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THE PHENOMENOLOGY AND ENVIRONMENT CONTROL IN BATTERY FACILITIES

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Currently, all concerned parties, at all levels, from the veterinarian to the breeder to the grouping technician agree that the essential factor in successful animal breeding is the environment.

This is, of course, obvious. In order for the animals to be able to take full adventage of their nutritional intake thus increasing their rate of growth (at the same time decreasing the index of waste), their respiratory system must be in perfect shape what is more, a stuffy atmosphere, inadapted temperatures, etc tend to weaken the animals immunitary system and increase the risk of disease.

However, there are divergent opinions as to how to create a quality environment. The aim of animal breeding is to make a profit. In order to make a maximumu profit, the animals produced must correspond to the market demand (this question is not treated in this article). On the other hand, the goal is to raise animals at the lowest possible cost price. The cost price is the result of a complex balance, all of the laws of which are not yet known.

In considering the definition of a favourable environment, the criteria of the meaning of quality must be established as well as the maximum number of variations which are acceptable to the attainment of optimum value.

The whole of that which defines an environment is composed of separates which we can refer to as "typical values".

A typical variable is the air supply.

If it is too weak, it can increase the risks of mortality, and certain risk factors of disease with all that infers in terms of negative results (veterananian bills, a higher global index of waste).

By contrast, it has the adventage of cutting down work costs such as the energising unit.

If the air supply is too strong, it can result in high heating costs as well as an increase in the risk of death or disease. The problem is to find the lowest point of air supply possible without incurring risks and to determine the proper control level. This last point intervenes in material investment (the quality of the regulation system, the air openings, etc...).

What is more, this variable is not independent of others. Air supply is linked to temperature level, the change of temperature in time and space, the quality and general state of health of the animal group, the distribution of air.

Air supply determination is a multi-faceted problem. A quality environment is therefore defined by a host of variable factors.

The definition of an environment. Among the very numerous variables which define an environment, the following can reasonably be considered to be the most important:

Ti - minimum interior temperature

Tm - maximum interior temperature

Dt - amplitude of the daily variation in interior temperature.

Vc(Te) - comparative variation in temperatures interior and exterior.

Tau - buffing coefficient of incoming air (natural exchange the building's pre-heating/incoming air).

Qp - air supply by Kg of live animals (m3/h).

N - minimum rate of air exchange (volume/h).

Nm - maximum rate of air exchange (volume/h).

Vp - volume per Kg of live animal (m3/h).

DEPp - surface loss per Kg of live animal (m3/h).

CO2 - percentage of carbon dioxide

NH3 - amount of ammonia in parts per million: CM3/M3.

H%(Ti) - percentage of relative humidity in relation to interior temperature.

V(Ti,H%) - airspeed at the level of the animals in function of the Ti and H%.

This list is incomplete. Even so, the values of only a few of these variables are relatively well-known as to the role they play in the success of the breeding business.

The nature of these values is empirical. Anything we can say about their respective actions is subject to change, as technical advances reveal more and more about them as well as variables which we cannot control at the present time.

Futhermore, some of these variables are interactive, and sometimes the advised values are incompatible in interaction. A list of priorities must therefore be established. The combination of these values create what we can call a typical environment.

For certain animals (the pig for example), the top priority is the structure of the building he lives in (gratings, wall temperature, etc...).

REMARKS

The arrival of new and sophisticated materials on the market, particulary computer-controlled regulation systems, has allowed the animal breeder to better control the components which make up the environment.

However, we constate that if the new methods of battery raising yield high growth performance, it would seem that animals are becoming increasingly vulnerable to disease and infection.

This leads us to say that as the ability to control the environment increases, so must the understanding of the typical environment.

Finally, it is probable that the evolution of environment control will be oriented towards the creation of day/night and seasonnan fluctuations in the batteries so as to develop, among other things, the auto-immune defense systems of the animals, and to stimulate growth.

Example: The typical environment of the rabbit.

On the next page...

	Maternity	Fattening
Vp(M3/Kg)	.55	.2
Ti	17	16
Tm	25	25
Dt	4	4
Qp(M3/H/Kg)	.5	.7
Nm	6	10
H%(25)	65	65
H%(17)	80	80
CO2	.14/.76	.14/.76
V(17,80)	.1	.15
V(25,65)	.4	.4

Environment control

Once the group of variables has been defined, which can reasonably be thought to have an impact on zoo-technilogical results, the next step, of course is to verify the results.

