Practical Manual

INSECT ECOLOGY

APE 504 3(2+1)

For

M.Sc. (Ag.) Entomology

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Department of Entomology
College of Agriculture
Rani Lakshmi Bai Central Agricultural University
Jhansi-284003

Practical manual

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Contents

Practical no. 1

Types of distributions of organisms.

The distribution of individuals follows 3 broad patterns.

1. **Random distribution**
2. **Uniform distribution**
3. **Clumped distribution**

1) **Random distribution:** The probability of locating individuals at a point in the populated area is equal for all the points. It is relatively rare in nature and it is expected to occur only when the environment is uniform and the resources are evenly spread.

2) **Uniform distribution:** It occurs where competition between individuals is severe and individuals are evenly spaced and tend to be as far apart from each other.
   a. Ex : Desert animals.

3) **Clumped:**The individuals of a population are found scattered in a groups here and there. This is most common pattern of distribution and result from non uniformity of the habitat or attraction among individuals. Ex : Bees.

Activities: Study on the distribution pattern of insect pests in RLBCAUagro-ecosystem.

Practical no. 2

Study of insect life table.

A typical life table contains

1. x = Age of cohort
2. dx = Number dying at age interval
3. lx = Number surviving at the beginning of age interval
4. 1000 qx = Mortality rate (per thousand) at the beginning of age interval or dx as a percentage of l
5. ex = Expectation of life or mean life time remaining to those attaining age interval

Example: Life table for the 1952–1953 generation in a relatively low population of spruce budworm in the Green River watershed New Brunswick. Modified from Morris and Miller 1954.

S. No.	1	2	3	4	5
	Age interval, x Eggs	Number alive at Beginning of x, lx	Factor responsible for dx, dxF	Number dying during x, dx	dx as percentage of lx, 1000qx
1	Eggs	174	Parasites	3	2
			Predators	15	9
			others	1	1
			Total	19	11
2	Instar I	155	Dispersion etc	74.4	48
	Hibernacula	80.6	winter	13.7	17
	Instar II	66.6	Dispersion etc	42.2	63
	instar III-IV	24.7	Parasites	8.92	36
			disease	0.54	2
			birds	3.339	14
			others	10.57	43
			Total	23.42	95
3	Pupae	1.28	Parasites	0.1	8
			Predators	0.132	10
			others	0.23	18
4	Moths (SR=50:50)	0.82	sex	0	0
	Female X 2	0.82	sixe	0	0
			others	0	0
			Total	0	0
	"Normal" Femal X2	0.82			
5	Generation			173.18	99.53
	Next Generation				
	Expected eggs	62			
	Actual eggs	575			
	Index of Population trends			Expected	-36%
				Actual	330%

Activities: Prepared the life table of *Spodopterlitura*

Practical no. 3

Pest survey and surveillance

Survey:

Survey refers to the supervision or assessing the incidence or population of key or major pests once in three to five years. A survey may be conducted to study the distribution and abundance of a pest species. Or An official procedure conducted over a defined period of time to determine the characteristics of a pest population or to determine which pest species occur in an area.

Pest surveillance

Surveillance refers to the constant watch on the population dynamics of pests, its ncidence and damage on each crop at fixed intervals or repeated surveys to measure or record the pests or diseases. Or Pest surveillance is the watch kept on a pest for decision making.

Objectives of Pest Surveillance

- ✓ To monitor the pest population and /or damage regularly to arrive at a decision
- ✓ whether control measures are required or not, if required when to initiate the control
- ✓ measures.
- ✓ Pest forecasting with reasonable precision.
- ✓ Endemic areas of various pests may also be marked
- ✓ To predict future population trends or the corresponding potential damage to the crops or both
- **Kinds of survey:**

  All insect pests' surveys attempt to asses some characteristics of the insect life systems, depending upon them the type of survey. Broadly divided in to two groups;

  - ✓ **Qualitative survey**
  - ✓ **Quantitative survey**

  Qualitative survey: This survey is important to study the interactions of herbivores and carnivores, and their relationship with the vegetation of the region. Here the primary concern firstly relates to the herbivores which act as pests of the crops as well as on the alternate hosts among the wild vegetation (weeds).

  Eg. Army worm *Mythimna separate*, which survives on Jhonson grass *Sorghum halepense*; and on Burmuda grass when the crops are not standing on the fields. It is a pest of graminaceous foliage whorl, particularly, paddy and sugarcane. Within the last decades it has started attacking ear heads of rice cultivars, now it has acquired new name as ear head cutting caterpillar.

Quantitative survey: Quantitative surveys estimating the abundance and population densities of insect in cropping systems. There are two types of measuring

- ✓ **Absolute estimates:**
- ✓ **Relative estimates**

Methodology for surveillance

(i) fixed plot survey and

(ii) roving survey.

- **Fixed plot survey:**
  - ✓ Two fields of about one acre in size are selected in two different villages in the jurisdiction of each agricultural officers.
  - ✓ Five micro plots each of the size of one squire meter area are fixed in each field.
  - ✓ These micro plots are laid one each in four quarters of the field and one in the middle.
  - ✓ The micro plots should be fixed about 10 meters away from the bunds.
  - ✓ The observations for most of the pests are confined to five micro plots in each field.
- **Roving survey:**
  - ✓ The roving survey is conducted every week at the rate of two fields in each of four villages in the in the jurisdiction of each agricultural officers (T & V).
  - ✓ The reports involved in the surveillance programme are of three kinds.
  - ✓ **White card report or Normal report:** This is a weekly report in which pest and disease situations are reported regularly.
  - ✓ **Yellow card report:** This is a special reporting system whichever pest or diseases is noticed at 50% of the economic threshold level but still not attained ETL status. The information is immediately passed on altering the Joint Director of Agriculture (T&V), his subject matter specialist and the scientists.
  - ✓ **Red card report:** This reporting system is adopted when a pests or disease has reached the critical economic threshold level where immediate action programme has to be launched for controlling the pests or diseases.

