OP-250 [Beekeeping Technology and Quality]
What's the best queen ? It depends ! A fitness based hybrid recommendation system for beekeepers

Nicolas Coallier, Maxime Fraser Franco
Nectar Technologies

Commercial beekeepers have access to a variety of queen providers and genetics. Performance of a genetic is highly dependent on its context making the performance of queens highly variable for beekeepers. Indeed, in evolutionary ecology, the performance of different genotypes and/or phenotypes is often defined in terms of fitness. Fitness can be described as the survival of the form that will leave the most copies of itself over successive generations. To address this issue, we've built a queen recommendation system from the Nectar database In this dataset, over 132 000 colonies are tracked on a daily basis by commercial beekeepers and present at least one queen type during its lifetime. Additionally, beekeepers will annotate the state of the colony and most beekeeping practices. The survival of the colony and the queen is also tracked and allows us to build performance metrics for each queen. We've built a fitness score based on the hive survival and the number of days spent in each location. We parametrized the location data using weather, air quality and landscape features. In the context of an hybrid model, these features will be used as input features for a deep learning model to parametrize the content. The target variable for the collaborative filtering side was built using a simple approach where we sum the days of each hive that pass by a yard and survive while we reduce the days spent at the yards when the hive ends up dying. The model then outputs the expected best match between location and queen type. For the baseline retrieval model, the true positive is in the top 5 retrieved items 35% of the time. This approach allows us to parametrize queen types to provide recommendations based on their provenance, the introduction period, the dominant genetics of the queen, and the type of yard in which we can expect these queens to perform better. This system can guide beekeepers to select queens that will perform well for their needs and context rather than trying to find a queen that works for all.

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What's the best queen ?
IT DEPENDS

A Queen recommender system

SEPTEMBER 2025

APIMONDIA SCANDINAVIA 2025
SWEDEN | DENMARK | NORWAY
23-27 SEPTEMBER

The universal best queen doesn’t exist

Performance of genetics depends on many factors

Evaluating queen performance – a focus on ecological fitness

“How well an organism's characteristics and behaviors enable it to survive and reproduce within a specific environment”

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How can we recommend a queen based on fitness ?

