Tuesday 8 March 2011, 11:30 – 12:50

- **This exam is composed of 12 questions worth a total of 50 marks**
- **The value of each question is indicated in square brackets**
- **Budget your time appropriately**

- **This exam should contain a total of 6 pages including this cover page**

- **No aids allowed**
- **Write only in the spaces provided**

1. When would the rarer of two hereditarily different phenotypes be considered an adaptation? **[1]**

a. When the rare phenotype acts in ways that prevent predators from consuming the more common phenotype.
B. When the rare phenotype becomes more common from one generation to the next because of its positive effect on individual fitness.
c. When the mutant allele underlying the rare phenotype confers some reproductive success on those with this form of the gene.
d. When the rare phenotype possesses the ability to adjust to changing conditions.

2. I study a fish-eating hawk that lives by large lakes and find that it could capture more pounds of fish per unit time if it were to hunt farther from shore instead of keeping close to the shoreline. The hawk, however, stays close to the shoreline. This finding demonstrates that **[1]**

a. natural selection theory is probably incorrect.
b. optimal foraging theory is probably incorrect.
C. an optimal foraging hypothesis based on calories alone is probably incorrect.
d. the fish species found close to the shoreline are more nutritious than those in the centre of large lakes.

3. The following is a breakdown of a paragraph written by a biologist in a research paper. Males of a species of bee (*Idiomelissodes duplocincta*) form sleeping clusters in the evening, in which dozens or hundreds of bees perch close together overnight. **[4]**

(A) An assassin bug kills bees at these sleeping sites, but usually only one or two per night.

(B) The bees do not join forces to fight the bug when one appears, which means we need another idea to explain the cluster behaviour. Perhaps a bee joins the cluster to dilute the risk that it will be one of the unlucky ones killed at random each night.

(C) The same sort of clustering of defenceless prey occurs in spadefoot frog tadpoles; hundreds of edible tadpoles swim and feed together in pools containing carnivorous water beetles that attack and kill them.

(D) In contrast, males of other bees in the genus *Idiomelissodes* that are larger and more capable of deterring a predator on their own sleep apart.

(E) In addition, the dilution effect hypothesis receives support from the observation that males of certain poisonous inedible flies do not form sleeping groups.

i. How many hypotheses were *tested* explicitly or implicitly by the researcher who wrote the paragraph above?

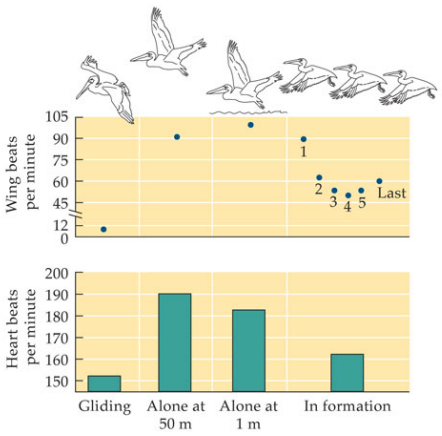
a. 1 **B.** 2 c. 3 d. 4

ii. Which sentence contains an example of divergent evolution? _**D**____

iii. Which sentence contains an example of convergent evolution? _**C**___

iv. Which sentence illustrates an improper use of the comparative method? _**E**____

4. The following four questions all refer to the accompanying figure. Choose the correct answer for each. **[4]**



i. If we apply optimality theory to flight behaviour in the African great pelican we assert that
   a. they cannot fly with less expenditure of energy.
   b. every attribute of this species is an adaptation.
   C. the flight decisions made by the pelican should generate a better benefit-to-cost ratio than alternatives.
   d. the benefits of flight exceed the costs.

ii. If I were to say that pelicans do not fly in V formation because of the energy savings it provides but because solitary birds are attracted to flying groups where they can sense the updrafts created by the birds in front of them, you would tell me that I
   a. had provided a true alternative to the energy savings hypothesis.
   b. had provided an example of an illegitimate use of the comparative method.
   C. was mistaken in thinking that a proximate hypothesis could replace an ultimate one.
   d. did not need the attraction hypothesis because the energy-savings hypothesis was correct.

