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Next Up, the Survivors

Part Two of Two Parts

by M.E.A. McNeil

The first part of this article surveyed research and various beekeepers breeding survival stock. The second part discusses cooperative programs and a range of breeders that contribute to one of them, using both IPM and untreated protocols.

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Brian Neuman, Ohio Queen Breeding Project

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John Jacob, Old Sol Enterprises

The end of the rainbow for beekeepers, survival stock, is pursued in a variety of ways. Some European models breed pure lines; Americans are more of mind to go for the ideal mutt -- if it works, add it in. Within that loose model, strategies range from "live and let die" with no chemicals to Integrated Pest Management[1] (IPM; treating only when needed and then with the most benign treatments). For many, IPM is a way of easing the most adaptive stock toward that pot of gold. In any case, it is not a quest for the faint of heart.

The Ohio Beekeepers' Association has begun a statewide breeding exchange, the Ohio Queen Program[2] (OQP), which teaches IPM. The project, involving hundreds of colonies, was founded by Dana Stahlman and is now headed by bee geneticist Joe Latshaw.

What a survivor stock needs to survive varies geographically, and the harsh Ohio winters were the first challenge for this program. "The harder the winter the better the selection pressures," said Latshaw. The program has had some success and has added goals of mite resistance and even, in at least one region, untreated stock.

The OQP works like this: Each of nine regional volunteer coordinators selects his best two survivor queens in a closed population breeding scheme.[3] Latshaw instrumentally inseminates the queens with pooled semen from 100 to 150 drones using equipment that he has invented.[4] Drones from the strongest survivors in each area provide the predominant genetics, although a number of other stocks are combined in the semen -- from Carniolans Latshaw has bred to VHS lines. He calls it "a hodge-podge," albeit a calculated one. The coordinators then rear the queens for a year, use their offspring to select for the next round, and sell open mated progeny to further distribute the genetics.

A regional coordinator in Northeast Ohio is actively pursuing local untreated stock. Brian Neuman started by choosing winter hardy New World Carniolans (a few Minnesota Hygienic, Russian and swarm-captured Italian bees added diversity to the original mix). Five years ago, he stopped feeding his bees and lost about one fifth. From those survivors he made splits. Then, in 2006, he withdrew treatment from his main mating yard, resulting in what he remembers as the "excruciating painful" loss of 52 of 60 hives by the following spring.

The daughters of those eight surviving queens went into the first round of the Ohio Queen Program, in 2007. They were instrumentally inseminated with the sperm developed by Latshaw. Losses had been huge statewide that year, so Neuman speculates that they had "hardy stock to start with." Last year 40 of Neuman's 50 colonies (80%) overwintered with no chemicals, with the exception of his outyards; there he reverts to IPM and uses a half treatment of thymol in spring and fall.

"Part of the OQP is to teach others how to raise their own queens," said Neuman, who said that participants in queen rearing classes go home with ripe queen cells. They have raised second and third generations, "distributing the genetics even farther than I alone could," he said. The program has trained 280 beekeepers in free classes in queen rearing and IPM management; it also offered free drafting. The program is funded and run by volunteers, with the Ohio State Beekeepers' Association providing support with such needs as class manuals. (This year a two or three day course will cost $50.)

"I'm cautious when I talk about this program," said Latshaw, recalling past claims for miracle bees. But "We're doing pretty well. The pie in the sky I'm aiming for is no treatment, but I'm not sure if the bees are capable. There are so many stresses." As difficult as it is, Latshaw says there is enormous interest in the Ohio model, with inquiries coming from Illinois, Michigan, Pennsylvania, and Virginia.

Last winter was exceptionally harsh in Ohio. "The last time we had this much snow was during the blizzard of '78. It looks like another good year for the natural selection process," said Neuman. "This method was developed as much for the genetics of the bee as for saving me time, money and labor."

The Southwest Survivor Queenbee Project is another network of beekeepers dedicated to breeding stock suitable to a rigorous local climate. Melanie Kirby and Mark Spitzig of the Zia Honeybee Company[5] formed a consortium with five other professional beekeepers in New Mexico with startup funding from Western SARE (Sustainable Agriculture Research Education[6]). State Bee Inspector Greg Watson serves as the project's technical advisor.