Extreme caution is advised in this kind of consideration. Unfortunately, this sort of test cannot be done in a laboratory. If any correlation exists, it must be obtained on the battery premises.

But who, at present, can quantify the necessary parameters, even the measure of air supply though a building, by such rudimentary means ?

Professionals in the animal breeding sector have responded to pressing demands by developing a methodology of computerised analysis, the primary aim of which is to examine animal behaviour in relation to preconceived criteria such as established temperature and humidity, maximum temperature, actual air supply etc...

From the time of its conception, the result of this methodology have become more and more precise and reliable. Today we have an effective and comprehensive tool for analysing the technical weak points of a given breeding farm.

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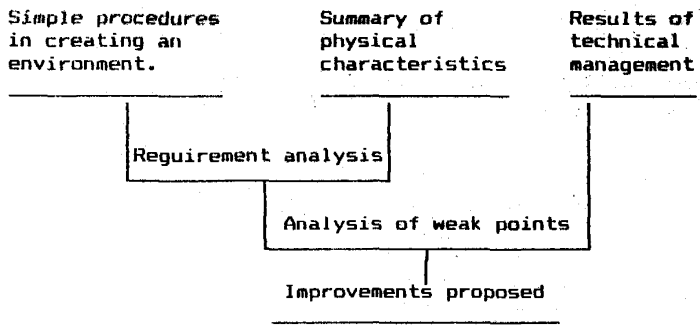
The following is a global analysis scheme:



The ultimate step will be to consolidate data taken from various breeding farms, and to present a system of optimised typical variables.

The methodology of a report:

Obviously, this consists first of all of analysing the surroundings in which the breeding farm functions. Then, if we are considering a farm already in existence, the actual way that it functions (or if the expertise is in the construction stage, the way that it is planned to function) in order to conclude the most efficient procedures which will assure its good running order.

Furthermore, it is possible to simulate technical results or the anticipated consequences of technical results.

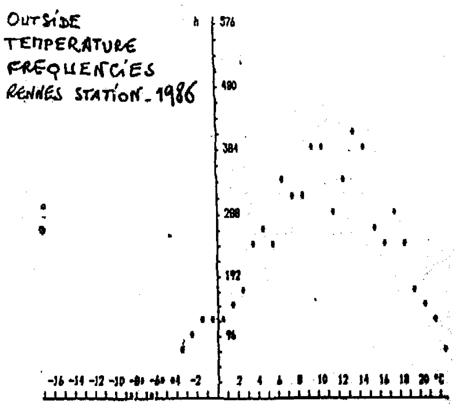
ANALYSIS OF THE SURROUNDINGS

In order to be accurate, this analysis must follow a strict scheme which includes the following elements:

- *climatic elements*

The temperature distribution in the building itself must first be taken into consideration, at an hourly frequency in regards to the outside temperature, degree by degree. At least during hot periods, it is useful to note the corresponding relative humidity.

From this data, the sum total of temperature differences (internal and external) are calculated up to the tempera-



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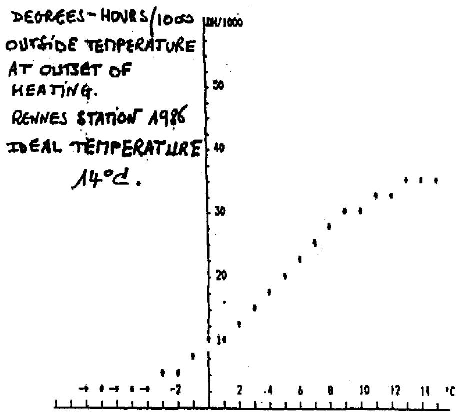
ture of equilibrium, that is, the outset of heating (where internal temperature barely compensates for heat loss) Cf (1) (3).

The curve of total temperature difference can be traced in function of the temperature of equilibrium. The form of the curve indicates the general plan to be followed regarding insolation and temperature control in the building.



Definition of minimum air flow. Minimum airflow is calculated in function of the planned occupancy of the building and of the hourly rate of air renewal/Kg of living animal.

