DEFINITION IN POULTRY IMPROVEMENT

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Up until 1932 there was relatively free importation of overseas poultry stock into Australia. However, the development of quarantine regulations prohibiting free importation of avian species and the eventual complete embargo on importation in 1947 led to the development of poultry breeding organizations engaged in genetic improvement of Australian poultry stocks.

The poultry industry today is clearly divided into a meat industry and an egg industry which have quite different structures. For the purpose of this discussion these two will be considered separately.

POULTRY MEAT PRODUCTION

Breeding for poultry meat production in Australia is only relatively recent. Up until the mid to late 1950's nearly all chickens raised specifically for meat production were crossbred cockerels from the layer industry. Following overseas developments, commercial enterprise in Australia commenced selection programs for meat production in the late 1950's. Synthetic lines were established with inclusion from various breeds with desirable characteristics.

In order to protect commercial advantage and to capitalize on possible heterosis, commercial broilers have usually been produced from matings between a sire line and a strain cross dam line. Somewhat different selection criteria have been used in the sire and dam lines.

1. Breeding Objectives

The overall objective of breeding in the chicken meat industry is to maximize economic efficiency of production, which includes both performance of the commercial chicken and reproductive performance of the dam line. More specifically the breeding objectives are:

a) The commercial chicken

- i) rapid growth rate
- ii) good food conversion efficiency
- iii) desirable carcass characteristics in terms of good conformation; lack of leg abnormalities; high dressing yield; lack of excessive abdominal fat; freedom from other blemishes, e.g. skin defects
- iv) good livability

b) The dam line

- i) high production of eggs of settable size
- ii) high efficiency of feed use for egg production

iii) high fertility and hatchability

iv) freedom from mating defects, e.g. leg abnormalities

v) good livability - disease resistance.

2. Selection Criteria

a) Growth Rate

To date almost all emphasis in commercial meat breeding programs has been for high body weight at about slaughter age. The heritability is high with sib estimates ranging from 0.1 to 1.0 (average 0.5) and realized estimates of about 0.35 (Kinney, 1969). Mass selection has generally been used.

b) Food Conversion Efficiency

Until recently there had been no direct selection for food conversion because of costs associated with measurement of individual food consumption and the belief that there is a high genetic correlation between food conversion and growth rate. Improvement in feed efficiency, which has been considerable, has been partly achieved as a correlated response to selection for growth rate and partly as a reflection of improvements in nutrition and management. The age at selection over the past 20 years has been almost halved with broilers currently selected at about seven weeks of age which has considerably reduced maintenance requirements with a resultant improvement in food conversion.

There is currently an increasing awareness of the importance of feed efficiency as the major criterion of profit in broiler production (Best, 1978). There is now some interest in direct selection for this trait both here in Australia and overseas. Evidence now accumulating indicates considerable variation in feed efficiency independent of growth rate (Wilson, 1969; Guill and Washburn, 1974; Pym and Nicholls, 1979) and methods for inclusion of this trait in breeding programs have been suggested (Pym and James, 1979).

c) White Feathering

The autosomal gene for dominant white (I) has been fixed in most sire lines so that commercial progeny are predominantly white feathering. Pigmentation of pin feather follicles in dark feathered birds is an undesirable carcass trait.

d) Sex Differentiation

In some lines the sex linked recessive gene for rapid feathering (k) has been fixed in the sire line (in poultry, males, not females, have two X chromosomes), and the female line carries the dominant allele for slow feathering (K). Male progeny are slow feathering and females rapid. Using this method, chicks can be sexed at hatching by relatively untrained personnel and males and females can be reared separately, which has certain advantages. There is, however, some indication that feed efficiency may suffer in the slow feathering males, particularly if the birds receive sub-optimal temperatures.

e) Leg Abnormalities

Although obviously affected birds have been discarded at selection and at mating time, leg weakness continues to present a problem in commercial

broilers. Sheridan (personal communication) suggests that selected males be X-rayed for detection of tibial dyschondroplasia which accounts for something like half of the leg weakness problems in broilers.

