

PLOS Science Wednesday: Hi reddit, my name is Brian and I published a study in PLOS Biology showing birds in the tropics have greater genetic variation than those in more temperate habitats – Ask Me Anything!

PLOSScienceWednesday ¹ and r/Science AMAs¹

¹Affiliation not available

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[REDDIT](#)

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Interesting study! What do you think the reason for this might be? What factors can cause genetic diversity to change in an area?

[hatmonkey3d](#)

Thank you everyone for your questions!

We speculate that the pattern is caused by long-term (millions of years) climatic instability. If populations cannot persist over evolutionary time because environmental conditions deteriorate then it is expected that genetic diversity will be lost.

I congratulate you for the great work. I am still reading the paper, but I have one query which if you could answer by dumbing down to my level will be helpful.

You mention combining species complexes as single species, won't that increase the genetic variation? Won't truncating ambiguous species group give you cleaner data?

[moronicverses](#)

Great question. You are correct, combining species into a single large super-species will increase genetic diversity. Combining species will also increase the age of the super-species. Therefore, in all our analyses we controlled for the age of the species.

I congratulate you for the great work. I am still reading the paper, but I have one query which if you could answer by dumbing down to my level will be helpful.

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[moronicverses](#)

Thanks. Species are one of the most difficult aspects of a comparative study like ours. Scientists continually debate about species. There is no easy solution to the "species" problem. That is why we used alternative groupings of species.

My question actually focuses on your position at AMNH: do you experience any issues with parasites in the specimen archives? I'd imagine all that plumage would be a nice place for mites etc to cozy up. If so, what steps does the Museum take to prevent/mitigate damage?

[true_spokes](#)

Indeed, next to some kind of catastrophic event like a fire, specimen damage due to insects is a collection's principal concern. However, parasites are not the primary culprits as these tend to die or leave the host shortly after it is collected. Its usually fly or beetle larvae we have to worry about. First, our specimens (rounds skins aka stuffed birds) are dried in the field and we remove as much excess tissue as possible to reduce the chances that, for instance, a fly will decide to lay its eggs and have its larvae grow up on the specimen. All the specimens are also stored in sealed cabinets in climate-controlled rooms to further reduce risk of exposure to insects. If we do find any evidence of a cabinet with specimen damage, we immediately fumigate it and seal the cabinet for a week or more to ensure any insects are dead.

Hi Brian,

This is a fascinating study. In my ecology class we were studying the birds of paradise and their astounding diversity. I had this exact question during class, so I am excited to see that there is a study on this topic.

My questions is do you think that the increased UV ray exposure around the equator has a significant effect on the diversity of these birds? I imagine that increased exposure may lead to more damaged DNA/cells, and therefore, more errors in the replication/translation process, which then leads to an increase in variance.

I do not know the exact effect of UV rays on DNA, so I apologize if this is a dumb question.

Thank you!

[Las_papas](#)

Good question. For mutations caused by solar radiation to have an effect on genetic diversity with species the mutations have to occur on the germ cells (eggs & sperm). These cells are stored safely inside the body cavity and are not exposed to solar radiation. More generally, birds in the tropics don't necessarily have greater UV exposure than birds in the temperate zone. Much of the diversity is found in the Andes where there is often cloud cover and many are understory species that avoid light. But definitely something to study!

Hi Brian,

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Thank you!

[Las_papas](#)

Thanks.

There has been some work on latitudinal variation in mutation rates but to get closer to the answer a lot of work will be required. There is evidence that would suggest mutation rates would be faster in the temperate zone because temperate birds have faster metabolisms. Photo periods would be tied to this.

Hey Brian, fascinating subject. My question is with climate change reshaping the tropics and it's climate. Would you say the effects might result in greater or less genetic variation for the birds that inhabit it?

[Archer2408](#)

Thanks!

Human-induced climate change will definitely have an impact of genetic diversity on birds. However, there is a lag-time in an event that reduces population size and the loss of genetic diversity. If the effects are moderate we may not see changes for a long time.

Which traits between species have the most variety? The least?

[WolfBangAlpha](#)

In general, the outward appearance of birds (plumage, bills, etc.) or their songs have the most variation. Internal anatomy and internal skeletal feature have the least.

What traits appear to be preserved despite all of these variations?

