

2nd International Seminar on Science Education

**TESTING EVOLUTIONARY HYPOTHESES IN THE
CLASSROOM USING PHENETIC METHOD**

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INTRODUCTION

- Evolution is the most important theoretically and practically framework of modern biology (Brewer, 1996), providing natural patterns of biological organisms.
- In taxonomy, evolutionary relationship has been used as a basic knowledge for the development of classification system.
- In Indonesia, evolution and taxonomy have led to be important part in biology curriculum. **HOWEVER, these two subjects have less attention to the students (descriptive, speculative, unprovable).**

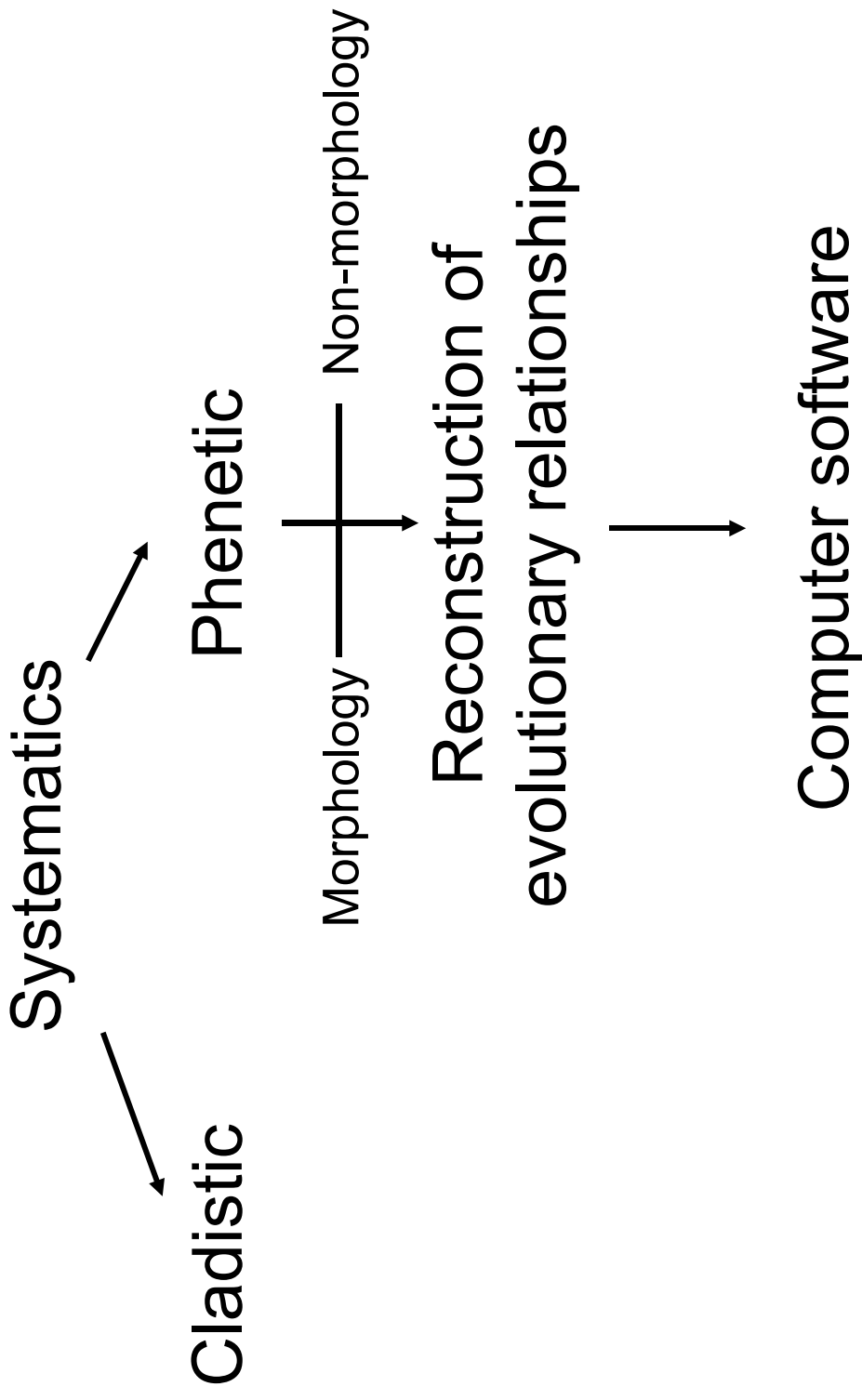
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- Harvey and Pagel (1991) suggested that the problems are mainly relied on the **lack of workable assignments**. Existing methods tend to boring and recalling.
- The assignments should be illustrated how biologists or taxonomists work to test hypotheses about pattern of evolutionary relationships of groups of biological organisms.
- This paper discuss possibilities the use of phenetic method as an alternative assignment to test evolutionary hypotheses in the group of seed plant.

PHENETIC METHOD ?

- Systematics plays a central role in biology to provide the means for characterising the biological organisms and the recognition in order to understand biodiversity.
- Important task of systematics is to reconstruct evolutionary history of groups of biological organisms.
- Phenetic is one of method for inferring evolutionary relationships.
- Phenetic observes the evolutionary relationships based mainly upon overall similarity of certain characters, morphology for example.

