EVALUATION AND UTILIZATION OF TURKEY AND WATER FOWL BREED RESOURCES

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SUMMARY

The vast majority of turkey breeding, production and consumption is in the highly intensified production areas of North America and the Western European community. Selection for heavy muscling and compact conformation has resulted in highly efficient meat producing white plumaged, small, medium and large commercial types. The native turkey, Meleagris gallopavo still exists. With plumage color mutants and numerous selected strains, there is considerable variety of turkey germ plasm. Selection has brought about rapid changes in both morphology and size; and with these concurrent genetic and phenotypic changes has resulted in a lowered reproductive fitness. Photoperiod management, artificial insemination, nutrition and disease control have counteracted this genetic loss for a steadily increasing life cycle efficiency in the modern turkey.

Ducks, both common and Muscovy, are widely distributed throughout the world. In major duck producing areas of Asia, ducks have been integrated with various types of agriculture systems and used for production of eggs and meat. European ducks are mainly used for production of meat, and to a less extent, for foie gras. Selection and breeding methods for genetic improvement of ducks for broiler production follow the trends set by chicken breeders in the past, but for integration of ducks in Asia with other agricultural systems (rice field, ponds, etc.), breeding strategies may have to be different.

Although geese genetic resources are increasing in East European countries, there is an overall decrease in demand for goose meat. Crossbreeding of various breeds or lines have resulted in higher productivity but lower fecundity. Selection and crossbreeding alongwith better management systems have been devised for improvement of existing breeds and lines of geese.

INTRODUCTION

Tremendous development of chicken industry throughout the world during the last five decades was possible due to the combined efforts of breeders, nutritionists, management and marketing specialists. Supply of breeding chicks from North America and Western Europe to other continents of the world is the major cause of this development. Compared to this, development potentials in turkeys, ducks and geese have not been properly exploited, although high yielding meat producing turkey and duck strains are available for production of cheap animal protein. Because of limited market, egg producing duck breeds have received little attention from breeders for their genetic improvement.
Modern strains of turkeys are highly efficient producers of quality meat which is high in protein, but low in fat and cholesterol. Feed efficiency in well managed flocks is expected to be 3 kilos of feed/1 kilo of marketable live turkey with a dressing percentage exceeding 85 percent. Recent estimates for production and consumption of turkeys lists North America at approximately 1.5 million metric tons, the Western European Community at 750,000 metric tons, other Western European countries, Eastern Europe, Middle East (Israel) and the USSR at 225,000 metric tons and other regions at some 60 metric tons of which Brazil produces some 40 metric tons. Of the 2.5 million metric tons produced world wide, nearly 90% is produced under intensive management methods in North America and Western Europe. Obviously there are many other regions of the world where turkey production has potential as a high quality protein food source.

Although domestic ducks (Anas Platyrhychos) are distributed throughout the world (Clayton, 1984), nearly 72% of these are found in south and East Asia under extensive and semi-intensive production systems. Indonesia, Taiwan, Thailand, India and Bangladesh with duck population of over 16, 10, 9 and 8 millions (Hetzel, 1980) are largest producers of dual purpose ducks (for meat and egg). Production and consumption figures of meat and eggs are not listed here due to the absence of authentic statistics but to stress the importance of this species in rural agriculture, it is perhaps desirable to note that 30% of eggs consumed in Indonesia are duck eggs. In Europe and North America, higher production cost and lower consumer preference of duck meat compared to chicken broilers have limited the scope for expansion of duck industry although intensive system of production has been practised since 30-40 years.

Domestic geese (A. Anser of Europe, A. cygnoides of South East Asia and A. canadensis of N. America) have never received the same type of commercial exploitation that have been accorded to chickens, turkeys or even ducks (Crawford, 1984). In absence of a well defined marketing system (Merrit, 1974) and increasing demand for goose meat, the goose farming activity will remain small.

