# Stored product mite *Tyrophagus longior* (Gervais) (Astigmata: Acaridae) with hive bees in India

Honeybee species are affected by various species of mites[1-8]. The primary problem mites are parasitic mites, viz. *Varroa jacobsoni*, *Tropilaelaps clareae* and *Acarapis woodi*. Phoretic mites are harmless to bees using them as transport from one plant to another. However, some stored product mites occasionally invade hives where they feed on stored pollen or honey.

In the subtropical areas of Jammu, India, both hive bees, *Apis cerana* F., and *A. mellifera* L., are managed for honey production and pollination. Fifty colonies each of *A. cerana* and *A. mellifera* were sampled for the presence of mites. Examination of bee combs, debris and honey-pollen stores from March to October 1992, revealed the presence of the stored product mite *Tyrophagus longior* in large numbers in debris as well as in combs of both the honey bee species. In general, infestation varied during different months and ranged between 5.2 and 31.6%. Peak infestation was observed from March to May coinciding with the peak of brood rearing activity of honeybees. The mean number of mites per g debris were $104.00 \pm 13.02$ ($n = 20$) and $120.00 \pm 17.20$ ($n = 20$) for *A. cerana* and *A. mellifera* respectively. Other mites observed in colonies were commonly occurring mites *T. clareae* in *A. mellifera* and *V. jacobsoni* and *T. clareae* in *A. cerana*. *Tropilaelaps clareae* and *V. jacobsoni* infesting *A. mellifera* and *A. cerana* colonies have been recorded in numerous earlier studies[5-10] but literature reveals that stored product mites have not yet been recorded from hive bees in India. However, they have been recorded associated with stored provisions of *A. mellifera*[1-4], termites and wasps[11,12] from various parts of Europe. It was found that these stores product mites feed on honey, pollen and contaminants thereof. This is the first report of association of the stored product mite *T. longior* with *A. cerana*. The association of *T. longior* with *A. mellifera* constitutes the first record from India.


1. DeJong, D., Morse, R. A. and Eickwort, G. C., *Annu. Rev. Entomol.*, 1982, **27**, 229–252.
2. Baker, E. W. and Delfinado, M. D., *J. Apic. Res.*, 1978, **17**, 52–54.
3. Grobov, O. F., *Apimondia Grenoble*, 1975, **25**, 366–370.
4. Weide, W., *Leipz. Bienenztg.*, 1960, **74**, p. 9.
5. Abrol, D. P. and Kakroo, S. K., *Environ. Ecol.*, 1993 (in press).
6. Atwal, A. S. and Goyal, N. P., *J. Apic. Res.*, 1971, **10**, 137–142.
7. Punjabi, A. A. and Saraf, S. K., *Indian Bee J.*, 1969, **31**, p. 44.
8. Eickwort, G. C., *Annu. Rev. Entomol.*, 1990, **35**, 469–488.
9. Abrol, D. P., *Curr. Res.*, 1993, **22**, 128–129.
10. Abrol, D. P. and Bhat, A. A., *J. Anim. Morphol. Physiol.*, 1990, **36**, 102–108.
11. Eickwort, G. C., in *Africanized Honey Bees and Bee Mites* (eds. Needham, R. R., Page Jr, R. E., Delfinado-Baker, M. and Bowman, C. E.), Horwood, Chichester, 1988, pp. 327–338.
12. Eickwort, G. C., in *Honey Bees Pests, Predators and Diseases* (eds. Morse, R. A. and Nowogrodzki, R.), Cornell Univ. Press, Ithaca, 1989.


Received 3 July 1993, revised accepted 9 December 1993


D. P. ABROL
S. K. KAKROO
B. N. PUTATUNDA*

*Section of Entomology*
*Shere-Kashmir University of Agricultural Sciences & Technology*
*Regional Agricultural Research Station, R. S. Pura,*
*Jammu 181 102, India*

**Department of Zoology*
*Chaudhary Charan Singh Haryana Agricultural University*
*Hisar 125 004, India*


OPINION

# Revitalizing aerodynamics in India: Challenges and opportunities

*Rajendra K. Bera*

## A self-evident need

India is a vast country with an enormous and self-evident potential for air traffic expansion which is currently under-exploited. Contrary to conventional wisdom, the bulk of the aircraft needed need not be expensive technological marvels, but they should be rugged, simple, fuel-efficient, and safe to fly. The number of such aircraft needed in the various categories per year, for a country of our size and economic growth, makes it economically viable to design and build them in the country. This calls for the building and nurturing of a world-class aerodynamics design team within the country

This apart, a major contribution to the delays experienced in indigenous aircraft design projects has been the lack of such an aerodynamics design team, thereby affecting our military and economic security. Moreover, we have the potential to provide a leadership role in aircraft design and manufacture to the Indian subcontinent. It will be a waste of opportunity if it is not exploited. What Indian aeronautics needs now is a change in outlook from its past licence production mentality to doing innovative design. It needs a vision to forge ahead.

