

# Can expert system simulation techniques support the decision-making tasks of pest management in sericulture?

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*Many scientific techniques were used in sericulture research and rapid progress in their methodologies can aid in solving various complex situations associated with sericulture systems. Management of pests in sericulture is one such typical situation which requires more advanced computer technologies, such as expert systems and simulation models. Understanding the concept of pest management in sericulture with an appropriate expert system simulation model (ESSM) is important because of the fundamental impact of its complexity on production systems. With suitable unified ESSM technique, many difficult problems involved in management of pests in sericulture can be solved. In this article we review some suggestions and guidelines for such model developers.*

THE history of silk began over five thousand years ago and has lots of myths associated with it. Silk is considered to be a luxury item among other fabric commodities of textile industry, because of its tensile strength, rich colours and sheen. Sericulture, a methodology to produce silk, has a great affinity to agriculture.

Sericulture has become more useful and profitable ever since man began practising it. In the past decades, many Asian farmers have been collectively trying to achieve optimum returns from the sericulture industry. Mulberry cultivation, silkworm rearing, silk reeling and trading are the kernel components of a sericulture system. Being an agro-based industry, sericulture has vast potential for generating income and employment, primarily to the rural masses in several Third World countries. Mulberry, the food plant for silkworm, cultivated under a wide range of climatic conditions, is usually attacked by a large number of pests. Similarly, pests of silkworm also cause serious concern to the farmers practising sericulture. Identification of various pests caused confusion and therefore sericulturists were unable to adopt suitable methods for their timely control. The real difficulty in managing these pest components is a fuzzy concept and requires more advanced technologies distinguished by modern methods of research. Developing of a suitable expert system simulation model

(ESSM) for appropriate decision making for pest management in sericulture is of significance and will benefit the silk growers and cultivators.

## Computers in sericulture

Computerization is a focus with much attention towards the achievement of radical innovations in sericulture research. Because of its rapid progress, and many problems vested in sericulture research, computers emerge to solve them quickly and accurately to attain maximum suitable solutions. One of the latest methods of using computers for solving such practical problem domains is through the use of expert systems (ES) and simulation models (SM), which are quite different in their context and analogy. The two components, ES and SM, need some explanation, as they are quite new to the sericulture science.

## Expert systems

Expert systems, the most elevated part of artificial intelligence (AI), are a set of defensive programming techniques implied through heuristics or rules of thumb. They process massive data on a subject, offer solutions on par with the human expert thinking faculty. An expert system is a program that contains a generalized inference engine and a rule-base, takes input data and assumptions, explores the inferences derivable from the rule base, yields conclusions and advice, and offers to explain its results by retracing its reasoning for the