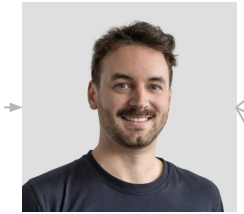
Recommender system 101

Netflix's use of collaborative filtering

Watched

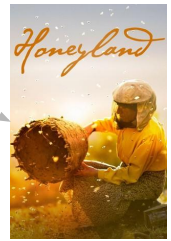
Watched

Similar Users



Watched

Watched



Watched

Likely to watch

Netflix's use of collaborative filtering

Survived the visit

Similar Queens

Survived the visit

Survived the visit

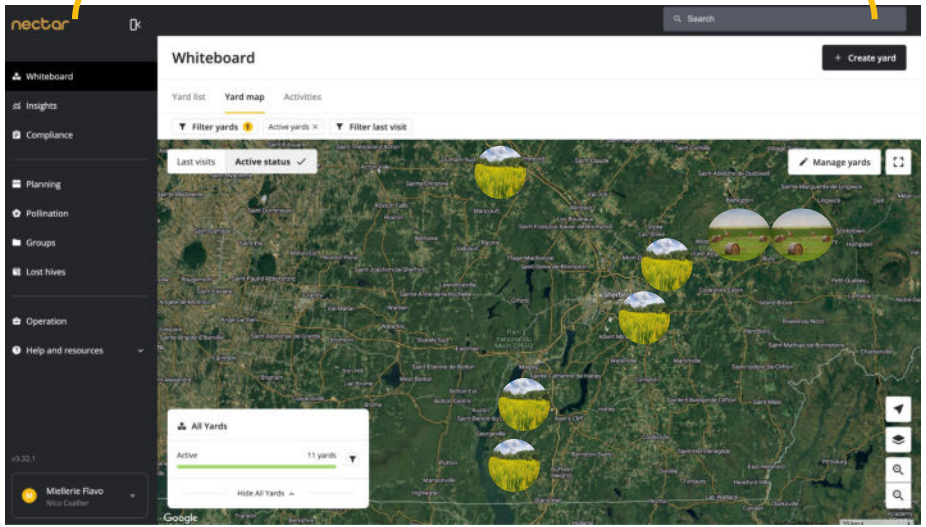
Survived the visit

Survived the visit

Likely to survive the visit

We can then either recommend queen by locations

Recommended Queen



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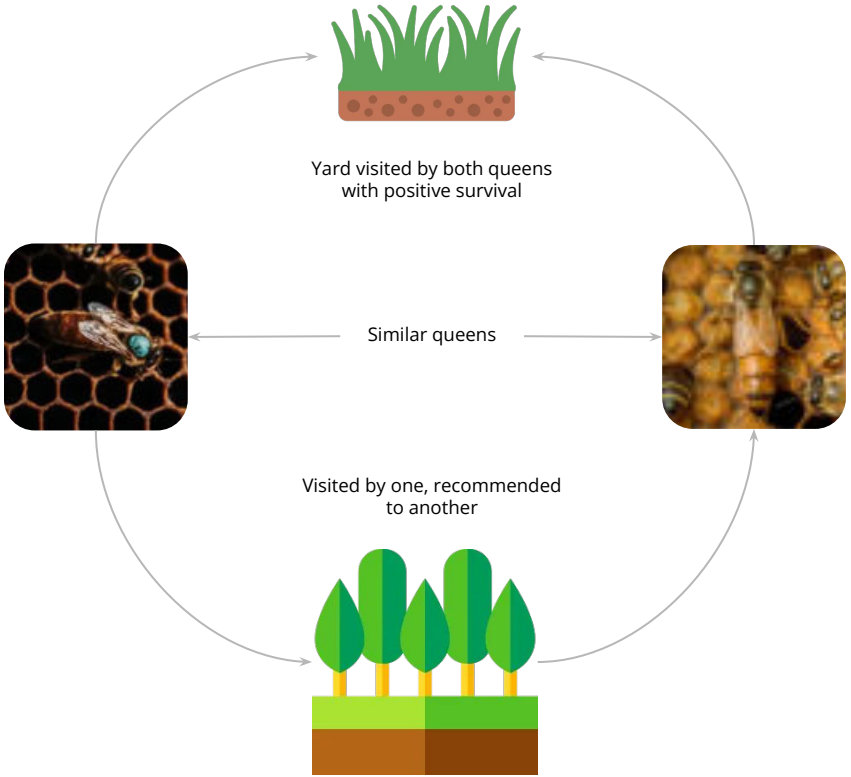
Fitness-based queen recommender system

Forget movies...



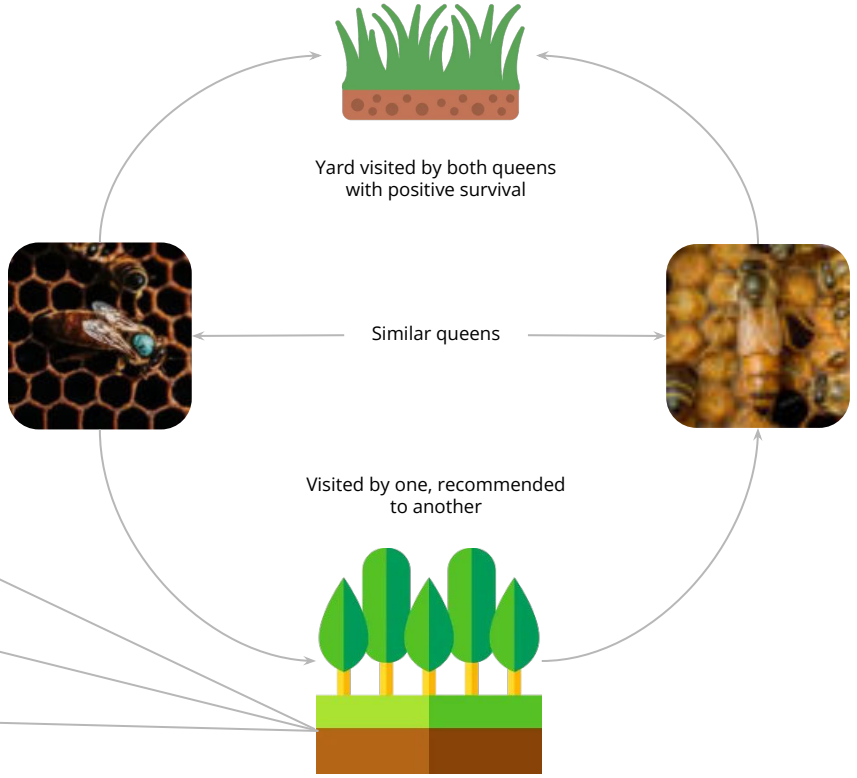
Precipitation

Wind speed

Temperature

AQHI

Satellite images



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Recommend me a queen!

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BEEFLIX

Browse Hives | My Queenlist | Hive Originals

You might also like:

The Honeycomb Heist, Buzz-Lightyear, and Bee Movie

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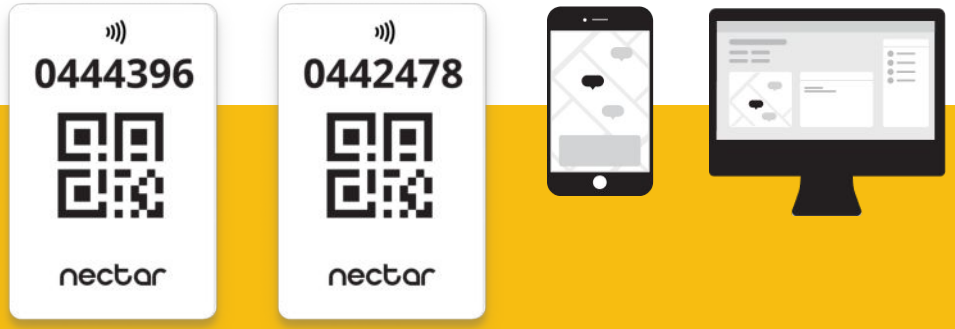
300k colonies tracked across 70 operations

Canada, U.S., and New Zealand!



