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TOP SCHOLAR

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship 2013
Biology

9.30 am Thursday 14 November 2013
Time allowed: Three hours
Total marks: 24

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write ALL your answers in this booklet.

Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–26 in the correct order. Pages 2–4 are blank and are to be used for planning. Pages 5–26 are lined pages for writing your answers.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

You have three hours to complete this examination.

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Planning page

Question One

- Two species - divergent evolution
  Allopatric (Congo River)
  Genetic drift, different selection pressures
  - genetic mutation
  (Humans diverged earlier - common ancestor)
  Isolating mechanisms → genetic similarity, behavioural diff.
- larger pop. common → aggression?
  MORE COMPETITION
  intra specific → gorilla
  inter
  Bonobo - inter specific? or smaller area?
  predation etc.

Planning page

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Q2

Scavenger — human impact or cascasses

Slow reproduction - K-strategy

Predation

Pecking order - reduce comp.?

Chondrodystrophy autosome - not sex linked recessive

* Bottleneck → few no.s little diversity

Ice age - less food

Civilisation impact. → killing

Goals → self sustaining pop.s → genetic div.

bred in captivity → learned ~~diff~~ knowledge, affection for humans

↓shooting?

allo. speciation? → gene flow

* genetic drift in small pop.

Planning page

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Q3

~~Caterpillar~~

beetle - spray kills

caterpillars - little difference

↑ #2 preys on dandelion more?

- sprayed - flower earlier, grow faster
  ↓ competition

Control more chemical produced - sprayed selected against (don't need it)

- Fruit more heavily predated.

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Question One

The two species of chimpanzee (common and bonobo) split from a common ancestor in divergent evolution around two million years ago. This is supported by their 99.6% similar DNA, showing they have the same genetic heritage but have slightly changed over time. It is also indicated because they belong to the same genus (Pan).

It is likely that the primary reason for their divergence was the formation of the Congo River 1.5-2 mya. This would have imposed a geographical barrier as it is too wide (hundreds to thousands of metres) for the chimps to swim across. As they were geographically separated they could not interbreed so there would be no gene flow between populations, allowing allopatric speciation to occur.

TAJ
1 A5

The genetic similarities with humans (1.6% with bonobo, and a different 1.7% with common) suggest that they were once one population from which hominins diverged and only separated themselves afterwards. If the humans had separated after chimpanzee divergence, they would be more similar to the one they diverged from, but not have different

1.6/7 pts.

Because humans diverged before separation, and therefore before the Congo River, there must have been some sympatric speciation occurring (or at least allopatric with a geographical barrier other than the river). Therefore the two populations may also have been sympatrically diverging before geographical separation; it may not be entirely allopatric. This would have to be due to slightly different selection pressures - such as less interspecific competition from gorillas for the southern bonobo resulting in slightly different adaptation selection. However, the river likely sustained (or as explored earlier, created) this genetic separation by preventing gene flow. Thus the river is inextricably linked to chimpanzee divergent evolution, ~~likely~~ and the distinct separation of common & bonobo chimpanzees shown in the map.

Once the species were separated, two factors - genetic drift or different selection pressures - were likely to have caused the ~~genetic~~ physical and behavioural differences we see today. Genetic

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4/6

TS

TS

drift is possible because the populations are reproductively isolated, so any genetic mutations that are passed on to the next generation will not be in the other population. If they are selected against the genetic similarities will remain, but silent mutations or those that provide an adaptive advantage may take hold, causing the species to genetically diverge and only become 99.6% similar. Furthermore, any prior genetic differences (from the possible sympatric speciation stated above, or in a random split by the river causing the populations to have slightly different frequencies of alleles by chance) may become more prevalent as they are breeding in a smaller population (somewhat like the founder effect) so the frequency of those alleles increase causing the population to diverge. This would be more likely in the bonobo population which seems to be smaller in size from the map, so possibly smaller population (or smaller original population) so the percentage of a few different alleles could be very high. Similarly, genetic drift would be more prevalent if this population were indeed small,

