Information and Communication Technologies (ICT)
Contribution to Broiler Breeding

Yoav Eitan yoave@kv-yavne.co.il

Update – October 2012

Abstract

Breeding broiler chicks for meat production comprises three unique production stages. This complicated production sequence is dictated by the fact that the modern broiler chick is a cross between three to four genetically different poultry lines. The first stage involves the selection and breeding of those lines. The second stage involves the cross breeding between the lines in order to get an optimized breeding combination of the industrial modern broiler. The last third stage is the mass production of those broiler chicks until their slaughter and processing for the meat market usually after 5 - 6 weeks.

A typical integrated poultry meat production entity includes breeding "Grandparents" of the broilers to produce the day old "parent" breeder chicks (Broiler Breeding Flocks - BBF), growing them and from them producing the third stage day old broilers. Such an entity includes the necessary facilities such as hatcheries, brooding facilities, broiler growing farms, broiler processing facilities, feed mills and marketing outlets. This paper outlines the crucial, indispensable contribution of Information and Communication Technologies (ICT) for the various broiler meat production stages.

It must be remembered, that one of the main changes that up-to-date ICT provides in the developing revolution in communication during the last decades is the opportunity for sharing data and problem's details. This results in a proliferation of many more original solutions available for solving the rather complex problems created by our scientific progress. This requires ongoing updating of ICT and scientific proficiency.

Background - Computerizing broiler breeding

Modern breeding or genetic selection is a very complex endeavor. It is complicated due to the need to breed simultaneously for several and sometimes conflicting, characteristics. It becomes evermore complicated due to the fact that attaining economically beneficial characteristics can have a negative genetic correlation with other characteristics involved in the breeding process.

As a result, synchronizing breeding and production involves employing advanced biometric procedures which in turn are dependent on manipulating large data sets – feasible only with powerful computing capacity. This in turn makes such expensive breeding without ICT inconceivable. For a perspective review of Poultry Genetics see Hunton, 2006. For a popular review from a farmer's perspective see Porterfield, 2006.

Before availability of computing capability, selection calculations were compiled manually and needed a large number of scientists. The introduction of computers made genetic selection more efficient and enabled introducing more advanced and complicated selection models and data management programs. The future of poultry breeding is claimed to be in selection by "genetic markers", a technique that is totally dependent on powerful computing capacity. Poultry breeding in this sense is in many respects similar to the modern procedures used for cattle, sheep, and other breeding programs.

The brooding and growing process

As mentioned, modern broiler breeding comprises three genetic stages within at least a three generation sequence. In each of the three breeding stages there is a need to brood chicks, raise the pullets till maturity and while fertile harvest their egg production. When hatched these eggs are the next generation of cross-bred chicks. The final product of this process – are the broilers marketed to the meat industry and market.

The management of this three stage process was relatively simple and straightforward at the beginning of modern poultry cross breeding - during the “forties” and the “fifties” of the last century. The farmer’s role was predetermined by tested “universal” recommendations which optimized food and water requirements and defined supplementary illumination when necessary.

Over the following 70 years, as a result of the successful genetic selection for faster growth rates and higher meat yields, the chickens became more sensitive to their environmental needs. Poultry farmers defined the situation by asserting that the modern broiler breeder flock and broilers are “unforgiving” to even small deviations from their optimal growing conditions. In practical terms the modern chicken became in many ways more dependant on each fine tuning grower more than even only twenty years ago. This dependence on a multitude of optimized production factors in fact dictated ICT support for integrating input parameter complexity and environmental considerations. This was by far more than the “simple” equation above of “providing food, water and supplementary illumination when necessary”.

This integration dictate was enforced by an ever growing need for management improvements just to maintain the results of e.g. 20 years ago – which in turn again increased the dependency on ICT. In essence it became necessary to keep running faster forward just to avoid regressing (Eitan and Soller, 2004). The following details the dependence of successful growing of the modern broiler and Broiler Breeder Flocks as expressed in various technical factors and ICT’s contribution to their optimization:

a. Temperature

In the past routine there were pre calculated recommended temperature requirements for brooding day old chicks with quite broad margins. They were adjusted during the day-calculated chick’s stages of growth. At present the modern broiler chicks have become more sensitive to even small deviations from the recommended temperatures. Consequently the optimal growing temperatures are confined to narrower safety margins and are age and humidity dependent. Much of the sensitivity to heat is the outcome of increased body heat produced in the growing process and a diminished body ability to get rid of it. Excess body heat is a cause of a poor feed digestion, of illness, of a higher rate of mortality and is apparently over time a factor affecting laying productivity and causing loss of fertility in males. Such heat related problems are augmented by excessive eating - characteristic to the modern broilers. In order to at least alleviate these problems it is imperative to monitor and control the temperature in the chicken growing facilities during the chick brooding.

