ON THE FERTILISATION OF A FEW COMMON PAPILIONACEOUS FLOWERS

[NOTE TO EDITOR.—THE enclosed paper was written in the autumn of 1869, and then submitted to Mr. Darwin. With his usual kindness he encouraged me to proceed with it; and with his usual thoroughness he advised me to make it more complete than it is before giving it to the public. At the same time, he lent me various publications containing articles on the subject of fertilisation, and, amongst others, some by the Italian botanist, Delpino, who has done so much in this field. I found that he had in two or three publications in the years 1867 and 1868, anticipated most of the observations contained in the accompanying paper; and I proposed to myself to attempt a *résumé* of what had been done of late years in the matter of fertilisation of flowers by Delpino, Hildebrand, and others. But this, though a labour of love, is a greater labour than I can manage, and other calls have grown upon me. I therefore send the paper to you as it stands, begging that this note may be prefixed in order that I may not be thought to be appropriating Delpino's observations.—T. H. F., *October* 1872.]

AFTER reading Mr. Darwin's book on Orchids and his papers on Lythrum and Primula, I made some notes on the fertilisation of Phaseolus and some of the Campanulaceæ, which had the good fortune to meet with his approval, and which he had the kindness to send for publication to the Annals and Magazine of Natural History, where they appeared in October 1868. The comparison of Phaseolus with other Papilionaceous flowers led me to think that Mr. Darwin's fertile ideas might receive many illustrations from the structure and functions of this beautiful and interesting tribe; and the following are observations made during the summer of 1869 upon

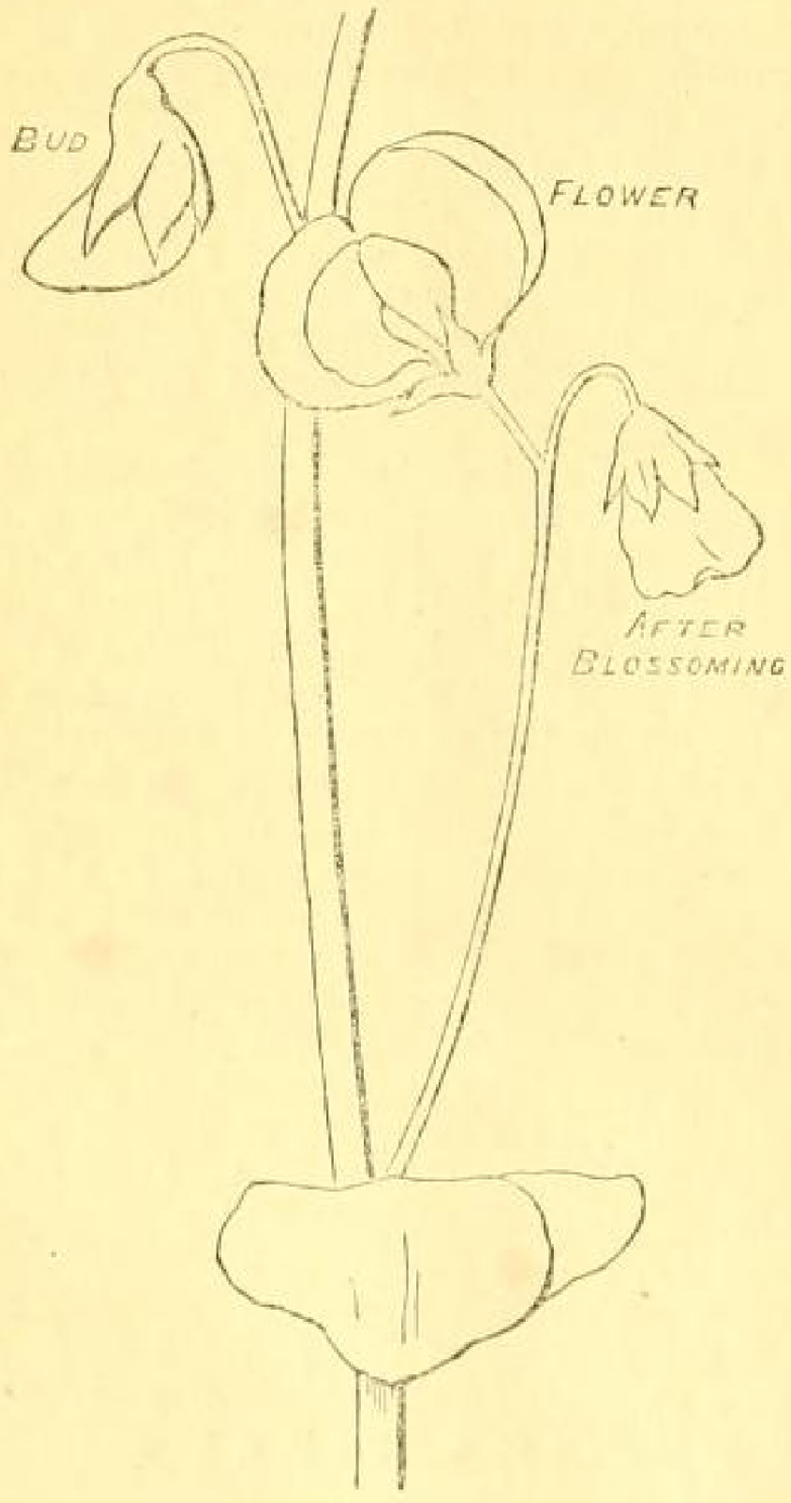

FIG. 1.—*Pisum sativum* (Common Pea) (peduncle and pedicels).

a few of the commonest of them. I am painfully conscious how imperfect want of time, of opportunity, and of knowledge has left them; and how many points there are, even in these few flowers, which require a much more careful inquiry. Indeed, every new flower has its own peculiarity; and almost every new peculiarity suggests the observation of facts in other flowers not previously noticed; so that the task is endless. Again it is difficult to feel sure of a conclusion unless the whole process of fertilisation by insects can be watched, and to a dweller in towns, ignorant of insects and their habits, it is impossible. If, however, these observations should lead to further inquiry and discussion, they may not be useless. The flowers in question are *Pisum sativum*, several species of *Lathyrus*, *Vicia*, and *Phaseolus*, *Robinia pseud-Acacia*, *Wistaria*, *Onobrychis sativa*, *Trifolium repens* and *T. pratense*, *Lotus corniculatus*, *Lupinus*, *Ononis*, *Anthyllis*, *Ulex*, *Genista*, *Sarothamnus*, and *Cytisus*.