Simplified winter	
Number of type 1	368
Corresponding weight Kg	4
Number of type 2	1440
Corresponding weight Kg	.35
Additional internal input	0
Renewing by Kg (M3/H/Kg)	.75
Suggested temperature	140
Appreciable heat (Kw)	15.6
Suggested minimum airflow (M3/H)	1482

Definition of surface:
The calory transmission coefficient of all surface elements that make up the building are calculated from the thermic qualities of the material used .

In other words "K" (W/M2/°C) of the diverse coefficients.

Calculation of coefficient K

Type	E. CM	Lambda	1/H or R	Res[illegible]
Internal convection			.11	0.110
External convection			.11	0.110
Cement fiber		.95		
Polystyrene class 4		.039		
Cement fiber	1	.95		0.010
Glass wool		.041		
Polystyrene class 2	8	.042		1.900
Styrofoam		.029		
Outside sheet-iron roofing		5		
Brick		1.15		
Air blade			.16	0.160
Int cement blocks		.6		

K=.43 W/M2/°C

The "Tau" coefficient:
The "Tau" coefficient will allow for the temperature planning of incoming unheated air, depending on external temperatures (Te) and internal temperatures (Ti), using the following formula: Ts=(Ti-Te)(1-Tau)+Te.

Calculation of "Tau" coefficient

Type	Ext	Int	K/Kl	Deperd
Air flow(M3/H)		1482		503.9
Int.partition		40	2.13	85.2
Recticel 7 roof	14		.38	5.3
Hallway & floor		48	2.15	103.2
Ext.wooden door	2.5		3.5	8.7
Int.wooden door	2.5	4	2	
Hallway conn.		50	1.75	87.5
Ext.hallway conn.	32		1.75	56.0
Gable	36		.38	13.6

Tau=.68

It is calculated by taking into account the relationship between internal and external exchange incoming air through an unheated volume of space (an entry-way, for example). If we call Φe(W/°C) the transitting heat flux per difference in degrees between the buffer space and the exterior, and Φ(W/°C) the transit of heated space, the "Tau" coefficient will be:

$$Tau = \Phi C/(\Phi e+\Phi i).$$

Definition of the envelope:
Total heat loss is calculated by taking into account the area (in meters) of a given room, the K coefficients, the surfaces, and eventual "Tau" coefficients.
These heat losses can be broken down into surface exchanges (dep) and air renewal exchanges

Table of heat loss

Position	Qty	K/K1/N	Tau	Deperd
Volume	787	1.88	.68	342.0
Int door	2.5	4	.68	6.8
Int partition	40	2.13	.68	57.9
Gable scraper conn.	8.4	3.5		29.3
Lateral cement blocks	48	2.44		117.1
Gables	33.5	.72		24.1
Lateral walls	72	.7		50.3
Roofing	517	.33		170.6
Skylight	25	1.5		37.5
Lateral shutters	36	1.5		54.0
Air entry hallways	41	2.15	.68	59.9
Hallway connection	50	1.75	.68	59.5

Heat loss: 1008.9 W/°C

Results:

From this given data and according to a group of formulae too long to go into here, it is possible to foresee the following characteristics for the room-in-question.
In this case, it is possible to say that the minimum temperature of incoming air will be in the order of:
Ts=(16-1.15)(1.68+1.15)=5.9 °C.

General results and consumption:

Reference	
G coeff (W/M3/°C)	1.28
Temperature stop & resumption	1.15
DH/1000 (°C.H)	11.0496
Avg. ext temperature	-2.35
Heated volume (M3)	787
Appreciable heat (Kw)	15.16
B coeff (W/M3/°C)	.23
Consumption (KWH/AN)	2105.3
Annual cost	1600
Minimum heating power Kw	6.3

Thus, it is evident that the temperature Ts is too low. Either a slight amount of pre-heating will be necessary or the air circuits must be modified to bring the "Tau" coefficient up sufficiently so as to increase the temperature of incoming air to at least 7 or 8 degrees Celsius.

It is also possiuie to analyse the planning of heat consomption in order to calculate the relative economic advantages of over- or under-insolation or the type of energy used for heating.

This of course is lies in the domainof the theory of traditional thermics. We refer anyone interested in this to a bibliography on this subject.

Procedure Analysis

This analysis is based on the procedure of measures and givens which permit the characteristics of the building in question to be determined from the previously cited information.

