Expert survey on topological model development for microclimate control in wintering bee colony

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Abstract

Expert survey is organised in Riga, February 25, 2001 to develop topological model for microclimate control in wintering bee colony. 6 of 11 experts are doctors of science in different fields or research

Due to low quality of available experimental data, expected expert's knowledge and only one possible expert meeting the methodology of expert survey is adapted. Main adaptations were use of alternative partial topological models and two possibilities to make suggestions: during expert meeting and within 30 days after meeting. . Expert survey meeting was carried out within 6 hours.

From totally 40 suggestions of experts 10 suggestions are regarded 14 suggestions discounted, 10 suggestions were fixed as assumptions and 6 suggestions repeated the other ones.

Keywords: *biological system, honey bee, expert survey.*

Introduction

Modelling activities in areas with high financial motivation are often supported by intensive experimental work (Klipp et. al., 2006) and model development is iterative combining experimental and computational experience. Examples can be found in medicine, biotechnology, industry and other fields.

Still there are many areas where this iterative improvement of model can not be supported by experiments because of various reasons: financial limitations, lack of experimental methods, experiments are very time consuming (Stalidzans, 2005). Then it is necessary to operate with best available information sources and to be able to interpret it.

Another problem is necessity of collaboration of different specialists to develop a model: specialists of problem domain and modelling specialists. Modelling specialist has to be able to interpret the available information correct way. Thus interpretation has to be checked by experimental data or specialist of domain.

Improvement of both items: getting data and their correct interpretation can be solved by expert survey if experimental approach can not be used or covers just part of research topic. Usually methods of expert survey have to be adapted depending on available experimental data of domain as well as on possible number of expert meetings.

Interpretation of expert survey results can be very specific depending on their form (submodel, causal relationship, concept).

Paper is devoted to expert survey on topological model (Ore, 1962; Osis, 1969, 1970) development for microclimate control in wintering bee colony to find out the natural control methods used by bees in winter cluster to keep four parameters involved in metabolic process: water, oxygen, carbon dioxide and temperature within acceptable limits. Data has to be implemented in topological model for further analysis of control loops (Stalidzans, 2005).

Goal of the paper is to demonstrate analysis process of expert information regarding its implementation in the model in case of expert survey on topological model development for microclimate control in wintering bee colony.

Methods of investigation

Expert survey on microclimate control in wintering bee colony was organised in Riga, February 25, 2001. The goal of expert survey is improvement of First Draft of Topological Model (FDTM) of natural microclimate control inside the bee cluster during winter. Earlier developed methodology of expert survey for topological model development (Stalidzans and Markovitch, 2000) was used with some adaptations. FDTM is primary model developed without experts and based on available information on investigated topic. Primary model is necessary to fix the joint terminology and save time on early stages of topological modelling.

Leading Latvian beekeeping researchers and practicioners took part in the expert survey (in alphabetic order): 1) Dr.sc.ing. Almars Berzonis, 2) agronomist Valdis Bilinskis, 3) Dr. sc. ing. Aivars Kakitis, 4) M.sc. agr. Armands Krauze, 5) ing., MBA Eriks Kristapsons, 6) Dr.sc.ing. Antons Mikoss, 7) agronomist Andrejs Mizis, 8) Dr. sc. agr. Monika Mize, 9) Dr.sc.ing. Janis Rozitis, 10) beekeeper Juris Steiselis, 11) Dr.sc.ing. Miervaldis Vaivars. 6 of 11 experts were doctors of science in different fileds or research. Expert survey was carried out within 6 hours and was guided by Dr. habil. sc. ing., professor Zigurds Markovics.