GERM PLASM RESOURCES

Turkeys:

The turkey Meleagris gallopavo is a native wild species of the North American continent. According to Martin and Marsden (1944), Schorger (1963), the bronze plumaged specimens kept by the Mexican Indians were transported to Spain and thence spread to other Western European countries. European domesticated turkeys were brought to the United States and Canada, and along with these imports and probable crosses to the indigenous wild turkeys formed the foundation for the Standard Bronze variety. Plumage color mutants include the Bourbon Red, Slate, White Holland, Crimson Dawn, Royal Palm, Buff, Black, Nebraskan and the sex-linked Narragansett and Brown varieties. Most of these varieties were revered more for their plumage color than economic qualities. The Standard Bronze variety was replaced by the Broad Breasted Bronze which in turn was altered by the gene transfer of the recessive white gene to produce the Large White. The commercial turkey types finally evolved into the white plumaged, well-muscled, small, medium and large genotypes.
The diversity of germ plasm now available includes the wild bronze turkey, small numbers of plumage color varieties, and the heavily muscled small, medium and large white genotypes. Several specially selected lines exist in research institutions and some of the prominent commercial breeders have gene pools with up to 20 separate strains.

Ducks:

Domestication of ducks (Anas platyrhynchos) was probably started in the Far East or South East Asia, but most of the activities related to breed development and intensive production have taken place in Europe and North America. In spite of the lack of continuous directed selection for improvement of egg production efficiency, egg laying strains of ducks capable of averaging 300 eggs per laying year do exist in Europe. In Indonesia, local Albie and Tegal ducks are known to produce 259 and 205 eggs till 72 weeks of age without being subjected to any artificial selection (Gunawan and Hetzel, 1982). Chuang Jiang Ya, En. Si Ma Ya, Miang Yang Ya are meat producing breeds of China which have the potential to be developed as dual purpose breeds. Native Paknam and Nakhon Pathom breeds of Thailand lay about 170 eggs and 160 eggs/year, and these have been crossed to Pekin and Muscovy to produce meat in Thailand, and to Khaki Campbell for egg production. Certain non-descript breeds of India and Bangladesh are also excellent producers of thin shelled eggs and meat.

Ducks as producers of meat and fatty liver had been the subject of intensive research and development in East and West European countries during the last 30 years. Several selected lines in research institutions and commercial farms have been developed. Amongst these, Cherry Valley is currently the leader and has established breeding farms in many countries of South East Asia from which parental stocks are supplied to farmers for the production of commercial progeny.

Plumage colour of ducks is not as widely studied as in chickens or even in turkeys. However tremendous variations in plumage colour exist. Recessive whites of Pekin and Aylesbury when crossed with Khaki Campbell produce coloured progeny but inter-se mating of these progeny produce 25% of progeny as white. Autosomal barring of Itek Java of Malaysia is found to be dominant to nonbarred coloured ducks. To evolve commercial strains or lines in South East Asia with specific colour patterns, a thorough study of plumage colour genotypes and their interactions would be necessary.

Geese:

Crawford (1984) reported that the typical European goose of today was domesticated from the greyleg, A. Anser, and South East Asian Geese were derived from swan goose, A. Cygnoides. Indigenous breeds existing between these two geographical areas are probably intermediate between the above two types. Hybridization between European and Asiatic types is possible.

Emben, Toulouse, Chinese, Gorki, Hungarian, Czech White, Adler, Landes White Italian, Kuban, Rhenish and African are the dominant breeds of Europe at present. Increasing population size of these breeds was not possible due to depletion of local genetic resources in most countries except Eastern Europe, where industrialization of geese has increased number of geese in
Russia, Hungary, Czechoslovakia, Poland and East Germany.

Plumage colour genetics of geese had been studied since 1950 when the dominant white pattern of Chinese white was well known. Since then many white breeds of geese have been formed. A detailed study involving 14 known breeds and some ornamental breeds by Tulacek (1982) suggests the presence of many genes at different loci controlling plumage colour. There exists large interaction effects of these genes on plumage colour.

FACTORS INFLUENCING DIRECTION OF BREEDING

A. Processing technology of consumer acceptance:

Turkeys:

The most compelling influence and the direction of turkey breeding has been in response to advances in processing technology, distribution and marketing methods and consumer acceptance. The development of complete evisceration and frozen carcasses placed in polythene bags encouraged year around production, making turkey an attractive food item. Currently, further processed products account for 50% or more turkey consumption. This development hastened the thrust to produce heavily muscled, compact types with increased meat yield.

