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sichtlich des Inhaltes ist dagegen „Ergologie" ein besserer Name als „Ökologie" (im weiten Sinne) für eine Wissenschaft, die so vielerlei Lebensvorgänge, Einrichtungen, Anpassungen und sonstige Leistungen der Pflanzen erforschen und darstellen soll.

Correlation in the Inflorescence of Sanguinaria.

By J. Arthur Harris.

The subject of correlation has received considerable attention from botanists. Goebel[1]) was a pioneer in the consideration of these problems, and nearly ten years ago De Vries[2]) named correlation as one of the most important problems in future evolutionary work, and emphasized the necessity for the use of quantitative methods.

The purpose of this note is to state in non-technical terms the results of a biometric study of the inflorescence of the Blood Root, Sanguinaria Canadensis. The data for two series, of 1000 and 400 inflorescences, are presented and analyzed in detail elsewhere[3]) and here only the chief points will be touched upon.

In Sanguinaria, a monotypic genus of the Papaveraceae, the fruit is borne on a slender pedicel sent up from the root-stalk. It is one-celled with two parietal placentae upon which the ovules are arranged in two or more irregular rows.

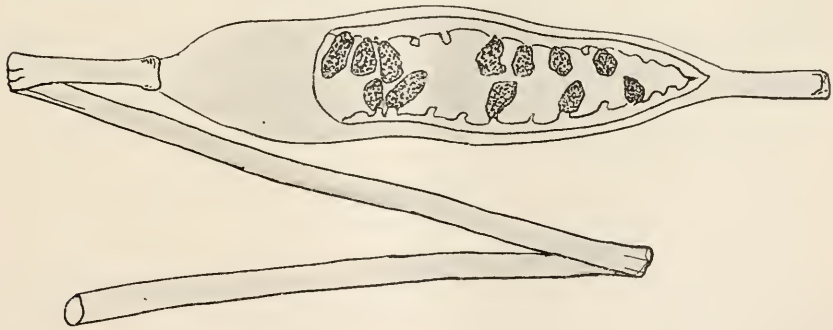

Diagram of upper portion of inflorescence. The fruit is opened on one side, showing the two placentae with the matured seeds and the abortive ovules.

Our problem is to measure the degree of interdependence of the several parts or characters of the inflorescence. The relationships we shall record in terms of the coefficient of correlation.

1) Goebel, K. Organographie der Pflanzen, p. 177—186, 1898. Also the literature cited there.

2) De Vries, H. Die Mutationstheorie. Vol. I, p. 113, 1901.

3) Harris, J. Arthur Biometrika. Vol. VII, 1910. In press.

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The coefficient of correlation of the statistician lies between 0 and plus or minus 1, a constant with the value 0 indicating that there is no relationship between the two characters of the series of individuals under consideration, while constants of the magnitude of 1 show that the interdependence is perfect, i. e. such that knowing the magnitude of one character of an associated pair we can state positively the magnitude of the other. The biologist must remember that the statisticians constant is purely descriptive and not interpretative. Generally we cannot know which character influences the other, or indeed whether both are not merely dependent upon some group of causes external to themselves. Being merely a description of the materials in hand, the correlation constant may be influenced by age differences or other heterogeneity of the material, and cannot be taken at once as the equivalent of the conception of correlation which the physiologist holds. It would seem to me, however, the most trustworthy and usable tool for analyzing out and measuring this physiological correlation.

Consider first the relationship between the length of the pedicel and the length of the fruit. For the 1906 series we find a correlation of $\cdot 335 \pm \cdot 019$, showing that there is a very substantial relationship between the two characters. This cannot be interpreted as meaning that the length of the stalk has a direct influence on the length of the fruit, or vice versa. Their interdependence may be due merely to their mutual dependence upon some other factor (age, physiological vigor, individual environment) but we have at least demonstrated the existence of the interdependence and measured its intensity on a scale directly comparable with other characters, thus allowing of further studies by comparative or experimental methods.

