Student Code:

# 24th International Biology Olympiad

## 14th-21st July, 2013

## Bern, Switzerland

BERN 2013 International Biology Olympiad

## Practical Exam 3

## Evolutionary Ethology

Total points: **94**

Duration: **90 minutes**

Dear participants,
親愛的同學，
This test consists of three tasks:
本測驗包括 3 個題項：



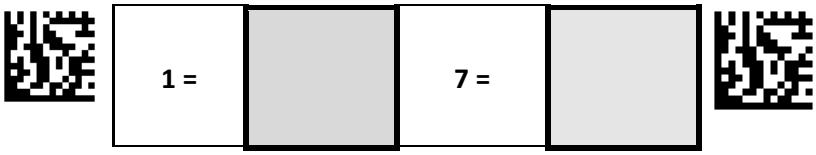
Please write your student code into the box on the title page.
請在首頁方格中填入你的學生代碼。

There is no separate answer sheet. Please fill in your answers into the specific answers boxes indicated with a gray background. **Only answers given inside these boxes will be evaluated.**

本測驗不另附答案卷，請將你的答案填入灰色方格中；若在其他地方作答，則不計分。

The answers have to be given either with a tick (√) or with Arabic numbers. The numbers "1" and "7" can look very similar in handwriting. To make sure that those two numbers can be well distinguished by the IBO staff, please write them as you normally would into the following box.

填答時請打勾（√）或填寫數字。手寫的數字「1」及「7」看起來可能很相似，請務必確保計分人員能夠清楚地辨識，不會誤判。請依照你平時寫「1」或「7」的方式填入下列方格中。




Stop answering and **put down your pen IMMEDIATELY** when the bell rings at the end of the exam. Put the entire protocol with all the answers back into the exam envelope. Make sure you wrote your student code into the box on the title page.

當測驗結束鈴響時，請停止作答並**立刻放下筆**，並將所有試卷及答案放入試卷袋。請檢查確認你已在首頁方格中填入你的學生代碼。

## Material and equipment

## 材料及器材

Make sure that you have received all the materials and equipment listed for each task. If any of these items are missing, please raise your hand.

請確認你所拿到的材料及器材，是否與清單所列相符；如果有任何缺漏，請舉手反映。

**Equipment**
器材

- 1 Tablet with preloaded movies
  1 個已置入影片的平版電腦
- scratch paper
  計算紙

# Introduction
# 序言

Most organisms are limited in resources such as food, mating partners or shelters. As a result, available resources are often defended by aggressive interactions with conspecific (same species) and heterospecific (different species) competitors. A very common phenomenon to monopolize resources is the establishment of a well-defended territory. But territorial defense is costly as it may expose the territorial resident to an increased risk of injury or predation or reduce the time available for other activities such as foraging, mating or brood care. Given this, a territorial resident that is able to adjust its aggressive response to match the degree of threat posed by an intruder is expected to have a selective advantage.

絕大多數的個體，會受資源如食物、配偶或棲所的限制，因此常造成同種或異種間的個體藉由攻擊行為來競爭並保衛可用資源。一種常見的獨佔資源的現象，就是建立一個完好的防衛領域；但要建立完好的防衛領域是要付出代價的，這可能使領主（領地擁有者）增加受傷或被天敵捕食的危機，也可能因此減少了從事其他活動（例如覓食、繁殖或照顧後代）的時間。因此，一個領主的攻擊反應如果能夠依據入侵者的威脅程度來進行調整，在天擇的壓力下，是較有利的。

In this practical you will test if individuals of the territorial African cichlid *Neolamprologus pulcher* are using visual and / or olfactory cues of a competing conspecific to adjust their aggressive response. *N. pulcher* is native to Lake Tanganyika where it forms breeding pairs, which defend a small contiguous territory (mean area = 0.3 $m^2$) used for feeding, breeding, and shelter from predators.

在本實作測驗中，你將檢測非洲口孵魚（*Neolamprologus pulcher*）為了調整攻擊行為，牠所用來辨識競爭者行為的方式，到底是藉由視覺或嗅覺，或者是兩者皆用。非洲口孵魚（*N.pulcher*）是 Tanganyika 湖的原生種，牠在湖裡配對繁殖，並建立了一個小而連續的防衛領域（平均範圍＝0.3 平方公尺），藉以覓食、繁殖及躲避天敵。

All experiments were conducted under laboratory conditions in aquaria and recorded on video. Your task is now to analyze these recordings by quantifying the behavior of different individuals. All videos are preloaded on a tablet computer and can be played at your convenience.

所有的實驗皆已在實驗室的水族箱進行，並已錄影記錄。現在你的工作是來分析這些紀錄，量化這些不同個體的行為。所有的影像紀錄皆已事先載入所提供的平版電腦中供你隨時使用。

# Task 1: Quantifying aggressiveness

# 題項 1：將攻擊行為予以量化

In this task, you will quantify the aggressive behavior of *N. pulcher* males by statistically testing if males use visual and / or olfactory cues to adjust their level of aggressiveness to the threat posed by a competing male.