Ducks and Geese:

Although the consumer preference for duck and goose meat in the European market favours the production of a not-too-fat carcass, completely eviscerated and frozen, yet Asian markets, particularly where consumer are mainly of Chinese origin demands live, plumpy carcass for roasting and barbecuing. Heavy muscling types produced in Europe with a bit of extra fat are accepted by majority of consumers. However for consumers of South Asia, preferring curried ducks, lean meat production using improved indigenous ducks may be desired.

Demand for geese with fatty liver by French people and East Europeans do not require a different processing technology than what is currently existing for turkeys, but further processing of carcass for preservation of giblets in Chinese dominated markets will fetch extra income. In South East Asia, where eggs are preserved by boiling and salting before consuming, processing technologies will mainly remain indigenous.

B. Genetics and breeding

A major breeding development in the U.S. was the National Poultry Improvement Plan (NPIP) in which breeders of turkeys were introduced to the systematic use of genetic principles and recording of body weight gains, hatchability, egg number, muscling and conformation for systematic selection. The growth of turkey breeding companies with competent genetic capability reduced the number of NPIP participants to zero. A significant genetic contribution during the 30 year period (1940-1970) was the development of a gene pool consisting of a variety of body conformation and size types developed according to the specific preferences of individual breeders.
Dr. Stanley Marsden (United States Department of Agriculture) developed a small size compact type turkey with white plumage known as the Beltsville White for a family size table turkey (Marsden, 1967). This small type successfully fit a demand niche and also contributed to the development of the major market types, small, medium and large, produced in response to consumer demand and production systems. Currently in the U.S. the large types are commanding a major share of the market and price advantage due to higher yields for further processed products.

The introduction of the Broad Breasted Bronze turkey with its heavy breast muscling characteristics marked a major milestone in turkey breeding. The source of this heavily muscled stock appears to have originated in Great Britain from a strain called the English Cambridgeshire Bronze. Another major accomplishment was the gene transfer of the recessive white (w) gene into the large BB Bronze stocks to eliminate the dark unwanted pinfeathers. This manoeuvre took several generations of crossing and backcrossing to establish the white plumage and regain the size and conformation of the large BB Bronze.

Ducks:
Breeding strategies for improvement of known commercial breeds of ducks for genetic improvement under intensive management systems will differ from strategies to be adopted for small scale development of dual purpose native breeds. Whereas the former will be mainly directed towards the meat production characteristics of ducks (live weight gain, higher breast muscle thickness, lower feed consumption and carcass quality) in a few breeding farms who have access to international markets for their products, the latter will be a major challenge to poultry geneticists whose objective should be improvement of egg and meat production efficiency of native breeds without sacrificing the indigenous attributes of genetic resistance to disease under poor management conditions and sub-optimal nutrition. Unless these two breeding strategies are separated, the whole business of duck production will be managed by few people, depriving the very poor some additional income earned through the integration of ducks with other agriculture systems in their habitat.

Development of commercial strains of ducks in the West was primarily due to selection for growth which has resulted in correlated response of higher feed conversion ratio. Powell (1985) reported that in the United Kingdom, reduction of slaughter age by one day improved the feed conversion ratio of ducks by 2%. However the marketing of ducks at an earlier age has presented problems of lowered breast muscle thickness and higher subcutaneous fat deposition. Therefore proper selection methods and crossbreeding systems should be developed for overall genetic improvement of commercial strains with wide adaptability in different continents. Such practices have already been undertaken (Pingel and Wolf, 1983; Powell, 1985).

