CONSIDERATIONS

ON

VEGETABLE NUTRITIO

BY

SALVADOR CALDERON

PROFESSOR IN THE FREE INSTITUTION OF MAD

(and formerly in the Institute of Las Palmas).

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I.

The study of insectivorous plants, at present an object of preferent attention from the scientific world, and the subject of a very luminous controversy, has not been dealt with, in our judgement, in the elevated and transcendental manner it requires.

Condensing all our thoughts upon the matter, we shall only hint at, that if it is possible to show that there is a single plant which possesses the faculty, of assimilating organic substance in virtue of a function of its own, then it must be forcibly admitted that it is the expresion of a general law in vegetable nutrition; otherwise the fact of their

(1) See *Nature*, núm. 370. vol. 15 (Biological notes), and *Anales de la Sociedad española de Historia Natural.* T. V. Actas; pág. 38.

being insectivorous plants, is but a mere paradox without any scientific sense. But if this assumption is admitted, the seizure of insects by plants which have so vividly attracted the attention of naturalists, is but a particular case, probably one of the most complex, of the faculty which plants may possess of assimilating organic substance.

For the present we shall limit ourselves to expose the results of our investigations, without leading the reader into all the tedious details and references which have led us to these conclusions, our only object being confined to expose this matter in such terms that the persons devoted to these studies, may direct their attention and observation through this channel, the direction of which we hardly yet see clear.

There is not the shadow of a doubt that the observations, which we principally owe to Hooker and Darwin, of the existence of plants which get their nourishment at the expense of the animal organisms has seriously compromised some of the most deeply rooted doctrines which, though chiefly based on prejudice, have been nevertheless generally admitted by men of science, regarding the distinction between the two organic kingdoms and their mutual relations, it being no longer possible to assert that the finality of plants is subordinate to that of animals.

In opposition to this fact, it has been maintained by many, that it is very small the number of plants, scarcely represented by a score, which possess this faculty, in comparison with the inmense number destitute of it, which constitute the vegetable kingdom.

But those who pretend with this assertion to discredit the great import of these investigations, seem to forget that the fact of their being carnivorous plants is of so fundamental a character in vegetable life, that, accepted for one plant, its generality must necessarily follow and especially considering the very different families to which insectivorous plants belong; as for example the *Lentibulariæ*, or *Utriculariæ*, which are *Coroliflorœ*, the *Droseracœ*, which are *Talamiflorœ*, and the *Nepentheœ*, which are *Monoclamidœ*.

But for the present we shall limit our task to point out the theoretical foundations on which the generality which we think should be attributed to this phenomenon is based, as well as to settle the parallelism which we consider should be established in the nourishment of all organic beings.

As a proof of this, we shall just call the attention of our readers to the existence of parasites in both kingdoms of nature, accomodating themselves to the identical conditions of living and nourishment, and that in the same manner as there are parasitic animals in plants, so there are also parasitic plants in animals; confirming what has already been to a certain extent, foreseen by Claude Bernard, that the nutritive medium requires a certain number of definite conditions necessary to all being , as light, heat, and constant supply of air perfectly common to all life.

The assimilation of nitrogen performed by vegetable organisms may consequently be considered as the touch stone of all our knowledge on the matter, and therefore a few words on the subject will not be out of place.

II.

It is known that nitrogen is the essential constituent of albuminous matter and that it therefore forms the protoplasm and the living element of the cell, yet the amount of it is but a small fraction of its total dry part.

Numerous investigations, above all those of Boussingault, have placed beyond a doubt that plants do not possess the faculty of taking free nitrogen from the atmosphere, and in order to account for its presence in them it has been appealed to the ammoniacal salts and nitrates as the source of this element; but this inference is insufficient, not only with regard to parasites and humicollæ, but with respect also to a great number of important families of plants, leguminosæ for instance, which take their principal food from the complex nitrogenized matter, without exhausting the earth of its ammonia and nitrates.

In opposition to the conclusive experiments which prove the inability of plants to assimilate nitrogen from the atmosphere, there are those of Mr. Mulder which show that if non nitrogenized vegetable tissues are submitted only to the influence of water and air they will condense a certain amount of nitrogen, as it is proved by their giving forth in dry destillation ammoniacal products.

