COMPUTER ASSISTED CONTROL OF GROWTH IN INTENSIVE POULTRY HOUSES

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SUMMARY

FLOCKMAN is the first monitor and control system of growth in poultry houses with the potential for profit optimisation. The system is particularly suitable for application in integrated operations where feed formulation and manufacture as well as bird processing through wholly owned premises is standard practice. Site managers and nutritionists can identify developing problems early and apply remedial measures before such problems can have serious effects on crop performance, mortality, bird health and carcase quality.

Feed is automatically blended under computer control daily from 2 bins at each house (one of which can contain whole cereal), so as to automatically deliver the daily intake of important nutrients to the flock necessary to achieve their planned growth rate and carcase quality. The daily feed mixture takes actual feed intake into account. The whole cereal allows an element of "choice feeding" to take place. Improvements in FCR of 4-8% as well as lower feed costs per tonne are achieved.

ABSTRACT

The inter-relationship between nutrition and environment has long been recognized. The performance of a poultry flock depends on the daily intake of critical nutrients. Optimal economic levels of daily nutrient intake can be estimated using modelling techniques. Daily nutrient intake is a combination of daily appetite (which is affected by bird age, stocking density and environmental conditions), together with diet composition. Practical application of nutrition models has been hampered in the past by the inaccuracies of predicting daily appetites of chicken.

FLOCKMAN is a microprocessor based system developed by the Poultry Research Unit at the National Institute for Poultry Husbandry, Harper Adams, which operates fans, heaters, feeders, lights, air inlets and automatic bird and feed weighers in controlled environment chicken houses. It reads sensors in 2 zones per house every 30 seconds and operates the above mechanisms to control temperature, relative humidity, ammonia levels and ventilation. The program optimises the use of heaters, fans and ventilators to maintain target environmental conditions. Target weight for age, carcase composition and the resultant target Nutrient Intake Profiles are set up at the start of each crop of birds. Input data on size of house, bird numbers, strain and mortality together with feed composition and date and weight of feed delivered to

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two bulk bins per house are also required. It ensures that actual feed composition is compatible with daily feed intake to provide the chickens with their planned nutrient intake so as to achieve target daily growth rates. The program measures feed intake daily and then blends feed from the two bins so as to provide daily nutrient intake in line with the target Nutrient Intake Profile. Colour graphs show target versus actual results. Up to 16 FLOCKMAN units can be operated from a central IBM PC which can itself be accessed remotely by modem. Improvements in bird welfare, carcass quality, fuel and feed economy have been shown commercially, with capital costs recovered in approximately one year. FLOCKMAN offers flock owners better management control and nutritionists and managers opportunities of profit optimisation in integrated poultry operations.

BACKGROUND

Computer technology

Computers have been in use in animal production for about 30 years. Apart from their use for linear programming for feed formulation in the late 50's, the earliest on-farm application I can trace was Project 360, a dairy cow feeding programme introduced by a UK feed compounder in the early 60's (Filmer 1980).

The advent of the cheap IBM compatible personal computer, with 40-100 Megabytes of hard disk and 1-4 Megabytes of Random Access Memory, means that sophisticated interactive programmes can now be run on site. This eliminates expensive central mainframe computers. Microprocessors can read sensors and weighers and activate control mechanisms and run in REAL TIME to make necessary adjustments to steer performance towards predetermined targets,

Large colour display screens and the clever use of spreadsheets can now reduce large amounts of information to simple graphical displays. These can be designed to be user friendly and offer warning and action signals when performances, such as liveweight, feed and water use and various economic parameters, start to deviate from the operator's targets by preset amounts, This gives the opportunity for feedback information to be used by poultry producers to make management adjustments to an individual flock DURING the course of the crop, so as to steer performance back onto target. Computer technology now improves the efficiency of many industrial processes. Chicken growers do not need to be computer experts to benefit from modern computer applications. The time is fast coming when those not so involved may suffer severe economic disadvantages.

Intensification of the poultry industry

Fewer poultry stockmen now control larger numbers of poultry. It is important that their limited time is augmented by relieving them of purely mechanical chores to allow them to concentrate on the use of their poultry, observational and husbandry skills.

Health, welfare and consumer issues

Consumers of foods from animals now express concerns for the health and welfare of these animals during their lives. The poultry industry should try to make production conditions as satisfactory as possible from the birds' point of view.