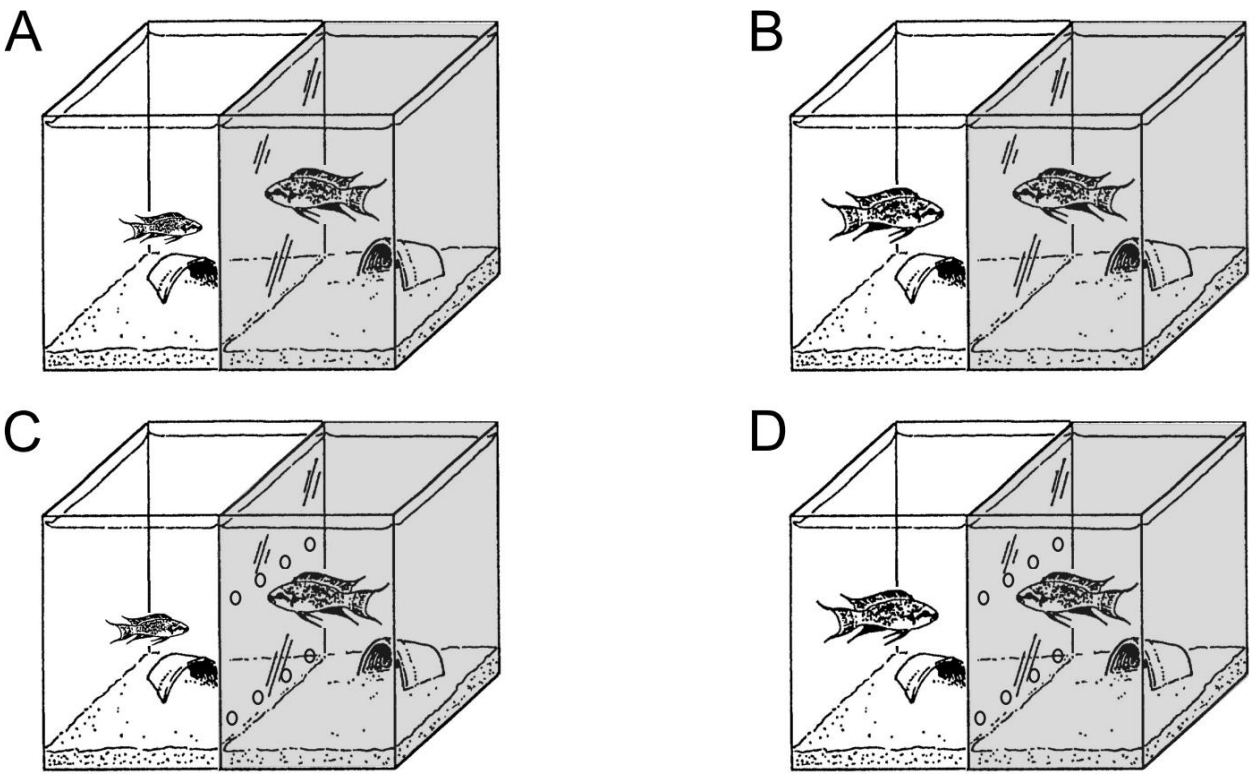
在本題項中，你須對雄性口孵魚（*N. pulcher*）的攻擊行為予以量化，藉由統計檢定來判斷，到底雄性口孵魚是經由視覺或嗅覺，或者是兩者皆用，以調整牠對雄性競爭者的攻擊程度。

## Part 1.1: Experimental setup

## 實驗設計

In each experiment, two males are freshly exposed to each other in a previously uninhabited test aquarium that is divided by a glass wall that either seals off the two compartments completely (Situations A and B) or is porous and allows for an exchange of water between the two compartments (Situations C and D). The focal male is always in the right compartment and is exposed to either a considerably smaller male (Situations A and C) or a male of equal size (Situations B and D).

在每一個實驗中，兩隻從未接觸過的雄魚被放入 1 個新的魚缸中，實驗情況可分成 A、B、C 及 D 共 4 種。其中 A、B 情況的水箱中是以玻璃完全隔離；C、D 情況則是以具有孔洞的玻璃隔離，在此情況下，水箱兩側的水可相互流動。實驗要觀察的對象是放在水箱右側的雄魚；至於水箱左側，在 A、C 情況中是放入體型相對較小的雄魚，在 B、D 情況中則放入與右側體型相同的雄魚。




Throughout this task, you will only have to consider the behavioral response of the focal male in the right compartment (indicated in gray).