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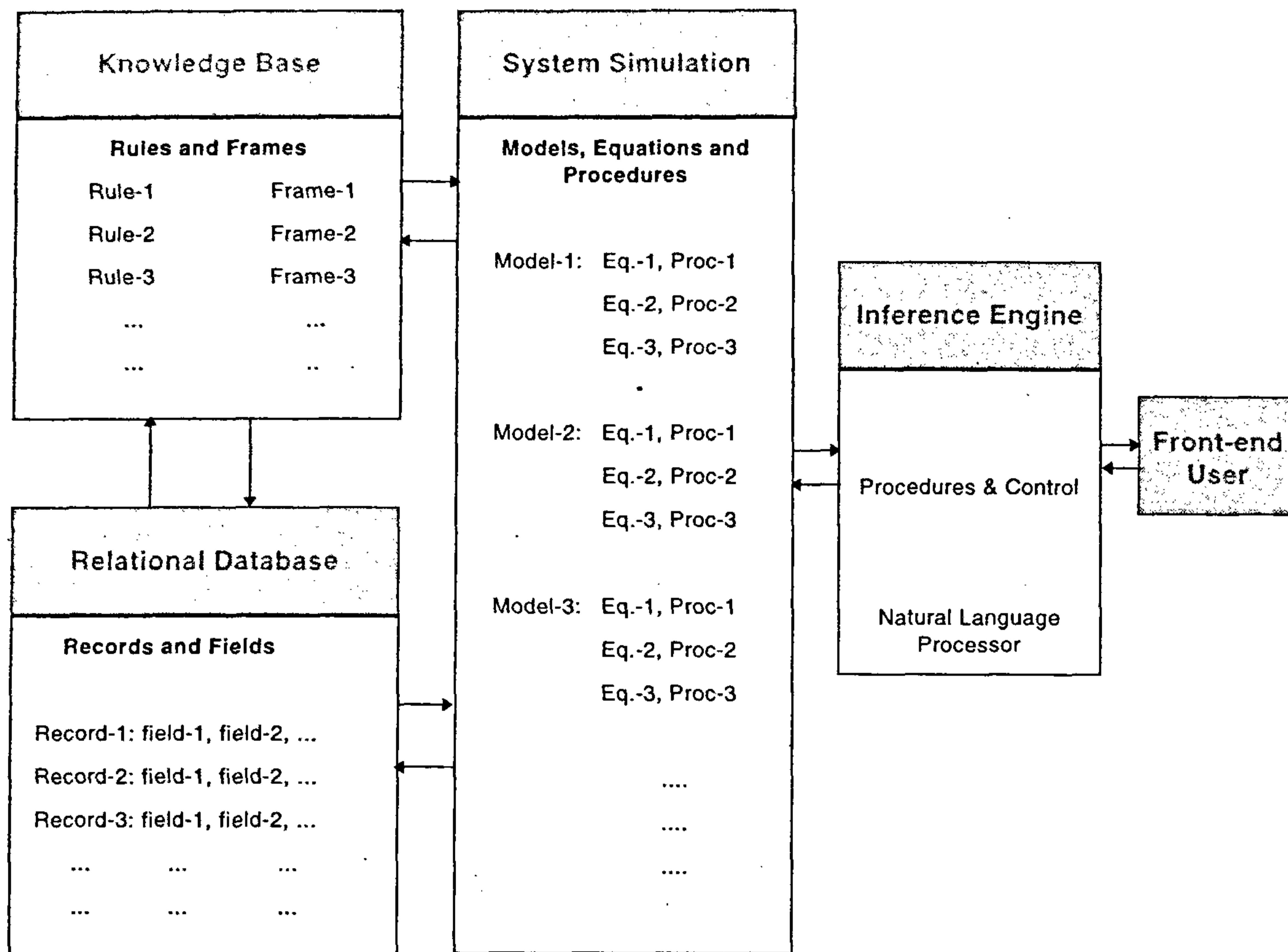


Figure 1. Expert system architecture.

user<sup>1</sup>. Hence, it is evident that the important components of an expert system are a knowledge base, a front-end user-friendly interface and an inference engine. Sometimes, they may require a relational database too. While there are many methods for building an expert system, the 'rule-based' systems are in common use, because of their logical cybernetics. Such rule-based systems are also called 'knowledge based (KB)' systems. They can convert uncertainty factors into estimates of certainty. The uncertainty principle says that if certain physical variables are prepared or measured precisely, then certain other variables become multi-valued or fuzzy<sup>2</sup>. The knowledge structures in a knowledge base include rules, frames, networks, procedures, uncertainty factors and even logical representations. The inference engine examines the facts and rules in the sphere of knowledge base through a set of 'if-then-else' rules to calibrate results. A typical representation of an expert system is depicted in Figure 1.

Indeed, the expert system technology is well advanced with appropriate tools for uniform data manipulation among rule-base, allows designers and users for testing, documenting and debugging the rules. The imaginary

scenario of data representation in a knowledge base can be regularized with these tools reducing the complexity of neural networks in the vicinity of KB. The most difficult and crucial part in building expert systems is knowledge acquisition and knowledge representation. An expert who can explore knowledge with his previous experience is essential for framing the rules to incorporate into the knowledge base.

### Simulation models

The second component, simulation models has an accumulated power of disseminating the complex conceptual constructs of the problem domains. More frequently, they induce inherent properties of predictability and control over the systems they represent. The approach is well defined by the terms: systems, models and simulation. The terminology has been dissected and clarified<sup>3</sup>: A system is a limited part of reality that contains interrelated elements. A model is a simplified representation of a system. Simulation can be defined as the art of building mathematical models and the study of their proper-

ties with reference to those of the systems they represent.