iii. Imagine that there are five different foraging types with five different benefit-to-cost ratios in a population. If the differences between the five foraging types are hereditary, can we say that the foraging differences between them are genetically determined?
   A. Yes
   b. No

iv. If the differences between the five foraging types were caused only by environmental differences, could we say that any one feeding type was an evolved adaptation?
   a. Yes
   B. No

5. Choose the theory (a.–d.) most likely to be used by behavioural biologists when they want to produce hypotheses on the situations listed below. *No one answer can be used more than once.* **[3]**

a. Game theory b. Optimality theory c. Group selection theory d. Conditional strategy theory

i. A seed-eating bird that forages solitarily. _**B**____
ii. A seed-eating bird that forages in groups with competitive companions. _**A**____
iii. A seed-eating bird in which smaller individuals select smaller seeds than larger birds. _**D**____

6. Label each sentence below with one of the following: causal question; hypothesis; prediction; test evidence; scientific conclusion. (The same answer may apply to more than one sentence; some potential answers may not apply to any sentence.) **[7]**

i. Researchers have wondered why young male Belding's ground squirrels disperse farther than young female Belding's ground squirrels in their first year of life. _**Causal Question**_

ii. Perhaps dispersal occurs because adult males attack juveniles of the same sex. _**Hypothesis**_

iii. But adult males are not more aggressive to young males than females are to young females. _**Test Evidence**_

iv. It could also be that males wander far from home because of internal signals that are generated when males have built up a certain level of energy reserves as fat stores. _**Hypothesis**_

v. If question 4 is true, relatively heavy young males should leave their natal area sooner than relatively light-weight males. _**Prediction**_

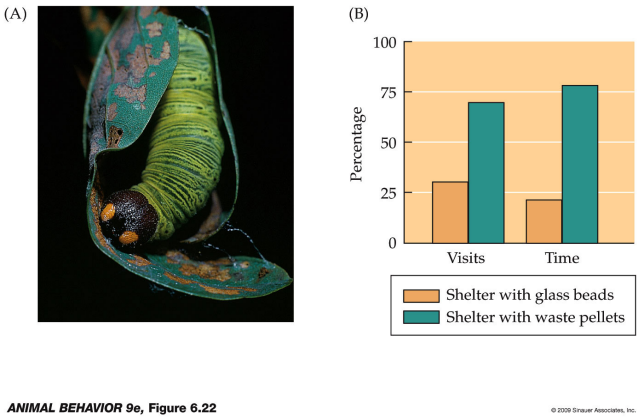
vi. As expected, weight gain is positively correlated with the onset of dispersal. _**Test Evidence**_

vii. Indeed, early dispersers reached a weight of about 150 grams about 2 weeks sooner than late dispersers. _**Test Evidence**_

7. The Bonaire whiptail lizard runs a short distance from potential predators and then raises one foreleg, which it waves about ostentatiously. This arm-waving behaviour might be another example of a pursuit deterrence signal. What predictions follow from this hypothesis with respect to when the arm-waving behaviour should be performed in response to the approach of a human being (a predator substitute)? That is, should arm waving occur more often when a person approaches slowly or rapidly? In response to a direct or a tangential approach? And which arm should be waved when the lizard is not directly facing the human? **[6]**

Slowly approaching potential predators should be signaled in an attempt to short-circuit a really serious attack; rapidly approaching predators require immediate, rapid escape. Likewise, tangential approaches should elicit a signal more than direct approaches because the tangentially approaching predator has evidently not yet decided to mount a full attack. If the arm waving really is a signal to the predator, then the forearm closest to the "predator" should be waved.

8. Martha Weiss studied the attractiveness of the shelters used by butterfly larvae to predatory wasps when the shelters were contaminated by faeces (see accompanying figure). She also collected information on the growth rates of caterpillars that either were forced to inhabit shelters that she contaminated with their faeces or were allowed to mature in clean shelters. She found no difference in weight between the pupae that experienced these two different conditions as larvae; moreover, the days required for the larvae to pupate did not differ between individuals growing up with and without waste pellets in their shelters. Why did Weiss gather these extra data? **[6]**



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Having demonstrated that the caterpillars were probably safer from wasps as a result of ejecting their feces from their shelters (as described in the text), Weiss also wanted to examine some alternative hypotheses for this waste management behavior. It is possible that the larvae could be infected by pathogens that grew on their waste, thus providing an advantage to individuals that safely disposed of their fecal frass. If, however, this hypothesis were true, then experimental contamination of the living space of the caterpillars should have resulted in sickly, lighter weight, slower growing larvae. Because this was not the case, Weiss could rule out the anti-contamination hypothesis for house cleaning by fecal pellet ejection.

