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Evaluation of Egyptian sheep production systems: II. Breeding objectives for purebred and composite breeds

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ABSTRACT: Objectives for this study were to estimate relative economic weights for performance traits for two native and two composite sheep breeds under two management systems in Egypt. Breeds studied were Rahmani (R), Ossimi (O), $\frac{3}{4}$ R- $\frac{1}{4}$ Finnish Landrace (RFR), and $\frac{3}{4}$ O- $\frac{1}{4}$ Finn (OFO); OFO and RFR were composite breeds. Management systems were one mating season per year (1M) and three mating seasons per 2 yr (3M). A dynamic computer model was used to simulate animal performance and enterprise efficiency and profit. Input parameters for the model were obtained from published results and analyses of data collected from experimental flocks of the same genetic stocks in Egypt. Responses for two measures of life-cycle feed conversion and one measure of enterprise profit were evaluated. Life-cycle feed conversion was calculated as kilograms of TDN input per kilogram of empty body weight output (TDN/EBW) and kilograms of TDN input

per kilogram of carcass lean output (TDN/CLN). Profit was measured as annual gross margin/ewe (GM/EWE). Traits evaluated were conception rate (CR), lambing rate (LR), mortality rate (MR), mature weight (MW), and milk production (MK). Based on responses to percentage changes in trait means, CR was most important for TDN/EBW, followed by LR and MR. For TDN/CLN, LR, MR, and CR were most important. For GM/EWE, CR was most important, followed by LR, MW, and MR. In the systems studied, there was little response to changes in MK. Based on changes in GM/EWE per genetic standard deviation change, LR was most important, followed by CR, MR, MW, and MK in all systems. Relative economic weights for O and OFO were similar, as were weights for R and RFR. Differences in economic weights between management systems for the same breed were not large enough to justify separate selection lines within breeds.

Key Words: Sheep, Breeds, Selection, Breeding Objectives, Systems Analysis

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Introduction

Efforts are being made in Egypt to intensify sheep production systems, primarily through changing reproductive management and crossing native breeds with introduced breeds. Two management systems have been studied, one mating season per year and three mating seasons per 2 yr (Aboul-Naga and Aboul-Ela, 1987).

In a companion paper, we evaluated life-cycle measures of performance for two Egyptian fat-tailed breeds of sheep, Rahmani (R) and Ossimi (O), and their crosses with the exotic Finnish Landrace under two management systems (Almahdy et al., 2000). Generally, crossbred groups were more efficient than native purebreds,

but rankings were sensitive to management system and definition of efficiency. Although F_1 crosses were most efficient, *inter se*-mated $\frac{3}{4}$ R- $\frac{1}{4}$ F (RFR) and $\frac{3}{4}$ O- $\frac{1}{4}$ F (OFO) were competitive and are being maintained as composite breeds in Egypt. This study focused on R, O, RFR, and OFO, with each breed targeted for use in purebred or rotational crossbreeding (R and O) mating systems.

In Egypt, most commercial sheep are raised in very small flocks in low-input systems. Genetic improvement is largely accomplished through government-owned flocks, with progeny from these flocks distributed to producers. Breeding objectives are needed to develop selection programs for these breeds (Harris and Newman, 1994). Our objectives for this study were to estimate relative economic weights for performance traits for the O, OFO, R, and RFR breeds under two management systems.

Materials and Methods

Simulation Model. A dynamic computer model was used to simulate animal and enterprise performance.

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The model was a modified version of the deterministic lamb and wool production model used by Wang and Dickerson (1991a,b,c), which they adapted from the Texas A&M University Sheep Model (Blackburn and Cartwright, 1987a,b,c). Model modifications were described in a companion paper (Almahdy et al., 2000).

Simulated management was patterned after management systems used by sheep producers in Egypt (Almahdy et al., 2000). During the winter and spring, flocks grazed Egyptian clover pasture, supplemented with concentrates. During summer and autumn months, flocks grazed crop stubble, green fodder (sorghum), clover hay, and rice straw in roughly equal proportions, again supplemented with concentrates. Additional supplement was provided to ewes at a rate of .25 kg·ewe⁻¹·d⁻¹ for 2 wk prior to the mating season and from the last 4 wk of pregnancy through the 1st wk of lactation. Animals were sheared in March and September. Ewes and rams were first mated at 18 mo of age. Ewes were culled if they exceeded 9 yr of age, failed to conceive for two consecutive seasons, or experienced health or soundness problems.

