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Poland, The Only Country Where Instrumentally Inseminated Queens Are Routinely Used In Commercial Production Colonies

by Sue Cobey, Małgorzata Bieńkowska, Jerzy Wilde, Jakub Gąbka

Poland is unique in that instrumentally inseminated queens, IIQs, are commonly used in production hives, as well as for breeding purposes. Annually, an estimated 50,000 to 80,000 IIQs are produced and sold by commercial queen breeders to beekeepers to head field colonies for pollination and honey production. Beekeeping in Poland has a long history of government support for quality control and selective breeding. For over 40 years Polish law has regulated breeding stocks, farm animal management and reproduction. This effort has resulted in the routine use and perfection of instrumental insemination techniques for honey bees.

Visiting Poland a few years ago, I had the pleasure of being hosted by Dr. Jakub Gąbka, honey bee researcher from the Agriculture University in Warsaw. Jakub spent several months with me at University of California, Davis in 2012. He labored long days and nights in the lab inseminating queens for various research projects and also greatly enjoyed the company of the bee lab crew. Covered in bees during a fun day of making bee beards, his bee bearded face was featured on the cover of ABJ, photographed by Kathy Garvey. I promised to return the visit, looking forward to again seeing Dr. Jersy Woyke, whose early work advanced the use of instrumental insemination at the production level.

This routine use of IIQs in production colonies is impressive. In the rest of the world, instrumental insemination is largely limited to the development and maintenance of breeding stocks and for research purposes. In Europe, especially Germany, most bee breeding programs are supported by the use of isolated mating stations. In some countries, such as Denmark and Sweden, isolated mating is accomplished on islands.

In the U.S., drone saturation of mating areas is practiced, although maintaining the purity of subspecies is of little concern. Most of the major queen producers are clustered, such as in northern California, where diverse sources of drones are inadvertently shared. This contributes to genetic diversity, yet dilutes the characteristics of select breeding stocks.

Honey bee mating behavior is difficult to control and presents a major challenge. Queens mate in flight with an average of 15 to 20 drones, in drone congregating areas consisting of an estimated average of 16,000 drones from 250 colonies. The random, multiple mating behavior of the queen functions to enhance intra-colony genetic diversity, which is well known to increase overall colony vigor and fitness — although this random mating behavior makes it difficult to maintain selected, valued traits with consistency.

In Poland four subspecies of bees are bred and selected: the national bee or the local black bee, *Apis mellifera mellifera*; the Carniolans, *Apis mellifera carnica*; the Caucasians, *Apis mellifera caucasica*; and Italian bees, *Apis mellifera ligustica*. In recent years,

Jakub's colonies at the Parliament in Warsaw.

Jakub, Sue and Jerzy Woyke (left to right) enjoying one of the many parks in Warsaw

beekeepers are also using Buckfast bees, although officially it is not allowed for breeding purposes in the national breeding program.

Two types of breeding programs are conducted in Poland, one focused on the conservation and selection of specific subspecies, the other on the selection of productive hybrids from two or more subspecies. There is an increased interest in conservation programs of the native subspecies. The number of queens evaluated in the hybrid breeding programs is declining.

The National Black Bee Genetic Resources Conservation Program, established in 2000, consists of four lines of *Apis mellifera mellifera*: these are called Asta, Pólnocna (the North Bee), Kampinoska and Augustowska. This program is designed to protect, preserve and conserve the indigenous population. Specific characteristics of the Black Bees are maintained while also selecting for commercially valued traits. Efforts to conserve and increase the number of Black Bee colonies is mainly in north-eastern and central Poland. This effort includes reintroducing the Black Bees into their natural habitat. Also, native to southern Poland is *A.m.carnica*. This Carniolan line is called Dobra, which means "good."

Gosia inseminating queens and Sue collecting bee semen in the Lab in Pulawy

Breeding stocks are evaluated and recorded in the National Breeding Book. Of the breeding material tested, only queens with the highest assessment are recorded and entered in these records. There are 72 breeding apiaries in Poland that offer high quality breeding stocks to beekeepers. Over 95% of breeding apiaries in Poland use instrumental insemination to support their programs.

