PREFACE

With its grounding in the "guiding pillars of Access, Equity, Equality, Affordability and Accountability," the New Education Policy (NEP 2020) envisions flexible curricular structures and creative combinations for studies across disciplines. Accordingly, the UGC has revised the CBCS with a new Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) to further empower the flexible choice based credit system with a multidisciplinary approach and multiple/ lateral entry-exit options. It is held that this entire exercise shall leverage the potential of higher education in three-fold ways – learner's personal enlightenment; her/his constructive public engagement; productive social contribution. Cumulatively therefore, all academic endeavours taken up under the NEP 2020 framework are aimed at synergising individual attainments towards the enhancement of our national goals.

In this epochal moment of a paradigmatic transformation in the higher education scenario, the role of an Open University is crucial, not just in terms of improving the Gross Enrolment Ratio (GER) but also in upholding the qualitative parameters. It is time to acknowledge that the implementation of the National Higher Education Qualifications Framework (NHEQF) National Credit Framework (NCrF) and its syncing with the National Skills Qualification Framework (NSQF) are best optimised in the arena of Open and Distance Learning that is truly seamless in its horizons. As one of the largest Open Universities in Eastern India that has been accredited with 'A' grade by NAAC in 2021, has ranked second among Open Universities in the NIRF in 2024, and attained the much required UGC 12B status, Netaji Subhas Open University is committed to both quantity and quality in its mission to spread higher education. It was therefore imperative upon us to embrace NEP 2020, bring in dynamic revisions to our Undergraduate syllabi, and formulate these Self Learning Materials anew. Our new offering is synchronised with the CCFUP in integrating domain specific knowledge with multidisciplinary fields, honing of skills that are relevant to each domain, enhancement of abilities, and of course deep-diving into Indian Knowledge Systems.

Self Learning Materials (SLM's) are the mainstay of Student Support Services (SSS) of an Open University. It is with a futuristic thought that we now offer our learners the choice of print or e-slm's. From our mandate of offering quality higher education in the mother tongue, and from the logistic viewpoint of balancing scholastic needs, we strive to bring out learning materials in Bengali and English. All our faculty members are constantly engaged in this academic exercise that combines subject specific academic research with educational pedagogy.We are privileged in that the expertise of academics across institutions on a national level also comes together to augment our own faculty strength in developing these learning materials. We look forward to proactive feedback from all stakeholders whose participatory zeal in the teaching-learning process based on these study materials will enable us to only get better. On the whole it has been a very challenging task, and I congratulate everyone in the preparation of these SLM's.

I wish the venture all success.

Professor Indrajit Lahiri
Vice Chancellor

Netaji Subhas Open University

Four Year Undergraduate Degree Programme
Under National Higher Education Qualifications Framework (NHEQF) &
Curriculum and Credit Framework for Undergraduate Programmes

Course Type : Honours in Zoology (HZO)
Course Title : Ecology (Praclical)
Course Code : 6CC-ZO-03

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: Members :

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(Chairperson)
Director, School of Sciences,
Professor of Zoology
NSOU

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Professor of Zoology
NSOU

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WBES Govt. General Degree College, Singur

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Professor of Zoology
West Bengal State University

Dr. Rupa Mukhopadhyay
Associate Professor of Zoology
Bangabasi College

: Course Writer & Editor :
Professor Bibhas Guha
(Chairperson)
Director, School of Sciences,
Professor of Zoology
NSOU

: Format Editor :
Dr. Bibhas Guha
Associate Professor of Zoology
Netaji Subhas Open University

Notification

Ananya Mitra
Registrar (Add'l Charge)

Netaji Subhas Open University

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(HZO)

Course Title : Ecology (Practical)
Course Code : 6CC-ZO-03

Unit - 1 ❑ Study of Zonation/Stratification of pond or lake ecosystem

Structure

1.1 Introduction

An ecosystem refers to a biological community that is made of different types of organisms. These organisms interact with each other to eater to environmental conditions. There are different types of ecosystems around us. The ecosystem may also be defined by the presence of surrounding environmental conditions. Some of the prime examples of ecosystems include pond ecosystems, forest ecosystems, ocean ecosystems and more.

The pond is an example of an ecosystem that is made in an area demarcated by overflowing water that has aquatic plants and animals. The different types of animals and plants in a pond ecosystem will interact with each other and the surrounding environment thereby forming an ecosystem. In the later sections of the article, we will be discussing the plant ecosystem in detail.

1.2 Definition of Pond Ecosystem

A pond ecosystem is a freshwate ecosystem that can either be temporary or permanent and consists of a wide variety of aquatic plants and animals interacting with each other and the surrounding aquatic conditions. The pond ecosystem falls under the category of a **leatic ecosystem** because the water remains stagnant for a longer period.

1.3 Characteristics of Pond Ecosystem

The following are the main characteristics of the pond ecosystem :

- The water in the pond ecosystem is stagnant.
- Either natural or artificial boundaries surround the pond ecosystem.
- The biotic components of the pond ecosystem occupy different levels in the pond ecosystem, therefore, avoiding the competition for survival. Scavengers and decomposers occupy the bottom level, and fish occupy the middle level. The plants enclose the pond's boundaries and provide shelte to small animals and insects.
- Pond ecosystem show a wide range of variety in their size.

1.4 Stratification in the Pond Ecosystem

Different factors such as distance from the shore, penetration of light, depth of water, plant and animal species, etc. determine the following zones found in the pond ecosystem :

- **Littoral zone :** It is the zone closer to the shore. It contains shallow water and allows easy penetration of light. Rooted plant species occupy it. Animal species include reeds, crawfish, snails, insects, etc.
- **Limnetic zone :** The limnetic zone refers to the open water of the pond with an effective penetration of light. This zone is dominated by phytoplankton. Animal species mainly include small fishes and insects.
- **Profundal zone :** The region of a pond below the limnetic zone is called a profound zone with no effective light penetration. Some amphibians and small turtles occupy it.
- **Benthic zone :** The bottom zone of a pond is benthic and is occupied by a community of decomposers. The decomposers are called benthos.

1.5 Importance of Pond Ecosystem

The importance of the Pond ecosystem can be discussed as follows :

- Some aquatic plants help to improve the water quality by absorbing pollutions and heavy metals.
- The shoreline plants absorb nitrogen and phosphorus and therefore prevent the algal bloom and maintain the oxygen level in the pond. Moreover,

aquatic plants absorb animal wastes to reduce the nutrient availability for plants and therefore prevent the growth of algae.

- The pond ecosystem is one of the sites for the conservation of biodiversity as different types of plants and consumers occupy different strata in the pond and live together by interacting with each other. Ponds in mountain regions conserve the endangered species.
- The pond ecosystem also serves as a source of water for the species that do not live in the pond.
- Pond ecosystems contribute to the beauty of nature as they accommodate a variety of ornamental flowering plants.
- Stratification in the pond ecosystem determine the distribution of animal species in the pond. It reduces the competition among the species to some extent.

1.6 Summary

The **pond ecosystem** is an aquatic ecosystem that comprises several submerged, emerged, floating plants and algae living together with different types of animal species. The pond is an example of an ecosystem involving aquatic animals and plants interacting with each other in an environment. Stratification is one of the characteristic features of the pond ecosystem that determines the availability of essential abiotic factors such as light, oxygen, minerals, etc., to the different levels of depth in the pond. The availability of abiotic factors also determines the distribution of consumers and decomposers according to their need for different abiotic factors. This article is a sum-up of the different features and components of the pond ecosystem.

1.7 Questions

1. What are the three producers in a pond ecosystem ?
2. What type of microorganisms can we observe in the pond ecosystem ?
3. What are the types of zonation in pond ecosystem ?

Unit - 2 ❑ Study of temperature and turbidity / penetration of light in pond or lake.

Structure

2.0 Introduction

Solar radiation is the source of heat for all water bodies. The amount and angle of incidence of sunlight would decide the energy entering the water body. Distribution of heat within the water by condition is negligible because of very low heat conductivityof water. Much of heat mixing takes place by convection aided by wind action. Heat is lost due to evaporation and also by direct exchange to air and subtration.

2.1 Temperature Changes in Small Water Bodies :

In artificial ponds where the depth is usually of 1–2 metres there will be only a minor difference between the surface and bottom water. This difference would increase in depth of the water bodies. Even in the tropical shallow ponds and tanks the surface water temperature can be much higher in hot summer afternoons and it is likely that fishes congregating in the cooler and deeper portions of the pond survive such a critical condition. Also it must be noted that even the daily amplitude of temperature change can be high in certain tropical areas, the upper limit reaching near 40ºC and the lower near 20ºC in the same day.

2.2 Fish Pond Temperature :

Since most of the radiant energy of light is absorbed as heat by the surface and upper layers of water in the fish ponds, (because of the high concentration of dissolved organic and particulate matter on the top layer of water) the lower water layer becomes cooler. This at times is quite beneficial, for during the hottest part of the day the fish can move down safely to the lower layers. Mixing of the layers would however take place due to wind action. Boyd (1979) (Fig. 1) clearly shows a well developed thermocline (thermal stratification) in a fish pond— as we have discussed elsewhere herein this thermocline is not strictly according to the classical concept of thermocline (see below), as the change in temperature with depth in a small pond of say 2.5m is much higher than 1ºC/one metre– e.g. given change from 28 to 21ºC in a depth change of 1.8 to 2.2 metres (*e.g.* 7ºC per 0.4m or 17.5ºC/one metre). In shallow ponds (1m) the water would destratify on cooling at night, whereas in deeper ponds (1.5–2m) at Auburn, Alabama remained stratified throughout the warm months (Boyd. 1979).