9. In some places, American crows open walnuts by dropping them on hard surfaces. Unlike northwestern crows opening whelks, American crows reduce the height from which they drop walnuts from about 3 meters on the first drop to about 1.5 meters on the fifth drop. If this tendency is adaptive, what prediction follows about a difference between whelks and walnuts in the likelihood of breaking on successive drops? In addition, American crows tend to drop walnuts from lower heights when other crows are present. If this trait is an adaptation, what prediction must be true? **[3]**

Unlike whelks, walnuts must become more likely to break on successive drops. If the adjustment in dropping height in the presence of fellow crows is adaptive, the willingness to pay a higher price for opening a walnut (more handling time required per nut) must be repaid by a greater likelihood of being the consumer of the nut rather than a thieving competitor.

10. One sometimes hears that the reason why so many species resolve their contests via mostly harmless threat signals is to reduce the number of injuries and thereby protect the breeding adults who are needed to produce the next generation of offspring. What's the problem with this hypothesis? **[4]**

This is a classic group selectionist hypothesis with the problems associated with hypotheses of this sort. According to this hypothesis, individuals that would have won fights if they went "all-out" make the decision to rely on threats in order to benefit the species as a whole, rather than to advance their own genetic success. It is hard to see how self-sacrificing behavior of this sort could evolve given the inevitable occurrence of a selfish mutant that would sacrifice the group's well-being for fitness gains for himself.

11. Wolfgang Kirchner and Andreas Grasser evaluated the performance of honey bee recruits from a special hive that could be turned on its side or held upright in the standard position. They found that when the hive was on its side, bees continued to dance in the darkness, but on a horizontal surface, not a vertical one. Under these conditions, recruitment at distant feeders (more than 100 meters from the hive) that had been visited by dancing bees was very poor. When, however, the hive was returned to an upright position and the comb surface on which recruiters danced was vertical (as it would be in natural hives), most recruits appeared at the feeders that the scouts had visited. How do you interpret these results? What bearing do they have on the argument about whether recruits derive information from the dances of their colonymates? What prediction can you make about relative rates of recruitment to sites less than 50 meters from the hive when it is turned on its side as opposed to when it is upright? **[5]**

These results can be interpreted as supporting the dance language hypothesis. Honey bee workers can only "read" the information in the waggle dances in a dark hive if the dances are performed on a vertical surface because only then can the information about the direction to the site relative to the sun be re-coded in terms of the displacement from a vertical line based on gravity. But the round dance is not dependent on a gravity-based code and therefore we can predict that when the hive is on its side, dancers will still be able to recruit hivemates to feeders placed close to the hive.

12. For some whale species that migrate from Arctic or Antarctic oceans to give birth in warmer water nearer the equator, food cannot provide an ultimate benefit, since the adults do not feed on the calving grounds. Therefore, other hypotheses for whale migration have been advanced, such as the idea that whale calves can gain weight more quickly in subtropical waters, where they need to invest less energy in keeping warm. Alternatively, some persons have suggested that infant whales in these waters are less likely to be attacked by predators, especially killer whales. How would you test these hypotheses, given the practical difficulties of directly measuring the metabolic costs of thermoregulation by whale calves or of actually observing killer whale attacks on other whales in any environment? **[6]**

The thermoregulation hypothesis generates the prediction that whales born in tropical waters will be born at a relatively low weight or with a relatively thin layer of blubber compared to their adult weight or adult blubber thickness whereas those that are born in cooler or cold waters will be relatively large and blubber rich compared to their eventual adult size. The anti-killer whale hypothesis predicts that killer whales will be relatively scarce in waters closer to the equator and that relatively defenseless small or slow-moving whales will be the ones that tend to give birth nearer the equator.