INTRODUCTION.

1. THE SYSTEMATIC POSITION OF THEOBROMA CACAO (LINN).

The investigations reported in this paper concern the selection and breeding of desirable types of cacao trees, as far as quality of produce is concerned, for subsequent propagation under plantation conditions. In this respect the work is really a part of the newly formed Cacao Research Scheme (8-10) which aims at the selection of desirable types of cacao trees, having regard to all characters, quality, yield, etc., for propagation as clones on an estate scale, and was undertaken during the year 1932-1933 as a post-graduate problem at the Imperial College of Tropical Agriculture, and with the idea of assisting the scheme.

Cacao is an extremely heterozygous crop; whilst it is true to say that the cacao trees of the whole cacao growing world show a remarkable uniformity in their habit and in the characteristics of their vegetative and floral organs, yet the wildest diversity of form and colour is encountered when one comes to examine and classify the fruits and seeds. Before, however, embarking too deeply upon the fons et origo of this problem it would, perhaps, be not out of place briefly to examine the systematic position of the cacao plant and obtain some idea of the range of variation possible.

Theobroma Cacao, L., which produces the cocoa of commerce, belongs to the family STERCULIACEAE, which together with the MALVACEAE and TILIACEAE form the cohort MALVALES. The genus THEOBROMA itself is characterised by the peculiar shape of the petals, which are concave at the base and narrowing to the top are sometimes spatulate at the distal end. The genus contains in all 18 species, subdivided on leaf shape, number of anthers in the stamina

and flower colour. Of these 18 species only two, Theobroma Cacao and Th. pentagona, produce the cocoa of commerce; Th. pentagona itself is regarded by some as a variety of Th. Cacao, so that there is only one species of economic importance in the genus. The 16 remaining species do not produce a marketable article and are not cultivated; whilst four of them are imperfectly known.

Theobroma Cacao is a much branched tree. It never attains any very great height, reaching 6 to 10 feet in three years and when fully grown at 10 to 12 years reaching some 15 to 25 feet. At 3 to 5 feet from the ground the main stem ramificates into 3 to 5 branches (called the jorquette and fan branches respectively in Trinidad), which themselves soon produce laterals and a very dense foliar canopy is evolved. These fan branches and their laterals have their leaves arranged in two rows, whilst the phyllotaxis of the main stem is 3/8. Other branches, called water-shoots or chupons, may grow vertically from the base of the trunk or from the laterals and have their leaves arranged also in a 3/8 spiral. The development of water-shoots may be very pronounced in a vigorous tree. The flowers are cauliflorous, and are borne in reduced dichasia in the axils of the leaves, but do not develop until after the subtending leaf has dropped. They thus appear scattered in clusters, apparently at random, on the leafless main trunk and laterals.

The individual flower is of a very peculiar structure; it has five sepals, white or rose coloured, with which alternate five petals. Each petal consists of a cup shaped basal portion, to which is attached a ribbon-shaped part spatulate at the distal end. The androecium is made up of five stamina alternating with five staminodes. The staminodes are awl shaped and project above the petals, forming a fence-like structure round the pistil. Each stamen itself consists of four anthers, and is really a concrescence of two stamina; it is

mounted on a bent filament, the anthers being tucked away in the pouch of the corresponding petal. The gynaecium consists of one pistil and is superior. Vigorous trees begin to bear blossoms when three years old, but little or no fruit is set until the fifth or sixth year.

The subject of pollination is a very interesting one, and since it has some bearing on the subject matter of this paper a brief account will be given. A cacao tree bears on an average some five thousand to six thousand flowers a year, but of this vast number 95-99% fail to set fruit. The peculiar structure of the flower, with the anthers hidden in the pouches of the petals and the pistil surrounded by the staminode fence, would seem to exclude the possibility of self pollination. For a long time nothing was known concerning the pollination mechanism until Von Faber (11) reported that it was quite possible for pollen to fall from the anthers on to the pistil of the same flower. This is facilitated by the long and supple flower stalk swinging in the wind. He further showed that when trees stand in close proximity, as in all plantations, cross fertilisation could easily be effected.

However, it is known that when plantations of fine quality cacao are planted in the vicinity of coarser grade ones, rapid deterioration of the fine grade trees takes place. Hence it seems probable that some pollinating agent is at work. More recent investigations by Harland (5) have gone a long way towards the elucidation of the problem. He found by isolating groups of flowers with cages and keeping out all insects that pollination was completely suppressed; by allowing access to ants some 0.8% set fruit, whilst 8.0% set when both ants and aphids were present. He therefore concludes that crawling insects, ants, aphids and possibly the normal flower inhabiting thrips are responsible for much

pollination. On trees naturally infested with the insects 35% of the flowers received pollen, whilst only 2% setting was observed; on trees not infested the figures were 5% and 0.2% respectively. Further, 1% of the flowers were pollinated by a night flying insect, at present unidentified, when crawling insects were excluded by sticky bands. Hence the self pollination is effected by the natural tree inhabiting insects and the cross pollination by the night flying insect.

The other cacao producing species, Theobroma pentagona, is indigenous to Nicaragua and its environs, and is of much less importance than Th. Cacao. The fruits differ from those of Th. Cacao in having five prominent longitudinal ridges, and are covered with warty excrescences giving it the name "alligator cocoa". It is a smaller tree and far less productive than T. Cacao, and is now rapidly disappearing from cultivation.

The three species Theobroma Cacao, Th. pentagona, and Th. leiocarpa form an intra-compatible sub-group, EU-THEOBROMA, which is marked off from the other sub-groups by possessing four anthers per stamen instead of six. Theobroma leiocarpa is the wild cacao, and all cultivated cacaos can be regarded ashaving been derived from these three by a process of hybridisation.