallower pitched roofs are more susceptible to being blown off in strong winds, particularly when the pitch angle is 15° to 20°. Shallower pitched roofs have less roof surface area, which reduces the cost of surfacing material, but because they are more affected by stormy winds, they need stronger support frames, which results in a much higher overall roof cost. A 42° pitch is the optimum compromise between roof surfacing costs and roof support costs.

The maximum width for an open-sided poultry building, under conditions of a slight breeze, which allows air movement across the shed at the height of the bird, is 8 m (26 ft). To maximise the volume and velocity of airflow across the shed width, the end walls of the shed should be closed. This forces the air to flow across the shed width, especially if the wind is not already coming from that side. Centre ridge ventilation is not recommended, as it discourages airflow across the full shed width. Air enters at the prevailing wind side and is drawn up at the centre to exit at the ridge, excluding the other half of the building.

Nests

To avoid excessive competition and minimize eggs laid on the floor, one nest should be provided for every five hens. If larger communal nests are used, at least one square metre per 50 birds should be allowed. Baskets, pots and cardboard boxes can be used for nests. Dimensions suitable for a basket or pot nest are a 25 cm base diameter, 18 cm high walls, and a 40 cm open top diameter. Nests should be situated in a secure, shady secluded place out of the sun, lined with fresh litter and kept clean. Nest boxes for individual hens should be constructed in multiple groups for larger numbers of hens. These are usually made of wood, and should measure approximately 30 cm on all sides, with a nest floor area of about 0.1 m^2.

Perches and roosts

Chickens prefer to roost at night on perches. Perching space of 15 to 20 cm should be allowed for each bird. Birds lower in the social peck order can also use the perches during the day. The cross-section of each perch bar should be 2 to 3 cm. Their length depends upon the number of birds to be housed. The perches should be placed within a frame, and aligned parallel to the wall, and horizontally, with a sliding, removable platform called the “droppings board” about 20 cm below the perches to catch the manure droppings. The first perch bar should be placed 20 to 25 cm out from the back wall, and subsequent ones at 30 to 40 cm intervals. The droppings board should touch the back wall and extend 30 cm in front of the front perch bar, as this will allow the birds to land from their flight from the floor before seeking a perching spot. Droppings boards should be a maximum of 75 cm from the floor of the house, and the perch bars should be about 20 cm above the droppings board, to facilitate cleaning of the droppings board. Fowls deposit over half their droppings at night, and the use of the droppings boards thus helps to keep the floor clean. The manure can then be easily collected, dried and stored in empty feed sacks for use as an excellent fertilizer for plants requiring organic nitrogen. The area under the droppings board then becomes an ideal site for a communal nest.

Providing feed

In both intensive and semi-intensive systems, laying hens need constant access to food and water, and feeders should be distributed evenly throughout the chicken house. In the semi-intensive system, birds scavenge during the day, mostly for protein (from such sources as insects, worms and larva), minerals (from stones, grits and shells), and vitamins (from leafy greens, oil palm and nuts), but energy supplements such as maize, sorghum and millet are important for higher productivity and should be given. Chapter 3 on Feed Resources discusses ingredients and feeding systems in more detail.

Feeders

A good feeder should be:

- durable enough to withstand frequent cleaning;
- stable enough not to be knocked over;
- of the correct height and depth;
- bird proof (such that birds cannot get into it or roost in it); and
- equipped with a lip to prevent birds from spooning feed out onto the floor with their beaks.

The height of the feed inside the feeder, which should never be more than one-third full, should be level with the back of the birds, to prevent them from scratching contaminated litter into the feeders and to limit feed wastage. This is achieved by adjusting the height of the feeder itself. To reduce spoilage and mould problems, feed should be supplied at sunrise and at about 14.00 hours (or more frequently if the birds empty the feeder), with all feed finished by sundown. Feeders can be made of wood, sheet metal or bamboo, and are best suspended from the roof to keep rats out. The height of the feeder should be adjustable. Supplementary vegetable matter should be fed at beak level, either hanging from the ceiling wrapped in a string or placed in a net or placed in a floor-standing hopper with wire or slatted sides. It should not be thrown on the floor.

Feeder space is measured as the linear distance of lip available to the birds. This is either the circumference of a round tube-feeder tray or twice the length of a trough if the birds feed from both sides. If troughs are used, at least 10 cm of feeding space should be accessible to each bird. When circular feeders are used, there should be at least 4 cm feeding space per bird.

Table 4.3 Feed and feeder space requirements for 100 chickens

Age (weeks)	Daily feed consumption (kg)	Suggested feeder depth (cm)	Feeder space (m)
1 – 4	1.4 - 5.0	5	2.5
4 – 6	3.2 - 7.3	8	3.8
6 – 9	5.0 - 9.5	9	6.1
10 – 14	7.3 - 15.9	12.5	9.6
15 and above	9.1 - 11.4	15	12.7

Creep Feeders

Creep feeders are used to enable baby chicks to have access (by “creeping” through a small doorway) to high-quality (high in energy and protein) feed, while blocking access to larger sized birds (especially the chicks’ mothers). The conical (open at the top and base) creep feeder can be made from split bamboo strips approximately 0.5 to 1 cm wide, bound at the joints with string or wire. The base of the creep feeder can be 75 cm in diameter and 70 cm high, with an access hole (reinforced to form a carrying handle as well) about 20 cm wide at the top. The gaps between the upright slats can be 2 to 3 cm at the bottom and about 1 cm at the top. The flexibility of the bamboo strips allows the size of the entryways to be enlarged, as the chicks grow bigger. If the chicks are reluctant to leave their mothers' side, then a more tightly formed weave can prevent their exit once they are placed inside the cone through an opening at the top. The bamboo can be preserved from insect attack with a coat of used engine oil.

Better nutrition for young stock boosts their immune response to disease challenge and to vaccine response by developing full immunity. Gunaratne *et al* (1994) reported that chick mortality rates could be reduced by the use of creep feeders but that this did not increase the growth rate. However, when the household waste was supplemented with protein and fed in the creep feeder, both the growth and the survival rate of chicks increased (Roberts *et al.*, 1994).

Table 4.4 shows that annual egg production can be doubled because of the increased laying time available to the hens if their chicks are fed in a creep feeder after hatching (Pratseyo *et al.*, 1985). If the gaps in the creep feeder are adjusted, it can also be used for growers over eight weeks, and if given less than the full ration, they will learn to compete for food with other chickens.

Table 4.4 The effect of creep feeding on flock egg production

Intervention	Period					
	June	July	Aug.	Sept.	Oct.	Nov.
Creep only	31.5	28.7	27.3	21.8	21.4	33.0
Creep + Low supplement	21.2	18.8	22.9	26.9	30.7	31.1
Creep + High supplement	24.3	24.5	32.5	34.1	27.4	31.1

Source: Gunaratne *et al.*, 1993

Providing water

Providing clean water is a priority often neglected. The amount of water, the right type of equipment and where it is situated are important considerations. Table 4.5 shows water consumption rates for hot dry conditions, and these can be halved for temperate regions.

Table 4.5 Minimum water and watering space requirements for 100 birds in hot dry conditions

Age (weeks)	Daily consumption (litres)	Water space (m)
0 – 1	3	0.7
2 – 4	10	1.0
4 – 9	20	1.5
9 or more	25	2.0
Layer	50	2.5

In countries with plenty of water, such as Bangladesh, Viet Nam, Indonesia, the Gambia, Sierra Leone, Zaire and Uganda, the only special measure to be taken is to ensure its cleanliness. In other regions, especially in the Sahel and other drought-prone regions, fetching and carrying water is a crucial task, usually assigned to women and children. In the rainy season, clean water and feed must be placed in the house, as brooding hens are kept inside to prevent poor hatchability resulting from contamination with mud and dirt.

The simplest equipment is a tin can inverted into a soup plate or the bottom of a larger tin can. A hole is punched about 2 cm from the open end of the tin can. The can is filled with water, covered with the plate and both quickly inverted. The position of the punched hole and the vacuum in the tin can will regulate the water level in the plate. Tin can waterers work well but quickly become rusty, especially in the humid tropics. A clay pot or gourd with holes around the sides sunk into the ground for stability can be used to water adult birds. Clay pots of any dimension can often be ordered from local pot makers. Because they are permeable they provide water half a degree Celsius cooler than other waterers, as heat loss through evaporation keeps the water cooler. This also means an appreciable loss of water over time, especially in very hot dry areas, so that the pots may have to be made more impermeable by glazing. If continuous drinking troughs are used, at least 5 cm of trough should be allowed for each bird. Alternatively, one cup or nipple drinker may be provided for every ten birds.

BABY CHICK MANAGEMENT

Baby chicks should be kept warm and dry. The nest, which they share at night with the mother hen, must be kept clean. In colder climates (below 20 °C at night), the nest site should be kept warm by lining it with straw and placing it near a stove or fireplace. The chicks should remain with the mother hen for nine to ten weeks, learning from her example how to scavenge and evade predators and other dangers. Clean drinking water and fresh feed in a clean container should be provided to supplement scavenging. See Chapter 3 “Feed Resources” for more detail on feeding techniques.

There is a close relationship between chick weight and growth and mortality rates. In an experiment where young chickens had access to supplementary feed in a creep feeder (Roberts *et al*., 1994), it was found that supplementary protein feed had a significant effect on the survival rate and growth rate. Chicks separated from the mother hens during the day from the age of three to ten weeks, and fed with chicken starter mash *ad libitum*, had a mortality rate of 20 percent and a body weight of 319 g at ten weeks, compared with a mortality rate of 30 percent and a body weight of 242 g for the control group which remained with the mother hens. See more supplementary detail in the section above, entitled “Creep Feeding”. A suitable strategy for rearing chicks therefore would be as follows:

- The chicks should be confined for the first weeks of life and provided with a balanced feed.
- A vaccination programme should be followed.
- Sufficient supplementary feed should be provided during the remaining rearing period to allow the chickens to develop in accordance with their genetic potential.
- Feed supplements and protection should be provided to naturally brooded chickens during the first four to eight weeks of life.

The composition of the supplementary feed will depend on the available scavengable feed, but a form of cafeteria free-choice feeding of a protein concentrate, energy concentrate and calcium mineral in each of three containers may be the best solution.