f) Body Conformation

Some selection has been exercised for body conformation, i.e. breast angle, body depth, keel length, shank length, all which show moderate to high heritabilities (Kinney, 1969).

g) Body Composition

It is now widely recognized that a problem exists with excessive adbominal fat in commercial broilers. The causes of the problem are not as yet clearly defined but the following factors are thought to contribute:

i) A greater awareness on the part of the consumer towards fat.

ii) An increase in the proportion of chicken meat sold as dissected pieces, thus exposing the fat.

iii) Nutritional factors, e.g. high density diets with added fat.

iv) The marketing of heavier birds.

v) Genetic factors.

There has been no direct selection for low abdominal fat in broilers. Although it has been suggested that selection to date in commercial programs has increased the problem, Pym and Solvyns (1979) found that the proportion of body fat in birds selected for increased growth rate alone, was similar to that in unselected birds whether measured at a given weight or age. In that report, however, selection for improved feed efficiency resulted in a marked reduction in body fat whereas selection for increased food consumption had the opposite effect. There is thus scope for genetic manipulation of body composition and it would seem timely to explore the possibilities.

h) Egg Production

There appears to have been little selection for egg production in broiler dam lines. Most dam lines are F_1 crosses between two parent strains with a view to capitalize on any possible heterosis for reproductive performance However, egg production from broiler dam lines allowed *ad lib* access to feed during both rearing and laying is generally low. Considerable improvement in reproductive performance in this stock has been achieved by the use of restricted feeding during rearing and control of energy intake during lay. With careful management manipulation, egg production from meat stock can approach that of layer strains and the overall profitability of the enterprise can be very markedly improved.

Some breeding companies in U.S.A. and U.K. select broiler dam lines for egg production but tend to regard the exercise as a holding operation to prevent any further decrease in genetic potential and rely on management manipulation to optimize performance.

i) Fertility and Hatchability

Some attention has been given to fertility to the extent that sires with poor fertility have been rejected from breeding programs. Significant

improvement in fertility has been achieved by changes in breeder flock management, particularly by restricted feeding during rearing and control of energy intake during lay. Most of the improvement in hatchability, which is currently about 85% of all eggs set in most commercial operations, has been achieved by management manipulation. Some improvement has been obtained through selection although the heritability is supposedly low (Kinney, 1969).

j) Livability

There has been some selection for livability in broilers to slaughter age although most improvement in this trait has been via the use of disease prevention measures such as vaccination, chemotherapy, sanitation and isolation. Because of selection of birds at slaughter age and elimination of unselected birds, there has been no effective selection for livability in adult broilers of the parent lines other than natural selection.

3. Future Development

More attention will need to be directed towards the following areas. The relative importance of each is dependent upon the strain of bird.

i) Food conversion - inclusion of direct measure in breeding programs

ii) Abdominal fat - direct and indirect measures and techniques for inclusion in breeding programs

iii) Leg weakness - use of objective measures at selection, e.g. X-ray to identify potential problems

iv) Egg production - techniques for inclusion in breeding programs

v) Growth rate - possible use of family information

vi) Dwarf breeder hens - possible value in future programs

EGG PRODUCTION

The Australian egg industry has been, until recently, based almost entirely on the White Leghorn x Australorp F_1 crossbred hen. This cross has been shown to exhibit considerable heterosis for egg production (Morley, 1958; Morris and Binet, 1966). In recent times, however, strain cross White Leghorns have increased in popularity in line with the U.S.A. and U.K. industries and one of the major Australian breeders has now released a White Leghorn x New Hampshire F_1 cross layer. All commercial layers are either breed or strain crosses to capitalize on possible heterosis and to protect commercial advantage.

Sheridan (1974) in a study of commercial strain performance in Random Sample Laying Tests during the period 1967 to 1972 suggested that the major Australian strains studied may have then been at a selection limit for egg mass production. Since then, however, there have been some significant changes in both the structure of the industry and in the strains of birds available from the major breeders.

