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SIMULATION STUDY OF FLOCK DYNAMICS: APPLICATION TO INTENSIVE PRODUCTION SYSTEM OF EGYPTIAN BARKI SHEEP

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ABSTRACT

A dynamic flock simulator model (DFM) is presented. This model studies the complexity reproduction management systems of three lambings in two years system. Two types of data were used to build the simulator model. Ewe data (concerned 13725 records for 3120 Barki ewes from 1970 to 2000) from Barki flock management database of the Maryuot Research Station, Desert Research Center, Ministry of Agriculture, Egypt. References, on three lambing in two years management practices, were implemented by researcher to ensure the generality of the model structure. The simulator model was based on some set of specifications. The flock was divided into two batches. Data were analyzed to estimate the biological responses that are necessary for setting the model parameters. Also, input/output data were economicly analyzed at each phase corresponded to the characterization of the each batch flock, which is the set of all the ewes used for reproduction, replaced system. The result shows that, The batch production cycle (BPC) was the basic management entity for the dynamic flock model (DFM) structure. The relation between biological responses and ewe productive trajectory was the basic unit of the studied DFM performance and evolution. The average gross output of lambs, wool, manure and culling animals per production cycle was 150450 LE, 1581 LE, 12635 LE and 53813 LE, respectively. This result shows that lambs, wool, manure and culling animals contributed 69%, 1%, 6% and 24% of total gross output, respectively. It could be concluded that, this is a very simple DFM and clearly could be much improved if more detailed information on the inputs relating to reproductive and productive performances were available. Consequently, the model could be expected to produce very different outputs for different mating seasons over a range of environments. In this model, a mating program was used with a ewe batch being joined at regular 4-monthly intervals. However, modification of the system to permit shorter or longer intervals between matings may be warranted and the model is capable of indicating the effect on output of such changes. Also, the DFM is promising economic rewording.

Keywords: Sheep, flock dynamics, simulation and intensive production system

INTRODUCTION

Barki sheep production system in North Western Coastal Zone (NWCZ) in Egypt is particularly extensive to the combination of production, reproduction and sales distribution differences (Aboul Naga *et al.*, 1985). The intensification allows accelerated lambing patterns such as the STAR system, where ewes can have five lambings in three years (Cournut and Dedieu, 2004). The intensive Barki sheep systems were not evaluated practically in Egypt. Yet, early in the 90's there was some degree of Barki production intensification that could have been observed along the Cairo Alexandria

Desert road. This intensive system ranged from one lambing per year to three lambing in two years. Moreover, demand on fattening Barki lambs for export increased in recent years. Therefore, the intensive management system could be a great assist to take a significant role in national income.

The evaluation of new flock management decisions may be caried out through a simulation of dynamic flock model over a long time period.

Simulation of a dynamic flock model focuses on the management and replacement of a flock (i.e., females used for reproduction). This dynamic model is based on stochastic models (Texeira and Paruelo, 2006), that require the formulization of input data, decisions and biotechnical aspects. The degree of formulization of each sub-system can be rather variable. The decisional sub-model is often reduced to a set of rules without the decision process being formulized (Kristensen and Pedersen, 2003).

In this paper a flock dynamic simulator model is presented based on the available data of Barki flock of the Desert Research Center in Masrout Experimental Research Station. The practical aim of this simulator model was to study the complex reproduction management systems of three lambings in two years system (3-in-2) and its relation to the production of the flock. In addition it produces knowledge on the flock dynamic model, its functioning and its regulation properties considering the complex interactions between flock management decisions and the animal responses.

MATERIALS AND METHODS

1. Flock management assumptions and data

A simulate flock is divided into two batches (B1 and B2). Three reproduction sessions are organized yearly; each session concerns one of the two batches. In a given year, a batch is mated in January and September, the other in May and vice versa in the next years. The ewes are synchronized at each period and the dose of PMSG is adjusted according to the season. After two months of mating, an ultrasonic pregnancy detection device is used to identify the non-pregnant ewes. A period of 35 days was elapsed for every mating in the whole flock. During this period, synchronised ewes in the batch can be mated, as well as the non-pregnant ewes of the other batch (repeated mating). Suckling lasts for two months. At each production period, ewe lambs are mated for first time at 12 month old depending on live body weight (at least 30 kg). At the end of a lambing session, the non-lambing ewes change batch. Ewes with health problems (e.g., mastitis, and non-milking teats) were culled from the two batches. Voluntary ewes culling is based on maximum age is 7 years (Ibrahim, 2005) and culling rams is based on maximum 2 mating with 4 years as average age.