The mortality rate of naturally brooded chicks, whose only source of feed is from scavenging under free-range conditions, is very high and often exceeds 50 percent up to eight weeks of age. Wickramenratne *et al* (1994) found that predators accounted for up to 88 percent of mortality and that coloured birds had a higher survival rate than white birds. The high mortality rate and the large number of eggs required for hatching are the main causes of low offtake from scavenging poultry flocks. Smith (1990) reported an offtake (sales and consumption) of only 0.3 chickens per hen/year from a survey done on flocks in Nigeria. This low offtake has also been observed in Bangladesh and India.

An efficient way of decreasing mortality rate (a costly loss) is to confine and vaccinate the chicks during the rearing period. This however is more expensive, the cost of feed in particular increasing production costs. A method used over the past ten years in many poultry development projects in Bangladesh confines the chicks during the first eight weeks of life. They are fed approximately 2 kg each of balanced feed and thereafter kept under semi-scavenging conditions. At eight weeks of age, they are less susceptible to attacks by predators and more resistant to diseases, due to their larger body weight and more effective vaccination immunization (due to their better nutrient intake).

HYGIENE

Manure management

Whatever the type of confinement, proper attention must be paid to manure management. Adult birds produce 500 g of fresh manure (70 percent moisture content) per year per kg of body weight. To preserve its fertilizer value, manure should be dried to about 10 to 12 percent moisture content before storage. This will retain the maximum nitrogen content for fertilizer value. Nitrogen in the form of urea is the most volatile component of manure, and is lost as ammonia if moisture content is too high in the stored material. If the moisture content is too high, then the stored manure releases ammonia, carbon dioxide, hydrogen sulphide and methane, which can have serious physiological effects on humans. Some of these components are also greenhouse gases, which contribute to the global increase in ambient temperature. Poultry manure is very useful as an organic fertilizer, as animal and fish feed and as a raw material for methane gas generation in biogas plants for cooking fuel.

Other hygiene management measures

Good ventilation discourages the spread of diseases and pests. In overnight houses, the provision of perches or loosely plaited bamboo mats (such as those used for sieving) placed on the floor can help to keep them dry.

If the birds are housed inside, the floor should be swept daily. An outside chicken house should be cleaned every week to break the breeding cycle of the common housefly. It takes about seven days to complete the breeding cycle from fly egg to hatching of the adult housefly. Wood ash and sand spread on the floor will discourage lice infestation. Mothballs (naphthalene) crushed with ash can also be applied to the feathers or the wings of the birds, or placed where the chickens usually take their dust baths. If the chickens are already infested with mites, the house can be fumigated (while the chickens are outside) with a rag drenched in kerosene. Lice live on the birds, and dust baths with naphthalene powder in the ash will be more effective than dust alone.

The practice of keeping chickens and ducks together should be discouraged. This results in wet floors, giving rise to diseases such as Fowl Cholera. Ducks are also much more tolerant than chickens to Newcastle Disease, and are thus often carriers of this viral disease. Adults and young stock of any poultry should be housed separately to minimize cross-infections and injuries from bullying.

MANAGEMENT OF FREE-RANGE POULTRY

The unrestricted free-ranging of poultry is often a problem. They trespass onto neighbouring fields and gardens, and are constantly at risk from predators. Confinement is often not practical because of the cost of feed and fencing, while surveillance is only feasible where the very old or very young of the household have time to help. Fencing of vegetable plots is in many cases the best option. Placing more cocks in the village might reduce the movements of the chickens, as the cocks and hens of each flock would keep more to their own territory. Cocks move within an eight-to-ten-house territory, and hens within two or three houses.

Under the free-range system, the difference between the amounts of food gathered through scavenging and the total food requirement for maximum production should be balanced with nutrients supplied from supplementary feed. To make up a properly balanced supplement, it is necessary to know the scavenger feed resource base (SFRB) and the composition of the crop contents (see Chapter 3, SFRB). If this is not known, it is recommended that the fowls have access (using a free-choice cafeteria system) to three containers (or three compartments of a bamboo stem feeder of ingredients comprising a protein concentrate, a carbohydrate source (for energy) and a mineral source (mainly for calcium carbonate for egg shell formation for the hen).

Poultry should have free access to this cafeteria system for two to three hours in the evening to supplement the day’s scavenging.

From a feed resource point of view, this recommendation is only economically viable (sustainable) if the consumption of supplementary feed per egg produced is equal to 150 to 180 g or less. Consumption of over 150 g is only justified if the supplements are cheaper than the commercial feed used in intensive poultry production. Supplements are usually recommended in the range of 50 to 80 g/bird/day, so it is usually quite viable. Seasonal variations in the SFRB have a substantial effect on production. During the dry season, scavenged feed from gardens, crops and wasteland (such as grass shoots, seeds, worms, insects and snails) stops, while the quantity and quality of household kitchen waste decrease. The feed supplement should be adjusted seasonally to maintain an optimum level of production or, alternatively, the chicken population could be adjusted to the amount of the SFRB and the feed supplement.

Hens in confinement fed a balanced diet will convert food weight to egg weight at an efficiency of about 2.8 kg of feed per kilogram of egg weight. Changes in husbandry alone may increase the productivity of scavenging village chickens, without the need for additional inputs. In planted orchards, a stocking rate of 120 to 180 birds/ha will clean up windfalls while also fertilizing the trees. In this example, the amount of fertilizer produced per hectare for 150 hens (weighing two kilograms each) is based on the assumption of 500 g of fresh (70 percent moisture) weight of manure produced per kilogram of live weight per year. This results in 330 g of dried manure (dried to a ten percent moisture content) per hen/year, and thus the 150 hens will produce 49.5 kg of dry manure per year. This has an equivalent fertiliser value of 13 percent ammonium nitrate, 8.6 percent super-phosphate and 2.9 percent potash (potassium) salts. Thus the 150 hens will produce the equivalent per hectare/year of 6.4 kg of ammonium nitrate, 4.3 kg of super-phosphate and 1.4 kg of potash salts.

Planning flock production and size

Production involves birds for meat and eggs. For both meat and egg production, the number of chickens in the flock is the most important factor. Flock size changes constantly as eggs hatch and hens are sold or eaten. Usually the main cause of flock depletion is mortality, particularly in chicks. Disease is the greatest cause of mortality, especially in the rainy season and in the weather changeable humid periods on either side. During summer and the rainy season, predators in the cropped fields also contribute to reduced flock sizes. Local birds lay an average of three to four clutches of 12 to 15 eggs in a year, with more eggs laid at crop harvest time because more feed is available. Given most traditional farming systems, keeping the flock number constant requires eight to ten eggs for reproduction, leaving an average of 35 to 40 eggs per layer for sale or consumption. Because the number of eggs needed for replacement may decrease with better management, the extra eggs can be sold or eaten.

Most egg laying takes place between sunrise to mid-morning. During the months of laying, nest location should not be moved, as this may upset the laying routine.

In village flocks, income derives from the sale of eggs and live birds. For example, a flock of 15 local hens laying 30 eggs/hen/year (with one local cock) will produce 450 eggs in a year. Of these 450 eggs, 120 may be incubated by broody hens (in ten clutches of 12 eggs each), of which 100 chicks may hatch, and 30 eggs may be cracked and consumed in the household, leaving a balance of 300 eggs for sale. Of the 100 day-old chicks, 30 may reach maturity (with rearing losses of 70 percent), to yield 15 cockerels and 15 pullets. The 15 pullets will replace the older hens, of which ten remain after the sale of cull hens, and one new cockerel will replace the old cock. The annual income from the flock can therefore be calculated as follows:

300 eggs + 10 old hens + 1 old cock + 14 cockerels = income

For improved productivity, culling is important and productive birds should be carefully selected. For simplicity, the above example assumes no adult mortality.

CASE STUDIES OF FAMILY POULTRY MANAGEMENT SYSTEMS

A free-range system in Ghana

In the traditional free-range system of the Mamprusi tribe in northern Ghana (van Veluw, 1987), the farmer releases his 19 chickens and six guinea fowls from the space under the grain store each morning. Grains are thrown on the ground to feed the birds. A young boy takes care of the birds during the day and protects the crops from poultry damage. Occasionally the boy will feed the birds with a piece of termite hill, and in the evening he returns with the flock and locks them under the granary store.

Chicken hens lay throughout the year, but guinea fowls lay only in the rainy season. Chicken hens produce about 20 to 40 eggs a year and guinea fowls about 50. Most of the eggs are used for hatching. Chickens also hatch guinea fowl eggs, as guinea fowls are not good mothers. Hatching takes place throughout the year, although most of the hens incubate their eggs in the rainy season. A reproduction cycle (laying, hatching, caring for chicks and resting) takes about 20 weeks. Mortality is high (75 percent) among the young chicks. Out of ten chicks, only about two reach adulthood, due mainly to disease, predators and road accidents. Newcastle Disease in particular kills many poultry in the dry season. Worms as internal parasites are a great problem, weakening the birds. Predators include snakes, birds of prey, cats and dogs. Mortality up to two months of age is 50 percent, with a further 25 percent thereafter up to sexual maturity.

Hatchability of guinea fowl eggs is very low (45 percent) compared with chickens (72 percent). Farmers keep hens for about three years and guinea fowls for two years, after which productivity decreases considerably and they are culled.

Table 4.6 Total annual production of a Mamprusi average flock

	Chickens		Guinea fowls		Total Production
	Flock	Production	Flock	Production	
Cocks	3	1	2	1	2
Hens	9	3	4	2	5
Cockerels	2	22	-	13	35
Pullets	5	19	-	11	30
Eggs (/hen)	-	45 (20)	-	65 (50)	110 (380)

Scavenging commercial hybrid layers in Sri Lanka

In a study carried out by Roberts and Senaratne (1992), Sri Lankan villagers reared hybrid egg layers in a semi-scavenging system. Day-old hybrid chicks were brooded under the heat of a small kerosene lamp. The chicks were provided with a little mixed supplement of local crop by-products, comprising 40 percent rice polish, 50 percent expeller coconut meal and 10 percent broken rice. The Proximate chemical analysis of this supplement was 16 percent Crude Protein, 8 percent Crude Fat, 7 percent Crude Fibre and 7 percent Ash.

