

PLOS AMA: Hi reddit, we're Andreas, Matthew, and Martin and we discovered changes in the honey bee genome that determine adaptation to high-altitude forest habitats – Ask us anything!

PLOSScienceWednesday<sup>1</sup> and r/Science AMAs<sup>1</sup>

<sup>1</sup>Affiliation not available

April 17, 2023

[REDDIT](#)

# PLOS AMA: Hi reddit, we're Andreas, Matthew, and Martin and we discovered changes in the honey bee genome that determine adaptation to high-altitude forest habitats – Ask us anything!

PLOSSCIENCEWEDNESDAY [R/SCIENCE](#)

[removed]

---

[READ REVIEWS](#)

[WRITE A REVIEW](#)

## CORRESPONDENCE:

### DATE RECEIVED:

June 15, 2017

### DOI:

10.15200/winn.149744.48231

### ARCHIVED:

June 14, 2017

### CITATION:

PLOSScienceWednesday ,  
r/Science , PLOS AMA: Hi  
reddit, we're Andreas,  
Matthew, and Martin and we  
discovered changes in the  
honey bee genome that  
determine adaptation to high-  
altitude forest habitats – Ask us  
anything!, *The Winnower*  
4:e149744.48231 , 2017 , DOI:  
[10.15200/winn.149744.48231](https://doi.org/10.15200/winn.149744.48231)

© et al. This article is  
distributed under the terms of  
the [Creative Commons](#)  
[Attribution 4.0 International](#)  
[License](#), which permits  
unrestricted use, distribution,  
and redistribution in any  
medium, provided that the  
original author and source are  
credited.



What can you tell us about how the high-altitude bees use oxygen more efficiently than their lower-altitude buzzing counterparts?

[clavmike](#)

Matt: Actually we do not know whether the high-altitude bees have any adaptations relating to oxygen usage. We think that the adaptations are related to different foraging strategies in mountain forests compared to lowland savannas.

What can you tell us about how the high-altitude bees use oxygen more efficiently than their lower-altitude buzzing counterparts?

[clavmike](#)

Martin: Currently, no physiological data are available to answer this question correctly. One might assume, however, that certain metabolic advantages are associated too, in which oxygen usage plays a role.

Can your research be used to help honeybees in other areas where they're struggling?

[CarinasHere](#)

Matt: African bees are interesting because they seem to be more tolerant to the Varroa mite, which is responsible for a lot of colony deaths. In general, African bees are also more aggressive, so not so desirable for beekeeping. The African mountain bees are however more gentle, so could be beneficial to use in beekeeping.

I noticed that the subject of bee populations (including colony collapse disorder, etc) has been an issue

for awhile now - I remember learning about it during my first year over at uni back in 2012. How has science and policy done since then? What I mean is that, in general, how much has been done since then? Are we on the right track in tackling the issue?

[hundredwaves](#)

Matt: There are many different factors that can cause colony losses and research is progressing along multiple lines. It seems that the varroa mite is an important factor and work is being done breeding bees that are more resistant to it. Scientists are also trying to evaluate the full impact of pesticides.

Hey guys, could you possibly elaborate on what a super gene is and what advantages these have for environmental adaption?

Edit : what made you guys choose these fields?

[pinwheeltwist](#)

Matt: A supergene is a region of a chromosome that contains many genes. Multiple mutations in these genes work in concert to produce a particular adaptation.

Hello Gentlemen! It seems I have found your post in the nick of time, I am about to purchase my first hive and I live in high mountains. My mountains are 7k feet and are located in Southern California, so the weather seasons do not get as extreme as the Rockies or the Sierras, however we still do get snow. My question is- Should I change the type of bee to the East African species to establish a healthy hive at 7500 feet?

[littleporcelaindahl](#)

Andreas: In the unlikely case that you would be able to get hold of live East African mountain honey bees, I would strongly advice against importing them due to ongoing struggle with Africanized honey bees in the US. Check with the local authorities first.

However, I think it sounds like a very exciting and interesting project to establish your own apiary in such an environment!

I suggest getting bees from a local experienced beekeeper that have perhaps already been selecting colonies for high productivity in your area and climate. Genetic variation is fairly high among honey bees (higher than in humans and many other domestic species), so it is perfectly possible that there as been some degree of "artificial" selection by beekeepers in favor of bees that do well in this climate. The "genetic architecture" (genes involved) in independent instances of highland adaptation could be very different, and depend on the genetic material that is available to select from.

Good luck!

PS. When you get going, start a blog and share your very much non-urban beekeeping experiences with the world :-)

Hello Gentlemen! It seems I have found your post in the nick of time, I am about to purchase my first hive and I live in high mountains. My mountains are 7k feet and are located in Southern California, so the weather seasons do not get as extreme as the Rockies or the Sierras, however we still do get snow. My question is- Should I change the type of bee to the East African species to establish a healthy hive at 7500 feet?