Have you found any association with the shade of the feathers with any environmental factors?

How great is the overlap between the diets of these birds? Does this potential source of competition drive a need to change?

[Cnguyen599](#)

We did not examine feather color in this study. There are lots of published studies that have.

We examined birds from a wide diversity of dietary guilds.

Is this phenomenon exclusive to birds only or is this the same for all flora and fauna?

Also, which countries do you draw your data from?

[Sobjack](#)

I would expect that this pattern is observed in other vertebrate groups. But we won't know for sure until other scientists do the work.

We used data from all countries in the Western Hemisphere, except we did not examine birds in the Caribbean.

Does this correlate with biodiversity in general? Are you able to extrapolate this research into how climate changes impacted early human genetic diversity?

[emanresumy](#)

Yes, we found that bird species and genetic diversity are correlated.

A typical bird species has a much more complicated evolutionary history than humans. Humans colonized South America within the Late Pleistocene whereas many of the birds in our study have been in SA for millions of years.

So this means migratory bird species should have a comparable variation level to species in the tropics?

[yanusdv](#)

We found that migratory birds have low genetic variation compared to sedentary tropical species.

How much niche-crossover did you find in the birds you studied? Would you say specification was the driving force, the result, or both?

[JaymesMarkham2nd](#)

That's an interesting question. Phrased another way, do birds that are more specialized tend to have higher intra-specific diversity? We did not quantify specialization (which is a very difficult and subjective) but we did include a decent proxy, flight ability. We quantified flight ability using the ratio of wing length to wing width. Essentially are the birds' wings stubby (poor fliers) or pointed (good fliers). Birds that are poor fliers, are poor dispersers and might be more susceptible to reductions in gene flow due to barriers like rivers or mountains that they can cross. We found very little evidence that dispersal ability affected levels intra-specific genetic variation.

Do you think that temperature itself is the factor driving this? Or is there overall a large pool of species in total in areas with a higher temperature?

Is this about the amount of energy in the biomass? IE sunlight into lots of trees, bushes etc, leading up the food chain from there?

Is this research being done on any other species non native to tropical areas? Or are birds the only critters who fit the criteria?

[the_timps](#)

We looked at a bunch of variables related to temperate and available energy. The ideas you discuss is one of the leading hypotheses proposed to explain why the tropics have so many species. We did not find support for this hypothesis.

We have only looked at birds, but patterns found in birds are often observed in other groups.

I am sure research is being done on the genetics of non-native species.

Hello, parrot owner here. My conure's area of origin is in a tropical part of South America. I would love to know what the implications of this might be for wild parrots, pet parrots, and their owners.

[buzzgirl123](#)

I am a big parrot enthusiast myself. Our study included several parrot species. In some cases individual parrot species might represent multiple parrot species. The more we know about wild birds that better equipped we will be to conserve them.

Hey there,Brian! I have always been fascinated by Biology. Congratulations to you and your team for having done this wonderful investigation on this very bewitching concept. As an aspiring Biology student myself, I am curious to find out the factors of this genetic variation caused by climatic differences.

Other than that, I am also quite curious about why you chose to specifically study bird species, and not other mammals, mammals as a whole or even all species that live within the habitats aforementioned.

Again,congratulations for your achievements,and good luck in your future endeavors!

[cyanaspect](#)

Thanks!

All the members of our team are Ornithologists and we love birds. Our work predominantly focuses on birds but we also work with scientists that work on snakes, lizards, mammals, etc.

This may be stupid and I know correlation/=/causation but since tropical regions generally have the greatest biodiversity of flora and fauna, wouldn't you expect all the organisms to be genetically varied? I mean by evolutionary standards, genetic variation leads evolutionary change, and being the tropics with all the crazy/wild ecology what would be the argument for lack of variations? Were you surprised by the variations, or were they expected due to the biodiversity of the region??

Hobby biologist. This may be a horrible question.

[Destins_Destiny](#)

Hi there. Indeed, the tropics hold an incredible amount of biodiversity. But try to think about the tropics not as static environment but as a dynamic system constantly churning out new species. Some of these species persist for a very long time and are very old, others just got came into existence. Our data shows this pattern. In the tropics we found species that were very old and had lots of intra-specific diversity as well as species that were very young with little intra-specific diversity. In contrast, we found that the temperate zone had only young species all with relatively little genetic diversity. We interpreted this as the effect of recent extinctions caused by glacial cycles in the temperate zone.