Two types of data were used to build the simulator model. Ewe data from Barki flock management data base, which follow one lambing per year system, of Maryuot Research Station, Desert Research Center, Ministry of Agriculture, Egypt. For each female in reproduction, the data available is relative to its productive life: date of birth, date and cause of disappearance (culling, slaughter or death), succession of production events (lambing or abortion, number of lambs born and mortality). Data included 13725 records for 3120 Barki ewes from 1970 to 2000. References, on three lambing in two years management practices, were implemented by researcher to ensure the generality of the model structure. Ewe longevity was identified in the Barki management database and eliminated from the model. Towing was ranged from 1.02 to 1.05, conception rate was 90%, 70% and 80% in September, January and May, respectively and lambing rate of 80%. Lamb mortality rate was 5-7% up to weaning and adult annual mortality rate was 3% (Mokhtar, *et al.*, 1983, Mokhtar, *et al.*, 1991, Ahmed, *et al.*, 1992, Galal *et al.*, 1993).

2. Simulator model

The simulator model was based on the following set of assumptions:

1. Production should be expressed as the number of live-born lambs per calendar fortnight.
2. Regular reproduction and replacement management systems of complex 3-in-2 system (e.g., lifetime or last lambing results, age at culling, date and duration of mating).
3. Female and male lambs were sold at weaning (3 months of age).
4. Labor and feed were proportional to number of animals.
5. The input data of the simulator model were assumed to be deterministic according to Wang and Dickerson (1991) and Blackburn and Cartwright (1987).
6. Reproduction and mortality rates were assumed to be stochastically and calculated according to Almahdy *et al.* (2000).

3. Simulation model analysis

General Algebra Modeling System (GAMS, 2000) software was used to analyze the input/output data. A procedure of simulator model analysis was used. The analysis phase corresponded to the characterization of each batch flock, which is the set of all the ewes used for reproduction, replaced system. The run of the DFM used different sequences of random numbers. One thousand runs of the random number generators to simulate the stochastic elements were done, it will necessarily produce different results each time that it is run with a changed sequence of random numbers. While, the means are not significantly different between these runs. In the majority of runs made, the average output was used. Also, SAS (1998) was used for statistical analysis depending on the basis of the available data, in order to estimate the biological responses that are necessary for setting the model parameters.

3. Economic analysis

Economic analysis was carried out using Egyptian pound (LE) according to the following equations:

Variable cost = feeding cost + labor cost

Feeding cost = feeding price/ head/ day (one LE) * No. of ewes of each batch * 240 days (8 months).

Labor cost = labor salary per day (15 LE) * 4 labor for each batch * 240 days (8 months).

Gross output = return of (weaned lambs + wool + manure + culling animals).

Gross margin = gross output – variable cost.

Economic analysis did not include replacement rams due to equal prices between culling rams with replacement rams. The input data and its official prices in LE (1 USD = 5.75 LE) were present in Table 1. These prices were obtained from the official Desert Research Center price list of animal and poultry products at 2006.

Table 1. Input data and its prices in LE (farm gate prices at 2006).

Item	Unit	Average production (head)	Prices/ unit/LE
Weaning lambs	Kg.	20 (Alsheikh, 2005)	30
Culled ewes	Kg.	35 (data of DRC flock)	15
Grease fleece weight	Kg.	2.5 (Galal, *et al.*, 2002)	2.5
Manure / head / year	m^3	3 (Younis, 1998)	20