This means providing the birds with the quantity and quality of food appropriate to their needs, and ensuring that the litter and atmospheric conditions are of a high standard. The general public are increasingly worried about pollution of the environment in general. Reductions in nitrogenous and other undigested organic material excreted improves litter quality, cuts down on hock and breast lesions and lessens the amount of atmospheric ammonia and soil contaminants.

Quality of the meat is now a key issue. Carcases with less fat, more lean and a higher proportion of breast meat are required. Taste, tenderness and overall eating quality of meat are of growing importance as consumers become more discerning and selective. Systems of keeping poultry which can meet all these consumer issues will gain their support.

Quantification of genetics, nutrition and the climatic environment

All of the three above sciences have moved from the descriptive or qualitative, to the numeric or quantitative. This allows economic evaluations and profit optimisation calculations to be performed. A statistical approach to population genetics can now describe the genetic potential of a flock.

Similarly, given the appropriate information, nutritionists can now estimate the amounts of the important body building nutrients that are required to support maintenance and a given level of growth for each day of life.

Combining this with the genetic data and information from linear programming on feed costs, together with the values of different carcase grades, allows calculation of the flock's economically optimal daily nutrient intake. This can then be plotted to produce a "Nutrient Intake Profile" for each critical nutrient, that will enable the most economic performance for the flock to take place.

The composition of the feed required to deliver these optimal daily nutrient intakes depends on the appetite (or . daily FEED intake) of the birds. This in itself increases progressively as the birds grow older and larger and is affected substantially by the climatic environment (particularly temperature) (Payne 1964; Filmer 1973), as well as by stocking density towards the end of the flock's life (Shanawany 1988).

Environmentalists also can now make quite good quantitative estimates of the effects of environment on appetite. These changes in appetite will of course alter the daily intake of nutrients, given a fixed feed composition, and therefore performance will be altered.

Alternatively the composition of the feed can be changed to ensure that the economically optimal daily nutrient intakes are supplied over a wide range of appetites.

There will be at any one time one particular combination of feed composition and environmental conditions (and thus appetite) which will be least cost. One of the objects of a sophisticated monitor and control system should be to continually evaluate and home in on this combination as economic conditions change.

Modelling

By combining the quantitative information from all three sciences, biological models can be constructed which can make estimates of expected performance from feeding given feeds to given genetic material in given environmental conditions (Fisher 1989). Modelling can also be used to devise feeds which optimise the economic performance of given genetic material in given environmental conditions.

One of the weaknesses of modelling is that a very large number of pieces of information go to make up the model. If the genetic material, the feed, the environment or any of the relationships turn out, in practice, to be different to those assumed in the model, then the predictions will be inaccurate. One of the weakest areas is the prediction of appetite as variations in the stock, the feed and the environment can all affect this.

Modelling is also iterative. The calculations predict growth rate for day one in order to find body weight and body composition for day two. It then assumes feed composition, appetite **and** environment for day two to predict bone, lean and fat growth for day two – to arrive at body weight and body composition for day three, and so on. If all the assumptions hold good for every day, predictions should hold good, but if not, errors tend to be cumulative and can soon become excessive.

Because real life events, such as actual feed composition and actual feed intake are not predictable, modelling has not yet seen much commercial application, although potentially it is very powerful. This would be particularly so if feedback information could be re-entered into the model as growth progressed and if modelling were done and applied THROUGHOUT the life of the flock instead of forecasting life performance just at the beginning.

Objectives of a monitor and control system

Currently nutritionists try to optimise the nutrition of a flock given a particular environment; (although in practice the same feed is often used in various environments).

Alternatively, if you are a producer you can try to optimise the husbandry and the environment given a particular series of feeds and feeding programme; (although in practice the actual composition of the feed fed will come from a population of feeds having a particular mean and standard deviation for its various nutrient parameters).

The objectives of the use of computers in controlling the environment (taken in the widest sense to include feeding) should be to optimise the combination of nutrition and the climatic environment for a particular chicken strain / breed / sex within a given set of economic conditions.

This would enable the producer to optimise the combination of environment in individual chicken houses and his feed composition and costs. For example if feed costs are high it would pay to run the houses at higher temperatures or adopt other strategies to decrease feed intake, but put more protein or amino acids into the feed, to get the daily intakes of nutrients right.