Earlier developed algorithm of expert survey (Stalidzans and Markovitch, 2000) was adapted because of several reasons:

1. Just some of the invited experts have investigated in detail microclimate in wintered bee colonies. The level of competence is very different.
2. Most of the asked questions are not discussed in practical beekeeping as their impact to industrial beekeeping has no direct economical impact.
3. Opening of beehive in winter under Latvian climatic conditions change immediately the behaviour of the colony or even cause its death. Thus there are very few visual observations of undisturbed winter cluster available.
4. Bees are generally sensitive to any noise and vibration. Thus measurements of different parameters are hardly possible and the results are questionable.
5. Only one several hours long meeting of experts was possible.

To reduce impact of FDTM on experts it was not put in the handouts to avoid possibility to agree completely with FDTM without giving new information. FDTM was presented limited time during the discussion.

Alternative partial models (fragments of the whole topological model) of the same process were implemented to avoid possibility to agree with the offered proposal without critical analysis.

At the beginning of expert survey the analysed topic was presented as well as basics of topological modelling and the first topological model (Stalidzans, 2005) developed by authors of this paper.

During introduction presentation handouts were distributed. Handouts included information regarding domain of the research and partial models – elements of the whole topological model developed by authors of this paper. Information in handouts and the way of its presentation was explained.

Following tasks were proposed:

1. Analyse and improve the partial topological cause-effect model from handouts. In case of alternative models (Figure 1), marked by "OR", experts should choose one of them or make a new one.

2. Analyse and improve used terminology.

Experts could express their opinion:

- - immediately during open discussion;
- - within 30 days after expert survey correcting the offered models or expressing their opinion in free form using proposed terminology.

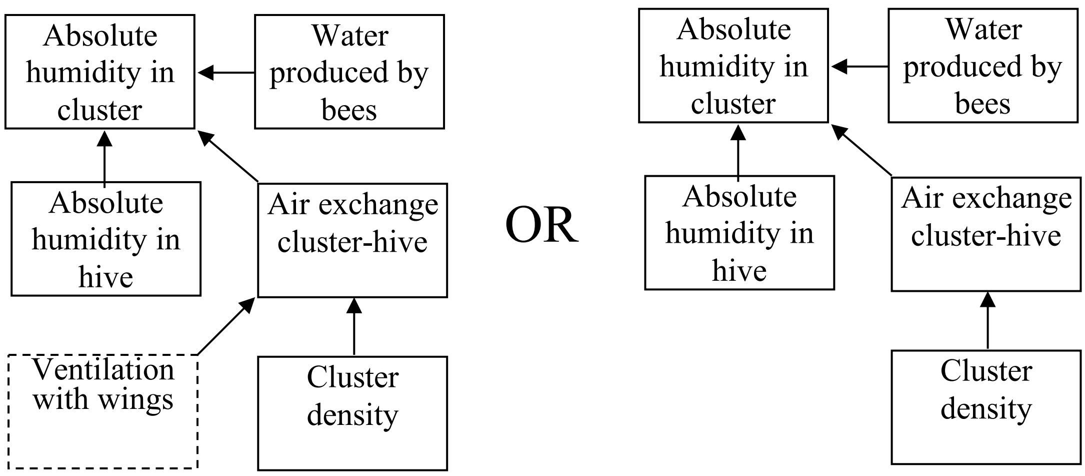

Figure 1. Example of alternative partial topological model.

Results

The models developed by experts and separately in free form submitted proposals were analysed and described in form of separate proposals, as the basic structure of FDTM was not corrected.

Proposals made during expert survey are marked with letter A and number. Comment and decision regarding implementation of the proposal into the model follow it.

A1. Individual bees in the winter cluster move their wings and cause air movement.

Comment: literature sources confirm that it is not clear. Decision: assumption that it does not cause oriented air movement.

A2. Winter cluster has specific structure: high-density shell and low-density centre. Thickness of the shell influence warms conductivity and air exchange.

Comment: literature confirms it. Decision: regard.

A3. Cluster can have different forms: spherical, and horizontally or vertically elliptic. That influence surface of the cluster at constant number of bees. Surface of cluster is directly related to exchange of warm and air.