Activities: study on pest survey and surveillance from different crop cafeterias.

Practical no. 4

Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters

Sampling: Where the population is too large or hypothetical, the investigator has to obtain information about the population from a part thereof "The selection of a part of the population to represent the whole population is known as sampling and the part selected is known as sample".

Sampling requires a representative part of the total population and base our estimate on that part.

Objectives of sampling:

- ✓ Identifying & monitoring pests & natural enemies
- ✓ Understanding biological & environmental factors that affect pests & natural enemies
- ✓ Using treatment threshold for control decisions
- ✓ Knowing efficacy of control tactics & impact on non-target pests & natural enemies

Measurement taken to estimate population density (sampling methods) fall into three groups

- ❖ Absolute methods
- ❖ Relative methods
- ❖ Population indices

❖ Absolute methods

(i)Distance of the nearest neighbor (pest)

(ii) Sampling a unit of habitat

(iii) Recapture of marked individuals from population in a field

(iv) Removal trapping method

❖ Relative methods

1. **Impaction or sticky trap method:** Insects are trapped in flight on a surface coated with long-asting glue. Using attractive colours increases the effectiveness of such traps. Selection of colour depends on the insect to be collected/ sampled. Usually used a monitoring device. The trap catches are affected by weather conditions and by the position and height of trap in the field. Sticky traps are useful to sample thrips, aphids, whiteflies, etc.

2. **Light traps:** A light trap usually comprises an electric bulb as an attractant, and a funnel to direct attracted insects into a container or collecting bag. Many insects are attracted to light in the near ultraviolet region (320-400 nm.), hence ultraviolet lamps are often used. Rapid kill of the

specimens is often necessary to have good specimens for examination. Temperature, wind speed, rain, cloudy weather, moonlight and open and woodland situations affect the trap catches. Light traps have been used to capture lepidopterans.

3. **Malaise trap:** The trap is a netting tent with one open side into which is placed a small container at the highest point. Insects flying or crawling through the opening, move up the netting and are collected in the container. These traps have been useful in the study of highly active Diptera and Hymenoptera, besides, Coleoptera, Lepidoptera and Planipennia.

4. **McPhail trap:** It is a simple invaginated glass trap, which is used principally to sample Diptera. Recent efforts have been made to improve the trap by using new yellow coloured, robust PVC bottle that increases the number of catches.

5. **Pheromone trap:** Pheromone traps are generally species-specific. Sex pheromone of female insects can attract males over long distances and have been used for monitoring pest populations. A typical pheromone trap is delta-shaped, open at both ends and protects a horizontally placed sticky trap. A sealed polyethylene vial containing the pheromone is placed upright on the sticky trap and acts as a slow release mechanism for the chemical. Speed and direction of wind, height of crop
relative to the trap and adhesive used affect the trap collection. Pheromone traps have been used to monitor Lepidoptera, but also find use for other insects such as Hymenoptera.

6. **Radar:** Entomological radars are usually small, mobile, incoherent pulse systems, which use a wavelength of 3.2 cm. These radars transmit short impulses from their antennae in a narrow, conical beam. Objects illuminated by the pulse reflect or scatter the pulse energy returning part of the scattered energy to the radar. The echo is detected and amplified at the radar receiver and the presence of the target displayed. Insects of around 100 mg can be detected using this method up to 2.5 km. Other sorts of radar of interest in entomology include ground-based scanning radar, airborne radar, tracking radar, frequency-modulated continuous wave radar, harmonic radar and bistatic and doppler radars.

7. **Suction traps:** Suction traps consist of machines with engine driven fans which suck insects into a fine mesh net, filtering out the insects which can then be collected in a container. Traps maybe fitted with a segregating device to separate the catch according to time, thus providing information on the periodicity of flight. They can be mobile or fixed. Originally, they were designed to sample aphids and other aerial pests of agricultural crops.

8. **Water traps:** Yellow water traps, also known as yellow pan traps have been used to sample a wide range of insect species including thrips, aphids and cabbage root fly. The traps are more effective if raised above ground and the catch efficacy increases if vertical baffles are placed in the trap. Use of a small amount of detergent or volatile chemicals in the water increases the catch. Ethyl nicotinate has been used with success. Painting the inner wall of the trap black improves the catch and at the same time spares the collection of beneficial insects.

Activities:Collection of insects pests from different sampling methods

Practical no. 5

Determination of optimal sample size

Objectives:

1. To study on spatial distribution and minimum sample size for insect monitoring.

Study area

A study conducte in a crop cafeteria, RLBCAU, Jhansi.The orchard was at an altitude & a latitude and longitude of -° N and -° E, respectively, and was sampled twice monthly from the beginning of crop season until end of the season. Choose any five spots from each cultivar, almost uniform and similar in sowing time, size, height, vegetative growth, etc. These randomly chosen crop plants did not receive any pesticidal control before and during the period of the study. Regular bimonthly collected the samples as per observation (specific instructions) per plant is randomly picke from the target site. Every sample will be place in a container; all samples were transferred to the laboratory for inspection using a stereo-microscope. The total numbers of live insects (nymphs and adult females) will counte and recorde, linked to the inspection date, and presented as mean number of individuals per leaf ± standard error (SE), to express the population size of pest.