RESULTS AND DISCUSSION

1. Characterization of dynamic flock model (DFM) of batch production cycle (BPC)

A conceptual of dynamic flock model (DFM) of batch production cycle (BPC) is shown in diagram (1) with the time scale attached. The model covers a 4 year period (4 production cycles of three lambing in two years). The model was designed with 4 months as a time lag between the 2 batches. This means that the program was run over 4 years plus 4 months. The BPC is the basic management entity for the DFM structure. It is linked to two functional bases that are the animal collectives (batches and ewe lamb stocks). A BPC is defined as the aggregation of ewe production cycles around the same reproduction period, organized by the dynamic model at the level of a batch with a view to obtain a lambing session. It corresponds to a combination of events linked to the management and biological processes that are characterized in relation to the production objective associated with it. It starts with the constitution of the mating batch and the introduction of the rams and ends when all the ewes are dry. The model output refers to that successive linkage within the BPC of a same batch when occurred (how to ensure that the ewes lamb approximately every 8 months). This will be translated into the computer dynamic model by the allocation of a particular linkage of BPC to each batch and the definition of deadline dates for the end of drying off (in the 3-in-2, to keep a minimum rest time and apply the sponges to dry ewes). In 3-in-2 management system, the model limiting defined by the length of the unproductive period of ewes that failed at mating, involves entering these in the following BPC, which concerns the other batch (via repeated mating and/or changes of batch when infertility is noted). The dynamic model depended on characterizing and meaning of reproduction and production cycle within each batch and between the two batches (i.e. replaced set of animals, introduction and disappearance of ewe lambs).

The relation between biological responses and ewe productive trajectory was the basic unit of the studied DFM performance and evolution.

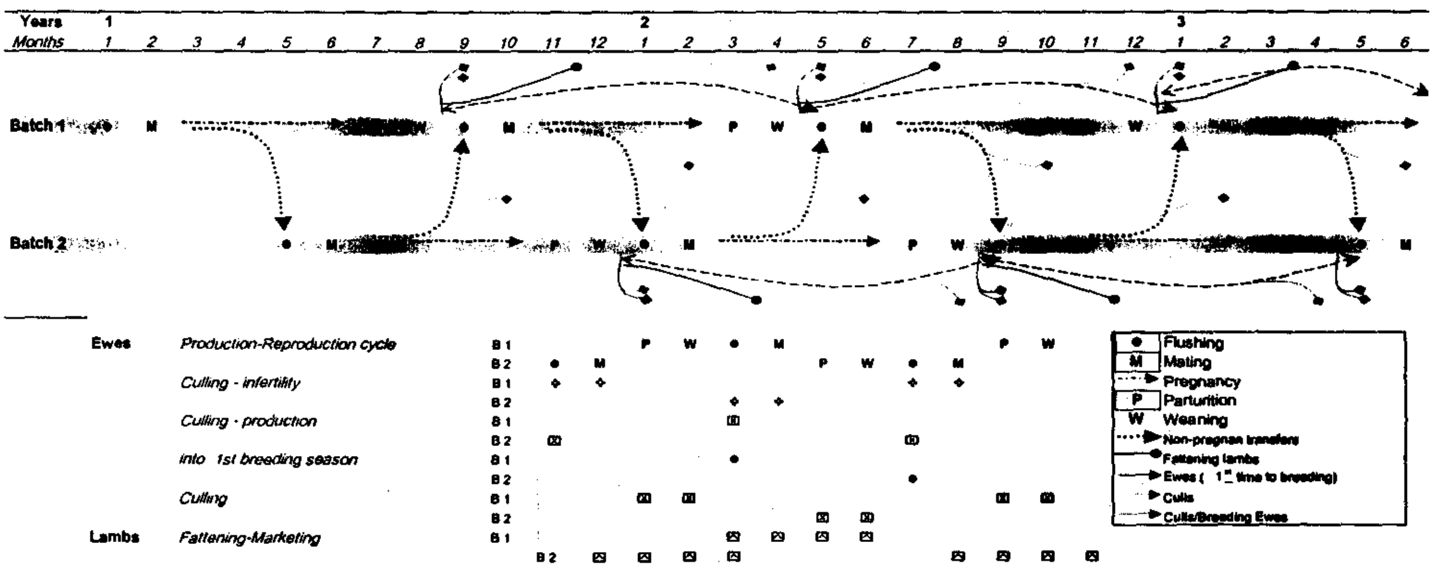

Diagram 1. Conceptual dynamic flock model of batch production cycles.

