MINISTRY OF PLANNING AND DEVELOPMENT

BESNet
Biodiversity and Ecosystem Services Network

UNDP

BES-Net TT Project

Pollinators in Secondary Science

Teacher Resource Book (Form2/NCSE)

BES-Net TT Project - Pollinators in Secondary Science

The United Nations Development Programme (UNDP) implemented the two-year project – Biodiversity and Ecosystem Services Network Trinidad and Tobago project (BES-Net TT) - on behalf of the Government of the Republic of Trinidad and Tobago (2021-2023). The overall project goal was to conserve globally important biodiversity in Trinidad and Tobago by addressing the science, policy and practice of pollination and pollinator management. Three major outcomes of the project were:

1. Improved scientific knowledge of pollinators and pollination services in Trinidad and Tobago;
2. Improved conservation of pollinators and pollination services through improved plans and policies;
3. The provision of education, tools and support to improve the practice and application of pollinator and pollination science in multiple contexts.

Further background information on the project is available at http://biodiversity.gov.tt/index.php/bes-net/bes-net-tt.html

One key project output under Outcome 1 was building public awareness and knowledge of pollinators and pollination. Students in local secondary schools were identified as a main audience with which such knowledge should be built. A Communication Working Group reviewed the Science curriculum at that educational level and selected topics for which information on pollinators would be relevant. The team brainstormed on ideas to develop content for incorporation in curriculum delivery while adding information to inspire students to value and conserve our local biodiversity.

This resource was based on selected topics in the Science curricula at the NCSE level, which are clearly indicated at the start of each section of this booklet. As far as possible, sections incorporate a basic introduction, a hands-on activity and links to additional resources that can be used in curriculum delivery. It should be noted that the treatment of the topic also integrates with other subject curricula, such as mathematics, social studies, agricultural science, language arts and art, and this is indicated in footnotes.

If any sections of the booklet are used, your feedback on the resource is welcomed. Please complete the Feedback Questionnaire at the back of the booklet and send to the Environmental Policy and Planning Division, Ministry of Planning (lena.dempewolf@planning.gov.tt). We hope you find these resources to be useful and that your students enjoy using them!

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Integrated Science Topic 2.8: Energy in Ecosystems

Learning Outcome 2.8.1 Illustrate energy flow from the sun to plants and animals.

- The food made by plants is eaten by animals (including humans) and provides energy.
- Energy made from plants is transferred directly or indirectly to animals through feeding.

Introduction

All energy comes from the sun, and in the environment, energy is captured by plants through the process of photosynthesis. The energy captured by plants in then invested in the manufacture of food. The food produced by plants is then consumed by animals in order for the animals to obtain energy. For this reason, plants are called **producers**, supplying food which forms the basis of the food chain.

The animals that feed on plants are called consumers, notably primary consumers. If plant-material is their only food source, these animals are also called herbivores, or plant-eaters.

Animals which feed on other animals are called secondary consumers. If these secondary consumers eat animals only, they are called carnivores or meat-eaters. If however, these secondary consumers also feed on plant material, they belong to a special group known as omnivores.

You are what you eat!

Herbivore – feeds on plants (herb = plant)

Carnivore – feeds on meat/animals (carne = meat)

Omnivore – feeds on plants and animals (omni = everything)

Plant = Producer

Rabbit = Primary Consumer Herbivore

Human = Secondary Consumer Carnivore or Omnivore

Diagram illustrating energy flow in feeding relationship = food chain

Nectar and pollen as food materials

Sometimes when we think about animals feeding on plants, we think about animals feeding on the leaves (like caterpillars), fruit (like birds) or on the roots or tubers (like humans). However, there are other plant materials fed upon that give animals energy. These other materials, associated with flowers, are nectar and pollen.

Nectar: Nectar is a sweet, viscous secretion produced by plants, usually from specialized glands near the plant blossom or flower. It serves as an attractant for pollinating species, and contains fructose, glucose and sucrose sugars, which provides energy to the feeding organism. As it is a liquid food, animals that feed on nectar usually have specially modified mouthparts which allow access to the nectary (the place where the nectar is stored in the plant) and which enable uptake of the nectar.

Pollen: Pollen is a material which is produced in the anthers of flowers of flowering plants and the pollen cones of other plants. It takes the form of fine grains known as pollen grains. Pollen is made up of vegetative material and a male reproductive cell. It is a source of proteins and lipids and is a food material used by bees in their developmental stages and for the production of royal jelly (for the developmental stage of the queen bee). Bees visit flowers to feed on nectar but also collect pollen.