在本題項中，你只需要觀察水箱右側（即圖中灰色水域）中雄魚的行為反應。

## *Part 1.2:* Aggressive behavior of *Neolamprologus pulcher*

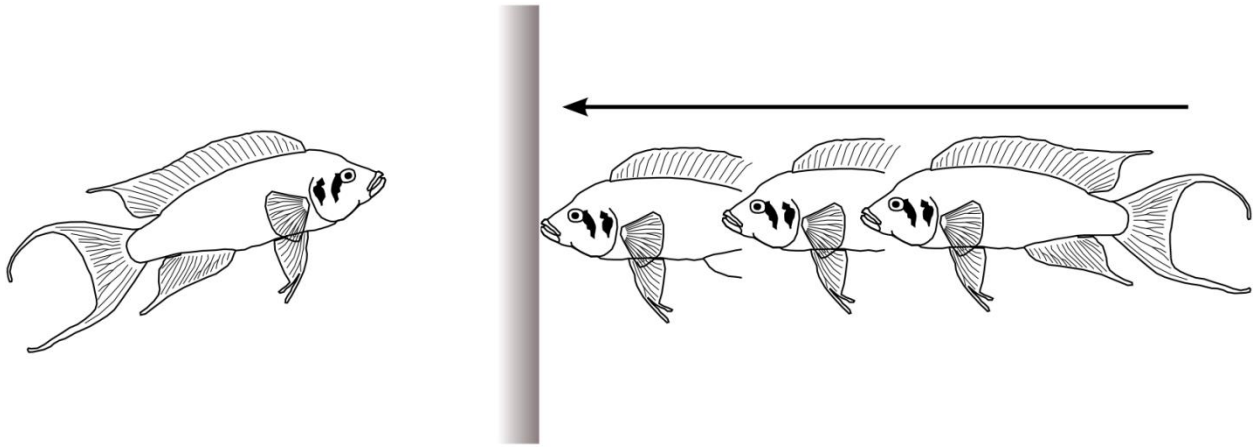
## 口孵魚（*N. pulcher*）的攻擊行為

In this task, you will count the frequency of a particularly conspicuous behavioral response of *N. pulcher* males to conspecifics: ramming or biting attacks.

本題項中，右側口孵魚（*N. pulcher*）遇到左側同種競爭者時，將會出現相當明顯的衝撞或咬的攻擊行為；你須計算這些行為出現的頻率。

Aggressive behavior is counted as ram or bite (ramming with its mouth open) when the fish is obviously attacking its competitor by swimming towards it and hitting the glass wall separating them. Each hit of the snout against the glass wall is counted as a single event, even if males ram or bite repeatedly within a few seconds. The following figure illustrates this behavior.

當右側的魚明顯地游向左側的競爭者並碰撞玻璃隔間板時，這些行為就被計算為衝撞或咬（「咬」是指衝撞時亦張開嘴）的攻擊行為。不論雄魚在幾秒內重複出現幾次衝撞或咬的行為，只要魚嘴端每碰撞到玻璃隔間板 1 次，就被計為 1 次。下圖說明了此類行為。



## Part 1.3: Examples of ramming or biting attacks

## 衝撞或咬的攻擊行為之範例

Activate your tablet by tapping and sliding with your fingers and open the Folder E_1. In that folder you will find three movies. Movie I contains a series of obvious biting or ramming attacks. Watch itto get a feeling of what to look for. Next, watch Movies II and III which indicate how these attacks are to be counted. Watch them carefully. Proceed with the protocol as soon as you feel confident with how to count this behavior in *N. pulcher*.

請按壓及滑動你的手指來啟動平版電腦，並打開資料夾 E_1。在此資料夾中，你會發現 3 部影片。影片 I 的內容包含了一系列明顯的咬或衝撞行為；請仔細觀察，以熟悉如何判斷此類行為。接著，請觀看影片 II 及 III，這些影片將教你如何計算攻擊行為。請仔細觀看。當你已經知道如何計算口孵魚（*N. pulcher*）的此類行為時，請立刻觀看考試的影片。

## Part 1.4: Quantifyramming or biting attacks of *N. pulcher*[30 points]

## 量化口孵魚（**N. pulcher**）的衝撞或咬的攻擊行為

Each of the Folders A, B, C and D contain three movies, showing sequences from experiments conducted under the corresponding Situations A, B, C and D indicated in the figure in Part 1.1 and the table below. Count the number of ram or bite attacks of the male in the **right compartment** for each of the twelve movies and report your results in the table below. It is recommended to count by using tally marks on the provided scratch paper.

請觀看資料夾 A、B、C 及 D 中的影片，每個資料夾都包含了 3 部影片，顯示了前述 Part 1.1 的圖及下表中的 A、B、C 及 D 的 4 種實驗情況。請計算 12 部影片中水箱右側雄魚出現衝撞或咬的攻擊行為的次數，並將計算結果填入下表中。建議你在觀看影片的過程中，可先使用計算紙逐次劃記記錄。

**Q1**

| **Situation 情況** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Separation 隔間板 | sealed 封閉 | sealed 封閉 | porous 孔洞 | porous 孔洞 |
| Size 體型 | different 不同 | matched 相同 | different 不同 | matched 相同 |
| Replicate 1 重複實驗 1 | | | | |
| Replicate 2 重複實驗 2 | | | | |
| Replicate 3 重複實驗 3 | | | | |

## Part 1.5: Additional replicates

### 重複更多次的實驗

The table below provides the results of three additional replicates for each experimental setup. These results are to be combined with your results for the statistical analysis below.