This apparent disagreement is easily explained if it is taken into account that in opening the flasks employed in Mr. Mulder's experiments, so as to prevent the partial vacuum which would naturally ensue and which would interfere with the taking out of the stoppers when the experiments were at an end, air teeming with living organisms was constantly being introduced into the flasks, which would account for the presence of nitrogen.

Once the assertions of Boussingault admitted, how can it be explained that trees that grow in the crevices of volcanic or plutonic rocks, where there is no nitrogen at all, or that the plants employed by this naturalist have got their necessary substance?

We are bound to accept that the atmosphere is the real source where the vegetable kingdom finds its necessary elements not on account of the nitrogen it contains, but on account of the living population that pervades it, a point of view to which we have been induced, since we have had the opportunity of studying certain virgin soils formed by the desintegration of very different rocks and which, instead of impoverishing in nitrogenized compounds, get richer and richer in these substances year after year.

Our knowledge about the manner in which this enrichment of the soil takes place, is as deficient as the actual state of chemical physiology respecting these and similar questions is imperfect. We will however remark that all the green parts of the plant and especially the leaves are a sort of laboratory where the albuminoid substance is generated.

If we suppose that very small organisms adhere to the surface of plants, in one way or another, it will then evidently happen that, in presence of the oxigen emitted by the leaves, through the influence of light, in that peculiar state formerly called *nascent*, there will be determined either a partial or a total combustion of the organic matter, and consequently the assimilation of nitrogen by a similar process to that which takes place in ploughed soils.

It must also be borne in mind that organic nitrogenized compounds are soluble in potash, of which and of phosphoric acid there is an extraordinary abundance in the albumen of young leaves (an abundance which, as will be shown hereafter, is concomitant with a greater evaporation) a fact which cannot be well explained by the nutritive processes admitted till now, but which will be clearly understood as a consequence of those we are at present studying; for potash, by its energetic basic properties, can well determine an opposite reaction in the products of decomposition of organic substance.

III.

Without insisting any longer on this subject, we shall limit ourselves to make a resumé of the different processes by which organic substance is assimilated both by plants and animals.

The simplest of these consists in the appropriation of dead organic matter in various degrees of decomposition: this process we shall call *necrophagy*.

The next in complexity is the assimilation of living organisms without elimination or distinction of any kind whatever between useful and useless materials, as for example the nourishment of parasites; which we will call *plasmophagy;* and finally the most complex of all, which consists in absorbing living organisms with the power of eliminating the non nutritive parts, as in the case of insectivorous plants: this process we shall call *biophagy*.

Necrophagy. — Plants, like animals, concur to make dead organic matter return to the circulation of life, these first being capable of substituting animals where these latter in their struggle for life cannot perform their purifying task, as it happens for instance in the gelatinous seas of the Pole, realizing at the same time the appropriation of the necessary nitrogen for their existance.

This process of nutrition is not in requirement of so highly differentiated organs, as are necessary in more complex cases, and therefore, it may be considered as the exclusive manner of nutrition of rootless plants, both terrestrial and aquatic, or possibly of those plants supplied with temporary roots only, as for example the *humicollæ,* which are entirely deprived of chlorophyl, as well as the *Epipogum* and the *Corallorhiza,* which are endowed with absorbing powers in every point of their surface.

Most plants are necrophagous to a certain extent, for they feed on vegetable and animal remains which are in the soil on which they grow; however it is necessary not to forget that, although ploughed soils contain a large, quantity of nitrogenized matter; this is insoluble, and therefore it requires to be thoroughly transformed previous to its being converted into assimilable substances, these changes being too slow to afford a supply proportionate to the expenditure of nitrogen in large cultivated fields.

Certain trees, which attain a gigantic size when planted in cemeteries or burial places of large mammalia, are decidedly necrophagous tipes. Several bacteria, incapable of development when generated in the tissues of a living organism, are very thriving ten or twelve hours after death; certain fungii, very similar to ferments, and analogous to ordinary yeast, which live on decomposed animal liquids, as those proceeding from the urine of persons suffering under diabetes, are also necrophagous tipes.