## Aerodynamics is the key

In aircraft design there are basically four major areas – aerodynamics, structures, propulsion and electronics. The latter three are not intrinsic to aeronautics, although the stringent requirements laid down for high performance aircraft have been the primary reason for major, even spectacular, advances in those areas. But what makes aircraft design so unique is its aerodynamics – the essence and soul of flight.

While imitation comes naturally to mind, imitating the flapping wings of birds did not bring aeronautical success. Something rather innovative did: the realization that forward motion can generate powerful and controllable vertical lift on inflexible wings, albeit, within constraints. For decades, aeronautics has tried to reduce these constraints, but it still has a long way to go One may get a fair idea of the task at hand by noting that even today, in a new aircraft project costing several billion dollars, several hundred million dollars are spent in getting the shape of the wing right. And yet, to a layman, the wing looks more or less the same in successive generations of aircraft!

The fact remains that the flow of air over wings is very sensitive to minor changes of shape and flight conditions. This sensitivity is of concern in several respects – controllability and therefore the safety of the aircraft, fuel efficiency, handling qualities, airframe structural life, autopilot design, etc.

While wing aerodynamics steals the show, air flows over other portions of the aircraft are also important, specially in the way they interact with and influence the flow over the wing. Some of the vexing problems facing aerodynamicists are described in the next section. From there, one cannot but conclude that getting the aerodynamics right is fundamental to a successful aircraft design. Unfortunately, our theoretical understanding of fluid flow is far from adequate. It is a subject where intuition is extremely hard to develop even after years of experience. There is, therefore, plenty of scope for doing pioneering research and to experiment with innovative ideas in design.

Experimenting with ideas through traditional laboratory experiments has become expensive and time consuming, apart from the fact that they also require huge infrastructural facilities. In some cases, experiments are not even possible short of building the aircraft itself. Computational aerodynamics, based on sound theoretical understanding, offers ample scope for doing innovative design-related aerodynamics research. Essentially, one seeks to study increasingly sophisticated mathematical models of fluid flow phenomena over shapes of aeronautical interest. However, such computational techniques are relatively new, require supercomputing capabilities, and have yet to mature before they can be routinely used with confidence. The interpretation of such computed results, therefore, will continue to require expert aerodynamicists.

## Problem areas in aerodynamics

The primary force responsible for flight and aircraft manoeuvrability in the air is aerodynamic. This is the most energy efficient means of doing so. It is also faster and more precisely controlled than the other forces generated on the aircraft (for example the thrust generated by the engine is considerably slower in building up, etc.). Aerodynamic force changes are generated through moveable or variable geometry aerodynamic surfaces which afford controlled, and when necessary, substantial force changes.

Proper and safe aerodynamic force and moment management must obviously require predictable and controlled flows throughout the aircraft's flight envelop. This generally suggests that within the flight envelope, the flow types be the same throughout, and all changes in forces and moments due to changing control surface actions, and atmospheric conditions, etc. be gradual and smooth.

A change in flow type (laminar to turbulent, attached to separated, etc ) is generally accompanied by abrupt and/or large changes in forces and moments. But more worrisome is the fact that the change may not be precisely repeatable even under seemingly identical flow conditions. A classic example is the natural transition of laminar flow to turbulent flow where within a broad range of flow conditions, transition may or may not occur, and the occurrence, under certain circumstances, could be affected by such seemingly innocuous things as a few dust particles or dead mosquitoes deposited, say, on the wing upper surface. Another well-known example is the hysteresis effect when some aspect of flow condition is cycled, for example, an aircraft will stall at different angles of attack when angle of attack is cycled, the difference being dependent upon the manner and rate of cycling. But the most baffling of all are the symmetry paradoxes encountered in aerodynamics. That is, an initially symmetric steady flow situation need not remain steady or even symmetric. A familiar example is the asymmetric and unsteady chaotic breakdown of leading edge vortices on a sharp edged delta wing at high incidences and zero sideslip. And after a good deal of initial scepticism of test data, we now live with the operationally uncomfortable fact that under apparently and visibly symmetric flight conditions, a slender aircraft or missile can show a steady side-force but of unpredictable left-right direction, over a range of 'high angle of attack', but beyond which the flow will break down in chaotic confusion. All flow breakdowns, no matter how they are triggered, lead to unsteady, chaotic flow behaviour and the breakdown itself occurs rather suddenly. Thus managing flows, when flight conditions are continuously changing, can be an enormously difficult and frustrating task, specially at high angles of attack and sideslip.