Nectar queen recommender system, data description

12 operations

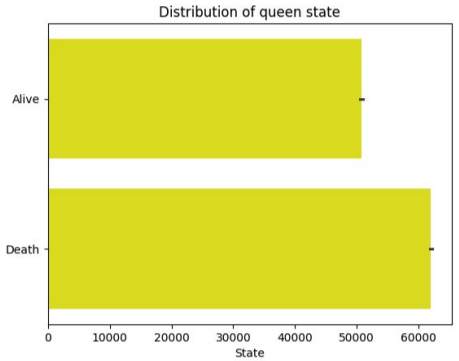
82,428 hives

216 queens

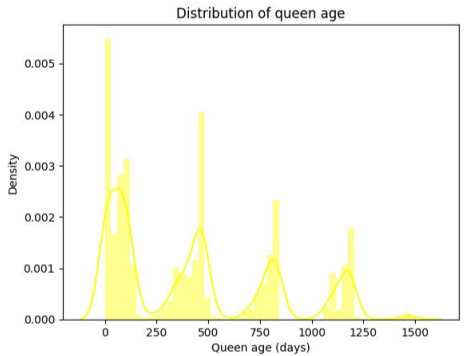
4,193 yards

110,440 queens history

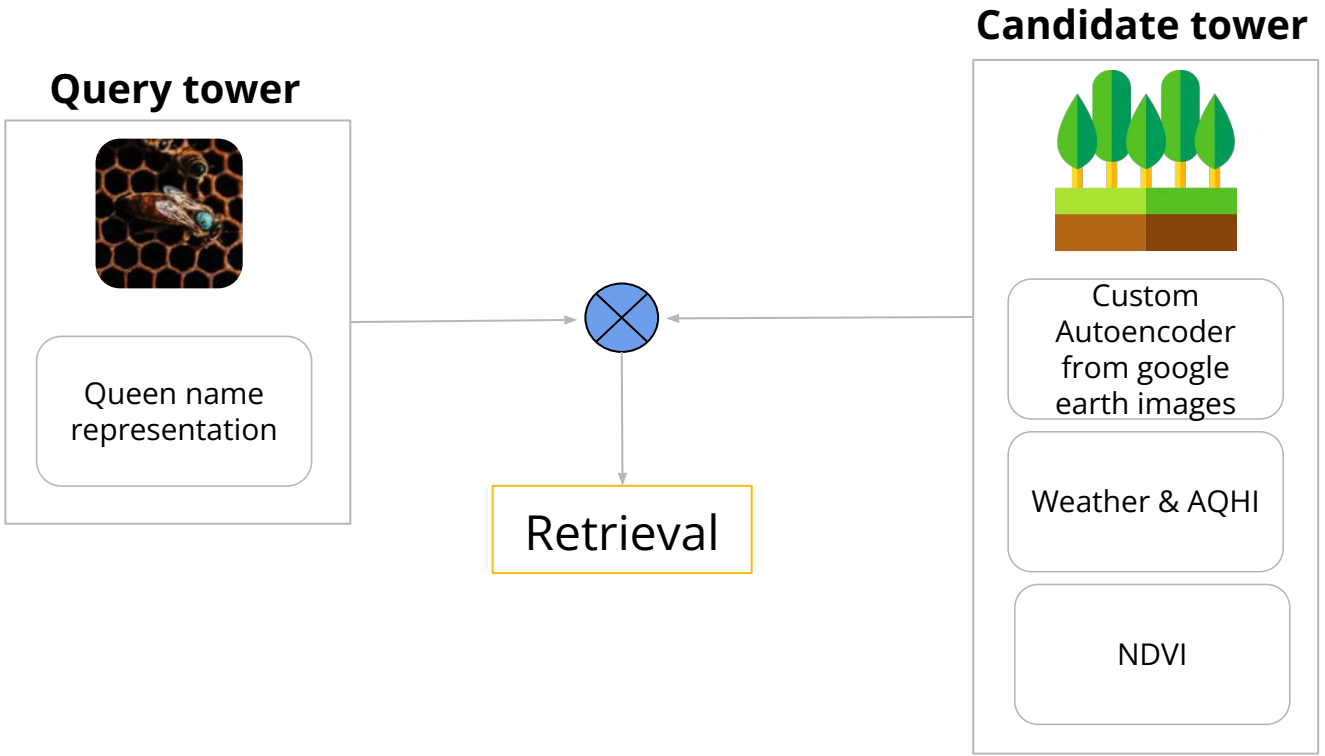