Pisum sativum, or Common Pea.—The blossoms are generally two upon a common peduncle, and each flower has a separate short pedicel (see Fig. 1). The peduncle generally approaches the perpendicular and

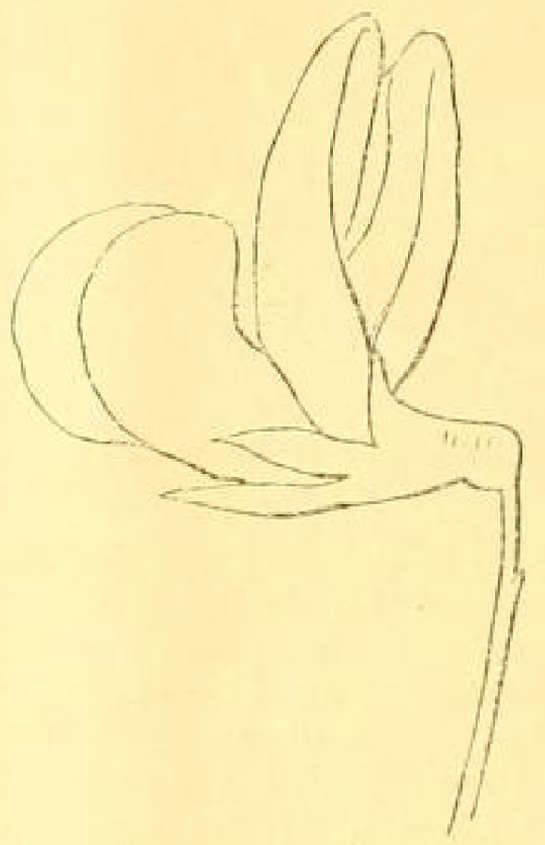

FIG. 2.—*Pisum sativum* (mature flower).

maintains its position through the stages of bud, blossom, and pod, except that it gets stiffer. The short pedicels, however, change their position twice. In the bud they are bent down so that the base of the calyx is uppermost, and the upper edge of the folded vexillum lowest. In this stage the large calyx covers with a weather-proof awning the tender blossom. As the flower opens the pedicel straightens itself; and when the blossom is fully open it is quite straight, and at an angle of 45° to the peduncle. The effect of this is to raise the flower so that the keel and wings become almost horizontal, whilst the showy limb of the vexillum, bent upwards from the claw, displays a perpendicular face (see Fig. 2).

The wings are slightly attached to the keel at the base of their limbs; and the limbs project outwards and a

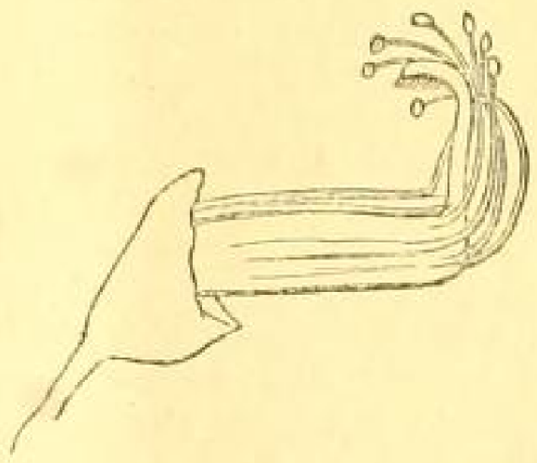

FIG. 3.—*Pisum sativum* (lateral view of pistil and staminal tube, with calyx and corolla removed, and tenth stamen separated).

little upwards in front of and above the keel, so as to make an excellent lighting place for insects. The keel is boat-shaped, recurved at the apex, and the lower edges

are joined together from the base to the apex. The stamens are diadelphous, the filament of the tenth stamen being separate at the summit and base, and separable in the middle (see Fig. 3). They are of nearly equal length, the pollen is abundant and rather moist, and is shed at the time the blossom expands. The upper parts of the filaments are stiff enough to keep their place, but not so stiff as the style. The lower parts of the filaments form a stiff tube, expanded towards the base, so as to leave a large cavity round the base of the ovary. This cavity is abundantly supplied with nectar. On each side of the tenth stamen at its base, there is a wide aperture, through which apertures, on removing the vexillum, this cavity with its nectar is easily seen (see Fig. 4).

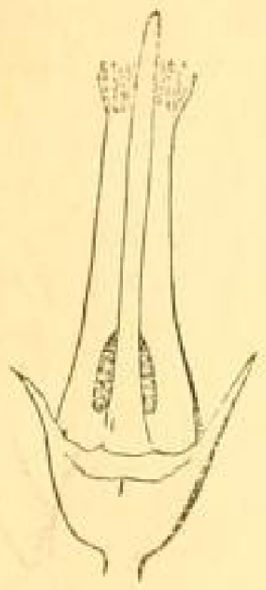

FIG. 4.—*Pisum sativum* (front view of staminal tube, with tenth stamen, front showing apertures into nectary on each side the tube).

The style is at right angles to the horizontal ovary, and curves towards the vexillum at the top. The stigma is at the extremity, and faces outwards and upwards towards the vexillum. On the inside for some distance below the stigma it is clothed with stiff hairs, which are set so as to point upwards towards the stigma (see Fig. 5). The style appears to be formed by two folds of the carpellary leaf, which bend outwards from the point where the style joins the ovary, so that the outer side or back of the style which lies towards the suture of the keel, and which has no hairs on it, is formed, not of the outer suture of the carpel, but of the edges of these folds.

At the time the flower opens the stamens have shed, or are shedding, their pollen, which lies in an abundant mass at the apex of the keel around and above the stigma.

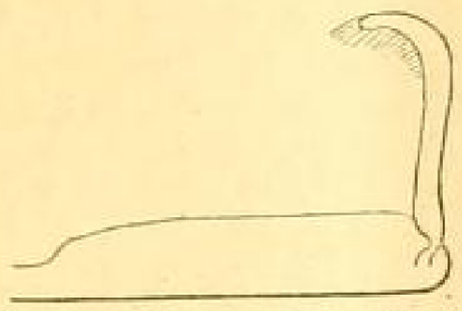

FIG. 5.—*Pisum sativum* (pistil).

The back of the stiff elastic style almost touches the keel; and on pressing down the wings, which, as above noticed, are attached to the keel, the back of the style, which has no hairs, is pressed against the keel, whilst the brush on the front and sides of the style sweeps the moist pollen upwards and pushes it out of the apex of the keel and against any object which is entering the flower, and to which the pollen, being moist, will adhere. On removing the pressure the parts take their place again, whilst on repeating the pressure the same process may be repeated, until the whole of the pollen in the upper part of the keel is brushed out.

As soon as the flower closes and before it withers, the pedicel again droops, the flower becomes pendent, and the calyx again acts as a pent-house to the young pod (see Fig. 1).