2.3 Temperature Relations of Large Bodies of Water

This aspects of study is relevant to aquaculture in as much as it is important in stocking and management of man-made reservoirs, lakes and large coastal water bodies. A phenomenon of much significance in temperate lakes and also in the deeper tropical water bodies is the thermal stratication of water in summer (ef. fish pond). The warmer surface water remains in a separate zone on the top, referred to as epilimnion, and cooler deep water, being heavier, remaining in the bottom, referred to as hyplimninon (Fig. 2). The two zones are separated by the thermocline where the temperature changes sharply with increase in depth– according to Birge the thermocline is characterized by change in temperature of 1ºC/metre- perhaps this definition need not be so rigid.

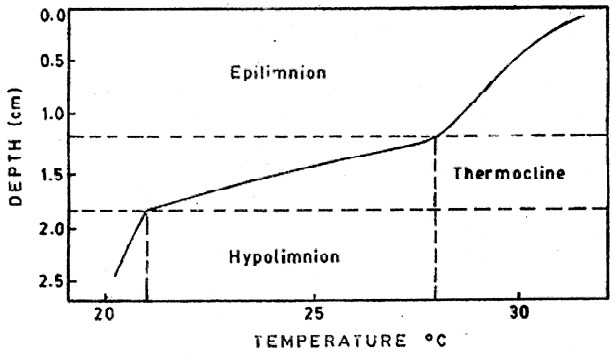


Fig. 1 Thermal stratification in a fish pond (after Boyd, 1979)

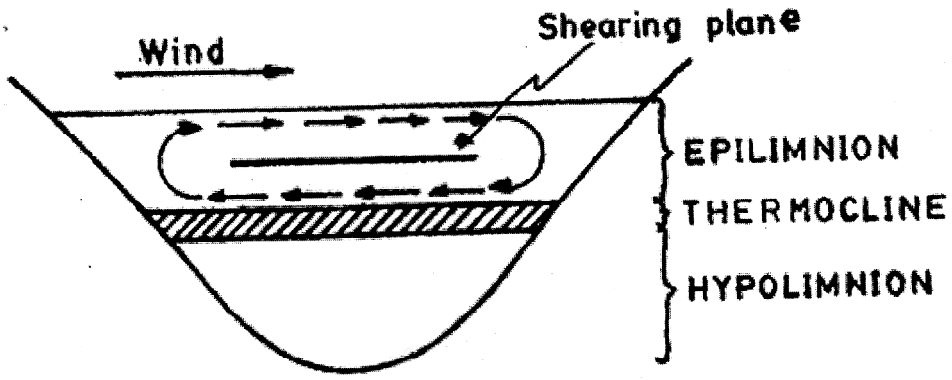


Fig. 2. Stratification of water in a natural water body (lake). Formation of horizontal water current and shearing plane in upper portion (epilimnion) is shown

Since water heated by sun remains in the epilimnion itself (mixing due to wind action restricted to the upper zone itself) there is a sharp difference in the physico-chemical and biological characteristics of epilimnion and hypolimnion. These aspects will be discussed separately. (See also water density).

2.4 Temperature Relations of Culturable Organisms

Temperature is often referred to as the master factor among environmental factors affecting aquatic life. All animals have a temperature range, the 'biokinetic range', within which they can live indefinitely. This range is limited by the upper and lower tolerance limit, and beyond these critical temperatures the animals may live for a brief period resistance time but would eventually die (lethal zone). Both the tolerance range and resistance time in lethal temperatures are subject to the acclimation temperature i.e. the temperature to which the organisms have been previously exposed. Therefore it is a matter of great concern for aquaculturists not only to know the seasonal and daily changes in temperature of the water body selected for aquaculture but also the thermal tolerance range and thermal history of the organisms to be introduced in the water body. The thermal tolerance of finfishes and shellfishes vary greatly, those with a wide range of tolerance being referred to as 'eurythermaf and those with a narrow range as 'stenother-mal'. The temperature range of a water body as obvious must depend on the latitude or geographical location and also the altitude at which it is located as already referred to; both these aspects have to be considered while transporting and stocking fishes.

In a continent as wide as Africa several temperature regimes would characterise specific locations. Generally the cichlids which are abundant in Africa have a high

upper thermal tolerance, *Oreochromis mossambicus* having as high as 38-39°C, but their lower tolerance limit is also high i.e. they are unable to tolerate cold temperatures even by gradual acclimation; several tilapias cannot be taken below 10°C. They also need warmer temperature to reproduce or even to be active. *O. mossambicus* ceases swimming activity, in a tunnel apparatus at temperatures below 15 - 20°C, in contrast to several culturable fishes such as the salmonids (stenothermal) - the salmonids cannot tolerate temperatures above 20 - 25°C; the cyprinids are relatively eurythermal, the common carp *Cyprinus carpio* and goldfish are good examples of eurythermal fishes. Quantified information on thermal tolerance of several cyprinids (Fry et al, 1942; Kassim, 1978), some mullets (Kutty, 1981; Kutty et al, 1978), *O. mossambicus* (Allanson and Noble, 1968; Aranthakrishnan and Kutty, 1976) and several salmonids - (Brett, 1962) are available in literature. Thermal tolerance range of tilapias are given in Balarin and Hatton (1979) and Pullin and Lowe Mcconnell (1982). The temperature history of the water body and of the selected organisms to be cultured have to be precisely known since growth of fishes is a major interest of the aquaculturist. Information on optimum thermal range for growth has to be known. Here temperature acts as a controlling factor regulating metabolism and thereby growth. Temperature acts also as a directive factor when it causes preference and avoidance of warmer or cooler areas in a water body, causing concentration or complete absence. The importance of these reactions in aquaculture and fisheries is obvious. More details are discussed separately under "Species selection for aquaculture".

2.2 Study of turbidity in pond

Definition of turbidity

Turbidity describes liquid that is cloudy due to suspended particles and measures relative clarity by how much light can pass through a water sample. Turbidity is most commonly seen in ponds with soft clay bottoms or where erosion and runoff are prevalent.

A pond is considered turbid if you cannot see past the top two feet of water. Beyond an unattractive appearance, turbidity blocks sunlight and lowers dissolved oxygen levels, which can harm fish and other aquatic life.

Causes of turbidity

Many *disparate organic and inorganic factors can contribute to water clarity issues.* In some areas, the chemical makeup of the water and soil may not mix well, and fine silt and clay particles never settle. Weather can also affect pond turbidity, especially storms with heavy rain and wind.

Turbidity can also result from animals causing erosion and agitating the water.

Cattle enjoy a good dip, and ponds are a great water source, but livestock wandering into the water can directly cause turbidity. It's the same story with aquatic wildlife like muskrats, large flocks of ducks or geese, catfish, buffalo fish, carp, and other creatures that root along the bottom and constantly kick up sediment.

Excessive nutrients and phosphates can lead to organic water turbidity issues. Phosphates enter a pond or lake from decaying vegetation and storm runoff, which introduces fertilizers and other contaminants. This debris decreases clarity and feeds algal blooms, which multiply and obscure the water even further.

How to Reduce Turbidity in Pond Water?

Diagnose It With a Jar Test: This is an important first step in determining the root cause of your turbid pond and whether the sediment will settle when left undisturbed. It's simple to do: dunk a clear glass jar into your pond, fill it with water, cap it, and keep it in the dark. We recommend letting your jar sit for about a week to see the full results. After a week, retrieve the jar and observe the water from the top down and the side.

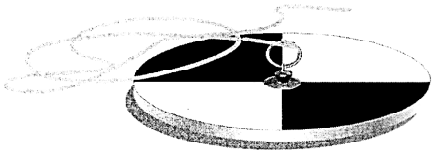
Bind Phosphates: If your water remains murky and cloudy during the jar test, it may indicate high phosphate levels. Farm runoff, lawn fertilizers, and animal waste are the primary contributors to extremely high levels of phosphates. Thankfully, treatment is easy with a clarifier or flocculant for ponds, like Airmax EcoBoost PRx. This highly effective, all-natural phosphate binder works within the water column to clear up cloudy or murky water and restore water quality.

Control Environment Factors: If the water clears during the jar test, your pond is turbid because of environmental factors. You will need to determine what those factors are and if you can control them. If you have determined that your murky pond is due to excessive erosion, you can plant marginal grasses to control erosion, wind, and storm runoff. If creatures are causing problems, you can remove or adjust livestock access, add predator fish to control an overpopulation of foragers, or deter undesirable wildlife with decoys.

Add Gravel & Bottom-Growing Vegetation: If you have determined that suspended clay is causing turbidity in your pond, you can take steps to keep the pond sediment in place at the bottom. Consider adding stones or pea gravel and allowing Chara and other plants to take root. The addition of gravel and plants will help settle your pond bottom and clear the water.

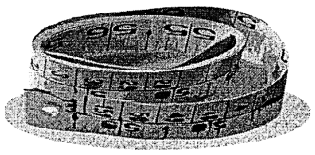
Study of Turbidity of Water Samples using Secchi's Disc Method

Materials Required:



Secchi's Disc tied with a rope of moderate thickness

Pins



A Meter Tap

Procedure:

- Reach the center of the pond in a small boat.
- Slowly immerse the Secchi's disc into water vertically holding the rope tightly till the black and white segments of the disc disappear.
- On reaching a particular depth, the disc becomes completely invisible.
- Using a pin, mark the length of the rope when the disc disappears (say A cm).
- Slowly pull up the disc till the black and white segments of the disc just reappear.
- Using a pin, mark the length of the rope where they just reappear, (say B cm).
- Using a meter tape, find the length of A and B.
- Find the mean length (Say X cm) of the rope by the following method. X=(A+B)2

Observation

The value of X represents the depth of the photic zone up to which sunlight penetrates in the water body and photosynthesis takes place.