The amount of the supplement increased from 8 to 60 g/bird/day until 12 weeks of age, and was maintained at 60 g thereafter. The growth rate was 38 g/bird/day up to 20 weeks of age. The mortality rate of the chicks was only four percent in the period up to ten weeks, which compared favourably with mortality of 68 percent up to six weeks in Indonesia (Kingston and Creswell, 1982) and 25 percent up to eight weeks in Thailand (Thitisak *et al*, 1989) in chicks hatched and reared by village hens. The comparative advantage of the Sri Lankan performance was attributed to supplementing the competitive scavenging, and to the protection against predators provided by the semi-intensive management system. It is probable that chicks would also benefit from the use of a simple creep feeder for feeding kitchen waste. The mortality rate, in the Sri Lankan example, increased after reaching eight months of age, perhaps due to a greater need for scavenger free-ranging, and almost reached a cumulated 60 percent loss by 13 months of age. Of the 142 hens lost up to 13 months of age, records were kept for 92. The causes of mortality were:

- 32 percent predators (such as dogs, mongooses, pole cats and snakes);
- 26 percent disappeared;
- 15 percent Newcastle disease;
- 15 percent intestinal infection;
- 5 percent stolen;
- 4 percent accidents (vehicles and falling coconuts); and
- 2 percent attacked by humans.

Hens laid their first eggs when they reached 21 weeks (146 days) of age, although 40 percent production (on a hen/day basis) was not achieved until they were 30 weeks of age. Peak egg production was just over 60 percent. A severe drop in production (beginning when the hens were eight months of age) corresponded with an outbreak of Newcastle Disease in local village birds and the start of the long dry intermonsoon period. Production fell to below 30 percent when the hens were ten months of age, and slowly rose again to over 60 percent at 13 months of age. The recovery in production began during the dry period and was maintained into the next season. Egg production was comparable with that of hybrid egg layers, which were introduced into the village as pullets, provided with a supplement and allowed to scavenge.

The production was much better than the 12 to 21 percent reported in village birds in Indonesia (Kingston and Creswell, 1982) and in Thailand (Janviriyasopaki *et al*, 1989) and (Creswell and Gunawane, 1982). The egg weight reported by Roberts and Senaratne (1992) was 60 g compared with about 40 g for village hens (Kingston and Creswell, 1982).

A free-range system in Senegal

In a study carried out on farms in Senegal (Sall, 1990), flock sizes ranged from under five birds to more than 15 birds, with an average flock size of ten birds. Seven percent of the flocks comprised under five birds, 38 percent comprised five to ten birds, 41 percent comprised 10 to 15 birds, and 14 percent comprised more than 15 birds.

Flocks with fewer than five birds had either recently lost hens or had hens that had not yet hatched their eggs. Flock size varied considerably during the year, due to additions (hatchings, purchases and gifts) and to chickens either sold or lost through disease or predators. The birds were permitted to scavenge during the day and were locked into wooden cages (*ngounou*) at night for protection. The cages were made on the farm from available materials (including bricks, galvanised iron sheets and wood). The doors were small, to prevent entry by thieves and predators. Stock density in the cages was about 25 birds/m^2. Feed and water was available to supplement kitchen waste and scavenging.

The proportion of young chicks and growers in the flock was about 60 percent while adults represented 40 percent. Mortality in the first month of age was 40 percent. There were four to five clutches of eggs laid per year, with 8 to 15 eggs per clutch. Egg weights ranged between 38 and 43 g with an average of 40 g. Almost all eggs were set for hatching and of these hatchability was about 80 percent. The production cycle was eight to ten weeks (10 to 15 days for egg laying, 21 days for incubation, and only 34 days for rearing). The chicks remained close to the hens for up to two weeks, during which time there was a relatively low mortality rate of 14 percent. On leaving the immediate protection of the hens, mortality increased sharply to 40 percent between three and four weeks, and up to 66 percent by three months of age. Similarly, the average daily live-weight gain of birds under this extensive system decreased from 10 g at eight weeks to 6 g at 12 weeks.

Table 4.7 Village flock structure in Senegal Source (Sall, 1990)

Age (months)	**Nº**	**Males**	**Nº**	**Females**	**Nº**	**Total %**
0 – 1	-	-	-	-	320	50.5
1 – 3	-	-	-	-	99	15.6
3 – 6	34	5.4	84	13.3	118	18.6
6 – 8	2	0.3	21	3.3	23	3.6
8 -10	1	0.2	19	2.9	20	3.2
10 +	15	2.4	39	6.2	54	8.5
Total	52	8.3	163	25.6	634	100

Table 4.8 Age-related mortality in local birds in Senegal

Age (weeks)	**% Mortality (cumulative)**
1	13 ± 5
2	15 ± 9
3	39 ± 20
4	42 ± 20
8	49 ± 20
12	66 ± 17

Source: Sall, 1990, p 37

Table 4.9 Body weight of local birds in Senegal

Age	**Nº**	**Males**	**Nº**	**Females**	**Nº**	**Males + Females**
1 week	-	-	-	-	81	34±5
2 weeks	-	-	-	-	75	58±10
3 weeks	-	-	-	-	66	101±43
1 month	-	-	-	-	98	171±70
2 months	-	-	-	-	41	464±242
3 months	-	-	-	-	58	631±211
4 months	29	975±20	63	746±170	92	860
6 months	5	1380±150	21	1229±165	26	1305
8 months	2	1826±75	21	1264±183	23	1544
10 months	1	1500	19	1245±150	20	1372
+ 1 year	15	1803±4	39	1350±223	54	1577

Source: Sall, 1990

Chapter 5
Incubation and Hatching

NATURAL INCUBATION

The broody hen chosen for natural incubation should be large (to cover and thus keep more eggs warm), healthy and preferably vaccinated, with a good brooding and mothering record. Signs of broodiness are that the hen stops laying, remains sitting on her eggs, ruffles her feathers, spreads her wings and makes a distinctive clucking sound. Brooding may be induced with dummy eggs or even stones.

Eggs usually become fertile about four days after the rooster has been introduced to the hens. A maximum of 14 to 16 eggs may be brooded in one nest, but hatchability often declines with more than ten eggs, depending on the size of the hen. Feed and water provided in close proximity to the hen will keep her in better condition and reduce embryo damage due to the cooling of the eggs if she has to leave the nest to scavenge for food.

The hen keeps the eggs at the correct humidity by splashing water on them from her beak. This is a further reason for providing her with easy access to water. In very dry regions, slightly damp soil can be placed under the nesting material to assist the hen in maintaining the correct humidity (between 60 and 80 percent). Fertile eggs from other birds are best added under the brooding hen between one and four days after the start of brooding. In Bangladesh, it has been reported that local broody hens will even sit on and hatch a second clutch of eggs, often losing considerable weight in the process (especially if insufficient attention is paid to the provision of food and water).

The incubation period for chicken eggs is 20 to 21 days, and increases up to 30 days for other poultry. After sitting for some days, a broody hen can be given some newly hatched chicks and, if they are accepted, the original eggs can be removed and replaced with more chicks. Thus hens with a better record of mothering can be better utilised for their abilities.

Eggs initially need a very controlled heat input to maintain the optimum temperature of 38 °C, because the embryo is microscopic in size. As the embryo grows in size (especially after 18 days), it produces more heat than it requires and may even need cooling. Moisture levels of 60 to 80 percent Relative Humidity (increasing during the incubation period) are important to stop excess moisture loss from the egg contents through the porous egg shell and membranes. Factors to consider for successful natural incubation include the following:

- Feed and water should be close to the hen.
- The broody hen should be examined to ensure that she has no external parasites.
- Any eggs stored for incubation should be kept at a temperature between 12 and 14 °C, at a high humidity of between 75 to 85 percent, and stored for no longer than seven days.
- Extra fertile eggs introduced under the hen from elsewhere should be introduced at dusk.
- The eggs should be tested for fertility after one week by holding them up to a bright light (a candling box works best. If there is a dark shape inside the egg (the developing embryo), then it is fertile. A completely clear (translucent) egg is infertile.

A hatchability of 80 percent (of eggs set) from natural incubation is normal, but a range of 75 to 80 percent is considered satisfactory. Setting of hatchings is best timed so that the chicks to be hatched are two months of age at the onset of major weather changes, such as either the rainy (or dry) season or winter/summer. A plentiful natural food supply over the growing period of the chicks will ensure a better chance for their survival. Successful poultry species instinctively lay and incubate their eggs at a time of the year when newly hatched chicks will have a better supply of high protein and energy food provided by the environment. For example, guinea fowl will only lay eggs in the rainy season. However, seasonal changes in weather patterns are also times of greater disease risk.

ARTIFICIAL INCUBATION (PARCHED PADDY RICE AND RICE HUSK TECHNIQUES)

There are many commercial artificial incubators of varying capacities. Most depend on electricity, but some use gas or kerosene for heating. All use a thermostatic switching device to keep the temperature constant within one Celsius degree. The correct humidity is usually maintained by having a pre-determined surface area of water appropriate for each incubator chamber.

Turning the egg several times each day is important to prevent the embryo from sticking to the shell membranes. With hand-turning systems, an odd number of times turned per day (five to seven times) will ensure that during successive overnight periods the egg is always oriented the opposite way from that of the previous night.

The broody hen carries out all of these incubation tasks instinctively, and artificial incubation attempts to duplicate these tasks. Traditional artificial incubation techniques have evolved over thousands of years in many parts of the world. One such technique, developed for hatching duck eggs in China, is the parched (heated) rice technique. It is based on the use of heated paddy rice and embryo-generated heat. It is still used in China and Bali, Indonesia, with hatchability results of up to 80 percent (Smith, 1990). The objectives of artificial incubation are met equally well using either parched rice or rice husks, and a hatchability of 65 to 75 percent is common. By candling the eggs between days 5 and 7, infertile eggs can be detected as “clears” (as the light is not obscured by the growing embryo). These eggs are still suitable for sale for human consumption, which improves the economic viability of this system.

As duck eggshells are less brittle than chicken eggs, the system was never adopted for chicken eggs in China. The original Chinese system used 80 duck eggs per bundle. However, with extra care, and fewer eggs per bundle (25 to 30 compared with 40 duck eggs), chicken egg incubation was found to be equally successful in Bangladesh when adapted there in the 1980s. The number of duck eggs per bundle was reduced to 40, which gave better hatching results as well as fewer breakages than 80 per bundle.