Now, undoubtedly, the stigma of one of these flowers is always covered with its own pollen; but if self-fertilisation were the rule, the elaborate structure I have described is meaningless, whilst if the purpose is that insects shall carry the pollen from flower to flower, it becomes a curiously elaborate and complete piece of mechanism having a special object. The change of position of the flower by the bending, straightening, and second bending of the pedicel, so that the tender opening bud and the young fertilised ovary are protected from rain and cold; whilst the open blossom displays itself in the most attractive and convenient form and position for insects; the conspicuous vexillum; the wings, forming an alighting place; the attachment of the wings to the keel, by which any body pressing on the former must press down the latter; the staminal tube inclosing nectar, and affording by means of its partially free stamen with apertures on each side of its base, an open passage to an insect seeking the nectar; the moist and sticky pollen placed just where it will be swept out of the apex of the keel against the entering insect; the stiff elastic style so placed that on a pressure being applied to the keel, it will be pushed upwards out of the keel; the hairs on the style placed on that side of the style only on which there is space for the pollen, and in such a direction as to sweep it out; and the stigma so placed as to meet an entering insect,—all these become correlated parts of one elaborate mechanism; if we suppose that the fertilisation of these flowers is effected by the carriage of pollen from one to the other.

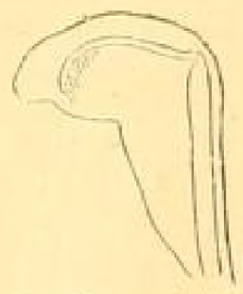

FIG. 6.—*Lathyrus* (keel and pistil).

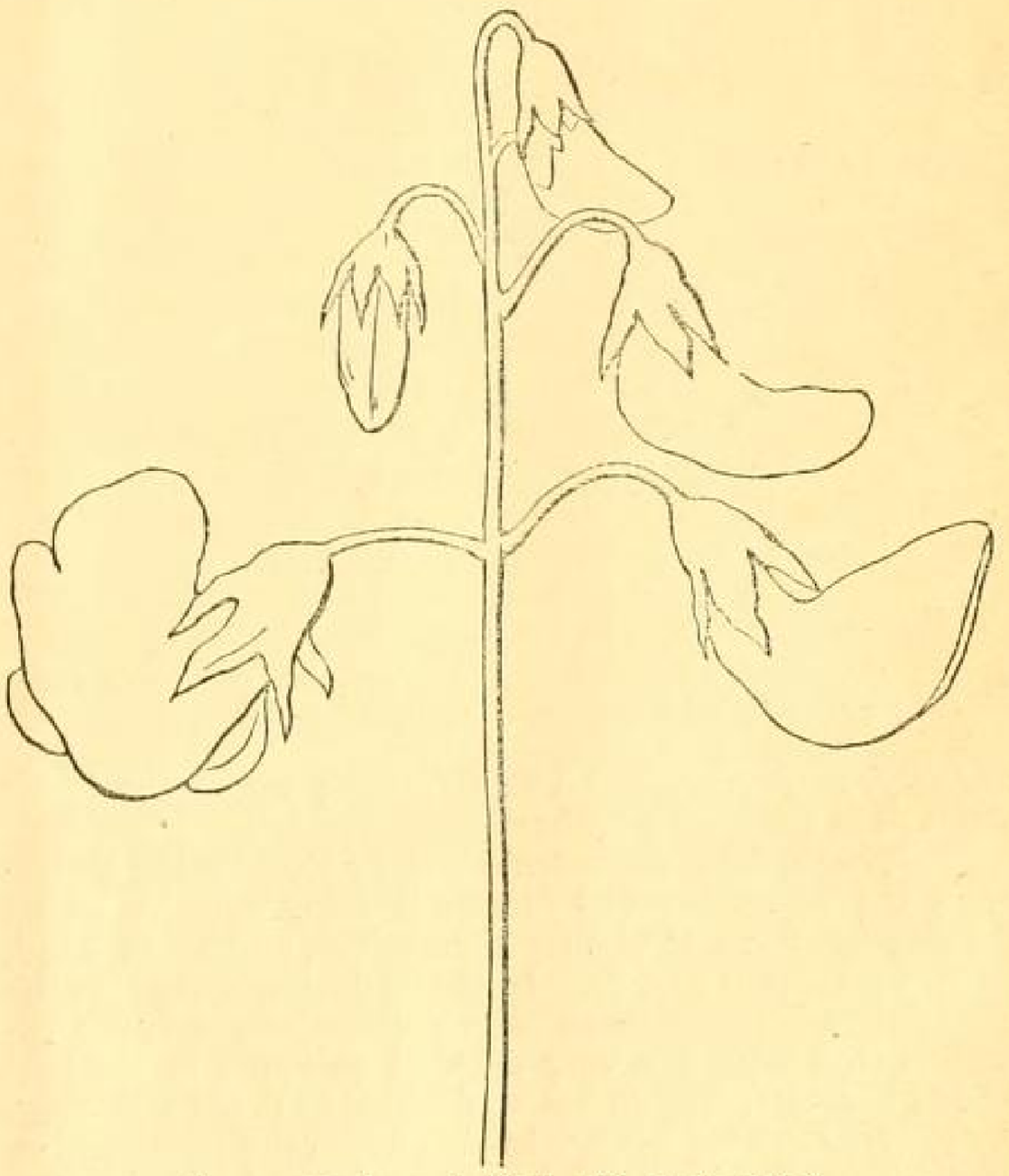

FIG. 7.—*Lathyrus latifolius* (Everlasting Pea).

I have, however, not observed the bees or other insects at work on these flowers, whilst they are to be found in abundance on the neighbouring broad beans and scarlet

runners. Do the white pea-blossoms attract night-flying insects?

Lathyrus odoratus.—This is, so far as the above functions are concerned, so like Pisum, that it is scarcely worth while to dwell on the differences. In colour and smell, of course the difference is great, and consequently in the attractions for different insects. The changing position of the pedicels; the brush to the style; the free or partially free stamen, and the nectar inside the case of the staminal tube, and the openings into that tube, are the same (see Fig. 6).

Lathyrus macrorhizus, is, so far as I have observed it, similar.

Lathyrus pisiformis is like the other Lathyri in the above points, except that in the long raceme of flowers, the whole peduncle, and not only the pedicels of the separate flowers, is pendent in the bud. It stiffens and becomes upright as the blossoms open, and the pedicels also stiffen and become horizontal. After flowering the peduncle remains stiff and upright, but the pedicels droop.