Interesting finding. Could this be due to the more recent habitability of areas receding from the last mini ice age?

[craftymethod](#)

We think glacial cycles (ice ages) are a very important part of this story. They likely resulted in the pattern of very young species with relatively little genetic diversity in the temperate zone, yet older species with lots of genetic diversity in the tropics where glaciers didn't wipe the slate clean!

A few questions for you, not having read the paper. Is the genetic variation you cite within each species, or across all species? Is there a species density (or species population size) effect? Did you correlate genetic variation with environmental factors?

[Evinrude44](#)

We estimated genetic variation in each species and performed an analysis across all species to look for a general pattern.

Yes, we examined the correlation between genetic variation and environmental factors. Genetic variation was lower in cooler and more seasonal environments.

Dear Dr. Smith,

I read some of your paper and have some questions. One of the main variables you suggest is affecting the genetic structure of populations is the lineage extinction rate, where tropical species are undergoing less extinction than species at higher latitudes.

But extinction rate is just a proxy for some other processes - like long-term climatic variability. So my first question is, what factors do we think contribute to extinction rate mechanistically?

Secondly, why would a group of species undergoing less extinction (tropical) compared to a group that is undergoing a lot of extinction (temperate) have more genetic diversity? I'm curious about how being around longer somehow increases your diversity.

And last question: as an aspiring developmental biologist, I really like looking at "process". The questions that drive me are mechanistic and process-oriented in nature. My phylogenetics friends have argued strongly in favor of looking at "pattern". What do you say?

Thank you!

[ducbo](#)

Glenn here. You've hit on perhaps the most difficult and intractable issue in the study of speciation and diversification, extinction! In terms of understanding patterns of diversification, extinction isn't a proxy but one of the two variables of interest, the other being speciation. While we can observe speciation events with genetic data, we can't directly observe extinction events because they leave no record in the genome. Our best understanding for what likely drives extinction comes from the fossil record and from recent extinction events due to humans. Rapid habitat loss (due to a meteor strike, volcanic eruptions, rapid global warming) is probably the single most factor. But there is surely variation among in their susceptibility to sudden habitat loss/change. Generalists (house sparrows, starlings, cockroaches) can do well in a variety of environments/habitats but specialists are likely more susceptible to habitat changes, especially if they are poor dispersers and can't get to new habitat quickly enough.

For your second question, in general, genetic mutations happen at a constant rate, so the longer two populations are separated the more genetic mutations they will accrue. Given a landscape with opportunities for population subdivision like mountains, rivers, or grasslands bisecting forest, these

genetic mutations will sort themselves across the landscape leading to intra-specific diversification.

I'm completely with you. I'm interested in understanding the processes that have led to the patterns of biodiversity we see. However, you can't study one, without the other. In order to understand the relative importance of different processes to diversification you need to first document patterns of biodiversity. Also, process in evolutionary biology generally means actual experiments, which means working on systems that are amendable to experiments i.e. those that can be kept in captivity (plants, fruit flies, fish, etc.). I love Neotropical birds and field work too much to give it up to study pure process so I've tried to find ways to infer processes from patterns.

Do you believe this diversity is related to predation at all? As in, something about the tropical environment provides a greater/lesser relative risk of predators that somehow drives the observed increased genetic diversity?

Edit: clarification

[SirHungtheMagnificent](#)

Could be. It would be really cool to have the data to look at predation.

A lot more data needs to be collected!

That was an interesting read. I am interning at amnh, working with hand-wing indexes and I was wondering what you would say are the downsides of using the hand wing index as a proxy for dispersal?

[Joltbug](#)

I think it is a great metric to work with, but like any data we collect it has its limitations. It gives you an idea about how well a bird could disperse but it does not give you an idea of how likely a bird is to disperse.

I hope you are enjoying your time at the AMNH.

Do different selecting factors in the tropical and temperate biomes play a role in genetic diversity?

[Mathbound314](#)

I would love to know the answer to this question. Our study measured neutral genetic variation. Phylogeographic studies, like ours, have typically not had the genetic markers to look at selection. However, advances in genetic sequencing technology now allow researchers to more easily sample across entire genomes and look at selection.