A major advantage of a control system operating in REAL TIME is that changes in performance, feed intake or feed composition that take place during the course of the life of the flock can be compensated for before any adverse result has long term permanent effects. Routine assessments of actual performance or inputs can be monitored against target values. Differences can be automatically recorded, and warning or action messages signalled to the flock owner when such differences reach values predetermined by the flock owner himself.

The objectives, therefore, give the opportunity for much more detailed management of individual flocks, by providing concurrent management information. Simple analyses of actual versus target performance and clear messages when particular performance inputs or control variables start to go off course can be given before serious consequences arise, and when there is still time for remedial action to be taken.

Computers should therefore be seen as aids to management and certainly not as replacements for it. They should enable the producer to implement and to evaluate any control strategy in detail, and to apply the best strategies to all similar houses under his control. Ultimately they should improve the health, welfare and living conditions of the birds and the quality of the human food produced, whilst at the same time reducing the costs of feed and fuel used and increasing the profitability of the enterprise.

They should also offer a much more informed and interesting job for the stockman and the flock owner to do, they should encourage enterprise, initiatives and new ideas and finally offer a greater measure of motivation and job satisfaction to all those concerned.

FLOCKMAN

Overall view

There are a number of monitor and control systems on the international market, most of which control temperature and relative humidity and some of which assess bird weight and feed usage. Apart from FLOCKMAN, I know of no other system that attempts to integrate genetics, nutrition and environment with economics. I will therefore attempt to describe it in some detail and assess some of its features and benefits.

FLOCKMAN is a microprocessor based system developed by the Harper Adams Poultry Research Unit at the UK's National Institute for Poultry Husbandry in conjunction with BOCM Silcock, Unilever's UK animal feed compounders, and Stonefield Systems plc, who supply the electronics. The system is based on a Stonefield dedicated microprocessor mounted in a box about the size of a fan control unit on the wall of a chicken house.

Linked to the processor are solid state sensors for monitoring inside and outside temperature, relative humidity and ammonia together with automatic bird weight and water monitors. Also an automatic feed blending system using 2 feed bins at each house one of which can hold whole wheat.

The system operates and controls fans, air inlets, heaters, lights and the feed dispensing and circulation system. It also monitors and logs alarm conditions which can be preset. In addition it operates on a fail safe basis, and allows for a full manual back-up in the unlikely event of failure.

FLOCKMAN can be programmed to control preset temperature, humidity and ammonia targets, but more significantly, enables a minimum ventilation rate strategy to be implemented based on several parameters. Individual lighting and feeding programmes can also be established independently for each flock.

A monitoring sensor determines if feed, circulating on a chain feed system, is returning uneaten. If so, the time cycle is overridden and the chain stopped to avoid recirculation and excessive breakdown of pelleted feed. Other sensors determine if the chain is actually circulating and sounds an alarm in the event of a breakage. Important aspects of **FLOCKMAN** are its versatility and ability to control rather than just to monitor.

FLOCKMAN won the 1986 European Poultry Fair best new equipment award.

Zones

In practice we have found that the ends of uncontrolled houses can often differ significantly from each other even though the same batch of chicks were delivered on the same day and the feed used was the same. The West end of the house used for Trial 5 in 1988 at Harper Adams produced significantly better results than the East end. The birds totalled 10,000 and were as hatched Cobb 500's at 47 days of age, stocked at 0.5 sq feet per bird (Table 1).

TABLE 1 Performance within a chicken house showing large end effects

		West End	East End
Liveweight	kg	2.19	2.11
FCR		2.025	2.170

Observation suggested that the West end benefited from direct exposure to the sun, whilst the East end was shaded by other buildings on the site and subject to adverse wind effects.

FLOCKMAN is therefore designed to manage 2 zones in any one house, operating fans, heaters and air inlets independently to attain the same environment throughout the house. This is possible because the speed of the microprocessor allows a typical poultry house to be set up with multi-point sensing within zones. Each sensor is scanned every 30 seconds and the means values within a zone taken as the action point. The **FLOCKMAN** memory retains all the data generated by the sensors for a 24 hour period.