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- Steps of phenetic analysis include:
 - Selection of biological organisms (taxa) and characters
 - Calculation of similarity coefficient (number of similar character states is divided by total characters used)
 - Matrix of similarity
 - Clustering
 - Phenogram reconstruction

TESTING HYPOTHESES

- In this section, how university students at UPI that enrolled Botani Phanerogamae course performing phenetic analysis will be presented.
- They will test evolutionary history hypotheses in plant group subclass Zingiberidae (Liliopsida; Magnoliophyta).
- They selected four genera and five morphological characters:
Four taxa= *Musa* (A), *Heliconia* (B), *Zingiber* (C), *Costus* (D)
Five characters= Spatha (1), Aromatic (2), Inflorescence form heart shape (3), Inflorescence erect (4), Rhizome (5)

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Matrix taxa and characters are arranged as follow:

	1	2	3	4	5
A	1	0	1	0	0
B	1	0	0	0	0
C	0	1	0	0	1
D	0	1	0	1	1

0 = absence 1 = presence

Continued...

Next step is calculate similarity coefficient:

$$\text{Similarity AB} = 4/5 = 0,8$$

$$\text{Similarity AC} = 1/5 = 0,2$$

$$\text{Similarity AD} = 0$$

$$\text{Similarity BC} = 2/5 = 0,4$$

$$\text{Similarity BD} = 1/5 = 0,2$$

$$\text{Similarity CD} = 4/5 = 0,8$$

Continued...

Similarity matrix becomes:

	A	B	C	D
A	1			
B	0,8	1		
C	0,2	0,4	1	
D	0	0,2	0,8	1

Continued...

Clustering is carried out through identifying the pair of taxa with the highest similarity. In this case, Cluster-1 is taxon A and B, called P for simplicity.

Next is calculate similarity:

$$\text{Similarity PC} = 0,2 + 0,4 = 0,6 / 2 = 0,3$$

$$\text{Similarity PD} = 0 + 0,2 = 0,2 / 2 = 0,1$$

Matrix becomes:

	P	C	D
P	1		
C	0,3	1	
D	0,1	0,8	1

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Cluster-2 is between taxon C and D, called Q.

Then, calculate similarity:

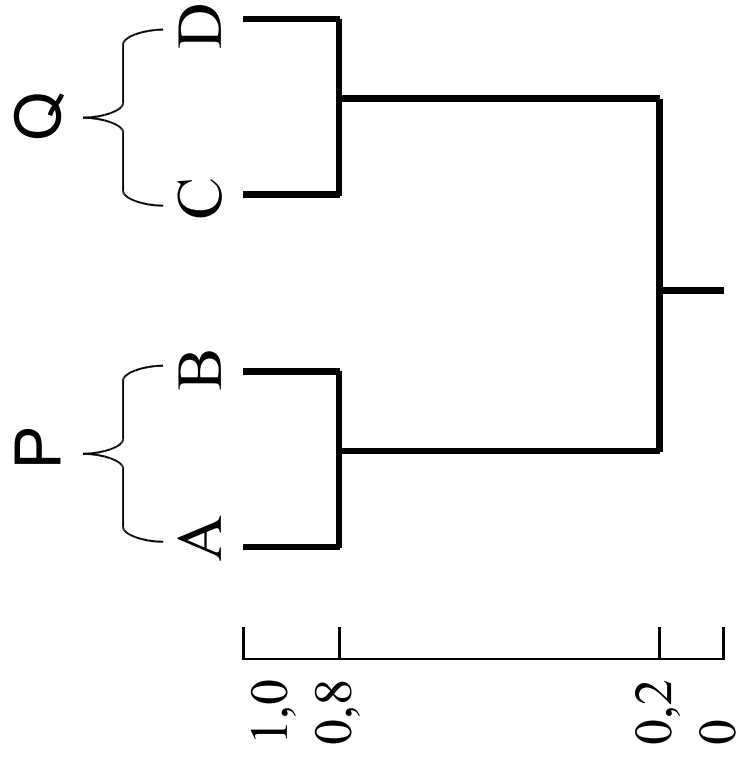
$$\text{Kesamaan PQ} = 0,3 + 0,1 = 0,4 / 2 = 0,2$$

Matrix becomes:

	P	Q
P	1	
Q	0,2	1

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Reconstruction of phenogram:



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- From above exercise, the students now are able to prove hypotheses that *Musa* is closely related with *Heliconia*. Similar situation is found in *Zingiber* and *Costus*.
- In previous classification, *Musa* and *Heliconia* are belong to a single family, namely, Musaceae, whereas *Zingiber* and *Costus* are placed in family Zingiberaceae.
- Due to rapid advancement of the molecular characters (DNA), now these four genera have been separated into four different family, namely, Musaceae, Heliconiaceae, Zingiberaceae, and Costaceae.

STRATEGY FOR EVALUATION

- Evaluation can be done through investigating the following components:
 1. Characters that already selected (They should be variative)
 2. Characters observation (accuracy and precision)
 3. Whether students do phenetic analysis systematically and logically (following the standard procedure)
 4. Phenogram topology
 5. How students interpret the results

RECOMENDATION

- Phenetic method can be applied in primary and secondary school with some modifications according to cognitive domain and needs of students.
- For first attempt, teachers can try to perform phenetic analysis by themselves and subsequently bring it into the class. Gradually, let students do it themselves beginning with the simplest cases.
- There is a hope that phenetic method can provide alternative way to learn and teach evolution and biodiversity.

**Thank you very much for your
kind attention**