# TWENTY REMARKS ON ECONOMIC EVALUATION OF SELECTION GOALS

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SUMMARY : Differents methods of evaluating the economical value of traits under selection are reviewed : statistical analysis of breeder's profits, simple efficiency models for one animal or one dam-progeny unit, complex models describing the herd as a system. For each of these methods, we discuss the meaning of the economic weighting obtained. We assume that the selection goal is to maximize decider profit.

INTRODUCTION : After SMITH (55), many authors turned their attention to the problem of optimal choice of reproducers in order to satisfy an economic goal. Published articles in this field have been reviewed several times (7, 17, 30, 37, 64). Our intention in this paper is to provide some food for thought about defining the goal and building associated rules.

GENERALITIES : The "goal" is the purpose of whoever is choosing between animals or breeds (the "decider"). The decider can use genetic improvment to help realize this goal. We assume it is measured in monetary terms, admitting this it is not the only case. This definition needs some remarks :

1) Whether the goal can be reached with genetic or non-genetic improvment must always be defined. When resources are limited, the best technique has to be choosen (23). A good example in sheep is the choice between hormonal treatment and crossbreeding with the prolific Romanov breed.

2) For one selection scheme, there are several deciders whose goals may be different : weaners vs. growers (6,35) breeders vs. producers (36) ; individuals (farmers) vs the collectivity (state) (38). Do the differences vanish in the long run due to the free market ? That is the hope of several authors (5, 28, 41,53).

3) Ideally, the choices reproducers have must be evaluated when taking into account all consequences affecting all the managing activities working towards the goal. In this way, a breeder choosing his replacement animals has to take into consideration his resource limitations for food, labour, stable room, finances. In practice, simpler approches are very often preferred to this global procedure when economically evaluating traits. We shall first describe them, before coming back to these global models.

LINEAR STATISTICAL MODELS : A first step is to write simple linear models, estimate their parameters on a sample and then use them for prediction. The observed random variable Wm is a measurement of the goal and it is written $E(Wm) = \sum ai\ Yim$, Yim being a covariable (weight, fertility...) measured on the $m^{th}$ individual. With this type of model the economic weightings of linear selection indexes are estimated by the ai : 34, 53, 59. Analyses, however, are rare. The interest of these models is their simplicity. Nevertheless, they present serious disadvantages :

4) being not at all explanatory they need a good sampling of deciders whose profit Wm is measured, and no price variation.

5) economic data are scarce, if not unavailable.

6) Theoritically, Wm is the part of the farmer's total profit given by one of his animals. Practically one uses the regression of the total profit in the average phenotypic values of the animals. Are the underlying linearity hypotheses satisfied when we use the selection indexes coming from these regressions ?

7) The utilization of a linear selection index I is mainly useful if the Wm, Ymi and the predictors Xj obey a multinormal law. Then selecting with I maximizes the expected profit

MODELS FOR ESTIMATING INDIVIDUAL EFFICIENCY : Considering the above difficulties, one can try to adjust simple models whose aim is to measure the profit part Wm, using values of some traits.

A first step, rough but simple, is to directly estimate the ai weightings factors. That is, (1, 53), ai = $\sum$qij . vij- $\sum$qik . vik where qij is the amount of j factor produced and qik, of k factor consumed, when the Pmi value is increased by one unit ; vij and vik being the unit prices of j and k factors. This step is, for instance, the one of 27, 32, 48, 57, 61, 63. These ai estimates are based on underlying models where decider returns R and costs C, for one animal, are associated one with the other. These one-animal efficency models have been explained by several authors, who either limited themselves to the returns R, proportional to the amount of products sold and to the unit value of the production (22,67, 68) or considered both R and C (18, 57).

These models may be criticized :
8) the profit evaluation concerns a more or less long period in animal life and results vary with the chosen definition (18, 57). This comes from differences in the underlying hypothesis : measurement period may vary for instance whether or not it exists relationship between parturition difficulties and weaning weight or variations in carcass sale prices with slaughter weight.

9) Results depend on breeding conditions, such as slaughter weight, ages at key events (weaning, first mating, slaughtering) and the feeding program. It would be necessary to considere and optimize these conditions (24, 28, 29, 30, 36).

10) In the models the part of the total profit supplied by one animal has to be isolated ; it is therefore subject to our sixth criticism, and clearly shows the need to work on the dam-progeny unit even if some simplified solution can be forseen (18, 63).