Precaution

Students are advised to perform this experiment under the strict supervision of a teacher to prevent danger, such as drowning.

Unit - 3 ❑ Measurement of pH in Water and Soil Sample

Structure

3.1 Soil pH

A. Electrometric method : This method gives direct reading and because of its accuracy and rapidity it is considered the best.

Procedure : Take 10 gm of soil in a 50 ml beaker and add 25 ml of glass distilled water (soil: water ratio as 1:2.5). The suspension is stirred at regular intervals for 20 minutes. Now the pH meter is set, electrodes are immersed into the samples and the pH is determined. This pH meters are mostly direct readings recording pH in 1 unit interval.

B. Colorimetric method : Colorimetric indicators are most useful for field testing kit and for soil testing laboratories. Though approximate, they give satisfactory results if properly and carefully used.

Reagents : (1) Neutral barium sulphate A. R. Grade

(2) Indicator solutions; viz,

Bromophenol blue	—	3.0 – 4.6	pH range
Bromo cresol green	—	3.8 – 5.4	,,
Bromo cresol purple	—	5.2 – 6.8	,,
Bromo thymol blue	—	6.0 – 7.6	,,
Phenol red	—	6.8 – 8.4	,,
Cresol red	—	7.2 – 8.8	,,
Thymol blue	—	8.0 – 9.6	,,

Procedure : Place a layer of neutral barium sulphate 1 cm thick in a 50 ml dry test tube, add 10 g of air dried powdered soil and 0.25 ml of distilled water. Shake well for 10 minutes and keep if for settling. Take 10 ml of clear aliquot in a small clear glass tube and add 0.5 ml of indicator. To know which of the above indicators is to be used, a preparatory test with a universal indicator may be done which gives

a very approximate value of the pH; otherwise phenol red would be used first and then, if necessary, indicators of higher or lower ranges. After adding the indicator to the sample, it is stirred gently and the colour developed is matched against colour discs in a comparator or standard colour charts.

3.2 Water pH

Aim : To determine the pH of water sample.

Theory : The ionisation of water results in the formation of hydrogen ion (H^+) and hydroxyl ion (OH^-). Change in the concentration of one brings about the simultaneous changing in the concentration of the other therby altering the condition of the water. So, a number scale, termed as pH scale, is used to determine the pH of a medium, i.e., the acidity or the alkalinity of the same.

Materials Required :

i. Beaker – 100ml
ii. pH meter
iii. Buffer solution with a known pH
iv. Tissue paper
v. Distilled water
vi. Sample of which the pH is to be measured.

Procedure :

i. The pH meter is set on a flat surface.
ii. The electrode of the pH meter is dipped in a buffer solution with a known pH to calibrate it.
iii. After calibrating, the pH meter, the electrode is washed by dipping into distilled water to get rid of any adhered buffer.
iv. The electrode is gently wiped with a tissue paper.
v. The electrode is then dipped in the sample solution and its reading is noted.
vi. The electrode is washed again by dipping in distilled water and the pH of the sample is measured two more times.

Observation :

	pH			
	1 dip	2 dip	3 dip	Average pH
Sample Solution				

Result: The pH of the given water sample was found to be _____,

which indicates that the sample is acidic/alkaline/neutral in nature.

Precautions:

i. The electrode bulb of the pH meter should always be clean, to avoid misleading of the result.

ii. pH estimation is carried on spot immediately after collection of sample or the value changes.

Review Questions :

1. What is pH?
2. Who discovered pH scale?
3. Why is pH taken as the negative logarithm of H+ activity?
4. What is the principle of pH measurement?
5. Name the most acidic and most basic known substance.
6. Why can't we measure the pH of solid substances?
7. Explain the Lewis concept of acids and bases.
8. Explain the Arrhenius concept of acids and bases?
9. What is the use of measuring pH of:
   a. Water sample, and
   b. Soil sample?
10. What is the use of a buffer in pH meter?
11. What is the pH of the buffer used?
12. What is iso-potential point of a pH electrode?
13. What are the factors affecting pH of a solution?

Unit - 4 ❑ Estimation of Dissolved Free CO_2 in a Water Sample

Structure

4.1 Principle

Free carbondioxide can be determined by titrating the sample using a strong alkali (NaOH) at PH 8.3. At this pH all the free CO_2 is converted into bicarbonates. Th ephenolpthalein indicator turns into faint pink. Amount of alkali needed to produce the pint colour indicates the amount of free CO_2 in the sample solution.

4.2 Reagents

i) N/44 sodium hydroxide

ii) Phenolphthalein

4.3 Procedure

i) Water samples are collected in different ways for different times & ana'ysed. For dissolved gasses, bubbling or mixing with air or other gasses are avoided. A kemmer's or friedinger water sample may be used. Water may be collected in a large beaker or in a plastic bucket & transferred to a sampling bottle by a siphon tube. The sample for dissolved CO_2 should be fixed immediately after collection because CO_2 is liable to escape easily from the sample.

ii) 50 ml of water sample is taken in a conical flask or in a Nessler's tube.

iii) A few drop (3-4) of phenophthalein indicator are added to the sample.

iv) The flask is placed against a white background.

v) If the colour turns pink free CO_2 is absent.

vi) If the sample remains colorless titrate it against N/44 NaOH. At the end point a faint pink color appears.

vii) The end point reading of burette is noted.

4.4 Precaution

Since atmospheric CO_2 is readily soluble in H_2O_2 methods of determing the amount of free CO_2 is always subjected to more or less 10% error. Tire degree of accuracy of the result increases if the following precautions are taken.

i) While collecting the sample care should be taken to avoid contact of sample with air. This can be achieved by collecting the sample from surface water by opening the stopper of empty sample bottle.

ii) The sample should not be agitated.

iii) The surface of water sample exposed to air during titration should be kept as small as possible.

iv) The sample should be stirred gently & not agitated during titration.

4.5 Result

In tabular form

4.6 Calculations

$$\text{Free } CO_2 \text{ (ppm)} = \frac{\text{ml of NaOH} \times \text{(N) of NAOH} \times 1000 \times 44}{\text{Volume of sample taken for titration}}$$

4.7 Significance

i) Dissolved CO_2 is a measure of one of the important environmental factors affecting aquatic life. Higher concentration of CO_2 have inhibitory effect on plants and animals.

ii) CO_2 signify the rate of decomposition of organic matters and the respiratory activity of aquatic plants and animals.

iii) Dissolved CO_2 is inversely related with the pit value of water as when CO, dissolves in water, carbonic acid is formed and pH is lowered.

iv) CO_2 is one of the most essential raw materials, necessary for photosynthesis of green plants. Thus productivity of a water system can be measured.

v) The pH of the blood as well as O_2 carrying capacity of vertebrate haemoglobin and the respiratory pigment of invertebrates are affected with increase of CO_2 concentration.

4.8 Comment

For pisciculture more than 15 ppm dissolved CO_2 is harmful to culture operation and sometime cause even mortality of fish. (Please justify your result)

Unit - 5 ❑ Estimation of dissolved oxygen in water by modified Winkler Iodometric method

Structure

5.1 Principle

Manganous sulphate reacts with KOH or NaoH to give a white precipitation of white manganous hydroxide. In presence of oxygen brown manganic basic oxide is formed. Addition of H_2SO_4 dissolves the brown manganic oxide yielding manganic sulphate which reacts instantly with iodide to yield iodine. Iodine is then determined by sodium thiosulphate with 1 % starch solution as an end point indicator.

$$2KOH + MnSO_4 \rightleftharpoons K_2SO_4 + Mn(OH)_2 \text{(white ppt.)}$$

The dissolved oxygen of the sample reacts with $Mn(OH)_2$ forming a brown precipitate of $MnO(OH)_2$

$$2\ Mn\ (OH)_2 + O_2 \rightarrow 2\ MnO\ (OH)_2$$

With the addition of H_2SO_4, $Mn\ (SO_4)_2$ is produced.

$$MnO(OH)_2 + 2H_2SO_2 \rightleftharpoons Mn(SO_4)_2 + 3H_2O, Mn(SO_4)_2 + 2KI \rightleftharpoons$$

$$MnSO_4 + 2K_2SO_4 + I_2$$

The quantity of Iodine liberated is equivalent to the quantity of O_2 present in the sample. The quantity of iodine is determined by titration with a standard $Na_2S_2O_3$ solution using starch as indicator;

$$2Na_2S_3O_3 + I_2 \rightleftharpoons Na_2S_4O_6 + 2\ NaI$$

Reagents

i) Alkaline iodide
ii) Manganous sulphate
iii) Concentrated sulphuric Acid
iv) Starch solution (1%)

Prodecure

i) In a narrow mouthed bottle (for stopping mixing of surface oxygen into the bottle content), the subsurface water is collected preferably at or before 8 A.M.
ii) Collected sample is fixed immediately & taken to the laboratory for analysis.
iii) Carefully the stopper of the sampling bottle is removed.
iv) 1 ml of manganous sulphate & 1 ml of alkaline iodide reagents are added by means of a pippette dipped into the sample bottle.
v) One minute is allowed for precipitation.
vi) The stopper is replaced & the sample bottle is inverted 3 or 4 times for a thorough mixing of the reagents.
vii) A precipitation is formed which settle at the bottom (if the ppt is whitish in color oxygen content is poor; light brown color indicates less oxygen while brown to red brown color means medium to high amount of dissolved oxygen.)
viii) For quantitative estimation 1 ml of cone. H_2SO_4 is added & the bottle is shaken well to dissolved the ppt.
ix) 50 ml of the solution is transferred to a conical flask placed against a white background.
x) 0.025 N sodium thiosulphate is added drop by drop till the colour turns into pale yellow.
xi) Then 3-4 drops of 1% starch solution is added to give a blue colour & the titration is terminated by turning this solution into colourless one.

