THE NON-INHERITANCE OF ASYMMETRY IN *COCOS NUCIFERA*

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Little is known about the inheritance of asymmetry in plants, animals, or men. In some species most individuals are asymmetrical in the same manner, for example almost all men have their hearts on the left, and most gastropod species are dextrally coiled. In such cases the abnormal type of asymmetry (*situs inversus viscerum* in man, sinistrality in gastropods) may be genetically determined. Much less seems to be known about cases where both types of asymmetry are common.

The coconut tree, *Cocos nucifera*, is always asymmetrical. The leaves are arranged along five distinct spirals which are right-handed (like an ordinary screw) or left handed, the direction being fixed at an early stage. Figures 1 & 2 illustrate the two types of spirals. In a bearing palm it is easy to determine the direction, since the spadices hang either on the left or right side of their subtending leaves. If the spiral is right-handed, the bunch hangs on the left side of the leaf, and conversely. The position of the bunch is always judged by looking from below the subtending leaf and towards its base.

Where the leaf scars (on the stem) are legible, the direction of the leaf spiral can be determined even without the crown. Since the leaves, as stated, fall along five spirals, the scar of the sixth younger leaf (counted from any leaf) which is almost above it in the same spiral, will fall above the scar of the first leaf, a few centimetres either to the right or left of the vertical drawn from the middle of the first leaf scar. The position of this younger leaf (sixth leaf) in relation to the vertical denotes the direction of the spiral. In figures 3 and 4, the leaves (scars) numbered 1, 6, 11 and 16 belong to the spiral A. Similarly leaves numbered 2, 7, 12, 17 etc. form the second spiral and so on. The dotted line connecting the widest region of the scars of leaves A_1, A_2, A_3 & A_4 is the direction of the spiral. It may be seen that the verticals drawn from these leaves fall a few centimetres apart. In this particular tree, the leaves A_1 and A_4 are about 90° apart from each other and leaf A_{13} (not visible in figure) falls vertically above A_1. In one of the trees observed by Patel (1938), the leaves numbers 1, 12, 24, 35, 49 and 64 of the same spiral occurred in one vertical plane.

The phyllotaxy of each leaf spiral is nearly two fifths, that is, any two successive leaves make an angle of deflection of a little less than 144°. While according to Sampson (1923) the figure for this deflection is 142°, Patel working on a greater number of coconut palms covering many age groups, states that each new leaf is set at an angle varying from 137° to 141° left or right of the previous one. It is also stated that there is an indication that this angle gets reduced as the tree grows older.

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Even in a non-bearing palm where there are fifteen or more fully opened leaves, it may not be difficult to determine the direction of the leaf spirals since each spiral will have three or more leaves. But where there are less than, say, ten leaves as in most non-bearing seedlings, and where sufficient aerial stem is not formed, it is somewhat hard for the non-trained eye to judge the direction of the leaf spirals. However, this determination can be made easy if the position of two successive leaves in the crown is looked for. As illustrated in Fig. 5, since of the two consecutive leaves numbered 1 and 2, the younger leaf (No. 2) falls within the right semicircle of the section of the crown, the division (arrow mark) being effected through the middle of the outer leaf, the direction of the leaf spiral is towards the left, and vice versa (Fig. 6). The effect will be the same if the positions of the consecutive leaves Nos. 2 and 3 are judged instead of leaves 1 and 2. (There is no need to make a transverse section of the crown, although for easy explanation cross-sectional views of the crown are illustrated).

A coconut seedling from its germination takes about fifteen to eighteen months to produce normal pinnate leaves having free leaflets. Before reaching this stage it produces seven to ten entire, unsplit, seedling-leaves, and still earlier about five rudimentry leaves devoid of any lamina region. Following the method indicated above, it is possible to judge the leaf spirals in young seedlings as well. In fact, it is easier with very young seedlings having only a few rudimentary leaves because these leaves invariably keep to the direction of their origin. On account of the lack of a proper lamina region, wind will have little influence on these leaves. Thus it is possible to judge the direction of leaf spirals in a seedling as young as three months old (from the time of sowing of the nut), where only two or three rudimentary leaves are produced.