MEASUREMENT OF DAM-PROGENY UNIT EFFICIENCY : Many studies have been done on this topic : 6, 11 to 16, 26, 30, 31, 38 to 43, 45, 49, 69. As with the previous models they compare the input (costs) and output (returns) flows. Depending on the authors, the analysis of these flows is more or less precise. There are two remarks :

10) Flows are made of different types of elements that have to be aggregated. Using a price system is the most "natural" solution. Nevertheless, several authors have rejected this solution, arguing for interest of an efficiency measurement which would be independent of market fluctuations.

11) The female life cycle may be split into two periods, (rearing and reproduction), more or less detailed according to the author. For instance, replacement conditions of females, and variation in performance with age are often forgotten. A demographic approach would also often be necessary.

The C and R flows were combined, using different criteria : R-C, R/C, C/R. The difference R-C considered as a profit, is expressed in monetary units, while the ratios are sometimes assumed to be independant of prices, therefore nearer to biological efficiency. In fact, this is possible only for the unirelational systems where there is only one input and one output flow. We note here several points :

12) Choosing one of the criteria R-C, R/C or C/R, is an important decision : these criteria may classify breeds or the economic importance of traits in different ways (30, 28). According to our first principle of choosing reproducers in order to satisfy the decider's goal, the R-C criterion is probably the best.

13) MOAV (41) and BRASCAMP et al (5) discussed the measurement unit choice (profit per female, per female and year, per progeny, etc...). This is mainly a problem of constraint choice. Calculating the profit per female is, in any case, the first step.

14) These dam-progeny efficiency models are subject to our 6th and 9th remarks as well. They assume that each unit acts independently on the total profit, the herd being an aggregate of isolated units (62). But, along side the series connections which are characteristic of this dam-progeny sub-system (with material flow : milk, fertility, and information flow : genes), one can find parallel connections for all animals of the herd that make use of the same limited inputs (food, labour). Moreover, the herd itself is one element in the whole system.

We shall show further on what was done to solve these problems. First, let us come back to the utilization of these first models for the economic weighting estimations.

UTILIZATION OF EFFICIENCY MODELS FOR SELECTION : Let Yi be the ith trait in the model W = f(Y1,Y2...Yn) = f(Y), and Xj the jth predictor used in the selection criteria $I = g(X)$ . R is the event : the value of the Xj predictors are in the selection region (10).

With the first approach, only linear indexes are considered and, in the global genotype ($H = \sum ai\ Yi$), the ai coefficients are determined by the partial derivatives $\partial f(Y)/\partial Yi$ calculated at the mean Y before selection (see for instance 5, 26, 28, 36). The justification of this step comes from TAYLOR formulae applied to $\tilde{W}=f(E(Y/R))$, the profit determined by the mean selected animal :

$$\tilde{W} = f(E(Y)) + \sum(\partial f/\partial Yi)_{E(Y)} \cdot E(\Delta Yi) + \mathcal{E}$$

where $E(\Delta Yi) = E(Yi/R) - E(Yi)$, and it is assumed that $\Delta\tilde{W} = E(W/Y) - \tilde{W} \simeq \sum ai\ E(\Delta Yi)$.
Maximizing $\tilde{W}$ is equivalent to maximizing $\Delta\tilde{W}$, and so$\sum ai \cdot E\ (Yi/R) = E\ (\sum aiYi/R)$. The Cochran rule (10) indicates that the best selection stategy is to select on $I = \sum ai\ \ E\ (Yi/X)$.

This approach has been criticized by 25,26,58 who, more or less explicitly, showed that the $\mathcal{E}$ quantity is not always negligible. As early as 1966, MOAV and HILL (43) proposed a "second" more consistent approach. Its principle was to get graphically the maximum value $\tilde{W}$ taking account of constraints on the type of selection : the criterion I must be linear in Xj and the selection rate q is fixed. From an algebraic point of view, the ai weights are the partial derivatives $\partial f/\partial Yi$, calculated at the mean Y after selection. They are obtained by trial and error.

A third approach was proposed by HARRIS (26) who suggests avoiding the linear limitation for the I index. His proposition is to use $I = f\ (E(Y1/x), E\ (Y2/x) \ldots E\ (Yn/x))$. In the general case, (e.g.50) this solution has no more advandages than its simplicity. But , when f(Y) is quadratic, one can find several interesting properties for I, particulary that $f\ (E\ (Y/X)) = E\ (f\ (E(Y/X)))$, (67). Quadratic indexes have been calculated by 22, 67, 68.

These developments suggest some remarks.