Genotype x environment interactions, where genotypes are produced in one location and reared under different location/environments, will not pose any serious problem if the management level is high. It has also been clearly demonstrated before in chickens that although G x E interaction exists, yet better strains developed under temperate conditions will perform better in
tropical environment, where the depression in performance is mainly due to environmental effects (Mukherjee et al., 1980) for chickens). Similar observation was also noted by Powell (1985) in ducks. Therefore breeding farms in the West would continue to dominate Asian baby ducklings market even more than what they had done in the past. However, G x E interaction could be important when duck performance under extensive management is practised (Gunawan and Hetzel, 1982). Genotype x management (single vs colony cages, cage vs floor) interaction has also been noted in the past but is of no serious consequence.

Sporadic attempts have been made in some countries for development of indigenous ducks, mainly through crossbreeding with imported breeds. However, in most cases crossbreeding involving local and exotic breeds has been done without prior evaluation of indigenous genetic resources at different levels of management and prior testing of crossbred performance as opposed to performance of local breeds under identical conditions. Therefore a detailed study of identification of various breeds in Asia, documented description of these breeds, evaluation of these breeds for their meat and egg producing ability, and wherever possible, genetic relationship between these breeds through electrophoretic study of enzyme and protein variants in blood and eggs, should be made. Some work in this regard has been done in Indonesia (Hetzel, 1983; Tanabe et al., 1983).

Geese:
Future emphasis in goose breeding would be mainly in the lowering of slaughtering age with the hope of increasing breast muscle thickness, and if possible, decreasing the percentage of skin with subcutaneous fat so much so that the final product will be of greater consumer acceptability. In addition to these characteristics, persistency of production and reproduction rate have to be improved in order to make geese reasonably competitive with turkeys and chickens. The dual objective of improvement of growth and reproduction will bring in the classical syndrome of body weight-egg production paradox, which had been so aptly described in laying hens by Nordskog and Briggs (1968).

Most of the future work in goose breeding will be conducted by East Europeans, where demand for geese meat and foie gras has been continuously increasing.

C. Estimates of genetic parameters
Genetic contribution in the form of basic knowledge was developed by personnel in the United States Department of Agriculture, the Agricultural Experiment Stations in State Universities, and similar centers in Canada and Great Britain. The reviews by Nestor et al. (1967), McCartney (1968), Mukherjee and Friars (1970) summarize the genetic parameter estimates for body weight and egg production. Calculated and realized estimates indicate that heritability for body size is relatively high (upwards of 30%) and corresponds with responses gained by commercial breeders. Egg production on the other hand has relatively low heritability, in the neighborhood of 10% which also corresponds with applied breeder experience. Unfortunately, body size and egg production are genetically negatively correlated in that intense selection for either trait results in reduction in the other.
Body conformation and heavy muscling are amenable to mass selection as demonstrated by breeders' success in developing a variety of heavy muscled body sizes. The heavy muscling and compact type is negatively correlated with reproductive traits, particularly fertility. The heavy muscled types appear to lose both mating drive and capability. Fertility as measured by percent of fertilized eggs, hatchability of fertile eggs, and poult liveability are all low heritability traits.

Obviously genetic improvement in egg production, fertility and hatchability would improve efficiency of production by reduction in poult cost. Progeny testing and family selection in turkeys is handicapped by seasonal production and low efficiency on recycling. Turkeys are produced for meat and poult cost is a minimum portion of the cost of production. Body weight gains and meat yield are the payoff traits and the time and expense of a selection program for reproductive improvement is not attractive to the commercial turkey breeder. Nevertheless, genetic capability for increased egg production is possible if and when the need arises. Use of early part record, indexing of family performance and traits, although expensive, can improve egg production.

Clayton (1970) proposed early part record for increasing egg production based on correlation of early part record with total egg number. Selection based on early part record from individual and full and half sib information was effective in increasing in egg production (Shoffner, 1986; Sheresta and Shoffner, 1974). Early part egg record is highly genetically correlated (.90+) with total egg record. However, in this selection experiment, there was a significant reduction in body size. Trait indexing has promise for minimizing this negative relationship as Nestor (1974) reported on a selection experiment begun by M.G. McCartney in which there was simultaneous selection for body weight and egg production that resulted in gains for both traits.