下表針對每種實驗設計，另外提供了 3 個重複實驗的結果；請將這些結果與你所觀察的結果合併計算，以進行後續的統計分析。

| **Situation 情況** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Separation 隔間板 | sealed 封閉 | sealed 封閉 | porous 孔洞 | porous 孔洞 |
| Size 體型 | different 不同 | matched 相同 | different 不同 | matched 相同 |
| Replicate 4 重複實驗 4 | 24 | 45 | 10 | 15 |
| Replicate 5 重複實驗 5 | 34 | 41 | 17 | 8 |
| Replicate 6 重複實驗 6 | 27 | 38 | 12 | 16 |

## Part 1.6: Statistical analysis of bite or ram attacks [20 points]

### 統計分析咬或衝撞的攻擊行為（**20** 分）

You will conduct an analysis of variance (or ANOVA) to analyze the obtained results. The goal of this analysis is to infer what part of the variance in your measures is due to stochastic differences between the individuals studied, and what part can be explained by the two factors manipulated in this experiment: 1) the type of separation (sealed vs. porous) and 2) the difference in the size of males (matched vs. different). This is done by partitioning the total variance into different components and testing the relative importance of these partitions

你須以變異數分析（ANOVA）來檢定得到的實驗結果，其目的是為了推論在你所測量結果的變異中，有多少部分是屬於被研究個體之間的隨機變異，有多少部分是屬於本實驗操弄的 2 個因子（1. 隔間板：封閉或孔洞。2.雄性競爭者的體型：相同或不同）所造成的變異。此種分析方式，是將總變異區分成不同的部分，再檢測這些不同部分的相對重要性。

**Variance within groups**

組內變異

Compute the mean and variance among the replicates 1 through 6 of each of the four experimental setups A through D. Report your results in the tables below with a precision of one digit after the decimal point. The variance is calculated according to

針對 A 到 D 四種實驗設計，分別就每一種設計下，計算重複實驗 1 到重複實驗 6 之實驗結果的平均值及變異數。請你計算到小數點後第 1 位，並將計算結果填入下表中。變異數的計算公式如下

$$\sigma^2 = \frac{1}{n-1} \cdot \sum_{i=1}^{n} (R_i - M)^2$$

where *i* runs over all replicates 1 through *n* and $R_i$ are the observed counts in replicate *i* and *M* is the mean across all replicates 1 through n.

其中 i 代表重複實驗的次別 1 到 n；$R_i$ 代表每種實驗情況下，各次重複實驗所得的數據；M 代表每種實驗情況下所得數據的平均值。

**Q2**

| **Situation**<br>**情況** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Separation<br>隔間板 | sealed<br>封閉 | sealed<br>封閉 | porous<br>孔洞 | porous<br>孔洞 |
| Size<br>體型 | different<br>不同 | matched<br>相同 | different<br>不同 | matched<br>相同 |
| mean (M)<br>平均值（M） | | | | |
| sample variance ($\sigma^2$)<br>樣本變異數（$\sigma^2$） | | | | |

Now compute the average sample variance within groups (***$V_g$***) as the average of the four variances. Report your results in the box below with a precision of one digit after the decimal point.

現在請計算組內的平均樣本變異（$V_g$），亦即前述 4 變異的平均值。請你計算到小數點後第 1 位，並將計算結果填入下格中。

**Q3**

average sample variance within groups(***$V_g$***)
組內平均樣本變異（$V_g$）

**Variance explained by the type of separation and difference in the size of males**

**變異數可分為「間隔板類型」及「雄性競爭者體型差異」所造成的變異**

Next compute the variance explained by the type of separation ($V_{separation}$) and the variance explained by the difference in size of males ($V_{size}$)**.** To do so, you will first have to compute the overall mean of bite or ram attacks across all 24 replicates. Report your result in the box below with a precision of one digit after the decimal point.

再來，請計算出**「間隔板類型」所造成的變異（$V_{separation}$）及「雄性競爭者體型差異」所造成的變異（$V_{size}$）**。要計算此二數據，你必須先計算 24 個實驗所得數據的總平均值。請你計算到小數點後第 1 位，並將計算結果填入下列方格中。

**Q4**

overall mean across all replicates ($M_{ABCD}$)
總平均（$M_{ABCD}$）

Next, compute the mean number of bite or ram attacks among all replicates for each of the type of separation and the difference in the size of males, independent of the other category. The mean number of bite or ram attacks among all replicates with sealed separations, for instance, is simply given by the average of $M_A$ and $M_B$, where $M_A$ and $M_B$ refer to the mean number of bite or ram attacks observed in Situations A and B, respectively, which you calculated above. Compute all these means and report your results in the table below with a precision of one digit after the decimal point.

