

Istraživanja u evolucijskoj ekologiji

GDJE?

1) LAB



prednosti?

- replikati, kontrole, kontrolni okoliš, genotip, generacijska vremena...

nedostaci?

- nedostaje informacija o određenim ekološkim čimbenicima, i o interakciji s drugim ekološkim čimbenicima

GDJE?

2) PRIRODA (prirodne ili eksperimentalno izložene populacije)

prednosti?

- uzima u obzir interakciju između ekoloških i evolucijskih procesa, te realne ekološke uvjete

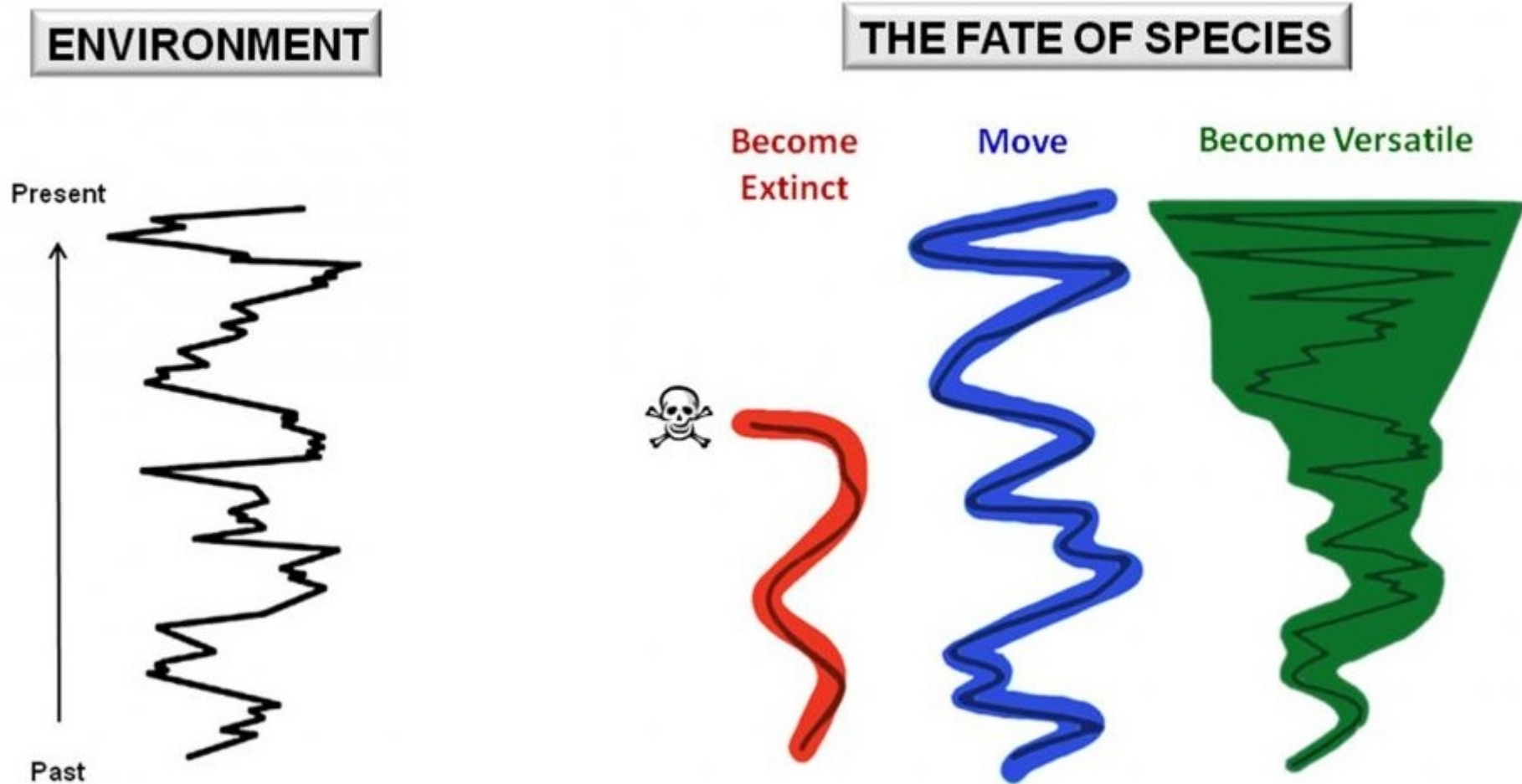
nedostaci?

- teško je izolirati i definirati učinak određenog ekološkog čimbenika ili određeni evolucijski učinak, teže je imati kontrolne populacije i replikate



Adaptivna evolucija

Promjena okoliša (kroz vrijeme ili prostor)



The Smithsonian Institution, <https://humanorigins.si.edu/research/climate-and-human-evolution/climate-effects-human-evolution>

Prilagodba

1) Fenotipska plastičnost

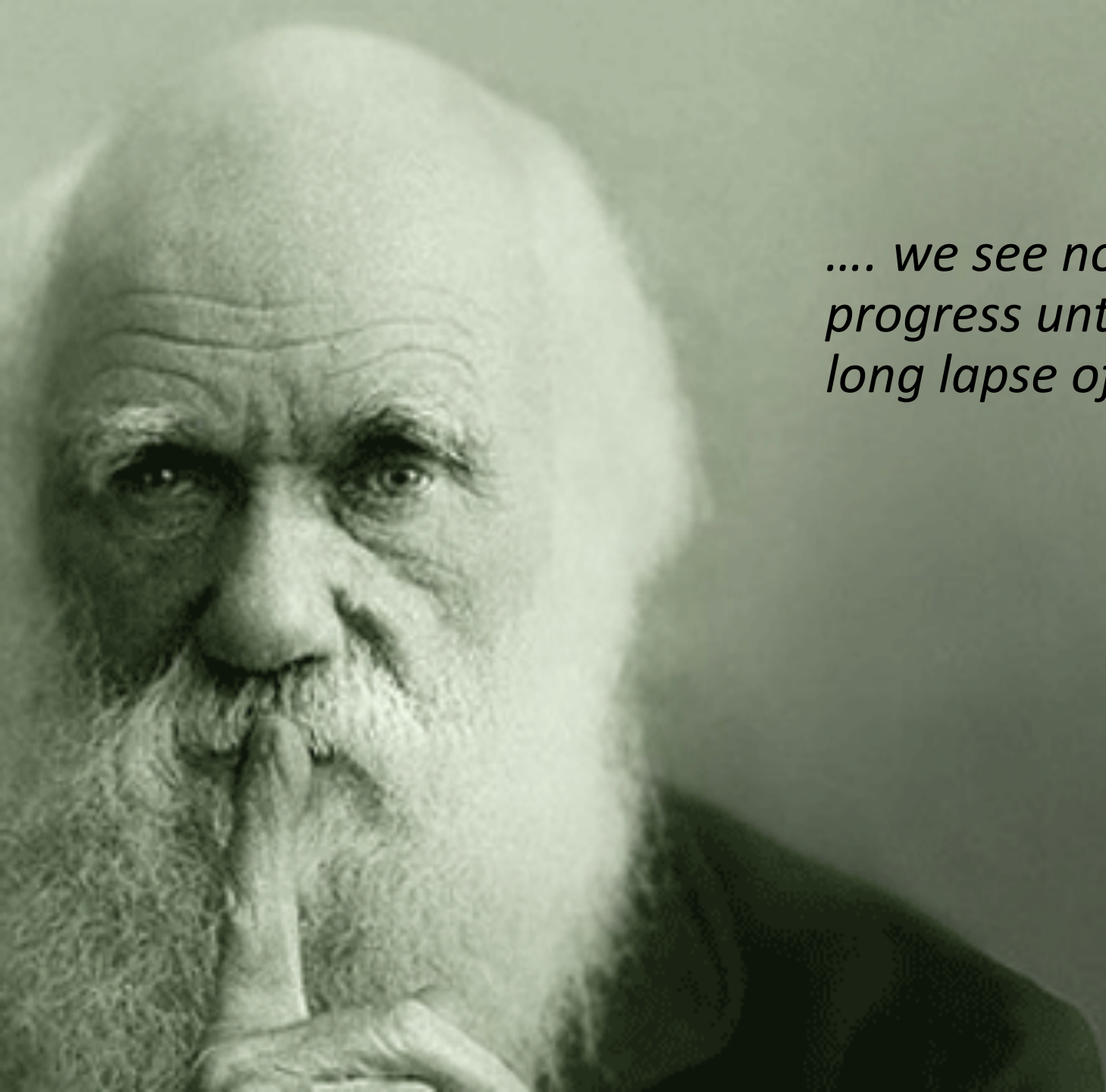
-mijenja se fenotip jedinke kroz životni vijek

2) Genetička adaptacija

- mijenja se fenotip populacije nasljedno kroz generacije

Become Versatile





.... we see nothing of these slow changes in progress until the hand of time has marked the long lapse of ages...