[littleporcelainidahl](#)

Matt: It's quite possible that East African mountain bees would do well up there, but they are not so easy to get hold of.

Are these super genes extremely prone to mutation? How are they useful for the honeybee population's adaptation?

[WolfBangAlpha](#)

Martin: I would not see that these super genes are extremely prone to mutation, rather one might argue that there is a higher fixation rate of beneficial mutations. The concept of super genes implies a benefit of linked haplotypes/genes to the individual.

Are these super genes extremely prone to mutation? How are they useful for the honeybee population's adaptation?

[WolfBangAlpha](#)

Andreas: super genes may not necessarily be prone to accumulate base mutations at a higher rate than the rest of the genome. However, super genes are often found to be made up of a long block of DNA where individuals are "structurally" different from each other. For instance, the DNA block could be inverted (run in the opposite direction) in some individuals, compared to others. One possibility for the origin of such blocks is that the particular DNA where this happens is very repetitive, causing the DNA copy machinery operating during cell division to make a mistake when copying the chromosome. If this is the case, it is possible that something could happen to the block again, i.e. that this is an instable part of the genome and that the size and shape of the super gene may continue to change over time.

Beekeeper, in Salt Lake City, UT here... does this finally mean that I can have killer bees in my climate? You know once the mountain African bees are breed with European bees...

[jackkerouac81](#)

Andreas: I am sorry I do not have full insights into the current situation regarding the northern limits of Africanized honey bees (AHBs) in the US. From a quick look at the web resources of the Utah Department of Agriculture and Food and the Utah County Beekeepers Association it seems as if AHBs are still rather rare and mostly restricted to the southern parts of Utah. It is possible that AHBs may spread further north and become more prevalent in Utah in the future and mix with European bees, as seen in other parts of America. Perhaps a warmer future climate could accelerate this process.

However, this process will be occurring independently from any mixing between the African mountain bees and European bees, as these mountain bees are restricted to African highlands. Furthermore, we have not detected the unusual genetic variants that are likely responsible for adaptations to cold African highland environments in any bees outside of Africa (not even in the European bees). Although we have not surveyed AHBs in detail in this study, I would say that it is very unlikely that these particular variants are present among AHBs in the US.

Thanks for the great question!

Beekeeper, in Salt Lake City, UT here... does this finally mean that I can have killer bees in my climate? You know once the mountain African bees are breed with European bees...

[jackkerouac81](#)

Matt: The African mountain bees can survive in cooler climates than regular Africanized bees, but they are also not as aggressive. Also, I don't think any African mountain bees have been brought to USA. So I think you need a warm climate to get killer bees.

How do the adaptations express physically? Is it more behavioral as in foraging, storage and brood raising tendencies?

[EJNettle](#)

Martin: We are going to elaborate this question further in the near future. What is known so far, that mountain bees e.g. can start forage at lower temperature. This is clearly a big plus.

I did not read the entire paper, so forgive me if this is answered within, or I if I make an incorrect assumption.

Given that super genes are linked together and also under selection, do you still see signatures of something like selective sweeps with neutral linked loci? If so, what implications might this have about how coding regions are created/maintained with respect to the genetic architecture of the genome?

I'm thinking that it seems more likely that large linked regions under selection are formed after the fact (i.e. the loci are adaptive and then stuck together, something like chromosomal inversion causing linkage disequilibrium) rather than changes occurring to the loci after they are already linked. This would imply that something like ecological speciation (or any mechanism that promotes linkage disequilibrium as described) could explain the existence of these supergenes.

My question is: do you suspect that the supergenes are the product of speciation/adaptation, or the cause of speciation/adaptation? Bit of a chicken or egg question, I know.

Thanks!

[monsieurintrovert](#)

Martin: Thanks - good point! From the data we see in our study that this haplotype blocks seems to be very old, likely predating the differentiation process of the subspecies in *Apis mellifera*. As we have here a chromosomal inversion that might happen quite suddenly, I favor to say that's supergene is causing adaptation.

Are highland bees less at risk than lowland bees from whatever environmental impact is effecting the worlds honeybees right now? Or are they all safe in that area of the world?

Also, how long does it take a bee to evolve to fit its environment?

[live1213](#)

In fact, we should worry about the highland bees due to the ongoing deforestation in the region of Kenya. In terms of climatic changes, the hot and dry seasons, that seems to be occur more frequently in that region, will in addition harm the mountain forest.

Can genomic modifications possibly prevent colony collapse?

[MolecularAnthony](#)

Martin: As for the moment cc is rather a complex and yet unsolved issue, I don't see how and where genomic modifications should help.