接著，請只考慮 2 種**「間隔板類型」及 2 種「雄性競爭者體型差異」，分別計算這 4 種類別**（category）**下各次重複實驗所得數據的平均值。舉例來說，在間隔板封閉類別**（category）**中的平均值，是**在 A 及 B 兩種情況（situation）下分別計算各次重複實驗所得數據的平均值（即**為 $M_A$** 及 $M_B$），再取 $M_A$ 及 $M_B$ 的平均值。

**Q5**

| | **Type of separation**<br>**間隔板種類** | | **Difference in the size of males**<br>**雄性競爭者體型差異** | |
|---|---|---|---|---|
| | sealed<br>封閉 | porous<br>孔洞 | different<br>不同 | matched<br>相同 |
| mean within category<br>同一類別內的平均值 | | | | |

The variance explained by factor ***x*** (either separation or size) is now computed as

屬於因子 x（間隔或體型）所造成的變異，計算公式如下

$$V_x = n \cdot \sum_{i=1}^{2} (M_{ABCD} - M_i)^2$$

Where ***i*** runs over both categories of the factor considered, ***n*** is the number of replicates within each category (12 in your case), $M_i$ is the mean within category ***i*** and $M_{ABCD}$ the overall mean computed in Q4. Compute the variance explained by each factor and report your results in the table below with a precision of one digit after the decimal point.

其中 ***i*** 涵蓋了 2 個類別因子，***n*** 是每一個類別下重複實驗的次數（在本實驗為 12），$M_i$ 是同一類別下所得之各平均值，$M_{ABCD}$ 則是前述第 4 題（Q4）計算所得之總平均。請分別計算由兩種因子所造成的變異，請你計算到小數點後第 1 位，並將計算結果填入下表中。

| | | Type of separation<br>間隔板種類 | Difference in the size of males<br>雄性競爭者體型差異 |
|---|---|---|---|
| **Q6** | variance explained by factor($V_x$)<br>因子 x 所造成的變異（$V_x$） | | |

If a factor does not explain any of the observed variance, we expect $V_x$ to be zero. However, due to the stochastic nature of this experiment, deviations from zero are expected. You will now test if the deviations from zero you observed for both $V_{separation}$ and $V_{size}$ are statistically significant, which would indicate that these factors are significantly explaining part of your observations. This is done by computing the probability of observing deviations as large as or even larger than what you observed. To do so, you will need a F-test, for which you now need to compute the test statistic $F_x$, which is given by the variance explained by factor ***x*** (either separation or size), divided by the average sample variance within groups ($V_g$) you calculated in Q3.

如果某一因子 x 未造成任何變異，則 $V_x$ 的期望值為 0。然而實際上，受限於實驗過程中所可能產生的自然變異，所得的變異通常不是 0。故你要進行檢測的是兩個因子所造成的變異 $V_{separation}$ 及 $V_{size}$ 不止是要大於 0，且此差異須達一定程度，即達到統計上的顯著水準，才算因子 x 造成變異。為此，你須進行 F 檢定（F-test），計算 $F_x$，其公式如下，亦即將因子 ***x***（間隔或體型）所造成的變異 $V_x$ 除以前述第 3 題（Q3）計算所得的組內平均樣本變異 $V_g$。

$$F_x = \frac{V_x}{V_g}$$

Calculate $F_x$ for both factors and report your results in the table below with a precision of one digit after the decimal point.

請分別計算 2 個因子的 $F_x$，計算到小數點後第 1 位，並將所得結果填入下表。

Q7

| | Type of separation<br>間隔板種類 | Difference in the size of males<br>雄性競爭者體型差異 |
|---|---|---|
| test statistic $F_x$<br>檢定統計數值（$F_x$） | | |

You can now use the properties of the F-distribution to translate the test statistic into the probability of observing the $V_x$ values you calculated or even more extreme $V_x$ values if factor *x* does not explain any of the variance observed. This probability is commonly referred to as the p-value. The table below shows the corresponding F values for a wide range of p-values.

你現在可利用 F 分佈（F-distribution）的特性，將你計算所得數值 $V_x$ （或是更極端的 $V_x$ 值，顯示實驗的因子 *x* 與所得的變異毫無關連）換算成相對的機率。此一機率，一般以「p 值」（p-value）表示。下表即顯示不同的 F 值所對應之廣大不同的 p 值。

| Fx | p-value |
|---|---|
| 0.47 | 0.5 |
| 2.96 | 0.1 |
| 4.32 | 0.05 |
| 8.02 | 0.01 |
| 14.59 | $10^{-3}$ |
| 22.89 | $10^{-4}$ |
| 33.28 | $10^{-5}$ |
| 46.27 | $10^{-6}$ |
| 62.46 | $10^{-7}$ |
| 82.65 | $10^{-8}$ |

Use this table to translate your test statistic values into p-values. For each factor, indicate in the table below, the smallest p-value for which the p-value corresponding to the calculated F-value is smaller.