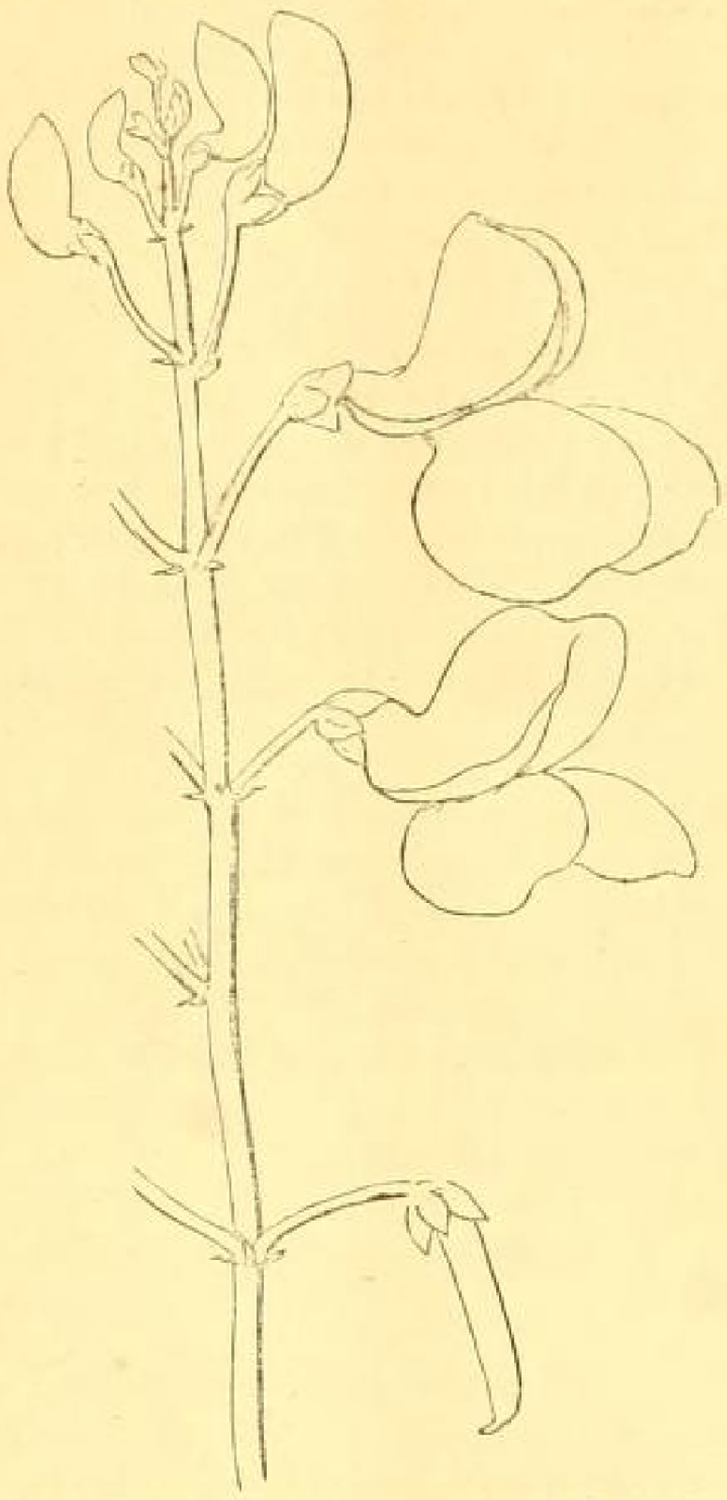

FIG. 8.—*Phaseolus multiflorus* (Scarlet Runner).

Lathyrus pratensis.—The fertilising apparatus is the same as in the above Lathyri.

Lathyrus sylvestris, or *latifolius*, or Everlasting Pea.—Here the many-flowered raceme is itself upright, whilst the pedicels bend, straighten themselves, and again bend, as in Pisum (see Fig. 7). In the fertilising apparatus the mechanism is the same as above described, with the exception that there is a very decided obliquity in the keel and in the style, though not so decided as in the following.

Lathyrus grandiflorus.—In this flower the peculiarities, as distinguished from the above-mentioned Lathyri, are as follows:—The pedicels bend, straighten, and bend themselves again, as above mentioned; but the effect generally, if not universally, is to make the large showy vexillum, and not the keel, horizontal. The vexillum, consequently, and not the keel, would be the natural alighting place for an insect. The wings are at right angles to the vexillum, and the recurved point of the keel projects between them and overhangs the vexillum. An insect alighting on the vexillum, and thrusting itself towards the nectary, must push the wings, and with them the keel, upwards, and make the style and the pollen come out; but they will come out downwards on to the back of the insect, and not on to his thorax or belly.

Another peculiarity is that the keel, and with it the style, is very oblique, and the upper part is flattened, and is twisted so that the back of the style does not press against the keel. Correlatively both sides of the style are well furnished with hairs, and both sides equally operate in sweeping the pollen out of the keel. In this respect *Lathyrus grandiflorus* seems to show a gradation towards Phaseolus.

Phaseolus multiflorus, or Scarlet Runner.—In the position of the blossom whilst flowering, in the nectar-holding cavity of the staminal tube, and in having an entrance to the cavity by the separation of the tenth stamen, this flower resembles Lathyrus and Pisum, but it offers the following peculiarities (see Fig. 8):—

The pedicel of the bud before flowering is perpendicular and stiff, and the bud consequently upright; the pedicel becomes rather more horizontal as the flower opens, and in blossom the wings are horizontal, whilst after flowering the pedicel becomes quite horizontal, and the pod gradually sinks, and ultimately becomes pendent. Correlatively, there is no large pent-house of a calyx, as in Pisum, to protect the young blossom; but the same object seems to be effected by the smooth, strong, thick vexillum, the edges of which are in the bud closed valvately over the tender folded interior petals; whilst in the bud of Pisum the whole of the petals, whilst sheltered by the calyx, are tender and unclosed. The young pod of Phaseolus, also unlike the thin glabrous pod of Pisum, is thick and covered with short hairs.

The keel, which in some Lathyri is very oblique, is in Phaseolus so twisted, and has its edges so joined, as to form an imperfect tube containing the stamens and style; it makes with them nearly two complete spiral turns, and its mouth points obliquely downwards. The stiff, elastic style is clothed with stiff hairs or bristles, forming a circular brush at the point in the tube where it is surrounded by, and in contact with, the moist, sticky pollen of the mature anthers. The stigma is on the lower side of the style, just appearing at the mouth of the tube, is sticky, and is clothed with fine hairs.

The filament of the tenth stamen is entirely separate from the others, and is furnished with a sort of tooth or appendage on the outside, upon pressing which the stamen is drawn back, and free access is given to the nectar-holding cavity. On the other hand, there is no such aperture on each side of the base of the tenth stamen as there is on each side of the base of the semi-adherent filament in Pisum and Lathyrus.