But such terminologies, perhaps, do not extensively investigate the most intricate parts of complexity, such as types of inter-relation, data validation and integration of explicit systems.

The attractive feature of the mathematical equations in simulation is its changeability. Of course, most of the models are mutable to trim the tasks. By changing a few parameters, for example, one can easily simulate a wide range of system's environment. That is the reason the entire strategy of system simulation has a robust locus on mathematical modelling. A mathematical model is neither a hypothesis nor a theory<sup>4</sup>. Unlike the scientific hypothesis, a model is not verifiable directly by experiment. For all models are both true or false. Unlike the theory, models are restricted by technical considerations to a few components at a time, even in systems which are complex.

Hence, models of these complex craft are necessary, but not sufficient to understand the systems they define, because they have to be systematic or empirical in nature.

### Unification of expert systems and simulation models

Many scientists are working hard to delve new methodologies in sericulture research enumerating for optimum hints. Such scientists prefer to contribute more effort, which allows them to be confident to get desired results from the problem domains. One such problem domain inspired by many scientists in sericulture, is the management of pests in mulberry cultivation and silkworm rearing.

Unlike in agriculture, the pest population: pathogen, parasite, predator, mite, insect, weed, mammal have been threatening sericulture production systems since long. They are a threat to the farmer practising sericulture. Various biological aspects of pest population can be studied vigorously through an expert system simulation model for their eradication. If not total elimination, at least they can be treated partially. A 'silk road'<sup>5</sup> may be the answer.

Unification of simulation systems and expert systems is not quite new. Many agricultural scientists have already applied the unification technique in their research

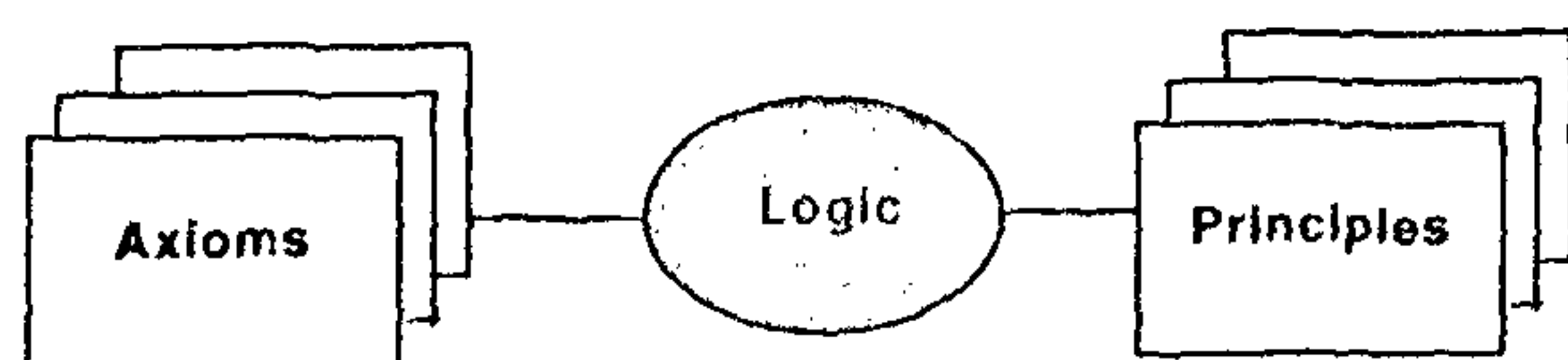


Figure 2. Axiomatic principles.

to yield axiomatic<sup>6</sup> principles (Figure 2). Some of the techniques are:

- An expert system, COMAX (cotton management expert), was developed and integrated with the computer model GOSSYM to determine the irrigation strategies associated with cotton crop management<sup>7</sup>.
- An expert analysis system was developed and employed as a component of FARMSYS (an integrated machinery management decision support system for multi-crop production systems) for analysing results of a field operations simulator<sup>8</sup>.
- A prototype expert system, SMARTSOY, was developed to aid soybean insect pest management along with a crop growth simulation model, SOYGRO<sup>9,10</sup>.
- An expert system was developed to combine a crop growth model, SOYGRO and water management (DRAINMOD 3.4) effects on crop growth<sup>11</sup>.