39% of queen alive as of today



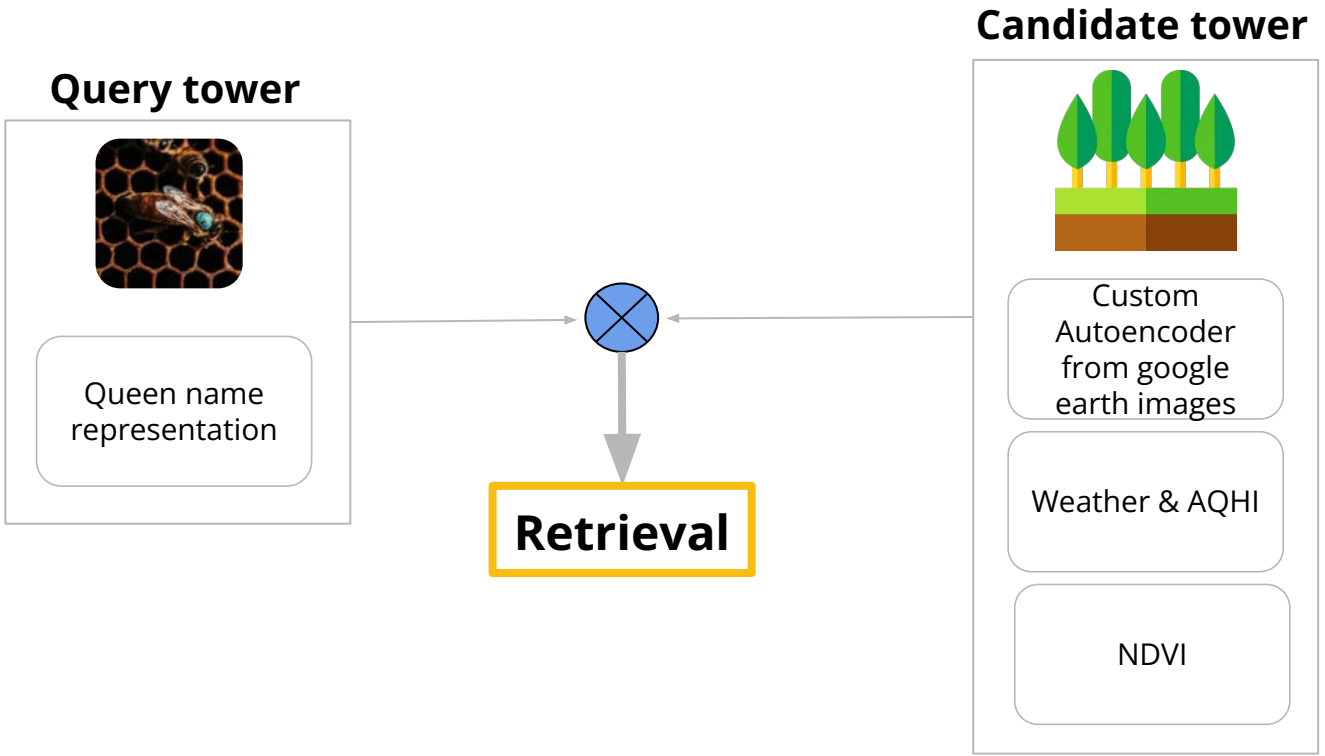
424 days in average alive



Nectar queen recommender system, overview of architecture

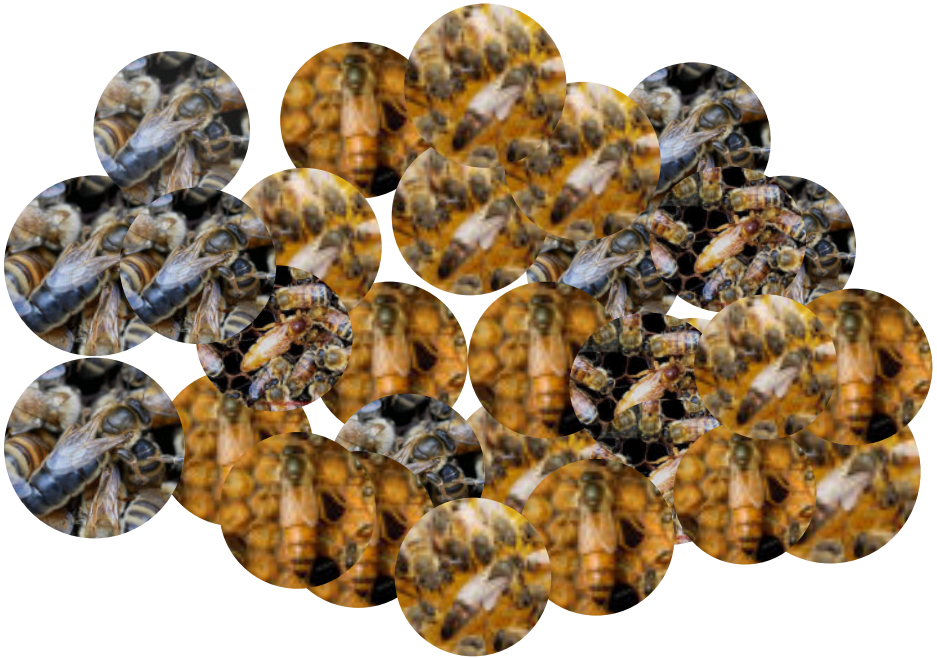


Nectar queen recommender system, overview of architecture