Ducks:

Heritability estimates of live weight, feed consumption, eviscerated carcass weight, breast muscle mass and egg production, and genetic correlation between these traits have been reported in the past (Clayton and Powell, 1979; Pingel, 1976). Similar genetic estimates of meat quality traits could be obtained (Pingel and Birla, 1982). In general estimates of heritability of body mass at slaughter, weight gain, breast weight, breast muscle mass and breast thickness are moderate to high, whereas estimates of heritability for feed conversion ratio and egg production were low and low to moderate respectively. Heritability estimates, reported for similar traits by Kosba et al. (1981) on White Pekin population of Egypt were found to be lower than the earlier estimates which suggest higher environmental effect on these traits in this location. Population size, type of population and effect of feeding may also contribute to this variation in these estimates. Methods of estimating heritability (sire + dam variance component in most reports and realised heritability estimate of Pingel and Heimpold (1983)) did not show any significant difference in the estimates of live weight and breast muscle thickness. For meat quality traits (pH, eviscerated weight, lower water content of carcass and cooking loss), environmental effects are much more pronounced than genetic causes. Optimum feeding and good handling of carcass during slaughter and storage seemed to be the most efficient means for improving carcass quality rather than selection.
Search on most of the papers on duck breeding published in Indian Journals or South East Asian reports from Government Farms and Universities do not indicate presence of any report on genetic estimates, although reports on phenotypic correlations between various growth, reproduction and carcass traits in native or desi (India) ducks as well as Khaki Campbell ducks are available. In view of very small sample size, these estimates also may not be reliable. Lack of duck geneticists in this region and emphasis on mainly production-type research is the main cause for absence of such literature.

Since the genetic variations for most of the growth traits are relatively high, a combined selection index involving desirable carcass weight at slaughter and some positively related carcass characteristics such as breast muscle thickness could be designed and practised for a few generations which will bring genetic gain for the traits selected as well as improve the feed conversion efficiency. Powell (1985) of Cherry Valley farm in U.K. suggests that reduction of one day in marketing age may result in an improvement of 2% in the feed conversion ratio. Pingel and Heimpoldt (1983) while obtaining improvement of 8-week live weight of ducks by 72 g and breast meat thickness by 0.040 cm generation in a 7 year selection experiment suggested that selection intensity should be at least $i = 1.4$, if significant genetic improvement has to be achieved.

Correlated response to direct selection for live weight will cause an increase in carcass fat. This problem could be avoided by selecting for feed conversion ratio rather than live weight or body weight gain. There is evidence in chickens (Pym and Nicholls, 1979) which suggest the possibility of substantial reduction in fat content of carcass and increased feed efficiency by selecting for feed conversion ratio. In ducks or even in geese, similar selection practices could be successful. As a matter of fact, nine generations of selection for improved feed efficiency in 3 lines at Cherry Valley farm at U.K. have resulted in considerable improvements in both feed efficiency (12-14%) and % skin and subcutaneous fat (reduction of 10.15%).

Perhaps the introduction of dwarf dam lines in ducks, as has been done by many commercial breeding farms in chickens could be beneficial in terms of production cost and carcass acceptance. Search for other major genes (biochemical markers) should be continued which have significant relationship with low fat content in the carcass, since direct selection (full sib or half sib) would be difficult in absence of accurate methods of estimating fat content in the muscle biomass. Past results on the relationship of triglyceride content in blood and fat content in the muscles or use of probe to measure abdominal fat have not been proved to be consistent.

Since there are wide variety of management systems of ducks in South, South East and East Asia (ducks herded on newly harvested rice, ducks on flooded fallow rice fields, ducks scavanging in dry fallow fields, ducks in ponds, canals and rivers and ducks fully yarded), selection objectives for these systems may have to be different for these systems compared to European selection objectives except when ducks are fully yarded and fed with normal ration. Although commercial broiler ducks have been found to be more efficient than local Itek Java in Malaysia when ducks are integrated into ponds cultivated with grass carp and big head carp (Mukherjee, 1985), yet for systems where egg production is more important than meat production, and ducks
are scavengers, selection work for total number of eggs produced, and persistence of production should be undertaken with the objective of future genetic gain. Past attempts to improve egg production or egg mass have been made by crossbreeding with local ducks, but faster genetic response could be obtained if crossbreeding is combined with selection of native stock which will be used as one of the parental lines in the cross.