### Suggestions and guidelines for expert system approach to pest management in sericulture

Pests causing considerable damage in agriculture are more frequent in sericulture also, because both the systems are rivals in nature. The biological parameters of pests such as population size and density, climatic conditions for growth, survival rates, damage potentiality, availability of host are to be studied carefully with experts and can be distilled into a knowledge base to explore heuristics. As per the requirement, the typical data items can be coded in an advanced relational database with access to a rule-base. The mathematical equations of simulation are then tuned to refine the rules in the knowledge base corresponding to the decisions, predictions, incidences and estimates of pests and crop damages caused by them.

This is the first attempt to use an unified technique, expert system simulation model (ESSM), in sericulture pest management. The entity-relationship diagram (E-R diagram) of ESSM system flow is shown in Figure 3. More precisely, some of the aids and suggestions are given below for such model developers.

- System study, highlighting pests in sericulture, expert systems and simulation.
- Knowledge acquisition from sericultural experts in relation to pest management.
- Preparation of knowledge base and relevant data base.
- Prediction of key factors for rapid development of pests using simulation model.
- Refinement of rule-base according to the predicted factors.
- Knowledge engineering and data validation.
- Modification of inference procedures accordingly.
- Drawing the solutions to user queries.

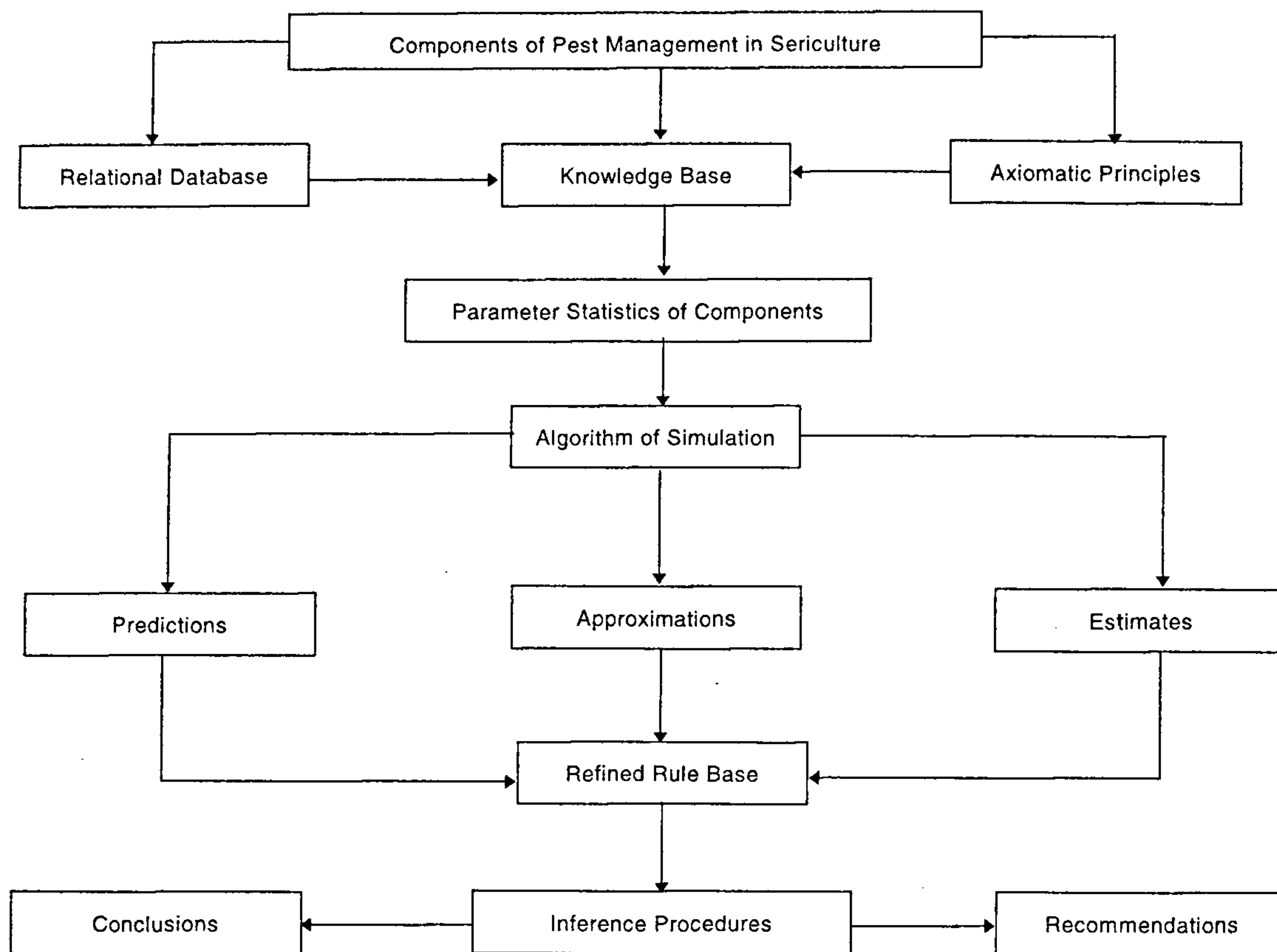


Figure 3. Entity-relationship diagram of expert system simulation model for pest management in sericulture.

Except the first two (a and b) constraints stated above, all other recommendations deserve one or more subsets of sequential processes. A process is an instance of execution of a command. The concept of parent-child processes is very common in ESSM and does not require explanation in this context. However, a great deal of insight into the process of simulation can gain fruitful solutions without leaving a number.

