II Scientific Method

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- A. Introduction
- B. Knowledge
- C. Types of Reasoning
- D. Example
- E. Formal Process

A. Introduction

- You are the new biologist
- in charge of a deer herd.
- Harvest has declined for 3 consecutive years.
- What should be done?

A. Introduction

- What caused decline in herd?
- List possible causes
- Gather relavant information
- Analyze it
- Select a course of action
- A methodical process to knowledge

B. Knowledge

- Definition: Knowledge is defined as the set of ideas that agree with or are consistent with the facts of nature.

B. Knowledge

- How do we attain knowledge?

Attainment of knowledge

- Logical argument (model)
- Descriptive observations
- Experiment

Attainment of knowledge

- Example: Number of mayfly larvae eaten by trout in an hour

Logical argument

- *No larvae eaten if none available*
- *If few available, few eaten*
- *If many available, many eaten*
- *Total eaten is limited*

Logical argument

- *Conclusion: Number of larvae eaten increases as density of larvae increases up to a maximum above which no more are eaten per hour.*

Logical argument

- *We can express this more clearly in numeric form as C. S. Holling did in 1950's.*

Holling's Model

- *n= number eaten*
- *a= search rate*
- *X = density*
- *t = time feeding*
- *t_s = time searching*
- *t_h = time handling prey*
- *h = handling time per item*

Encounters

- *Number eaten =*
- *search rate x*
- *prey density x*
- *time searching*
- *$n=a X t_s$*

Time feeding

- *time feeding =*
- *time searching +*
- *time handling prey*
- *$t = t_s + t_h$*
- *$t_s = t - t_h$*

Handling time

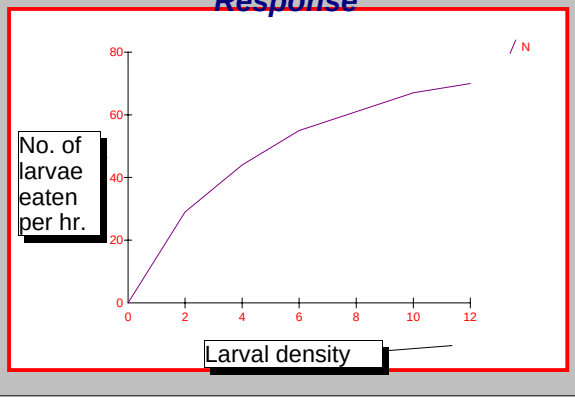
- *time handling prey =*
- *number eaten x*
- *handling time per item*
- *$t_h = n h$*

Holling's Model of Functional Response

- *$t_s = t - t_h$*
- *$t_s = t - n h$*
- *$n = a X (t - n h)$*
- *$a X t$*
- *$n =$*

- *$1 + a X h$*

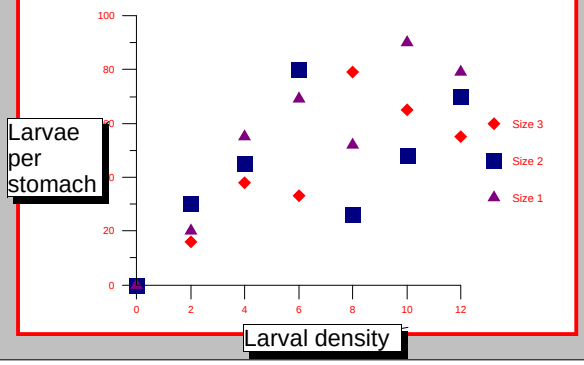
Logical argument: Functional Response



2. Descriptive observations

- *Find streams with different densities of larvae*
- *Collect fish*
- *Cut open and count larvae*
- *Relate number eaten to density of larvae in streams*

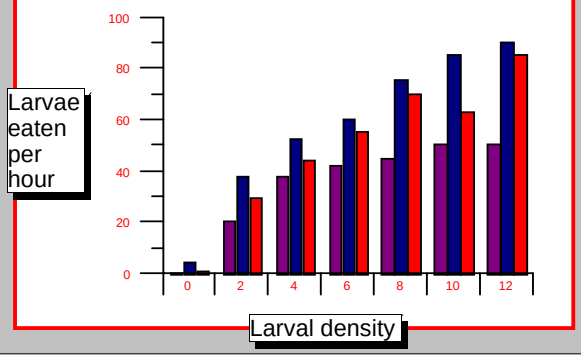
Descriptive observations



3. Experiment

- *Maintain trout in experimental stream sections in laboratory*
- *Expose individuals to a range of densities of larvae*
- *Determine consumption per hour*

Experiment



Attainment of knowledge

- *Logical argument (model)*
- *Descriptive observations*
- *Experiment*

C. Types of Reasoning

- *Induction*
- *Deduction*

C. Types of Reasoning (Romesburg)

- *Inductive Reasoning*
- *Retroduction*
- *Hypothetico-Deductive Reasoning*
- *Arguments by Authority*

D. Example

- Winter distribution of partridges on the Palouse
- Chukar (Alectoris chukar)
- Gray Partridge (Perdix perdix)

Chukar and Gray Partridge on Palouse

- Introduced species
- Huns on ridge tops
- Chukar lower down, rocky areas
- Native distributions

Conceptual Model

- Temperature may be separating
- Proposition: Huns more cold hardy than Chukars
- Conceptual model
  - from initial observations, literature, suggestions of experts, experience, insight, and logic

Conceptual Model

- Chukars occur in lower sheltered areas because they are less able to withstand cold temperatures than huns.