Two management systems were simulated: annual lambing (**1M**) and an accelerated system of three lambings every 2 yr (**3M**). In 1M, breeding started May 15 and lasted until August 15 (lambing October to January). Lambs were weaned at 4 mo of age. In 3M, mating seasons started May 15, January 15, and September 15 and lasted 35 d. Lambs were weaned at 2 mo of age. In both systems market lambs were sold at 6 mo of age.

Three measures of system performance were considered. Life-cycle feed conversion was calculated as kilograms of TDN input per kilogram of empty body weight sold (**TDN/EBW**) and kilograms of TDN per kilogram of carcass lean sold (**TDN/CLN**). To calculate TDN/EBW and TDN/CLN, outputs of wool, weight (or lean), and manure were adjusted to a market lamb equivalent based on the relative values of outputs from different ages and classes of sheep. Profitability was defined as gross margin (income minus variable costs per ewe per year, **GM/EWE**). Income included weaned lambs, surplus replacement ewes, culled ewes, wool, and manure. Variable costs included annualized costs for buildings and equipment, feed, veterinary care and supplies, shearing, and labor.

Experimentation and Statistical Analysis. Economic weights were calculated as partial regressions of system performance (i.e., TDN/EBW, TDN/CLN, and GM/EWE) on the genetic means (equivalent to mean breeding value) for single traits, when genetic means for all other traits were held constant (Tess et al., 1983b; Hazel et al., 1994). Five genetic components were considered for evaluation: conception rate (**CR**), lambing rate (**LR**), mortality rate (**MR**), mature weight (**MW**), and milk production (**MK**). Flocks of 1,000 ewes were simulated for 10 yr.

Simulation procedures were similar to those used by Tess et al. (1983b). For each trait within each breed by management combination, system performance was

simulated for 0, 5, 10, 20, and 25% changes in the mean, holding genetic levels for other traits constant. Genetic levels for CR, LR, MW, and MK were increased, while levels for MR were decreased. Ten replications were run for each trait-level within each breed by management combination. This set of simulations was used to prepare graphs of system responses to single trait changes.

Mean breed performance was considered as the genetic mean for each breed, which served as input parameters for the model (Almahdy et al., 2000). Note that for a given performance trait, changing management or genetic levels of other traits could produce environmental and, hence, phenotypic changes in simulated performance for that trait (Tess et al., 1983a).

Biological or economic efficiency may be regarded as a response surface of n-dimensions, where n is the number of genetic components (Tess, 1981). Evaluations of joint effects and interactions of the genetic components over the response surface were conducted. All possible interactions between genetic levels for pairs of traits were simulated to study the effects of linear, quadratic, and linear × linear of different genetic levels on biological and economic efficiency.

This series of simulations was analyzed using regression procedures (SAS, 1990). Each breed × management system was analyzed separately. The model included linear, quadratic, and all possible linear × linear interactions. Relative weightings for each trait (β_i) were calculated as the average responses in profit to a 1% unit genetic change in each trait using the partial derivatives of the regression of profit on changes in each trait.

Because the model included stochastic as well as deterministic elements, replications of simulations using identical inputs showed variation in results. Hence, hypothesis tests were possible, such as the evaluation of partial regression coefficients. We do not claim that this variation is of the same magnitude expected from replications of real production systems; however, it serves as a means to compare differences in simulated results. We chose to use a threshold of $P < .01$ for declaring differences significant.

Results and Discussion

Figures 1 through 3 present the independent effects of changes in each of the five traits on the three measures of system performance. The pattern of responses was quite similar among management systems and among breeds. Hence, to save space, we only present graphs for the RFR breed in 3M. These graphs illustrate the curvilinear nature of the responses discussed below as well as the relative importance of changes in each trait based on percentage changes in the means.