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TM

TM

TMJ

TMJ

BFJ

BFJ

at least to begin with.
Different selection pressures could also influence evolution of the species. If one population's climate were slightly warmer, ~~were~~ different (warm temperate) ~~allele~~ traits (and therefore alleles) would be selected for. This is unlikely as they are in close proximity, but the same principle applies to the likely biotic selection pressures.
The bonobo land area seems smaller on the map, so they may have a smaller population or less available habitat. Both factors would cause individuals that can cooperate to reproductively succeed - a 'lone wolf' either won't have enough room away from the others or not enough other chimps to mate with. Therefore the cooperative breeders will be more successful and pass on ~~their~~ their genes to increase in frequency - the cooperative genes are being selected for.
The common chimpanzee is different - it has more land area, ~~but~~ so those that are aggressive and territorial will have more food and mates (as others will not compete for resources in their territory). Bonobo cannot successfully be aggressive in their smaller area

TSJ1
TSJ1
TSJ2
TSJ2

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population. Therefore common chimpanzees are selecting for aggressive, territorial behaviour and large males to protect their area (supported by the robust appearance, sexual dimorphism [larger males for fighting], male dominant society [territorial protection] and territorial behaviour all of which allow more aggression and territory control). In contrast the bonobo want (more cooperative behaviour (females dominant to reproduce rather than males to fight, little sexual dimorphism as fighting is disadvantageous) and not much territoriality (little aggression, free mating, overlapping territory). Thus the bonobo and common chimpanzee have selected for different characteristics because of their environment & different selection pressures. This has led to different behaviour (possibly learned for survival, and very likely a genetic difference from (reproductive success), and likely genetic differences causing the two species to diverge allopatrically. It is also likely that the intraspecific competition is increased by interspecific competition, particularly from gorillas. They are also great apes so have similar niches to chimpanzees-

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BP ✓
BS ✓
BP ✓
BS ✓

Therefore there will be interspecific competition for resources. They are only north of the Congo River, so ~~they~~ will only compete with the common chimpanzees. Therefore aggression is likely to be advantageous where it is not for the bonobo, who have less competition. This could have led to marked sexual dimorphism, territoriality & robust build in common chimpanzees to successfully compete for resources. Bonobo have less competition so only require a slender build (possibly less energy to sustain – less food required), little sexual dimorphism & cooperative behaviour. Common chimpanzees may also have to hunt for a wider food source due to the increased competition where bonobo do not. Thus the two have adapted differently for behaviour and physical appearance due to different selection pressures, made possible by the lack of gene flow due to the Congo River geographical isolation. This has resulted in the species diverging, and they should be considered different species because though they may be genetically compatible (99.6% identical), they are unlikely to mate due to behavioural

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and physical differences even if they were in the same area. Thus they are reproductively isolated; they are different species.

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Just

Just

TAJ ✓ BFJ ✓ Just ✓
TSJ1 ✓ BPJ ✓
TSJ2 ✓ BSJ ✓
TMJ ✓ BQJ ✓

9J (4 each area)

Question 2

The primary evolutionary disadvantage to the Californian condor (condor) ~~is its~~ in the world today is its reproductive strategy. They have long lifetimes and very slow reproduction with significant care for the chicks (commonly called a 'K-strategy'), often only reproducing every second year. Therefore it requires (assuming both chicks survive to adulthood) 4 years to replace 1 monogamous pair breeding, so population growth will be very slow and any death devastating to the population. As they cannot reproduce quickly, more death to individuals has drastically reduced population size and brought them to near extinction. This is enhanced by predation of ravens on condor eggs and bears/golden eagles on chicks. The predation will reduce numbers of adult condor over time, the only response being 'double-clutching' which is ineffective if the predator threat still remains; it can just prey on the next egg too.