請依據上表將計算所得 F 值轉換為 p 值，並選擇最小且可確定的 p 值（即依據所計算的 F 值查上表，查得最接近但比該 F 值還小的 F 值所對應的 p 值，就是最小 p 值），並填入下表。

Q8

| | Type of separation<br>間隔板種類 | Difference in the size of males<br>雄性競爭者體型差異 |
|---|---|---|
| p-value <<br>p 值小於 | | |

Indicate with a tick (√) for each factor if it explains a fraction of the total variance significantly (p-value < 0.05) or not in the table below.

請於下表打勾（√），以表示各因子是否造成（p 值小於 0.05，達顯著水準）整體變異內的部分變異。

**Q9**

| | **Type of separation**<br>**間隔板種類** | **Difference in the size of males**<br>**雄性競爭者體型差異** |
|---|---|---|
| Explains part of the total variance<br>能造成整體變異內的部分變異 | | |
| Does **not** explain part of the total variance<br>不能造成整體變異內的部分變異 | | |

Indicate with a tick (√) if each of the following statements is a valid conclusion from your results or not.

請根據你的結果，以打勾（√）表示下列敘述是否為有效結論。

**Q10**

| | **valid**<br>**有效** | **not valid**<br>**無效** |
|---|---|---|
| Males of *N. pulcher* use visual cues of a competing conspecific to adjust their aggressive response.<br>雄口孵魚根據視覺線索來調整其對同種競爭者的攻擊程度 | | |
| Males of *N. pulcher* use olfactory cues of a competing conspecific to adjust their aggressive response.<br>雄口孵魚根據嗅覺線索來調整其對同種競爭者的攻擊程度 | | |

# Task 2: Puffed throat behavior

# 題項 2：喉部鼓脹的行為

In this task, you will check if a second aggressive behavior indicates the same pattern you found for the number of ramming or biting attacks in the previous task by concentrating on the puffed throat behavior.

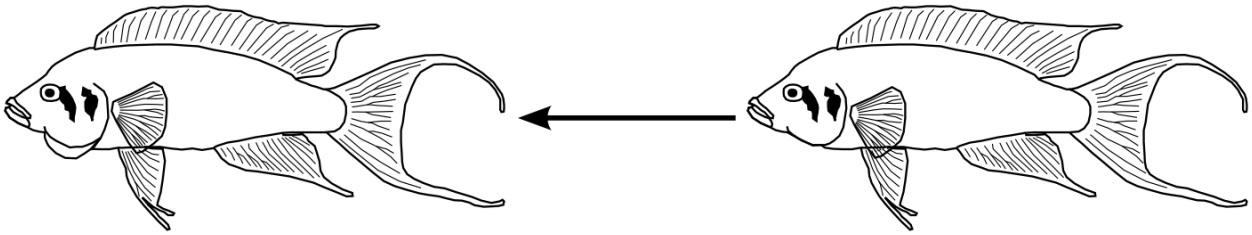
在此題項中，你將針對第 2 類攻擊行為—喉部鼓脹行為進行量化觀察，以檢測其是否與你先前所觀察之衝撞或咬的行為所產生的結果是一致的。

## *Part 2.1:* Puffed throat behavior of *N.pulcher*

## 口孵魚（*N. pulcher*）喉部鼓脹的行為

*N. pulcher* males use puffed throats to impress conspecifics, possibly because it makes them appear larger. A behavior is counted as puffed throat whenever the focal fish flares out its operculum and lower jaw and swims in the direction of his competitor on the other side of the glass wall. Note that males may flare out their operculum and lower jaw cavity for a very short time or an extended period of several seconds. Each flaring out of the operculum and lower jaw is counted as a single event. Be aware that some males may flare out their operculum and lower jaw multiple times within a few seconds, each of which is counted as a single event.

雄性口孵魚利用喉部鼓脹威嚇同類，可能是鼓脹會使其體型看來較大。當被觀察的雄魚擴張其鰓蓋及張口（打開下顎骨）朝向玻璃間隔板另一方的雄魚游去，即稱為喉部鼓脹行為。注意此種行為的表現，有時極為短暫，有時可長達數秒。每擴張其鰓蓋及張口 1 次，即計算 1 次。注意，有些雄魚在數秒內擴張其鰓蓋及張口多次，每次皆要計算。



## Part 2.2: Examples of puffed throat behavior

## 喉部鼓脹行為的範例

Activate your tablet by tapping and sliding with your fingers and open the Folder E_2. In that folder you will find three movies. Movie I contains a series of obvious puffed throat behaviors. Watch it to get a feeling what to look for. Next, watch Movies II and III which indicate how this behavior is to be counted. Watch them carefully. Proceed with the protocol as soon as you feel confident with how to count this behavior in *N. pulcher*.