The ability of a ewe to react to stimuli induced by management referred to biological response, in addition to its calculations as a random factor plus the other components of the model i.e. environment factors, (e.g., types of feed resources, movements and season) as a fixed factor. This DFM was dependent on four biological response variables. The 1st was the fertility, which is defined as the ability of ewe to be fertilized during a mating session. The 2nd was lambing, which is defined as the fecundation date and thus the lambing date. The 3rd was the number of lambs born. The 4th was longevity, which is defined as the ability of ewe productive and not to be culled for involuntary reasons, health problems or death. All of fertility, lambing, number of lambs born and longevity factors depend on defining all related affecting factors of ewes (i.e., mating season and parity). The ewe trajectory was designed according to the succession of production events of the ewe and the path followed by this ewe through successive batch production cycles. The output of the studied model shows that, the management information and biological responses were the main components of the DFM. The general approach adopted for each of these components was to identify the random variables brought into the model run and to study the factors affecting these variables whether they are associated with the animal or with the environment, combining these over time.

2. DFM output solution

The model was operated to simulate the system over a 4 cycle period. The output solution from the model is shown in table (2). This table shows the fluctuations in the sizes of the two batches B1 and B2. that take place as ewes are transferred back and forth, together with information on the lambing statistics. Ewes have been removed from any of the two batches on their date of death. Fluctuations that can take place in the total number of lambs sold over the 4 year of study as the time of first mating is changed. A second type of output shows the percentage of ewes in each lambing frequency over a different three mating seasons for all ewes in the model that survived the full 4 years run. The output solution of the model has been found to be remarkably stable system over the 4 studies years. Minimum levels of production are approximately 5 % below maximum level. This is so despite the fact that detailed results for separate lamb crops show variation with changes of mating season. The number of lambs weaned also shows little variation between different mating seasons.

Ewes mating at different seasons fed on irrigated pasture or special supplementary feeding to achieve satisfactory market lambs weights at 60 days of age. No attempt has been made in the model to calculate additional feed costs to promote uniform growth rates nor to calculate the net value of lambs produced in this FDM system. The return value of lamb crops does not, however, take into account seasonal fluctuations in lamb prices, which reflect normal supply and demand factors operative in North Western Coastal Zone environment.

Table 2. Output solution of flock dynamic model.

Batch	Mating season	Crop	Number of. ewes mated	Ewes lambing	Ewes barren	Lambs born	lambs weaned	Replacement Rate of yearling ewes
			1st cycle of the two studied batches					
B1	Sept.	1	100	90	10	92	83	0 out - 0 in
B2	Jan.	2	110	77	33	80	72	0 out - 0 in
B1	May	3	123	106	17	110	103	0 out - 0 in
Total							258	
			2nd cycle of the two studied batches					
B2	Sept.	4	94	85	9	89	85	0 out- 0 in
B1	Jan.	5	125	88	37	89	85	10 out-20 in
B2	May	6	132	106	31	104	99	10 out-20 in
Total							269	
			3rd cycle of the two studied batches					
B1	Sept.	7	134	121	13	126	120	20 out - 35 in
B2	Jan.	8	134	94	40	96	91	20 out - 35 in
B1	May	9	176	141	35	148	141	20 out - 35 in
Total							352	
			4th cycle of the two studied batches					
B2	Sept.	10	149	134	15	140	133	30 out - 50 in
B1	Jan	11	176	123	53	130	124	30 out - 50 in
B2	May	12	207	166	41	171	162	30 out - 50 in
Total							419	
Total of 12 crops							1298	
Average per year							162	

3. Economic return

The economic return of four cycles of the three lambings in two years is presented in table (3). Results show the optimal output solution of DFM. The four cycles gave different gross output, which led to different gross margin. The model solution showed that differences of gross output of number of lambs sold ranged between 33600 LE to 67200 LE per mating season. The average gross output of lambs, wool, manure and culling animals per cycle was 150450 LE, 1581 LE, 12635 LE and 53813 LE, respectively. This result shows that lambs, wool, manure and culling animals contributed 69%, 1%, 6% and 24% of total gross output, respectively. In addition, the result shows that gross margin of the 2nd cycle was less than the gross margin in all other cycles. Also, the gross margin in first cycle was higher than the next two cycles. These results could be obtained due to appalling the replacement strategy.

Table 3. Economic rewording for four repeated cycles of three lambings in two years.