Nectar feeding and pollination

As mentioned earlier, some animals visit plants to obtain nectar which provides them with liquid food to meet their energy needs. While extracting nectar, because of the strategic location of pollen-producing anthers, pollination is carried out by the flower visitors. From this perspective, pollination is mostly incidental and not deliberate.

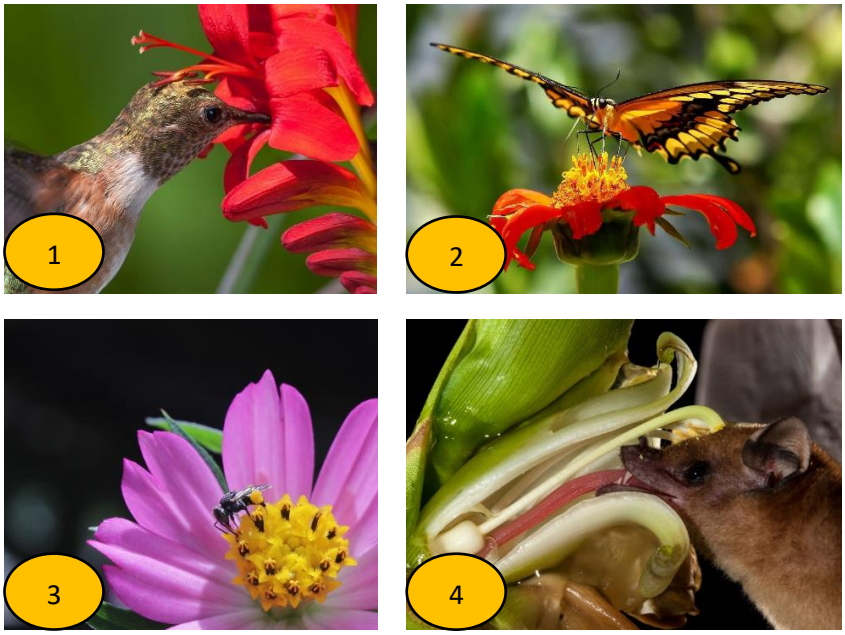
Activity 1: Pollen capture

The images on the right illustrate how pollen may be picked up by animals while visiting flowers.

Ask students to Identify where the pollen is picked up on the animal's body and suggest how it may be transferred to another flower.

(*Hint: observe what part of the animal is in contact with the anthers*)

(Answers given on back page)



Photograph credits:

1. Photo by Martin Dollenkamp on flickr Rufous Hummingbird feeding nectar on flower.
2. https://i0.wp.com/wallpapershero.com/wp-content/uploads/sites/13/2013/10/Butterfly-Feeding-With-Nectar-Wallpaper.jpg?fit=1920%2C1200&ssl=1
3. Photo by Celeste Chariandy
4. https://www.nytimes.com/2017/01/06/science/bats-nectar.html

Activity 2: Observation Exercise

Feeding in animals can be observed in a garden setting. For this exercise, a range of gardens can be used to carry out observations – a school garden, a kitchen (food producing) garden, a public garden e.g botanic garden, public park, nature centre. The exercise can also be done collectively as a class exercise during school hours, or can be done as an individual (weekend) homework assignment.

Instructions:

1. Select a garden in which the observation exercise will be carried out.
2. Use a photocopy of the data collection table on the following page or use a notebook and copy the table template. Take the table out into the field together with a writing instrument (pen/pencil) and record your observations. (Two sample observations are recorded as examples in the table below).

Date of exercise:		**Time of observation (start - finish):**		
Garden type (select one):		**Floral** □ **Food** □ **Mixed (floral and food)** □		
	Animal seen feeding	**Where seen**	**What was eaten**	**Consumer category**
e.g.	Hummingbird	On red flowers	Nectar	Herbivore
e.g.	Praying mantis	On plant stalk	Spider	Carnivore
1				
2				
3				
4				
5				

Questions:

1. How many animals did you observe feeding?

2. How many animals were feeding at flowers?

3. What types of pollinators did you observe?

4. How many animals were feeding on plants?

5. How many animals were feeding on other animals?

Follow-up:

Develop as many food chains as you can based on the data you collected in the garden.