Comment: form of cluster is taken into account in the model and it is defined as spheric as deviations from sphere normally are not very significant. Surface of cluster is taken into account based on experimental data. Decision: discount.

A4. Air has internal thermal resistance because of air between cluster and inner walls of hive.

Comment: true. Decision: regard.

A5. Different wind speeds cool the hive in different way. That becomes significant above wind speed 2 m/s.

Comment: true. Still we do not have measurements of moment values of wind.

Decision: assumption that hives are in the shelter where wind speed is low.

A6. Bee behaviour can be stressed due to overfilling of intestine.

Comment: modelling is oriented on the beginning of winter when intestine is not overfilled. Decision: discount.

A7. Bees act as individuals until some number of bees in the colony. Decisions are made social way if there are more bees in the colony.

Comment: model is developed for colony with 20 000 bees and at this size bees act as a colony. Decision: discount.

A8. Under stress due external impact (noise, vibration) colony activities change significantly.

Comment: true. Decision: assumption that there is no stress in the colony due external impact.

A9. Avalanche-like reaction of colony can take place if humidity in the hive increase.

Comment: that should be result of modelling to determine this kind of process. Decision: discount.

A10. Are form and size of cluster the same or different decisions?

Comment: should be result of modelling. Decision: discount.

A11. Condensing of water and its evaporation is part of wintering process with impact on warm.

Comment: true. Decision: regard.

A12. Bees adjust temperature pulsating way. Control can be proportional or impulsive.

Comment: should be result of modelling. Decision: discount.

A13. Radiation impact warm processes.

Comment: true. Decision: regard.

A14. Cross section of entrance should be a separate parameter. Perhaps air exchange has to be split in two parts: through entrance and through walls of beehive.

Comment: model is developed for fixed cross section of entrance. Decision: discount.

A15. Subspecie of honeybee (genetic characteristic) has impact on behaviour of bees.

Comment: true. Experimental data are available on Middle Russian dark honeybee. So model is relevant for this subspecie. Decision: discount.

Within 30 days after expert survey following suggestions were applied (marked with letter B and number):

B1. Density of cluster impact thermal conductivity.

Comment: true, it is already implemented. Decision: discount.

B2. Movement of wings in the cluster does not cause oriented air movement.

Comment: ≠A1. Decision: assumption that it does not cause oriented air movement.

B3. Solar radiation warms up the hive.

Comment: true. Decision: assumption that beehives are hidden from direct solar radiation by placing them in shadow.

B4. Movement of wings in the cluster does not cause oriented air movement.

Comment: =A1, ≠B2. Decision: assumption that it does not cause oriented air movement.

B5. Radiation from cluster impacts the hive temperature.

Comment: = A13. Decision: regard.

B6. Cluster density should be replaced by surface of cluster.

Comment: depends on calculation method of heat exchange. Decision: regard.

B7. Cluster density should be replaced by cluster gas conductivity.

Comment: depends on calculation method of gas exchange. Decision: regard.

B8. Impact of the colony stage in the winter has to be taken into account.

Comment: true. Decision: assumption that broodless stage in the first part of winter is analysed.

B9. Parameter "t^o in hive" replace by "t^o in on cluster surface" (2 experts).

Comment: depends on calculation method. Decision: regard.

B10. Bees can not make orientated air exchange.

Comment: =A1, =B4, ≠B2. Decision: assumption that it does not cause oriented air movement.

B11. Invent nest volume as a parameter.

Comment: model contains this parameter. Decision: discount.

B12. Amount and quality of winter food is critical.

Comment: true. Decision: assumption that there is enough food in good quality.

B13. Density of cluster depends on ventilation channels built by bodies of bees.

Comment: there are no clear evidences in the literature. Decision: assumption that bees do not build ventilation channels.

B14. Water can be collected in the body of bee.

Comment: true, but it is not relevant to the model. Decision: discount.

B15. Water condensing impact absolute humidity of air.

Comment: true. Decision: regard.

B16. Cluster density increase when bees instinctively move to warmer place in the centre.