Darwin, 1859

EKO –EVO

- adaptacija populacija na promijenjeni okoliš

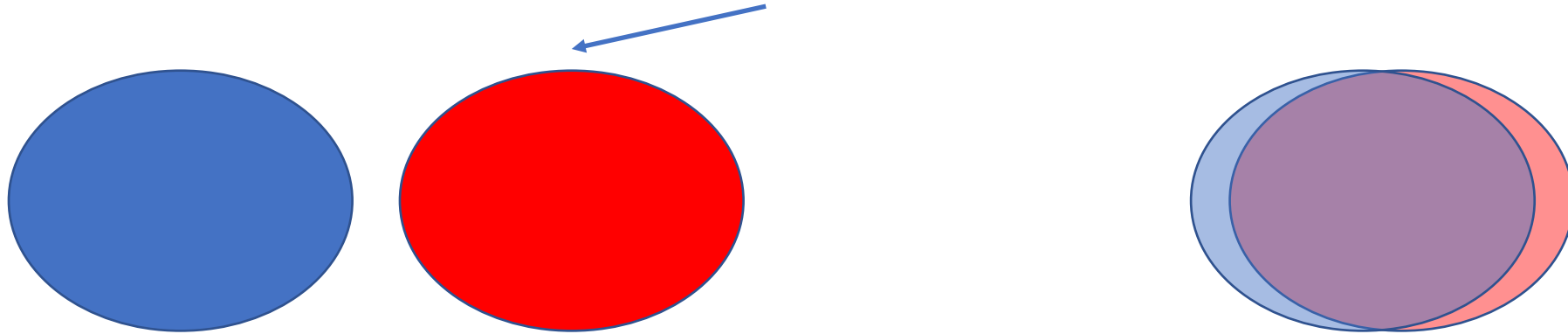
EVO- EKO

- promjena svojstava u populaciji mijenja populacijsku dinamiku, utječe na strukturu zajednice ili mijenja procese u ekosustavu (suvremena evolucija dovodi do ekološke promjene)

ECO → EVO →ECO

- Koji procesi nisu ECO-EVO?

evolucijske promjene koje nisu pod izravnim učincima ekoloških promjena (npr. **genetički drift**- često dovodi do alopatrijske specijacije)



EVOLUCIJSKE SILE:

Selekcija

Protok gena

Genetički drift

Mutacija

Rekombinacija

- **SELEKCIJA?**

Preferencijalno preživljavanje i reprodukcija jedinki s određenim genotipom, kroz prirodne ili umjetne čimbenike (Encyclopedia Britannica)

Prirodna selekcija odvija se kada je dogodi konzistentna promjena u fitnessu između jedinki koje se razlikuju u bilo kojem aspektu fenotipa (Losos, 2014)

Može se odvijati na različitim razinama biološke organizacije (geni, DNA, stanice, jedinke, populacije, vrste...) (npr. broj linija herbivornih kukaca povećava se brže nego kod drugih kukaca)

- **FENOTIP ILI GENOTIP?**

SELEKCIJA DJELUJE IZRAVNO NA FENOTIP, NE GENOTIP!!!

Ekološki učinci se isto događaju kroz promjene fenotipa

- **GENOTIP → FENOTIP?**

- monogenska ili poligenenska fenotipska svojstva, plastična svojstva, interakcija s okolišem

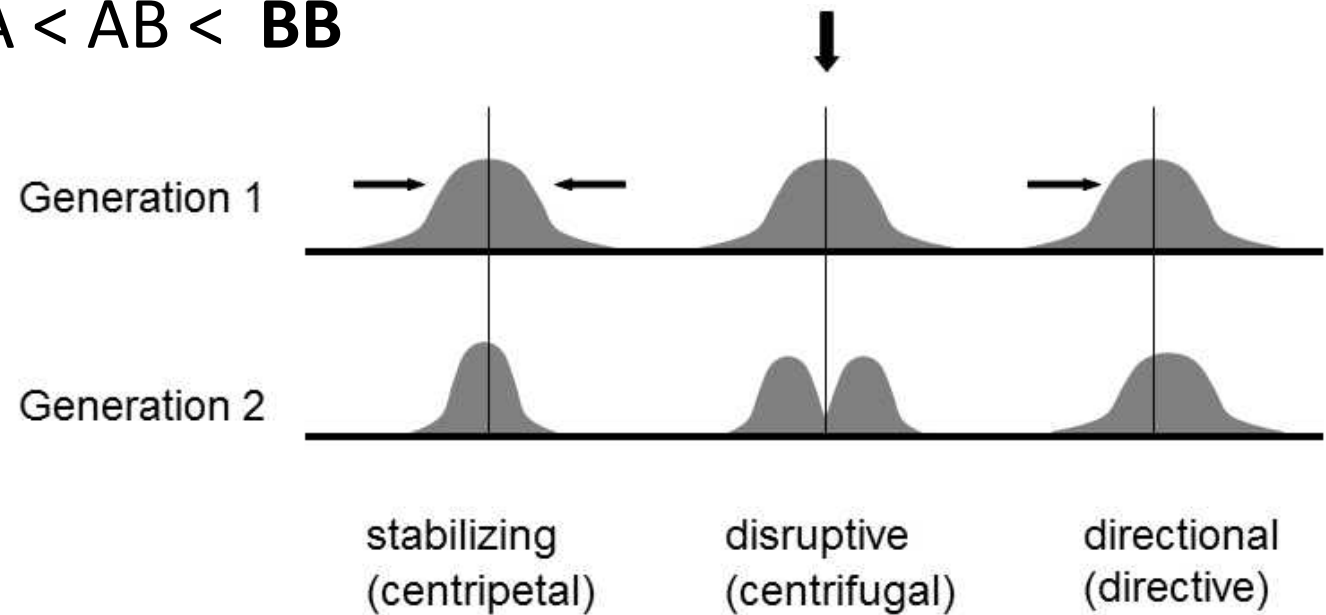


SELEKCIJA

AA AB BB

tip selekcije ovisi o relativnom fitnessu tri genotipa

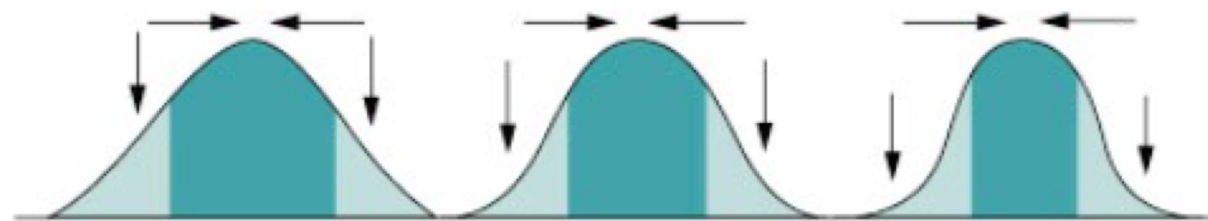
- 1) usmjerena $AA > AB > BB$, $AA < AB < BB$
- 2) disruptivna $AA > AB < BB$
- 3) stabilizirajuća $AA < AB > BB$