Pollinator Observation Exercise

Recording Sheet

Date of exercise:		**Time of observation (start - finish):**		
Garden type (select one):		**Floral □ Food □ Mixed (floral and food) □**		
	Animal seen feeding	**Where seen**	**What was eaten**	**Consumer category (Herbivore, Carnivore)**
e.g.				
e.g.				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Student Name: _____

Class: _____

Pollinator-flower associations

Scientists have determined that the shape, colour and sometimes scent of some flowers have attractions for particular types of pollinators.

Scent is a powerful signal which draws some pollinators to particular flowers. No two flowers have exactly the same scent. Bees and flies are generally attracted to flowers with sweet scents and beetles and bats to flowers with musty or fruity scents. The scent level is highest when the pollinators are active: bees and butterflies are attracted to flowers whose scent is highest in the daytime while bats and moths are attracted to flowers whose scent is highest at night. Birds have no sense of smell and flowers that they pollinate generally are unscented.

The birds are, however, attracted by colour and visit mainly red and yellow flowers, as do butterflies.

Some flowers also have nectar guides. The nectar guides are lines, patterns or markings on the petals of the flower which direct pollinators, mainly bees, to the location of nectar.

Flower shape and size also provide visual cues to pollinators and scientists also say that a coevolution is represented between flowers and pollinators in this regard.

Beetles and butterflies pollinate flowers that open widely and provide a 'landing pad' for the insect.

Trumpet-shaped flowers are pollinated by hummingbirds, which are able to reach deep into the flower to obtain nectar because of their long, narrow beaks.

Activity 1: Is there a trend?

Let students go back to the (previous) observation exercise and document any patterns seen in flower colour/shape and type of pollinator that visited. Discuss findings in class.

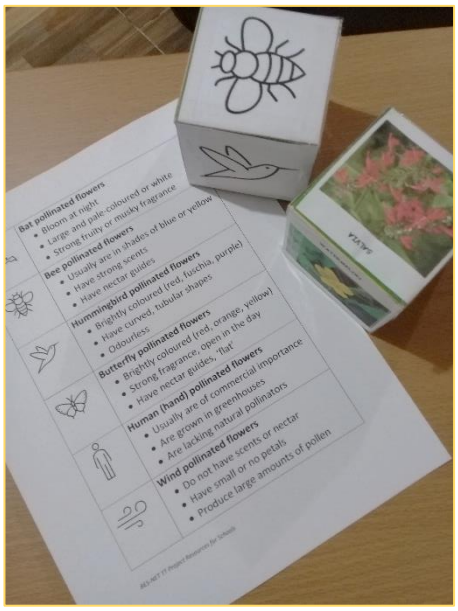
Activity 2: Crop Pollinators

Provide a suite of commonly known crop plants (including tree crops), incorporate pictures of the flowers (and fruit) of each crop and provide a list of known pollinators. Have the students try to determine which organism/s is/are the main pollinator/s based on characteristics of the flowers. After ideas are put down, let the students research the actual pollinators on the Internet or in the library. A suggested checklist and table for documenting results is given on the following page.

Crop Pollinators

Crop	Proposed pollinator (state reasons for suggestion)	Actual pollinator (state information source)
Avocado		
Banana		
Cucumber		
Guava		
Hot pepper		
Ochro		
Pumpkin		
Soursop		

Match the Pollinator Game



In this game, some clues are given to help match a pollinator or pollination method to a flower type. The clues support the background information on how colour, shape, size and scent of flowers may attract particular pollinator types, so it is advisable to recap this information with the students before playing the game. The list of clues below will assist.