This new reality, together with the growing need to control the light intensity and its duration during pullet and broiler growing and egg production, created a worldwide trend to concentrate the modern poultry production in climate controlled, and eventually environmentally controlled buildings. In such buildings internal heat control is dependent on advanced ventilation systems which maintain optimum temperatures and humidity. The external temperatures outside the buildings and the internally generated heat from the chick/pullets/chickens are factored into this process.

Monitoring and maintaining the desirable heat and humidity levels involves integrating multiple systems which include various monitors, ventilators, cooling pads, sprinklers, opening and closing of windows, curtains, heating elements and proper heat dissemination facilities. Advanced ICT is essential in order to monitor the relevant variables and integrate them in order to assure the necessary safety margins. These results can only be attained by using computers and computerized controllers. Monitoring the data generated enables the farmer to follow the peculiarities of each flock in each building and adapt the climate control systems accordingly. These are constantly updated to adhere to the strict temperature, climate and environmental safety margins which are optimized to the biological requirements of each flock of broilers.

b. Feed intake limitation

Past practice included free access to an unlimited feed supply. This was based on the assumption that individual feed intake would be subject to and regulated by each chick according to its individual needs. As a result of breeding for large and fast growing broilers with much better feed efficiency the modern broilers and their parents were genetically inclined towards uncontrolled eating, unchecked by the natural "feeling" of satiation. The destruction of satiation and feeding control mechanisms seriously affected laying ability, fertility and even the hatch percentage of fertile eggs. The introduction during the last 15 years of intense selection for a higher meat yield and a larger breast component in each broiler changed the broiler breeder flocks physical characteristics. Physical deviations from past standards had additional implications serious affecting mating ability.

From the early 1970s it became clear to growers that in order to maintain an acceptable level of laying ability the feed intake of pullets designated for broiler breeding flocks has to be controlled from an early age throughout their growth cycle. Consequently feed restriction was derived from comparison of an optimal weight chart and feeding schedules with actual body weight measured manually or by automatic weighing units.

With time the success of breeding for a faster growing and heavier broiler made feed intake control of the broiler breeding parent flocks in general a critical issue as well. This in turn dictated the need for a daily controlled and uniform flock feed rationing. With the continuing success of the selection programs the difference between the recommended restricted feed allotment and every new generation's growing appetite increased (Renema et.al 2007). To maintain the balance between growing appetites and the optimal feed ration the time allotted daily to consume the feed ration was shortened. For this purpose specialized feeders were developed to ensure a uniform and rapid feed rationing. Initially they were based on measuring the weight of feed portions. This proved to be inadequate technically and not accurate enough for the industry's growing efficiency standards. The manually supervised rationing was replaced by computer controlled electronic devices. Their additional advantage was online, real time reporting of feed delivered, feed consumed and feed consumption rates.

Since the 1980's breeder males were diagnosed as suffering the same feed related afflictions as the females and in addition from too heavy breasts. It became clear that in order to attain proper flock fertility performance males needed separately monitored feeders and different quantities of food. Later, the continuing genetic changes caused a more dramatic drop in fertility and forced the "spiking" of broiler breeder flocks with young males in the middle of the production cycle. The timing decisions connected with this "spiking" including the number of young males needed, their feeding schedule and their effects on fertility and fertile egg hatching rates became ICT dependent.

Current studies indicate that feed intake control is necessary not only for the proper production of the broiler "parent" flocks but for the broiler offspring as well. It was found that in order to get the best broiler results it is best to ration their food intake as well. This helps to avoid increased health deterioration caused by excessive eating during their critical first weeks. Management and control of feed rationing and precise feed allocation distribution in all stages of broiler brooding and growing became complicated. Labor constraints, labor efficiency and the need to produce broilers in larger production facilities made dependency on computers unavoidable and a critical success factor in broiler and broiler breeder flocks.

c. Limiting water intake

In the past, water intake was unrestricted with unlimited access to water. As breeding became more sophisticated it became apparent that water intake must be controlled as well. The severe feed intake restrictions in the broiler breeder flocks induced excessive drinking to counter the feeling of hunger, and it began to appear in the broiler flocks as well. Excessive water intake is detrimental to health due to an unbalanced feed utilization and excess discharge of liquids and minerals. This in turn results in continuous damp litter related problems which aggravates existing health problems.