Spitzig said their experience has shown "It makes sense to develop bees locally." The group selects queens that have overwintered at least two years, with longevity their first criterion followed by honey production, disease resistance, behavior, and temperament. Zia grafts from them and crosses their daughters to other lines. The group is mindful of the importance of diverse drone saturation to create variation in sub-sister families and has the advantage of isolated mating yards in the Sangre de Cristo mountain range of the Southern Rockies.

Daughters are distributed back among the members for review. Kirby reports low mite counts in the colonies, no foul brood and rare chalk brood or nosema. She attributes the health of the bees to what she calls a "thrive and survive" approach. "When we encounter hives that are displaying below normal health, they are merely monitored. We either see them bounce back or dissipate. Either way, we have not had to use any commercial medications on our bees."

The bees are moved to follow the availability of bloom from 3900' to 8400' elevation – desert to alpine conditions. Summer monsoons and wet winters make fall and spring good foraging seasons, but the bees must adapt to widely varying conditions. For example, unusually high winds had a heavy impact on their naturally mated queens last spring.

Spitzig speculates that African honey bees in the Las Cruces area in Southern New Mexico may not create enough stores to survive the six month winter dearth; in dozens of swarms he has found very few to be aggressive or runny, so they have not proven to be a problem for the project.

"The essence of our protocol is that we allow Mother Nature to weed out the weak for us," said Kirby. But Mother has helpers: the data on each colony is extensive, with lineage and location histories traceable and a name for every second year hive. The bees are supplemented twice a year with essential oil pollen patties and dusted with powdered sugar and garlic powder "nothing that the humans wouldn't eat" – albeit novel cuisine.

Now, the project is gathering stock from other survivor queen producers across the country to be kept in the isolated mountain breeding yards. Bees that test best for hygienic behavior, by liquid nitrogen assay, will be grafted and outcrossed. Daughters will be made available to other queen rearers as well as to the public. The sources of untreated survivor stock for this project cover the map: Old Sol Enterprises, Oregon; Champlain Valley Bees and Queens,[7] Vermont; Purvis Brothers Apiaries, Georgia; Olympic Wilderness Apiaries, Washington State; VP Bees, Maryland; Bee Weaver, Texas; and their own Zia Queenbee Company, New Mexico.

Kirby and Spitzig invite experienced beekeepers to share their untreated stock in order to help develop the survivor cross-stock genetic pool. They hope to expand their network of cooperating beekeepers throughout the Southwest and Rocky Mountains.

It is worth a look at some of these wide-flung apiaries propagating survivor stock that are supplying the Southwest project.

In his family run apiary, Old Sol Enterprises,[8] John Jacob has selected and hybridized bees over six years, resulting in breeder queens from untreated stock. Old Sol expects to sell 7,000 queens this season – although he is so far north that his queens are ready weeks later than many.

Jacob, trained as a biologist, is president of the Southern Oregon Beekeepers' Association. He collaborates with other beekeepers, selecting from their survival colonies and from feral bees. He maintains several lines, used primarily for pollination – although he also selects for honey production, which, he says, has not diminished with the resistant stock. The Jacobs have about 500 hives for pollination and 750 mating nucs between Medford and Grant's Pass.

"Survivor stock is more of a strategy than a strain," says Jacob. In 2000, he found mites crawling on his Apistan strips, and so, he says he had no choice but to breed more resilient bees. His attempts brought on several years of heavy loss. He acquired Russian resistant stock from the USDA breeding program to add to his surviving Minnesota Hygienic Italians and New World Carniolans. Although the Russian line was "a vast improvement," the casualties continued. By 2002, with his apiaries naturally culled out, he added SMR (Suppressed Mite Reproduction) genetics. These "smart bees," later renamed VSH (Varroa Sensitive Hygiene), were developed by John Harbo and Jeffery Harris of The USDA Honey Bee Breeding and Genetics Laboratory at Baton Rouge.[9] (The name change reflects the understanding that they don't suppress mite reproduction, as first thought, but have varroa sensitive hygiene, sensing and cleaning out infected brood.)

Jacob's stock strengthened until two years ago, when he bought a few Australian colonies and observed that "there were more mites than I'd ever seen." He speculated that the upsurge may be related to the DNA of susceptible Australian drones, which have no varroa exposure in Australia, or bees weakened by the arrival of *Nosema cerana*. After ten years without treating for nosema, he treated last year where he found spores.