Materials: 1 list of clues 2 labelled cubes

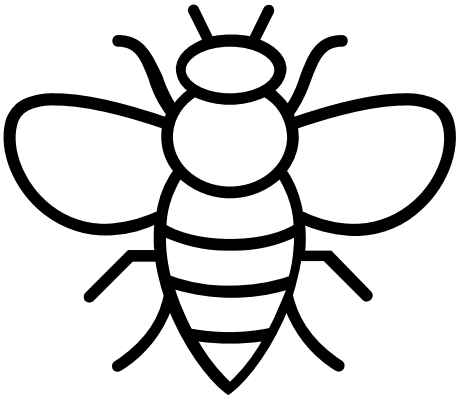
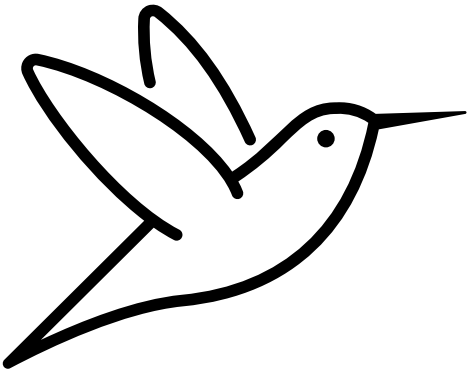
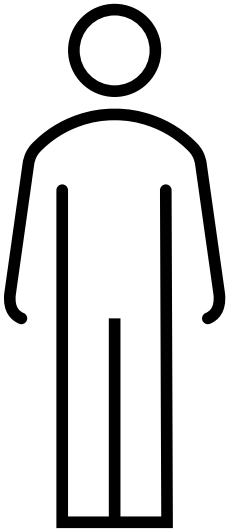
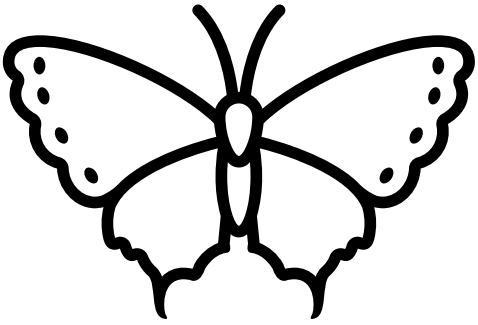
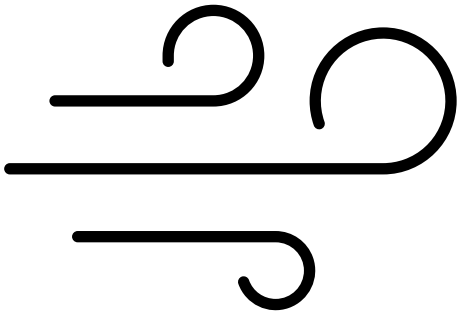
Instructions:
Create the game cubes by using small cereal boxes (the single serving size) and images on the following pages. One box should be covered with drawings representing six pollinators/pollination method and the other box with the photographs of six different flowers (print in colour).

You can divide a group of players into two smaller groups to play this game.

Option 1: The two teams in turn get to roll the cube with the flower types (like rolling die). The team must look at the photograph on the upper face of the cube and guess how the flower is pollinated, using only choices from the second cube. After 6 throws each, the team with the most correct responses wins.

Option 2: The two teams in turn roll both cubes. The team then determines if the pollinator type on the upper face of the cube matches the flower being pollinated on the second cube. The team getting all six correct matches first wins the game.
Note: some of the flowers may have more than one pollinator type. For the purpose of this game, however, only six specific matches can be agreed upon at the start of the game. At the end of the game the two teams can discuss why specific flowers may have more than one pollinator type.

Bat pollinated flowers • Bloom at night • Large and pale-coloured or white • Strong fruity or musky fragrance	**Butterfly pollinated flowers** • Brightly coloured (red, orange, yellow) • Strong fragrance, open in the day • Have nectar guides, 'flat'
Bee pollinated flowers • Usually are in shades of blue or yellow • Have strong scents • Have nectar guides	**Human (hand) pollinated flowers** • Usually are of commercial importance • Are grown in greenhouses Are lacking natural pollinators
Hummingbird pollinated flowers • Brightly coloured (red, fuschia, purple) • Have curved, tubular shapes • Odourless	**Wind pollinated flowers** • Do not have scents or nectar • Have small or no petals Produce large amounts of pollen

SALVIA 	**WATERMELON** 
BANANA 	**CORN** 
ZINNIA 	**VANILLA** 

Integrated Science Topic 3.3 Environmental Impact of Human Activities

Learning Outcome 3.3.1 Explain the impact of human activities on the local and global environment

- Work in groups to research a topic and prepare a presentation
- Dramatize the consequences of human activities if they go undetected
- View photographs or a documentary on a local environmental concern and discuss how the problems can be addressed
- Organize activities to promote environmental awareness
- Field trips to any site of interest

BES-Net TT Resources on Pollinators

The BES-Net TT project was implemented jointly by the Ministry of Planning and Development (MPD) with the support of the United Nations Development Programme (UNDP) over a two-year period (2021-2023). The project assisted in building awareness of pollinators and their importance to biodiversity sustainability.