One practical solution was to develop a new nipple drinker to dispense the allotted, limited water rations to the broilers. Another solution was to schedule and restrict the drinking hours in the broiler breeder flocks. Monitoring water availability periods and water quantities were consequently computerized. This in turn, as with feeding monitoring, provided real time data of water consumption and rate of water consumption. Over time it was realized that monitoring the amounts of water consumed provided an indication of health disorders and/or flock management problems.

In order to refine water consumption control a new management parameter was calculated - the ratio between the average daily water and feed intakes. This relatively new parameter fluctuates less than the actual daily water consumption rate making decisions about "drinking hours" according to flock age and internal environmental temperature much easier. Consequently controlling water consumption became an important management tool supported with ICT supplied data sets. It became unfeasible in modern production units to make water related management decisions without them.

d. A practical example

The firm for producing day old broiler chicks that I work for can provide an example for the above mentioned steps.

Initiating feed restrictions of breeders during the “seventies” dictated changing the actual feeding facilities – mainly feeders and using “electric watches”. Later as feed restrictions became more severe new feeders were bought. They enabled reducing the daily feed allotment from about 70% of Ad. Libitum fed breeders to less than 50%. Feed was given by allocated quantified “meals”. The exact timing of the meals for each building, together with the new need to feed the males with separate feeders on a different schedule uniformly, made the dependence on many more such “watches” impossible. The solution was an “electronic controller” and later on a computer monitored system.

Roughly the same process was used for the other changes. Examples include the change in managing drinking water’s hours and light availability and especially with the growing need for climate controlling. The “electronic controller” and later the computer embedded controller became a must.

In the current broiler meat production technology monitoring climate control, feed and water intake, egg production and body weight became essential. It has become apparent that in order to enable optimal decision making the ongoing, real time collection of relevant data during all stages of broiler breeding and growing is imperative. This data collection involves a relatively large number of physical production areas and buildings – often spread out geographically. It is conditional that the data collection should not interfere with growing and production processes and employee work routines. Computerization enables circumventing such interruptions while providing real time data and information. These in turn facilitate ongoing consultations between growers, their consultants and their managers.

Computerizing the incubating process

During the last decade a new constraint in broiler incubation had been identified, which influenced not only the hatching of fertile eggs but also post-hatch performance of the modern broiler chick. An excess of heat generated by the new genetically bred broilers while incubating, caused dramatic changes in hatcheries. Once again the genetic changes caused by breeding created an urgent need to change the management procedures. This time the dictate for this change was the result of increased heat generated by the embryos in the eggs.

The remedial changes at first reaction in incubation facilities were focused on better ventilation procedures while incubating the modern broilers. Other changes included were changes in planning the daily temperature schedules in the hatching chambers, monitoring the CO_2 levels during incubation and the following weight loss of the hatching eggs during their incubation period. An easy option of one plan of hatching for all kinds of hatching eggs, with a fixed recommended temperature during incubation is no longer feasible.

To cope with these changes innovative incubators were developed and named a “Single Stage Incubating System”. In this procedure each incubating batch includes eggs of only one setting date instead of having the “multi stage” cabin with eggs of different entering dates from different breeding flocks and different eggs' size. The goal is to maintain a uniform and better controlled heat and humidity at egg's level in the hatching chambers in order to attain an optimal hatching rate – compatible with the embryos growing excess energy production and their sensitivity to temperature deviations. The ever growing heat production in the hatching chambers enforced a change in the incubation schedules as well. These were changed from maintaining a constant uniform three week temperature to an almost daily temperature management program.

It is hard to conceive effective control of modern incubation complexity which involves heating, cooling, ventilation and humidity control in the new incubators without computerization of all routines and procedures. The resulting precise data collection and accurate data recording facilitated a learning process resulting in new formulas how to optimally operate each incubator. Operating the new incubators, collecting relevant data, processing it and deciding on the proper feedback to operators was and is totally dependant on ICT.