Regression Equations

Effects of linear, quadratic, and two-way interaction of percentage change of five genetic components (i.e., regressions) were examined as affecting biological effi-

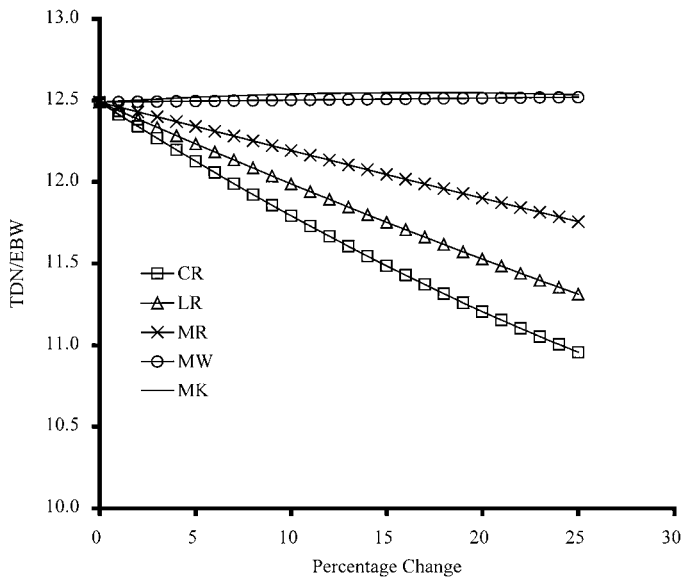


Figure 1. Responses in kg TDN/kg empty body weight sold (TDN/EBW) to independent changes in the means of conception rate (CR), lambing rate (LR), mortality rate (MR), mature weight (MW), milk production (MK) for the RFR breed in 3M. All traits were increased except mortality rate.

ciency and profit in four breeds managed in two mating systems. Regression equations for TDN/EBW, TDN/CLN, and GM/EWE are presented in Tables 1, 2, and 3, respectively. Regression coefficients represent average responses in efficiency and profit to 1% unit changes

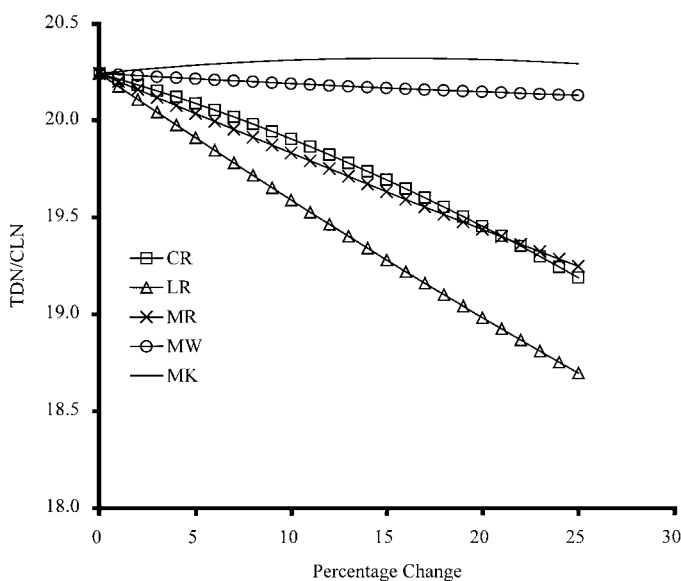


Figure 2. Responses in kg TDN/kg carcass lean sold (TDN/CLN) to independent changes in the means of conception rate (CR), lambing rate (LR), mortality rate (MR), mature weight (MW), milk production (MK) for the RFR breed in 3M. All traits were increased except mortality rate.

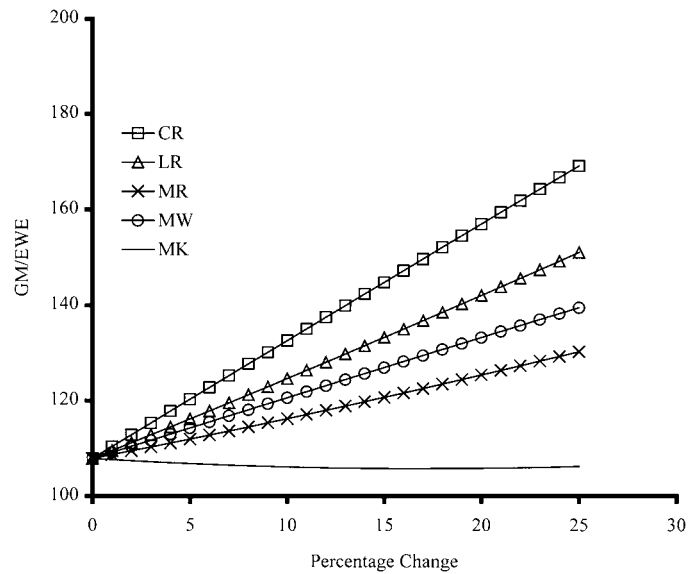


Figure 3. Responses in gross margin/ewe (GM/EWE, LE) to independent changes in the means of conception rate (CR), lambing rate (LR), mortality rate (MR), mature weight (MW), milk production (MK) for the RFR breed in 3M. All traits were increased except mortality rate.

in each trait. Coefficients of determination (R^2) were considerably lower for TDN/CLN than for TDN/EBW and GM/EWE due to the greater variability in fat stores in fat-tailed sheep. Because few interactions were important, linear and quadratic effects of individual traits will be discussed first.