PROMJENA U FREKVENCiji ALELA KROZ GENERACIJE

1) stabilizirajuća

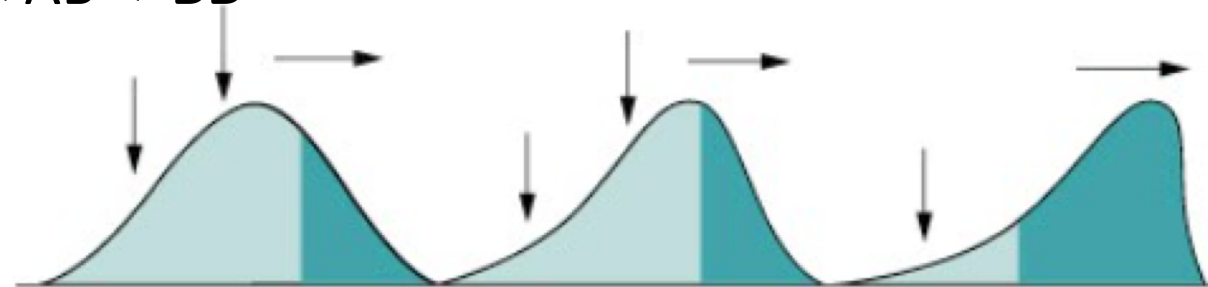
$$AA < \mathbf{AB} > BB$$



(a) Stabilizing selection

2) usmjerena

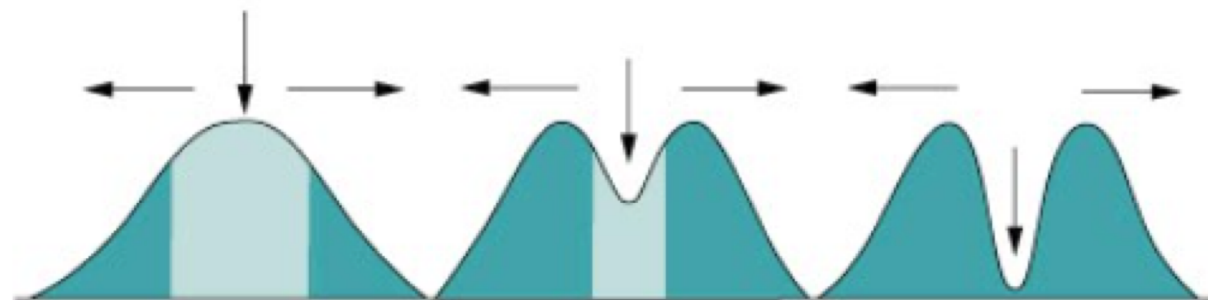
$$AA > AB > \mathbf{BB}, AA < AB < \mathbf{BB}$$



(b) Directional selection

3) disruptivna

$$AA > AB < \mathbf{BB}$$



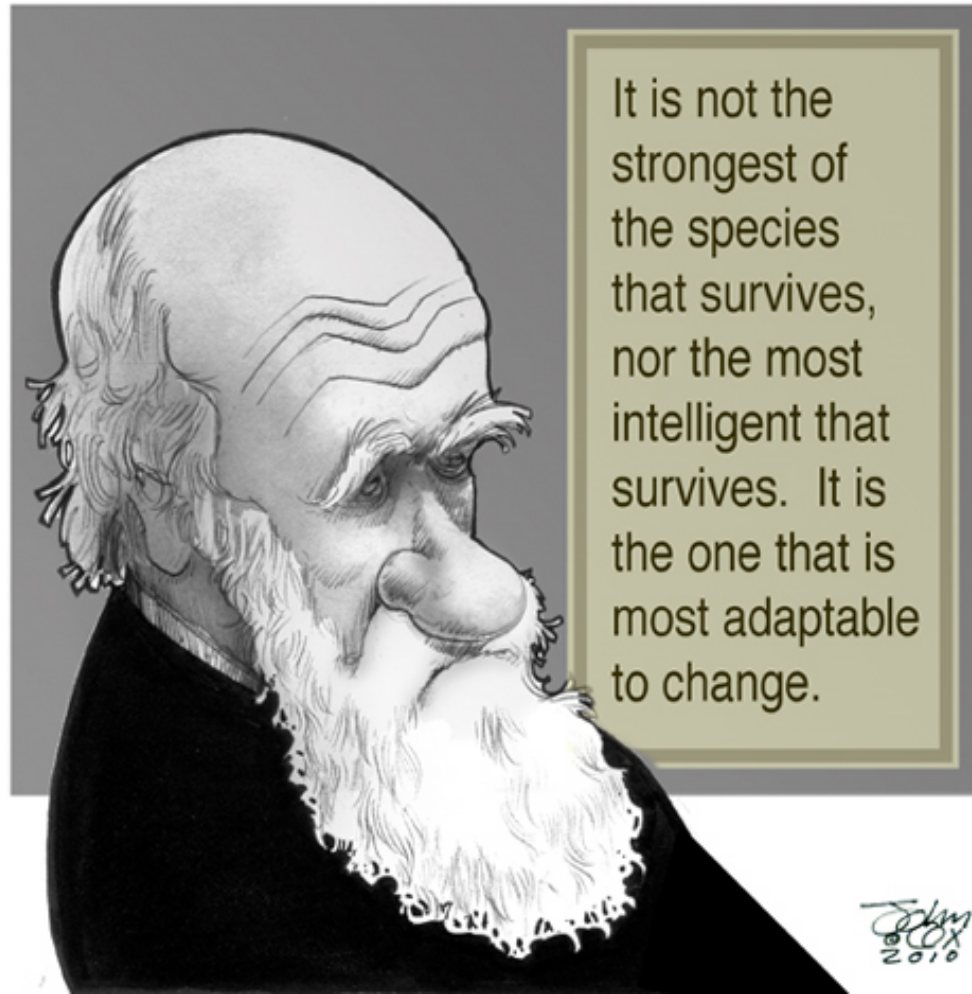
(c) Disruptive selection

PROMJENA U FREKVENCiji ALELA KROZ GENERACIJE

- **ZA PROCES PRIRODNE SELEKCIJE NEOPHODNA JE GENETIČKA VARIJABILNOST!!**
- npr. ako sve jedinke u jednoj populaciji imaju isti genotip (npr. AA), nema razlike u fitnessu između genotipa, ni promjena u frekvenciji alela kroz generacije, sve jedinke u sljedećoj generaciji su opet AA

AA=AA

Proces prirodne selekcije dovodi do genetičke adaptacije- preživljavaju i razmnožavaju se više jedinke genotipa koji ima veći fitness



It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change.