5.4 Result

The results are represented in tabular form.

No of observation	Vol. of Sample used for titration	Burette reading (ml)		Difference in burette readins (ml)	Mean (ml)
		Initial	Final		
1					
2					
3					

Calculations

The amount of dissolved oxygen is calculated by the following formula :-

$$\text{Oxygen (ml/L) or ppm} = \frac{V_1 \times N \times 8 \times 100}{\frac{V_4 (V_2 - V_3)}{V_2}}$$

Where, V_1 = volume of titrant (ml) ($Na_2S_2O_3$)

N = normality of titrant (0.025) ($Na_2S_2O_3$)

V_2 = Vol of sample bottle after placing stopper (ml).

V_3 = Vol. of manganese sulphate & concentrated H_2SO_4 added (ml).

V_4 = Vol. of fraction of the sample water as per titration (ml).

8 = Equivalent wt. of oxygen.

Significance

Dissolved oxygen is one of the most important parameters in water quality assessment & reflects the physical and biological processes prevailing in water.

i) It is a measure of one of the important environmental factors affecting the aquatic life & the capacity of water to receive organic matter without causing hazards.

ii) Little dissolved oxygen values indicated a very high organic pollution.

iii) Almost all plants & animals need oxygen for respiration. So, dissolved oxygen gives an idea of total plants present in water, also it helps to evaluate the gross production of water bodies.

iv) Dissolved oxygen value also helps to find out the BOD values indicating the pollution condition in water.

v) The concentration of O_2 will also reflect whether the process undergoing are aerobic or anaerobic. Low O_2 concentration are usually associated with heavy contamination of organic matter. In such conditions oxygen sometimes totally disappear from the water.

vi) The level of sufficient oxygen concentration is a limiting factor in the distribution of aquatic organisms.

vii) The permissible level of dissolved oxygen in tropical climate is 5 ppm.

Comment

Give your own comments.

Unit - 6 ❑ Estimation of gross and net primary productivity (GPP & NPP) of an aquatic system by using light and dark bottle technique

Structure

6.1 Principle

This is based on the estimation of oxygen (O_2) released by the producers over a period of time. O_2 produced is simultaneously used up in respiration. Photosynthesis depends on light which varies with the time of the day, clarity or transparency of the water and also with the concentration of the chlorophyll type of plant organisms.

This method consists of taking the water sample containing natural plankton populations in a glass bottle and exposing the bottle (light bottle - LB) to light in the euphotic zone. In a parallel experiment, a portion of the initial sample is held in a dark bottle (DB) for the same length of time and same temperature as the light bottle sample. The initial oxygen content (IB) of the sample is determined by-modified Winkler Method. Difference between this concentration and the concentration found from freshwater in the light bottle after a suitable period of exposure (L. B.) is calculated. (LB - IB) is a measure of the net evolution of O_2 due to photosynthesis. This is not necessarily equal to true net photosynthesis of the plant enclosed in the LB as O_2 may have been consumed by respiration of the plant cell proper. It is more common to the dark and light bottle technique to measure gross photosynthesis. This is done by finding the difference betwen initial oxygen content of IB of water and O_2 remaining in the DB, that is (IB - DB). Such a difference is assumed to be equal to the total respiration occurring in the light bottle over the same period of time and thus if added to the net value obtained from LB - IB above, it gives a measure of gross photosynthesis from the relationship.

6.2 Procedure

Light and dark bottles (150 ml capacity) are fixed in the morning into the studied eaberbody at surface. At this point, initial bottle oxygen is measured. Analysis of oxygen is done from LB and DB after removing them out of the pond following a time exposure (say 4 hours). The following prodedure is followed for O_2 measurements:

i) Sample bottle stopper is removed carefully. 1 ml of manganous sulphate and 1 ml of alkaline iodide reagents are added into each of the bottles.

ii) 1 minute time is allowed for precipitation. The stoppers are replaced and each bottle is inverted 3-4 times for thorough mixing of reagents. Aprecipitate is formed.

iii) 1 ml of cocentrated H_2SO_4 is added to each of the bottles. The bottles are agitated well to dissolved the precipitate.

iv) The total volume of the water in each of the 3 bottles are measured by a measuring cylinder.

v) 50 ml of water sample from each bottle is transferred to a conical flask and placed against a white background. 0.025 (N) Na_2SO_3 is added dropwise till the colour turns pale yellow. 3-4 drops of 1 % starch solution is added to give a blue colour and the titration is terminated when the solution turns colourless.

vi) The value of titrant required for titration is noted. Three observations are usually taken for each bottle for mean result.

6.3 Result

The results are represented in tabular form as shown below—

Initial bottle				Light bottle				Dark bottle			
V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
Mean				Mean				Mean			

$$\text{Dissolved oxygen } (mgL^{-}) = \frac{V_1 \times M \times 8 \times 1000}{V_4 (V_2 - V_3) / V_2}$$

When V_1 = Volume of titrant required

V_2 = Volume of sample water after placing stepper.

V_3 = Volume of alkaline iodide & manganous sulphate added.

V_4 = Volume of sample water used for titration.

IB, LB and DB oxygen concentration is thus calculated.

6.4 Calculations

$$\text{Gross primary productivity} = \frac{LB - DB \times 12 \times 1000}{T \times 32}$$

net primary productivity =

Where IB = O_2 content in initial bottle

DB = O_2 content in dark bottle

LB = O_2 content in light bottle

T = Tune (hrs) of incubation period.

1,000 = Conversion factor to change litres to cubic metres

We use the factor $\frac{12}{32} = 0.375$ to convert O_2 to carbon.

1 molecule of O_2 (32g) is released for each molecule of carbon (12 gm) that is fixed.

General ranges of primary productivity of phytoplankton and different trophic categoreis (Revised by WETZEL, 1983 in 'Limnology')

Trophic type		**Mean NPP (mg c/m^2/day)**
Ultra oligotrophic	→	<50
Oligotrophic	→	50 – 300
Mesotrophic	→	250 – 1,000
Eutrophic	→	>1,000
Dystrophic	→	<50 – 500

6.5 Comments

Give your own comments.

12 = atomic weight of carbon

32 molecular weight of oxygen

Unit - 7 ❑ Transact method-Point and line

Structure

7.1 Point transact method

The point transect method is a technique based on point sampling to determine cover. To follow this method, point readings are taken at either systematic or random locations along a tape that is extended to create a transect across the site. A variety of devices, including sighting tubes, bayonets, and plumb-bobs have been used to ensure a vertical reading of the point through the tape.

The length and number of sampling points along the transect depend upon the vegetation, but it is usually more efficient to record more transects with fewer points per transect. Each transect is considered a sample unit, and summarized data from several transects are required for statistical analysis of cover data to compare differences among years or sites.

According to the objectives of the study, either ground cover, basal cover, canopy cover, and species composition can be determined by this method. Leaf area index can also be determined by recording all layers of the vegetation that are hit at each pin placement.

The point transect method is regularly used for rangeland inventory or monitoring purposes because it is easy to follow. Although it is a slower technique than the step point method, it eliminates much of the bias arising from subjective pacing. Using a tape instead of the point frame method is also less cumbersome in many vegetation types.

7.2 Transact Metho

Several methods of estimating the density of plants and animals have been proposed. Although no method is bias free, the most accurate density estimates are obtained from complete counts [Davenport et al., 2007; McNeilage et al.,2001]. However, these methods require sampling effort that is often impractical, especially over large areas. The line transect sampling method is the most practical method [Plumptre,2000; Struhsaker,1997] in most cases. The line transect sampling provides

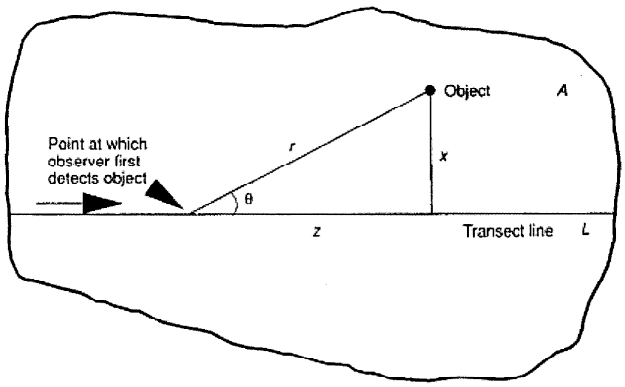
a convenience method of estimating the number of objects in a study. The objects may be any species of animal or plant that is easily visible, at least at close range.

7.2.2 Line Transect Sampling

Distance sampling is a widely used group of closely related methods for estimating the density and/or abundance of biological populations. The main methods are line-transect sampling and point-transect sampling. In both cases, observer(s) perform a standardized survey along a series of randomly located lines or points, searching for objects of interest (usually animals or clusters of animals). For each object detected, they record the distance from the line or point to the object. Not all objects will be detected, but a fundamental assumption of the basic methods is that all objects that are actually on the line or point are detected. The key to distance sampling analyses is to use the observed distances to fit a detection function that describes how detectability decreases with increasing distance from the transect. The fitted function is used to estimate the average probability of detecting an object, this enables one to readily obtain point and interval estimates for the density and abundance of objects in the survey area.