IBM central computer

An IBM (or IBM compatible) computer with a colour VDU, enables proper interpretation of the data to take place. The central computer would typically be located in the farm office in a clean dust free environment. It would be linked by a land line cable to up to 16 chicken houses. Remote sites can be linked by telephone using a modem system at each end. At the end of each 24 hour day, all the data from individual houses are automatically down loaded to the IBM computer which stores and interprets the information ready for access by the operator.

The central IBM computer also acts as a terminal from which each **FLOCKMAN** unit in each poultry house can be set up prior to the start of each flock. In addition, modifications to the control variables can be down-loaded at any stage throughout the life of the flock should management wish to make changes as a result of feedback data.

Only authorized users with the necessary password are permitted to set up or modify the control variable targets.

IBM software

Software for the IBM computer enables not only the flock performance, but also the performance of the building to be summarized in graphical form, thus enabling a complete evaluation of any control strategy to be made.

A number of graphs are automatically available from the menu system. The age range required can be selected, enabling more detail to be observed over a specific few days if desired. Comparisons between actual and target values are set up as standard for the following :

Liveweight
Liveweight gain
Feed intake
Feed Conversion
Mortality

Water intake
Temperature
Relative humidity
Ammonia
Fuel usage

In addition, access to the **FLOCKMAN** spreadsheet is available to more sophisticated users (or their consultant advisers) who wish to interpret the data further to assess relationships between the variables or to give better advice on nutritional / environmental / economic relationships.

Remote interrogation of the IBM computer

A facility exists for a remote computer to log into the IBM central computer using the telephone network and modems at each end. This allows authorized third parties to evaluate current performance and to advise on adjustments if required. It also allows the manufacturers to check on performance of the sensors and on the correct operation of the program if necessary.

This is particularly valuable for large integrated operators who will have several remote sites each controlled by an IBM computer, on which they would like information. Such information would be the status of each house regarding numbers and weights of birds, anticipated slaughter dates and forecast slaughter weights.

An overall assessment of health status and general management and performance of the site can also be monitored remotely.

SETTING UP **FLOCKMAN**

Part 1 - General details of flock owner

This ensures that computer printouts are correctly identified.

Part 2 - Details of individual house

This includes the house number and its dimensions from which the floor area and air volume is calculated. The **FLOCKMAN** configuration needs to be set up initially for each house. This includes for each zone, the number of fans and heaters as well as the number of Temperature, Relative humidity and Ammonia sensors. Also the presence or absence of a water meter, feed flaps, corner sensors, feed weigher, motorized inlets and lighting control as well as the number of bird weighers and feed chains.

Part 3 - Details of the particular flock

This includes the number of live birds delivered, their sex and breed, the dates delivered and the target slaughter date and weight.

Part 4 - Details of feed to be used

This includes the code and name of each feed and information on feed analysis and costs per tonne. In many cases the feed programme will be predetermined either by age or by quantity of feed per 1000 birds and this needs to be entered. Alternatively a preplanned mixture between compound feed (in one bin) and whole cereal (in the other) can be entered at the start of the crop. Alternatively the system of the following a preplanned Nutrient intake profile can be invoked - so allowing the computer to calculate and then deliver the correct daily blend from each bin, taking actual feed intake into account.

Part 5 - Setting up environmental controls

These enable the producer to set up a wide range of control strategies, ranging from the controls used in practice by his best stockman, to alternative systems used elsewhere, to new ideas he may have to improve various aspects of production. He may wish to seek advice from nutritionists, environmentalists, veterinarians and breeding companies. Ultimately he will need to decide; but he has the safeguard of knowing that if performance starts to go wrong, he can revert quickly back to his existing system in which he has experience and confidence. However, the ability to experiment with new ideas must enable the forward looking producer to develop advanced control strategies to give him economic advantages over his competitors! Targets need to be set up for :

Temperature	Lighting cycle
Relative humidity	Control and alarm bands
Ammonia	Ventilation
Feeding cycle	Start up times

This completes the setting up of **FLOCKMAN** for a particular flock. **FLOCKMAN** will now work to these set values (until given further instructions), by automatically operating heaters, fans and air inlets as well as feed augers, chain feeders and lights.

Note that Parts 1 and 2 are permanent features of the system and are set up on installation. Parts 3-5 should be re-entered for each flock but will default to previous values if unchanged.