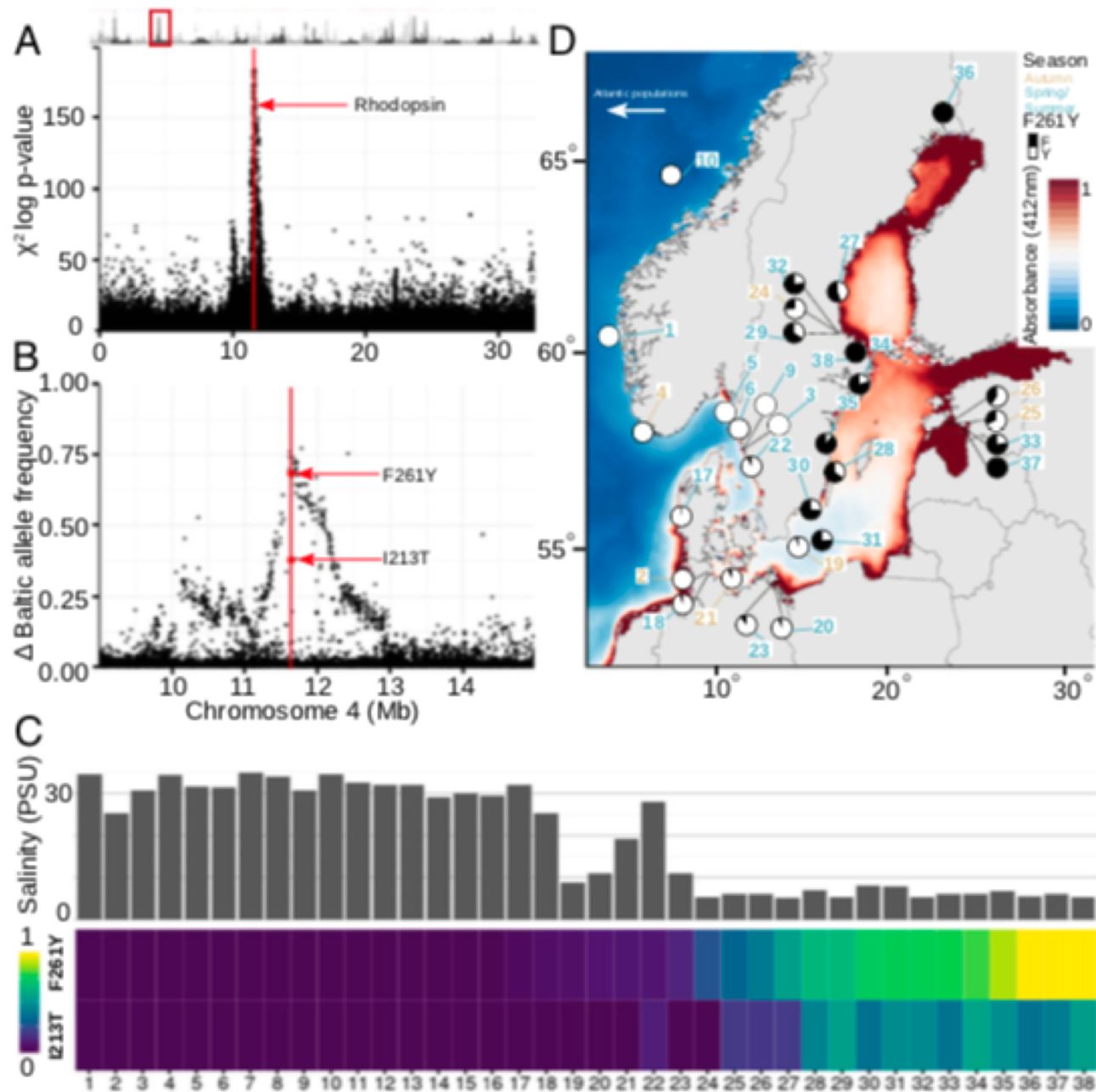
John
2010

Adaptacija Baltičke haringe (sleđa) na promjenjene uvjete svjetlosti

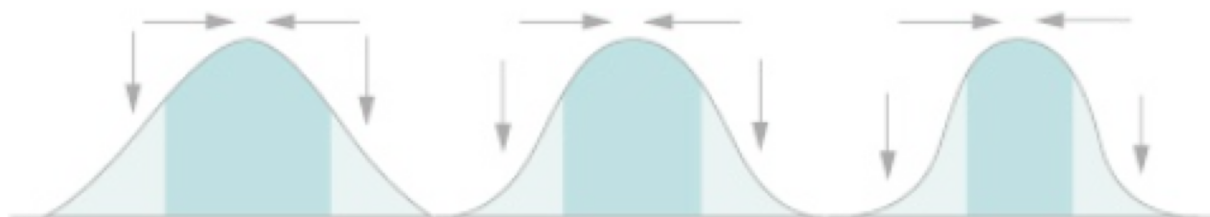


Adaptacija Baltičke haringe (sleđa) na promijenjene uvjete svjetlosti

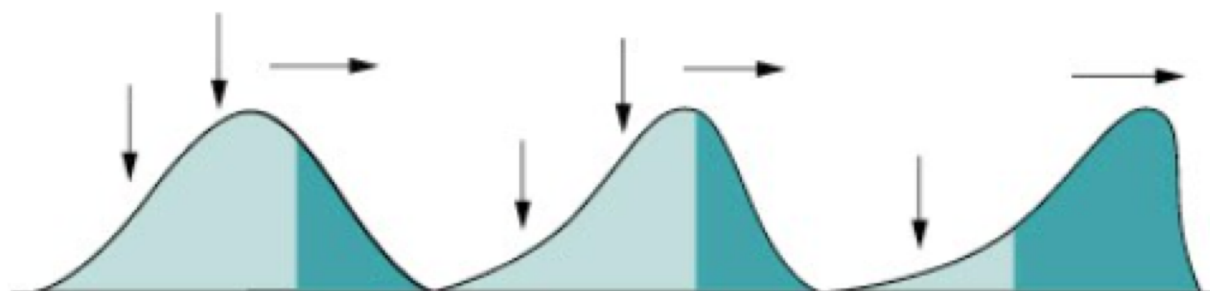
- haringa je iz Atlantskog oceana naselila Baltičko more prije 10,000 g
- Baltičko more ima niži salinitet ali i drugačije propušta i apsorbira svjetlost (više organskih tvari)
- u Baltičkoj populaciji dogodila se promjena jedne aminokiseline u rodopsinu (Phe -> Tyr). Ova varijanta se iznimno povećala u frekvenciji u zadnjih nekoliko stotina godina
- ista mutacija se pojavilo neovisno preko 20 puta u evoluciji različitih ribljih vrsta prilagođenih na brakične vode (konvergentna evolucija)



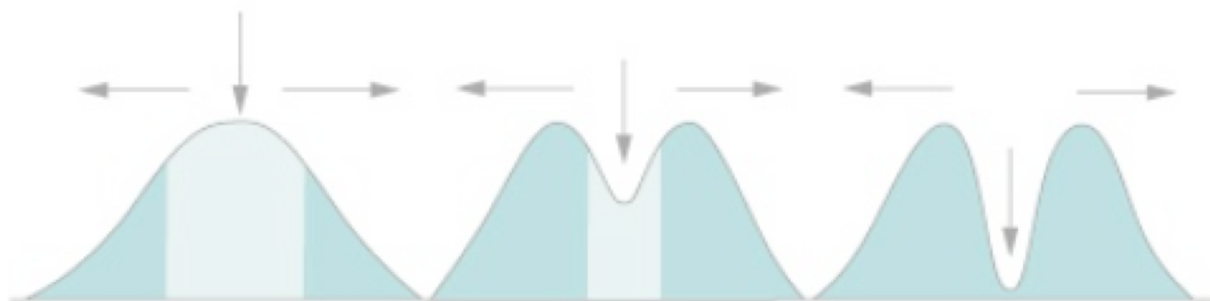
Signal of selection and frequencies of rhodopsin alleles in Atlantic and Baltic herring. (A) Genome-wide scan of **allele frequency differences in the contrast** between Atlantic and Baltic herring populations revealed a highly significant signal on chromosome 4. The genome-wide plot at the top of the panel highlights the signal containing rhodopsin; the remainder of the panel shows the signal in the context of chromosome 4. (B) Delta allele frequency of SNPs that are fixed in Atlantic populations and polymorphic in Baltic populations, and therefore novel to the Baltic populations. The location of rhodopsin is highlighted with a red line in both A and B. (C) The correlation between salinity (Upper), as a proxy for visual environment, and allele frequencies of Tyr261 and Thr213 (Lower), is shown for each population numbered on the x axis. (D) Location of herring populations in the East Atlantic and Baltic Sea used in this study ([Dataset S1](#)). Pie charts are the frequency of the Phe261Tyr mutation in each population, and label colors denote autumn- or spring-spawning populations. Absorbance values at 412 nm are derived from MODIS-Aqua satellite data (30); higher values correspond to more absorbance at 412 nm and, as a consequence, a red-shifted visual environment.