15) Let us first limit ourselves to models concerning the efficiency of one indidividual. In all the works described above the fixed aim is to maximize the profit given by the mean of selected animals (25). This is not in accordance the ultimate goal which is, say, to maximize the profit. With the necessary (for the efficiency models) hypothesis that profit parts given by each individual are additive, then the real objective will be to maximise the mean profit for selected animals $\hat{W} = E\ (f\ (Y)/R)$ instead of the profit of the mean selected $\tilde{W} = f\ (E\ (Y)/R)$. Then, there are 2 questions :

. what is the optimal selection criterion for $\hat{W}$ ? Generalizing (10) it appears that $I = E\ (f(Y)/X)$ is the best one. I is simple only in the linear and quadratic cases where $E\ (f(Y)/X) = f\ (E(Y/X))$.

. Are the results obtained when selecting for $\hat{W}$ or for $\tilde{W}$ really different ? We have no general response. Simulating (5000 points/case) these two situations for a profit fonction of the HILL and MOAV - type ($W = 10.6 - .1\ Y1 - 320/Y2$) with different values of the heritabilities $h^2g_2$ and $h^2g_2$ and of the genetic correlation $\varrho$ we find that the maximum relative differences

(1000 x $(\hat{W}-\tilde{W})/\tilde{W}$) are less than 4 % :

| Selection rate | $h^2g1$ = .25 and $h^2g2$ = .1 $\varrho$ = 0 | $\varrho$ = - .8 | $\varrho$ = .8 | $h^2g1$ = .5 and $h^2g2$ = .5 $\varrho$ = 0 | $\varrho$ = - .8 | $\varrho$ = .8 |
|---|---|---|---|---|---|---|
| .010 | 1.3 | 9.5 | -.2 | 23.8 | 35.9 | 3.2 |
| .020 | 1.1 | 2.7 | -.4 | 1.5 | 22.5 | 5.8 |
| .050 | -1.5 | 4.6 | -.3 | 7.3 | 20.7 | .6 |
| .100 | .8 | 3.4 | .2 | 6.9 | 18.7 | .8 |
| .200 | .6 | 2.2 | .1 | 3.8 | 15.3 | .7 |
| .500 | .2 | 1.3 | -.0 | 2.4 | 5.9 | .2 |

16) With dam-progeny efficiency models, both father and mother, (may be from different strains) selection are involved. SMITH (54), MOAV and HILL (53) worked on the mean profit part given by each unit and not the profit of the mean unit. Nevertheless Goddard, in a slightly different situation, rejects the idea of maximising W when genetic gain is given through the two parental paths. May be would it be useful to adapt the ALLAIRE (2) ideas concerning assortative mating to this topic.

SYSTEM ANALYSIS APPROACH : System analysis may be define as a synthetic approach of the working of a complex unit (4, 56, 60, 62). System analysis was recommended 15 years ago for making choices in genetic improvment (6,29,44). It is not possible here to review all the papers published on this topic. Roughly, they may be classified in two groups :

* global and synthetic approach of the working of a herd. Two North-American teams used it for beef cattle production : a Texan team (8,21,33), and a Canadian one (46,47,65,66). The models integrate : a demographic description of the herd, the idea of an optimum slaughter weight, financial aspects, parallel connection between individuals consuming limited resources.

* global but more analytical approach with special attention to biological mechanisms. Texan studies concerning beef cattle (19,51,52) and all studies on sheep coming from numerous Australian and Scottish teams (eg 9, 20) can be cited here.

17) The aim of these investigations is often far from calculating economic weights since their general objective is to compare breeding systems and /or genotype. MORRIS and WILTON (47) used, for estimating the economic weight of a trait, the slope of the curve giving profit as a function of the trait level, obtained by optimizing the model for different mean values of the trait.

18) If they give answers to some of the previous questions (parallel connections, breeding conditions, etc) these models are heavy and one can doubt their usefulness on a short-term basis.

CONCLUSION : At the end of this review, one can ask what type of model should be writen for the evaluation of economical weights ai ? We saw the limits of the simplest models and the heaviness of the most precise. Two last remarks may be done as a conclusion.

19) It exists simpler systems than the beef cattle one. Writing and using "global" models in their case is more practicable. Pork and poultry growing industries are examples. In the others situations complex models may be writen in order to create standard for simpler models which, then, would be extensively used in their true domain of validity.

20) Several authors (e.g.,59) showed that economic weighting is a very robust process. Large uncertainty is frequently allowed without trouble on the results. This phenomenon extends the usefulness of simple models, showing they have to be tested against more complex ones comparing their final effects on selection results.

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