The artificial parched rice or rice husk incubation process is started by heating the eggs, either in the sun or in an insulated warming room equipped with a heat source. On sunny days, approximately 25 to 30 chicken eggs or 40 duck eggs, (presumed fertile, and carefully dated and labelled) are placed in the sun on pieces of padded cloth for about 30 minutes and turned occasionally to raise the temperature of the eggs to the required 37 to 38 °C. This temperature can be judged by the appearance of water droplets on the shell or by touching the egg to the eyelid. On sunless days, eggs must be placed on a cloth in a shallow bamboo basket and put on racks in a heated warming room to slowly achieve the same temperature. This usually requires approximately one to three hours. Any slow-burning fuel is suitable, and kerosene and charcoal are commonly used. In Egypt, dried beanstalks were used for thousands of years for their characteristic slow-burning property, and are still used today in the Fayoumi district (from where the well-known chicken breed of the same name originates). A well-vented stove will prevent any toxic fumes affecting the embryo. In Bangladesh, slightly heated (to 38 ^{o}C) sand or wood-ash, covering the eggs for approximately one minute, is also effective in warming the eggs. Human clinical thermometers, now readily available, can be used to assist training in using the eyelid’s sensitivity to temperature. If the humidity drops below 70 percent, 60 percent, 50 percent or even 40 percent (particularly in typical progressively drier months), a wet (and slightly warm) cloth should be placed over the eggs with a frequency corresponding to the above humidities of one, two, four or six times daily. This will raise the humidity of the egg so that the embryo will not dry out.

The unhusked (paddy) rice is heated (parched) and continuously stirred until it reaches a temperature of 60 °C, to provide heat for the eggs for the first two weeks of incubation. About 2.5 to 3.0 kg of the heated rice is enclosed in a cloth pillow and placed into the egg basket. The pillows have the same diameter (40 cm in the Bangladesh example) as the basket, and should be about 8 cm thick. Where rice-husk is used, pillows can be made with black-coloured material, which easily absorb the sun’s heat. When the temperature of the pillow has dropped to about

40 °C, a loosely bunched bundle of 40 duck (or 25 to 30 chicken) pre-warmed eggs are placed on top of the warm rice. The bundle is made from a square piece of cloth about 45 cm on each side. A soft duster cloth with pinholes is suitable. Alternating pillows of warm rice and egg bundles are added until the basket is full, finishing with a pillow of rice. The basket is then covered with padding to conserve as much heat as possible. This procedure is repeated until all the eggs are placed in baskets, leaving one basket empty to allow the addition of freshly warmed rice. The incubating baskets are cylindrical in shape (50 cm in diameter and 80 cm in depth in China, and 40 cm in diameter and 70 cm in depth in Bangladesh and are made of woven bamboo strips. In China, a few layers of bamboo paper are pasted on the inner surface of the sides and bottom to seal the gaps against temperature loss through convection.

In warmer parts of southern China, rice husk is substituted for paddy rice, and the pillows containing the husks are made from black-coloured material, which easily heat up in the sun. Rice husks also provide very good insulation against loss of heat from the older eggs, which is instead transferred (by conduction) to younger eggs placed in contact with them in separate bundles. This rice-husk system was adopted on a large scale in Bangladesh after being introduced by poultry development projects in the 1980s. The system has evolved, and the cylindrical egg baskets are now set into larger bamboo frame setting boxes, with more insulating rice husk material placed between the cylinders and the walls of the enclosing setting boxes. The cylinder wall should be about 10 cm from the setting box wall and 8 cm from the next cylinder. With this greater insulation, there is less heat loss, thus less need to provide supplementary heat from costly fuels.

For the first three days, reheated paddy rice (or rice husk) is added three times a day at regular intervals. During days four to six, this may be reduced to twice a day. The object is to ensure that the eggs are kept at the temperature most suitable for embryo development. The spare basket is used to transfer eggs from an adjoining basket when adding freshly warmed rice or rice-husks. Thus the top layer of eggs becomes the bottom layer and the bottom layer ends up on top of the spare cylinder. The newly emptied basket is then ready to receive eggs from the third basket, and so the cycle continues.

In China, heat is provided for days 13 to 14 in summer and in the colder months also on days 18 to 19. After that, the developing embryos are able to produce enough heat to maintain the incubation process without further need of an outside heat source. Eggs set for the first six days are called "new eggs", those between days 6 to 13 (which neither need nor produce extra heat) are "in-between eggs" and eggs after day 13 (which give out excess heat) are "old eggs". Once a basket contains "old" and "in-between eggs", it is possible to use embryo-generated heat alone to incubate "new eggs", which are usually introduced at intervals into the basket and placed between layers of "old eggs". Even when outside heat is not added, the eggs in the baskets must be regularly turned and aired three to five times a day in the process of transferring them to adjoining baskets. In order to use the embryo-generated heat effectively (almost all year round), the layers of eggs in the baskets are organized to a particular pattern, a typical example of which is shown in Table 5.1.

The eggs are candled on days 5 and 13, both to identify infertile eggs and dead embryos and to assess the degree of embryo development; which is used as one of the guides in adjusting basket temperature. Placing the egg on the upper eyelid allows the egg temperature to be assessed. The temperature of the basket may be adjusted in the following ways:

- by varying the proportion of eggs in a basket at different stages of incubation (for example, the temperature may be lowered by removing some of the bundles of "old eggs");
- by varying the arrangement of eggs in a basket (for example, as heat dissipation from eggs near the sides of the basket is faster than from those in the centre; a bundle of "old eggs" can be placed in the centre core and bundles of "new eggs" shaped to enclose them); and

- by changing the top covering of the basket using heavier padded material in cold weather and at the beginning of the incubation period, and a lighter covering if less heat retention is required.

Table 5.1 Arrangement of eggs in the incubation baskets prior to and after transfer to adjoining baskets

		Incubation time (days)		
Layer	**Before transfer**	**Summer**	**Winter**	**After transfer**
1	A	14-6	17-20	J
2	B	1-3	1-4	I
3	C	10-13	13-16	H
4	D	4-6	5-8	G
5	E	7-9	9-12	F
6	F	7-9	9-12	E
7	G	4-6	5-8	D
8	H	10-13	13-16	C
9	I	1-3	1-4	B
10	J	14-16	17-20	A

Source: Fuan, 1987

Eggs in the advanced stages of incubation produce a lot of heat, so on days 13 to 14 in summer (days 18 to 19 in winter), the "old eggs" are transferred to hatching beds, where they are placed in a single layer for final development and hatching. The surface of the bed is covered with a thin layer of rice husks and then covered with a straw mat. The edges of the bed are lined with padding to protect the eggs. The covering for the developing eggs in the bed may be heavy or light cloth, depending on the degree of insulation required. The temperature in the hatching bed is maintained at 36 to 37 °C, slightly lower than that of the basket. The temperature can be adjusted by changing the thickness of the covering, varying the space between the eggs, and moving the eggs twice a day so that those on the perimeter change places with those at the centre. In very hot dry weather, the eggs are sprayed with a fine mist of water. They are kept in the bed until the chicks hatch out and dry.

The hatching bed should be two-storied (like a bed-bunk) and can be made of wood. An example hatching bed with a 500-egg capacity has a length of 90 cm and width of 68 cm. The height of the side wall on all sides should be 20 cm from the bed base level, with a 25 cm gap above the side wall for ventilation and ease of access.

Chapter 6
Health

In most family flocks, disease is an important problem. Although farmers are familiar with the signs and symptoms of disease (see Table 6.1), the underlying causes are less well known. Almost every farmer and most extension workers hold Newcastle Disease (ND) responsible for most deaths, and the disease has a local name in all languages.

Table 6.1 Signs of poultry disease observed by farmers in East Kalimantan villages, Indonesia

Signs	**Frequency %**
Chickens huddle together	16.1
Coughing, sneezing, rapid breathing	13.2
Discharge from mouth and nostrils	10.9
Dullness, no appetite, closed eyes	10.9
Paralysis of legs and wings	9.2
White droppings	8.6
Turned or twisted neck	8.0
Dark red colour of head and comb	6.9
Greenish or yellow droppings	4.6
Bloody reddish droppings	4.0
Swellings of head and comb	2.9
Pale comb	1.7
Worms in faeces	1.7
Eye worm	1.1

Source: Ramm *et al.*, 1984

However, not all infectious diseases are due to the Newcastle Disease Virus (NDV). Digestive problems resulting in slow growth and diarrhoea may be the result of rancid feed or too much salt, and may also be symptoms of diseases such as coccidiosis, salmonellosis, or Gumboro Disease (Also called Infectious Bursal Disease [IBD]). ND often has the symptom of greenish faeces, which indicates a loss of appetite.

Poultry have highly developed and sophisticated respiratory systems. Their heart and breathing rate are faster than humans, and their body temperature is 5 °C higher. Their lungs are connected at the lower ends to a complex series of membrane-enclosed air sacs, which in turn are connected to air cavities in their major skeletal bones. These features contribute to their lightness and flying ability. The disadvantage is extreme susceptibility to respiratory infections caused by a wide range of bacteria, viruses and fungi. These infections become more of a problem in domestication, which usually involves some degree of increase in stock density – even if only for overnight accommodation – and thus increases the risk of cross-infection.

Inadequate ventilation of poultry houses results in a build-up of ammonia gas from poultry faeces, which contain urea. This can predispose the poultry to respiratory disorders, such as sneezing, running eyes and mucous discharges from the mouth. Providing good ventilation easily prevents this. More prolonged respiratory disorders are usually caused by diseases such as ND, Infectious Bronchitis (IB), Infectious Laryngotracheitis (ILT), Chronic Respiratory Disease (CRD) and diphtheria.

Coordination disorders such as paralysis, limping, twisted neck and slow movement may be caused by a variety of factors, such as physical injury, nutrient deficiencies and diseases, including ND (twisted necks or *torticolis*), Marek's Disease (paralysis), synovitis (tendon infections in which feet joints feel warm) and Avian Encephalomyelitis (AE).

COMMON DISEASES

The common diseases and disorders of free-range poultry may be either infectious or non-infectious, and are caused by a wide range of organisms or deficiencies. These are summarised in Table 6.2. Disease control is discussed in a later section of this chapter.

Table 6.2 Causes and examples of poultry diseases

Causal Agent	Example
Infectious	
Virus	Newcastle Disease, Avian Encephalomyelitis,
	Fowl Pox, Marek's Disease, Infectious Bronchitis
	Infectious Laryngotracheitis, Gumboro Disease (Infectious Bursal Disease), Duck Virus Hepatitis
Mycoplasma	Chronic Respiratory Disease
Bacteria	Fowl Cholera, Salmonellosis, Pullorum, Fowl Typhoid, Infectious Sinusitis, Colibacilosis
Parasites	**Ectoparasites**: lice, mites, ticks
	Endoparasites: nematodes, Histomoniasis, Haemoparasites, round worms, hair worms, Avian Malaria
	Protozoa: Coccidiosis, Blackhead
Fungus	Aspergillosis: *A. flavis* (toxins), *A. fumigatus* (airsaculitis)
Non-Infectious	
Deficiencies	rickets, curled toe paralysis, encephalomalacia
Toxicities	salt poisoning, food poisoning (Botulism *Clostridium botulinum* and *C. perfringens)*, poisonous plants

INFECTIOUS DISEASES

Viral diseases

Viral diseases are some of the most important infectious diseases affecting poultry. They are characterised by not being able to be treated, but most can be prevented with vaccines. The more important viral diseases are outlined below.