(a) Stabilizing selection



(b) Directional selection

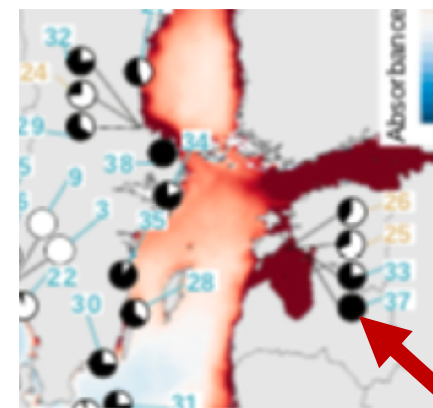


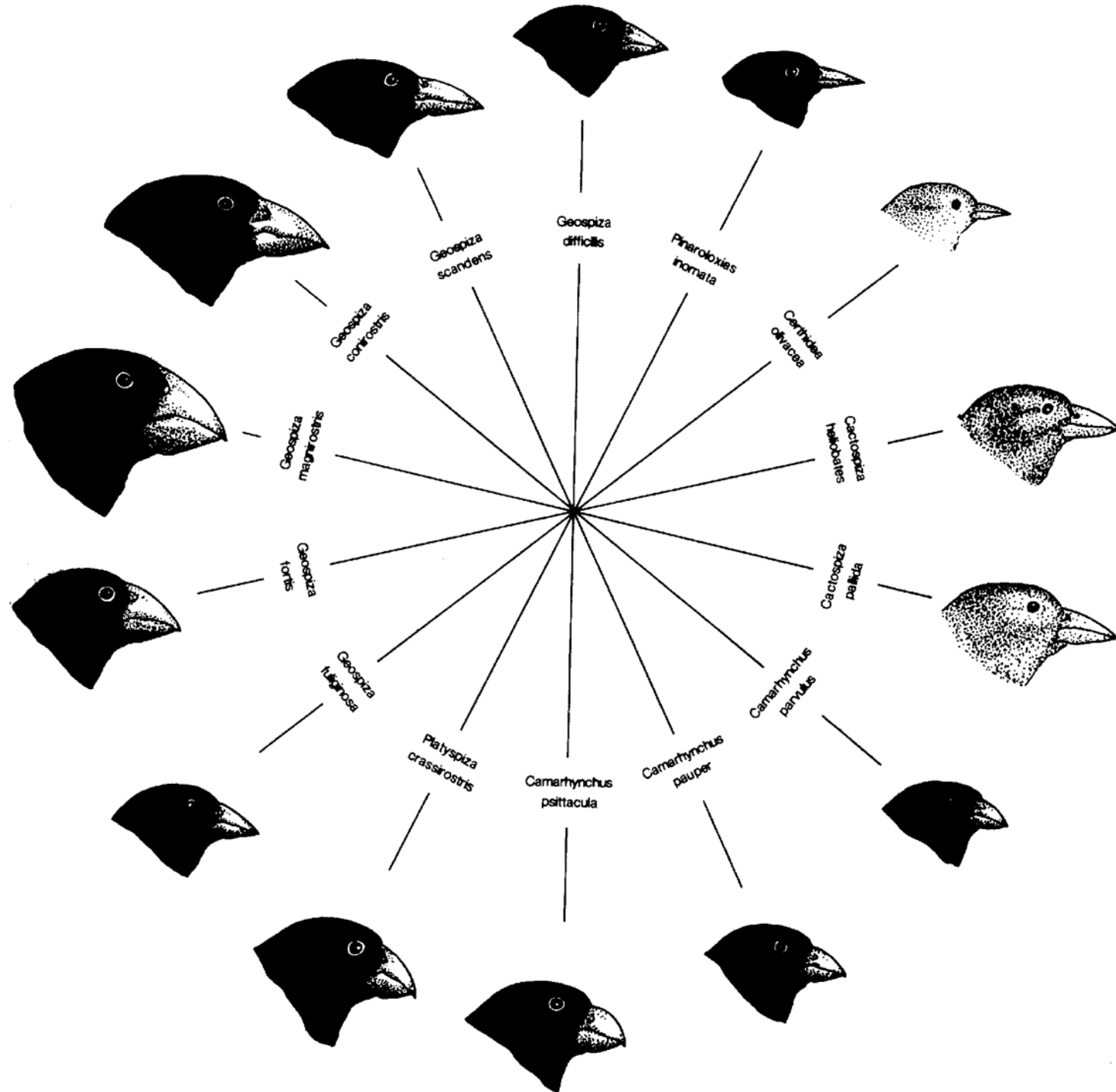
(c) Disruptive selection

VIŠE JEDINKI S RODOPSINOM S
Phe261Tyr MUTACIJOM

USMJERENA SELECIJA!

U nekim Baltičkim populacijama ta
mutacija je fiksirana- posjeduju je sve
jedinke- nema više genetičke
raznolikosti





Intense Natural Selection in a Population of Darwin's Finches (Geospizinae) in the Galápagos

PETER T. BOAG¹, PETER R. GRANT¹

✚ See all authors and affiliations

Science 02 Oct 1981:
Vol. 214, Issue 4516, pp. 82-85
DOI: 10.1126/science.214.4516.82

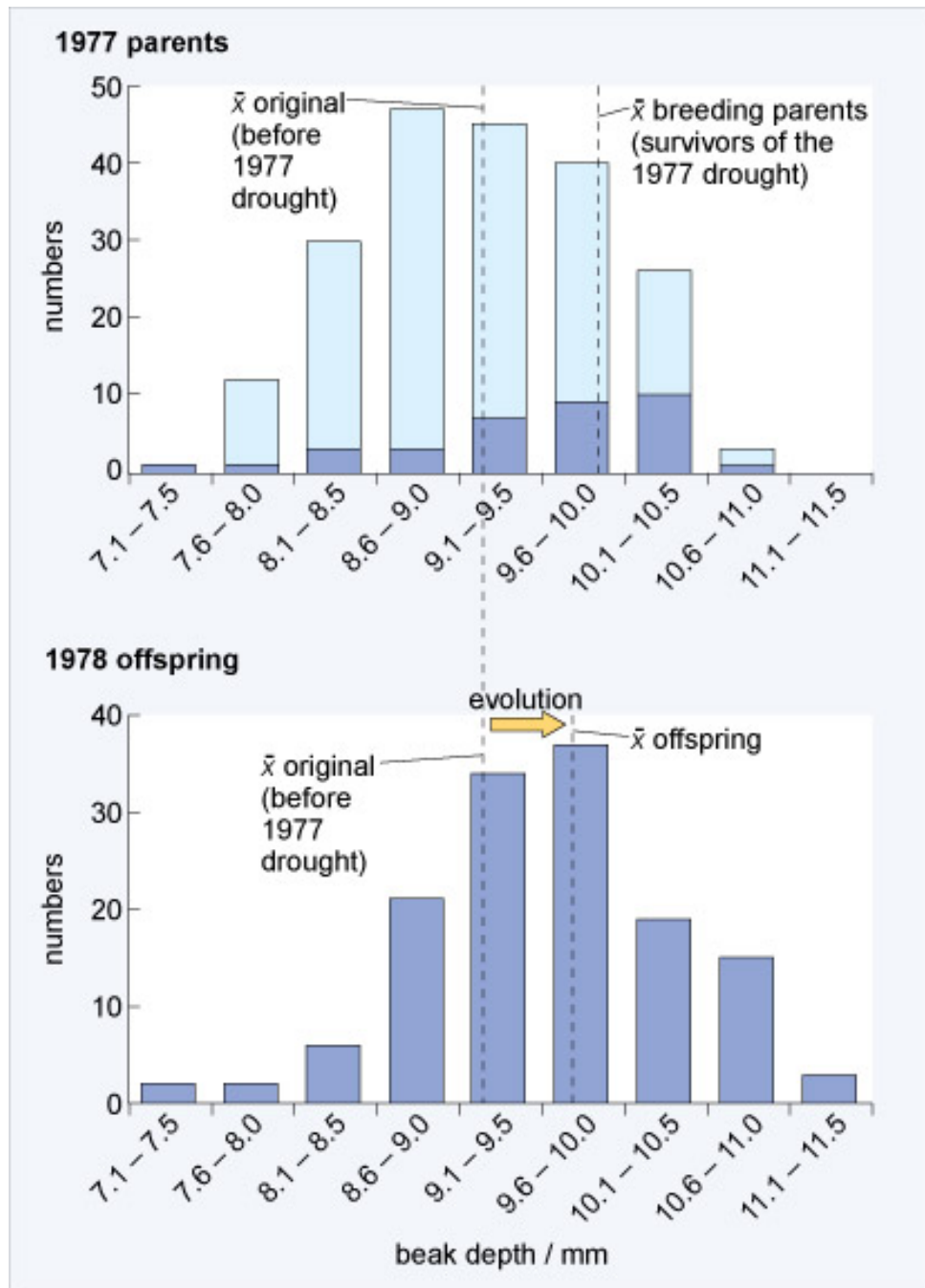


Abstract

Survival of Darwin's finches through a drought on Daphne Major Island was nonrandom. Large birds, especially males with large beaks, survived best because they were able to crack the large and hard seeds that predominated in the drought. Selection intensities, calculated by O'Donald's method, are the highest yet recorded for a vertebrate population.

