

EXPERT SYSTEM FOR CULLING MANAGEMENT OF BEEF COWS

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Story in Brief

A prototypical expert system was developed to recommend whether to keep or cull commercial beef cows. A reproduction specialist was interviewed and 20 rules reflecting his knowledge were programmed in an expert system knowledge base. The program is interactive, querying the user for information about each cow, making a decision, and responding with its recommendation. Evaluation revealed close correspondence between the expert's and the system's decisions.

(Key Words: Artificial Intelligence, Reproductive Management)

Introduction

Expert systems are computer programs which emulate the reasoning process of human experts in a particular area. These tools have been shown to be effective decision makers for problems which require heuristic knowledge, a set of rules derived through experience. Thus, they are also called knowledge-based systems. An expert system bears many similarities to a human expert. It has a reasoning procedure for attacking a problem and arriving at a decision. It has a base of experience, or rules—many of which are rules of thumb, by which it arrives at a decision. An expert system has the advantage of potentially containing the expertise of many of the world's greatest experts; however, it is tireless, does not become ill or take vacations. Expert systems will replace many of the other kinds of decision-aid software, because of their basic user-friendliness and their greater utility in situations where only incomplete data are available (Holt, 1985).

The integration of expert systems tools with traditional systems analysis (optimization and simulation modeling) is a relatively new and unexplored area of animal science. The potential is particularly great for agricultural extension, where the equivalent of an expert's knowledge is needed for typical day-to-day problem solving and decision making. Ultimately expert systems may allow local extension agents with a microcomputer utilize the knowledge of an expert in each of the diverse fields for which he/she has responsibility. Therefore, its application is appropriate for reproduction management in beef cow herds.

Materials and Methods

A prototypical expert system was developed to recommend whether to keep or cull commercial beef cows. A reproduction specialist was interviewed by a knowledge engineer who programmed the expert system in

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LISP using Texas Instruments Personal Consultant software. The knowledge base was arranged as 20 rules reflecting the expert's knowledge. The following is a list of the knowledge base.

- Rule 1. If the cow's age is greater than 10, then the cow should be culled.
- Rule 2. If the cow's condition score is less than 3, and the cow is not pregnant, then the cow should be culled.
- Rule 3. If the cow's age is greater than 8, and her performance ratio is less than 1, then the cow should be culled.
- Rule 4. If the cow's performance ratio is not known, then the cow's performance ratio is her calves' average weaning weight divided by herd average weaning weight.
- Rule 5. If the cow is pregnant, and her udder is less than 3/4 functional, then the cow should be culled.
- Rule 6. If the cow's eye damage is extreme, then the cow should be culled.
- Rule 7. If the cow has had a C-section, then the cow should be culled.
- Rule 8. If the cow's calving difficulty score is greater than 2, and she is pregnant, and she has had 4 or more calves, then the cow should be culled.
- Rule 9. If the cow has structural problems, then the cow should be culled.
- Rule 10. If the cow is not pregnant, and her age is greater than 8, then the cow should be culled.
- Rule 11. If the cow is not pregnant, and she has missed one or more calves, then the cow should be culled.
- Rule 12. If the cow is not pregnant, and her condition score is less than or equal to 3, then the cow should be culled.
- Rule 13. If the cow is not pregnant, and her calving difficulty score is more than 1.5, and she has had 4 or more calves, then the cow should be culled.
- Rule 14. If the cow is not pregnant, and her eye damage is at least slight, then the cow should be culled.
- Rule 15. If the cow is not pregnant, and her udder is less than fully functional, then the cow should be culled.
- Rule 16. If it is not known whether to cull the cow, then the cow should not be culled.
- Rule 17. If the cow's age is 5, and her performance ratio is less than .80, then the cow should be culled.
- Rule 18. If the cow's age is 6, and her performance ratio is less than .85, then the cow should be culled.
- Rule 19. If the cow's age is 7, and her performance ratio is less than .90, then the cow should be culled.
- Rule 20. If the cow's age is 8, and her performance ratio is less than .95, then the cow should be culled.

The program is interactive, querying the user to input information about each cow in question; allowance is made for uncertain responses. When enough information is collected for a decision to be made the program reports its recommendation.

Results and Discussion

Examples of two interactive sessions with the expert system are shown in tables 1, 2 and 3. The five year-old cow in the first example and the seven year-old in the third have the necessary traits to be kept

Table 1. Example interactive session using the culling expert system.

Expert System	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	5
Has this cow ever had a C-section?	NO
Which of these condition scores is this cow? 2 3 4 5 6 7 8 9	5
Is this cow pregnant?	YES
How many functional quarters does this cow have?	4
How much damage does this cow have to her eyes? NONE SLIGHT EXTREME	SLIGHT
What is the average calving difficulty of this cow using the 1-5 scale?	1.4
Does this cow have any structural problems?	NO
Enter the average weaning weight of this cows calves.	475
What is the average calf weaning weight for your herd?	515
This cow should be kept in the herd. This cow should not be culled.	

Table 2. Example interactive session using the culling expert system.

Expert System	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	4
Has this cow ever had a C-section?	NO
Which of these condition scores is this cow? 2 3 4 5 6 7 8 9	3
Is this cow pregnant?	NO
This cow's poor body condition is most likely why she is open. The cost of bringing her to a higher condition so that she will cycle would be prohibitively high so she should be culled.	

in the commercial cow herd, although one is pregnant and one is not. In contrast, the four year-old in table 2, which also is not pregnant, is suggested to be culled. The expert system recommended culling for this cow because of her poor condition (rule 12). It can be seen that the order in which the consultation occurs is influenced by the backward-chaining reasoning process which the expert system employs. Thus, in

Table 3. Example interactive session using the culling expert system.

Expert System	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	7
Has this cow ever had a C-section?	NO
Which of these condition scores is this cow? 2 3 4 5 6 7 8 9	6
Is this cow pregnant?	NO
How many functional quarters does this cow have?	4
How much damage does this cow have to her eyes? NONE SLIGHT EXTREME	NONE
What is the average calving difficulty of this cow using the 1-5 scale?	1.1
Does this cow have any structural problems?	NO
How many calves has this cow missed?	0
How many calves has this cow had?	6
Enter the average weaning weight of this cows calves.	520
What is the average calf weaning weight for your herd?	515
This cow is in good condition and is still open this year. She should be suspect and a candidate for culling next year if she is kept in the herd.	

the second example (table 2), a recommendation is made as soon as enough information is collected to apply rule 12, and thus this session is shorter than the other two.

Debugging and testing revealed several decision-tree like structures which suggested minor changes to several rules to allow the system to execute without redundancy. For example, rule 1 requires all cows over a given age to be culled, hence if a cow's age is known and greater than the maximum, the system culls her without asking for additional data.

To make this a more useful tool, information for each cow may be stored in a database file, and the program modified to interact with the file to output a list of cows to keep and to cull. Also, additional rules reflecting optimal strategies which depend on economic considerations are needed.

Literature Cited

- Holt, D. A. 1985. Computers in production agriculture. Science 228:422.