"I want to emphasize the IPM approach and collaboration," said Jacob. He suggested that all beekeepers rear queens. "Withhold treatments, and look for those that thrive. It may be only 1% or 2% but it will increase over the years." He invites an exchange of his queens for proven survivor stock. "If more people work together nationwide, we can spread the genes around."

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In 1997, Dan and Judy Harvey heard that most feral bees were wiped out by varroa mites, and they went looking for survivors. Their Olympic Wilderness Apiary[10] is located in the temperate rain forest of the Northwestern Olympic Peninsula in Washington State. They put out the word to loggers, and soon were collecting swarms. "We just assumed they had some resistance," he said. "We didn't know what we were doing."

It was a steep learning curve for them, finding out how to evaluate the bees and rear queens. They came up with a combination of tests, which they still find effective: Erikson's screen wash test[11] for mites, liquid nitrogen[12] for hygienic behavior and professional lab tests for disease. They found a lot of variability and bred from the healthiest bees. In 2000 they began adding USDA genetics, first Russian and later VHS/SMR bees as well as semen for tracheal mite resistance, from Baton Rouge. The initial aggressiveness of the Russian stock was bred down.

With no chemicals in the production colonies and an overall IPM philosophy (antibiotic and organic mite control when needed in mating nucs), hand made chemical free cappings-wax foundation, and good grooming behavior in the bees (evidenced by microscope observed bite marks on dead mites), Harvey said the program worked out well. But in the spring of 2008, a freak weather pattern collided with the arrival of the microsporidian *Nosema cerana,* resulting in the loss of 90% of the carefully bred colonies. Cold, wet weather persisted for a year, from one summer to the next, causing pollen shortages and leaving nutritionally distressed bees going into winter and

susceptible to infection. Tests found very high levels of *N.cerana* in his apiaries, but none in some feral populations in the area.

Harvey speculated that because microsporidians are common in the naturally damp Northwest environment, the feral bees may defend themselves well from them – after all, he observes, they deal with bears. He remarked that the fungus chalkbrood can be inhibited by probiotic yeasts and molds, as well as by hygienic behavior. Down but not out, Harvey is breeding the nosema-free feral bees with the survivors of the environmental pressures of last year. He thinks that the advantages must go both ways; the genetics help the surrounding feral bees as well.

Working with bees in trees has led Harvey to conclude that standard hive systems hold too much moisture. He leaves a 3/8" opening across the back and front of his hive tops. Observing how high in the tree cavity the nest is naturally built, far from potentially infectious hive debris, he is experimenting with an added empty 6 5/8 sterilized box on the bottom board.

In the spirit of natural selection surfers, the Harveys have stayed afloat through the latest crisis, "greatly encouraged to find ourselves once again in a unique situation."

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Adam Finkelstein and Kelly Rausch, at VP Bees[13] near Frederick, Maryland, have been breeding bees without chemicals for ten years. Finkelstein was an apiary inspector in Virginia when he witnessed decimating losses to varroa in the early '90s. With a background in biology, he understood from population genetics that a combination of traits can evolve to suit an environment. "I thought I could do something," he said. He and his wife, who is an NIH biologist, "could afford to take the challenge. We both had other jobs. We weren't betting our livelihood."

They chose to work with a closed mating protocol, with Rausch doing instrumental insemination to help control the variables. They started with bees from the Honeybee Improvement Project[14] of Jack Griffes, who worked on isolating a line of chemical free bees. Together with some early VSH/SMR stock from Harbo's project, they added Minnesota Hygienic and Carniolan bees.

Abandoning chemicals from the start, they went full face into the forces of selection, losing almost all of their 60 colonies. Finkelstein remembers one hive, in the year 2000, thriving in the midst of colonies crashing all around it. The next year there were four left. They kept making II queens from survivors, adding more genetics, and the bees came back stronger. "I decided ok, I believe this," he said.

Along the way, the pair found that bees with hygienic behavior simply clean out the brood nest, whereas bees with VHS/SMR behavior can tell which pupae have mating mites, open the cells and clean them out specifically. Even though bees with pure SMR expression did poorly for them and needed to be cross-bred, Finkelstein considers the genetics to be crucial to their program: "If it wasn't for the research Harbo did, I wouldn't be here," he said.