What do you believe are the main reasons for the tropics being much more diverse than the temperate regions? Also, what tropical bird do you think is the weirdest/most interesting?

[Isovenator](#)

I think there is less extinction in the tropics and it is easier for organisms to colonize the tropics than the temperate zone.

The Hoatzin is at the top of the list of weird birds. Look it up.

Have you been to Australia

[WonderPutty](#)

Yeah, I loved it. I hope to return soon.

just exactly how close are birds related to dinosaurs? When i look into a birds eyes, i see reptilian intel staring back.

[BigWill16](#)

Paleontologists have proposed that birds were derived from theropod dinosaurs. From an evolutionary perspective that is really close.

Is it beneficial for a bird community to have a greater genetic diversity? Why? What happens when the diversity is too big or too small? Thanks!

[piesdesparramaos](#)

Interesting questions.

Typically greater genetic diversity with a population allows a population to be more likely withstand change. This same idea could be extrapolated to an entire community. The genetic diversity in our study characterizes the genetic variation across a species entire range. It has important implications for taxonomy, conservation, etc.

If a species continues to accumulate genetic variation across a geographical area then th different groups will likely evolve into separate species. The less variation a species has the more likely it could go extinct if environmental conditions change.

Hello!! recently did a report on humans in Africa more genetic variation than people in other parts. Why would that happen for birds? Can't they just fly to new places easier? Why was it the tropics, and not, say, Europe or South America?

[Dragon_Queen](#)

That's a common misconception about birds, that because they can fly, they can go anywhere. Setting aside flightless birds, of which there are many, many flighted birds may never fly more than foot at one time their entire lives! Instead, the prefer to walk or hop on the ground or in dense understory vegetation. A river 10 feet across might be insurmountable! Look up the genus of South American birds Scytalopus to see what this looks like. This genus is basically the avian equivalent of mice.

Would an increase in genetic variation be caused by more biodiversity (more niches) in tropical areas?

[Wangjanglen](#)

Many have proposed this idea. Based on our findings we think the pattern is best explained by greater extinction in the temperate zone.

Thanks for stopping by, my question is:

Does this imply that birds first arose in the tropics and then branched off to other areas of the world?

[Reoh](#)

We looked at the recent evolutionary history of birds (last 10 million years) so our study has no bearing on the early evolution of birds.

Congrats on your pub! I love PLoS, it's a great journal!

[juliadale22](#)

Thanks!

Could it be the extra sun exposure causing more mutations contributing to the genetic variation..?

[myke113](#)

The patterns we found are not attributable to mutations alone.

Could be, but we did not look at the causes and patterns of mutation rates.

Hi Brian! Few questions for you from a fellow ecologist, apologies in advance I didn't have much time so if I misinterpreted anything please let me know:

- 1) In figure 2 of your paper where you show the heatmap for the phylogeographic structure across all species, why do you think that there appears to be the greatest mean diversity well south of the equator/tropics? Or am I interpreting this incorrectly?
- 2) I notice that you say changes in climate since the Last Glacial Maximum were not significant in your model, but climate traits which are likely correlated to current latitude likely are. But you later discuss that "these environmental effects were particularly profound in northern latitudes, where large ice sheets covered much of the terrain". How can you reconcile these two things, do you think maybe the metric you used doesn't accurately capture the effects of glaciation on the temperate zones?
- 3) I notice that lineage extinction rate is quite a significant difference, what do you think practically contributes to this metric? Is it just a reflection of climate variability perhaps?
- 4) How do you expect the strength of abiotic vs biotic forces separating the species to vary across this space? would it be correct to say that we may be looking at abiotic forces playing a disproportionately larger role in the higher latitude than in the tropics?
- 5) Have you thought of doing anything along the lines of QST vs FST comparisons to tease apart whether this variation you are seeing in phenotypic traits reflects local adaptation to a different latitude, or is just present because of neutral genetic processes like genetic drift?

Really enjoyed your paper! :) I notice your sample size for your Morphological data is 5 birds per trait, I'm a plant ecologist so unsure really when it comes to birds but is this a normal sample size or is it on the low side? Anyways, I immensely enjoyed the read, thank you and good luck with the future of your project.