Distribution indices:

Several estimates are based on sample means and variances, such as index of dispersion, clumping, crowding and Green's index (Green, 1966).

- Mean (X): the mean number of individuals as a general average per leaf during the whole year.

- Range of means of a population: The difference between the maximum mean number of a population and the minimum for the whole year was calculated by applying the following equation:

- Range of Density (R) = Population density maximum – Population density minimum during the entire year.

- Variance (S2), standard deviation (S), standard error (SE) and median (Me) for samples were determined.

- Coefficient of variance (C.V.): To assess the fidelity of sampling, the coefficient of variation values for the studied years were compared

$$\text{C.V.} = \frac{S}{X} x\ 100$$

Where, S is the standard deviation of the mean and X is the mean of population.

- Relative Variation (R.V.) is employed to compare the efficiency of various sampling methods (Hillhouse and Pitre, 1974). The relative variation for the studied years was calculated as follows:

$$\text{R.V.} = \frac{SE}{X} x\ 100$$

Where, SE is the standard error of the mean and X is the mean of population. - Variance to mean ratio (S 2 / X): The simplest approach used for determining the insect distribution was variance to mean ratio suggested by Patil and Stiteler (1974). The value of variance-to-mean is one for 'Poisson' distribution, less than one for positive binomial and more than one for negative binomial distribution. Dispersion of a population can be classified through a calculation of the variance-to-mean ratio; namely: S2 / X = 1 random distribution, < 1 regular distribution, and > 1 aggregated distribution (where, S2 = sample variance; X = mean of population).

- Index of Lewis (IL): Lewis index was also calculated as per the formula given hereunder to determine the dispersion of P. oleae

$$I\,L = \sqrt{\frac{S2}{X}}\,x\ 100$$

The value of this index revealed >1 contagious; Ca = $\frac{S2-X}{X2}x\ 100$

The spatial distribution pattern is aggregative, random and uniform when Ca>0, Ca = 0 and Ca,0, respectively.

- The K value of negative binomial distribution:

The parameter K of the negative binomial distribution is one measure of aggregation that can be used for insect species having clumped or aggregated spatial pattern. When K values are low and positive (K< 2), they indicate a highly aggregated population; K values ranging from 2 to 8 indicate moderate aggregation; and values higher than 8 (K> 8) indicate a random population (Southwood, 1995). The K values were calculated by the moment's method (Costa et al., 2010), and given by:

$$K = \frac{\bar{X}\text{ squar}-\bar{X}}{X2}x\ 100$$

Departure from a random distribution can be tested by calculating the index of dispersion (I_D), where, n: denotes the number of samples:

$$I_D = \frac{(n-1)S\text{ squar}}{X}$$

ID is approximately distributed as x 2with n-1 degrees of freedom. Values of ID which fall outside a confidence interval bounded with n-1 degrees of freedom and selected probability levels of 0.95 and 0.05, for instance, would indicate a significant departure from a random distribution. This index can be tested by Z value as follows:

$$Z = Z = \sqrt{2ID} - \sqrt{(2v-1)}$$

v = n - 1 If 1.96 ≥ Z ≥ -1.96, the spatial distribution would be random, but if Z < -1.96 or Z > 1.96, it would be uniform and aggregated, respectively (Patil and Stiteler, 1974).

- Index of mean clumping (IDM): $(Idm) = \left(\frac{Ssquar}{\bar{X}}\right) - 1$

The David and Moore index of clumping values increase with increasing aggregation. If the index value = 0, the distribution is random, positive value for negative binomial(aggregated) and negative value for positive binomial (regular).

- Lloyd's mean crowding (* X):

Activities:

1) To study on Population density of insect pest in different crop.
2) To study on -Spatial distribution
3) To study on regression methods: Taylor's power law and Iwao's patchiness regression (IPR)

Practical no. 6

Population growth models

Objectives:

2. To study on exponential growth model
3. To study on logistic growth model

Exponential growth model

Malthus' model, once population size exceeds available resources, population growth decreases dramatically. This accelerating pattern of increasing population size is called **exponential growth**, meaning that the population is increasing by a fixed percentage each year. When plotted (visualized) on a graph showing how the population size increases over time, the result is a J-shaped curve.

$G = r \times N$ ***OR***

$dN/dt = r \times N$

In these equation

- G (or dN/dt) is the population growth rate, it is a measure of the number of individuals added per time interval time.
- 'r' is the per capita rate of increase (the average contribution of each member in a population to population growth; per capita means "per person").
- 'N' is the population size, the number of individuals in the population at a particular time.

Per capita rate of increase (r)

In exponential growth, the *population growth rate* (***G***) depends on population size (***N***) and the per capita rate of increase (***r***). In this model *r* does not change (fixed percentage) and change in population growth rate, ***G***, is due to change in population size, ***N***. As new individuals are added to the population, each of the new additions contribute to population growth at the same rate (*r*) as the individuals already in the population.

r=(birth rate + immigration rate)–(death rate and emigration rate)

- If r is positive (> zero), the population is increasing in size; this means that the birth and immigration rates are greater than death and emigration.
- If r is negative (< zero), the population is decreasing in size; this means that the birth and immigration rates are less than death and emigration rates.
- If r is zero, then the population growth rate (G) is zero and population size is unchanging, a condition known as zero population growth. "r" varies depending on the type of organism, for example a population of bacteria would have a much higher "r" than an elephant population. In the exponential growth model r is multiplied by the population size, N, so population growth rate is largely influenced by N. This means that if two populations have the same per capita rate of

increase (r), the population with a larger N will have a larger population growth rate than the one with a smaller N.