Such moody flow behaviour has made substantial departures from established aircraft shapes risky unless backed by an extensive and expensive R&D programme. Also, even though one may arrive at a predictable and controllable flow, it may not be aerodynamically efficient, by which we shall mean that energy losses in the airflow, as it traverses the aircraft, are unacceptable. In other words, aircraft drag is high, and in consequence, engine power required for flight is high This is the reason, why in a given category, aircrafts resulting from a given design bureau have remarkably similar shapes even after a decade or two, the discerned changes being more evolutionary in nature than revolutionary.

Current aerodynamics research has focused attention on certain important flow phenomena and their mutual interactions – vortices (their development, paths, breakdown, etc.), boundary layers (laminar, turbulent, transition, separation), separated flows and wakes, attached flows, and shock patterns – as each provides a means of controlling some aspect of flow behaviour. These flow phenomena are generated by aircraft surfaces hence improved understanding of not only existing but also of newer aerodynamic surfaces and devices are being sought to generate, sustain, and manipulate various types of flows, specially, separated, reattached, and unsteady flows, to a desired composite whole which would be predictable, controllable, and aerodynamically efficient. There are huge gaps in existing knowledge, specially in separated flows and wakes, turbulence, and flow breakdown, and in some cases, there are uncertainties as to the directions research should take.

## Where should we focus?

A survey of national air traffic needs, growth, and economics makes it quite evident that subsonic aircraft will continue to dominate the market well into the future. They will include all commercial transport categories (from general aviation and commuter aircraft to intercontinental transport aircraft), military transports and heavy-lifters, a large array of helicopters, sports aircraft, reconnaissance and surveillance aircraft, aerial ambulances, etc.

In order to expand air traffic in India without an astronomical investment in airport infrastructure development (specially in land and long runways which, for small and medium airports, will cost more than 50% of the total cost) it is necessary to build fuel-efficient STOL (short take-off and landing) aircraft. STOL aerodynamics is still rather new and should be our primary thrust area. It should primarily be explored using computational aerodynamics

## Why computational aerodynamics?

In the scientific investigative triad – theory, experiment, computation – the last has gained enormous visibility in the past decade since the advent of supercomputing power. Computation, viewed as a tool of scientific investigation of similar importance as theory and experiment, is a recent phenomenon. The discipline is too young to have contributed to breakthroughs but it does have great potential However, from a technology development point of view, which is an undefinable mixture of art and science, computations can replace experiments (specially those which are very expensive, time consuming, and risky to perform) and extend theoretical results (when analytical methods become too difficult to apply). In the hands of a designer, computations provide enormous flexibility for studying options and variations, and when linked with high powered graphics, permit rapid viewing and absorption of results. That is, it is now possible to generate information at the high rate comfortable to a designer at his moments of peak mental concentration.

For computations to play a vital role in design, we require

- Computational algorithms and their conversion to usable software,
- Means of running the software (computers, peripherals, etc.),
- A software architecture amenable to organized change,
- An innovative group which uses the software as an aid to innovation, not as a substitute to it.

However, our current abilities in computational aerodynamics are poor and rely heavily on borrowed codes. There is, therefore, a compelling need to develop indigenous state-of-the-art computational aerodynamics codes within the country.

## Build a design team

The aeronautics industry falls squarely within the knowledge-based industrial sector. Aeronautical design requires considerable proficiency in mathematics and physics (analytical abilities) Our IITs and other top academic institutions provide these skills to an excellent degree but our aeronautical curricula remain weak in providing design courses.

Consequently, India's top aeronautical engineers are top analysts, not top designers. This has created an imbalance in Indian aeronautics resulting in an erosion of our aeronautical design base. Design is the central activity of the aeronautical profession. Our top priority should now be to form a world-class aerodynamics design team which can rapidly build upon the skills of our analysts. This group should then become a national asset in aerodynamic design for the next few decades. One might add that outstanding designs follow from an uncanny ability to synthesize. Synthesis is aided if one can easily tap large intellectual resources.

Design is a creative exercise and requires talent Our goal should be to bring together a young group of talented people motivated to do design work, train them into multi-disciplinary areas required of design, and provide them with efficient means of tapping the intellectual capital of the analysts sitting in R&D institutions.