Conception Rate. Of the five traits, CR had the largest effects on TDN/EBW. Linear and quadratic regressions of TDN/EBW on CR were significant ($P < .01$) and indicated that increased CR would improve TDN/EBW at a decreasing rate. Largest responses were for O and OFO, which have the lowest CR (.68 and .69). In general, responses in both mating systems were similar for different breed groups. Responses of TDN/CLN to the same genetic changes in CR were smaller than for TDN/EBW. Quadratic effects were significant for RFR in 3M and for O and R in 1M. Negative quadratic terms suggest that increased CR improved TDN/CLN at an increasing rate; however, these effects were small. In general, responses in feed conversion to increased CR for O and OFO were slightly greater than for R and RFR.

Increasing CR improved GM/EWE for all breed groups in both systems. Quadratic coefficients were negative for OFO ($P < .01$) in 3M, but they were not different from zero for other breeds and management systems. Although significant, curvilinear effects of CR on GM/EWE for OFO were very small.

Higher fertility increases system outputs, thus reducing unit cost of production by spreading fixed inputs over more output (Wang and Dickerson, 1991b). Higher CR allows more females to remain in the breeding herd longer. Hence, less energy is used to develop replace-

Table 1. Multiple regressions of TDN/EBW on five traits for four breeds in two management systems^a

Item	Three matings/2 yr				One mating/yr			
	O	OFO	R	RFR	O	OFO	R	RFR
Intercept	16.15342	14.59830	14.16139	12.48817	17.31252	15.48130	15.31334	12.93706
CR	-.13659*	-.11264*	-.09541*	-.07523*	-.12387*	-.11134*	-.09261*	-.07861*
LR	-.06949*	-.06895*	-.04853*	-.05202*	-.05277*	-.08105*	-.05230*	-.06562*
MR	.02595*	.03841*	.01857*	.02980*	.02032*	.02548*	.01589*	.02410*
MW	-.01219*	-.00517	-.00076	.00143	-.00743	-.01044*	-.00701	.00209
MK	-.01948*	-.01253*	-.00248	.00723*	-.01528*	-.01212*	-.00777	-.00214
CR × CR	.00140*	.00119*	.00084*	.00056*	.00105*	.00093*	.00077*	.00062*
LR × LR	.00028	.00030*	.00002	.00020	-.00034	.00021	-.00009	.00043*
MR × MR	.00006	.00034*	-.00008	.00002	-.00008	-.00019	-.00009	-.00002
MW × MW	.00017	.00015	-.00010	.00000	-.00008	.00024	-.00007	-.00007
MK × MK	.00017	.00016	-.00031*	-.00021	.00019	.00014	.00008	.00017
CR × LR	.00053*	.00054*	.00040*	.00037*	.00027	.00072*	.00030*	.00022*
CR × MR	-.00013	.00001	-.00007	-.00013	-.00019	-.00028	-.00006	-.00014
CR × MW	-.00003	-.00020	.00000	-.00009	.00007	.00012	.00004	-.00002
CR × MK	.00025	.00002	.00001	-.00008	.00012	.00013	-.00004	-.00005
LR × MR	.00015	.00006	-.00005	-.00002	.00028	-.00024	-.00004	-.00001
LR × MW	.00012	-.00007	-.00007	-.00007	-.00012	.00009	-.00010	-.00005
LR × MK	.00032*	.00010	.00037*	-.00010	.00002	.00007	.00017	-.00005
MR × MW	.00010	.00014	-.00003	-.00005	-.00005	.00003	.00005	-.00008
MR × MK	-.00014	-.00004	-.00003	.00008	.00002	-.00012	.00015	.00011
MW × MK	.00016	-.00011	.00006	-.00006	-.00006	-.00001	.00010	.00007
Model R ²	.96	.96	.95	.96	.93	.95	.93	.96

^aTDN/EBW = kg TDN per kg empty body weight sold, CR = conception rate, LR = lambing rate, MR = mortality rate, MW = mature weight, MK = milk production, * = coefficient different from zero ($P < .01$).

ment ewes, and fixed costs associated with replacements are reduced. Further, due to age of dam effects, average number born and weaned also increase. In practice, it is essential to identify infertile ewes as early as possible to reduce feed inputs for nonproducing ewes.