In like manner the correlation between length of pedicel and the fertility of the fruit may be obtained. We find:

Length of pedicel and total ovules per fruit, $\cdot 323 \pm \cdot 019$,

Length of pedicel and total seeds per fruit, $\cdot 363 \pm \cdot 019$.

The closeness of interdependence is therefore about the same as for length of peduncle and length of fruit.

The correlation for length of pedicel and number of seeds developing is slightly higher than that for length of pedicel and number of ovules formed, but the difference is only $\cdot 040 \pm \cdot 027$, hence no biological significance can be attached to it. If the degree of development of the peduncle furnishes some indication of the vigor of the individual one would rather expect to find a closer correlation between it and the number of seeds developing than between it and the number of ovules formed. In Sanguinaria as I have studied it over 75 per cent. of the ovules develop into seeds

4) Pearson, K. Proc. Roy. Soc. Lond. Vol. LIX, pp. 301—305, 1896.

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and the correlation between these and a third character would necessarily be of the same general order of magnitude. I fancy it would be well worth while for some one to work out such relationships as we have here in some form in which the numbers of ovules and of seeds are not so nearly the same.

Indeed the whole field of problems presented by the relationship between somatic characters and fertility and fecundity seems worthy of intensive cultivation. At present our knowledge is very meagre. For animals Pearson[5]) has secured evidence that tall women are more fertile than short ones, and he tells me that data for other mammals will be published. In agricultural literature much has been written on the amount of straw and grain in cereals, but the methods of experiment and record leave much to be desired. In Nothoscordium and Allium it has been shown[5]) that there is a correlation of about ·500 or over for length of flowering stalk and number of flowers per umbel. In Cercis[6]) and Celastrus[7]), however, when we work within the individual there seems to be no relationship between the size of the inflorescence as measured by the number of flowers produced and the fertility of the ovaries. There must be reasons for differences such as these and it lies before the biologist to find out what they are.

Size and fertility of fruit — both number of ovules formed and number of seeds developing — are found to be correlated, the degree of the interdependence being about ·500—700. The constants for both ovules and seeds are obout ·100 higher in 1907 than in 1906, possibly due to the somewhat more mature condition of the fruits which must be taken before they are quite ripe if the countings are to be made for the placentae. The constants for length of fruit and number of seeds maturing are slightly higher than those for length of fruit and number of ovules formed, but the difference is of no practical value.

Since both length and fertility of fruit are correlated with pedicel length there would necessarily be some statistical correlation between length and fertility whether they were in any measure biologically interdependent or not. By means of a suitable formula we can remove the influence of the correlation of the two characters with pedicel length upon their own interdependence. We find that the removal of this factor disturbs only very slightly the values as given above, and conclude that the correlation must be due chiefly to other factors than pedicel length.

The correlation between the number of ovules formed and the number of seeds developing per placenta or per fruit is high, lying

5) Harris, J. Arthur. Ann. Rept. Mo. Bot. Gard. Vol. XX, pp. 105—115. 1909.
6) Harris, J. Arthur, Biometrika. In press.
7) Harris, J. Arthur. Ann. Rept. Mo. Bot. Gard. Vol. XX, pp. 116—122. 1909.

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in the neighborhood of ·800. This would be the expected condition from the high percentage of seeds which develop, and is of interest chiefly in comparison with the results from other species. A constant showing the relationship between the number of ovules per fruit and the capacity of the fruit for maturing its seeds, gives discordant results for the two series of material, thus leaving it still an open question whether there is any difference in the capacity of the pods for maturing their ovules into seeds depending upon the number of ovules which they bear.