Newcastle Disease (ND)

This disease (called Ranikhet Disease in Asia) spreads rapidly via airborne droplets spread by the coughing or sneezing of infected birds. The virus can be carried by wild birds, through contaminated eggs, and on clothing. As mortality is often 100 percent in young chickens, ND is probably the most important constraint to family poultry development. Birds of any age can be affected, although young ones are more susceptible. Mortality in older chickens is usually lower, but egg production is usually severely reduced.

The incubation period of three to five days is followed by dullness, coughing, sneezing and gasping. Rapid breathing is accompanied by a gurgling noise in the throat. The respiratory signs usually develop first and are sometimes followed by nervous signs, characterized by twisting of the neck, sometimes combined with dragging of wings and legs. Depending on the environment and the degree of resistance of the birds, not all symptoms may be shown, or they may be in a mild or subclinical form. Some farmers have observed that the twisting of the neck occurs only in birds that survive. Early loss of appetite results in a greenish diarrhoea. The most obvious diagnostic sign of ND is very sudden, very high mortality, often with few symptoms having had time to develop. Diagnosis of ND can be difficult from just the symptoms, as they are so varied, and as many other diseases share the same symptoms. For a discussion on the control of ND, see the “ND Control” section below. The high incidence of ND among family free-range flocks is due to the following factors:

- the prevalence of virulent strains (velogenic, viscerotropic and pneumotropic) in tropical countries;
- continuous contact with other domestic and wild species of birds (such as ducks and pigeons), which can carry the virus without showing the disease (Majiyagbe and Nawathe, 1981); and
- uncontrolled movement of birds between villages.

There is a seasonal pattern to outbreaks of ND (Sharma *et al.*, 1986), influenced by:

- the arrival of migratory birds;
- changes in climatic conditions leading to stress, which predisposes birds to the disease;
- hot, dry and windy periods, which encourage airborne spread of the virus; and
- overuse of the few supply points of water available (during the dry season), which then become heavily contaminated with the virus.

Fowl pox

Fowl pox is still prevalent in many poultry flocks, for the following reasons:

- The fowl pox virus can remain alive in the pox scabs (which have fallen off the birds) for up to ten years, which contaminate the environment.
- Mosquitoes and other blood-sucking insects can transmit the virus.

The disease tends to be seasonal, occurring after mosquito breeding times. It is endemic in Papua New Guinea, where it is significant economically because the only NDV in the country is the non-symptomatic form (Sugrim, 1987). It is also a major disease in many other tropical countries.

Marek's Disease

Infection occurs early in life, and once a bird is infected, it can shed the virus in skin flakes throughout its life, if it survives. Clinical signs occur in young growing birds in the Acute Marek’s Disease (MD) form, characterised by high mortality from visceral tumours. Another peak of mortality occurs in the Classical MD form, characterized by nerve paralysis in the legs and wings of birds aged from 15 weeks to early in the laying period.

Mycoplasmal diseases

Mycoplasmas are not classified as bacteria or viruses, but as Pleuro-pneumonia-cocci-like organisms (PPLO). These are primarily associated with Chronic Respiratory Disease (CRD), a complex syndrome caused by *Mycoplasma gallisepticum* in partnership with bacteria (often *E. coli*), fungi and viruses (often Infectious Bronchitis). *M. gallisepticum* can be transmitted through the egg. Multi-age flocks, nutritional deficiency and water deprivation are important factors in the epidemiology of the disease in rural poultry flocks.

Bacterial diseases

Fowl Cholera (Avian Pasteurellosis)

This is a contagious septicaemia (caused by *Pasteurella multocida*) that affects all types of fowls. It is often transmitted by wild birds or other domestic birds, and spreads by contamination of the feed or water and by oral or nasal discharges from infected birds. The incubation period is four to nine days, but acute outbreaks can occur within two days of infection. In some cases, birds die within a few hours of showing the first signs, which vary depending on the form of the disease. The respiratory form is characterized by gasping, coughing and sneezing, while in the septicaemic form there is diarrhoea with wet grey, yellow, or green droppings. In the localized form, the signs are lameness and swelling of legs or wing joints. In acute cases, the head and comb change colour to dark red or purple. If the infection is localized in the region of the ears, a twisted neck (*torticolis*) can sometimes be observed. In chronic cases, the comb is usually pale, with swellings around the eyes and a discharge from the beak or nostril. Fowl Cholera is common everywhere among free-range village flocks, because they are comprised of different species and are in continuous contact with wild birds.

Pullorum (Bacillary White Diarrhoea)

This is an egg-transmitted disease (caused by *Salmonella pullorum*) that spreads during incubation or just after hatching. White diarrhoea can be seen from three days to several weeks of age. The chicks refuse to eat, keep their heads tucked in and their wings hanging down. They huddle together and make a peeping sound. Mortality in the acute form ranges from 20 to 80 percent, and in the chronic form is around five percent. In the chronic form, the signs are a marked swelling of the hock joints, poor feather development, lack of appetite and depression. Table 6.3 shows the results of a survey in Zaria, Nigeria, conducted by Adesiyun *et al.* (1984) for Pullorum antibodies, which indicate a past infection with the bacteria.

Table 6.3 Prevalence of *Salmonella pullorum* antibody in chickens in northern Nigeria

Management	Age (wks)	Nº tested	Nº positive	(%)
Free-range	young	59	15	25
(indigenous)	adult	101	40	40
Backyard	young	90	8	9
(exotic)	20 +	70	24	34
Confinement	young	70	22	31
(exotic)	20 +	90	69	77

Source: Adesiyun *et al.*, 1984

The free-range stock sampled was indigenous, and the other two groups were exotic. As the age of the birds in the free-range survey was not known, birds not in lay were counted as young.

Fowl Typhoid

Fowl typhoid is caused by *Salmonella gallinarum*, and commonly affects adult fowls. When it occurs in young birds, the signs are similar to those of *S. pullorum*. The incubation period is four to five days, and two days later the birds become depressed and anorexic. The colour of the comb and wattles becomes dark red; the droppings become yellow and the birds close their eyes and keep their heads down. Usually the affected chickens die within three to six days. Pullorum and fowl typhoid complex are both prevalent under free-range conditions.

Avian Salmonellosis (Paratyphoid)

Salmonellosis is usually used to describe infection with any organism of the Salmonella group other than *S. pullorum* or *S. gallinarium*. In countries with intensive poultry systems, poultry meat and eggs are a major source of infection for humans. The opposite may be true of family poultry, with humans infecting poultry. Ojeniyi (1984) reported that *S. hirschfeldii* was isolated from cloacal swab samples in fowls and from an adult human male in the same village.

Parasitic diseases

External parasites (ectoparasites)

These are very common in scavenging poultry, and include:

- **Lice**: these live on the skin of the birds, especially around the cloacae and under the wings. The irritation they cause can lead to reduced production. Lice species commonly found on poultry are *Menacanthus straminens, Lipeurus caponis, Monopon gallinae, Goniodes gigas* and *Chelopistes meleagride.*
- **Mites**: these are troublesome ectoparasites, which hide in the cracks of housing and perches, and come out only at night. They are bloodsuckers and lower egg production. Mites such as *Dermanyssus gallinae* can also transmit the bacteria *Borrelia,* which causes fever, depression, cyanosis and anaemia (spirochaetosis).
- **Ticks**: a heavy infestation can produce severe anaemia and, in extreme cases, death due to blood loss. *Argas persicus* is particularly dangerous, being the vector of several blood parasites such as the haemoprotozoa and microfilaria. In Malaysia, it was reported (Sani *et al.*, 1987) that out of 201 blood samples taken from village birds, more than 100 contained *Leucocytozoon sabrazesi*, 30 had microfilaria, and six carried *Plasmodium gallinaceum* (Avian malaria). Avian malaria infection is much higher among exotics and cross-breeds.

Internal parasites (endoparasites)

The more important internal parasites are:

- Helminths (worms): these are common in scavenging poultry, especially nematodes and cestodes. Ssenyonga (1982) showed that worms were a major cause of lowered egg production of scavenging poultry in Uganda, the most commonly found being *Ascaridia galli* (Round Worm), *Heterakis gallinae* (Caecal Worm), *Syngamus trachae* (Tracheal Worm) and *Raillientina* spp. (Tape Worm).
- Protozoa: the most pathogenic are the coccidiosis disease species of *Eimeria tenella* and *E. necatrix*. Coccidiosis is a common parasitic infection in scavenging poultry. It affects mostly young birds, and the most important signs are emaciation, thirst, listlessness, ruffled plumage, bloodstained faeces and birds huddling together. Surveys in Southeast Asia and East Africa showed that 73 and 47 percent of birds, respectively, had positive faecal samples of *Eimeria* spp. (Eissa, 1987). The presence of the coccidia organism in faecal samples indicates an infection, but not necessarily at clinical disease levels. Like antibody presence in blood samples, it may indicate a degree of immunity. This should not be “treated”, as doing so eliminates the immunity.

Fungal diseases

Mycotoxicosis

The fungus *Aspergillus flavus* commonly grows on stored feed ingredients where moisture content is over eleven percent, especially cereal grains (such as maize [corn]) and oilcake meal (such as groundnut [peanut] meal). The aflatoxin called mycotoxin is the specific toxin produced by *A. flavus.* The toxin itself may remain after all sign of the fungus mould is gone. Ducks are more vulnerable to the toxin (with a lethal dose in the feed of one part per million [ppm] of aflatoxin) than chicken, which can tolerate up to four ppm. In acute forms of the disease, mortality can be as high as 50 percent. Common adverse effects include immunosuppression, reduced growth in young stock and reduced egg production in hens (Smith, 1990).

Aspergillosis

This disease is also called airsaculitis. The fungus *Aspergillus fumigatus* causes the disease by growing as a fungus in the lungs and interconnected air sacs. The fungus grows on damp litter or feed, and the bird breathes in the spores, which grow into easily visible lesions as green and yellow nodules, which can completely fill the lungs.

NON-INFECTIOUS DISEASES

Deficiencies

Poultry health is also affected by nutritional and environmental factors, such as insufficient feed or feed deficiencies. A high mortality rate among chicks during the first days or weeks after hatching may be caused by insufficient feed and water. A high mortality in adult birds may be due to nutritional problems, such as salt deficiency.