This process of nutrition seems to generally prevail in all fungii, on account of the imperfect differentiation there is in the absorbing organs of these elementary plants. But the humicollæ, for example, require, as J. Sachs says, to possess the faculty of dissolving their nutritive elements from their surroundings by means of especial juices, which essentially is the identical phenomenon of carnivorous plants.

Plasmophagy.—This second process of nutrition corresponds to a somewhat greater development of organic activity than the first one, though it is not in requirement of better differentiated organs. The parasites belong to this group; but some distinctions must be made amongst them.

There are some which though during a certain period of their lives lead a parasitic life, they really do not feed upon the organisms on which they inhabit, whilst others only take their abode or merely limit themselves to combine the oxigen of their tissues.

The real phytoparasites are however considerable in number, they settle both on vegetable and animal organisms and when living on the latter deserve all our attention. They are found in every creature of the zoological kingdom; their abode varying in the extreme.

There are parasitic algæ in the bowels, stomach, larynx, esophagus, eyes, matrix, skin, hair, etc., and most likely all chronic phlegmasie of the mucous membrane, proceed from parasites of this kind, as M. Pasteur has suggested respecting the catarrh of the bladder, Leeuwenhoeck and Lébert of diarrhea, Pouchet of cholera, etc., the generality of which, as J. Sachs has discovered, secrete juices capable of dissolving the nutritive substances from the medium they live in.

Biophagy.—The feeding on dead organic substance, tissues, etc., are not the only cases of assimilation of organic matter by vegetable organisms.

This assimilation may also take place directly from living organisms, after their capture, as it happens in the case of carnivorous plants.

J. Sachs says that the secretion of liquids capable of disolving animal sustances, as well as the faculty of absorbing the dissolved products—effected by certain plants, called carnivorous,—are perfectly comparable with some of the phenomena of germination in seeds, of which he has already shown that the embryo secretes, a juice which dissolves the albuminous substance of the endosperm, which product is absorbed by the embryo and applied to its development. A proof of this is offered by some roots which possess the faculty of dissolving mineral matter through an acid juice which they secrete.

But the limits of this paper do not allow us to enter into long considerations upon this subject, and we shall therefore limit ourselves to mention some other series of plants which must also be considered carnivorous. Such are, for instance, viscous plants.

IV.

It has not escaped Mr. Darwin's sagacity, the fact of there being plants which secrete through their hairs mortal juices for insects, though perhaps not ascribing to the fact all the importance it deserves.

On the cortical and foliated surfaces of plants it has often been found sticky secretions called glutinous when soluble in water, and viscous when insoluble, for instance the abundant secretion which covers our common *Cistus ladaniferus*.

If the state of the insects stuck to these viscous plants is observed, it is easily perceived that there is no sensible change in those provided with resisting carapaces, but for example the common vine fretter, is seen on the contrary to experience a series of changes which indicate a gradual transformation.

These plants—capable of seizing insects through the medium of their secretions,—are more numerous than real insectivorous plants.

Therefore we consider the nourishment of plants mainly to spring from that inexhaustible microscopic world which fills the atmosphere, the sea, and the stagnant waters.

The minuteness of these organisms is so remarkable that M. Pouchet has shown that in the bones of birds several microscopic algæ have penetrated.

The seizure of these microscopic organisms we need hardly say, is easier than that of the larger ones, water being in our judgement, the medium through which this is accomplished in aerial plants, especially through that condensed on their surfaces by exhudation, which makes these organisms to adhere to their surfaces, and after a certain time are reduced and assimilated.

In stomata we possess a proof of this fact, for plants which secrete viscous juices through all their surfaces, as crassular plants for instance, possess very few stomæ and as a consequence aqueous elimination is at its minimum.

In this case there is the exchange of a particular way of seizing insects for the more general one brought about by condensation of water on the leaves.

The cleansing of the atmosphere from germs and other impurities performed by certain trees, has no other interpretation.

As a proof of this, we may mention our observation during our stay in the Canary Islands upon the destructive influence the *Eucalyptus* has on the microscopic algæ, which appear to be the cause of intermittent fevers and other virulent diseases.

The recent researches made by Professor Tyndall, though made with a different aim, leave no doubt with respect to the efficacy which both viscous and damp surfaces possess of catching living organisms.