The continuing selection process includes survivor bees that have overwintered for two years from many other survivor stock producers. Breeder queen daughters are open mated in drone saturation areas. At last, VP Bees has begun to sell their hard won queens, and a SARE farmer grant will help support further research into selection methods.

Finkelstein cautions that breeding such stock takes careful observation, meticulous records and a degree of obsessiveness. “I breathe and live and think about these crosses. And now I am finding people as interested in these crosses as I am…It takes time and patience, but it is achievable.”

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Dann Purvis, of Purvis Brothers Apiaries[15] in Blairsville, Georgia, knew he was in it for the long haul. In 1996 he concluded that bee breeders were “dead men walking” – with genetic diversity depending on too few queens. He took on the task of breeding survivor stock, which he thought might take 25 to 30 years. In the eight years it did take, he said, “I thought I’d lose everything.”

He now has 1000 colonies and 1800 breeding nucs, kept without chemicals, with the exception of thymol in his production colonies. The survival rate in his apiaries, which continues to rise, is now about 70%. He intentionally brings it down every year to 50%, using what he calls “a simple weeding program.” He sells all of the three week old queens he can produce, which tend to be large, some as big as a quarter.

Purvis began this odyssey by gathering what he calls his “tool box”: six different lines brought into a large closed population breeding group. “We collected lots of 50 queens each from anyone who had something different,” including feral, Old and New World Carniolan, German Black Bees, purebred Italians and English Buckfast as well as Russians for grooming behavior – with European stock coming through Australia while it was open.

“I used to breed fish,” he said, “It was easy. I came into bees thinking I could breed the same way, but there are so many factors with bees. If you roll a pair of dice you can count the sixes. But breeding bees is like having a bucket full of dice and rolling it once a year.” It’s one thing to focus on just the goal of survival without chemical treatment, he pointed out: “This is binary; do they survive?” But there are myriad other characteristics to consider in addition -- not the least of which is honey production.

He instrumentally inseminates 400 breeder queens a year, keeping track of various lineages (none of which now includes Italian stock). To do it, he collects an equal number of drones from each survivor colony in a large cage. He randomly selects drones and collects semen directly into a tube, cutting out the homogenization step. A queen is inseminated by about 15 drones each. The large gene pool (20 drones from each of 1000 colonies) makes inbreeding unlikely. “Sue Cobey came up with this system,” he said, “I didn’t agree at first, but I found out that she was right.”

He also found that a highly analyzed, micro-managed approach is limited to developing specific genetic traits. He has found it quite possible to breed for foul brood and chalkbrood resistance, initially using the nitrogen test. But he concludes from his experience that it is much more difficult to breed for varroa/virus resistance. He has abandoned the nitrogen test because the best survivors were not necessarily the most hygienic by that assay. To breed viable survivor stock, he said, “You have to look at the whole picture, observe them over a year.” He calls it “God’s breeding program.”

To create selection pressure, the bees are inoculated with mites, which Purvis calls “eight legged hypodermic needles” for their propensity to inject viruses. Collecting mites for that purpose was a skill he learned from the Australian bee virus expert Dennis Anderson, who visited Purvis’ apiaries and speculated that there is virus resistance

among his bees. Success with tracheal mite resistance has created the reverse problem: finding enough *Acarapis woodi* to inoculate the bees in a similar way for selective pressure.

He is encouraging yet realistic when he recommends his path. Some tips from his experience: "Put away those pest strips and collect the survivors." Cull mite infested bees two months before the colony dies, when the mites would move horizontally on robbers. Don't breed from swarm cells; it perpetuates swarming. "If I had to pick one trait, it'd be grooming behavior," he said.

The eponymous Purvis brothers are four bee-savvy young men, now off to other careers. Dann Purvis said, "We could sell many times the queens if we could produce them. I'm looking for a young person to train to do this."

He concludes after trying "every breeding program: You've got to have a large gene pool. You have to dump the diseases on them and select the survivors. It's so simple it's stupid." In sum, "It just takes time, money and work."

"My entire operation is resistant and untreated," said Danny Weaver, of his 5000 Bee Weaver[16] colonies. "We got mites early on, within a few months of when they were discovered in the country, in '88 and '89 in North Dakota," where he summers some of his Texas stock during dry months. Colony loss immediately followed.