It is also often possible to predict the direction of leaf spirals of a palm by examining even one of its shed leaves. The coconut leaf is always asymmetrical, the area as well as number of leaflets of one linear half being greater than the other. A leaf of an adult palm will have 72 to 127 leaflets with the mean of 109·05 leaflets (based on the figures for 1,583 leaves from 55 bearing coconut palms under Central Kerala conditions) on one linear half and the number of leaflets of one half will invariably be greater than that of the other. This difference may go even up to fifteen in some leaves. The fruit bunch developing from the axil of a leaf will hang on the side having the extra number of leaflets. The leaf seen in Fig. 7 has nine additional leaflets on its left half (right in the figure) and hence the palm bearing this leaf should have right-handed leaf spirals.

Table 1 gives the numbers of right-spiralled and left-spiralled trees of the tall variety of coconut in nine populations. The first three are in a northern suburb of Calcutta, and are merely grouped by locality. There is no reason to think that any of these groups was grown from related seeds, and soil and other conditions differed. The next four are from plantations at the Regional Coconut Research Stations, and the Central Coconut Research Station, in Kerala. Each group had a fairly similar treatment and their ancestries were probably fairly homogeneous. The eighth group is from the extreme south of India, now in Madras State. The last is the group of experimental

trees described in Tables 2 and 3. 52·05% ± 0·91% of the trees had left-handed spirals. The difference of the totals is significant (P = ·020) by the usual criterion. This would not be so if the ratios in the different groups were significantly heterogeneous. But χ_8^2 as a test of homogeneity is not very high, in spite of the one exceptional population from Neyyattinkara. It is perhaps worth noting that the effect of omitting this population would raise the percentage of lefts to 53·34%. But χ_7^2 for heterogeneity would be reduced to 1·054, giving P = ·994, which would indicate unexpected homogeneity. There is no reason to reject this sample. But I propose to count another 10,000 or so trees, first, to establish the existence of the excess of lefts with higher probability, secondly to discover whether exceptional populations are common, and thirdly to detect regional or racial differences, if they exist. Patel also states that the spiral is towards the left in a majority of the trees although no figures

Table 1

Place	Right	Left	L-R	χ^2	% L
I.S.I., Calcutta	115	130	+ 15	0·918	53·06
Barrackpore Trunk Road	63	76	+ 13	1·216	54·68
G.L. Tagore Road	103	123	+ 20	1·770	54·42
Neyyattinkara	231	189	− 42	4·200	45·00
Kumarakom	185	215	+ 30	2·250	53·75
Kayangulam A	178	205	+ 27	1·903	53·52
Kayangulam B	180	216	+ 36	3·273	54·55
Kanyakumari District	303	311	+ 8	0·107	50·65
Experimental (Table 2)	94	111	+ 17	1·410	54·15
Totals	1,452	1,576	+124	17·044	52·05

χ_1^2 (on totals) = 5·078
χ_{1c}^2 (on totals) = 4·996, P=·020
χ_9^2 = 11·966, P=·15

are given to support this. Petch (1911), one of the earliest to report on the existence of right-handed and left-handed coconut palms, on the other hand mentions that in a random population of fifty-five trees, twenty eight were right spiralled. His observations were based on the direction of the vascular bundles of the outer layer of the stem and not on the actual arrangement of leaves.