If the inside of a box containig atmospheric air is moistened with glycerine and kept in repose, the floating organisms of the air fall down, on account of their weight, and sticking in the glycerine render the air in the box free from all organic matter, or *optically empty*, as the eminent Professor says.

We have investigated some lichens, whose nutrition, as is well known, instead of being a parasitic one, is taken directly from a sufficiently damp atmosphere. If to these lichens distilled water and filtered air only have access, it is then observed that all their physiological functions are suddenly suspended.

These facts agree with those arrived at by Prof. Tyndall on the unfitness of air to support life under certain circumstances. Is this to be attributed to the absence of germs in the air subjected to these conditions?

As for the inmersed plants, such as *confervæ, callitriche* and *ceratophylle*, it is on their surfaces where the infusoriæ, as well as the sistolidœ, must be sought for. The diatomœ, which both live in fresh and salt waters, stick to the mucilaginous secretions of the inmersed weeds. And finally, the two different ways in which infusoriæ multiply either by diffusion, as M. Muller has observed, or by exhudation of the albuminous matter, seem also to contribute to the nourishment of aquatic plants; it being easy, when these plants are studied with the microscope, to see the infinite number of the above mentioned organisms, which adhere to their mucilaginous varnish.

Regarding floating plants, it has already been attempted to explain their nourishment by the assimilation of the organic substances suspended in the water.

To understand the importance of this view, it is sufficient to mention the band of algæ which surrounds for more than a mile all coasts, as well as the sargasso sea, which measures more than 3 millons square miles.

The origin of organic matter in sea water,—so easily to ascertain with regard to its quantity by permanganate of potash,—is, according to Prof. Thompson, derived from the organisms which live at great depths below the surface.

V.

Whilst printing this pamphlet it has come to our knowledge that Prof. Morren of Liege has arrived to a similar conclusion *(La digestion végétale. Note sur le Rôle des Ferments dans la nutrition des plantes)*.

According to this gentleman: «Animal digestion is merely a process of fermentation consisting essentially in a transformation of colloids in crystalloids, this process being the same in all plants. The vegetable ferment is ordinary diastase for the conversion of starch in glucose but for fermentation of nitrogenous substances it is pepsine which has been observed in the viscous secretions of carnivorous plants, in the nectaries of *Helleborus* and also in the latix of *Carica Papaya*.

He further states that the nutrition of plants is made up of three successive processes, elaboration which consits in the production out of its elements of a carbo hydrate and can take place only under the influence of light; digestion which essentially consists in hydration associated with an evotution of carbonic acid and a molecular change which renders soluble and diffusible the resulting products, and assimilation which consist in the absorption by the living tissues of the substances thus prepared, but it is a process which can only succeed digestion.

The existance in plants of a true digestion has been already proved by F. Sachs, whose opinion we have already quoted in page 11, but Prof. Morren's novelty consists in the analogy he establishes between animal and vegetable digestion.

He endeavours moroever to show that the presence of the same organic products in both kingdoms, is easily demonstrated; for instance butyric acid exists in sweat and in the pulp of tamarinds; formic acid in ants and in the hairs of the sting-nettle; palmic acid in animal fats and in palmar sugar; ox alic acid in renal secretions, and in almost all plants. The protoplasm again offers the same esential characters in animals and plants, showing the same contractility and the identical reactions.

Therefore though through a different direction M. Morren's arrives at the same final conclusions that we have arrived at, that carnivorous plants may be regarded, apart from their peculiar structure, as a particular case of á general rule, and that the nutrition of every living organism constitutes a sole process in nature. Our wiews regarding this process in virtue of which both animals and plants take their organic substance, are naturally complemented by those of Prof. Morren's; and therefore our belief in the unity of origin by which we pretend to close the circle of the struggle for existance being efficiently supported by the identity of the products originated in both kingdoms of nature.

If this theory is duly demonstrated, the problem of the struggle for life, will be in its way to its final solution, the several important phenomena of genesis and morphology of the microzoæ and microphyte will be easily explained; and, perhaps pushing these especulations to the higher grounds where the most important questions on dynamical physiology are debated, the old idea which attributes to plants a character of mere subordination to animals, will be finally abandoned for the more comprehensive law which governs the whole of the organic kingdom, «That every living creature is capable of taking its mineral food from the mineral world, and its organic food from the organic world.»