Here are resources developed by the project that can help build knowledge of pollinators, the process of pollination, the threats facing pollinators and how to reduce these threats. Share these resources with students to build knowledge and awareness. Following use of these resources, students can engage in follow up activities.

You Tube videos:

Introduction to Pollination https://www.youtube.com/watch?v=Pj8f1zLThG4 (Running time: 9 minutes, 25 seconds)	• Describes pollination process • Distinguishes pollination from fertilization • Identifies pollinators • Mentions decline in pollinators • Identifies factors for successful pollination
Introduction to Stingless Bee Biology and the plants they utilise https://www.youtube.com/watch?v=4HegiqPygv0 (Running time: 40 minutes + 24 minutes)	• What are stingless bees • Stingless bees in Trinidad and Tobago, the Caribbean and worldwide • Nesting, hive structure and reproduction • Food requirements, honey production • Role in pollination, threats they face • Plants that attract stingless bees

Newspaper articles:

Pollinators – wildlife worth saving	https://newsday.co.tt/2023/03/02/pollinators-wildlife-worth-saving-2/
Protecting native bees	https://newsday.co.tt/2022/05/20/protecting-native-bees/
Let the flowers bloom again	https://newsday.co.tt/2023/07/04/let-the-flowers-bloom-again/

Activity 1: Knowledge Building and Class Action

- Let each student develop a checklist of what is negatively affecting pollinators (Threats), what is the result of removal of pollinators (Impacts) and what can be done to reduce threats (Solutions).
- Compile all the checklists into one large checklist to be shared with the class. Checklist can be made into a poster for the classroom. Use photos taken by students or downloaded from the Internet or cut out from magazines to develop the poster.
- Ask the students what they can do as a school project to address threats to pollinators and provide a solution and develop a plan to get it done.

Activity 2: We the Pollinators![1]

- Let students brainstorm a story about pollinators and what happens when they face a threat. The pollinators come up with a solution to address the threat which involves the help of humans. Let students design costumes or masks to develop the characters in the story and devise props. Let students develop the story into a play to be performed in the classroom/school for a special environmental observance day (e.g. Earth Day – April 22; International Day for Biodiversity – May 22; World Environment Dy – June 5). Propose the play as an entry for Schools' Drama Festival.

Activity 3: Bees- pollinators and other roles

- Organise a field trip to a local estate where bees are kept (Carmel Valley Estate, Maraval; Wa Samaki Ecosystems, Freeport). Let students take notes during the field trip. On return to the classroom, ask students each to share one thing new that they learned about bees and bee management. Let students work in small groups to prepare posters on the importance of forests to bees.

Activity 4: Investigating pollination in food production[2]