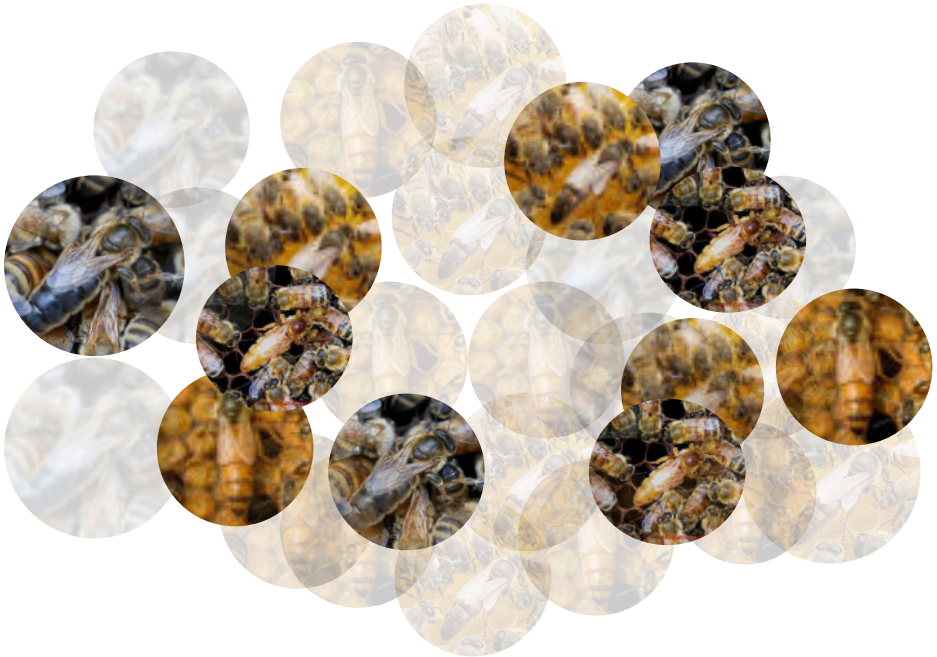
Two-Tower Architecture:

Pool of queens to select from for a given yard



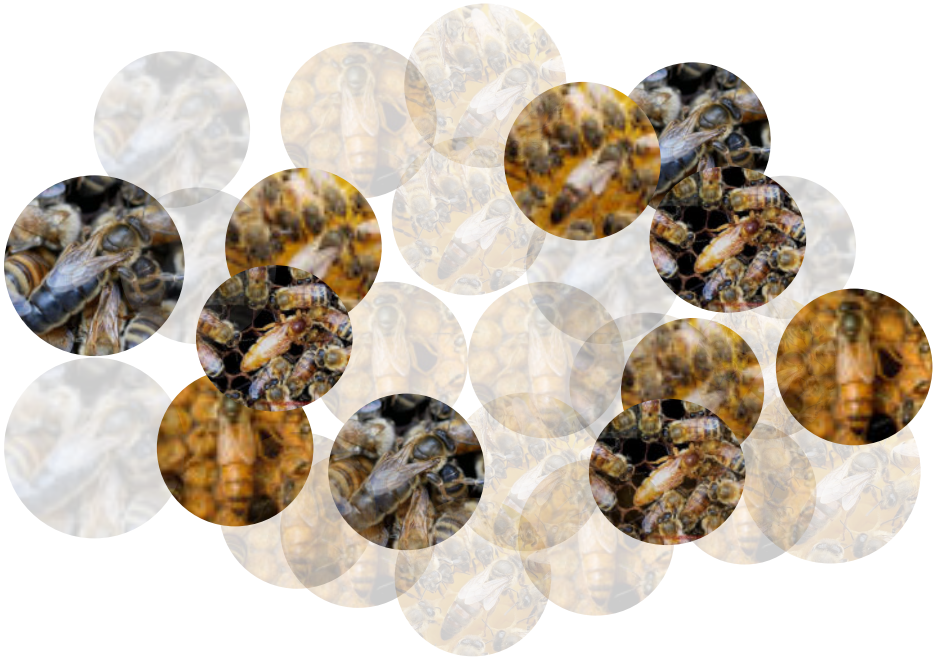
Two-Tower Architecture:

First Model Identifies the Best Queens Candidates



Two-Tower Architecture:

First Model Identifies the Best Queens Candidates

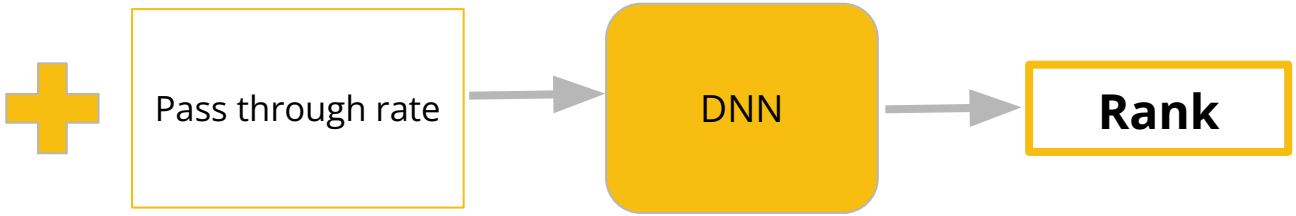


Model Performance:

78% of the Candidates retrieved have high-fitness for the selected location

Fine tune ranking achieved higher performance

- Once we fine tuned on the pass through rate, we increase our **performance to 90% top 3**



Pass Through Rate = Queen rating

Stayed 90 days

Stayed 50 days

Stayed 10 days

Stayed 140 days

Stayed 90 days

Two-Tower Architecture:

Second Model Ranks the Candidates for Ecological Fitness

Two-Tower Architecture:

Second Model Ranks the Candidates for Ecological Fitness

Model Performance:

90% of the top 3 Rank retrieved has high-fitness for the selected location

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Use cases and discussion

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Couple use case and improvements....

Provide a queen **fitness score** prior to buy. Huge potential in a network effect (Nectar Amazon)

Extend **the queen representation** by leveraging history on the colonie and **beekeeping practices**

Extend **the rating score** by leveraging honey data and mite loads.

Reverse engineer the model to determine **best hives to breed queen** from in regards to your context (habitat...)

Integrate crop predictor , recommend best queen to introduce in regards to the plan pollination events.

Recommend movement of colonie based on the queen fitness match with their current and future location

Contact me
nico@nectar.buzz

Thank you !

Tauzer Apiaries	OHB	Evergreen Honey Company	Merrimack Valley Apiaries, Inc.	Miller Honey Farms	Busy Bee Farm Ltd.	Noyes Apiaries
Island District Honey Company	Barkman Apiaries	Belleville Honey	Royal Honey Company	Sustainabee	Beaverhead Honey	Prescott Honey Farms
Lamb's Honey Farm	St Joe Valley Apiaries	Foothills Honey	Beelogic Enterprises Farms	Moyen Honey Farms	Old Florida Bee Company	Pure Honey Drange Apiary
interMiel	Beetopia	Wolfe Honey Alberta · Canada	California Apiaries	Le Miel d'Émilie	Hill & Ward Apiaries Inc.	
Sowers Apiaries	Shoreline Honey Farm	Can-Am Apiaries Inc. Orland	Moore Honey	Honey Bees Unlimited	Stayer's	307 Honey

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Annexe and supporting papers

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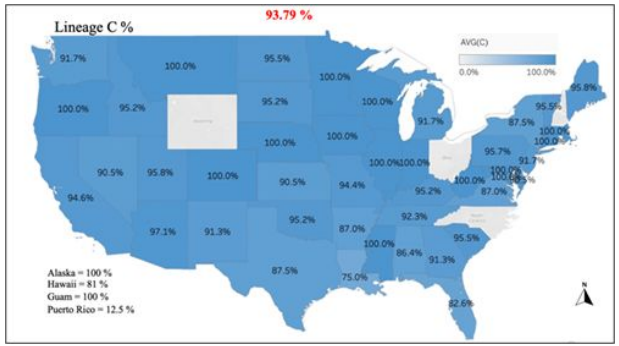
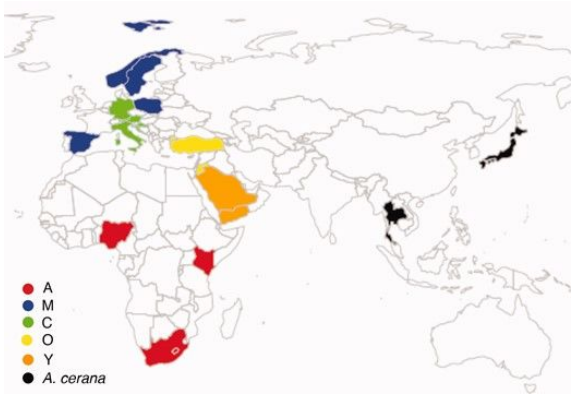
Honey bee diversity in North America is extremely small



The domestic honeybee isn't native from North America and most ferals colonies can’t survive without human interventions
→ In Northern climate, feral colonie would die in the winter.