The evolution of condors to live like this was likely in the Pleistocene ice age ~~There may be~~ when they were abundant. There may have been less predators, so more condor survived, yet

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ERS

ERS

not enough food to warrant the energy of having offspring more frequently, so their reproductive/life-cycle characteristics could have been selected for as an adaptive advantage. However, nowadays there are predators which the condors cannot compete with. There is also less large fauna, so less carcasses and hence less food for the condor. The climate is also likely warmer than the ice age, causing meat to decay faster giving the condors less time to feed on it. The lack of food may also be contributing to condor extinction as it won't give the birds enough energy to be reproductively successful, so their reproduction and hence population will decrease. The impact of humans may also reduce condor numbers. Habitat destruction, power lines and shooting will directly kill or impact the survival of condors, making bringing them closer to extinction. The cyanide and lead poisoning of other animals (such as coyotes) which condors, being scavengers, eat and hence ingest the poison also indirectly kills condors by poisoning their cells with chemicals

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GF
E4

E7
E4

reducing their ability to carry out life processes such as respiration. Therefore these also reduce the numbers of condor. Humans may also remove carcasses, such as sending cows to the freezing works rather than having them die in a field, which deprives the condor of large fauna carcasses and reduces their food supply, further limiting their reproductive success and numbers.

Chondrodystrophy may also impact condor populations. It is not sex linked, so possible to be passed on to all offspring, and as both parents could have one allele a large possibility of the offspring dying from the trait. As a recessive allele it is also possible to be passed through many generations without appearing ('silent' gene) or being selected against, so it is likely to always be prevalent in condor populations. However, it is difficult to know which individuals have it (particularly for breeders) so it cannot be removed. This will reduce numbers of condor as some offspring, already very few, will not survive. It is also a great danger as an estimated 9%

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of the population have the allele so this could influence the extinction of the species further. There are also ~~inherited~~ problems with having such a small population. Genetic conditions such as chondrodystrophy will be prevalent as the breeding pairs are so closely related. There is also little genetic diversity (from the genetic bottleneck of 22 individuals in 1987), so a disease or other environmental change could affect the entire population in the future (bringing it to extinction) as there is not much variation to allow natural genetic resistance. Thus the genetic problems also influence the species' survival or extinction.

EBJ EBJ

The CCRP attempting to conserve the condor face these problems? Their goal is to produce two self-sustaining populations (geographically isolated). This will be achieved by breeding birds in captivity and releasing them together, hopefully to mate and increase the population size through wild offspring. However, they will still face problems with the lack of genetic diversity. All of the condors originate

from 22, so have similar genes and will be susceptible to disease. It is possible that by genetically isolating the populations genetic drift (or different selection pressures such as different habitat requiring more/less aggressive behaviour) will cause the populations to diverge due to random (genetic) mutations that are passed on. This could increase diversity and make the condors less susceptible to disease. However, by separating the populations they also make them smaller, so having more similar genetics that may increase the likelihood of genetic disorders like chondrodystrophy, which could kill condors and undermine the CCRP goals. The CCRP must also limit human interference with the birds. Even if they are legally protected, lead/cyanide poisoning may harm them so an alternative, clean food supply (perhaps with artificial food, or placed carcasses) is advised. It is also important that the condors do not become to attached to humans (hence the condor glove rather than hand in feeding chicks) as this learned behaviour may reduce their survival in the wild or make them too friendly to humans who may shoot

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EE

GWS

WPJ

GPJ

AR

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~~them~~.

The two separate population also run the risk of allopatric speciation, creating two incompatible species which would in essence halve their numbers and bring them closer to extinction. This could be avoided by continuing to breed ~~them~~ condors in captivity ~~and~~ together but release them separately, effectively creating artificial gene flow so they do not diverge too much. MTJ

All of these factors influence the goals of the CCRP, and their success in preventing the extinction of the Californian condor. MTJ

ERJ ✓ EH ✓ GGJ ✓ MTJ ✓
EBJ ✓ EF ✓ GPJ ✓

5.5 (each area)
2.D

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Question 3

The ~~competitio~~ composition of the sprayed plots includes much more dandelion than in the control, which can be regarded as what normally happens. However, there appears to be a similar amount of primrose.