### Conclusions

In this article we presented some useful suggestions and guidelines for model developers to build a unified ESSM, taking pest management in sericulture as an example. In many sericultural situations, the approach described in this paper can have an outstanding impact on sericultural components, especially in silkworm rearing and seed technology, sericultural engineering, mulberry irrigation and water management. Newly available commercial expert system shells can allow access to these sensitive components in sericulture and such unified ESSM techniques can solve many more self-organized critical situations in systems evolution.

1. Brooks, F. P., in *Information Processing '86* (ed. Kugler, J. H. Elsevier Science Publishers B.V., North-Holland, 1986.
2. Deutsch, D., *New Scientist*, 1989, 124, 25-26.
3. Rabbinge, R., Ward, S. A. and Van Lear, H. H. (eds), *Simulation and Systems Management in Crop Protection*, Pud. Wageningen Pub., Netherlands, 1989, pp. 3-15.
4. Levins, R., *Am. Sci.*, 1966, 54, 421-431.
5. Feltwell, J., *The Story of Silk*, Alan Sutton Publishing Co., U.K., 1990, pp. 2-10.
6. Sangalli, A., *New Sci.*, 1987, 116, 42-45.
7. Lemmon, H., *Science*, 1986, 233, 29-33.
8. Lal, H., Peart, R. M., Shoup, W. D. and Jones, J. W., *Computers and Electronics in Agriculture*, Elsevier Science Publishers B. V., Amsterdam, 1991, vol. 6, pp. 123-141.
9. Batchelor, W. D., McClendon, R. W., Jones, J. W. and Adam D. B., *Trans. ASAE*, 1989, 32, 335-342.
10. Batchelor, W. D., McClendon, R. W. and Wetzstein, M. E. *Computers and Electronics in Agriculture*, Elsevier Science Publishers B. V., Amsterdam, 1992, vol. 7, 97-107.
11. Perry, C. D., Thomas, D. L., Smith, M. C. and McClendon R. W., *Trans. ASAE*, 1990, 33, 991-997.

ACKNOWLEDGEMENTS. We thank Dr Pradip Kumar, Pest Management Laboratory and Dr Satish Verma, Sericulture Engineering Division, Central Sericultural Research and Training Institute, Mysore for their co-operation and suggestions.