The national breeding programs have two steps of evaluation; the evaluation of colonies in stationary breeding apiaries and the field evaluation of colonies in production apiaries. The traits evaluated include: honey yield, spring development, swarming, wintering and gentleness. Although not obligatory, some beekeepers also evaluate varroa infestation levels and hygienic behavior. The number of breeder colonies assessed in stationary apiaries increased from 1700 in 2008 to over 2200 in 2017. Of these, about half qualified for registration.

The practical value assessment of breeding stocks also includes the field analysis of the offspring of breeder queens entered in the National Breeding Books. This assessment provides supplemental information on the practical and breeding value of queens selected within the breeding lines and on the recommendations for matings. The field assessment results are published and can be viewed by all beekeepers to help them choose quality queens from the lines and matings that promise desirable characteristics.

There are over 1.55 million colonies kept by about 70,000 beekeepers in Poland.

Beekeepers produce about 300,000 queens annually; of these, registered breeders produce 68% of the queens. Of the unregistered beekeepers, about 32%, produce Buckfast (about 37,000 queens) and *A.m carnica* (about 55,000 queens).

A study estimating beekeepers' stock preferences was conducted between 2008 and 2017 by the Research Institute of Horticulture, Apiculture Division in Pulawy, Department of Bee Breeding. Generally, Carniolans were preferred, used in 45% of apiaries, 14% of apiaries used the national Black Bee and 3.8% used Caucasians.

Krzysztof Loc's Breeding Apiary in Siedlce (Left to Right) Jakub Gąbka, Urszula Cisak, Sue Cobey, Sławomir Rogaczewski, Gosia Bieńkowska, Krzysztof Loc and his wife Małorzata

Of the remaining apiaries hybrids were preferred, the most popular from the crossing of two races, *A.m. carnica* and *A.m. caucasica*, followed by of the crossing of three races, *A.m. carnica, caucasica and mellifera*.

Regional preferences were also observed. In the northern regions of Poland beekeepers prefer and maintain the national Black Bee, while the southern and central regions mostly prefer Carniolans. However, beekeepers also introduce bees of various races and their hybrids; for example, a growing popularity of the Buckfast line was observed between 2006-2010.

To promote increased colony productivity and to enhance the use of quality breeding stocks, the sale of nationally certified queens is subsidized by the government. A government subsidy program was established in the late 1990s and now supports the sale of about 150,000 queens annually, under the National Stock Certification Program.

Among the 72 commercial queen producers in Poland, the use of instrumental insemination is routine, with most preforming this themselves.

There are over 500 Polish beekeepers and researchers trained and certified as insemination technicians. Of these, about 50 are highly skilled and practice this — about 15 at the production level.

Animal improvement has been a major focus of the Polish government since communist times. Dr. Jerzy Woyke's early and prolific work in honey bee mating behavior and instrumental insemination has had a profound influence on Poland's beekeeping industry. His students and colleagues continue to explore, research and apply this specialized and essential technique to beekeeping.

Dr. Małgorzata "Gosia" Bieńkowska and her team at the Division of Apiculture in Puławy operate the leading institution conducting research related to the improvement of insemination techniques. Dr. Jerzy Wilde, at the University of Warmia and Mazury, and bee researchers at the Agriculture University in Warsaw, have also made major contributions to this body of work.

To determine the best practices for production of IIQs, collaborative research efforts have explored various factors influencing queen performance. These include: insemination techniques, the pre- and-post insemination care of queens, age of virgin queens at insemination, carbon dioxide treatments to induce oviposition, optimal semen dosages, practices that improve sperm migration into the spermatheca, and queen introduction methods.

The queen has a narrow window of time for optimal mating, and benefits from active movement and attendance by nurse bees to promote sperm migration and storage. The practice of caging and banking queens and insemination of queens beyond the appropriate age reduces their performance and success. Polish beekeepers utilize beekeeping practices known to increase the success and performance of IIQs.