Over the two years that he used acaracides, he observed deleterious effects on queens. He had studied molecular biology in a University of California PhD program, and began to think about genetic solutions, but it was new territory. "I thought it possible, but there were those, like Ruttner, who said it was like trying to make sheep resistant to wolves."

With a decision to "bet the farm," he started breeding in 1992 from queens that survived exposure without treatment. It was far from an odds-on bet. He initially devoted 2000 colonies to the experiment, eventually losing thousands.

"I didn't know if the survivors just got lucky or there was a strain of less virulent mites. It was unknown. I was trying to extrapolate from what had been done with other species." Not many more colonies survived in the third year. "I was very discouraged the first few years," he said.

Weaver calls his stock "mongrelized." Russian stock was suggested by Thomas Rinderer[17] of the USDA at Baton Rouge, with the observation that the mites first came together with *Apis mellifera* on Russian bees. Weaver collaborated with John Harbo on the development of SMR/VHS bees. Minnesota Hygienic bees proved less resistant in his apiary. "They just remove dead brood," he observed, whereas "VHS will remove live brood.

"By 1999 we had real traction, a high level of resistance," he said. "We could go off chemicals and go organic." But, it's a "trade-off. The bees are not as strong and don't leap into spring."

The selection process is ongoing. Drones are reared as "mite factories" to maintain selective pressure. Genetics from other beekeepers' resistant stock are added. But Weaver says that the VHS and Russian stocks are important contributions, noting that "fewer than 1% of colonies headed by other standard commercial stock will survive without treatment for a year."

Disease management is handled primarily by requeening. In the off season, treatment, if any, is by IPM (for example, a hive with active European foulbrood too early in spring for requeening is sometimes, but not always, treated with oxytetracyline mixed in sugar).

Weaver, who was on the honey bee genome steering committee, has a new quest: to research the genetic markers for survival traits. "Now it takes a year to identify survivor queens, but this way perhaps it will be possible to identify the markers without wasting a year." He has received a Small Business Innovative Research Grant from the USDA to pursue the research.

In describing his odyssey toward breeding survival stock he says, "Plenty of beekeepers dismiss the whole idea. Some are disbelievers. Our bees are living proof that you can do it."

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So the question, "How do we do it?" has a many answers. "There is probably not one way to do a breeding program, says Dave Tarpy[18] of North Carolina State University, "But there are a lot of wrong ways. There needs to be a large enough population to avoid inbreeding, enough stock to see variation in alleles. It's a tremendous amount of work to do this properly, but the problems are avoidable."

Sue Cobey of UC Davis suggests that small scale beekeepers organize in geographically specific groups to increase genetic diversity, agree to stop treating, then requeen or use IPM for susceptible bees. She suggests connecting with a research program that can help establish a viable evaluation and selection program. "If it seems like selecting in the dark," she said, "Well, that's where we are."

Indeed, there is a sense of the blind men and the elephant, with many opinions about the nature of this huge subject. "The key point here," said Vermont beekeeper Kirk Webster, "Is that now there's a viable and growing pool of unrelated, mite-resistant bee stocks and management techniques being used in the U.S. that all beekeepers can test, combine and utilize in their own locations and circumstances. All regions of the country should now be able to move toward really healthy bees and long-term solutions to our beekeeping problems. This is enormously good news."

(Side Bar)

Learning Queen Rearing

- David Tarpy, North Carolina State University, will teach microbreeding and genetics to beekeepers in a class congruent to, but not specifically for, survival stock breeding. The classes will begin in the spring and summer of '09 or '10, depending on staff. To see the schedule, see: http://www.cals.ncsu.edu/entomology/apiculture/
- Marla Spivak will teach the Successful Queen Rearing Short Course, July 10-12, 2009 at the St. Paul Campus, University of Minnesota
- Sue Cobey teaches The Art of Queen Rearing Workshop each spring at the Harry H. Laidlaw Jr. Honey Bee Research Facility, University of California, Davis. For spring '10 see: http://entomology.ucdavis.edu/courses/beeclasses/queenrearing.html

- The Ohio State Beekeepers' Association offers classes for members at various locations across the state: http://www.ohiostatebeekeepers.org/Ohio%20Queen%20Project/ohioqueenprojecc.html

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