There are two basic methods of distance sampling, line transect sampling and point transect sampling. In line transect sampling, a series of lines is distributed according to some design (usually a systematic grid of parallel lines and an observer travels along each line, searching for animals or animal clusters). For each animal or cluster detected, the observer measures or estimates the (perpendicular) distance x of the animal or cluster centre from the nearest part of the line. In many surveys, it is easier to measure or estimate the observer-to-animal (radial) distance r at the time the detection is made. If the sighting angle 9 is also measured, then the perpendicular distance may be found by simple trigonometry, x = r x sin# (Fig. 1). The line transect sampling is associated with a detectability function g that indicates the detectability of an animal at a given location. The detectability function g is often a decreasing function of distance from the line transect and detectability on the line is assumed to be perfect. That is, if x is the perpendicular distance to the line, then g(x) decreases as x increases and g(0) = 1. Under certain circumstances, animals may avoid the observer which can result in less than perfect detectability on the line (g(0) < 1) while the maximum detectability occurs at some distance xmax from the line. We use the recorded distance x of the detected animals from the line to model the detection function, g(x), which is defined to be the probability of detecting an animal that is at distance x from the line.

Figure 1 : A single transect line



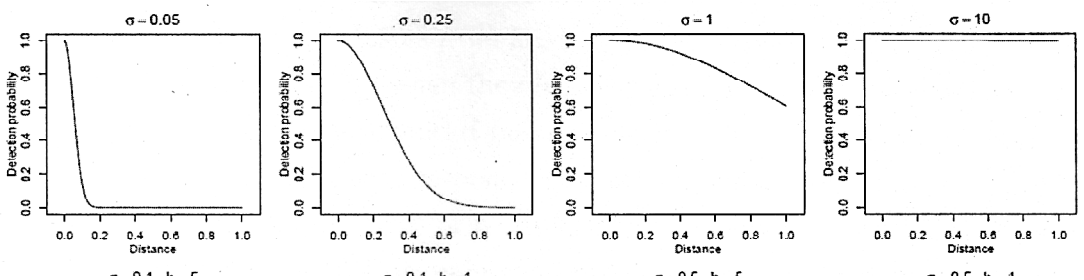
7.2.3 Selecting line Transect

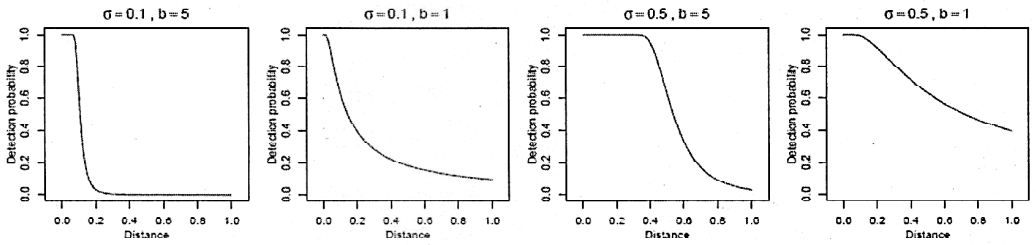
The sampling design in a line transect study is the procedure by which the transect locations are selected. In line transects sampling, several sampling methods may be considered in selecting the line transects. Usually, single or multiple transect lines are randomly placed on the study region. Estimates of abundance from multiple transect lines are obtained by averaging the abundance from each transect line used.

7.2.4 Detection

In Line transect sampling, detection function is a key concept in estimating abundance of species. The detection function g(x) is the probability of detecting an object, given that it is at distance x from the transect line. The distance x refers to the perpendicular distance from the transect line. The detection function decreases with increasing distance but lies between 0 and 1. Thus, $0<g(x)<1$. When object is located on the line, then we assume perfect detection such that the detection function is $g(0) =1$. This indicates that the object on the line is detected with certainty. Figure 2 displays a graph of the detection function g(x) for a given distance x.

Figure 2 : Graph of the detection function





The graph above represents half-normal (top row) and hazard-rate (bottom row) detection functions without adjustments, varying scale(cr) and (for hazard-rate) shape (b) parameters(values are given above the plots). On the top row from left to right, the study species becomes more detectable as the parameter, cr increases. The bottom row shows the hazard-rate model's with different parameters. In detection of objects, only small percentage of the object of interest are detected in the study region. Although this is the case, analysis of the associated distances allows reliable estimates of true density to be made.

7.2.5 Assumptions

In line transect sampling method, the design is associated with four main assumptions which includes;

- Animals are distributed independently of the lines.
- Objects on the line are detected with certainty.
- Distance measurements are exact.
- Objects are detected at their initial locations.

The assumption that animals are distributed independently of the line is characterized as one of the key design assumption. We assume that animals are distributed uniformly with respect to distance from the line. This assumption will hold based on a suitable randomized design (Strindberg et al. 2004). Thus, lines should be positioned according to a random design. However, we cannot ensure that assumptions related to the model holds by adopting a suitable design. Instead, we need to consider whether field methods can be adopted that will ensure low bias when they fail. For example, if animals show responsive movement, then field methods should if possible ensures that animals are detected and their locations recorded before they respond. This will ensure the assumption that objects are detected at their initial locations to be reasonable. Generally, movement independent of the observer causes no problems, unless the object is counted more than once on the same unit of transect line or if it is moving at at roughly half the speed of the observer or faster. Animal movement after detection is not a problem, as long as the

original location can be established accurately and the appropriate distance measured. It is problematic when animals move to the vicinity of the next transect in response to disturbance by the observer. However, if movement is random, or at least not systematically in a single direction, then animals moving in one direction will tend to be compensated by animals moving in the other direction. It is also assumed that, objects on the line are detected with certainty. This assumption ensures that all objects at zero distance are detected such that $g(0) = 1$. Practically, detection on or near the line should be nearly certain. Distance measurements are assumed to be exact in line transect sampling. Thus, there is no measurement errors or recording errors of the distances and angles. Rounding errors in measuring angles near zero are problematic, most often in the analysis of ungrouped data. If errors in distance measurements are random and not too large, then reliable density measurements are still likely, given that the sample size is large. (Gates et al 1985).

Unit - 8 ❑ Quardral Method

Structure

8.0 Objectives

By studying this unit learners would be able to understand about

- Preparation of nested quadrate
- Estimation of effective quadrate size
- Quadrate number of different plant species

8.1 Introduction

The quadrat is a square sample area of varying size required for the acquisition of dependable data to realise the biotic diversity of the entire community in an ecosystem. It is also effectively used to determine the exact difference or similarity in the structure and composition between two or more communities of related or unrelated regulation.

In a sampling terrestrial ecosystem the objective is not only to study the availability of particular species but also equally to emphasize their distribution frequency and abundance. Although it is not always possible to count and measure the entire biotic community in a large area modern sampling method emphasises for a particular species. With the knowledge on optimum quadrat size, one can have information about the diversity of the entire biotic community.

8.2 Preparation of nested quadrate

Generally a measured area for example 80 × 80 cm^2 are laid down at random in a chosen field at different sites. Different species that are found in each quadrat are recorded; the number of species is then listed in the ascending order (Table-1).

Table-1 : Quadrat number and the plants

Quadrat Number	Plant species
1	*Peparomea* sp., *Eaplia alba*, *Caccinia* sp., *Solanum nigrum*, *Amaranthus* sp., *Oxalus* sp.
2	*Enhydra* sp.
3	*Phylanthus* sp.
4	*Cynodon* sp., *Vandelia* sp.

8.3 Estimation of effective quardrat size

The procedure is to select a point randomly in the study area. A quadrat measurement (20 × 20 cm) is then taken. No of plant species within it are counted. Gradually the size of the quadrat is increased i.e., 40 × 40 cm, 60 × 60 cm and like that. Subsequently plant species are counted in different quadrat of different size. Experiments are then completed when three numbers of same species are consequently recorded (Table-2).

Table-2 : Determination of minimum quadrat size

Sl. No.	Size of quadrat	No. of species	No. of additional species	Total no. of species
1	20 × 20 cm^2	5	0	5
2	40 × 40 cm^2	5	0	7
3	60 × 60 cm^2	7	1	8

Sl. No.	Size of quadrat	No. of species	No. of additional species	Total no. of species
4	80 × 80 cm^2	8	2	10
5	100 × 100 cm^2	10	0	10
6	120 × 120 cm^2	10	0	10

This can be plotted in a graph also. The size of the quadrat used are plotted in the X-axis against the number of species plotted in Y-axis. A curve is obtained and the point at which the curve start flattening indicates the size of the quadrat required for sampling in the chosen study area (Figure-1). Since the curve gets flattened at 80 × 80 cm^2 point, it represents the optimum size of the sample area necessary to determine the plant community present in the ecosystem and it appears that in the chosen study area the optimum size of the quadrat is 80 × 80 cm^2.

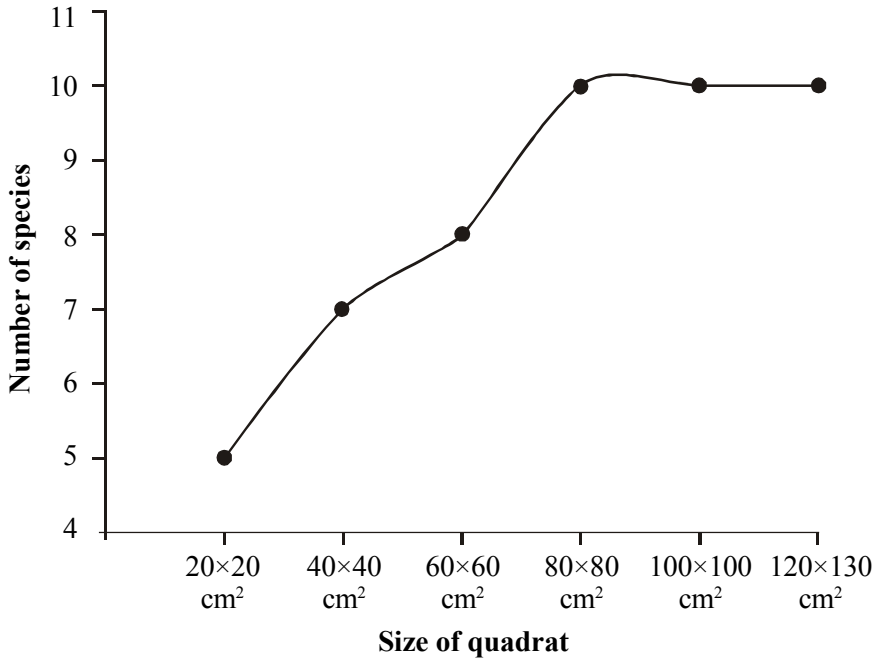


Figure 1 : Curve to show number of quadrats required for sampling

To determine the minimum number of quadrats, in a grassland ecosystem for example, it is necessary not only to study the type of the species which are absent but also it is important to determine the no of quadrats required for biotic diversity analysis (Table-3).