Comment: can be checked by modelling. Decision: discount.

B17. Bees make individual decision about warm production to keep acceptable body temperature.

Comment: is not relevant to the model. Decision: discount.

B18. Health of bee colony is critical.

Comment: it has impact that is hard to assess. Decision: assumption that bee colony is healthy.

B19. Age of bee queen is critical.

Comment: hard to assess. Decision: assumption that bee queen is younger than 3 years.

B20. Position of entrance in the hive: on side below the nest, on side in the middle of the nest or open floor as entrance.

Comment: model is developed for entrance on side below the nest.

Decision: assumption that entrance is on side below the nest.

B21. Temperature in the hive depends on condensation warm on the internal surface of hive.

Comment: =A11. Decision: regard.

B22. Temperature on the cluster surface depends on thermal conductivity of cluster.

Comment: true. Decision: regard.

B23. Cluster density influence thermal conductivity cluster surface – internal wall of hive.

Comment: it takes place indirectly through volume of cluster. Decision: discount.

B24. Warm losses of hive depend on wind speed.

Comment: =A5. Decision: assumption that the hives are in the shelter where wind speed is low.

B25. Implement a parameter “Warm power at minimal muscle activity”.

Comment: important parameter. Decision: regard.

From totally 15 suggestions from A group and 25 suggestions from B group there are 10 suggestions regarded (4 from A group and 6 from B group), 14 suggestions discounted (8 from A group and 6 from B group) and 10 suggestions were fixed as assumptions (3 from

A group and 7 from B group) and 6 suggestions from B group were equal to the other A or B group suggestions. Thus the model was more improved by suggestions within 30 days (group B – 6 regarded suggestions and 7 assumptions) than suggestions on site (group A – 4 regarded suggestions and 3 assumptions). One can conclude that understanding of model needs time and it was very useful to collect expert suggestions after 30 days. Of course this is very important in case of one possible meeting of experts.

Expert's suggestions can be split in following groups:

1) relevant suggestions for given level of model (decision: regard),
2) contradictory suggestions without experimental evidences. Their impact has to be analysed in literature (decision: regard, discount or put in the group of assumptions),
3) parameters which have impact on the process but can not be measured (decision: regard or put in the group of assumptions),
4) parameters are taken into account in the model in hidden form (decision: discount).
5) contradictory suggestions (decision: regard, discount or put in the group of assumptions).

Expert survey can be assessed as successful as main targets were reached:

1) there were no complains about unclear information or terminology in partial models and first draft of topological model,
2) several items were regarded and used in the model as parameters or assumptions,
3) experts used additional possibility to give information on the model within 30 days after survey,
4) many suggestions are addressed to next modelling stage – implementation of functional relationships.

Methodology had following drawbacks:

1) because of only one meeting with experts their suggestions were evaluated by authors of this paper,
2) not all experts were able to discuss specific items as for instance thermal conductivity and radiation.

Conclusions

Expert survey is made on topological model development for microclimate control in wintering bee colony. Due to low quality of available experimental data, expected expert's knowledge and only one possible expert meeting the methodology of expert survey was adapted. Main adaptations were use of alternative partial topological models and two possibilities to make suggestions: during expert meeting (A group of suggestions) and within 30 days after meeting (B group of suggestions).

From totally 15 suggestions from A group and 25 suggestions from B group there are 10 suggestions regarded (4 from A group and 6 from B group), 14 suggestions discounted (8 from A group and 6 from B group) and 10 suggestions were fixed as assumptions (3 from A group and 7 from B group) and 6 suggestions from B group were equal to the other A or B group suggestions. Thus the model was more improved by suggestions within 30 days (group B – 6 regarded suggestions and 7 assumptions) than suggestions on site (group A – 4 regarded suggestions and 3 assumptions).

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4) parameters are taken into account in the model in hidden form (decision: discount).
5) contradictory suggestions (decision: regard, discount or put in the group of assumptions).

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