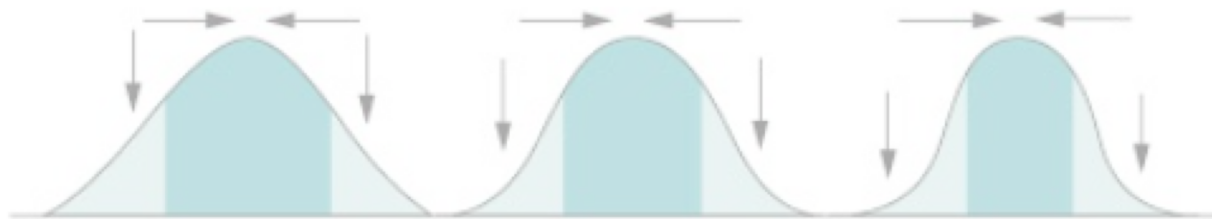
1976-1977 – **suša** je smanjila reprodukciju mnogih biljaka. Populacija zebice *Geospiza fortis* ubrzo je smanjila **količinu dostupnih sjemenki**, mnoge jedinke ugibaju od gladi, i populacija se smanjuje za 85%. No, sjemenke nisu izjedene nasumce, jer **samo zebice s velikim kljunovima mogu pojesti velike sjemenke**. Kako je suša potrajala, samo jedinke s velikim kljunovima imaju dovoljno hrane i imaju veću mogućnost preživljavanja- i razmnožavanja- **usmjerena selekcija prema većim kljunovima (NASLJEDNO SVOJSTVO!!!)** Kada je suša prestala, zebice koje su se nastavile razmnožavati imale su uglavnom veće kljunove.

usmjerena selekcija!

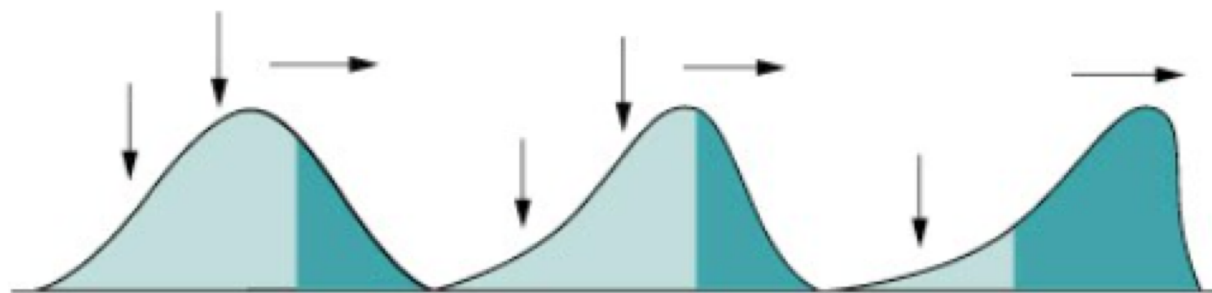


a) Svijetlo plavi stupci pokazuju ukupan broj ptica na otocima s veličinom kljuna u svakoj kategoriji. Plavi stupci pokazuju broj ptica u svakoj kategoriji koje su preživjele i razmnožile se.

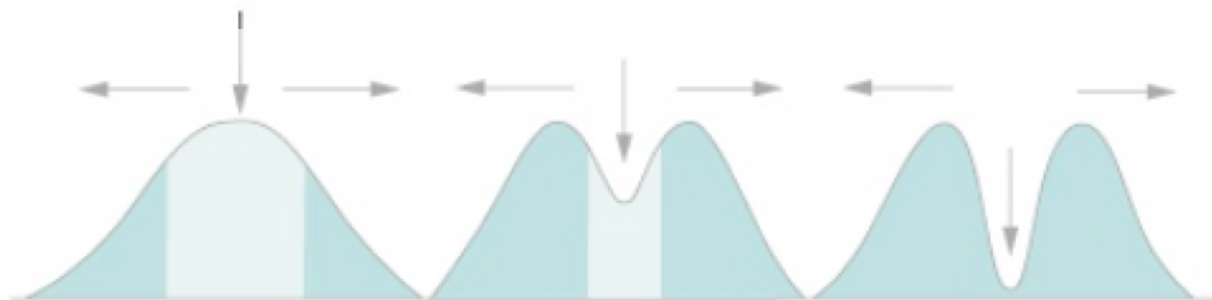
(b) Prosječna veličina kljuna potomaka roditelja koji su preživjeli sušu. Isprekidana crta pokazuje prosječnu veličinu kljuna od jedne do druge godine. Grant et al. (2003).