Table-3: To determine the minimum number of quadrats, the following observation can be made

Size of quadrat	No. of quadrats	No. of Species	No. of Additional species	Total no. of species
80 × 80 cm^2	1	5	0	5
	2	5	3	8
	3	8	2	10
	4	10	1	11
	5	11	1	12
	6	12	0	12
	7	12	0	12

Table-3 indicates that total number of species is not increased beyond 5 quadrats. Therefore, the minimum no of quadrat necessary is calculated as 5.

8.4 Selected questions

(i) Mention at least three observation points to determine number of quadrats in any ecosystem.

(ii) Why it is necessary to count the number of plants, for example, in any particular area with quadrats of different sizes?

(iii) What is indicative of flattening of curve in a graph of number of species versus size of quadrats ?

8.5 Suggested readings

1. Magurran, AE (2004). *Measuring Biological Diversity*. Blackwell, UK

Unit - 9 ❑ Pitful Trapping Method and Light Trapping Method in Practice

Structure

9.1 Pitful trapping method

9.1.1. Introduction :

A pitful trap is a simple device used to catch small animals— particularly insects and other invertebrates those who spend most of their time on the ground. In its most basic form, it consists of a container buried so that its top is level with the surface of the ground. Any creatures that wander nearby may fall in.

9.1.2. Structure and composition of Pitfall trap

Pitfall traps come in a variety of sizes and designs. They come in two main forms : dry and wet pitfall traps. Dry pitfall traps consist of a container (tin, jar or drum) buried in the ground with its rim at surfacelevel used to trap mobile animals that fall into it. Wet pitfall traps are basically the same, but contain a solution designed to kill and preserve the trapped animals. The fluids that can be used in these traps include formalin (10% formaldehyde), methylated spirits, alcohol, ethylene glycol, trisodium phosphate, picric acid or even (with daily checked traps) plain

water. A little detergent is usually added to break the surface tension of the liquid to promote quick drowning. The opening is usually covered by a sloped stone or lid or some other object. This is done to reduce the amount of rain and debris entering the trap, and to prevent animals in dry traps from drowning (when it rains) or overheating (during the day) as well as to keep out predators.

Traps may also be baited. Lures or baits of varying specificity can be used to increase the capture rate of a certain target species or group by placing them in, above or near the trap. Examples of baits include meat, dung, fruit and pheromones.

9.1.3. Uses of pitfall trap :

Pitfall traps can be used for various purpose :

- During the mating seasons of toads, frogs and salamanders in temperate climates, these animals often have to cross busy roads on their way from wintering grounds to breeding ponds. To prevent them from being killed, volunteers my place low fences along roads which the animals have to cross. On short distances, dry pitfall traps are then placed along the fences to collect the animals, which subsequently are manually transferred to the other side of the road, thus preventing massive roadkill.
- Collectors and reseachers of various ground-dwelling arthropod species my use pitfall traps to collect the animals they are interested in. This can be done without bait (for example ground beetles and spiders) or with bait (for example dung beetles).
- When used in series, these traps may also be used to estimate species richness (number of species present) and abundances (number of individuals), and this combined information may be used to calculate biodiversity indices (e.g. the Shannon index).

9.2 Light Trapping Methods

9.2.1. Introduction :

The light trap method uses a light source to attract insects, which then fall into a trap. Light traps cn be used to monitor and study insects, and to detect pests.

9.2.2. What is a light trap ?

That method involves using light traps. Light traps rely on the fact tht many nocturnal insects are strongly attracted to light. By setting up lights to shine on white

surfaces, we can induce large numbers of such insects to land on those surfaces. If the surface is slick and slanted sharply, many of them will fall to it's base where a collection bin of some kind can hold them until they can be gathered and examined. The sooner they can be collected, the better.

Many entomologists will line the bottom of the collection bin with poison that kills the collected insects quickly, before the specimens can be damaged by each other, or by struggling to escape. I'm not going to do that. Instead, I'll try to use a collection bin, without them either escaping once it is opened, or damaged by the collector when they are removed.

9.2.3. How to Build a Simple Light Trap ?

Equipment :

1. One collection sheet (A flexible sheet of white material, smooth plastic works best.)
2. One collection bin, (may be almost anything with smooth vertical walls, a jar, for example) duct tape
3. One light source (This may be turned on for hours so use rechargeable batteries or an approved outdoor extension cord).

Step-1 :

Curl the plastic so that it forms a small opening inside the collection bin, and the sides conform to the shape of the collection bin. Use a piece of duct tape to hold the collection sheet together as shown in Figure 1.

Step-2 :

Use duct tape to pull the plastic collection sheet tight to the edges of the collection bin so that no openings remain except the one inside the curled collection sheet.

Step-3 :

Lean the back edge of the collection sheet against a tree or other support, so that it will not fall down in the wind. Place the flashlight so that it shines onto the front of the collection sheet as shown in Figure 2.

9.2.4. Collecting Insects with the Light Trap

Once the collection bin has many insects inside, you can shake the collection sheet to drop any insects still hanging on into the collection bin. Then, remove the collection sheet and quickly cover the collection bin.

9.2.5. Converting the Light Trap Collection Bin into a Killing Jar

The collection bin will a numbe of insects of unknown species. If you are unsureof

the safety of handling the insects you have caught, or have any allergies to stings or bites, you may wish to convert the collection bin into killingjar so that the insects are dead before you attempts to handle them. This can be ascomplished by using tweezers to dip a cotton ball into nail polish remover and then placing the cotton ball inside a smller container inside the collection bin. Cover the collection jar or bin immediately. Depending upon the size of your collection bin, you may need to use several nail polish soaked cotton balls to achieve a concentration of fumes sufficient to kill the insect inside. Allow several minutes for the fumes to take effect. Be sure to avoid inhailing the fumes yourself nd follow all safety warnings from the manufacturer of the nail polish remover.

Unit - 10 ❑ Commodity analysis by diversity and abundance estimation

Structure

10.1 Comparing communities : Jaccard's Index (J)

Of course, we are usually interested not just in the diversity of a single site, but in comparing biodiversity levels across sites. Communities can differ in a number of ways. Considering only the plant component of a system, two communities can differ in species composition (taxonomy), total number of species (richness), and the relative abundance of species (evenness). Species diversity refers to a community-level concept that combines both richness and evenness.

We use a number of different indices to estimate the similarity of two communities. Considerable controversy exists about the effectiveness of these indices as they vary in performance for things like total number of species involved, influence of rare species, etc. A number of papers recently have explored what an appropriate index might be.

An intuitive measure of similarity between two samples can summarize the fraction of species they share.

Jaccard's index is the simplest summary of this, taking the following form :

$$J = \frac{S_c}{S_a + S_b + S_c}$$

Where S_a and S_b are the numbers of species unique to samples a and b, respectively, and S_c is the number of species common to the two samples.

Interpretation : Jaccard's index of similarity is very straight forward since it is simply the fraction of species shared between the samples. Keep in mind, however, that Jaccard's index only utilizes the richness component of diversity, since it does not entail any information on abundance. As a pair wise measure, we can examine how Jaccard's index varies with the distance or environmental differences between the sites.

The Jaccard index, also known as the **Jaccard similarity coefficient** (originally coined coefficient de *communaute* by Paul Jaccard), is a statistical component used for comparing the similarity and diversity of sample sets. The Jaccard coefficient measures similarity between sample sets, and is defined as the size of the intersection divided by the size of the union of the sample sets. This index only uses presence-absence data.

10.2 Other indices to measure similarities between communities

Sorensen-Dice (Sorensen or Sorensen binary) (presence or absence)

$$SSD = \frac{2a}{2a + b + c}$$

Where :

a = number of species in both sites

b = number of species in second site only

c = number of species in first site only

The Sorensen index, also known as Sorensen's similarity coefficient, is a statistics used for comparing the similarity of two samples. It was developed by the Botanist Thorvald Sorensen and published in 1948. It also uses presence-absence data. When we use both the Jaccard and Sorensen index on the same data set, how they differ in performance may be seen below.

Sorensen's index is easily extended to abundance instead of incidence of species. This quantitative version of the Sorensen index is also known as the Bray-Curtis Similarity index. When using the Bray-Curtis quantitative index, the "minimum" value (# individuals or % cover or Importance Value) for a species when comparing

two samples is used for the numerator values.

Bray-Curtis (sometimes called Pielou's percentage similarity or Czekanowski's) **index**

$$S_{BC} = \frac{\sum 2 * \min(n_{1i} . n_{2i})}{\sum n_{1i} + \sum n_{2i}}$$

Where :

n_{1i} = the number of individuals or % cover or importance value of the ith species in sample 1

n_{2i} = the number of individuals or % cover or importance value of the ith species in sample 2

min = refers to the lower abundance value for the species of the two samples being compared

10.3 Laboratory problems

We will use a made-up data set to compare the performance of these similarity indices. Imagine comparing two communities (samples) with 30 species each and 25 species are found common in both samples. Run the calculations. Then modify the proportions in the two samples so we can understand how the indices perform. Change the proportions so both samples keep 30 species, but only 20 are in common, then 15, then 10, then 5. Then contrast a 30 species community with a 20 species community (start with 20 species in common), and make similar proportion shifts.