請按壓及滑動你的手指來啟動平板電腦，並打開資料夾 E_2。在此資料夾中，你會發現 3 部影片。影片 I 的內容包含了一系列明顯的喉部鼓脹行為；請仔細觀察，以熟悉如何判斷此類行為。接著，請觀看影片 II 及 III，這些影片將教你如何計算喉部鼓脹行為。請仔細觀看。當你已經知道如何計算口孵魚（*N. pulcher*）的此類行為時，請立刻觀看考試的影片。

## Part 2.3: Quantify puffed throat behavior of *N. pulcher* [21 points]

## 量化口孵魚（*N. pulcher*）喉部鼓脹的行為（21 分）

Watch the three movies found in each of the Folders A, B, C and D you already analyzed in the first task. Count the number of puffed throat behaviors of the male in the **right compartment** for each of the twelve movies and report your results in the table below. It is recommended to count by using tally marks on the provided scratch paper.

請觀看先前題項 1 已考的 12 部影片（A～D 四組，每組 3 次重複），計算水箱中右側雄魚的喉部鼓脹次數，將結果填入下表中。建議你在觀看影片的過程中，可先使用計算紙逐次劃記記錄。

**Q11**

| **Situation 情況** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Separation 隔間板 | sealed 封閉 | sealed 封閉 | porous 孔洞 | porous 孔洞 |
| Size 體型 | different 不同 | matched 相同 | different 不同 | matched 相同 |
| Replicate 1 重複實驗 1 | | | | |
| Replicate 2 重複實驗 2 | | | | |
| Replicate 3 重複實驗 3 | | | | |

## Part 2.4: Interpret your results [4 points]

## 對你的結果提出解釋（4 分）

Based on your observations, indicate with a tick(√)if each of the following statements is true or false.

請根據你的觀察，以打勾（√）表示下列敘述是正確或錯誤。

**Q12**

| | **true** 是 | **false** 否 |
|---|---|---|
| These results are in line with *N. pulcher* males using visual cues of a competing conspecific to adjust their aggressive response.<br>此結果顯示，口孵魚會利用視覺線索來察覺競爭者的行為表現，再藉以調整其對競爭者的攻擊程度。 | | |
| The results are in line with *N. pulcher* males using puffed throat behavior to bluff about their size, which is most effective if males are of equal size.<br>此結果顯示，口孵魚利用喉部鼓脹行為來彰顯牠的體型，尤其是當競爭者體型與牠相同時，最為有效。 | | |

# Task 3: Social groups

# 題項 3：社群

In nature, *N. pulcher* lives almost exclusively in social groups made up of a dominant breeding pair and 1 to 20 smaller subordinates called helpers (average group size = 7 to 9). In each social group, the breeding male is always the largest individual (5.6–7.0 cm in length), the breeding female is usually the next largest fish in the social group (4.8–6.0 cm) and subordinate helpers are generally smaller (1.5–6.4 cm).

在自然界中的口孵魚絕大多數行群體生活，由一對繁殖的個體與 1 至 20 隻體型較小、位序（地位）低的個體稱為幫手（helper）所組成（每群個體數平均為 7 至 9 隻）。在每一社群中，繁殖的雄性一定是體型最大的個體（體長 5.6 至 7.0 公分），繁殖的雌性個體通常是此群體中體型次大者（4.8 至 6.0 公分）。而位序低的幫手一般較小（1.5 至 6.4 公分）。繁殖個體及幫手會表現下列 3 種主要的行為：

1. territory defense (against predators and conspecific or heterospecific territory competitors)
   領域防衛（抵抗天敵及同種或異種領域的競爭者）
2. territory maintenance (by digging and removing debris)
   領域整理（挖掘及移除雜質）
3. brood care (by cleaning and fanning eggs and defending the young)
   照顧子代（清潔魚卵、提供水流循環及保護小魚）

The goal is to understand task sharing in such groups by observing such a group for several minutes.

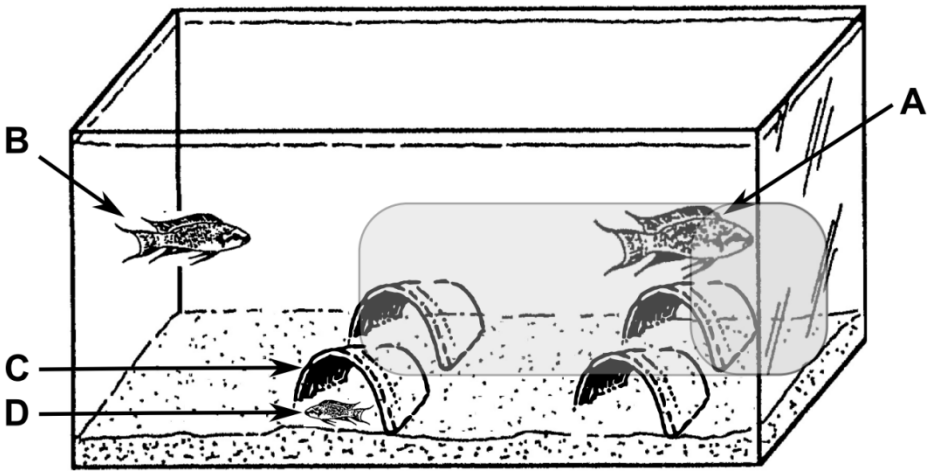
觀察此影片的目的是為了瞭解群體生活的分工，藉由觀察群體生活幾分鐘後，量化其行為。