Further entries during the flock cycle

Although **FLOCKMAN** will report back on performance and achievement of the control parameters, there are two further pieces of information that it needs in order to complete its evaluation. These are :

Part 6 - Details of feed actually delivered

These are entered manually on the day of delivery of each lorry to the site. The date, ticket number and quantity of feed delivered in total and to each bin is recorded on a single screen. The computer allocates these quantities to each house and keeps a log of the amount of feed remaining in each feed bin each day. It also forecasts the number of days before the feed bin becomes empty. There is a facility for entering the ACTUAL analysis of the feed delivered. For example, if NIR or other rapid analysis data accompanies the lorry, then these values for protein, amino acids etc can be entered and will be used by the computer in preference to the target feed analyses, which otherwise would be used by default.

Part 7 - Details of mortality

These are entered daily as they occur. The computer needs this information to calculate the live birds remaining in the house, average feed intakes per bird per day, FCR etc.

RUNNING AND INTERPRETING **FLOCKMAN**

The site manager

The site manager monitors each house each day for the key parameters which are shown graphically on the colour monitor. A wide range of graphs are produced but the key ones from a management point of view are:-

(i) Liveweight - Actual versus target (Absolute and % comparisons)
(ii) Liveweight - Distribution (Histogram showing distribution)
(iii) Liveweight gain - Actual versus target (Absolute and % comparisons)
(iv) Feed intake/day - Actual versus target (Absolute and % comparisons)
(v) Lysine intake/day Actual versus target (Absolute and % comparisons)
(vi) Water intake/day Actual versus target (Absolute and % comparisons)

Monitoring feed intake is critical to good management. In practice with most commercially produced feeds, it is lack of feed intake that limits performance. If a grower can encourage his birds to eat more, they grow faster and more efficiently. There are many practical ways of stimulating birds to eat more:

Temperature Birds eat more at lower temperatures. Roughly speaking birds eat 1% more feed for each 1 Deg C drop in temperature at 20 Deg C. This rises to about 2% for each 1 Deg C drop in temperature at 28 Deg C.

Pellet Quality Birds eat more feed if pellets are hard and do not crumble into meal. A simple way to reduce feed intake is to feed meal instead of pellets, even though the formula is the same. This is mainly because the birds can eat pellets quicker than meal. But also because meal tends to form a paste around the beaks of the birds which slows down eating. Birds also visit the water lines more frequently to wash out their mouths so reducing feeding time. with bell drinkers, the water becomes more contaminated with food particles when pellets are mealy or when meal is fed. This encourages growth of bacteria, slime organisms and other growths, making the water stale and less palatable. Less water is drunk. It is a well known fact that water intake and feed intake are related, so reduced water intake reduces feed intake still further.

Height of feeders A good rule is that the lip of the trough or pan should be level with the bird's back. This means that the height should be adjusted every few days. If the flock is as-hatched, the problem is worse, for if the feeders are raised infrequently they may be alright for the males, but too high for the females, particularly when just raised to the new height. A commercial flock suffered from hens being too light in weight recently (but cocks were on target) due primarily to this.

Type of feeders and augers Some feeders such as chain feeders damage pellets more, due to attrition, as they convey the feed around the feeders lines. Feed chain design is important with some of the plastic chains being less abrasive. If chain feeders are run too long and feed recirculates round the chain more than once, undue friction leads to excessive pellet breakdown. There are sensors available which switch off the chain feeder motors if feed begins to build up on the return section of the chain just as it re-enters the bin supplying the chain.

Fat level of pellets and manufacturing equipment Fat spraying onto preformed pellets and other modern compound equipment can produce excellent quality pellets even with the high fat levels. However, not all feed mills are properly equipped and producing the top quality pellets that are necessary to maximize feed intake.

Cooling and handling of pellets Pellets should be properly cooled and conditioned before delivery. Pellets should be screened immediately prior to loading into bulk lorries at the feed mill and discharged, preferably pneumatically, at the farm into feed bins. Pellets blown too fast into bins, particularly if the pellets are blown onto the sides of the bin, suffer more damage than necessary.

Pellet size Smaller pellets of 1.5 to 2mm diameter increase feed intake with smaller chicks. 3mm pellets for birds over 3-4 weeks produce higher intake than 3.5 or 4mm pellets.