Now let's see how the total number of species influences things. Start with comparing a two communities of 30 species with 20 species in common (you did this above). Now change it so they both have 30 species, but only 19 in common. Now compare two communities of 15 species each with 10 species in common, and then with 9 species in common. Finally, compare two communities of 3 species each, with 2 species in common, then change it to 1species in common. In this second round, we're only shifting 1 species each time, but because of 'proportion' shifts, the measures perform quite differently. If we were using Bray-Curtis values, the shifts might not have been changed in the same manner.

10.4 Selected questions

(i) State the significance of Simpson Index and Shannon Index in a biodiversity study.

(ii) What are the indices used to deduce similarities between two species ?

(iii) Why it is important to assess biodiversity index in ecological communities ?

10.5 Suggested reading

1. Magurran, AE (2004). *Measuring Biological Diversity*. Blackwell.

2. Samal, PK, Dollo, M, Singh, J, Lodhi, MS, Arya, SC, Dhyani, PP and Paini, S (2013). Biodiversity conservation through community based natural resource management; G B Pant Institute of Himalayan Environment and Development, Highlanders Communication, Almorah, Uttarakhand.

Unit - 11 ❑ Sorenson's Similarity & Shannon-Weiner diversity indices

Structure

11.0 Objectives

By studying this unit learners would be able to understand about

- Definition of Shannon index
- Calculation of Shannon-Weiner index
- Definition of Simpson's index
- Other indices to measure similarities between communities

11.1 Introduction

Measurement of biodiversity is of prime interest to ecologists for explaining structure and function of ecological communities. The measurements are based on statistical sampling of species and calculation of indices. Consequently methods of measuring several indices of biodiversity have been developed (Magurran, 2004), which are based on two separate components:

(i) Number of species indicating species richness

(ii) Relative abundance of a species indicating dominance or evenness of species.

A community may have huge number of species indicating high diversity of species with a few species showing abundance in number (or dominance) or all species showing equal abundance (evenness).

Three indices of biodiversity have been explored here :

1. The Shannon index (H′), also termed as Shannon-Wiener index indicating both diversity and evenness of a community.
2. Simpson's index of dominance (D).
3. Jaccard's similarity index, which is used to compare diversity among communities.

11.2 Shannon index

The idea behind this index is that the diversity of a community is similar to the amount of information in a code or message. It is calculated in the following way :

$$H' = -\sum p_i \ln p_i$$

Where pi is the proportion of individuals found in species i. For a well-sampled community, we can estimate this proportion as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community. Since by definition the p will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why we take the inverse of the sum.

This has been explained in Table-4 on a set of hypothetical data.

Table-4 : Calculation of Shannon-Weiner index

Species	No. of individuals (ni)	ni/N	$(ni/N)^2$	ln (ni/N)	ni/N{(ln(ni/N)}
Species – 1	12	0.333	0.111	–1.099	–0.6627
Species – 2	11	0.305	0.093	–1.187	–0.3620
Species – 3	6	0.167	0.028	–1.789	–0.2987
Species – 4	3	0.083	0.007	–2.488	–0.2065
Species – 5	1	0.028	0.001	–3.575	–0.1001
Species – 6	3	0.083	0.007	–2.4889	–0.2065
Total (Σ)	N = 36		0.247		1.8365

Shannon index (H′) = Σpi lnpi or $\Sigma(n_i/N)\ln(n_i/N)$ = 1.8365

Simpson's Dominance index $\{\Sigma(n_i/N)^2\}$ = 0.247

Interpretation : Typical value of H′ generally lies between 1.5 and 3.5 in most ecological communities and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. The fact that the index incorporates both components of biodiversity (variety and evenness), it has both strength and a weakness. The strength lies in its simple, synthetic summary, but it has a weakness because it makes it difficult to compare communities that differ greatly in richness.

Due to the confounding of richness and evenness in the Shannon index, many biodiversity researchers prefer to stick to two numbers for comparative studies, combining a direct estimate of species richness (the total number of species in the community, S) with some measure of dominance or evenness. The most common dominance measure is Simpson's index.

11.3 Simpson's index

Evenness and dominance are contrast to each other and their measures are thus complimentary to each other. Simpson's index indicates whether individuals of different species in a community are present in equal or unequal proportion. More the degree of inequality more is the dominance. It is calculated by the following formula (Table-4) :

$$D = \sum p_i^2$$

Where again p_i is the proportion of individuals found in species i. For a finite community, this is

$$D = \sum \frac{n_i (n_i - 1)}{N(N-1)}$$

Interpretation : D is a measure of dominance. As D increases, evenness decreases. Thus, Simpson's index is usually reported as its complement 1-D (or sometimes1/D or -lnD). Since D takes on values between zero and one, D approaches one in the limit of a monoculture, (1-D) provides an intuitive proportional measure of diversity that is much less sensitive to species richness.

Unit - 13 ❑ Report on a visit to National park/ Biodiversity park/ Wildlife sanctuary/Sea shore

Structure

13.1 Objectives

By studying this unit learners would be able to prepare reports on a visit to National park/ Biodiversity park / Wildlife sanctuary/Sea shore

13.2 Introduction

Any of these visits should be reported in a manner that has to be informative and will have to be expressed to the point.

13.3 Preparation of report

An outline of the report should be as follows :

(a) Introduction : It will highlight the uniqueness of such a place having national importance with reference to ecological and socio-economic point of view. If it is, for example, in connection with a visit to mangrove forest in Sundarbans, then certain salient features depicting uniqueness of Sundarbans forest, importance of mangrove ecosystem, Sundarbans as Ramsar wetland and natural heritage site, socio-economic aspects of Sundarbans should be described under this heading.

(b) Purpose of the visit : It has to be clearly stated and in what way it would

benefit over and above fulfilling the requirements as laid down in the syllabus should also be mentioned.

(c) The team members : Along with the supervisor teacher and the specific responsibility entrusted upon individual / group team member(s) with regard to sample collection, photography, field observations to be done – all these should be recorded under this head.

(d) Geographical location : The geographic location including longitude, latitude, height above mean sea level, like that and then land and water remarks, flora and fauna to the extent possible and any other relevant point will also have to be noted.

(e) Description of the journey : Since journey is also no less important than the destination itself even if it is not a very long distance from the Institution/ University campus, students should give a description of the journey to make the report interesting.

(f) Technical details of the field visit : It will be the major feature in the report. This will have to be supplemented with photograph, sketch, an interview with local peoples, if any. To make the report informative the data should be presented in tabular form as much as possible.

(g) Comments/feedback : With regard to the particular tour comments or suggestions, if any, regarding the visiting place, journey, time of visit that may be considered useful for future visits should be made.

(h) Acknowledgements : Students should acknowledge the assistance received from institution, teachers, local guide or anybody else, from the planning stage till the end of the tour i.e. back home from the trip - should be incorporated.

13.4 Selected questions

(i) Why it is important to take part in academic excursion periodically?

(ii) Mention certain principles, ethics and guidelines to be followed during a visit, for example, to a location rich in biodiversity.

13.5 Suggested readings

1. India tourism development corporation guidelines to sanctuaries and wildlife

Unit - 15 ❑ Darwin's Pinches with diagram / Cut outs of beaks of different species.

When a species splits into a number of new forms as well as a change in the environment makes new resources available or creates new environmental challenges. For example, finches on the Galapagos Islands have developed different shaped beaks to take advantage of the different kinds of food available on different islands.

In some cases, a population of one species disperses throughout an area with each finding a distinct niche or isolated habitat. Over time, the varied demands of their new lifestyles lead to multiple speciation events originating from a single species. This is called adaptive radiation because many adaptations evolve from a single point of origin, causing the species to radiate into several new ones. Island archipelagos like the Hawaiian Islands provide an ideal context for adaptive radiation events because water surrounds each island which leads to geographical isolation for many organisms. The Hawaiian honeycreeper illustrates one example of adaptive radiation. From a single species, called the founder species, numerous species have evolved.

Four features can be used to identify an adaptive radiation :

1. A common ancestry of component species : specifically a *recent* ancestry. Note that this is not the same as a monophyly in which *all* descendants of a common ancestor are included.
2. A phenotype-environment correlation : a *significant* association between environments and the morphological and physiological traits used to exploit those environments.
3. Trait utility : the performance or fitness advantages of trait values in their corresponding environments.
4. Rapid speciation : presence of one or more *bursts* in the emergence of new species around the time that ecological and phenotypic divergence is underway.