(a) Stabilizing selection

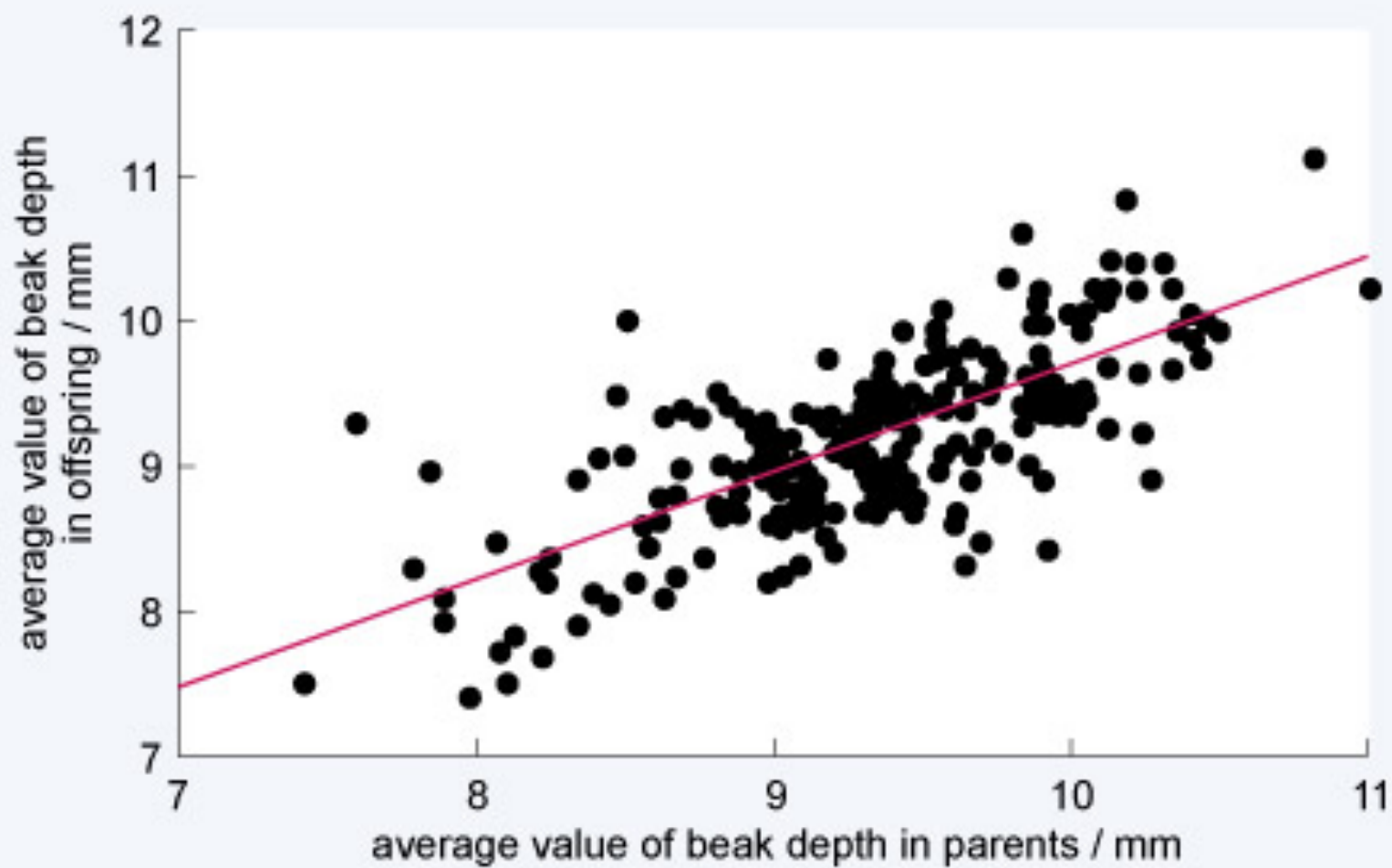


(b) Directional selection



(c) Disruptive selection

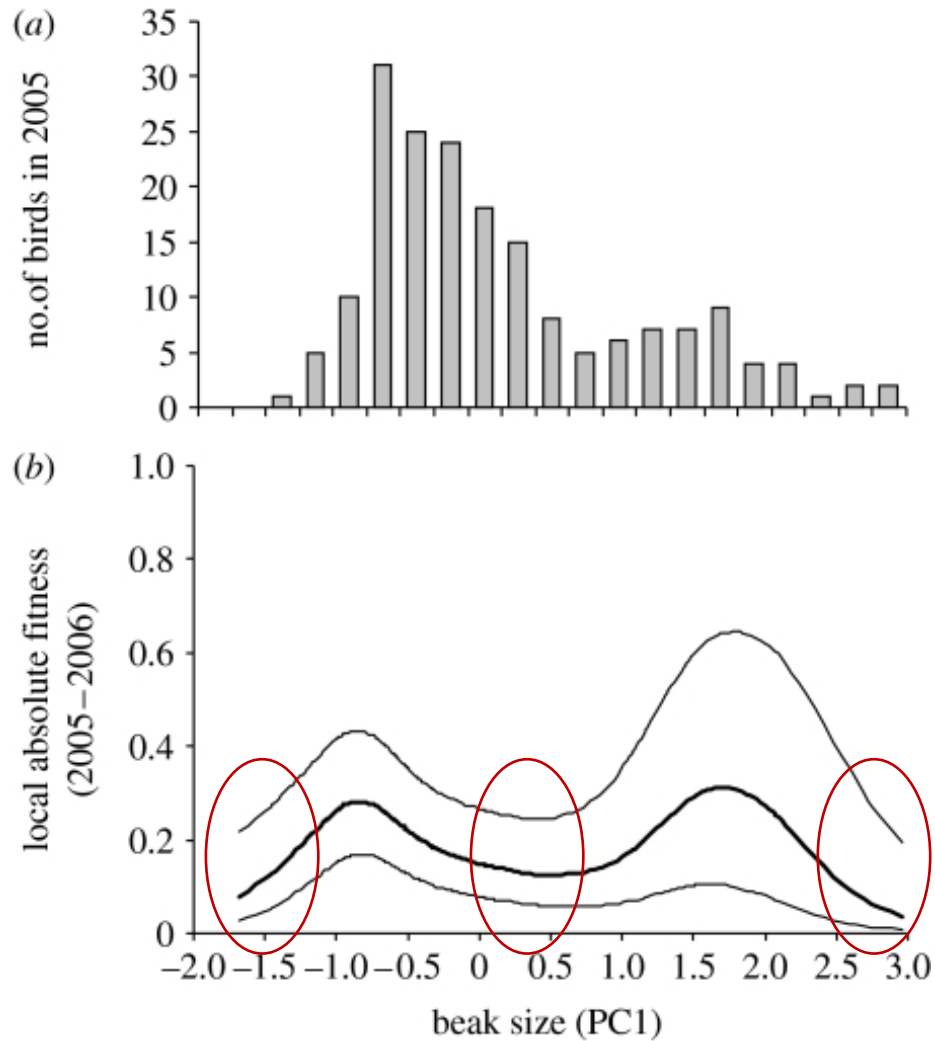
VIŠE JEDINKI S VELIKIM KLJUNOVIMA
USMJERENA SELEKCIJA



**Nasljednost se očituje
u korelaciji svojstva
između generacije
roditelja i potomaka**

Disruptive selection in a bimodal population of Darwin's finches

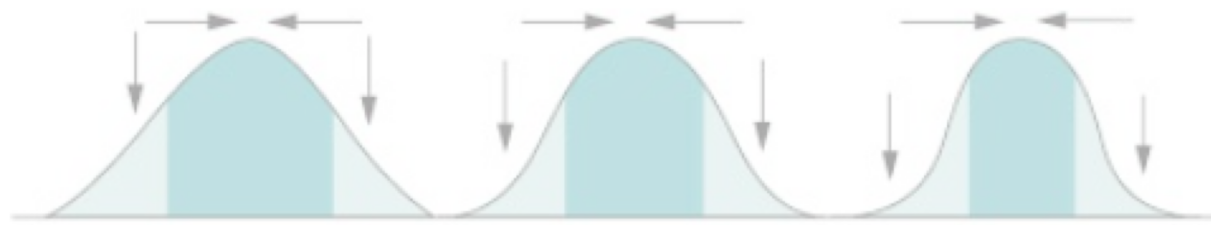
Andrew P. Hendry,^{1,*} Sarah K. Huber,^{2,3} Luis F. De León,¹ Anthony Herrel,⁴ and Jeffrey Podos²



Tijekom perioda suše - manje preživljavanje ptica sa srednjom veličinom kljuna, ali i onih s najmanjim i najvećim kljunovima zbog kompeticije s drugim vrstama ili zbog distribucije raspoloživih resursa.

Selekcija u isto vrijeme održava bimodalnost i sprječava daljnju divergenciju!

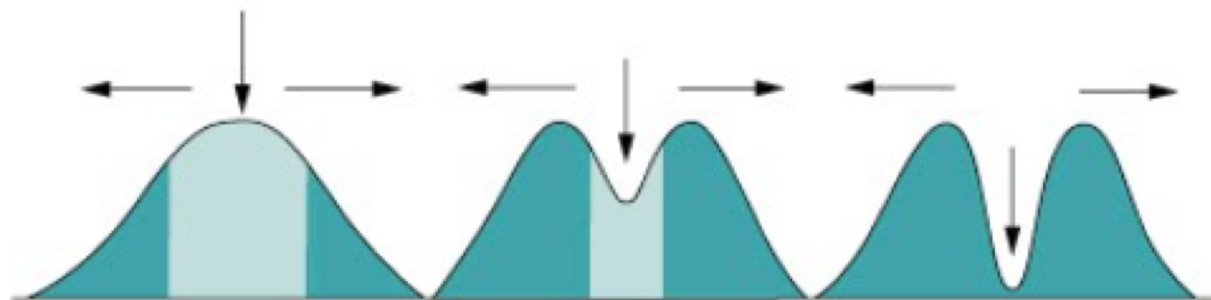
- „...the medium **ground finch (*Geospiza fortis*)** of El Garrapatero, Santa Cruz Island, Galápagos. We examined patterns of selection in this population by relating individual beak sizes to interannual recaptures during a prolonged drought. Supporting the theory, disruptive selection was strong between the two beak size modes. We also found some evidence of selection against individuals with the largest and smallest beak sizes, perhaps owing to competition with other species or to gaps in the underlying resource distribution. Selection may thus simultaneously maintain the current bimodality while also constraining further divergence.”



(a) Stabilizing selection



(b) Directional selection



(c) Disruptive selection

VIŠE JEDINKI S VELIKIM I MALIM KLJUNOVIMA
DISRUPTIVNA SELEKCIJA

DISRUPTIVNA SELEKCIJA !

- Disruptivna selekcija česta je u populacijama s visokom stopom kompeticije za resurse
- *Mexican spadefod toads: **ovalno tijelo** (omnivori) ili usko tijelo (karnivori).*