Sławomir Rogaczewski collecting semen using the Polish Loc-Woyke instrument, designed with the long handled syringe guide

The introduction of IIQs into colonies takes more care and if overlooked can result in poor acceptance. The use of IIQs in production colonies in Poland initially was problematic. IIQs were sold to beekeepers before egg laying was established and when introduced into full size colonies had a high rate of non-acceptance. Pheromonal and physiological differences between virgins, IIQs and naturally mated queens (NMQs), signal their reproductive status. IIQs that have not begun egg laying are often more difficult to introduce.

Significant work on the factors affecting performance of IIQs has been a focus of research in Poland. Dif-

Krzysztof checking the status of a batch of IIQs in his apiary

Sue and Jerzy Wilde at his Lab in Olsztyn

ferent treatments in the care and introduction of queens, both IIQs and NMQs, affect their performance. Recommendations applied, based upon this body of work, have improved the success of IIQs in productive field colonies. To encourage use of quality breeding stocks, the Polish government subsidy supports the sale of IIQs that have been established and laying for 2 weeks. Beekeepers who receive non-laying IIQs first introduce these into nucleus colonies, greatly increasing their success rate.

During my trip to Poland, Jakub arranged visits to see bee researchers and queen breeders. A highlight was seeing Dr. Jerzy Woyke; at 90 plus, he remains active, writing and advising students, and continues to be sought after for his expertise and advice. His keen sense of curiosity, his approach in exploring scientific questions, and his advice continues to be a valuable resource for students and researchers worldwide. Woyke's interests have taken him all over the world exploring the variety of species and subspecies of honey bees. During his career, travel was difficult and resources scarce, yet his curiosity overcame the obstacles. In his house hangs a certification of his climb on Kilimanjaro in 1984, which speaks loudly of his nature.

Jerzy Wilde's apiary of mating nucs in Olsztyn

From Warsaw, we traveled to the government laboratory in Pulawy, the Research Institute of Horticulture. Here the Apiculture Division houses four departments: bee breeding, pollination, bee management and beekeeping technology. Poland participates in the EU community to test and certify product quality of honey, pollen and beeswax. Testing for residues of miticides and the adulteration of honey are conducted. My interest was the breeding aspects. I had the pleasure of finally meeting Gosia Bieńkowska and her team. Gosia inseminates thousands of queens annually and teaches insemination classes. It was a great pleasure to meet her and share experiences of insemination practices.

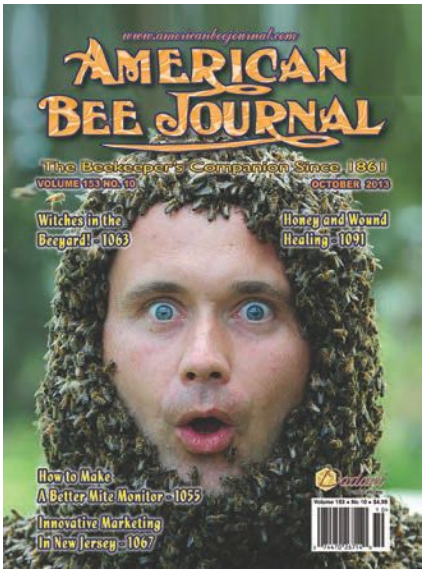
The main research objects of this laboratory include improvement of queen performance by improving queen rearing and insemination techniques and selection methods with a focus on hygienic behavior, resistance to fungal diseases and varroa. Subspecies identification of bees in Poland and the influence of interactions between environment and genotype are studied, exploring the impact of genetic variability on productivity and survivability of bees. They are also monitoring factors of mass colony losses and the changing climatic factors influencing colony development.

Two programs of genetic improvement, working with two subspecies, are conducted at the institute in Pulawy. A Caucasian line, called Cau Puławska, was established in crossing two lines from Russia. A Carniolan line, called Marynka, was established in crossing several lines from Germany, Hungary and Austria. Also, a line of *A.m.mellifera,* originating from Norway, is kept mostly for scientific research.