1. Breeding Objectives

The specific breeding objectives in layer programs are:

i) improvement in rate of egg production

ii) improvement in efficiency of feed use for egg production

iii) maximize the proportion of large but not over-large eggs

iv) maintenance of acceptable egg quality in terms of:

a) shell strength

b) albumen quality

c) freedom from internal blemishes (blood and meat spots)

d) shell colour (in case of brown egg market)

v) good livability

2. Selection Criteria

Because of the low to moderate heritability for egg production (Kinney, 1969), family information has been used in layer breeding programs. Indices combining individual, full and half sib information have been used with a weighting for egg weight and egg specific gravity (a measure of shell strength). There has been some selection pressure for livability but since the use of Mareks disease vaccine, this has assumed less importance.

a) Egg Production

Selection to date for egg production has been generally based on a part period test, i.e. up to about 6 months of lay, in order to reduce generation interval. Work by Morris (1963) however, indicated that continuous selection for part period production may result in decreased production during the residual period with the ultimate effect of failing to make gains in full period production. An extension of the egg production recording period is indicated.

b) Egg Weight

The heritability of egg weight is moderate to high although there is a negative genetic correlation with egg production (Kinney, 1969) which limits gains in the two traits. Unfortunately the relative price paid to producers for the different egg grades varies according to supply and demand and as such the geneticist does not have a clear goal. Sheldon and Podger (1974) presented data on selection for low variability of egg weight and suggested that it should be possible to select for an optimum distribution of egg weight on age, i.e. maximum rate of increase to premium size, minimum increase beyond that level and minimal variation about the curve. One major problem, however, is in defining the premium size given the variable market requirements.

c) Food Conversion

It has been suggested that most of the variation in the efficiency of feed use for egg production is attributable to variation in egg production, egg weight and body weight (Arboleda *et al*, 1976). Since body weight is very

much easier measured than food consumption, selection for lower body weight is now exercised in some layer breeding programs. Recent work (Sheridan, personal communication) has shown differences in the proportions of yolk and albumen in eggs from different strains. It is possible that this may be a significant factor influencing residual variation in feed efficiency for egg production.

d) Egg Quality

The heritabilities of both egg specific gravity (a measure of shell strength) and Haugh Index (a measure of albumen quality) are moderate to high (Kinney, 1969), although only the former trait has received any real attention in commercial breeding programs. Specific gravity as it relates to egg breakage is an important determinant of profitability whereas there is no particular incentive at present for improvement in albumen quality. There is a negative genetic relationship between egg production and both specific gravity and Haugh Index (Kinney, 1969). From limited information the heritabilities of blood and meat spot incidence are low to moderate (Kinney, 1969) and it is unlikely that these traits have been included in commercial breeding programs.

e) Shell Colour

In response to consumer demand for brown shelled eggs, some companies now produce a brown shell layer. Although the heritability of shell colour is moderate to high (Kinney, 1969), body weight of the brown shell layer tends to be fairly high since the breeds supplying the necessary genetic variation, e.g. Australorps, New Hampshires, Rhode Island Reds are themselves heavy. Consumers overseas have, however, been willing to pay a premium for brown shelled eggs to offset the difference in production efficiency. As a result of continued selection, however, production from some overseas brown shell layers is now reportedly almost equivalent to that of the better strain cross White Leghorns.

f) Livability

The degree of emphasis placed on selection for livability has decreased since the introduction of Mareks disease vaccination. Nevertheless attention is still paid to this trait to the extent that families exhibiting high mortalities are eliminated from selection. This can be achieved by selecting on hen-housed rather than hen-day production.

3. Future Development

The following areas now warrant attention, the relative importance of each depending on the strain.

i)	Efficiency of production	- more emphasis required in reducing bodyweight in some strains
		- variation in yolk:albumen ratio and scope for inclusion in breeding programs
ii)	Brown shell egg production	- maintenance of production efficiency with introduction of brown shell strains.
iii)	Part-period test	- arguments for extending test period.

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