Table 2

Pollen parent		Seed parent		Progenies			
No.	Spiral	No.	Spiral	Right	Left	Died early	Total
58/I	L	15/IV	R	4	7	..	11
,,		195/IV	L	7	3	..	10
,,		208/VI	R	5	5	..	10
,,		354/IV	L	..	2	..	2
,,		393/VI	R	7	3	..	10
,,		406/VI	R	2	7	..	9
,,		418/III	R	2	2	1	5
,,		429/VI	L	4	5	..	9
,,		444/VI	L	3	6	..	9
117/I	R	58/I*	L	5	4	1	10
,,		104/I	R	1	..	..	1
,,		302/I*	R	3	6	..	9
,,		338/I*	R	3	8	..	11
,,		345/I	L	4	5	..	9
,,		354/I	L	4	5	1	10
,,		421/VI	L	3	5	1	9
,,		442/VI	R	1	..	..	1
302/I	R	202/III	L	..	..	2	2
338/I	R	67/V	R	5	8	1	14
,,		117/I*	R	5	5	..	10
,,		181/III	L	7	4	..	11
,,		196/III	R	5	4	1	10
,,		290/III	R	5	4	..	9
,,		360/III	L	6	5	2	13
,,		420/III	L	3	8	1	12
4		24		94	111	11	216

* Seed parents also used as pollen parent.

The coconut palm is usually cross-pollinated, but the pollen parent is generally unknown. In the years 1950-52, at the Central Coconut Research Station, Kayangulam, Kerala, controlled hand pollination was effected between 24 seed parents and four pollen parents of the tall variety which looked apparently resistant to a major (Wilt) disease prevalent in Central Kerala. All the pollen parents were used as seed parents as well. Most of the progenies (barring a very few extreme weaklings) were planted in a separate block in Kayangulam. I studied the direction of the leaf spirals of all the progenies (excepting a few already dead plants) in the year 1958 when the seedlings reached a stage old enough to detect the leaf spirals. The parents were also examined similarly. The results are given in Tables 2 and 3. It is clear that there is no suggestion that the direction of the spiral is inherited from the parents, or genetically determined in any other way. The excess of left hand spirals in the total is not significant. With Mc Mullen's (1936-37) correction, the totals give $\chi^2_1 = 1{\cdot}249$, $P = 0{\cdot}26$. The subtotals of Table 3 are surprisingly homogeneous, with $\chi^2_3 = 0{\cdot}1010$ only. So close an agreement would only occur by chance about once in fifty trials.

Table 3

Pollen parent	Seed parent	Progenies	
		Right	Left
R	R	28	35
R	L	32	36
L	R	20	24
L	L	14	16
	Total	94	111

I am now testing the effect, if any, of operations on seedlings upon the direction of the spiral.

Data on asymmetry are often not collected or published because they are not explicable on any particular theory. Thus S. K. Roy (1958) found that extra nipples were equally common on the right and left sides of cattle of both sexes, but twice as common on the left side in goats. Such facts should however be published in the hope of reaching generalizations, even if explanation is still far distant. And the great example of Pasteur suggests that the explanation, when it is found, may be of the utmost importance.

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SUMMARY

The direction of the foliar spiral in *Cocos nucifera* is not determined genetically.