Batch	Mating season	Batch size	Variable Cost (LE)		Gross output (LE)				Gross Margin (LE)
			Feeding	Labor	Weaned lambs	Wool	Manure	Culling ewes	
B1	Sept.	100	24000	14400	49800	625	6000	--	
B2	Jan.	110	26400	14400	43200	625	6000	--	
B1	May	123	29520	14400	61800	--	--	--	
Total / cycle (LE)			123120			168500			45380
B2	Sept.	94	22560	14400	51000	588	4230	--	
B1	Jan.	125	30000	14400	39000	781	5625	5250	
B2	May	132	31680	14400	47400	--	--	5250	
Total / cycle (LE)			127440			159124			31724
B1	Sept.	134	32160	14400	51000	838	6030	10500	
B2	Jan.	134	32160	14400	33600	838	6030	10500	
B1	May	176	42240	14400	63600	--	--	10500	
Total / cycle (LE)			149760			193436			43676
B2	Sept.	149	35760	14400	49800	931	6705	15750	
B1	Jan.	176	42240	14400	44400	1100	7920	15750	
B2	May	207	49680	14400	67200	--	--	15750	
Total / cycle (LE)			170880			225306			54426

CONCLUSION

This is a very simple DFM and clearly could be much improved if more detailed information were available on the inputs relating to reproductive and productive performances. Consequently, the model could be expected to produce very different outputs for different mating seasons over a range of environments. In this model a mating program was used with a ewe batch being joined at regular 4-monthly intervals. However, modification of the system to permit shorter or longer intervals between matings may be warranted and the model is capable of indicating the effect on output of such changes. Also, the DFM is promising economic rewording.

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دراسة محاكاة لديناميكية القطيع : تطبيقا لنظام الإنتاج المكثف في لأغنام البرقي المصرية

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تم عرض نموذج محاكاة ديناميكية للقطيع. يهدف هذا النموذج إلى دراسة العلاقات المعقدة لنظام الثلاث ولادات في سنتين. تم استخدم نوعين من البيانات لبناء نموذج المحاكاة. النوع الأول، بيانات النعاج (تم استخدام ١٣٧٢٥ سجل لعدد ٣١٢٠ نعجة برقي من عام ١٩٧٠ إلى عام ٢٠٠٠) من قاعدة بيانات قطيع البرقي المربى في محطة بحوث مريوط التابعة لمركز بحوث الصحراء، وزارة الزراعة، مصر. النوع الثاني، الأبحاث التي أجريت على نظام الثلاث ولادات في سنتين. وقد تم محاكاة هذا النموذج استنادا إلى مجموعة من الافتراضات المنطقية. وقد تم تقسيم القطيع إلى مجموعتين. وتم تحليل البيانات لتقدير الاستجابات البيولوجية التي تعتبر ضرورية لتحديد معالم النموذج. كما تم تحليل مدخلات ومخرجات النظام اقتصاديا لكل مجموعة على حدي.

أظهرت النتائج أن دورة إنتاج كل مجموعة كانت أساسية لدراسة ديناميكية نموذج قطيع. وقد وجد أن العلاقة بين الاستجابات البيولوجية و إنتاجية النعاج هي الوحدة الأساسية في بناء نموذج محاكاة ديناميكية القطيع. كان متوسط إجمالي العائد الكلى من الحملان، الصوف فى دورة الإنتاج ، السماد، الحيوانات المستبعدة هو ١٥٠٤٥٠ جنيه ، ١٥٨١ جنيه ، ١٢٦٣٥ جنيه و ٥٣٨١٣ جنية على الترتيب. بنسبة ٦٩ % و ١ % و ٦ % و ٢٤ %من إجمالي العائد الكلى لكل من الحملان، الصوف، السماد، الحيوانات المستبعدة على الترتيب .

ويمكن استنتاج أن، هذا النموذج بسيط ويوضح نموذج محاكاة ديناميكية القطيع ويمكن أن يتحسن كثيرا إذا توفرت معلومات في المدخلات أكثر تفصيلا عن الأداء المتعلقة بالتناسل والإنتاج. بالإضافة إلى ذلك فان هذا النموذج صمم على أساس فترة مدتها ٤ شهور بين موسمي التلقيح في المجموعتين محل الدراسة. و أي تغير في هذه المدة قد يؤدى إلى نتائج مختلفة. ولكن تعديل النظام لفترات اقصر أو أطول من ٤ شهور بين مواسم التلقيح بين المجموعتين قد يكون له ما يبرره ، وهذا النموذج قادر على توضيح الأثر الناتج عن هذه التغيرات. يعتبر هذا النموذج أيضا ذو عائد اقتصادي واعد.