Computerization as a tool for industrialization of poultry meat production

Industrializing poultry meat production has elicited stricter control of production conditions which facilitate transmission of diseases between farms. One effective sanitation measure was the isolation of farms and hatcheries to an extent that entrance to them is limited only to a small number of specific laborers. As a result the only feasible option for constant real time accessing of flock data is via computerized remote data gathering (numerical, visual, etc). Such computerization enables sharing of critical information and involvement of specialists in real time decisions necessary in the modern breeder and production flocks.

An additional ICT contributory element is derived from the increased complexity of these decisions. An example would be the daily/weekly decision of the feed ration for a breeding flock which is dependant on the following input:

- automatic individual weighing;
- averaging weight of individuals in the broiler breeder flocks;
- adjusting feeding time duration;
- actual water consumption;
- water feed consumption ratio;
- calculating the average egg weight;
- monitoring the daily number of eggs laid;
- monitoring the daily hatching eggs' percent;
- monitoring the daily culled eggs and their causes;
- following the daily mortality for veterinary and management surveillance.

Sharing data and information

In the past the need for transferring data and sharing information between farmers and the poultry farm managing directors was minimal. Data about the number of eggs laid and hatching statistics were sufficient. Integrated production in the poultry meat industry and the ever growing practical problems caused by the genetic improvement has changed this situation. The scientific progress made poultry growing a much more complex task and there is a growing need for a stronger interaction between the grower, the professional staff, the management teams and service providers. ICT facilitated and even opened new opportunities for solution with data and information sharing tools, by enjoying many more people sharing the problem and looking for solutions. Interestingly, ICT is motivating the professional staff to accept a more open approach and the chance of solving problems is much higher.

It is very common in commercial broiler growing practice to use a booklet of “management guidelines“. Such manuals are supplied by management specialists employed by large broiler breeding firms. The earlier manuals relied on data sets gleaned from specifically, pre designed experiments and field trials. Currently the management recommendations are based on computerized analysis of on-going, real time data sets collected from hundreds of “good” flocks. During the last few decades this aggregate data analysis has been performed in the U.S by private firms specializing in Statistics and data collection. Usually their recommendations are the only source of up to date information available for daily decisions made by growers.

One example is the “COBB 500 Management Guide” manual which was updated once in 1-2 years and now only once in about 5 years. The manual includes directives for proper brooding of the day old chicks, for growing the broiler breeder pullets and the broiler breeder flocks while in production. The guidelines include management parameters such as feed, water, temperature, light, etc. The complexity of integrating these parameters into daily operative management decisions increases inline with the genetic improvements. The dependence on statistics for writing those “Management Guides” is the result of the fact that applied scientific research can not keep pace with the rapid changes imposed by the pace of the genetic selection programs. This drawback emphasizes the importance of ICT in obtaining shared and up to date information from grower and market sources – and disseminating the results.

Another value added to sharing information and decision making is worker involvement in the production process – a human satisfaction factor critical to production success. It is important to emphasize that transfer of true information is multi directional and depends on satisfaction. It includes a flow of information and ideas from the grower and sending news of innovations and study results from specialists to the grower’s computers. Knowledge becomes available to all those responsible for all aspects of breeding and growing broilers. The “decision making” deliberations that were delegated by growers to specialists, are partially returning to the grower by ICT implementation, interaction with other farmers, feed back to and within the broiler industry information systems.

In addition utilization of computers for transfer of knowledge from and to the farms is increasing in parallel to the yearly increased importance of poultry meat production for human consumption. The growing importance of this industry dictates severe restrictions on individual’s movement in and out of poultry farms as defined by “Bio security” rules. This difficulty can be alleviated by proper use of ICT.

ICT Implementation

The readers of this article might think that ICT is a must for a poultry farmer raising broilers everywhere on the globe. This is not necessarily so, for several reasons:

The first reason is that the modern lines for meat production are not economically feasible for all growing conditions. The modern and efficient broiler can only thrive in optimal conditions in which its excellent growth rate and amazing feed efficiency can be realized. In many situations farmers may prefer buying lines from an “earlier” genetic generation or lines that are genetically selected for different characteristics than the mainstream modern broiler. The outcome is a more robust and less “sensitive” broiler breeder flock and broilers that can survive in sub-optimal environments. Regardless, in such situations ICT supported production and management systems might still be used with beneficial results.