The genetic pool is therefore highly dependent on bees importation and survival amongst managed colonies.
→ 94% from the lineage C which correspond to Italian honey bees

The influence of genetic origin and its interaction with environmental effects on the survival of *Apis mellifera L.* colonies in Europe

Ralph Büchler, Cecilia Costa, Fani Hatjina, Sreten Andonov, Marina D Meixner, Yves Le Conte, Aleksandar Uzunov, Stefan Berg, Malgorzata Bienkowska, Maria Bouga, Maja Drazic, Winfried Dyrba, Per Kryger, Beata Panasiuk, Hermann Pechhacker, Plamen Petrov, Nikola Kezić, Seppo Korpela & Jerzy Wilde

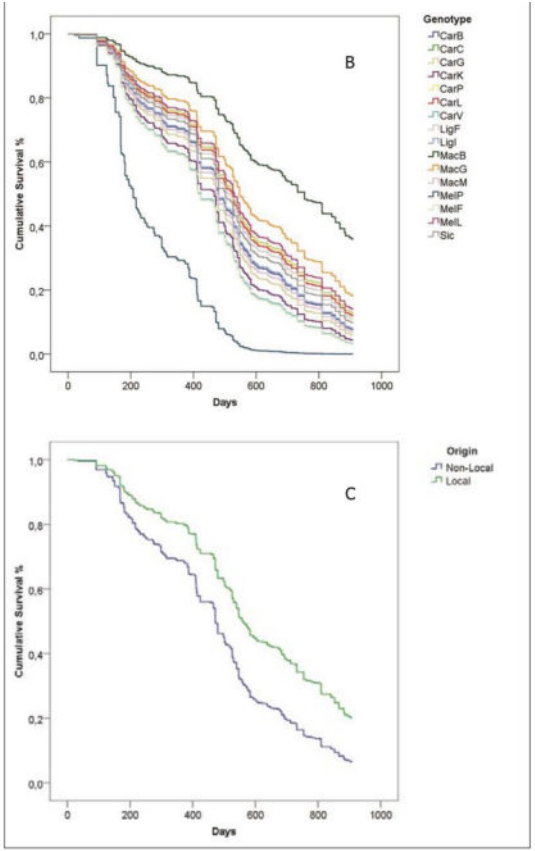


Fig. 1. Trajectories of colony survival for the different locations (***A***), genotypes (***B***) and the origin of queens (***C***) during the experiment.

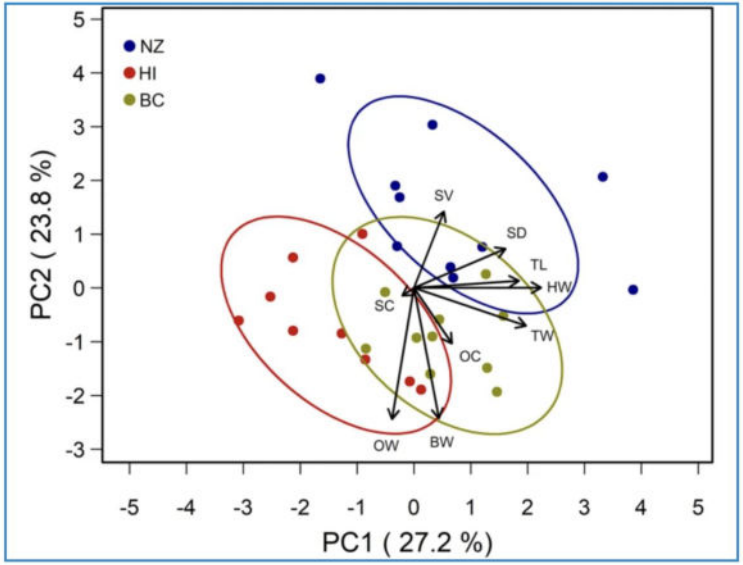
Article | Open access | Published: 12 October 2023

Queen quality, performance, and winter survival of imported and domestic honey bee queen stocks