Any possible conclusions concerning the ventilation running procedure (minimum air-flow, regulation control, shafts, heating, etc..) can be imputed.

- minimum air-flow

Obviously, the knowledge of air-flow transit within the battery building is an important advantage in mastering air-flow function. Unfortunatelly, its measure (by anemometry) is extremely inexact; in other words, impossible. The only recurse is indirect measurement, of which there are five kinds. These measures can allow us to quantify minimum air-flow. The first two can check the variations in air-flow with the internal temperature; that is to say, how temperature control works in situ. Since all measurements are incertain, we must be able to estimate air-flow by diverse methods and to correlate the results. Of course, the differentiation depends upon the building in question.

All of these methods depend on the representative equations representing the total heat release, appreciable and latent, of the animals, with their evolution due to the atmospheric temperature and to the weight of living animals. Cf (2) (3).

Experience shows that if it is still possible to improve on this system of equations, data processing allows us to obtain extremely positive results.

1) Calculation through hygrometric equilibrium and CO_2 obviously, the principal is to measure the internal and external temperatures and humidity within a given period during which their energy is weak.

We must know the distribution of animals which occupy the room, according to the four following families:

- prepubescent
- reproducters
- young rabbits in nest
- young rabbits in fattening

The amount of carbon monoxide (0,01 % /A) is also necessary in order to confirm the results: that is the measured "Tau" coefficient in regards to the "Tau" calculated by the machine.

2) Calculation by thermic equilibrium

This calculation depends on the same elements fore-cited, including heat lost by the building, as well as perfunctory heating by the sun and possible cooling due to eventual evaporation and latent heating. The thermic résumé gives the actual transitting air-flow (mechanical flow + parasitic leaks).

It allows for the functioning of the building during the hot season, with the transitting calculation of maximum air-flow, the surface production of a cooling system, the water flow evaporation as well as the maximum internal temperatures resulting from local climatic conditions. Otherwise, we can easily deduce the limits of variation to be conferred for optimal efficiency (3). This limit of variation is another important characteristic which is unfortunately too often negleeted. It is in facts the difference between the ideal temperature and the internal temperature, from which the ventilation should be at its maximum.

Calculation by hygrometric equilibrium

Average weight of type 1 animals	3.5
Number of corresponding animals	350
Average weight of type 2 animals	2.5
Number of corresponding animals	25
Average weight of type 3 animals	.25
Number of corresponding animals	1323
Further data	.3
Ideal interior temperature	16
Int. humidity	82.8
Ext. temperature	7
Ext. humidity	100
Atmosphere pressure	760
Water vapor	500
Total heat (Kw)	16.95
CO2 (%)	.123
Water vapor (Gr/h)	7610
Appreciable heat (Kw)	12.46
Corresponding air flow (M3/h)	2978
Flow per Kilo of living animal (M3/h/Kg)	1.84
Total weight of living animal (Kg)	1618.25

Calculation by thermic equilibrium	
Total heat (ideal temperature) (Kw)	16.95
Complementary water vapor emission (Gr/h)	500
Incidental south surface (M2)	90
K coefficient of surface (W/M2/°C)	.6
Ext. humidity (%)	100
Ext. temperature (°C)	7
Humidity after cooling system (%)	100
Maximum int. temperature (°C)	16
Atmospheric pressure (mm Hg)	760
Surface heat loss (W/M2/°C)	666.9
Alpha coefficient of absoption	0
"Tau" coefficient of air	.68
Internal input to considered temp	12.158
End internal humidity (%)	82
Corresponding air flow (M3/h)	2958
Water flow to be evaporated (litres/h)	0
Temperature after cooling system (°C)	7
Free latent heat (Gr/h)	7607

3) Calculation by heat dynamic

The registration of internal and external temperatures in winter can also indicate the rate of reaction at which the heating system is thrown into gear and released the analysis of the rate of reaction along with occupancy and heat losses can also allow us to calculate the present moving air-flow (taking into consideration the building's own inertia). Cf (3).