Logistic Growth model

Exponential growth cannot continue forever because resources (food, water, shelter) will become limited. Exponential growth may occur in environments where there are few individuals and plentiful resources, but soon or later, the population gets large enough that individuals run out of vital resources such as food or living space, slowing the growth rate. When resources are limited, populations exhibit **logistic growth**. In logistic growth a population grows nearly exponentially at first when the population is small and resources are plentiful but growth rate slows down as the population size nears limit of the environment and resources begin to be in short supply and finally stabilizes (zero population growth rate) at the maximum population size that can be supported by the environment (**carrying capacity**). This results in a characteristic S-shaped growth curve. The mathematical function or logistic growth model is represented by the following equation:

$$G=r\times N\times(1-N/K)$$

where \(K\ ) is the **carrying capacity** – the maximum population size that a particular environment can sustain ("carry").

Activities:

1. To study on exponential growth model in cereal or pulses crops in natural condition.
2. To study on logistic growth model in cereal or pulses crops in natural condition

Practical no. 7

Testing the goodness of fit for insect population

Objectives:

1. To study on testing the goodness of fit for insect pest population.

- ✓ The chi-square test (Snedecor and Cochran, 1989) is used to test if a sample of data came from a population with a specific distribution.
- ✓ An attractive feature of the chi-square goodness-of-fit test is that it can be applied to any univariate distribution for which you can calculate the cumulative distribution function.
- ✓ The chi-square goodness-of-fit test is applied to binned data (i.e., data put into classes).
- ✓ This is actually not a restriction since for non-binned data you can simply calculate a histogram or frequency table before generating the chi-square test.
- ✓ However, the value of the chi-square test statistic are dependent on how the data is binned.
- ✓ Another disadvantage of the chi-square test is that it requires a sufficient sample size in order for the chi-square approximation to be valid.
- ✓ The chi-square test is an alternative to the Anderson-Darling and Kolmogorov-Smirnov goodness-of-fit tests.
- ✓ The chi-square goodness-of-fit test can be applied to discrete distributions such as the binomial and the Poisson.

The Kolmogorov-Smirnov and Anderson-Darling tests are restricted to continuous distributions.

he chi-square test is defined for the hypothesis:

H_0: The data follow a specified distribution

H_a: The data do not follow the specified distribution

Test Statistic: For the chi-square goodness-of-fit computation, the data are divided into k bins and the test statistic is defined as

$X^2 = \sum_{i-1}^{k}(Oi - Ei)square/Ei$

where Oi is the observed frequency for bin i and Ei is the expected frequency for bin i. The expected frequency is calculated by

$E_i = N(F(Yu) - F(Yl)$

where F is the cumulative distribution function for the distribution being tested, Yu is the upper limit for class i, Yl is the lower limit for class i, and N is the sample size.

This test is sensitive to the choice of bins. There is no optimal choice for the bin width (since the optimal bin width depends on the distribution). Most reasonable choices should produce similar, but not identical, results. For the chi-square approximation to be valid, the expected frequency should be at least 5. This test is not valid for small samples, and if some of the counts are less than five, you may need to combine some bins in the tails.

Significant level: α

Critical region: The test statistic follows, approximately, a chi-square distribution with (k - c) degrees of freedom where k is the number of non-empty cells and c = the number of estimated parameters (including location and scale parameters and shape parameters) for the distribution + 1. For example, for a 3-parameter Weibull distribution, c = 4.

Therefore, the hypothesis that the data are from a population with the specified distribution is rejected if

$\chi^2 > \chi^2_{1-\alpha,k-c}$

where χ21−α,k−c is the chi-square critical value with k - c degrees of freedom and significance level α.

Activities:

1. To test the Chi-square test with population of insect pest.

Practical no. 8

Lotka-Volterra model

Objectives:

2. To study on predator-prey interactions with Lotka-Volterra model.

- ✓ Lotka-Volterra model is the simplest model of predator-prey interactions.
- ✓ The model was developed independently by Lotka (1925) and Volterra (1926).
- ✓ Initially proposed by Alfred J. Lotka in the theory of autocatalytic chemical reactions in 1910.
- ✓ In 1925 he used the equations to analyse predator– prey interactions in his book on biomathematics.
- ✓ The same set of equations was published in 1926 by Vito Volterra, a mathematician and physicist, who had become interested in mathematical biology.
- ✓ Volterra's enquiry was inspired through his interactions with the marine biologist Umberto D'Ancona, his son-in-law.
- ✓ The Lotka–Volterra equations, also known as the predator–prey equations, are a pair of firstorder nonlinear differential equations.
- ✓ Frequently used to describe the dynamics of biological systems in which two species interact, one as a predator and the other as prey.

Assumptions

1) The prey population finds ample food at all times.
2) The food supply of the predator population depends entirely on the size of the prey population.
3) The rate of change of population is proportional to its size. During the process, the environment does not change in favour of one species, and genetic adaptation is inconsequential.
4) Predators have limitless appetite.

Lotka–Volterra equations

Prey equation = $\frac{\delta x}{\delta t} = \alpha x - \beta xy$

Predator equation = $\frac{\delta y}{\delta t} = \delta xy - yy$

x is the number of prey

y is the number of some predator

$\frac{\delta x}{\delta t}$ and $\frac{\delta y}{\delta t}$ represent the instantaneous growth rates of the two populations;

t represents time;

α, β, γ, δ are positive real parameters describing the interaction of the two species

Prey equation = $\frac{\delta x}{\delta t} = \boldsymbol{\alpha x - \beta x y}$

- ✓ The prey are assumed to have an unlimited food supply and to reproduce exponentially, unless subject to predation
- ✓ This exponential growth is represented in the equation above by the term $\boldsymbol{\alpha x}$.
- ✓ The rate of predation upon the prey is assumed to be proportional to the rate at which the predators and the prey meet, this is represented above by $\boldsymbol{\beta x y}$.
- ✓ If either $\boldsymbol{x}$ or $\boldsymbol{y}$ is zero, then there can be no predation.