Hello all,

As a research technologist in genomic research and next-gen sequencing, how were your samples processed? I'm curious if you completed de-novo genome sequencing or something less costly/time consuming such as SNP or Microsatellite analysis to determine the difference between subjects. New technology at a lower cost can perform whole genome sequencing now a days! Super curious, because I only work with human and mouse samples with a lot of genomic data already!

Thanks!

[DiosaRubia12](#)

Martin: We have done whole genome sequencing and used the available Honey bee genome version as reference.

Hello all,

As a research technologist in genomic research and next-gen sequencing, how were your samples processed? I'm curious if you completed de-novo genome sequencing or something less costly/time consuming such as SNP or Microsatellite analysis to determine the difference between subjects. New technology at a lower cost can perform whole genome sequencing now a days! Super curious, because I only work with human and mouse samples with a lot of genomic data already!

Thanks!

[DiosaRubia12](#)

Matt: The study is based on whole-genome sequencing of 39 mountain bee samples that were mapped to the honeybee genome reference sequence in order to identify variant sites.

To what extent are these genetic changes adapted to attitude vs. the plants you find at altitude?

[sruffian](#)

Andreas: While most of the traits that have been documented about the mountain bees have been interpreted in the context of altitude and temperature (abiotic factors), it is very much possible that adaptation to biotic factors such as local flora, the length of the flowering season and/or risk of predation or infection could be just as important for bees to survive in the highlands.

Our finding suggests that some gene variants which are important to memory formation and foraging behavior are very different in the mountain bees. Whether these variants are mostly related to physiological adaptations towards say lower oxygen or temperature levels or to different scouting or foraging behaviors to match different distributions of resources in African mountain forests compared to savannas is pretty much unknown I would say.

The next step in this kind of research is to observe the bees in their natural habitats more closely and perhaps even move colonies between different local conditions to see how they respond depending on which gene variants that they have.

Great question!

My understanding is that insect respiratory system is highly diffusion dependent, and not efficient at extracting oxygen at low concentrations. This is one reason why giant insects only existed during time with high  $F_{iO_2}$ .

Do these mutations allow for greater oxygen extraction, meaning that these bees could eventually become larger at lower altitudes, assuming there is some sort of evolutionary pressure for larger size?

[PussyStapler](#)

Martin: Actually, the larger bees are found in the high altitude - so the other way around you are proposing. Good point to think about more into the physiological benefits too.

I think we have all been told that honeybee population has been declining over the past decade, but I personally haven't been informed of any changes I can make in my life to prevent honeybee deaths. Do you have any general advice for people who want to help honeybees of all altitudes?  
Thanks!

[BenjaminReed](#)

Matt: plant a lot of flowers in your garden!

I think we have all been told that honeybee population has been declining over the past decade, but I personally haven't been informed of any changes I can make in my life to prevent honeybee deaths. Do you have any general advice for people who want to help honeybees of all altitudes?  
Thanks!

[BenjaminReed](#)

Andreas: you can help honey bees and other pollinators such as bumble bees, solitary bees and butterflies by planting flowers and plants that produce rich nectar, leave some parts of your garden unmanaged (many insects like to build nests among old leaves and branches) and put up bee hotels (for solitary bees and other insects).

Do you think that CCD as a behaviour is a sign that bees need to swarm to create more genetic diversity to cope with all the diseases and pressures they are being put under?

[tightlyslipsy](#)

Matt: I think the queen is usually still present in a CCD hive, which doesn't happen when swarming. So most likely the colony has not reproduced.

what are the potential practical applications of this discovery?

[pahnkayx](#)

Martin: 1.) That we have learned how evolution can drive local adaption in different systems, including bees. 2.) That we see, that these mountain bees have some unique genomic feature associated to their - highly endangered ! - mountain environment. So- very pratical, we have arguments to foster conservation management programs in that region.

Given the importance of epigenetics in honeybees (HDACs in the royal jelly etc) did you see any epigenetic variance based on habitat? Did you look at how these supervene changes impacted transcription?

[greengreenyellow](#)

Martin: Good point, - this is exactly what we are doing next!

How similar are the East African honey bees to those of other areas in the world? Have you seen these "supergenes" in other populations of bees, but more infrequently?

Dr. Martin Hasselmann I'm currently studying down the road at HFT - Stuttgart

[cg1bs](#)

Martin: We found these particular haplotypes not outside Africa anywhere else and at very low frequency in parts of south africa. Best to HFT S.!

You two are awesome! I want to start beekeeping in a residential area but don't want to bother any neighbors. Any suggestions on how to do this?

[MikeDinSD](#)

Martin: Thanks - Maybe you start 1.) asking a beekeeper to obtain kind of gentle bees and 2.) Say hallo to your neighbor, and provide them with all the benefits of more pollinator in the area. They will like it. 3. ) A glas of honey at the end of the season for them.