[suppishguy](#)

Five is reasonable to capture the course-scale differences we looked at.

What kind of bird did the T-Rex evolve into? And how about the Triceratops, I know it LOOKS like a mamm, but clearly it was a sauropod.

[rodney_melt](#)

Excuse the brief answers. We need to have a more in-depth and long conversation.

1) The high diversity in temperate SA is an artifact of low sampling and driven by one species. Look at the SD map. 2) Part of it is the resolution of the metric, but it is also what information on climate change the metric captures. 3) We suspect that the lineage loss index reflects greater extinction due to climatic instability at high latitudes. 4) Yes, I agree 5) We have discussed numerous follow-up studies. Collecting more detailed phenotypic data would be great idea and provide a lot more information.

What kind of bird did the T-Rex evolve into? And how about the Triceratops, I know it LOOKS like a mamm, but clearly it was a sauropod.

[rodney_melt](#)

The T-Rex is part of an extinct lineage of theropods, as such, it could not evolve into anything else but T-Rex. Birds are descended from a different lineage of theropods that were much smaller in size than T-Rex.

What's the most bizarre bird you came across? (I'm a great fan of birds, my fav animals)

[lotekjeromuco](#)

Hoatzin!

This is fascinating! Jeez. An aside, it would be neat to hear a conversation between you and Dr. Bostwick: https://www.nytimes.com/2017/05/05/opinion/sunday/are-these-birds-too-sexy-to-survive.html?_r=0

[EscCtrlEndEnter](#)

Glenn here. We'll have you over for dinner sometime. Kim is a friend of mine.

I've heard that humans living/originating in Africa have more genetic variation than humans from everywhere else. IIRC, they said this was due to the fact that humans had been living longer in Africa, allowing for more variations to arise. Is there something similar here? Were the tropics the places that most modern species' ancestors originated in?

[AFreebornManoftheUSA](#)

Yes, this is almost exactly the same idea. The longer a lineage (humans or birds) exists in a landscape the more mutations will accrue and the more opportunities there are for those mutations to be partitioned into genetic units

Is it likely that tropical pathogens, particularly associated with tropical-adapted mosquitoes may be driving this genetic diversity? The thinking being that adaptation to such pathogens would represent a constant arms race between adapted variants of the bird species and variants of the pathogen that bypass the avian adaptation.

[Lucretius](#)

The process you describe (the Red Queen's Race) will only affect the evolution of traits important to dealing with pathogens like malaria. This likely has little effect hemispheric patterns of intra-specific variation.

Isn't this true for humans as well? I read once there is likely to be more genetic diversity between two groups of people from Africa, compared to say, Northern Europeans and East Asians.

If true, are the reasons generally the same?

[rjcarr](#)

Yes! As the song goes, you and me baby ain't nothing but animals, and are thus succumb to the same basic evolutionary process as all other animals. Fun to think about!

Does this account for the latitudinal species gradient hypothesis? I.e. that there are more species in the tropics because more species' ranges overlap in the middle?

[firefox1216](#)

That's the idea! More intra-specific diversity may lead to more inter-specific diversity.

I've always found the seemingly frivolous evolutionary traits of some of the birds in the tropics to be astonishing. It's almost as if the evolutionary drive behind some of them is aesthetics alone, perhaps the aesthetic preference of the bird species themselves. Do you have any thoughts on how these sorts of seemingly purposeless traits (the bower bird's color sorting behavior or the outrageous mating displays of tropical birds) fit in to the evolutionary model and how they came to be? Why does evolution behave the way it does in the absence of predators and abundance of resources?

[dregan](#)

not so frivolous if it means the male gets to mate with more females! You've arrived in the realm of sexual selection and sexually selected traits. In world of sexually selected traits, the trait has no utilitarian value, i.e. not for camouflage or catching insects, but its value is purely in its ability to attract females. The idea goes that when resources are abundant the female no longer needs the male to collect food for the young, so her preferences can be more frivolous.

Hi! I recently read your paper out of curiosity and instead of preparing for my MSc defence. I know a little about birds and genetic diversity, but I am mainly focused on reclamation and remediation work. My question is fairly simple (I think)!

With longitudinal shifts in vegetation as a result of man-made climate change, how can we expect diversity to shift in populations for birds? Will we start to see bottleneck effects emerge? Or the rise of

more islands or meta populations?