Predator equation = $\frac{\delta y}{\delta t} = \boldsymbol{\delta x y - y y}$

- ✓ In this equation, $\boldsymbol{\delta x y}$ represents the growth of the predator population.
- ✓ Note the similarity to the predation rate; however, a different constant is used, as the rate at which the predator population grows is not necessarily equal to the rate at which it consumes the prey.
- ✓ $\boldsymbol{\gamma y}$ represents the loss rate of the predators due to either natural death or emigration, it leads to an exponential decay in the absence of prey.

Activates:

1. To study on prey-predatore interaction in cereal crop.
2. To analyses Lotka-Volterra model between aphid and *Coccinella* species.

Practical no. 9

Assessing and describing ecological niche

Objectives:

3. To study on assessing and describing ecological niche

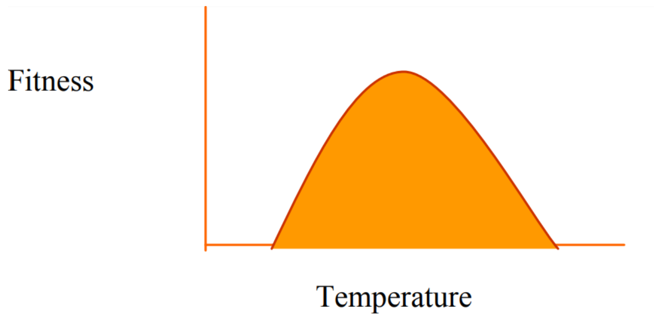
Ecological Niche: 'the total of the adaptations of an organismic unit'

Niches identify the 'role of an organism in its community', or 'the way a species makes its living'.

The niche of a species (or an individual) refers to the ways in which it interacts with its environment, so niches are closely related to environmental tolerance curves, but niches can have behavioral dimensions (e.g method of locomotion - running, swimming, flying) as well environmental ones (e.g temperature limits).

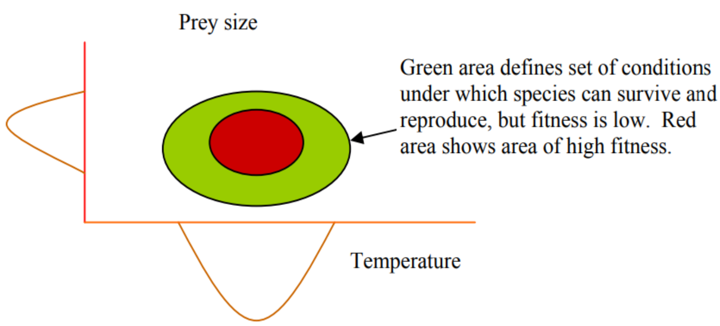
Data on niches can be used to:

1) Make comparisons of the composition and organization of communities.
2) Examine shifts in the behavior or ecology of one species in response to another species. (In particular, niche shifts are commonly used to study interspecific competition, based on Gause's Principle of Competitive Exclusion).

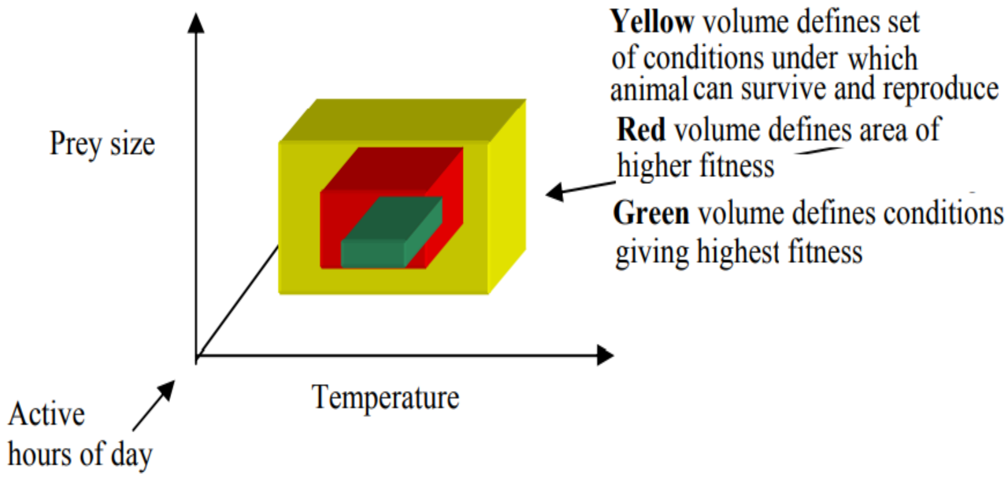


Hutchinson's model of niche as a 'hypervolume': Niches can be described or defined by relating fitness or utilization to environmental variable (abiotic and biotic)

Start with a tolerance curve for one environmental variableand a second variable that affects the animal's fitness.



Then add a third variable that affects the animal's fitness:



If we then add a fourth axis (and onward), the result is a hypervolume - a range if conditions defines by many axes, which defines the set of conditions under which the animal can survive and reproduce. Can refine to show 'fitness density' (as in 2-d example).