The correlations between the number of ovules formed or the number of seeds developing on the two placentae of the fruit are high. The actual constants are as follows:

Characters of the two Placentae	Correlation and Probable Error		
	1906	1907	Difference
Ovules of „First" Placenta and Ovules of „Second" Placenta . .	·9239 ± ·0031	·8868 ± ·0072	— ·0371 ± ·0078
Seeds of „First" Placenta and Seeds of „Second" Placenta	·8014 ± ·0076	·8443 ± ·0097	+ ·0429 ± ·0123
Aborted Ovules on „First" Placenta and Aborted Ovules on „Second" Placenta . .	·6793 ± ·0115	·7070 ± ·0169	+ ·0277 ± ·0204
Ovules on „First" Placenta and Seeds Developing on „Second" Placenta	·7356 ± ·0098	·7191 ± ·0163	— ·0165 ± ·0193

So large correlations between the two sides of the fruit as those for ovules per placenta indicate great symmetry, and so a high degree of perfection in the morphogenetic processes giving rise to the fruit.

The relationship for ovules is obviously quite independent of that for the other fertility characters, but the converse is not at all true. The number of seeds developing on a placenta is closely correlated with the number of ovules formed and so a correlation between the number of seeds on the two placentae would necessarily be found even though there were no physiological relationship between the two placentae. Again we may have recourse to a rather complex partial correlation formula which removes the influence of the correlation between the numbers of ovules on the two sides upon the correlation for the numbers of seeds for the two sides. Comparing the results for the correlations for seeds we find:

	1906	1907
Gross Correlation	·801	·844
Influence of correlation for ovules removed	·590	·714

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It is clear, therefore, that while a certain amount of the correlation for number of seeds developing is due to the influence of the correlation for ovules, it is mainly due to physiological and ecological factors upon which the development of ovules into seeds depends.

The reader who cares for further details may consult the original paper. The purpose of the present resumé will have been amply fulfilled if it interests other workers in the biometric method of approaching some of the problems of vegetable morphology.

Cold Spring Harbor, March 19, 1910.

Die phylogenetische Bedeutung der Protura.

Von Carl Börner.

Die Auffindung des von Silvestri[1]) zuerst aus Italien beschriebenen *Acerentomon doderoi* und des bald darauf von Berlese[2]) entdeckten *Eosentomon transitorium* in einem Walde bei Frankfurt a. M. gibt mir Gelegenheit, die systematisch-phylogenetische Stellung der für *Acerentomon* und seine Verwandten begründeten Ordnung Protura hier in aller Kürze zu besprechen, da ich sie vor Jahresfrist bei Aufstellung meiner vier Hauptgruppen der Insekten aus Mangel an Untersuchungsmaterial noch nicht hatte berücksichtigen können. Inzwischen haben allerdings bereits Schepotieff[3]) und Berlese[4]) dieser Frage einige Worte gewidmet, ohne indessen zu einem befriedigenden Ergebnis gelangt zu sein.

Wie Silvestri halten auch Berlese und Schepotieff die Protura für recht altertümliche Insektenformen, indem sie besonderes Gewicht auf die Zwölfzahl und die stummelförmigen Extremitätenreste der vorderen Abdominalsegmente legen. Dass die Protura daneben auch stark spezialisierte Eigenschaften besitzen, wird nur nebenbei erwähnt, und Berlese wie Schepotieff glauben gar, dass die Protura Myriopoden und Insekten phyletisch zu verbinden geeignet seien. Aus diesem Grunde taufte Berlese die Protura Silvestri's in Myrientomata um, indem er die Möglichkeit zugab, sie könnten den Pauropoda nächstverwandt sein. Ich darf hier gleich anschließen, dass mir Silvestri dazu verwundert schrieb, er könne die Insekten nicht mehr definieren, wenn seine Protura

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1) Descrizione di un nuovo genere di Insetti Apterigoti, rappresentante di un nuovo ordine. Bollett. Labor. Zool. gen. ed agraria di Portici. Vol. I. 1907. p. 296—311, 18 Textfig.

2) Nuovi Acerentomidi. Redia, vol. V, fasc. 1°, 1908, p. 16—19, Tab. I.

3) Studien über niedere Insekten. I. Protapteron indicum n. g., n. sp. Zool. Jahrb. Abt. Syst. etc. 28. Bd., 2. Heft, 1909, p. 121—135, Taf. 3—5.

4) Monografia dei Myrientomata. Redia, vol. VI, fasc. 1°, 1909, 182 p., XVII tab. und 14 Textabb.

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