Lambing Rate. Increased LR improved both measures of system feed conversion in a generally linear manner ($P < .01$). Quadratic coefficients were positive ($P < .01$) for RFR in both management systems and for OFO in 3M (TDN/EWE only), suggesting decreasing marginal

Table 2. Multiple regressions of TDN/CLN on five traits for four breeds in two management systems^a

Item	Three matings/2 yr				One mating/yr			
	O	OFO	R	RFR	O	OFO	R	RFR
Intercept	24.62838	21.95316	23.94163	20.24335	25.79084	22.77315	25.40868	20.71474
CR	-.04538*	-.04942*	-.03981*	-.02848*	-.00906	-.03043*	-.02243*	-.03583*
LR	-.08194*	-.08060*	-.07469*	-.06798*	-.05683*	-.08551*	-.06346*	-.08177*
MR	.02992*	.05069*	.02544*	.04216*	.01974*	.02733*	.02198*	.02808*
MW	-.02320*	-.01828*	-.00653	-.00583	-.01469	-.01585*	-.01041	-.00620
MK	-.02212*	-.01990*	-.00001	.01002	-.01393	-.01705*	-.01117	-.00180
CR × CR	-.00011	.00017	-.00041	-.00055*	-.00088*	-.00049	-.00060*	-.00033
LR × LR	.00032	.00032	.00025	.00024	-.00035	.00011	-.00030	.00042*
MR × MR	.00005	.00051*	-.00008	.00009	-.00020	-.00025	-.00003	-.00013
MW × MW	.00035	.00044*	-.00002	.00005	-.00008	.00027	-.00007	-.00007
MK × MK	.00019	.00025	-.00049*	-.00032	.00004	.00032	.00026	.00019
CR × LR	-.00011	.00002	.00010	.00004	-.00046	.00000	-.00033	-.00030
CR × MR	.00011	.00024	.00012	.00009	-.00015	.00002	.00014	-.00004
CR × MW	.00001	-.00020	.00007	-.00004	.00019	.00009	-.00007	.00007
CR × MK	.00029	.00013	-.00011	-.00013	.00016	.00009	-.00020	-.00010
LR × MR	.00005	.00003	-.00008	-.00008	.00020	-.00026	.00005	.00003
LR × MW	.00031	.00007	.00004	.00005	-.00003	.00016	-.00027	.00013
LR × MK	.00053*	.00026	.00047*	-.00007	.00009	.00006	.00014	.00000
MR × MW	-.00008	-.00002	.00001	-.00027	-.00012	.00007	.00007	-.00022
MR × MK	-.00030	-.00024	-.00007	.00011	-.00004	-.00014	.00022	.00025
MW × MK	.00040	.00008	.00006	-.00002	.00010	-.00013	.00002	.00009
Model R ²	.80	.85	.82	.87	.67	.83	.76	.89

^aTDN/CLN = kg TDN per kg carcass lean sold, CR = conception rate, LR = lambing rate, MR = mortality rate, MW = mature weight, MK = milk production, * = coefficient different from zero ($P < .01$).

Table 3. Multiple regressions of GM/EWE on five traits for four breeds in two management systems^a