OMNIVOR

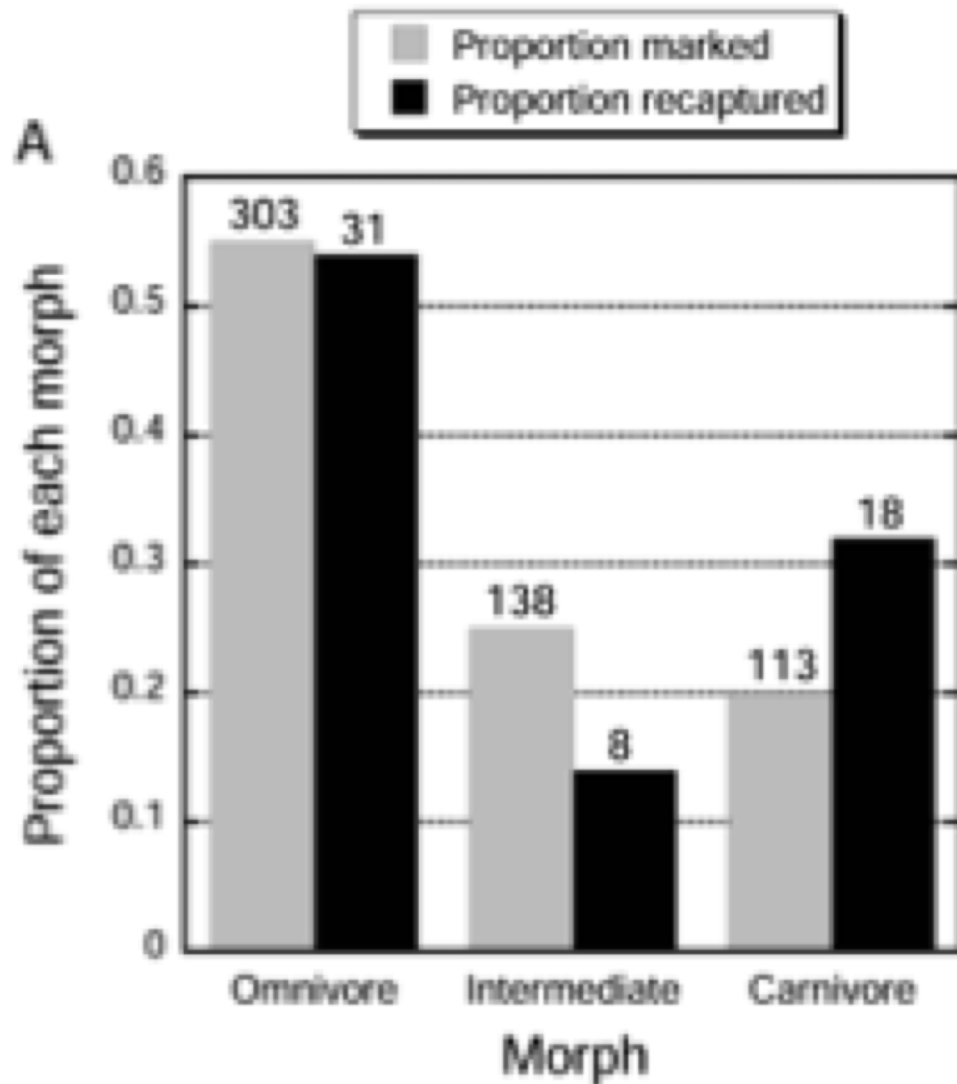


KARNIVOR

Omnivore on the right, carnivore on the left

- Punoglavci s intermedijanom morfologijom imaju manju vjerojatnost preživljavanja i manja tijela od drugih.
- Jedinke koje su imale najviše “omnivorni fenotip” najbolje su se hranile detritusom. Jedinke koje su imale više “omnivorni fenotip” rasle su bolje u eksperimentu nego jedinke s više “karnivornim fenotipom”. Jedinke s karnivornim fenotipom puno su uspješnije lovile račiće.

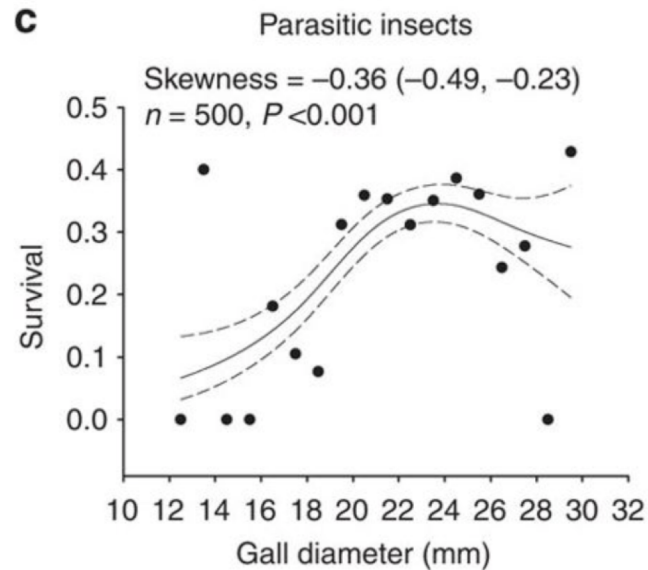
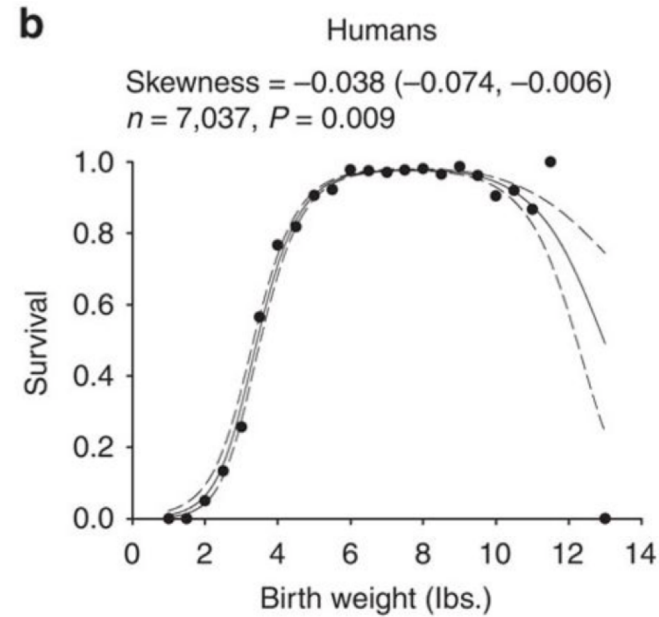
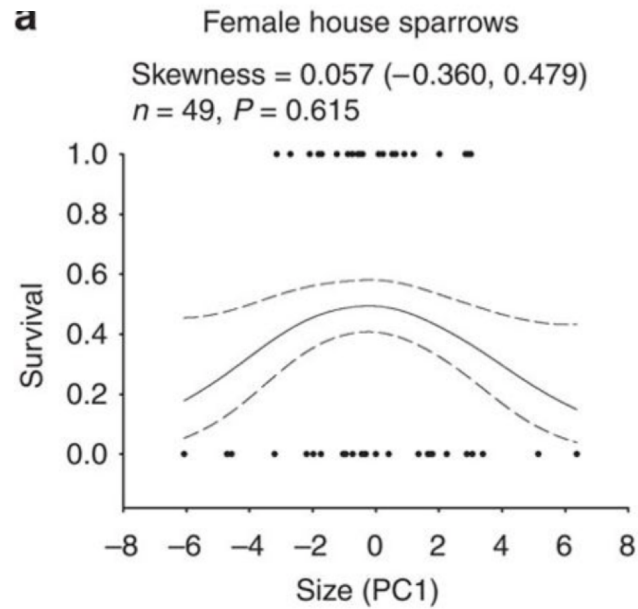
DISRUPTIVNA SELEKCIJA !



Omnivore on the right, carnivore on the left

554 punoglavaca ulovljeno u bari i markirano, te pušteno nazad u okoliš. Intermedijani fenotip najmanje zastupljen u ponovnom ulovu – slabije preživljavanje.

STABILIZIRAJUĆA SELEKCIJA!



Najviši fitnes intermedijanog fenotipa: veličina ženki vrapca, porođajna težina čovjeka, promjer šiške parazitnih kukaca



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Rapid hybrid speciation in Darwin's finches

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Homoploid hybrid speciation in animals has been inferred frequently from patterns of variation, but few examples have withstood critical scrutiny. Here we report a directly documented example from its origin to reproductive isolation. An immigrant Darwin's finch to Daphne Major in the Galápagos archipelago initiated a new genetic lineage by breeding with a resident finch (*Geospiza fortis*). Genome sequencing of the immigrant identified it as a *G. conirostris* male that originated on Española >100 km from Daphne. From the second generation onwards the lineage bred endogamously, and despite intense inbreeding, was ecologically successful and showed transgressive segregation of bill morphology. This example shows that reproductive isolation, which typically develops over hundreds of generations, can be established in only three.



Geospiza conirostris mužjak došao je na otok Daphne major gdje je bila prisutna vrsta *Geospiza rostris*. Potomci križanci su bili reproduktivno izolirani i stvorili novu populaciju (vrstu), koja se od domorodačke vrste razlikuje u morfologiji kljuna.