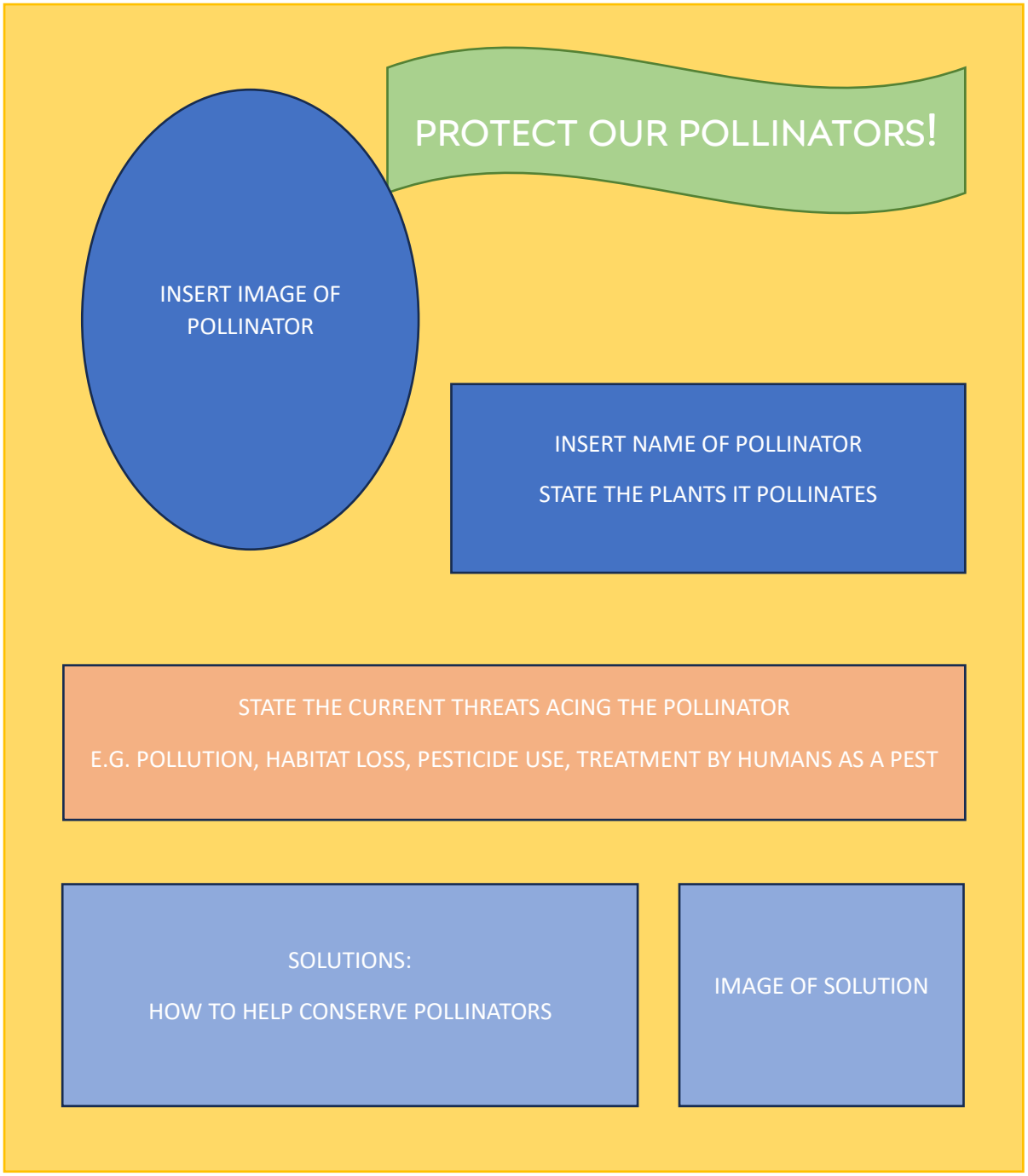
- Can be carried out in school garden; if school does not have garden. draw up a list of estates/farms that students can visit. Contact owner to ask if sampling can be done.
- Equipment needed: butterfly net, covered clear glass jars, mobile phone camera, notebooks
- Pre-briefing before visit – importance of pollinators, preference for particular crops, need to know and protect beneficial organisms.
- Instruction for on the estate/farm - Students visit and see range of animals that are functioning as pollinators, particularly bees. Teacher to do sampling for observation and release and/or photography. Students to note plant-pollinator links.
- Post visit/classroom exercise: Students to develop poster of importance of pollinators/bees.

Activity 5: Poster Development

- Review various key pollinator groups – bees, birds, butterflies, bats
- Think about how each type is impacted by human activity (Class Discussion).
- Assign group activity to research each pollinator (one per group) noting what they pollinate (value) how they are impacted by human activity (threat) and how they can be protected.
- Let each group present its research to the class on a poster (which can be put onto the classroom wall, school notice board). [See template (following page) for suggested content].

[1] Creative Arts
[2] Agricultural Science

Suggested template design for student poster



Activity 6: Pollinator Math

- Play the game Pollinator Math on the following page. The game was developed to illustrate the impact of broad-spectrum insecticides on pollinators. After playing the game, pose questions to students to discuss the outcomes of the game. Then view the video A story about VIPs and VAPs (https://www.youtube.com/watch?v=lKBwg-tulDY) which shares simple messages about regulation of use of pesticides in farming.

Pollination Math

What you need:

- A group of students
- Laminated pictures of flowers with elastic loops
- Washable coloured markers (at least 6 different colours)
- Recording sheets

Instructions:

1. This is a whole-class activity. Select four to six students to be bees/bees and butterflies. Ask two students to take on the role of recorders. Let the rest of the class represent crop plants.

2. Line up the students representing crop plants (Encourage the students to set the scene: crops are often planted in rows, there are two flower types these can represent two crop types). Let each of the 'crop plants' hold two flower motifs affixed on their fingers using elastic loops (Animate the activity, let them hold their flowers in different "poses").