Energy and protein deficiencies and imbalances can arise when the feed contains insufficient quantities of these nutrients, resulting in poor growth in young stock and a drop in egg production and egg weight in laying hens. Mineral and vitamin deficiencies may result in poor growth, low production or death. Vitamin D deficiency causes rickets (bone deformities) in young chicks and, if combined with a calcium deficiency, in chickens of all ages. A lack of manganese results in deformities of the feet of older chickens.

Toxicities

An excess of certain nutrients, especially minerals, can cause abnormalities. An excess of common salt (NaCl), for example, results in deformed eggshells as well as increased water consumption, and if drinking water is restricted (as is often the case with free-ranging birds), signs of toxicity may develop. Free access to feed of high carbohydrate and low fat, combined with lack of exercise, high temperatures and stress, can cause Fatty Liver Syndrome, which can result in high mortality.

Ingestion of toxic plant parts (such as leaves, seeds and sap) is a common hazard for free-range birds. Some toxins are produced by micro-organisms, such as those liberated by the bacteria *Clostridium botulinum* and *C. perfringens,* both found in the soil. *C. perfringens* causes necrotic enteritis, caused when the bacteria multiplies in the favourable conditions of the digestive tract and liberates a potent toxin that results in high mortality. Occasionally affected birds show anorexia, depression and diarrhoea, but most die without showing any clinical signs. *C. botulinum* causes botulism disease, which is acute food poisoning. This is more common in ducks, which show the nervous symptoms of neck bent down and feathers falling out easily when lightly pulled. Botulism results from the bird eating rotting vegetable scraps, which contain the toxins produced by the *C. botulinum.* Household vegetable scraps which are not regularly removed are a potential hazard for botulism.

EPIDEMIOLOGY

Management system effects

Although nearly all the important poultry diseases are found under all types of management, the pattern of disease in free-range birds is different from that seen in intensive poultry production. Free-range flocks usually comprise different species of all ages, and are constantly exposed to the weather, environment and seasonal outbreaks of disease, as well as to germs and parasites found in the soil and in wild birds and animals.

In a 15-year study of the incidence of poultry diseases in northern Nigeria, Sa'idu *et al.* (1994) found viral infections (such as ND in chickens and pox in turkeys) to be the most common cause of disease, although concurrent viral infection with parasites constituted about half the cases studied (see Table 6.3). They concluded that viruses and parasites caused the most important diseases in indigenous chickens and that they were seasonal in their onset.

Table 6.4 Diseases affecting local chickens and turkeys in Zaria, northern Nigeria

Chickens	
Disease	**Proportionate mortality (%)**
Newcastle Disease	36.1
COMBINATIONS	28.5
Snake bite	8.6
Other Diseases	8.6
Gumboro	7.1
Fowl Pox	5.1
Ectoparasites	3.5
Endoparasites	2.5
Turkeys	
Disease	**Proportion of all diseases (%)**
Turkey pox	16.5
Ectoparasites	15.7
Newcastle Disease	12.2
COMBINATIONS	10.6
Infectious sinusitis	10.2
Endoparasites	3.5
Other Diseases	31.3

Source: Sa'idu *et al.,* 1994

Another study (Adene and Ayandokun, 1992), which looked at the changing pattern of diseases in southern Nigeria over the period from 1949 to 1955, found that mortality in the free-ranging flocks at the University of Ibadan was due mostly to the following:

- Helminthiasis, due to *Raillietina, Heterakis, Ascaridia, Capillaria, Tetrameres* and *Syngamus* spp.;
- Pediculosis, due to *Menopon, Gonoeodes, Goniocotes and Lipeuris* spp.; and tropical poultry mites (*Ornithonyssus bursa*) in chickens, and *Numidilipueria tropicalis* in guinea fowls.

These parasitic infections were greater causes of mortality than Newcastle Disease at that time.

Another survey of backyard chicken flocks in Zimbabwe (Kelly *et al.*, 1994) tested 450 blood samples from 52 flocks, and found Infectious Bronchitis (IB) in 85 percent and Newcastle Disease (ND) in only 27 percent of the samples (see Table 6.4). A possible explanation for the lower frequency of ND is that the mortality is usually much higher from ND than for IB, so fewer birds survive to be counted.

Similarly, in Zambia, a survey based on 2000 blood samples (Alders *et al.*, 1994) found that the mean seroprevalence of Newcastle Disease was 37 percent, which varied between 29 percent in the northern province and 51 percent in the Copper-belt province. A summary of the relative importance of poultry diseases gathered from other sources is tabulated in Table 6.5.

Table 6.5 Disease status in backyard chicken flocks in Zimbabwe as shown by blood testing

Pathogens	Percent positive samples
Infectious Bronchitis	85
Reticulo-endotheliosis	65
Gumboro Disease	55
Pasteurella multocida	52
Mycoplasma gallisepticum and /or	
Mycoplasma synoviae	33
Newcastle Disease	27
Encephalomyelitis	11
Avian Leucosis	9
Reovirus	3

Source: Kelly et al., 1994

Table 6.6 Relative importance of family poultry diseases

Rank	Saunders 1984 Burkina Faso	Adene 1990 Nigeria	Ramm *et al.*, 1984 Indonesia	Ahmed 1987 Bangladesh
1	ND	ND	ND	ND
2	Trichomonas	Gumboro	CRD	Fowl Cholera
3	Fowl Pox	Fowl Pox	Fowl Pox	Coccidiosis
4	Salmonellosis	F. typhoid	Coccidiosis	Fowl pox
5	Pasteurellosis	Marek's Disease	Fowl Cholera	Pullorum
6	Parasites	Parasites	Pullorum	Parasites

Poultry species effects

In tropical countries, Newcastle Disease is considered to be the most important disease of village flocks because of its high mortality, which is above 70 percent in most African countries. However, not all poultry species are equally susceptible. Guinea fowl, although sometimes affected, appear to have better resistance to ND even when kept with chickens. They are however more susceptible to *Trichomonas*, to which chickens appear to be immune. Ducks are not thought to be susceptible to ND (although they are significant carriers of the disease), or to most other common diseases of chicken, but they succumb easily to diseases specific to ducks, such as:

- Duck Virus Enteritis (Duck Plague): this is an acute and highly contagious disease of ducks, with a mortality rate of up to 100 percent.
- Duck Virus Hepatitis and Mycotoxicosis: these pose a great danger for ducklings. Mycotoxicosis is mostly contracted from ingesting aflatoxin from mouldy compound feeds; a dose of 0.75 ppm can kill a duckling.
- Duck Cholera (*Pasteurella multocida* infection): this is a widespread disease of ducklings in village flocks, and chickens can also be infected.
- Pasteurellosis (*Pasteurella anapestifer*): this is an important disease of ducklings, while *Escherichia coli* infection (Colibacillosis) is a septicaemic disease of growing ducks. Chickens can also be infected with *E. coli*.

The above diseases are largely responsible for the huge losses of ducklings that are a feature of free-range duck production.

Although salmonellosis is not a major disease in ducks, duck eggs are a significant source of salmonellosis in humans. This may explain the taboo against touching duck eggs prevalent in many cultures, particularly in Africa. Duck eggs should not be stored in contact with vegetables that will be eaten raw, such as carrots, lettuce and cabbage.

Season and age effects

Disease patterns vary according to the season. Newcastle Disease is more serious during the dry season. In Thailand, Pasteurellosis, Coryza and streptococcal infections also occur more frequently in the dry season, and Fowl Cholera, Colibacillosis and Pseudomoniasis in the rainy season (Thitisak, 1992). In northern Nigeria, where Sa'idu *et al.* (1994) studied 522 cases involving 8 800 chickens, ND accounted for 30 percent of all cases. Of these, 38 percent occurred immediately before the dry season of October to December, and only 10 percent during the rainy season of July to September. As for Fowl Pox, more outbreaks occurred in the rainy season and were highest in the month of July, and about 60 percent of the outbreaks affected young chicks. In Thailand, Thitisak *et al.* (1989) noted that a catastrophic mortality had occurred in March in both 1987 and 1988, this being the late dry season when early storms cause sudden drops in temperature which chill the birds. They also found that chickens under two months of age (normally a rapid growth-rate phase), and those over six months of age (in the process of becoming sexually mature) were more susceptible to infectious diseases (see Table 6.6).

Table 6.7 Cause-specific mortality rates per 100 birds at risk

Cause of death	**Age (months)**			
	under 2	**2 to 6**	**Over 6**	**Total**
Infectious Coryza	6.8	0.7	16.8	24.3
Avian Pasteurellosis	4.6	1.1	2.4	8.1
Newcastle Disease	4.1	1.4	0.7	6.2
Fowl Pox	3.2	0.3	0.0	3.5
Salmonellosis	1.4	0.0	0.3	1.7
Pseudomonas	0.0	0.3	0.0	0.3
Total	**20.0**	**3.8**	**20.2**	**44.1**

Source: Thitisak *et al.*, 1989, and Janviriyasopak *et al.*, 1989.

Data from surveys in 1987 of 2231 and 3239 birds

Need for epidemiological studies

Epidemiological studies of village poultry are essential for the development of appropriate village-based poultry health programmes. These have been attempted in many countries, but the work undertaken in Thailand (Janviriyasopa *et al.*, 1989) will be used as an example.

The North-Eastern Regional Veterinary Research and Diagnostic Centre, Tha Pra, Khon Kaen, Thailand, with assistance from the German Agency for Technical Cooperation (GTZ) and the Department of Veterinary Clinical Sciences of Massey University, New Zealand, embarked on a long term-study (“Health and Productivity of Native Chickens”). This was part of a programme of epidemiological investigations of factors affecting livestock productivity in the region. The objective of the study was to decide on the priority of the problems for which control programmes could be developed within the regional Basic Poultry Health Service.

In selected villages, about 15 families with flocks of 15 to 20 birds were recruited. In most of the villages, vaccinations against ND, Fowl Pox and Fowl Cholera were carried out in order to encourage interest. Two villages were paid to represent a totally unvaccinated control population. Birds were wing-tagged and grouped by age:

- under two months;
- two to six months;
- six to twelve months;
- one to two years;
- two to three years; and
- over three years of age.