L. A. Holmes ✉, L. P. Ovinge, J. D. Kearns, A. Ibrahim, P. Wolf Veiga, M. M. Guarna, S. F. Pernal & S. E. Hoover

Scientific Reports **13**, Article number: 17273 (2023) | Cite this article

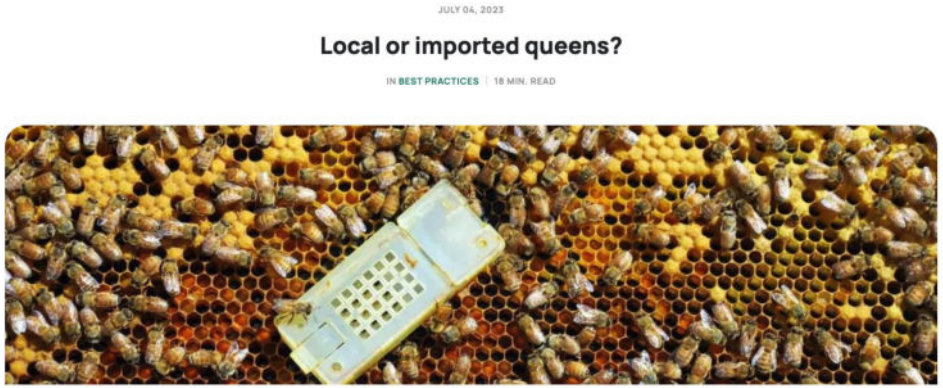
Figure 1

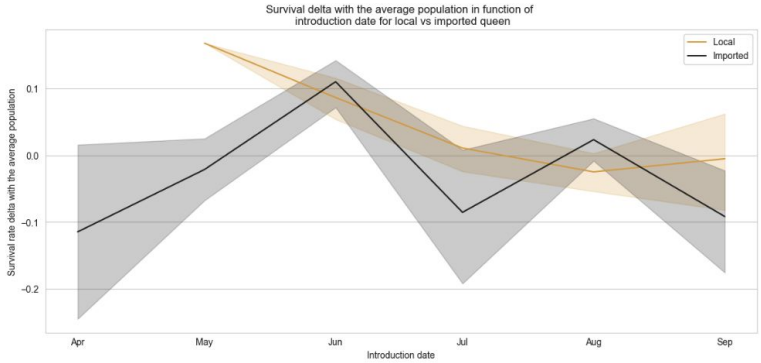


Principal component analysis on queen morphological traits including thorax length (TL), thorax width (TW), head width (HW), body weight (BW), ovariole count (OC), ovary weight (OW), sperm count (SC), spermatheca diameter (SD), and sperm viability (SV) from three queen stock sources, British Columbia (BC), Hawaii (HI), and New Zealand (NZ) in yellow, red, and blue, respectively. The variation in queen morphological traits explained by principal components one and two are indicated in parentheses. The figure shows that head width, thorax width, thorax length, and spermatheca diameter were most correlated with PC1. Body weight and ovary weight were most correlated with

Genetic is important but good queen rearing practices seems more

As we showed in this blog post, the beekeeping practices and the type of beekeeping done by the breeder seems to have more importance on the queen survival and fitness than the origin of the queen (breeding location or genetics).





Nectar queen recommender system, in actions !

Provider A

Provider B

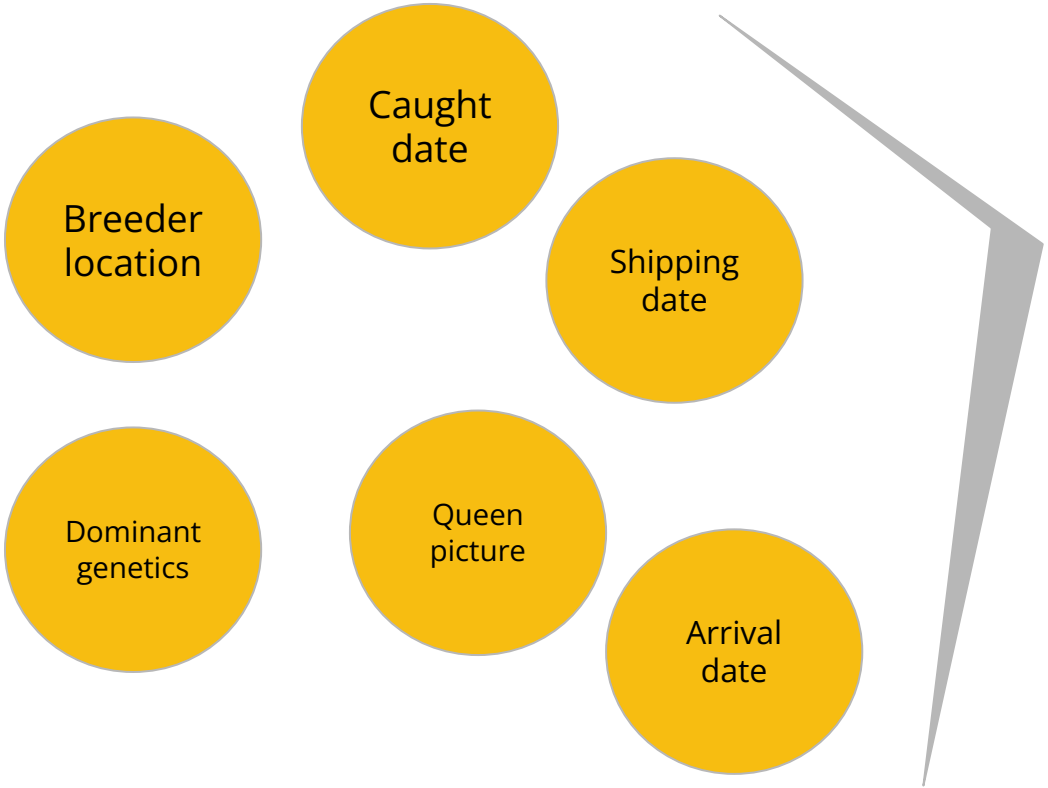
Provider C

Retrieve

Rank

Queen	Ranking score
Provider A	**88.23**
Provider B	67.15
Provider C	15.02

Metadata on queen that could provide high ROI



Network effect:

- OHB sales queen to Tauzer
- We could capture all this information and highly improve our understanding of drivers of performing queens

Parametrization of queens:

- Allow us to discriminate between breeder practice, freshness, genetics and all attributes of the queen currently gather under a simple name