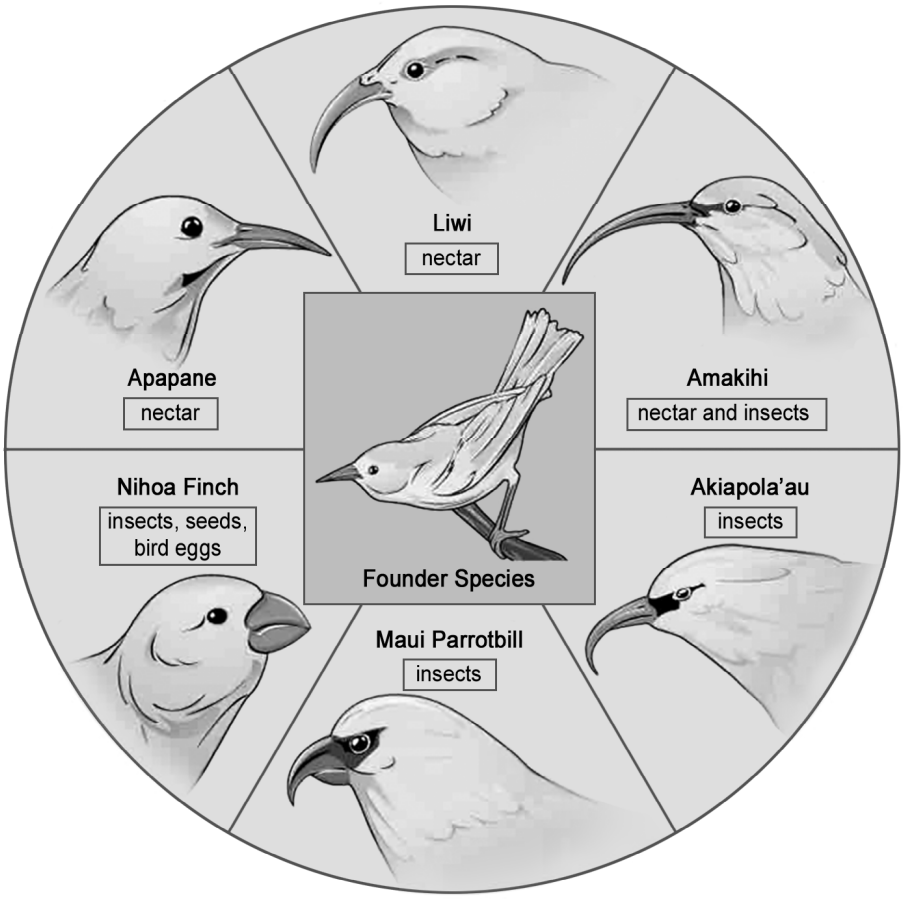


Figure – 15.1 : Adaptive Radiation : The honeycreeper birds illustrate adaptive radiation. From one original species of bird, multiple others evolved, each with its own distinctive characteristics. In Hawaiian honeycreepers, the response to natural selection based on specific food sources in each new habitat led to the evolution of a different beak suited to the specific food source. The seed-eating birds have a thicker, stronger beak which is suited to break hard nuts. The nectar-eating birds have long beaks to dip into flowers to reach the nectar. The insect-eating birds have beaks like swords, appropriate for stabbing and impaling insects.

Adaptive radiation tends to take place under the following conditions :

1. A new habitat has opened up : A volcano, for example, can create new ground in the middle of the ocean. This is the case in places like Hawaii and the Galapagos. For aquatic species, the formation of a large new lake habitat could serve the same purpose; the tectonic movement that formed the East African Rift, ultimately leading to the creation of the Rift Valley Lakes, is an example of this. An extinction event could effectively achieve

this same result, opening up niches that were previously occupied by species that no longer exist.

2. This new habitat is relatively isolated. When a volcano erupts on the mainland and destroys an adjacent forest, it is likely that the terrestrial plant and animal species that used to live in the destroyed region will recolonize without evolving greatly. However, if a newly formed habitat is isolated, the species that colonize it will likely be somewhat random and uncommon arrivals.

3. The new habitat has a wide availability of niche space. The rare colonist can only adaptively radiate into as many forms as there are niches.

Adaptive Radiation : Darwin's Finches

Darwin's finches are an often-used textbook example of adaptive radiation. Today represented by approximately 15 species, Darwin's finches are Galapagos endemics famously adapted for a specialized feeding behavior. There are now at least 13 species

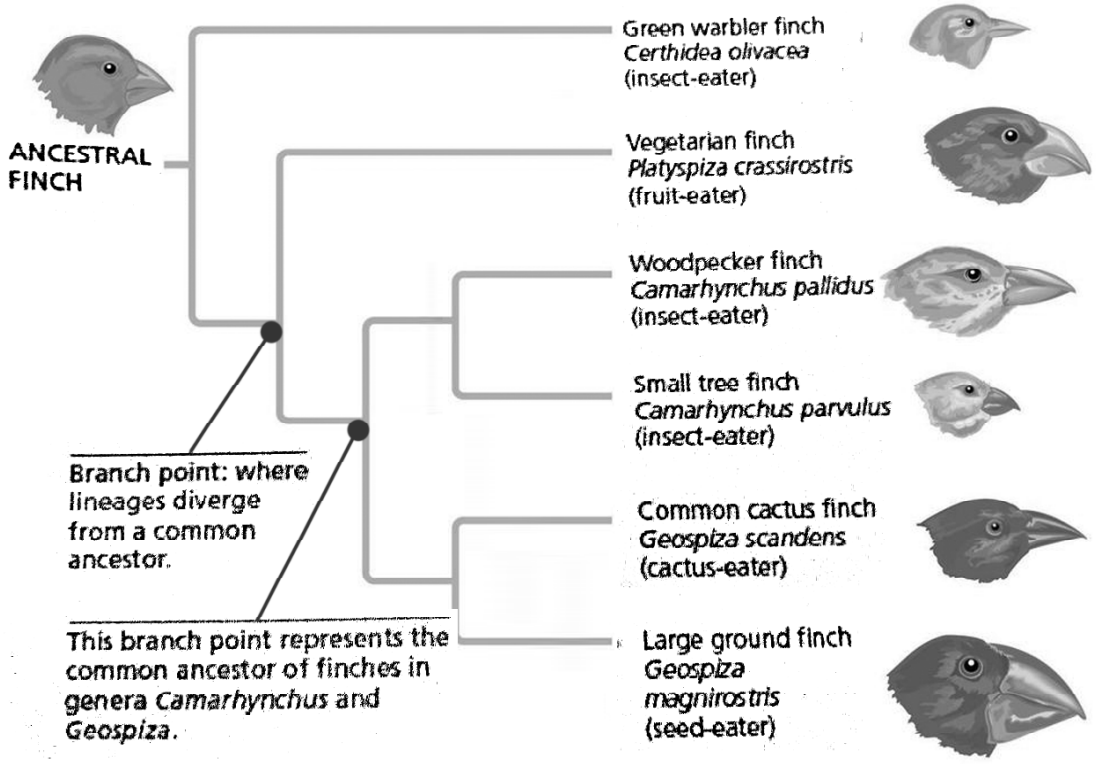


Figure – 15.2 : Adaptive radiation and speciation of Darwin's finches as revealed through food habit.

of finches on the Galapagos Islands, each filling a different niche on different islands. All of them evolved from one ancestral species, which colonized the islands only a few million years ago. This process, whereby species evolve rapidly to exploit empty ecospace, is known as adaptive radiation.

The ancestral finch was a ground-dwelling, seed-eating finch. After the burst of speciation in the Galapagos, a total of 14 species would exist : three species of ground-dwelling seed-eaters; three others living on cactuses and eating seeds; one living in trees and eating seeds; and 7 species of tree-dwelling insect-eaters. Scientists long after Darwin spent years trying to understand the process that had created so many types of finches that differed mainly in the size and shape of their beaks.

Darwin wondered about the changes in shape of bird beaks from island to island. So-called cactus **finches** boast longer, more pointed **beaks** than their relatives the ground finches. Beaks of warbler finches are thinner and more pointed than both. These adaptations make them more fit to survive on available food.

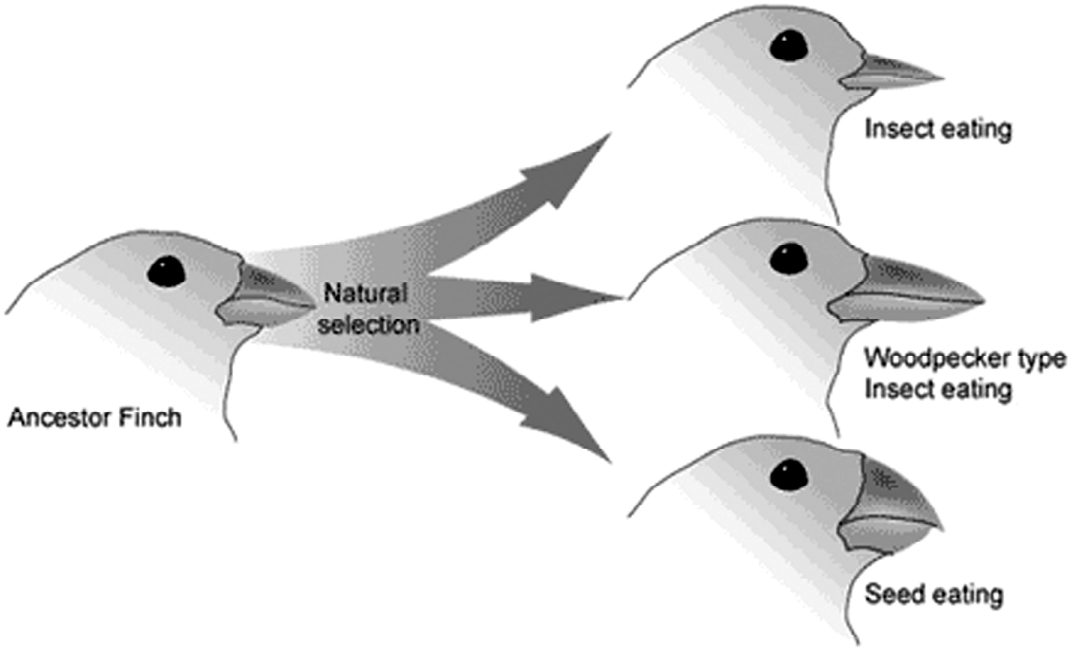


Figure – 15.3 : Figure explains how natural selection acted on the food and feeding habits for the radiation of finches.