[gutsch](#)

You work sounds really important!

I think we can anticipate both scenarios you propose. Man-made "island" populations are very common. The long-term evolutionary implications of these islands is yet to be determined.

Could it be because tropical climates tend to be more lush (as in more resources available) leading to a greater biodiversity of all things in general? Are there any naturally barren tropical environments?

[GrumpleKelkins](#)

Greater niche availability allows the tropics to maintain more diversity, but it does not explain how the high diversity originated. The goal of our study was to look at variation within a species from a long-term evolutionary perspective (millions of years).

The Atacama desert is barren.

Are there any connections between higher UV light exposure as a factor in genetic mutation (and thus diversity)?

[delphi_edict](#)

See answers above. Thanks!

Doesn't it make sense already that species living in more extreme and diverse environments tend to have more genetic variation? What does this study contribute to that?

Thanks for your work professor.

[dolmatastesgood](#)

It definitely makes sense. We needed to do the research so we could reject alternative hypotheses. Logical explanations of natural phenomenon are a great place to start any scientific study.

Possibly ignorant question, but if you assume tropical birds mate more often (year round?), why *wouldn't* you expect to see more variation in those regions?

[RabidMortal](#)

That is not necessarily the case. The pattern we observed formed over millions of years.

Can it be because the temperature has influence on hormonal stimulation and thus there is more random copulation going on than in lower climate regions?

Same applies to humans, so why not birds?

[justavault](#)

I am not familiar with this research

Hi Brian. Just saying what's up from the UNLV systematics group!

[MojaveRat](#)

Go Rebels!

What about birds in Chernobyl?

[RaoulDuke209](#)

The genetic signature we examined are the product of millions of years of evolution. Any effect observed in birds exposed to nuclear radiation would have a different molecular signature than the ones we found.

Is your study entirely based on "the now"? Is it possible that greater diversity did exist at one time in the temperate zones comparable to the tropics, but with greater human population concentrations, development and wild habitat loss in temperate regions as compared to tropical regions, the difference is due human population density?

[shiningPate](#)

We did not find any evidence that suggests that the diversity gradient was caused by humans. Based on the totality of our data we propose the pattern is due to long-term evolutionary process that operated over millions of years.

I've previously seen discussions about the great diversity in tropical rain forests being attributed to the longevity of those environments. The argument being that tropical rainforest environments have existed essentially unchanged for 100's of millions of years whereas temperate zone environments have shifted with the waxing and waning of ice ages, movement of the inter tropical convergence north/south, and the changing of ocean circulation patterns as continents moved and mountain ranges rose and fell. A parallel example in the temperate zone is the difference in diversity in the North American eastern and western temperate zone forests. The Appalachian forest of the east has existed in one form or another for going on 200 million years whereas the forests of the Rocky Mountains are only 20 million years old. In the eastern forests a 100x100 meter quad is likely to have upwards of 70 tree species whereas the same 100x100 quad in the west will only have about 7 tree species. Is the difference you cite simply a case of the stability of the environments allowing speciation to occur in the same stable environment for a very long time.

[shiningPate](#)

That is what we suspect. The difference between the studies you mention and ours is that we focused on a much more recent evolutionary time frame. At this scale a big difference between the tropics and temperate zone is the extent and impact of glacial-interglacial cycles.

Hi, thanks for your time.

Did your study include Shoebill Storks? Or have you studied them at any time in the past? If so, can

you tell me anything about their evolutionary history? I have read that even though they were originally classified as storks, it's now thought that they are more closely related to pelicans or even herons. Do you have any up to date information on this? I am a mod over at [/r/ShoebillStorks](#) so any other interesting information on shoebills that you may know, I would love to hear!

Thanks.

[HopeSandoval](#)

We did not include the Shoebill in our study.

What does this mean for humans?

[AlexaRhino](#)

It means we have a better understanding of the diversity in the world we inhabit. What we do with that knowledge is up to us.

Which traits between species have more overall genetic variation compared to sedentary tropical species.

[saulens81](#)

We looked at how traits were correlated with genetic variation. Tarsus length was significant in some of our tests.

Is it because there's more of a liberal "anything goes" attitude in tropical regions vs. more "temperate" zones?

[phasegen](#)

I don't follow.