During each visit, the number of eggs and chickens were weighed, counted and scored, and blood was collected from the wing vein for determination of ND titre and for Pullorum, CRD, IB and Gumboro (IBD) tests. Each tagged bird was subjected to health, feather and ectoparasite scoring. Sick and dead birds were collected for pathological examinations at the laboratory, in order to identify the cause of death or illness, and refrigerators were provided in some villages to store dead birds for later examination. Dead or diseased birds were exchanged for healthy birds in order to examine as many as possible, but as the villagers would sometimes eat dead or dying birds, most of those exchanged tended to be the immature birds which owners were less willing to eat. By calculating age-specific mortality rates and then determining cause-specific rates within each age-group, the contribution of each disease to the mortality within an age-group was determined. A questionnaire was used to gather additional information.

The objectives of the survey were to establish:

- a productivity index;
- population dynamics;
- the importance of common diseases, their incidence and prevalence;
- the average life span of birds;
- patterns of disease outbreaks; and
- the relationship between disease and production levels.

The parameters used for the survey were:

- egg production;
- egg hatching rate;
- number of deaths in each age group;
- weight gain of growers;
- number of birds killed for eating;
- number of birds sold; and
- unexpected losses.

Some of the results of the survey are seen in Table 6.6 above. Poor management of eggs, hatching and young chicks, as well as malnutrition, particularly in the dry season, were found to be important predisposing factors to infectious diseases and parasitic infestation (Thitisak *et al.*, 1989).

DISEASE CONTROL IN FAMILY FLOCKS

Non-medical disease control

The most economical and effective means of preventing non-viral diseases is improved management and nutrition, of which the most important aspects are hygiene, housing, flock structure, and young chick care and feeding.

Hygiene

The following simple hygiene measures, which help in disease prevention, were recommended by the FAO/UNDP Small Stock Development Project in North Kivu, Zaire (FAO/Anonymous, 1989):

- Droppings, feathers and dead birds are sources of pathogens and should be removed from overnight housing and the free-range compound, and then properly disposed of. This will also reduce the incidence of external parasites.
- New arrivals to the flock should be isolated. Birds bought or received as gifts should be quarantined in a basket or cage for at least 15 days; if they remain healthy, they can then join the flock.
- All new arrivals should be treated for ectoparasites and endoparasites as well as vaccinated on arrival if possible.
- Sick birds should be isolated or slaughtered promptly, and dead birds buried.
- The litter in the poultry house should be turned frequently and changed if wet.
- Overnight security baskets should be put in the sun to dry properly or suspended near a fire during the rainy season.
- Feeders and drinkers should be cleaned frequently.
- Broken pots used as drinkers should be heated over a fire before refilling.
- The poultry house or basket should be regularly disinfected every two months.

Housing

Simple improvements and maintenance can be carried out when the poultry house is not in use. Important factors in good housing are:

- **Ventilation**: if poultry baskets are used for overnight housing, they should not be covered with cloths or sacks. Huts, coops and baskets should not be placed near dunghills or pit latrines.
- **Proper spacing**: overcrowding should be avoided, and numbers of poultry should be restricted to the space available. Weaned chicks and growers should be kept in separate overnight housing. Laying and brooding nests should be left undisturbed.
- **Separate species**: it is better to keep only one species of poultry but if this is not possible, the species should be housed separately overnight to avoid the spread of disease.

Flock structure

Of all the common free-range poultry species, chickens are the most susceptible to disease. Ducks, geese and guinea fowl are often symptom-less carriers of chicken diseases, or have mild forms of them. This represents a common source of infection in chickens, while the opposite is rare. Therefore in mixed flocks special attention should be paid to the health of chickens. Separation into different species and age groups may not be possible, but simple devices such as creep cage-baskets may be used as a temporary measure for procedures such as vaccination of chicks or special feeding.

Feeding

The importance of nutrition in flock health is well known. There is a need for further research into alternative feeds for rural poultry, which avoid the use of grain for human consumption (see Chapter 3).

Medical disease control

Simple medical control measures appropriate for free-range village flocks include:

- Vaccination against Newcastle Disease, Fowl Pox and Fowl Cholera.
- Deworming for internal parasites in a mixed flock, with a polyvalent poultry dewormer such as Piperazine (added to drinking water). With guinea fowl, a dewormer against *Trichomonas* should be used.
- Treatment for external parasites. Insects and other external parasites build up quickly in poultry huts, coops and baskets. There are effective traditional methods against ectoparasites. All the surfaces of the basket, coop or hut can be sprayed with a suitable insecticide, using the same type of hand-pump used for spraying mosquitoes. This procedure should only be carried out when the house is empty in the morning, and the birds should not be allowed back inside until evening. External parasites living on poultry can best be treated by adding powdered mothballs (naphthalene) and ash to the dust bath area. Ash dust is more abrasive than ordinary soil dust, and thus removes the waxy coating of the insect exoskeleton when the bird takes a dust bath. If enough of the waxy coating is removed, the insect will dehydrate and die.

Newcastle Disease control

There are three general approaches to the control of ND:

- **Hygiene:** this is always important, especially in the control of ND in semi-intensive systems where birds are confined within a fenced yard or house. Hygiene includes measures such as cleaning, disinfection, limiting access to wild birds, and personal hygiene of the farm staff.
- **Slaughter of infected flocks**: this is a drastic measure, which has been successfully employed in isolated regions or islands that are essentially free of the disease.
- **Vaccination** in combination with appropriate hygiene measures: this remains the most effective way of controlling ND.

Newcastle Disease vaccines and vaccination campaigns

For viral diseases, vaccination is the only form of prevention. A proper vaccination campaign can rapidly and significantly minimize losses due to disease. In Indonesia, after an ND vaccination campaign, mortality in village flocks dropped from 50 to 8 percent and the population of chickens increased from 900 to 3 500, representing a 250 percent increase (Moerad, 1987). ND vaccines are available in either “live” or “dead” forms:

- **Live vaccines** are fragile and have very precise rules for use, requiring a cold chain up to the point of application to the bird. Their effectiveness is reduced if there are residual antibodies in the chickens. This is especially important with maternal antibodies, which are retained by the newborn chick and protect it for up to ten days. Even a low level of maternal antibody reduces the effectiveness of gaining immunity from the vaccine. Group vaccination can be administered in very clean drinking water in very clean drinkers, or by aerosol (in enclosed buildings). The conventional live vaccine, Hitchner B1, cannot be given in drinking water to village flocks, but can be given using the eye-drop method, which has the advantage that each bird receives its dose individually. This has been successfully carried out in Morocco, where it led to a considerable reduction in mortality (Bell *et al.,* 1990a). The eye-drop method should be used only if there are veterinary personnel available for training vaccinators.

- **Killed vaccines** give good immunity but require priming with a live vaccine for best results, unless a natural infection has already served this purpose. They have been used successfully in Burkina Faso (Verger, 1986, and Ouandaogo, 1990). Killed vaccines have two disadvantages: they must be administered individually by intramuscular injection, which requires some veterinary training, and – as with live vaccines given by eye-drops – the birds must be caught, a cumbersome task which cannot be avoided with the techniques presently available. Killed vaccines have the advantage that they do not require as rigid a cold chain as do live vaccines, and, because they have a consequently longer shelf life, they can be used in more remote locations. They appear to be most effective in birds that have already acquired some degree of immunity from natural NDV exposure or an initial live vaccine inoculation. Another advantage of killed vaccine is that the virus-killing chemical used in its preparation also acts against all other possible vaccine pollutants, such as unwanted viruses, bacteria and other micro-organisms. Killed vaccines are usually cheaper than live vaccines because the product is more durable, but this is only viable for large flocks. Evidence from Burkina Faso and Niger indicates that because each vial contains at least 100 individual doses, there was a high degree of wastage, as the villagers only managed to vaccinate a few dozen birds a day at best. Much of the advantage gained in efficient manufacturing, packaging and dispatching can be lost at this final stage if the contents of the vial are not fully utilized.

Constraints to rural flock vaccination

The low success rate of ND vaccination is almost entirely due to inactivation of the vaccine because of the absence of an efficient cold chain. This in turn is aggravated by the scattered distribution of village flocks, bad road conditions and lack of transport. In Indonesia, the period between the vaccine leaving a central laboratory and vaccination in the village can be several days.

Vaccination programmes should be carried out at appropriate times. There are seasonal patterns to outbreaks of ND and Fowl Pox, the diseases for which vaccination campaigns are usually carried out. The farming programme should be taken into consideration. In Thailand, for example, ND vaccinations are carried out in the dry season when the farmers are not involved with rice cultivation (Danvivatanaporn, 1987).

It has frequently been said that lack of motivation is a major cause of the low vaccination rates in rural areas. To overcome this problem, a pilot project in Thailand organized a training course in primary schools for children of 12 years of age. They were introduced to the concept of the advantages of vaccination against ND and taught to recognise the simple clinical signs of the disease. Another training course for livestock volunteers was given to five selected young village leaders. Upon return to their village, they gave their services and advice on ND control to the village, free of charge. It was hoped that the increased knowledge and commitment would result in better motivation of the villagers to develop their own vaccination programmes.

In Bangladesh, the subdistrict livestock officer organizes special training in vaccination and livestock husbandry, in consultation with the local subdistrict committee chairman and members, who then select the farmers and volunteers for vaccinator training. The course is divided into two phases: theoretical and practical. On completion, the vaccinators are supplied (at cost) with vacuum flasks and other necessary equipment, to vaccinate their own and other villagers' flocks, for a fee. They then return the empty vials and receive fresh vaccine. The Department of Livestock Services runs the livestock disease control programme for small farmers as part of its poultry development programme, usually with the assistance of local non-government organization (NGO) groups (Bangladesh Department of Livestock Services, personal communication 2000).

The ND V4 vaccine

This is a new vaccine, which has the following advantages:

- It is a heat-tolerant vaccine selected from non-virulent forms of NDV naturally occurring in Australasia. In an experiment conducted in Malawi, young chicks which received the vaccine after it had been exposed to ambient temperature for six weeks developed high antibody titres and resisted challenge with a velogenic, viscerotropic ND virus strain (Sagild and Spalatin, 1982).
- After about half of the birds of a household flock are caught and vaccinated, and if all the birds are then confined together overnight, the vaccine will spread naturally from vaccinated to unvaccinated birds. The antibody response of these “naturally” vaccinated is comparable with that of the vaccinated birds (Young, 1991).
- Unlike conventional vaccines, which cannot be given if the birds are under stress, the ND V4 is so mild that it can be given to birds under stress.
- The vaccine can be administered by mixing with feed, although the eye-drop method of inoculation is much more effective.