Item	Three matings/2 yr				One mating/yr			
	O	OFO	R	RFR	O	OFO	R	RFR
Intercept	37.40854	63.85465	66.97178	107.93929	33.50927	61.58807	61.90743	114.68757
CR	1.81390*	2.28808*	2.03912*	2.47556*	1.68165*	2.35329*	2.02075*	2.92380*
LR	1.01729*	1.41271*	1.06572*	1.62922*	.83438*	1.61412*	1.21513*	2.16775*
MR	-.33541*	-.73720*	-.34722*	-.78680*	-.26134*	-.47464*	-.24389*	-.76768*
MW	.90921*	1.06998*	.96357*	1.27018*	.77548*	1.14054*	1.02034*	1.26608*
MK	.26151*	.21847*	.03935	-.25298*	.24786*	.26101*	.11538	.08307
CR × CR	-.00327	-.00728*	-.00368	-.00094	.00104	.00043	.00011	-.00221
LR × LR	.00044	.00215	.00533*	.00397	.00892	.00874*	.00596*	-.00094
MR × MR	-.00032	-.00589*	.00251	.00430	.00102	.00560	.00417	.00188
MW × MW	-.00281	-.00297	.00326	-.00018	.00066	-.00580	.00227	.00138
MK × MK	-.00372	-.00452	.00689*	.00750*	-.00526*	-.00483	-.00054	-.00536
CR × LR	.01392*	.01783*	.01559*	.02269*	.01799*	.02313*	.02129*	.03989*
CR × MR	-.00588*	-.01566*	-.00852*	-.01404*	-.00415	-.00664*	-.00573*	-.01330*
CR × MW	.01833*	.02409*	.01958*	.02478*	.01606*	.01741*	.01957*	.02379*
CR × MK	.00051	.00287	.00434	.00135	.00140	.00140	.00397	.00086
LR × MR	-.00726*	-.01120*	-.00406	-.01357*	-.00809*	-.00533	-.00456	-.01384*
LR × MW	.00786*	.01499*	.01267*	.01769*	.01139*	.01368*	.01557*	.02156*
LR × MK	-.00242	-.00030	-.00763*	.00190	.00158	.00138	-.00269	.00175
MR × MW	-.00478*	-.00994*	-.00287	-.00815*	-.00170	-.00598	-.00526	-.00497
MR × MK	.00102	-.00102	.00011	-.00193	-.00068	.00180	-.00286	-.00209
MW × MK	-.00005	.00448	.00011	.00220	.00281	.00160	-.00066	-.00203
Model R ²	.98	.97	.98	.98	.97	.97	.97	.98

^aGM/EWE = gross margin per ewe in Egyptian pounds (LE; U.S. \$ = LE × 3.39), CR = conception rate, LR = lambing rate, MR = mortality rate, MW = mature weight, MK = milk production, * = coefficient different from zero ($P < .01$).

returns in this system, yet these effects were very small. Quadratic terms were not different from zero for other systems. Relative to CR, LR was more important for TDN/CLN than for TDN/EBW, apparently because twin-born lambs were leaner than single-born lambs.

Higher LR also improved GM/EWE in all systems. Quadratic terms were positive and significant for R in 3M and for O, OFO, and R in 1M, suggesting that improving LR would be especially rewarding in these systems.

Nitter (1986) reported that economic weights per .1 lambs born in German Merinos were high as long as average litter size did not exceed 1.5 but dropped dramatically when the average surpassed 2.1. In general, an increase in litter size is accompanied by a decrease in birth weight and lamb survival. Lower birth weight is associated with slower lamb growth and increased feed costs. Dickerson (1976) stated that increasing number of progeny reared per female decreases breeding female costs per offspring at a decreasing rate, except as it increases female feed costs above maintenance for gestation and lactation.

Mortality Rate. Reducing MR improved TDN/EBW and TDN/CLN in all systems (linear, $P < .01$). Responses were greater in 3M than in 1M, probably because MR is expressed more frequently in 3M. Linear coefficients were larger for the composite breeds than for native breeds, possibly because base MR was greater in the composites. Mean MR for O, R, OFO, and RFR was 14, 14, 20, and 22%, respectively. Quadratic coefficients were small and only significant for OFO, indicating diminishing marginal returns.

Reductions in MR increased GM/EWE in all systems. Negative quadratic terms were significant for OFO in both 1M and 3M, indicating that profits improved at a slightly declining rate as MR declined in these systems.

Mature Weight. Increasing the genetic component of this trait did not have clear effects on system feed conversion. Desirable but small linear responses in TDN/EBW were found for O in 3M and OFO in 1M. For TDN/CLN, linear coefficients were significant for O and OFO in 3M and OFO in 1M. Curvilinear effects were detected only for OFO in 3M.

Mature weight had more important effects on profit. Increased MW improved GM/EWE in all systems (linear, $P < .01$). Quadratic coefficients for MW were not different from zero.