Analysis of heat slope		
Original heat slope (°C/H)		4
Original int. temperature		15
Original ext. temperature		1
Original cooling slope		-5
Original int. temperature		17
Original ext. temperature		-1
Heat power interlocked (Kw)		6
Appreciable heat (ideal temp)		12.46
Surface loss		666.9
Tau coefficient on air flow		.68
Corresponding air flow (M3/h)	1445.0	
Inertia (°C/Kj)	0.00025	
Equivalent mass (cement) (tons)	4.781	

4) Method of energy consumption due to heating system. As we have said before, it is possible to foresee the amount of energy consumption needed in heating the building. The same holds true that if the actual consumption is known, it is easy to deduce the average moving air-flow during the heating period.

Finally, data processing will give the number of hours during which the heating system should have been functioning. Some systems register the actual time they have been working, so it is easy to cross-check.

5) Method of calculation of the temperature of equilibrium.

The animal breeder's experience as well as temperature registration at critical times can provide the external temperature at which the heating system begins to get into gear (the temperature of equilibrium) and consequently the present air-flow.

A simulation of technical management.

Among all of the means available for analysing the relative efficiency of a breeding farm and making improvements on it, the simulation of technical results is certainly not the least important.

In fact, it can allow us to zero-in on the weak points of the breeding farm in question and to draw extremely useful conclusions as to improving productivity.

Result of simulation of technical management on a rabbit farm	
No of mothers	166.95
No of weaned young/year	8738
No of animals sold/year	7562
No of prepubescent animals (aug)	24.07
No of males	20
No of rabbits in fattening	8161
No of maternity cages occupied with nest	104
Tons of food for fattening purposes	61344
Tons of food for maternity purposes	12406
Total food cost/year	130537.5
Economical consumption index	4.082
Food cost margin/maternity cage/year	607.582
Gross food total margin/year	96605.68
Food cost total/present mother/year	578.65
Self perpetuation rate of mothers	86
No of mothers replaced/year	272

Simulation of technical management on a rabbit farm	
No of maternity cages	159
Occupating rate	105
Total births per litter	8.3
Interval between 2 litters/maternity cage (d)	42.5
Mortality rate up to weaning	22.9
Mortality rate during fattening	10
Average weight of living sold rabbits (Kg)	2.349
Average price per kilo (f)	12.99
Farm compensation	1
Days to weaning	28
Average price fattening food/kg	1.77
Average price maternity food/kg	1.77
Annual replacement rate of females	163
Female to male ratio	8
Number of rabbits consumed/year	30
Number of stud animals bought/year	40
Number of stud animals sold/year	0
Price of stud animals bought	90
Price of stud animals sold	0

The analysis and balancing adjustment of a ventilation shaft. The phenomenon of simulating and improving the distribution of air intake and outlet in the ventilation shaft is so complex that calculations must be performed on a data processing unit.

Inspite of the complexity of the actual state of analysis, the systems of equation can no doubt be improved on. However, the results obtained with them are sufficiently reliable so that the total picture is very close to reality, at least in the great majority of cases. Cf (3).

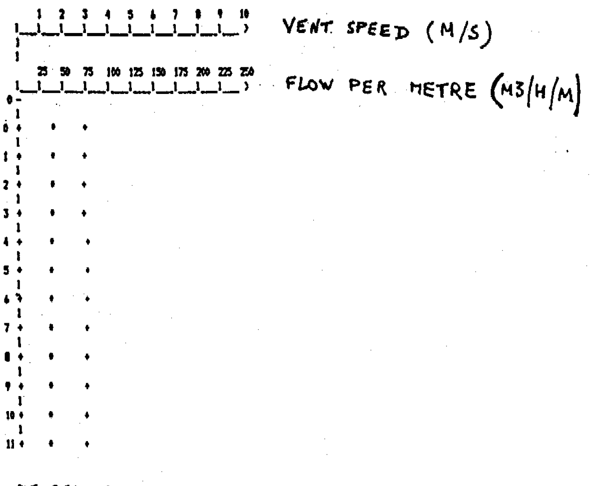
The following tables indicate the profile type of air speed which the simulations allow us to attain. This is a considerable improvement over the classical manual methods.

On the next page....