This indicates that the spray allowed dandelion to be much more successful than usual in comparison to primrose. It is likely that the insecticide was particularly effective against the Glocianus punctiger (beetle), which eats dandelion seeds. Without this beetle eating the seeds, ~~many~~ (as it was killed by the spray to a large extent) the dandelion could reproduce more effectively/faster/have more offspring, so it was more successful and grew more than was normal (the control). This is supported in the photograph.

The Mompha brevivittella ~~was~~ seems to have been less affected, as the primrose grew ~~as~~ a similar extent to normal. Alternatively, this caterpillar may not have much effect on primrose reproduction normally, so its absence due to the spray had little effect on primarose growth.

CHJ

CHJ

CHJ

CHJ

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The final insect, Noctua pronuba would have been influenced equally by the spray, so should not give primrose or dandelion a competitive advantage. However, if it had ~~influenced~~ grazed on one plant (likely dandelion) more heavily to begin with, its absence could increase plant species' reproduction significantly. Therefore this, along with (or even instead of the absence of G.K plunckiger) may have influenced the increase dandelion reproduction we witness with the spray, leading to the community ~~competed~~ composition difference between the ~~plants~~ plots. CCJ2 CCJ2

It is likely that the spray and ~~predation~~ insect grazing relationship directly influenced the Oenothein A production phenotype. For both leaves and fruit it is higher in the control group. As this is a natural insecticide it will be selected for normally to have a high production. This will reduce insects, allowing more reproduction and growth hence ~~passing~~ those plants survive and have more (clone) offspring, so the aggregate population allele frequency of those alleles will increase POJ1 POJ1

even without sexual reproduction. However, with the spray killing many insects this is not such an advantage. High production will not be strongly selected for - it may even be selected against as it requires energy so the lower production plants can grow faster/ reproduce more. Thus the spray group will in time favour lower production, causing the trend in the graphs.

The graphs also show higher production in fruit than leaves for both groups. This indicates that the fruit is more heavily grazed on than the leaves. Therefore ~~Mompha~~ M. brevivittella is likely more influential on primroses survival ~~than~~ (feeding on fruit) than N. pronuba (on leaves).

The greater drop in fruit production than in the leaves (of Oenothein A) between the graphs also indicates that M. brevivittella is more affected by the spray - the proportion of Oenothein A needed to combat it is less than in the leaves with N. pronuba. However, it could also demonstrate that production in the fruit requires more energy, so is more strongly selected against than

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in the leaves regardless of how heavy the grazing is. As any of these adaptations are selected for, those plants better suited will flourish and have more done offspring than those without, so their genes will increase in frequency. This in turn creates the frequency of phenotype; it depends on how many of the plants that have the genotype ~~that is how~~ because genotype causes phenotype.

Finally, the flowering/growth phenotype changes are likely the result of interspecific competition with the dandelion. The dandelion flourishes with the spray, more so than the primrose, from the reduction of insect exploitation. It then takes more resources than it used to from the primrose, so niche differentiation has occurred. The primrose flowers ~~faster~~ earlier to not breed with dandelions (if there is some sexual reproduction the hybrids are selected against - do not flourish - so those primrose flowering earlier have more done

C O
C O

offspring so ~~their~~ their genes increase in frequency - are selected for). It is also possible they flower earlier to have their offspring grow before the dandelion and gain an advantage. Again these ~~gen~~ plants would be more successful so the genes increase in frequency.

The faster growth is likely to directly compete for sunlight with the dandelions, so the primrose can photosynthesise more to have more energy for reproduction.

All of these factors increase reproduction to have more done offspring with the same genotype. As phenotype ~~depends on~~ is dictated by genotype, it means there are more plants with that phenotype so the composition of the community, and phenotype of primrose plants, is changed.

CO /CHSJ ✓ POJ ✓ PC ✓ PFJ ✓
CHSJ ✓ POJ ✓ RD PCJ ✓
CCJ ✓ PAJ ✓ PX

8J (3 each area)
3D