A bee lighting on the wings, or rather on the outer wing, opens for himself a way to the base of the flower. At the same time, the wing being attached to the spiral tube of the keel, he pulls it outwards, the consequence of which is that the stiff style is thrust outwards and at first downwards, so that the sticky stigma first touches the entering insect and sweeps from his proboscis any pollen he may have brought from other flowers. As he passes further, the stigma protrudes further, turns upwards, and the brush of the style, loaded with the sticky pollen of its own anthers, sweeps against, and leaves its load on, his proboscis, with which he departs for other flowers.

The mechanism of this flower is truly wonderful. For further details I could refer to papers by Mr. Darwin in the *Gardener's Chronicle* of October 24, 1857, and November 14, 1858, and to the notes of my own in the *Annals and Magazine of Natural History*, October 1868.

Phaseolus vulgaris is similar to *P. multiflorus*.

T. H. FARRER

(*To be continued.*)

ON THE FERTILISATION OF A FEW COMMON PAPILIONACEOUS FLOWERS

II.

VICIA SATIVA.—In the general structure and character of petals, stamens, and pistil, this flower agrees with Lathyrus; but there is a remarkable difference in the shape of the keel, and correlatively in the hairs or brush on the style.

In Lathyrus, as we have seen, the upper part of the elastic style is curved, so that the curvature corresponds with the curvature of the keel; the back or outside of the style presses against the inside of the keel, and is not furnished with hairs, there being no space for pollen on that side, whilst the inside of the style is covered with hairs set upwards, so as to sweep out the pollen which accumulates on this side.

In *Vicia sativa* the keel forms a less regular curve, whilst the style, instead of following the curvature of the keel, is set on at right angles to the ovary, and is straight and perpendicular throughout its whole length. There is, therefore, a large nook or corner outside the style, and between it and the keel, into which the pollen gets. Correlatively the style is not furnished with abundant hairs on the inside, as in Lathyrus; but there is a little tuft of stiff hairs on the outside, a little below the stigma, set on upwards so as exactly to brush out the pollen from the nook of the keel, when the keel is pressed down by an insect (see Fig. 9).

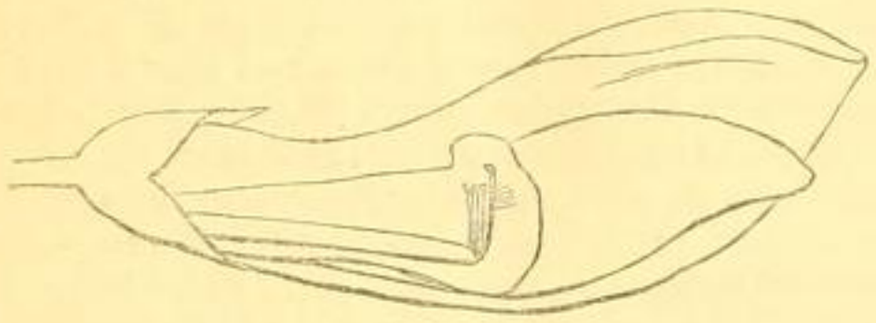

FIG. 9.—*Vicia sativa* (keel and pistil).

Vicia sepium is similar in construction to *V. sativa*. I have not observed whether there is nectar within the staminal tube of *V. sativa* or *V. sepium*, but feel assured that it is to be found there.

Vicia Faba. In the several positions of its buds and pods, Faba (broad bean) differs from Pisum and Lathyrus, and agrees with Phaseolus. The buds are upright; in the flower they are horizontal, and in the pod they are again upright; but the blossom, when open, is, as in all the other cases, horizontal, so as to afford a good lighting place for bees which seek the nectar in the interior of the staminal tube. This tube, the separate stamen, the shape of the keel of the style with its brush, are similar to those of *V. sativa*.

Robinia pseud-Acacia.—This plant bears its flowers in a pendent raceme; consequently, the position of the flower is reversed. The fifth sepal should be uppermost, and the vexillum lowest, with its back to the peduncle; and this is the position of the unopened buds. But as they approach maturity, *i.e.* as the blossom opens, the pedicel of each flower takes a half twist, so as to bring the flower into what we may call the normal position of Papilionaceæ, but with the vexillum uppermost and upright, or nearly so, and the wings and keel horizontal, the open side of the keel being uppermost. The keel is obtuse, and is free from the wings.

The filament of the tenth stamen is joined to the others in the middle, with apertures between it and the others at the base, and there is a cavity at the base of the staminal tube containing nectar. The stigma has a very small brush round it, and there are a few hairs on the inside of the style which seem to sweep out the pollen. The flowers are much frequented by bees.

Wistaria sinensis.—The pendent raceme of this plant displays, as regards the position of the buds and flowers, the same features as that of *Robinia pseud-Acacia*, which it also resembles in the free boat-shaped keel, the semi-separated tenth stamen, and the nectar-holding cavity of the staminal tube. It differs in having no hairs on the style, a difference possibly connected with the character of the pollen. But as the flower does not usually produce seed in this country, it seems unsafe to speculate on such a point.

Onobrychis sativa, or Sainfoin.—In the long raceme of this plant, the pedicels of the flower are nearly perpendicular in the bud, horizontal, as usual, in the flower, and again, after flowering, resume a position approaching the perpendicular. The wings are very small, and are not attached to the keel, and seem to play no part in fertilisation. On the other hand, the keel is large, boat-shaped, prominent,

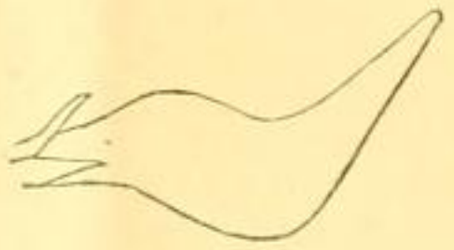

FIG. 10.—*Lotus corniculatus* (keel).

and being joined together to the apex, and having the petals folded over one another when not joined, affords a broad and easy alighting place for insects. The tenth stamen is separate at the base, and the staminal tube so formed that it may contain nectar. Whether it does so or not I have not observed. The filaments are stiff, and the pollen sufficiently dry and dusty to come out in abundance on pressure being applied to the folded top of the keel. The stigma comes out first, and often remains outside the keel, whilst the stamens, on pressure being removed, resume their position.

Trifolium repens (Dutch Clover).—These flowers, being in an umbel, afford a good foothold for bees, and do not require an alighting place on each flower so much as in the case of larger and separate blossoms. Nevertheless, they are upright in the bud, inclined in the flower, pendent and recurved after blossoming. No flowers are upright in full blossom, and consequently the centre or summit of the umbel becomes bare. The flowers thus tend to the usual position, even though in an umbel.

The claws of the wings and keel are united, and form a half tube, containing within them the staminal tube. The tenth stamen is perfectly free, and the staminal tube, as usual in such cases, contains nectar. Bees are fond of the flowers, and must, in entering the half tubes of the keel and wings, meet the stigma and carry away pollen.