Geese:

Since the most important trait for improvement in geese is fecundity, research on estimation of genetic variation of egg production and fertility has been carried out in many experimental stations of Eastern Europe. Heritability of egg production has been found to be between 0.09-0.35 (Smirnov and Ivchenko, 1981) and egg production was highly correlated with age at maturity. Heritability estimates of fertility was found to be very low. Similar estimates have been also reported by other East European workers.

Most important traits to be considered for selection in future are number of goslings produced and reduction of period of broodiness in females. These could be easily done by sib selection and control of photoperiod. Lowering of slaughter age by selection for live weight gain has been made in the past but further genetic gain through individual selection is possible because estimate of heritability of body weight is still high.

D. Crossing systems - Turkeys

A considerable number of crosses between breeds and strains with different size and muscling types have resulted in heterosis for at least one or more traits, usually the low heritability traits. Heterosis is defined here as performance exceeding the midparent mean. Kondra and Shoffner (1955) found that efficiency of production was greatest when a larger, heavier muscled male parent line was crossed to a female parent line with higher egg production. Currently the common breeding system is based on the planned and tested complementation cross wherein the male parent line is heavily muscled with lesser reproductive capability and the female parent line has somewhat less muscling and greater reproductive ability.

In spite of little or no genetic progress in the reproductive traits, life cycle efficiency has kept increasing due to improved management practices. Photoperiod control has reduced age at which breeder hens commence laying, reduced broody incidence, and prolonged the laying season. Artificial insemination (AI) technology has been developed to the point that 90% or greater fertile eggs are commonplace and nearly all commercially grown turkeys result from AI. Nutritionists have developed rations with the essential ingredients to maximize hatchability, and improvements in incubation technology have provided an expectation of greater than 90% hatch of fertile eggs. Progress on the elimination of egg borne infections, effective vaccination programs and isolation of young stock has resulted in high percentage of disease free poult. The combination of these management factors have compensated for the lack of progress in reproductive fitness in the turkey.
Ducks:

Crossbreeding of ducks for meat and egg production and for foie gras production had been the most common method of improvement in intensive or even extensive management systems. Heterosis or hybrid vigour have been obtained for various traits due to the presence of dominance and overdominance at various loci in hybrid progeny, and difference in gene frequencies between parental populations. Commercial breeding farms have formed various lines typical for certain improved characteristics and in addition to heterosis, they are deriving complimentary effects of the parental lines in the hybrid progeny. In actual fact, future duck breeding will follow the trends of chicken breeding in which several lines will be crossed in diallel mating patterns, progeny produced will be tested to determine mainly the combining ability of parental lines, possibly in various locations. Heterosis and complementation will be sought in the crossbred progeny.

For extensive production systems, straightforward crossbreeding of local stock with imported breed or line will be the main methodology for improvement. Some within line selection in the indigenous breed would be beneficial before undertaking such a cross.

Geese:

Crossbreeding for improvement of live weight gain, egg production and fertility have been made in many parts of Eastern Europe. Intensive studies have been also made for the production of foie gras through crossbreeding. Presently line crossing has become very popular to increase egg production and decrease mortality (Schneider, 1985). Therefore future breeding objectives in geese will not be different from chickens or ducks whereby two-way or three-way line crosses would be the commercial progeny in different markets.

General comments:

1. Unlike chickens, and to a certain extent ducks, turkeys and geese are not so popular commodities in the world market as a whole, although these two latter species can contribute significantly in the production of cheap animal protein. Therefore the international breeding franchises have a special role in the creation of markets for these two species in animal protein deficient countries.

2. Although the sales of commercial parental lines produced in Western nations will continuously increase, there should be an awareness on the part of the planners of Asian countries for making provision of proper identification, documentation and evaluation of indigenous breeds of turkeys, ducks and geese. This could be only done if proper human resources are developed who in addition to the above task will initiate within-line selection for desirable traits in breeds/species, and teach farmers the importance of selection, pure breeding and cross breeding.
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