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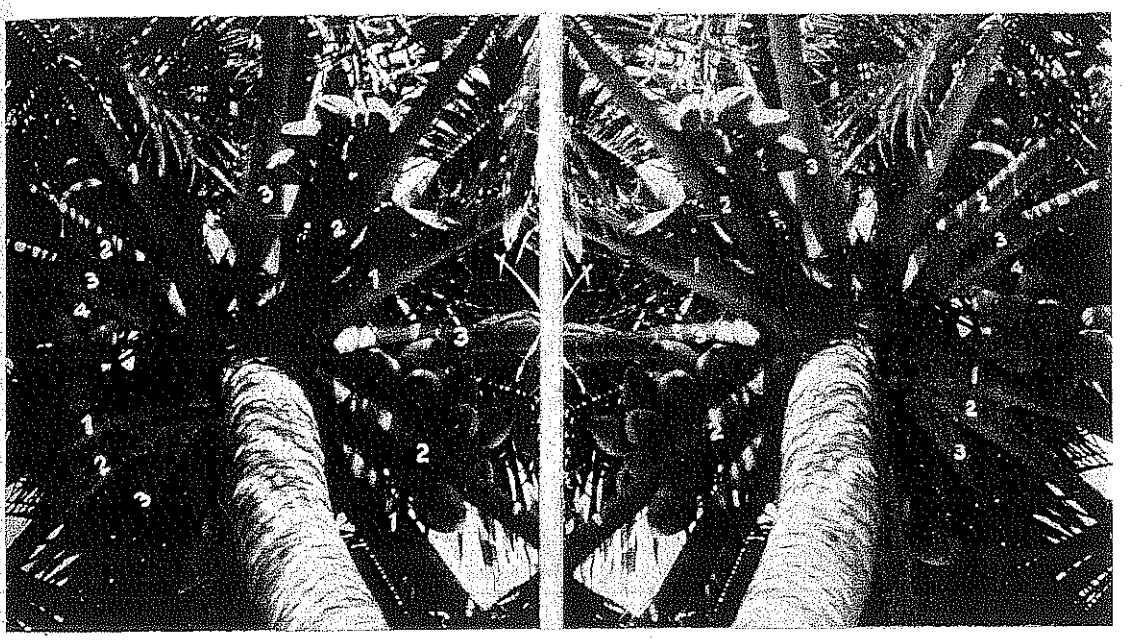
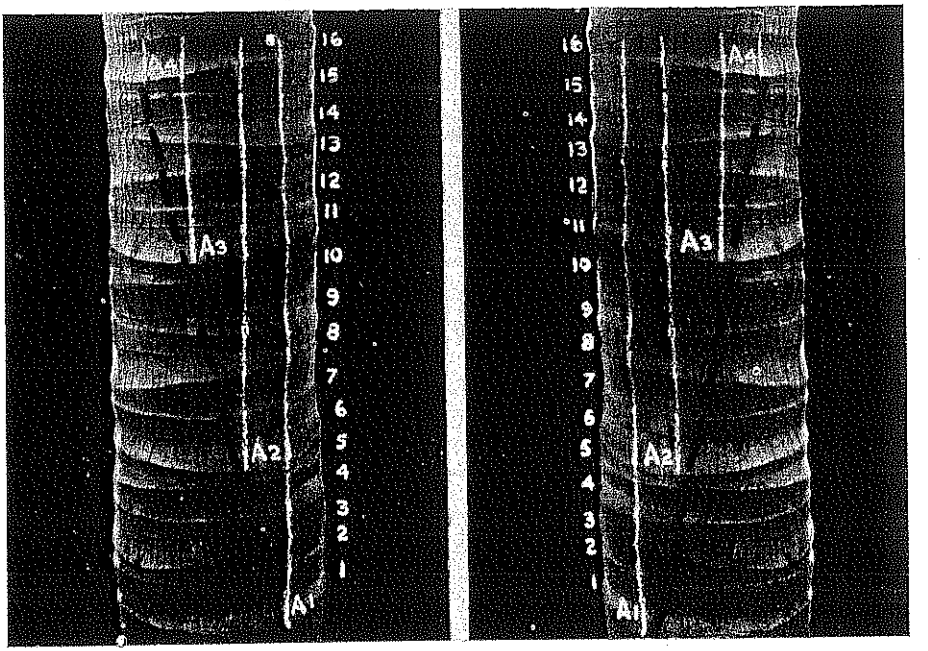
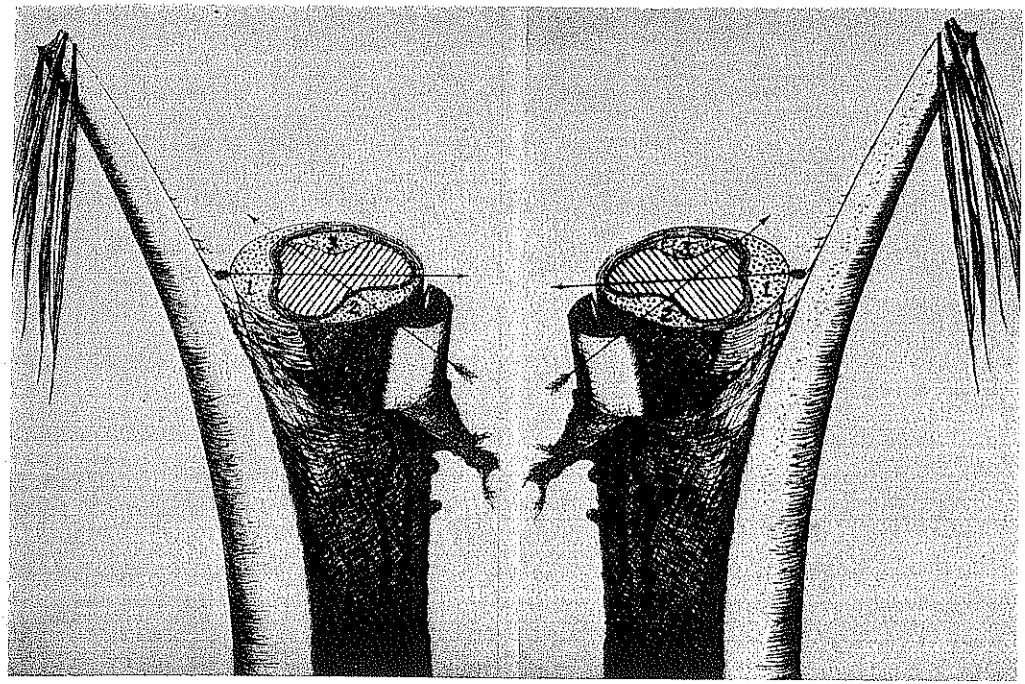