FIG. 11.—*Lotus corniculatus* (dilated filament).

Trifolium pratense.—The position of the flowers in the umbel changes as in *T. repens*, though in a less marked manner.

The long claws of all the petals, including the vexillum, are united so as to form a complete tube, at the bottom of which is much nectar. The limb of the keel is open at the top, but the aperture is small, so that an insect entering cannot fail to touch both stigma and anthers.

The filaments of the nine stamens cohere to one another, and to the tube of the corolla from the point of union of the petals, so that there is no separate staminal tube. The tenth stamen is entirely separate for its whole length. Looking to the course of the apparent veins of the petals and stamens on the tube, it seems as if the vexillum really formed the tube, and as if the nine united filaments of the stamens by themselves would

leave a large aperture, and were widely separated from the tenth stamen. If so, it is curious to see the nectar-holding cavity so often formed by the stamens here formed by the vexillum. The entire freedom and wide separation in the tenth stamen, in a flower displaying such a tendency to cohesion, is also curious. Possibly this is necessary in order to preserve a sufficient aperture to give access to the nectary.

Lotus corniculatus.—The flowers of this plant again, though in umbels, when open assume the normal position with the vexillum uppermost.

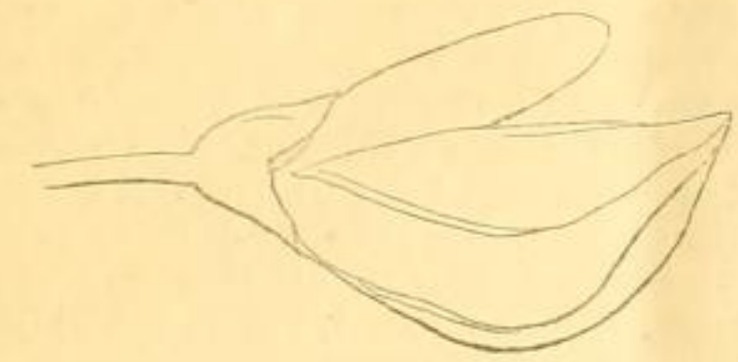

FIG. 12.—Lupin (flower with one wing cut off).

The wings are free from the keel. The keel is long, pointed, and united for some distance above as well as below, with an aperture at the apex (see Fig. 10). The tenth stamen is free, and is separate from the others at the base; the staminal tube is stiff and enlarged at the base into a cavity, which contains nectar. The pollen is moist and abundant. The style is capitate and stiff, but without hairs or brush. How then can the moist pollen be forced out of the narrow mouth of the long pointed keel so as to meet an entering insect? In a very curious way. Five

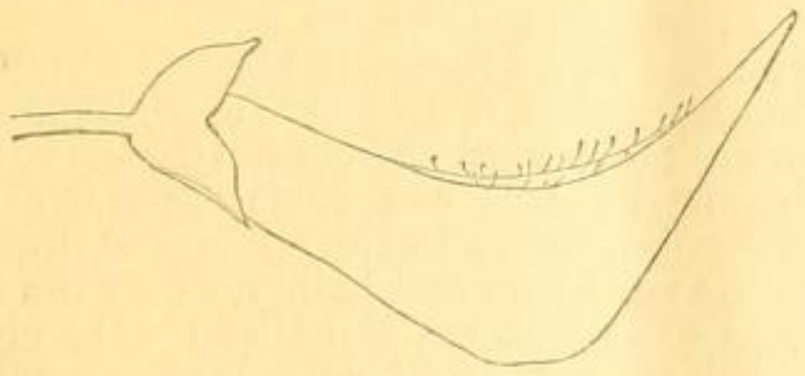

FIG. 13.—Lupin (keel).

of the stamens, viz. those of the inner whorl, are shorter than the others, and their filaments are dilated at the top. These filaments are stiff, and, I believe, continue to grow after the five anthers of the other whorl have shed their pollen. The dilatation of the filament is wedge or club-shaped, the broad end of the wedge being uppermost (see Fig. 11). Consequently, on any pressure being applied to the keel, the broad ends of these wedges, supported by their stiff filaments, collect the pollen, and push it before them to and out of the mouth of the keel, where it is seen to adhere to

FIG. 14.—Lupin (Stamens in bud).

the body of the insect which is passing down the keel. It is to be observed that the shape of the dilated filament is such that, whilst pollen might work past it from below upwards, the broad flat upper end of the filament meeting the narrowing tube of the keel can scarcely allow it to pass downwards.

Garden Lupin (common tall blue and white).—In the long raceme of this plant the pedicels are nearly perpendicular in the bud, become horizontal whilst the blossom is open, and rise so as to approach the perpendicular again afterwards. The wings are attached to each other below, are blunt, and are folded over at top so as to afford an excellent resting place. They are not attached to the keel, and move downwards more easily than it does. The keel is very long, very pointed, and the upper edges are slightly connected with an opening at the apex so as to form an approach to a tube. The apex just appears between the wings. The upper edges of the keel are furnished with a few hairs (see Figs. 12 and 13).

The filaments of the stamens are entirely joined together so as to form a close fitting tube round the ovary. There is no cavity within the tube for nectar, no apertures into it at the base, and it is too long and too close fitting for an insect to thrust its proboscis down.

FIG. 15.—Lupin (keel with one side cut off).

There is a cavity at the back and base of the vexillum in which I have not been able to find nectar. But the bees, which constantly visit these flowers, certainly go to this cavity for what they want, and not to the staminal tube. Five of the stamens compose, I believe, what must be the outer whorl, are longer in their filaments than the other five, and have longer anthers (see Fig. 14). These are mature, and before the flower opens have shed their pollen, which remains in a moist mass towards the mouth of the pointed keel. Their filaments then wither and contract. The other whorl of stamens are shorter, and the anthers much

FIG. 16.—Lupin (style and stigma).

smaller, but they are later than the first whorl, and their filaments grow and remain stiff after the filaments of the first whorl have withered. They consequently, on pressure being applied to the keel, thrust the mass of pollen upwards to its mouth. The style is long, and a ring of hairs surround the stigma, of which the upper and inner are the longest, and all of which are set upwards, so that on pressure being applied to the keel the hairs sweep out the mass of moist pollen which the stamens have thrust to the mouth (see Figs. 15 and 16). It is quite pretty to watch the little stream of bright orange pollen

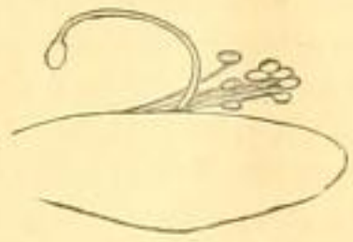

FIG. 17.—*Ulex* (Gorse).

emerging from the narrow aperture of the blue keel, and between the bright blue wings.