These results identify incentives to increase MW, especially for the smallest breeds in this study. In the model, MW affected growth rate throughout the life-cycle. Sanders (1974) reported that calves characterized by high growth rate attain slaughter weight sooner and have improved feed conversion. Dickerson (1970) came to the same conclusion and added that higher growth rate subsequently reduces lamb production costs and improves the biological efficiency of ewes.

Milk Production. System responses to increased MK tended to be smallest among the five traits and followed a pattern similar to that for MW. Linear improvements in TDN/EBW were detected for O, OFO, and RFR in 3M and for O and OFO in 1M. For TDN/CLN, increasing MK improved O and OFO in 3M and OFO in 1M. Small, desirable quadratic effects were found for R in 1M for both TDN/EBW and TDN/CLN.

Increased MK improved GM/EWE for O and OFO in both 3M and 1M but decreased GM/EWE for RFR in 3M. Mean milk levels for O and OFO were lower (4.78 and 5.50 kg/wk), than for R and RFR (6.95 and 7.00 kg/wk), which helps explain these results. Overall, in the systems studied MK had very small effects on profit. The observed responses were generally curvilinear and suggested optimum levels of milk yield near current levels.

Interactions. Few interactions were detected for system feed conversion, and those found were small in magnitude. Due to the stochastic nature of the simulations, we interpret some of these interactions to be due to sampling. The one more consistent interaction was between CR and LR for TDN/EBW. In all systems, improvements in TDN/EBW or TDN/CLN due to increased CR were smaller at higher LR. Wang and Dickerson (1991c) also found that improving fertility (i.e., CR) was less important for efficiency when LR was high.

The LR \times MK interaction was significant for O and R for both TDN/EBW and TDN/CLN in 3M but not 1M. Improvement in efficiency due to increased LR was reduced at higher levels of MK. Milk levels for O and R were lower than for other breeds; hence, increasing MK may have improved weaning rate at higher levels of LR. Although not different from zero, coefficients for LR \times LR were positive for these breeds in 3M, which may suggest that, for O and R, increasing both MK and LR served to increase the rate of change in weight output due to increased number weaned. These results suggest decreased marginal improvements in feed conversion with increased output.

For GM/EWE, interactions involving CR, LR, MR, and MW were generally significant. Signs on the coefficients all indicated complementarity among these traits. Because CR, LR, and MR are all rates, and because outputs are largely determined by the products of these traits, changes in these parameters have multiplicative rather than additive effects on performance. Our results suggest that the effects of these changes on revenue are greater than their effects on expenses.

Relative Economic Weights

Because profit is ultimately more important to producers than biological efficiency, it is a more justifiable measure of system performance upon which to develop breeding plans than some measure of biological efficiency. Hence, we present economic weights only for GM/EWE. Other authors support this view (e.g., Ponzoni and Davis, 1989; Harris and Newman, 1994; Tess, 1995; Hirooka and Groen, 1999), although an argument has been made for using biological measures of performance alone (e.g., Fowler et al., 1976; Land, 1981; Finlayson et al., 1995). Harris and Newman (1994) discuss these issues in more detail.

Results presented in Tables 1, 2, and 3 can be used to develop selection indexes or can be used as weighting factors for estimated breeding values (or EPD). We il-

lustrate this for GM/EWE in Table 4. First derivatives of the regression equations in Tables 1 through 3 with respect to each trait represent the relative economic weights for each trait at the mean (or base) level of performance for each breed. Because the regression equations were computed based on percentage changes in the means, the first derivatives for each trait are equal to the linear partial regression coefficients for the trait. To be used, these relative weights need to be expressed in the units of measurement for each trait. This can be accomplished by dividing the first derivatives by the mean for the respective trait.

Table 4 shows the relative economic weights for each trait when system performance is measured as GM/EWE. Following Dickerson (1982) and Tess et al. (1983b), relative economic weights were multiplied by their corresponding genetic standard deviations ($\beta_i\sigma_G$) to account for differences in variation among traits. To facilitate comparisons across breeds and systems, these values are presented as ratios to the product for MW in Table 4. Mature weight was chosen as the basis for comparison because relative economic weights for MW were most similar across breeds and systems.