Simulation of a shaft

Wall (1:wood/ 2:plastic/ 3:cement)		2
Number of holes per section (1, 2, 3)		2
Diameter or width of shaft		.5
height of shaft (0 if circular)		0
Length of shaft		14
Diameter or width of holes (cm)		2.5
height of holes (0 if circular)		0
Conicity of shaft (M2/M) (0 if not conical)		0
Distance between first holes (m)		.07
Proximity factor (1 if distance constant)		1
Distance between ventilator and first hole (m)		1
Diameter of ventilator (m)		.35
Global air flow desired		4000
load loss in shaft (mm/ce)	4.6	
speed in last vent (m/s)	6.1	
speed in first vent (m/s)	5.7	
total flow (m3/h)	3920	
space between last holes (cm)	7	
total number of holes	370	

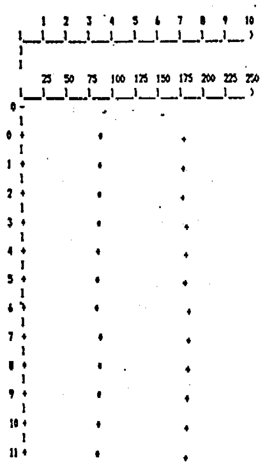
DIAGRAM OF SHAFT'S SPEED AND AIRFLOW VARIATION



METRES OF SHAFT

TOTAL FLOW OF SHAFT : 980.2264 M3/H

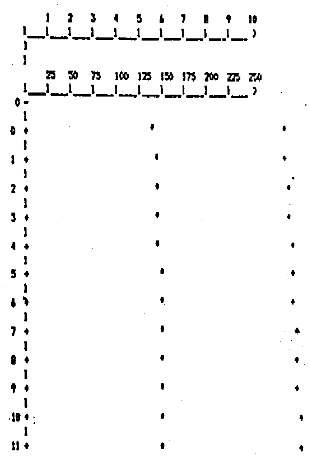
TOTAL LOAD LOSS IN SHAFT : .29 mm/CE



METRES OF SHAFT

TOTAL FLOW OF SHAFT: 2450.565 M3/H

TOTAL LOAD LOSS IN SHAFT: 1.81 mm/CE



METRES OF SHAFT

TOTAL FLOW OF SHAFT: 3920.905 M

TOTAL LOAD LOSS IN SHAFT: 4.65 mm/C

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CONCLUSION

If mastering the environment remains a major problem in present-day battery-style breeding farms, today's rational methods can increase the breeder's control and efficiency.

The systematic application of these methods will increase our knowledge of real working conditions on breeding farms today, in correlation with their technical and zootechnical results. This will allow us to disassociate the relative importance of given parameters and consequently to elaborate on the definition of a typical environment, the animals who live in it and the food that nourishes them.

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There exists a methodical global approach to animal raising which allows for the quantification and analysis of the environment of buildings used for this activity. This method is based on the analysis of temperature and hygrometric evolution, air supply and energy needs due to eventual heating in the buildings and the parameters of regulation. It allows fot the etablishment of a proper state of building operation as well as for the smooth evolution of its environment.

The objective of this article is to present the method on which this analysis is based as well as the parameters on which it rests. It must be emphasised that there is neither the time nor the space in the scope of this article to present all of the mathematical representations and equation systems included in the application of this method.

The essential point is to realise that this method exists, that it works efficiently and that its results have proven an extremely small margin of error.

PHENOMENOLOGIE ET CONTROLE DE L'AMBIANCE DANS LES ELEVAGES HORS SOL

Il existe une méthode globale d'approche de l'élevage des animaux qui tient compte, pour la quantification et l'analyse, de l'environnement du bâtiment dans lequel s'effectue cette production. Cette méthode est basée sur l'analyse de l'évolution de la température et de l'hygrométrie, les apports d'air et l'énergie nécessaire à un éventuel chauffage du bâtiment et sur les parametres de régulation. Elle permet aussi bien l'étude initiale nécessaire à une bonne conception du bâtiment, que le contrôle progressif de son évolution.
L'objet de la présente communication est de présenter la méthode sur laquelle cette analyse est basée ainsi que les parametres sur lesquels elle se fonde. Il convient de souligner qu'il n'est pas possible dans le cadre nécessairement limité de cette communication, de fournir toutes les représentations mathématiques et les systèmes d'équations impliqués dans la mise en oeuvre de cette méthode. Le point essentiel est de prendre conscience que la methode existe, qu'elle fonctionne avec efficacité, et qu'il est prouvé qu'elle conduit à une très faible marge d'erreur.

World Rabbit Science Association