Hypervolume idea is good for illustration, but remember:

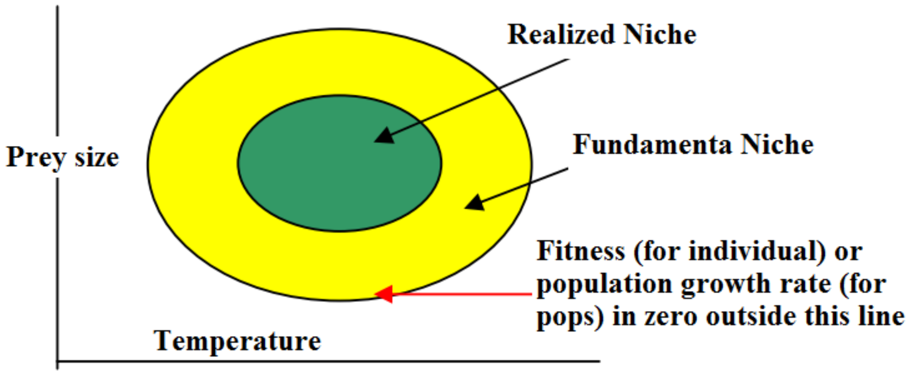
1. not all niche axes are environmental - some niche axes are behavioral (e.g. nocturnal vs diurnal activity pattern)

2. not all axes can be ordered linearly (e.g types of antipredator behavior), so they don't lend themselves to this graphical approach.

Fundamental *vs* Realized Niche

Fundamental niche is the entire set of conditions under which an animal (population, species) can survive and reproduce itself.

Realized niche is the set of conditions actually used by given animal (pop, species), after interactions with other species (predation and especially competition) have been taken into account. Sometimes FN and RN are termed precompetitive and postcompetitive niches, reflecting a traditional focus on interspecific competition's effect on niches.



Activities:

3. **To study on assessing and describing ecological niche based on insect population in cereal crops.**

Practical no. 10

Assessing insect biodiversity in agro-ecosystem

Objectives:

1. To study on assessing insect diversity in crops.

❖ **Diversity Indices:**

A. A diversity index is a mathematical measure of species diversity in a given community.
B. Based on the species richness (the number of species present) and species abundance (the number of individuals per species).
C. The more species you have, the more diverse the area, right?
D. However, there are two types of indices, dominance indices and information statistic indices.
E. The equations for the two indices we will study are:

Shannon Index (H) = $\sum_{i-1}^{s} pi \ln pi$

Simpson Index (D) = $1/\sum_{i-1}^{s} pisquare$

The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. Can you point out any problems in these assumptions?

In the Shannon index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

The Simpson index is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. Can you point out any problems in these assumptions?

In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species.

Sl.No.	Order	Insect species	No. of individuals (n)	n/N	p_i	Pi^2	ln p_i	p_i ln p_i

Community Similarity

A. Calculating community similarities (what the communities have in common in terms of species) helps us determine if we are comparing apples to apples and oranges to oranges.
B. There are many indices that do this, we will use Sorenson's coefficient.
C. Sorenson's coefficient gives a value between 0 and 1, the closer the value is to 1, the more the communities have in common. a. Complete community overlap is equal to 1; complete community dissimilarity is equal to 0.
D. The equation is:

   Sorenson's Coefficient (CC) = 2C/ S1+S2

Where C is the number of species the two communities have in common, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2

Activities:

1. To study on Shannon Index and Simpson Index of insect population in cereal crops.
2. To calculate similarity index between two insect population of two different ecosystems.

Practical no. 11

Functional and Numerical responses of Holling's Equation

Functional and Numerical Response

Holling (1959) studied predation of small mammals on pine sawflies, and he found that predation rates increased with increasing prey population density. This resulted from 2 effects:

(1) Each predator increased its consumption rate when exposed to a higher prey density, and

(2) Predator density increased with increasing prey density.

Holling considered these effects as 2 kinds of responses of predator population to prey density: (1) the functional response and (2) the numerical response.

Modeling Functional Response

Holling (1959) suggested a model of functional response, which remains most popular among ecologists. This model is often called "disc equation" because Holling used paper discs to simulate the area examined by predators. Mathematically, this model is equivalent to the model of enzyme kinetics developed in 1913 by Lenor Michaelis and Maude Menten.

His model illustrates the principle of time budget in behavioral ecology. It assumes that a predator spends its time on 2 kinds of activities:

1. Searching for prey.
2. Prey handling that includes chasing, killing, eating and digesting.

Consumption rate of a predator is limited in this model because even if prey are so abundant that no time is needed for search, a predator still needs to spend time on prey handling. Total time equals to the sum of time spent on searching and time spent on handling:

Assume that a predator captured Ha prey during time T. Handling time should be proportional to the number of prey captured, where Th is time spent on handling of 1 prey.

Capturing prey is assumed to be a random process. A predator examines area (a) per time unit (only search time is considered here) and captures all preys that were found there. Parameter (a) is often called "area of discovery", however it can be called "search rate" as well.

After spending time T-search for searching, a predator examines the area = a T search, and captures a HT-search prey where H is prey density per unit area: Hence: Now we can balance the time budget: The last step is to find the number of attacked prey Ha: This function indicates the number of prey killed by 1 predator at various prey densities. This is a typical shape of functional response of many predator species. At low prey densities, predators spend most of their time on search, whereas at high prey densities, predators spend most of their time on prey handling.

Holling (1959) considered 3 major types of functional response:

• **Type I** Functional response is found in passive predators like spiders. The number of flies caught in the net is proportional to fly density. Prey mortality due to predation is constant.

• **Type II** Functional response is most typical and corresponds to the equation above. Search rate is constant. Plateau represents predator saturation. Prey mortality declines with prey density. Predators of this type cause maximum mortality at low prey density. For example, small mammals destroy most of gypsy moth pupae in sparse populations of gypsy moth. However in high-density defoliating populations, small mammals kill a negligible proportion of pupae.