A second reason is the availability of inexpensive labor. Where semi skilled workers can be hired cheaply, part of the computerized tasks can be done manually without a major loss of reliability.

Other reasons for not adopting ICT or inefficient ICT implementation for broiler meat production include: Lack of farmer training, better alternatives, cost constraints, unsuitable ICT and ICT unavailability, awareness, personal farmer impediments and more. Alleviating these problems in general on regional and national levels depends on national ICT priorities, country “top-down” commercial interests, international involvement including loans, training and close, online guidance.

Looking closer at these issues identifies an issue of extreme importance related to the “not adopting” issue namely the rate of ICT Adoption. Empirical evidence time and again shows that an ICT’s proven economic viability is not necessarily a guarantee for its adoption. Anecdotal evidence suggests a wide range of reasons influencing this rate. Among them are adoption only after proven reliability of the ICT supported innovation - “I’ll install it after I see it working on my neighbor’s farm”; dependency on overall renovation/expansion/development schedules with ICT supported equipment and/or related systems appended to them; delay in identifying a locally perceived need; human factor elements such as acceptance, reluctance to innovate, illiteracy, loss of social positioning e.g. “being replaced” by a computer, conservatism; changes dictated by requirements of new genetic lines; cost and availability of the innovation; past failures in adopting earlier ICT versions, and more.

A new problem that ICT stressed is the need for developing the ability of coping with much more information along the chain from the farmer to scientist. Using ICT without knowing the "whole picture" may cause the users to feel as if "drowning in a sea of data". This is augmented by the inability to define and focus on priorities leading to an inability of properly using the new data. ICT adoption needs proper preparations.

In summary planning adoption of a “good, economically viable, and/or beneficial” ICT supported system must consider the above constraints for its successful and timely implementation. It can be assumed however that in a free and secure market the comparative advantage of the advanced broiler genetic lines with their superior feed efficiency will stimulate if not dictate ICT adoption. It is a prerequisite for their successful breeding, growing and marketing.

Summary

The availability of computer supported data collection, its integration including newly available and calculated parameters enables more precise and updated decision making by a wider range of decisions makers. Adoption of computers into broiler breeding and production routines was the result of the need to monitor and control production variables and manage large amounts of data and information. These are indispensable for the viability and success of modern broiler breeding and production.

The various ICT tools to share, deliver and/or access written, graphic and real time data optimizes the circle of involved professionals, simultaneously. This in turn enables their inspection and control of the breeding process, provision of advice, instructions and feedback. The easy accessing of data and ease of processing data and information inherent in modern computers enables analysis of parameters that in the past were not monitored carefully, if at all. Recent examples which have almost become a daily routine in many firms include:

- monitoring of CO_2 ratios and humidity in the incubating chambers,
- following the daily average loss of egg weight during incubation,
- monitoring the rate of daily changes in water consumption in breeding flocks,
- analyze implications of different restricted feeding programs on production parameters in broiler breeder flocks and more.

Without the advanced utilization of computers and computer embedded monitors broiler breeding and hatching would have regressed to much lower levels without being able to exploit the tremendous advancements made in the genetically improved broiler stock. The female breeder stock would be producing less hatching eggs, the broiler breeder male would be less fertile with lower hatching rates of fertile eggs.

Computers enable achieving production parameters equivalent to the past with genetically improved broiler stocks attaining almost the same meat production level with less chickens and with improved meat quality.

References

Eitan Y., Soller M., 2004. Selection Induced Genetic Variation. Evolutionary Theory and Processes - Modern Horizons. Edited by Solomon P. Wasser p. 158-176.

Hunton P., 2006. 100 Years of Poultry Genetics. World Poultry Science Journal, 62:417-423.

Porterfield M., 2006. High Technology Enters the World of Poultry Business. The Register Herald 16 August (Beckly, West Virginia).

Renema R.A, Rustad M.E, Robinson F.E, 2007 Implication of changes to commercial broiler and broiler breeder body weight targets over the past 30 years. World Poultry Science Journal 63:457-472.

Dr. Yoav Eitan *completed his Ph.D in Animal Genetics in the Hebrew University in Jerusalem. He is currently the Chief Information Officer of the Yavneh broiler breeding company currently responsible for managing the broiler breeder flocks for the Yavne Hatcheries.*