Figs. 1 and 2 illustrate left-handed and right-handed leaf spirals respectively in coconut. Four spirals can be recognised in each crown, the fifth being mostly hidden by the stem. In each spiral, the leaves are numbered 1, 2, 3 etc. from the oldest existing leaf of the spiral.



Figs. 3 and 4 show how the direction of the leaf spirals can be determined from the leaf scars also. The leaf scars A_1, A_2, A_3 and A_4 are those of consecutive leaves from one of the five spirals. The dark line in dots connecting the bases of these leaves denotes the direction of the leaf spiral.



Figs. 5 and 6 explain how the direction of the leaf spirals is determined in seedlings. The leaves Nos. 1, 2 & 3 are consecutive ones. No. 1 being the oldest of them. The arrow passing through the thickest portion of leaf No. 1 points out that leaf No. 2 falls within the right semicircle (of the section of the crown) in Fig. 5 and the left in Fig. 6. Between leaves Nos. 2 & 3, the same effect may be noticed if the arrow passing through leaf No. 2 is followed. The leaf spiral in Fig. 5 is left, and right in Fig. 6.

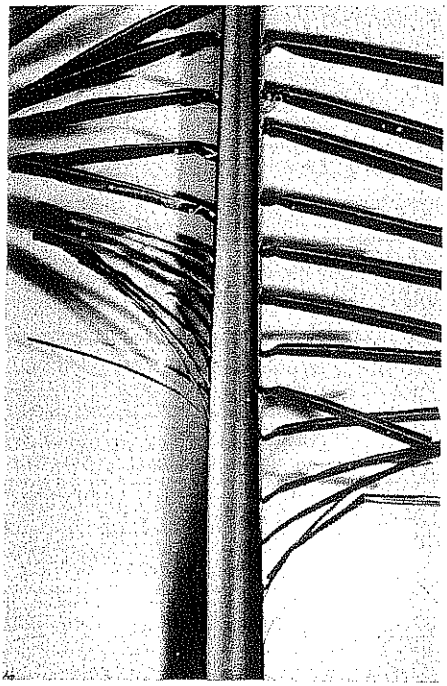


Fig. 7. A leaf from a right spiralled coconut palm having 7 extra leaflets on its left half.