To compare traits for their relative importance in selection indices, some authors have also presented the product of economic weight, heritability, and phenotypic standard deviation ($\beta_i h^2 \sigma_P$) (e.g., Smith et al., 1983; Tess et al., 1983b). Note that this value can be easily calculated from Table 4 by multiplying $\beta_i\sigma_G$ by the square root of heritability. We think it more likely that breeders will compute estimates of breeding values using BLUP techniques (i.e., exploiting information from all relatives and correlated traits) rather than compute selection index scores from phenotypes. Hence, in our judgment, the product of economic weight and genetic standard deviation ($\beta_i\sigma_G$) is more useful.

Results presented in Table 4 show that improvement in CR is more important in R and RFR than in O and OFO. For RFR, CR is more important in 1M than in 3M systems. Similarly, LR should receive relatively more emphasis in R and RFR than in O and OFO, especially in 1M. Mortality rate tended to be more important in 3M than in 1M. Milk production was the least important of the five traits in all systems. Low heritabilities for CR, LR, and MR reduce their net contributions to selection programs.

Overall, economic weights for O and OFO were similar, as were weights for R and RFR. This is not surprising based on the genetic similarities of these breeds. Smith et al. (1983) found that economic weights developed for different management systems were often similar and that rather large changes in economic weights were needed to lead to important differences in genetic responses to index selection. In view of the results of Smith et al. (1983), differences in economic weights between management systems for the same breed found in this study do not seem large enough to justify separate selection lines within breeds.

Table 4. Relative economic weights of five traits for four breeds in two management systems^a

Trait	σ_P	h^2	β_1 in 3M	$\beta_1\sigma_G$ in 3M	β_1 in 1M	$\beta_1\sigma_G$ in 1M
Ossimi						
Conception rate	.387	.01	2.668	231	2.473	251
Lambing rate	1.249	.03	.834	404	.684	388
Mortality rate	.316	.02	-2.396	-240	-1.867	-219
Mature weight, kg	4.295	.24	.021	100	.018	100
Milk production, kg	.894	.15	.055	42	.052	47
OFO						
Conception rate	.387	.01	3.316	278	3.411	268
Lambing rate	1.249	.03	.942	441	1.076	473
Mortality rate	.316	.02	-3.686	-357	-2.373	-215
Mature weight, kg	4.295	.24	.022	100	.023	100
Milk production, kg	.894	.15	.040	30	.047	33
Rahmani						
Conception rate	.400	.03	2.832	560	2.807	524
Lambing rate	1.158	.09	.814	807	.928	869
Mortality rate	.548	.02	-2.480	-549	-1.742	-364
Mature weight, kg	3.370	.26	.020	100	.022	100
Milk production, kg	.894	.15	.006	6	.017	15
RFR						
Conception rate	.400	.03	3.391	533	4.005	637
Lambing rate	1.158	.09	1.058	841	1.408	1123
Mortality rate	.548	.02	-3.576	-634	-3.489	-621
Mature weight, kg	3.370	.26	.025	100	.025	100
Milk production, kg	.894	.15	-.004	-3	.012	9

^aRahmani and Ossimi are native breeds, OFO is a composite based on $\frac{3}{4}$ Ossimi and $\frac{1}{4}$ Finn, and RFR is a composite based on $\frac{3}{4}$ Rahmani and $\frac{1}{4}$ Finn. Management systems were three matings every 2 yr (3M) and one mating per year (1M). σ_P = phenotypic standard deviation, β_1 = partial regression of gross margin per ewe on the 1th trait in actual units of for each trait, $\beta_1\sigma_G$ = product of β_1 and genetic standard deviation expressed as a ratio to this product for mature weight. Estimates of σ_P and h^2 were taken from Aboul-Naga et al. (1988), Metawi (1991), Shaat (1995), Pollott et al. (1998), and Almahdy (unpublished data).

In this study, discounting procedures were not used to adjust contributions to system performance by different traits for differences in frequency and timing of expression. Several authors have reported that discounting had negligible effects on relative economic weights (Ponzoni, 1986; Newman et al., 1992; MacNeil and Newman, 1994; Hirooka and Groen, 1999).

Implications

In Egypt, most commercial sheep are raised in very small flocks in low-input systems. Genetic improvement is largely accomplished through government-owned flocks, with progeny from these flocks distributed to producers. Our results establish breeding objectives for native and composite breeds currently in feeding and management systems used in Egypt. Recording schemes to facilitate the computation of estimated breeding values for growth rate, lambing rate, conception rate, and lamb survival are needed. Development of specialized lines within breeds selected for performance in accelerated vs traditional lambing systems is not warranted.

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