• **Type III** Functional response occurs in predators, which increase their search activity. with increasing prey density. For example, many predators respond to kairomones (chemicals emitted by prey) and increase their activity. Polyphagous vertebrate predators (*e.g.*, birds) can switch to the most abundant prey species by learning to recognize it visually. Mortality first increases with prey increasing density, and then declines.

Numerical Response

Numerical response means that predators become more abundant as prey density increases. However, the term "numerical response" is rather confusing because it may result from 2 different mechanisms:

• Increased rate of predator reproduction when prey are abundant (numerical response/ se)

• Attraction of predators to prey aggregations ("aggregational response")

Reproduction rate of predators naturally depends on their predation rate. The more prey consumed, the more energy the predator can allocate for reproduction. Mortality rate also reduces with increased prey consumption. The most simple model of predator's numerical response is based on the assumption that reproduction rate of predators is proportional to the number of prey consumed. This is like conversion of prey into new predators. For example, as 10 preys are consumed, a new predator is born. Aggregation of predators to prey density is often called "aggregational response". This term is better than "numerical response" because it is not ambiguous. Aggregational response was shown to be very important for several predator-prey systems. Predators selected for biological control of insect pests should have a strong aggregational response. Otherwise they would not be able to suppress prey populations. Also, aggregational response increases the stability of the spatially-distributed predator-prey (or host-parasite) system.

Activities: Calculations of Hollings equations.

Practical no. 12

Pest Forecasting

Pest forecasting - Forecasting of pest incidence or outbreak based on information obtained from pest surveillance. Or

Forecasting is the prediction of the type of fluctuation which will ensue. Forecasting pest incidence often requires systematically recorded specific field data in an elaborate manner over considerable period of time which can be easily retrieved and analyzed.

Types of pest forecasting -

1.) Short term forecasting- It covers a particular season or one or two successive seasons only and is usually made employing insect trapping methods or some other sampling of the pest with in the crop. Or one or two crop seasons.

2.) Long term forecasting- It covers large areas and based mainly on the possible effects of weather on the insect abundance or by extrapolating from the present population density into the future. Or cover large areas & based on weather conditions.

Pest forecasting comprises following three main points: -

- Quantitative measurement of population of pest on ecological zones.
- Study of life history of the insect pest.
- Study of fluctuation in pest population due to natural enemies & other factors

❖ **Uses of pest forecasting -**

i.)Predicting pest outbreak which needs control measure.

ii.) To know the suitable stage at which control measure gives maximumprotection.

Activities: Study on insect pest forecasting in mustard.

Practical no. 13

Liebig's Low of Minimum

- In the 19th century (1840), the German scientist Justus von Liebig formulated the "Law of the Minimum,"
- Liebig's law of the minimum, often simply called Liebig's law or the law of the minimum,
- Which states that if one of the essential plant nutrients is deficient, plant growth will be poor even when all other essential nutrients are abundant.
- Liebig's Law of the Minimum was developed for the nutrition of agricultural plants, but can also be applied to population abundance.
- Reproduction (birth of new organisms) and death are the fundamental processes regulating change in population size over time.
- Low abundance of resources, or other nonideal environmental conditions, reduces the reproduction rate or increases the death rate in a population, in addition to lowering rates of growth or activity for individual organisms.
- As an example, if a plot of ground is deficient in iron, but has plenty of other nutrients, a plant that requires a lot of iron will struggle if it is grown in that plot without amending the soil. Adding more nitrogen, potassium, or phosphorus to the soil won't change the plant's difficulty in growing. It could actually make the situation worse if it increases the plant's need for iron.
- Liebig's Law has been extended to biological populations (and is commonly used in ecosystem models). For example, the growth of an organism such as a plant may be dependent on a number of different factors, such as sunlight or mineral nutrients (e.g. nitrate or phosphate). The availability of these may vary, such that at any given time one is more limiting than the others. Liebig's Law states that growth only occurs at the rate permitted by the most limiting. For instance, in the equation below, the growth of population *O* is a function of the minimum of three Michaelis-Menten terms representing limitation by factors *I*, *N* and *P*.

$$\frac{dO}{dt} = min\left(\frac{I}{k_I + I}, \frac{N}{k_N + N}, \frac{P}{k_P + P}\right)$$

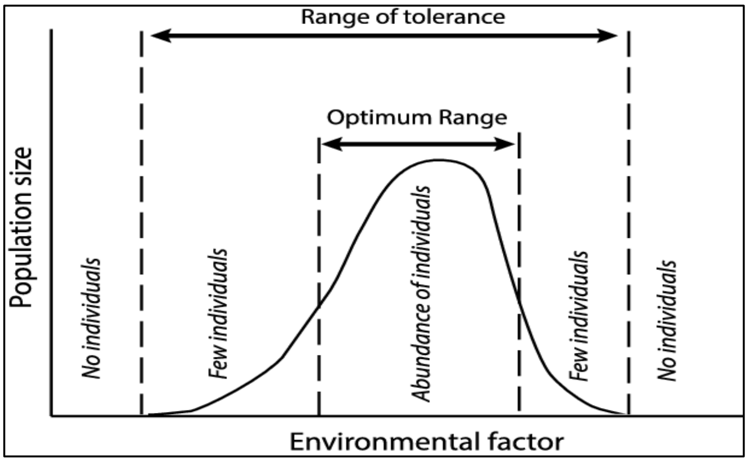
It is limited to a situation where there are steady state conditions, and factor interactions are tightly controlled.