Alders *et al.* (1994) reported a laboratory vaccine trial with the heat tolerant V4 and the Hitchner B1, in which vaccination with the Heat Resistant (HR) V4 gave slightly higher HI (Haemaglutination Inhibition) titres than vaccination with the Hitchner vaccine. The live HRV4 vaccine was used successfully in the control of ND in village chicken flocks in Malawi (Saglid and Haresnape, 1987). In these field trials, vaccinated birds showed a good immune response when the vaccine was administered through very clean drinking water in very clean drinkers. However, this method can only be used in the dry season, because of the difficulty of confining the birds in completely dry conditions during the rainy season.

A Heat Resistant derivative of the V4 vaccine added to feed was used successfully in Southeast Asia (Copland, 1987). It did not require individual doses, and it spread between birds to some extent. The choice of feed to be used as the vaccine carrier was crucial. Commercial feed as a vaccine carrier has two disadvantages: firstly, its composition varies, and certain components can prove toxic to the vaccine virus; and secondly, prepared feeds are expensive, and one of the essential factors in a smallholder poultry vaccination scheme must be low cost.

In Malaysia, the vaccine is sprayed onto wheat while it is being mixed in a simple, locally manufactured auger-driven mixer. Up to 10 000 doses of vaccine can be mixed at a time. The feed-virus mixture is then put into small plastic bags, each containing 200 g (enough for 20 birds). Even after 45 days storage at ambient temperatures, the bagged vaccine provides up to 90 percent protection.

In other Asian countries where wheat is not readily available, rice has been used. Both rice and wheat have a water-soluble viral inhibitor in the grain coat; thus washed grain maintains a higher virus titre than unwashed grain. Washing is carried out by soaking the grain for 24 hours and then mixing the vaccine with the wet grain. At the village level, the required amount of washed grain (10 g per bird) is measured into a plastic bag and the vaccine added. After mixing thoroughly, the feed-vaccine mixture is fed directly to chickens. It is important to provide creep-feeding for the chicks and growers, otherwise the older birds get all the vaccine.

The V4 strain is being tested in several African countries (Ethiopia, the Gambia, the United Republic of Tanzania, Zimbabwe and Nigeria). The first field test of HRV4 (Heat Resistant V4) was conducted in the Gambia (Jagne *et al.*, 1991). In July 1993, FAO and the governments of the Gambia and Ethiopia signed a Technical Cooperation Programme project agreement, "Assistance to Rural Women in protecting their chicken flocks from Newcastle disease” (TCP/RAF/2376T). The objectives were to introduce and evaluate, under African rural conditions, the HRV4 oral vaccine, which had proved effective in Southeast Asia, and to involve rural women in the implementation of the project. In both countries, repeated oral vaccination (up to four times at regular intervals) did not generally produce the high immunity found in Southeast Asia. However, parallel groups inoculated by eye-drop did achieve high levels of immunity.

In 1995, confined laboratory trials of ND HRV4 feed-based vaccines were carried out in Ethiopia. Oral vaccination, administered in barley, wheat and crushed maize feeds, was compared with eye-drop vaccination and with an unvaccinated control. Eight days after the birds were challenged by the ND virus, the survival rates were: 80 percent of the eye-drop vaccination group; 20 percent of the oral vaccination groups; and none of the control group. Of the three feeds used in the oral vaccination trials, barley proved to be the most efficient vaccine carrier in terms of providing disease resistance, followed by maize and lastly wheat.

Zimbabwe was free of ND from 1986 until 1994, when suddenly infection was introduced from South Africa. Because of unrestricted poultry transport, it spread rapidly across most of the country. During 1994/95, ten million rural chickens nationwide were vaccinated at a project cost of US$1.50 per bird. In early 1996, a FAO-assisted Technical Cooperation Programme was initiated to establish a community-based programme for the prevention of ND epidemics in rural chickens. The approach combined the immediate administration of the V4 vaccine using the conventional eye-drop vaccination method with community-based trials using the feed-mixed oral method under Zimbabwe conditions. Thus it was hoped to avert other epidemics and generate data for planning regular feed-based vaccination of rural chickens as part of the veterinary extension service.

Although V4 has shown promising results in overcoming the major constraints associated with ND vaccination, there are still problems with its use in scavenging systems at the village level, where feeding is irregular and poultry are hatched, bought and sold throughout the year. In all countries, laboratory trials to assess various feeds as carriers and to familiarize technicians with the vaccine and virulent challenge systems should be conducted before field trials. Production data should be collected before, during and after vaccination. This is essential to evaluate the efficiency of vaccination.

Traditional poultry disease control in Africa

Traditional treatment and control of disease is important, as most developing countries cannot afford to import or subsidize veterinary drugs and vaccines for smallholder farms. There is also increasing concern about the effect of synthetic drugs on animals and the environment. Ojeniyi (1985) found a correlation between the use of antibiotics and drug resistance among *E. coli* strains isolated from intensively managed poultry at the University of Ibadan, Nigeria. All 1248 *E. coli* strains from the University poultry farm, and 2196 strains from a commercial poultry farm in Ibadan, were resistant to tetracycline, streptomycin and sulphonamide. In contrast, all 2284 strains isolated from free-range town and village poultry were sensitive to these drugs.

Most of the information presented below on traditional medicine used for poultry has been collected informally (Bizimana, 1994), and has not been scientifically tested. The main reason for its inclusion here is to encourage formal research.

Viral diseases

- **Newcastle Disease**: in Nigeria, either *Lageneria vulgaris* or the bark of *Parkia filicoidea* are given to the flock in drinking water (Nwude and Ibrahim, 1980). In Zimbabwe, the leaves of *Cassia didymobotrya* or the latex of *Euphorbia matabelensis* are given in drinking water (Chavunduka, 1976). In the United Republic of Tanzania, in the regions of Arusha and Kilimanjaro, the stem of *Euphorbia candelabrum* Kotschy var. *candelabrum* or the fruit of *Capsicum annuum* together with the leaves of *Iboza multiflora* are given (Minja, 1989).
- **Fowl pox**: in Zimbabwe, the leaves of *Aloe excelsa* are soaked and the extracted fluid is added to drinking water (Chavunduka, 1976). A poultry disease named "*Yoko yoko*" by the Fulani of Mauritania, Mali and Senegal, is a serious epidemic, affecting hens of all ages. The exact cause of the disease is unknown, but Ba (1982) suggested that it might be a type of Fowl Pox. The signs and symptoms, as described by the Fulani, are dejection, breathing difficulties with the emission of the sound *'yok yok'* and sneezing. Obstruction of the nostrils by yellowish crusts makes the birds breathe through their beaks, which are also encrusted. Lack of appetite and purulent conjunctivitis have also been noted. Eventually, the birds suffocate and die. The mortality rate can be as high as 100 percent in growing chickens, but some adults survive. The birds are systematically

slaughtered and the hen house burnt to prevent spread. The symptoms, as described above, are indicative of the “wet” form of Fowl Pox, where eventually the bird suffocates from a cheesy growth in the trachea. The pox lesions are sometimes less obvious in this type of Fowl Pox disease, but they can be found on close examination.

- **Colds**: in Nigeria, *Hibiscus subdariffia* is pounded, mixed with drinking water and given to birds with ruffled feathers (Nwude and Ibrahim, 1980).

Protozoan diseases

Coccidiosis: in Nigeria, *Lageneria vulgaris* is dipped in the flocks’ drinking water (Nwude and Ibrahim, 1980).

Bacterial diseases

Fowl Cholera: in Nigeria, the fruit of *Adansonia digitata* is broken and soaked in the birds' drinking water. The fruit of *Capsicum annuum* is mixed with soot from the ceilings of thatched buildings (Hausa: *Kunkunniya*) and given in drinking water (Nwude and Ibrahim, 1980).

Metabolic and infectious diseases

- **Abdominal disorders**: in Nigeria, the young leaves of *Boswellia dalzelii* are chopped and soaked in water, and the extracted fluid is given as a diarrhoea treatment (Nwude and Ibrahim, 1980). In South Africa (Natal Province), *Leonotis leonurus* Ait.f. is given to treat both yellow and green diarrhoea (Watt and Breyer-Brandwijk, 1962). In Southern Africa, farmers use a cold infusion of the leaves of *Aloe saponaria* Haw. to treat enteritis and indigestion in poultry (Watt and Breyer-Brandwijk, 1962). In West Africa, the chopped leaves of *Pergularia extensa* are fed to turkeys suffering from diarrhoea (Dalziel, 1937). In Zimbabwe, the bulb of *Adenium multiflora* is soaked in water for 12 hours, after which the sick animals are drenched to treat for bloody and watery diarrhoea. For the same purpose, the latex of *Aloe chabandii* or *Euphorbia matabelensis* is given in drinking water (Chavunduka, 1976).
- **Blood in the excreta**: in Zimbabwe, the bark of *Cussonia arborea* is soaked in water, and the sick birds are drenched with the fluid (Chavunduka, 1976).

Poor growth and low production

In Nigeria, the fruit of *Cucumis pustulatus* is mixed with bran and placed in drinking water to help growth, prevent disease and increase egg production. The fruit of *Cyperus articulatus* is also placed in drinking water (Nwude and Ibrahim, 1980). In West Africa, the fruit of *Cucumis prophetarum* or *C. pustulatus* is placed in drinking water to help growth, prevent disease, discourage predatory hawks and increase egg production (Dalziel, 1937).

Ectoparasites

- Various ectoparasites and parasitic diseases: in Nigeria, the dried leaves and twigs of *Guiera senegalensis* Lam. are burned in poultry houses to reduce ectoparasites (Nwude and Ibrahim, 1980). In Bulawayo, Zimbabwe, *Thamnosma africana* Engl. is placed in chicken pens to repel fleas and ants (Watt and Breyer-Brandwijk, 1962).
- Lice: in Nigeria, the leaves of *Bandeiraea simplicifolia* are placed in hen houses to kill lice (Dalziel, 1937; Nwude and lbrahim, 1980). Ash from the burnt leaves of *Nicotiana rustica, N. tabacum* or *Carica papaya* is rubbed into feathers to protect against infestation (Nwude and Ibrahim, 1980). In Senegal, the leaves of *Calotropis procera* Ait.f. are used to kill lice on poultry (Dalziel, 1937; Watt and Breyer-Brandwijk, 1962).

Endoparasites

Worms: in Nigeria, the fruits of *Cucumis prophetarum* and *Solanum nodiflorum* are used by the Hausa people to treat poultry for worms (Nwude and Ibrahim, 1980).

Others

Lameness in ducks: in Nigeria, the Hausa people pulverize the leaves of *Momordica balsamina* and mix them with feed to treat ducks for lameness (Nwude and Ibrahim, 1980).