The shorter yellow and blue garden lupins and *Lupinus arboreus* are similarly constructed. In the latter flower the folding over of the wings at the top, and the cavity at the base of vexillum, are strongly marked.

What is the use of the hairs on the edges of the keel?

Ononis arvensis.—The vexillum in the opened flower is perpendicular or a little bent back; and the wings, which are small, are also perpendicular, so that an insect may light either on the vexillum or on the wings, and has to thrust itself between the vexillum and the wings.

The keel is long and pointed as in Lotus and Lupin: and the stamens push out the pollen as in those flowers.

The stamens are quite monadelphous, the staminal tube is close fitting, and there is no nectar and no space for nectar within it. The humble-bee certainly does not put his proboscis down the tube, but between the tube and the vexillum.

Anthyllis Vulneraria.—This flower being in an umbel needs no peculiar position to give insects a foothold. Its peculiarity is that the large calyx, the sepals of which cohere up to their narrow mouth, forms a dilated tube or vessel which contains abundance of nectar. The limbs of the wings are attached to the keel, but the claws of all the petals are long, narrow, threadlike and perfectly free, so as to leave free access to the nectar when the proboscis of an insect has once passed the mouth of the flower.

The aperture between the vexillum and the coherent wing and keel is however very narrow, so that an insect in passing it cannot fail to push the keel outwards and bring out the stiff style and stamens. The filaments are entirely joined together, and form a long close fitting tube in which there is space neither for nectar nor for the proboscis of an insect.

Ulex nanus (Autumn Gorse.)—This flower is upright in the bud, assumes the usual horizontal position when in blossom, and reverts to the upright position in the pod. The bud is protected by a stout, large and hairy calyx, and the pod is stout and hairy.

The wings are perfectly free from the keel, and the rounded lobes of the keel are separate from one another at the extremity and for a considerable part of the lower side, so as to make the flower comparatively open. The stamens and pistil are stiff, and come out on the keel being pressed down; and the pollen, which is dusty, comes out in a cloud.

The staminal tube is perfectly closed and close fitting. There is no cavity in it for nectar, and no aperture at the base. There are traces of nectar on the veins and in the hollows of the vexillum, especially on the midrib and in the hollow towards the base. The bees are fond of it. They settle on the keel and thrust their heads between it and the vexillum, pushing the latter upwards. In struggling to do this their legs are in violent motion on the top of the keel, pressing it down. In doing this they invariably open it, make the anthers project, and dust their own body with pollen ready to meet the stigma of the next flower (see Fig. 17).

The contrast between the free wings, the obtuse and semi-attached lobes of the keel, the stiff filaments, the hairless style, and the dusty pollen of Ulex, and the adherent wings, closed keel, moist pollen, and brush-clad style of Pisum, Vicia, Lathyrus, &c., and the correlation between these differences, having regard to the ultimate object in both cases, viz. the conveyance of pollen by an insect, are very striking.

Ulex Europæus is similar to *Ulex nanus*, and I have seen bees upon it in April. But are there enough of these insects abroad during the winter season, when this flower blossoms, to fertilise it?

Genista Anglica.—The wings are separate from the style, the keel is straight and horizontal, but is reflexed after maturity, probably when it has once been visited by an insect. The anthers have stiff filaments and dusty pollen, all of which is shed when the flower is once opened.

The style is stiff, and coils back on the opening of the keel, whilst the stigma is oblique. When so curved back the stigma would touch an entering insect. I have not ascertained where the nectar is in this flower, but probably not in the closed and close-fitting staminal tube.

Sarothamnus (Broom.)—The keel is perfectly free from the wings, is obtuse and closed when the flower first opens. In this stage the style is bent against the keel in such a way that its stigma (which is at the extremity) is turned away from an entering insect. At a touch the keel opens and falls down by a sort of hinge, and does not recover its position. The stiff stamens shed their dusty pollen, as in Ulex and Genista. The elastic style at the same time coils itself inwards towards the vexillum. In a few moments it has curved back so far as to complete one spiral coil, and bring the stigma round so as to meet an insect subsequently entering. In opening the flower with the finger or a pencil, the stigma does not catch its own pollen, but after recoiling can hardly fail to rub the next body which enters.

The staminal tube is complete, and there is no space for nectar or aperture into it. I have not ascertained where the nectar is to be found, but not, I think, in the thin, close-fitting staminal tube.

Cytisus (*qu. nigricans?*)—common in London greenhouses.—The raceme is terminal; the peduncle is nearly horizontal. The pedicels are set on all round the peduncle, but in blossoming are so bent upwards as to make the vexillum of each flower nearly upright, and the keel and wings nearly horizontal, *i.e.*, so as to bring the flowers into the normal position.

The separation of the petals, the reflexion of the keel, the closed staminal tube, and the dusty pollen, are the same as in Sarothamnus and Genista. There is no nectar, and no place for any in the staminal tube.

The above details seem to point to some generalisations concerning papilionaceous flowers.

1. The position of the flowers in blossom, whatever their other wants and habits, is such as to make them attractive and convenient to insects. In general the showy vexillum is upright, and the keel and wings horizontal. This is effected in various ways: by the raising and straightening of the stalk, as in Pisum and Lathyrus; by the lowering of it, as in Faba, Phaseolus, and Ulex; or by giving the pedicel a half twist, as in Robinia, Wistaria, and Laburnum.

2. The cohesion of the petals (which in this single tribe is so various) is in each flower correlated to the position of the nectary, the structure of the fertilising apparatus, and the nature of the pollen. Thus in Ulex, Genista, and Sarothamnus, the cohesion of the petals is at a minimum, the wings do not adhere to the keel, and the keel itself is comparatively open. Correlatively the filaments are stiff and the pollen dusty, and the insect gets freely dusted with it, without aid from any union of the petals. In Pisum, Lathyrus, Vicia, Phaseolus, and others, the wings not only serve as a landing place for insects, but, being united to the keel, serve to pull it down and force out the pollen. In Trifolium, the coherence of the petals is at a maximum, and produces a complete long tube containing much nectar, and having the organs of fertilisation in the access afforded by its narrow mouth. In Anthyllis the claws of the petals are so thin and so free from each other as to afford no receptacle for nectar, whilst the staminal tube is closed and tight fitting, but the want of a nectary is made up by the cohesion and form of the calyx. The various degrees of cohesion between the petals of the keel—from the comparatively free keel of Genisteæ, through the prolonged acute keels of Lupin and Lotus, and the oblique keel of Lathyrus, to the spiral tube of Phaseolus—and the adaptation of each of these forms to its own stamens and pistil, is no less remarkable.