Practical no. 14

Shelford's Law of tolerance

- Shelford's law of tolerance is a principle developed by American zoologist Victor Ernest Shelford in 1911.
- Shelford's law of tolerance states that an organism's success is based on a complex set of conditions and that each organism has a certain minimum, maximum, and optimum environmental factor or combination of factors that determine success.
- According to the law of tolerance, populations have optimal survival conditions within critical minimal and maximal thresholds.
- As population is exposed to the extremes of a particular limiting factor, the rates of survival begin to drop.
- **The distribution of a species in response to a limiting factor can be represented as a bell-shaped curve with three distinct regions:**

1. **Optimal zone:** Central portion of curve which has conditions that favour maximal reproductive success and survivability.
2. **Zones of stress:** Regions flanking the optimal zone, where organisms can survive but with reduced reproductive success.
3. **Zones of intolerance:** Outermost regions in which organisms cannot survive (represents extremes of the limiting factor).



Practical no. 15

Problem Solving–Analyzing frequencies

Field biologists spend a good deal of time counting and classifying things on nominalscales such as species, colour, habitat, etc., hence statistical tests that analyze the frequenciesareimportant.**Chi-squares**testsarevariouslyreferredtoastestsforhomogeneity,randomness,association,independence,andgoodnessoffit.The***G*-test**isanalternativetothe chi-square test for analyzing frequencies. The two methods are interchangeable; if a chi-square test is appropriate then so too is a *G*-test and the assumptions in each are the same.Moreover, the outcome of the *G*-test is a test statistic (*G*) which is compared with thedistribution of chi-square in the same tables as the chi-square test. *G*-test is easier to executewith a desk-top hand calculator, especially with contingency tables. Second, mathematiciansbelieve that the *G*- test has theoretical advantages in advanced applications (Fowler *et al*.,1998).

Example 1: A biologist collects a sample of dipteran (*Dixella*spp.) pupae from emergentvegetationfromapond.Basedonthepupalcharactersthebiologistcouldidentifyfourspeciesinthepond.Isthedistributionoffrequenciesamongthespecies/categorieshomogeneous? Theobservationstakenwereas:

D.autumnalis	*D.aestivalis*	*D. amphibian*	*D. attica*	Total
24	32	10	9	75

Example 2: A biologist collects leaf litter from a 1-square metre quadrat placed randomly atnight on the ground in two woodlands – woodland with clay soil and another with chalk soil.Thebiologistsortsthroughthelitterandcollectswoodlice(Isopoda)of2species,*Oniscus*and *Armadilidium*. Find out as to which type of woodland is preferred by which species ofwoodlice?

Table:Frequencyofwoodliceindifferentwoodlands

Species/Woodland&soiltype	*Oniscus*	*Armadilidium*	Totals
Claysoil	14	06	20
Chalksoil	22	46	68
Totals	36	52	88

Practical no. 16

Problem solving ecology

Solved example: An Entomologist collects different insect orders at the light trap from two locations and has the following data for each order:

Location(A):12,10,18,24,8,16,14,22,26,20

Location(B):8,14,22,20,26,18,6,4,24,16

Loc-A	Loc-B	InsectOrders	Loc-A	Loc-B
12	8	Hymenoptera	132	56
10	14	Diptera	90	182
18	22	Coleoptera	306	462
24	20	Orthoptera	552	380
8	26	Hemiptera	56	650
16	18	Thysanoptera	240	306
14	6	Isoptera	182	30
22	4	Dictyoptera	462	12
26	24	Lepidoptera	650	552
20	16	Neuroptera	380	240
		$\sum n_i(n_i-1)$	3050	2870
170	158	**N(N-1)**	28730	24806
		$\sum n_i(n_i-1)/N(N-1)$	0.1062	0.1157
Simpson Index (D)= 1- $\sum n_i(n_i-1)/N(N-1)$			**0.8938**	**0.8843**

TheSimpsonDiversityIndicescomputeddonotdiffersignificantlyforthetwolocationsA&B.

RelativeDensity(%)estimates:

InsectOrders	Loc-A	Loc-B
Hymenoptera	7.06	5.06
Diptera	5.88	8.86
Coleoptera	10.59	13.92
Orthoptera	14.12	12.66
Hemiptera	4.71	16.46
Thysanoptera	9.41	11.39

Isoptera	8.24	3.80
Dictyoptera	12.94	2.53
Lepidoptera	**15.29**	**15.19**
Neuroptera	11.76	10.13

Note: The relative density estimate in dicatesthatatbothlocationsLepidopterawaremost abundant,followedbyOrthopteraandColeoptera.Problemsolving:

(a) **MeasurethealphadiversityforthegivendatausingSimpson'sIndex**

(b) **Indicatewhichmeadowlocationismostdiverse**

(c) **FindouttheRelativeDensityofdifferentinsectordersateachlocation**

S. No.	**Insect Orders**	**MeadowLocations**		
		A	**B**	**C**
1.	Orthoptera	10	15	ZERO
2.	Coleoptera	20	30	20
3.	Hymenoptera	ZERO	05	10
4.	Isoptera	05	10	20
5.	Diptera	ZERO	05	10
6.	Dictyoptera	05	10	ZERO
7.	Lepidoptera	05	10	25
8.	Neuroptera	20	15	ZERO
9.	Odonata	10	05	05
10.	Hemiptera	10	10	25

Practical no. 17

Field visit on ICAR-IGFRI, Jhansi

Objective: To study on Biodiversity in agro-ecosystem

Practical no. 18

Field visit on ICAR-IGFRI, Jhansi

Objective: To study on Biodiversity in agro-forest-ecosystem