Frequency of feeding When chain feeders run, the sound of the motors and the chain movement stimulates the birds to feed. Increasing the number of times per day that chain feeders run increases feed intake,

Timing of feeding When animals feed they give off heat. In hot weather this heat is difficult for the birds to dissipate in addition to the heat from movement and other bodily functions. So they eat less. However, at night time, even in hot weather it is easier to get rid of this extra heat. So changing the feeding pattern from day time feeding to more times during the night often increases feed intake in hot weather.

Ventilation and air speed The apparent temperature to a bird is a combination of actual air temperature less the additional cooling affect due to air movement. High Speed Jet and other systems leading to good air circulation at bird level, cool the birds and stimulate them to eat more.

Stocking density Birds stocked at high density eat less feed due to competition and crowding.

Feeder space per bird In general birds eat more if they have more space. This is more important as bird weight per square foot increases.

Quality and quantity of water supply Published guides set out maximum desirable levels of contaminants in the water. Attention to water supply AT BIRD LEVEL is of great importance. Bell drinkers should be cleaned at least weekly or water intake'will suffer. Drinker design affects water consumed AND feed intake as well as water spillage.

Intermittent lighting patterns Birds are stimulated to eat when lights come on. Various experiments with intermittent lighting programmes have shown good effects on feed intakes and feed conversions.

The processing factory manager

If equipped with an IBM compatible PC complete with modem, the processing factory manager can access each house on each site. This enables him to plan schedules more accurately, bringing fast growing houses forward in time and delaying slow growing houses until they achieve the correct weights at a later age. Messages to the overall growing manager to slow down or accelerate growth to meet changing markets are possible.

The overall growing manager

Again equipped with an IBM compatible PC complete with modem, this manager can exercise greater control over all the sites for which he is responsible. He can identify particular houses that have problems, and by visits of himself and the company veterinary surgeon, can spot the very early signs of disease or management or equipment faults and take the necessary remedial action, before the particular problem has time to seriously damage the performance and profitability of the flock.

Nutritionists, veterinarians and financial advisers.

Access to detailed day to day data allows the assessment of the current situation and the planning of future activities to be more soundly based. FLOCKMAN itself facilitates the asking of "what if" questions and will allow some assessment of likely outcomes. However it can operate as a very effective research tool. As it works with real life situations, there is no longer need to extrapolate results from small pen trials to commercial practice. New ideas can be tried out on some houses on a suitable site, compared with other houses run under standard conditions.

Statistical analysis of results is no problem as sufficient replication and randomization can be practiced. Moreover, if a particular treatment starts to go badly wrong, this is spotted early and can be discontinued. The scope for trying out new management methods, different environment control settings, changed nutritional targets, different feed materials etc is unlimited. FLOCKMAN encourages innovations and initiatives, and can lead to rapid improvements in performance and economic advantages.

COMMERCIAL RESULTS FROM FLOCKMAN

Commercial installations in the UK have now been in operation for 15 months and continuous evaluation of identical houses with or without FLOCKMAN takes place. Table 2 shows results from a site of 12 houses.

TABLE 2 FLOCKMAN results on a large integrators site

	Without FLOCKMAN	With FLOCKMAN	+/-
Number of houses	8	4	
Number of birds	240,000	120,000	
Age killed (days)	42.7	43.8	+2.6%
Liveweight (kg)	1.76	1.89	+7.4%
Food conversion ratio	1.966	1.847	-6.4%
Feed/bird (kg)	3.46	3.49	+.03 kg
Feed cost (p/bird) @ £170/tonne)	58.8	59.3	+.5 p
Value of bird (p) @ 55p/kg	96.8	103.9	+7.1 p
Margin over feed cost (p/bird)	38.0	44.6	+6.6 p
Margin /crop of 360,000 birds			+ £23,760
Margin /year (6 crops/year)			+ £142,560

Future developments

Currently the setting of the control parameters (temperature, RH, ammonia, lights, feeding cycle etc) are decided by the producer with help from his advisers. It is possible that future extensions based on further research and development could suggest optimal settings to the producer for him to consider. Equally, the system lends itself to the application of a built in chicken growth model. This is an area which will be investigated at various research and development centres in the future.

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