3. The degree to which the cohesion of the stamens is carried (so remarkable a feature in this tribe) appears to depend on the necessity for access to nectar. In

those flowers in which the stamens are monadelphous, viz., Ulex, Sarothamnus, Genista, Cytisus, Ononis, Lupin, there is no symptom of nectar within the staminal tube, no space for it, and no access to the interior. In some, at any rate, of these, viz., Ulex, Ononis, and Lupin, the bees certainly resort to other parts of the flower. On the other hand, where the tenth stamen is entirely free, or where it is separated at the base, so as to give an insect access to the interior of staminal tube, as in all the other flowers I have described, there is a cavity for nectar within the staminal tube, and there is nectar within this cavity.* As regards the double aperture, viz., one on each side of the base of the separate stamen, which so often occurs, Mr. Darwin suggests that, one aperture being necessary, the law of symmetry will account for there being two.

4. Other points in the structure of the filaments, anthers, and pollen seem also to be more or less related to and to depend upon the same function of fertilisation by insects. In Ulex, Genista, and Sarothamnus, where the flower is open, and in Lupin and Lotus, where the agency of the filaments is required to drive the pollen out of the keel, the filaments are stiff. In Phaseolus, where the style performs this function, they are limp. In Lotus and Lupin, the peculiar form and growth of the second whorl of stamens, and their adaptation to this function, is most remarkable. In Pisum, Lathyrus, Vicia, Phaseolus, and Lupin, where the pollen is moist, there is an apparatus for sweeping it out. In Ulex, Genista, and Sarothamnus, where it is dusty, the flower simply opens and it comes out of itself.

5. The structure of the style and stigma is in every case adapted so as to bring the latter in contact with an entering insect. In some cases, *e.g.*, in its emergence from the spiral keel in Phaseolus, and in the recoil of the style in Sarothamnus, this is effected by a very elaborate process. But the most peculiar function of the style in many of these flowers is that of sweeping out the moist pollen of its own flower from the keel. For this purpose it appears to be furnished with hairs or bristles, placed in different flowers on different parts, but always so placed as to perform the function in question. In Pisum, and, generally, in Lathyrus, the brush is on the inside of the style ; in *Lathyrus grandiflorus* on both sides ; in Phaseolus all round the style, but more thickly on the side next the entering insect than on the other ; in Vicia on the outside of the style ; in Lupin at the very extremity ; but with all these differences it is always so placed as to find the pollen and sweep it out of the variously constructed keels. In this respect these flowers remind one of the brush-clad styles of the Campanulaceæ.

6. It is scarcely necessary to repeat that the nectar is found in various parts of the flower—within the staminal tube, in the vexillum, and in the calyx. But in all cases the correlation of the parts is such that an insect seeking the nectar must touch the stigma and carry away pollen.

These generalisations, if even partially correct, seem to me to be of considerable interest, not simply as illustrations of the mode in which insects fertilise flowers by carrying pollen from one to the other, but because by connecting the facts of morphological structure with living physiological functions, they give meaning and interest to the former, and possibly indicate the direction in which the true cause of that structure is to be sought.

It is but right to add that there is one genus, *Coronilla*, which, so far as I have been able to observe it, forms an exception to the above generalisation ; but I have not been able to procure sufficient flowers to enable me to state any positive conclusion with respect to this genus ; and I only mention it in order to call the attention of other observers to it.

T. H. FARRER

* I have not actually looked for and found nectar in *Onobrychis sativa* and *Lathyrus macrorhizus*, but have no doubt that it is there. I have found it in all the rest.

NOTES

DURING the absence of Prof. Tyndall in America, the opportunity is being taken to rebuild the laboratories of the Royal Institution on a considerably enlarged scale.

IT will be seen from our University intelligence that Mr. E. Ray Lankester, Scholar of Exeter College, Oxford, has been appointed Deputy to the Linacre Professor of Anatomy and Physiology at the University.

THE open Scholarship in Natural Science at St. Mary's Hospital Medical School has been awarded to Mr. Alfred Tilley, and the Exhibition to Mr. W. H. Weddell. Both these gentlemen are students of the London University.

THERE are now no fewer than five separate organisations at Cambridge for the improvement of female education—all of them thriving. 1. The examination of women, senior and junior girls, and of schools managed by a syndicate, of which the Rev. G. F. Browne, M.A., St. Catherine College, is the secretary. 2. A system of lectures for women, associated with four exhibitions, and a fund for assisting governesses, managed by a mixed committee of ladies and gentlemen, of which H. Sidgwick, M.A., Trinity College, and Mrs. Bateson, St. John's College Lodge, are the treasurers. 3. A series of classes by correspondence arranged by Mrs. Peile. 4. A lending library for students, managed by Miss J. Kennedy. 5. A college for women, called Merton Hall, of which Miss A. J. Clough is the principal. We understand that this last establishment is rapidly filling. The lectures commence this week.

THE Vestry of St. George's, Hanover Square, advertised some time ago for a medical officer of health and analyst for the parish, and a considerable number of candidates have, we understand, come forward. It has been suggested in various quarters that the Vestry would do well to appoint two officers instead of one ; and on this point minds are divided. While some are in favour of a double appointment (with, we suppose, double pay ?) others say that the Vestry are not likely to do this, and that it is undesirable that they should, seeing that their real want is an accomplished scientific sanitarian, who will, if necessary, appoint an assistant to do the routine chemical work, just as he has an inspector to do the routine sanitary work, but who will supervise everything and be responsible for everything. It is further urged that it is absurd to suppose that chemical knowledge is not continually required from a medical officer of health, quite apart from the provisions of the Act for the Adulteration of Food and Drugs, and equally absurd to suppose that a medical man without previous special sanitary experience is at all fitted to become at once medical officer of health to so important a parish as that of St. George's, Hanover Square. We confess we have a leaning to the latter view.

AT the last meeting of the Council of the Pharmaceutical Society, it was resolved unanimously that the resolution passed in 1862, prohibiting ladies from attending the lectures, be rescinded, and that ladies be admitted as students to the lecture classes of the Society. At present but one lady has taken advantage of the privilege offered ; but as soon as the resolution becomes more widely known it is probable that the liberality of the Society will be recognised by ladies, who will avail themselves of this excellent opportunity of studying practical chemistry and botany. The lectures on chemistry are by Prof. Redwood ; those on botany by Prof. Bentley, commencing early in October. The chemical lectures are continued three days a week until the end of July ; the botanical lectures, lasting for the same period, being delivered on two days in the week. During the summer months they are delivered in the Botanical Gardens, Regent's Park.

A RUSSIAN lady, who desires to be anonymous, but is rumoured to be "still very young, and a native of Siberia," has