## Expertise transfer: laboratory to industry

Conceivably, the most efficient means of expertise transfer from the laboratory to the industry is by means of software, that is, through software systems with embedded expert systems and sophisticated human–computer interfaces. An excellent interface, driven by expert systems, will provide a vantage view of the software architecture and its capabilities, and with every selection from the interface or interaction with it, the user will be steadily guided through successive levels till a complete description of the problem to be solved is made. The software can then proceed towards a solution, at least in principle.

Design is a highly innovative task There is, so to say, no best solution to a design problem, let alone a unique one The reason is that apart from the formal description of a design problem there are a variety of unstated assumptions, intuitions, hunches, aesthetics, needs, etc. which play a highly subjective and influential role in deciding the final design solution. This is where embedded expert systems, if properly designed, will play a crucial role by helping the designer explore plausible alternatives Software is a powerful means of capturing intellectual capital and for distributing it in highly usable form.

Conventional expert systems generally solicit information which the user can provide (if necessary, with an estimate of the confidence level on the information provided) and in return, apart from the solution, if one exists, it provides the user with its 'thought process', if asked. This is a step ahead of conventional programme which do not provide any explanation of how they arrive at a solution, but it is not enough for a creative designer. To appeal to his creative instincts and unique associative powers, a designer needs to 'talk' to the expert system, argue with it, set impossible tasks to it! Essentially, the expert system should be able to function extensively in the 'what-if' and 'why-not-that' mode. Indeed, it may plead ignorance to most such queries, nevertheless it must serve as a good sparring partner to exercise the designer's mind. The expert system thus becomes the essential expertise transfer link between an expert and the designer, and to a designer it becomes an intellectual resource for his creative acts which depend upon his private visions and private mental constructions.

Such ambitious expert systems do not yet exist and their development is a high challenge both to aerodynamicists and to AI (artificial intelligence) researchers. Their development would require a strategic plan and plenty of investigator initiated research.

## A national aerodynamics software project (NASP)

From the foregoing it is clear that:

- aerodynamics is a complex subject
- real experts are few
- their knowledge is a crucial input in aircraft design
- much of their knowledge is software encodable
- such software can directly assist the designer
- it can function as a surrogate aerodynamicist.

The last fact has an important bearing on improving market competitiveness because anything that can be efficiently organized into software improves its accessibility and utility and speeds up decision making in the design activity. Being first in the market with a product often has decided advantages in capturing a market. Cost savings from the use of such software can literally mean the difference between survival and obliteration of an aircraft project.

On the other hand, the very nature of such a powerful software tool with embedded expert systems implies that it can, with equal facility, be used for teaching and in advancing R&D, resulting in the spectacular benefit of the entire aerodynamics community speaking the same language and working in the same intellectual environment without anyone being denied their specific needs or curbing their creativity. When such a software is placed on a network, the benefits increase even further because consultation within the aerodynamics community no longer demands travel.

If India is to retain a viable aircraft industry it must hasten to start a national aerodynamics software project. It simply cannot afford otherwise. What encourages optimism is that recent advances and those visible on the horizon in software and hardware computer technology now permit the development of highly integrated, innovative, and ambitious software products, which are knowledge-base driven. India does not lack talented people but it does lack a scientific tradition of nurturing them and a management structure to support them.

The national aerodynamics software must have at least the following elements:

- sophisticated interactive human–computer interfaces
- context sensitive expert systems
- data banks and databases
- functions library (algorithms, math, graphics)
- flow simulation and visualization library
- tutorials
- test cases and benchmarks
- tool kit for maintenance and upgradation
- network links and human communication links
- computer-aided-design (CAD) features
- documentation tools.

The technical success of NASP will crucially depend on the base software architecture it adopts and the libraries, tools, test cases, etc. it develops. Jointly they must provide a unified platform for both code development and code use to ensure zero time lag between the completion of a piece of code development and its public release. The base architecture must be designed by a small but talented group. This will require people of the calibre of Ritchie and Thompson. It must be amenable to organized change.

The national aerodynamics software will

- provide a powerful means of aerodynamic analysis and implementation of design rules to test innovative ideas and for exploring alternatives
- free the designer, as much as possible, to do creative thinking.

## Final words

Few, if any, will contest the need for a world-class aerodynamics design team and the need to provide them and the entire aerodynamics community in the country with a national aerodynamics software package. But fulfilling this need means adopting new ways of doing aerodynamic design which will fully exploit available and emerging computing hardware and software technologies. Time and again scientific and technological rewards have come from unconventional thinking. In the aerodynamic design of aircraft, NASP can provide the means for doing it more frequently and more efficiently.

*Rajendra K Bera is in the National Aerospace Laboratories, Bangalore 560 017, India*