Hypothesis

- Chukars will lose weight more quickly at -10 deg. C than Huns
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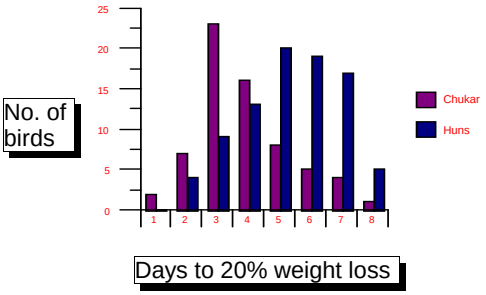
- Design a test

Cold hardiness of Chukar and Huns



Cold hardiness of Chukar and Huns

- What do you conclude?

Is there really a difference?

- Statistical Test
- Null hypothesis
- H_o: There is no difference.
- H_a: There is a difference.
- May reject H_o.
- What if fail to reject H_o?

Fisher (1947) said

- *"It should be noted that the null hypothesis is never proved or established but is possibly disproved in the course of experimentation. Every experiment may be said to exist only in order to give the facts a chance of disproving the null hypothesis."*

A Fact

- *A fact is something that has existence. It is an event, an occurrence, observation, or relation, the reality of which is manifest in experience or may be inferred with certainty.*

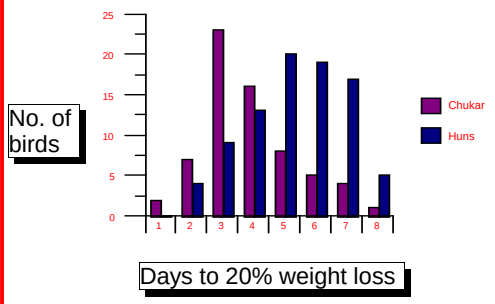
Certainty

- *How certain of conclusion?*
- *Probability level*
- *Facts never established with absolute certainty.*

Interpretation

- *Re-evaluate the experiment*
  - *Was it valid?*
  - *How were subjects chosen?*
- *Re-evaluate in context of larger question*
- *Logical assumptions*

Cold hardiness of Chukar and Huns



Report Results

- *Publication*
- *Why bother?*
-
- *Recycle to next hypothesis*

E. Formal Process

- *1. Literature review and observations*
- *2. Conceptual model (theory)*
- *3. Formulate hypothesis*
- *4. Test hypothesis*
- *5. Data analysis*
- *6. Evaluation and interpretation*
- *7. Speculation and new hypotheses*
- *8. Publication*

Schematic Outline

- *Garton, Ratti and Giudice (2005)*
- *Fuller, more comprehensive list of steps*

Alternate Hypotheses

- Platt (1964) pointed out that we tend to be narrow-minded.
- Platt (1964) and Chamberlain (1897 reprinted in 1965) said we should formulate alternate hypotheses.

Strong Inference (Platt 1964 after Chamberlin 1897)

- Consider all reasonable alternate hypotheses and design one experiment or set of observations which would rule out many hypotheses.
- Then design another experiment, etc.

Multiple Causes

- Strong Inference has proven very powerful in molecular biology and other sciences where single causes predominate.
- Most population questions are multi-causal so use an approach directed at examining Multiple Competing Hypotheses (Caughley and Gunn 1996) similar to model selection of Burnham & Anderson (1998)
-

Multiple Causes - Example

- H_0

Major Fallacies

- Populations and samples
- Replication
- Controls

Science and Planning

- Science and planning are intertwined
- Decision-making
- Science and planning compared as processes
- Models
  - Multiple factors
  - Forces us to be clear and systematic

Smart People Believe Weird Things

Scientific American (2002)

article by Michael Shermer (Skeptic)

- "Rarely do any of us sit down before a table of facts, weigh them one against the other, and choose the most logical and rational explanation, regardless of what we previously believed."
- "Rather, such variables as genetic predisposition, parental predilection, sibling influence, peer pressure, educational experience and life impressions all shape the personality preferences that, in conjunction with numerous social and cultural influences, lead us to our beliefs."

Smart People Believe Weird Things

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- " We then sort through the body of data and select those that most confirm what we already believe, and ignore or rationalize away those that do not."
- = confrimation bias
- "...science is not a database of unconnected factoids but a set of methods designed to describe and interpret phenomena, past or present, aimed at building a testable body of knowledge open to rejection or confirmation."

Try it

- *An interesting observation*
- *Conceptual model*
- *Formulate a test*