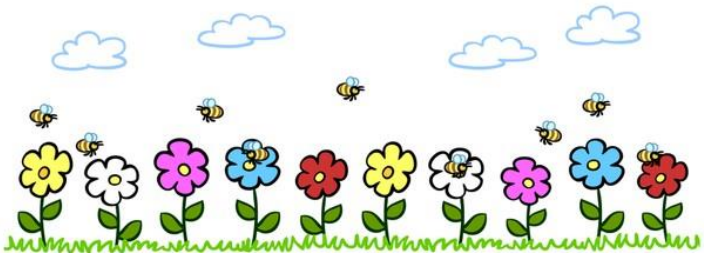
3. Allow the pollinators to take turns visiting the flowers; each will have a washable marker of a different colour. Pollinators must visit the flowers one at a time and spend at least 15 seconds with a flower (Say "Fly!" to alert them to move). Two pollinators cannot visit the same flower at the same time; while at a flower, they put a mark (1, 2 etc) on the flower to document the visit.

4. After 15 seconds the pollinator leaves the flower; it should not return to any flower it has already visited, but it can visit another flower on the same 'crop plant'. Each pollinator must ensure that the mark it makes on the flower is not placed on top of a previous mark.

5. Give pollinators a total of 2 minutes to do their visits. After 2 minutes, transfer the flowers to the recording students. The students must write down how many marks are on each flower (= how many pollinators have visited) and how many flowers have marks of each colour marker (=how many flowers each pollinator was able to visit).

6. Clean the flower surface at the end of each cycle. Repeat the exercise with i) half the number of 'bees' and with ii) 2 bees, keeping the same time limit and the same number of plants/flowers.

Pollination Math – Recording Sheet



	First Cycle	Second Cycle	Final Cycle
Number of Pollinators			2
Number of Crop Plants (fixed number)			
Number of Flowers (fixed number)			
Number of Flowers Visited			
Number of flowers visited by Pollinator #1			
Number of flowers visited by Pollinator #2			
Number of flowers visited by Pollinator #3			
Number of flowers visited by Pollinator #4			
Number of flowers visited by Pollinator #5			
Number of flowers visited by Pollinator #6			

Discussion

a.	How many crop plants were in the field?	
b.	How many flowers were available to be visited by bees?	
c.	In the first run of the exercise, how many bees were available to pollinate?	
d.	How many flowers were visited in total by the bees in the 3-minute time period?	
e.	What was the *average* number of flowers visited by a bee?	
f.	In the second run of the exercise, how many bees were available to pollinate?	
g.	How many flowers were visited in total by this reduced number of bees in 3 minutes?	
h.	What was the *average* number of flowers visited by a bee this time?	
i.	In the last run of the exercise with 2 bees, how many flowers were visited in 3 minutes?	
j.	What was the *average* number of flowers visited by a bee this time?	

What do you notice about the number of flowers that are visited as the number of bees lessen?

_____

What does this mean for how much pollination is carried out with less bees?

_____

What does this mean for the quantity of food that can be produced when there are less bees?

_____

Feedback Questionnaire

Teacher Resource Book Form 2/NCSE

1. At what school do you teach? _____

2. What level do you teach? Form 1 □ Form 2 □ Form 3 □ Other _____

3. Did you enjoy using the activities in this booklet? Yes □ No □

   Explain your answer _____

   _____

4. How many of the booklet's activities for your class level have you used?
   Approximately 25% □ 50% □ 75% □ 100% □

5. Did you find the content to be relevant to the curriculum? Yes □ No □

6. Was it easy or difficult to integrate content in your teaching? Easy □ Difficult □

7. Describe the experience the children had while taking part in these activities.

   _____

   _____

8. What did you like best about this resource? _____

9. What did you like least about this resource? _____

10. Were there other aspects of pollinators you would have liked to see in this booklet? If yes, please share these, below.

    _____

    _____

11. If you have any recommendations about how this resource may be improved, please share below.

    _____

    _____

    _____

Thank you for your feedback. Kindly send your completed form to bes-net.tt@gmail.com

Answers to activity on pollen capture, page 2:

1. Pollen is picked up on the head feathers of the hummingbird.
2. Pollen is picked up on the feet of the butterfly.
3. Pollen is captured on the hairs on the bee's body (and is collected in pollen baskets).
4. Pollen is picked up on the hair on the head of the bat.

This Teachers' Resource booklet was produced under the
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