At the Pulawy laboratory, I collected germplasm (semen) for our Washington State University project to import bee stocks to enhance genetic diversity in the U.S. honey bee population. These stocks are also held in cryopreservation at the WSU Honey Bee Germplasm Repository for future breeding purposes. The Carniolan stock collected has been incorporated into the New World Carniolan program.

We traveled to Siedlce to visit Krzysztof Loc, one of the most renowned commercial queen breeders in Poland. He produces 12,500 IIQs annually. He has scaled down his operation, formerly producing about

Jerzy Wilde explaining his system of tracking the status of queens in nucs using the orientation of bricks, sticks and leaves.



Jakub Gąbka with a bee beard at UCD, featured on our October 2013 cover

twice this number. Krzysztof also supplies virgins and naturally mated queens, as well as laying and nonlaying IIQs. Queen producers in Poland offer a lot of choices in the reproductive status of their queens, addressing customer demand.

I was particularly interested in the insemination instrument Krzysztof uses and produces. This has the long-handled syringe micromanipulator, designed by Woyke**.** Of course, I brought one home to work with. At my request, Krzysztof sent additional instruments with modifications to my preferences. A skilled machinist, he included the forceps pressure grip sting hook and ability to accommodate the Harbo large capacity syringe.

Traveling farther north to Olsztyn we visited Dr. Jerzy Wilde, a full time professor and head of the Apiculture Department at the University of Warmia and Mazury. His current projects include studying ways to speed up the onset of oviposition of IIQs, overwintering extra queens in nucs, and looking at levels of resistance to pests and pathogens among different subspecies of honey bees. He is also involved in the collaborative development of an innovative system to detect and monitor honey bee parasites and pathogens through the use of an "Electronic nose," tackling factors that cause colony collapse disorder.

In addition to his University work, Jerzy Wilde is director of the Apiculture Centre Honey Bee Queen Breeding, a private business that produces 20,000 IIQs annually. His operation was busy with student interns from many countries who came to learn queen rearing and insemination techniques. Students have come from France, Morocco, Nepal, Austria, Germany and across Poland. His operation consists of 500 – 800 colonies for the production of Carniolan queens. Here, I also collected semen to incorporate into the New World Carniolan program.

To complete my trip, Jakub arranged a historical tour of Warsaw, a city devastated by WWII and astonishingly rebuilt, mainly from pictures, to return to the magnificent architecture and history of the country. The streets were lined with flowering trees in full bloom: linden, horse chestnut and locust. The Vistula river runs through the city, a beekeeping paradise with 25% green space. The 98 parks within Warsaw are lush, fragrant and colorful with flowers. The nearby forests are full of wild raspberries and honeydew, and the surrounding fields in bloom with purple phacilia and white buckwheat flowers. On the Parliament grounds, by invitation, Jakub's colonies produce an excellent honey crop. Honey bees and beekeeping are highly valued in Poland.

The use of IIQs in production colonies in Poland is a testament to their performance. The perception that IIQs do not perform as well as NMQs is a long held misconception by many. To help dispel this myth, a review of a series of studies dating from1946 to 2007 clearly establishes similar performance levels between the two groups, based upon brood production, honey production and queen longevity. These comparison studies show the treatment of queens was a major influence. Poor performance is largely due to poor technique, inadequate care of queens, injury and infection, all practices which are correctable, rather than the insemination technique..

The use of proper techniques and proper beekeeping practices yields successful results. Queen productivity and longevity are affected by many factors, from the rearing conditions to the establishment of IIQs to head productive field colonies. The purpose of this article is to build confidence in the use of instrumental insemination. Controlled mating is essential to enable the selection, maintenance and conservation of valuable honey bee breeding stocks. Selective breeding also offers a sustainable approach to maintaining honey bee health.

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An acknowledged international authority in the field of honey bee breeding and instrumental insemination, **Susan Cobey's** focus is enhancement of honey bee stocks and improvement of colony health through selective breeding. She works with Washington State University on the germplasm importation project and runs Honey Bee Insemination Service, offering training, specialized equipment and insemination services. Founder of the New World Carniolan Closed Population Breeding Program, she has maintained this stock for 36 generations.