## Part 3.1: Quantifying task sharing in social groups of *N. pulcher* [15 points]

## 量化口孵魚社群行為的分工（15 分）

Activate your tablet by tapping the screen with your fingers and open the Folder X. This folder contains the Movie x with two sequences showing typical territory maintenance and brood care behaviorof the simplest social group of *N.pulcher* consisting of a large breeding male, a slightly smaller breeding female and a small helper. You can recognize each individual easily in the very first scene of the sequence (see figure below): the breeding male (A) is standing in the ceramic nesting cave in the background on the right and the breeding female (B) is swimming in open water on the left. The only eggs in the aquarium are attached to the top of the inner wall of the ceramic cave(C)within which the helper (D)hides.

請按壓及滑動你的手指來啟動平板電腦，並打開資料夾 X。在此資料夾中，有影片 X，內容包含了最簡單社群組成（繁殖雌雄個體及 1 小幫手）的兩種行為，一為領域整理，另一為照顧子代。你可由影片開始的影像中，很容易辨識出每一個體（如下圖所示），繁殖雄性個體（A）是停立於此圖右方背景中的陶製巢穴；繁殖雌性個體（B）則在左側開闊水域中游動。水箱中，唯一的卵塊是附著在陶製巢穴（C）內壁的上方，而幫手（D）亦躲在其內。




While watching this movie, you will focus on two typical behaviors:

當你觀察此影片時，請專注下列 2 種典型行為：

- Digging behavior is a typical territory maintenance behavior in which the fish takes up sand, carries it away in its mouth and spits it out at another location. Count the number of digging sequences performed for each of the three individuals.
  挖掘行為屬於典型的領域整理行為。魚以口將沙移除，吐在其他地方。請計算此 3 隻個體挖掘行為的次數。
- *N. pulcher* individuals perform egg care by cleaning the eggs from small particles such as fungi or biofilms. This behavior is visible by back-and-forth movements in front of the eggs and simultaneous mouth movements. Estimate the total time spent on this behavior by each individual.
  口孵魚個體進行卵的照顧，即清理附在卵上的小顆粒，如菌物或生物薄層（biofilms）。此一行為可由魚在卵前來回移動及同步的口腔動作來顯示。請估算每一個體進行此種行為總共花費的時間。

Report the total number of digging behavior for each individual in the table below.

請將每一個體的挖掘行為次數填入下表。

**Q13**

| | **Breeding male**<br>**繁殖雄性** | **Breeding female**<br>**繁殖雌性** | **Helper individual**<br>**幫手** |
|---|---|---|---|
| Total number of digging behavior events displayed<br>挖掘行為的總次數 | | | |

Indicate with a tick (√) the time spent on egg care for each of the three individuals in the table below.

請以打勾（√）表示此 3 個體花費在照顧卵的時間。

**Q14**

| | **Breeding male**<br>**繁殖雄性** | **Breeding female**<br>**繁殖雌性** | **Helper individual**<br>**幫手** |
|---|---|---|---|
| no egg caring or caring for < 5s<br>無照顧卵的行為，或照顧卵的行為小於 5 秒 | | | |
| egg caring for > 5s and < 30s<br>照顧卵的行為在 5 至 30 秒間 | | | |
| egg caring for > 30s<br>照顧卵的行為大於 30 秒 | | | |

## Part 3.2: Interpret your observations [4 points]

## 解釋你的觀察結果（4 分）

Indicate with a tick (√) if each of the following statements is true or false.

請以打勾（√）表示下列敘述是否正確。

Q15

| Assuming that the observed social group is a good representation of the majority of social groups in nature, we would conclude that …<br>假設所觀察到的社群能代表在野外大多數的社群，我們可下結論如下 | **true**<br>是 | **false**<br>否 |
|---|---|---|
| … helpers are likely to have a larger effect on the survival rates of clutches of breeding pairs after an oligotrophic (nutrient-poor) environment was suddenly converted into a highly eutrophic (hypertrophic) environment.<br>在一貧養環境，突然轉變為高度優養化的環境時，幫手可能對繁殖個體所產的卵塊其存活率產生較大的貢獻。 | | |
| … large-bodied breeding males are crucial in maintaining breeding caves by digging large quantities of sand.<br>大型雄性個體所展示挖掘大量沙的行為，是維持繁殖巢穴的關鍵。 | | |
| ... the presence of helpers allows the breeding female to spend most of her time patrolling the territory rather than on territory maintenance.<br>幫手的存在，使雌性繁殖個體可花費大多數的時間在領域的巡邏，而不必花在領域整理。 | | |
| ... helper individuals accommodate the large breeding male by following it and maintaining the cave currently occupied by it.<br>幫手跟隨雄性個體及整理雄性目前居住的巢穴，以提供大型雄性繁殖個體的住所。 | | |

**End of practical exam.**

**實作測驗結束**