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SOME FOOD REACTIONS OF SNAILS

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The following work was done at the University of Chicago Zoological Laboratory under the supervision of Dr. W. J. Crozier to investigate primarily the method of innervation of the food reflex. For the studies, various forms of common snails were experimented with, but the domestic snail known as the Singapore was used for most of this work because of its ready availability and suitableness for the work due to its large size, activity and omniverousness. The main objection to them is that they do not swim on the surface of the water as do many forms. In order to obviate this difficulty they were studied by placing the snail to be observed in a Petri dish on the stand of a dissecting microscope and watching its movements along the bottom of the dish with the aid of the reflecting mirror. It was found that the snails varied considerably in physiological activity, so that during the experiments it was often necessary to discard an animal because of inactivity, necessitating work with a considerable number of individuals in order to get approximately accurate results.

Suitable food for the experimentation was the first necessity, and various common grasses and leaves were tried. It was found that the snails gave a very strong positive food reaction towards dandelion leaves with almost as strong a negative reaction against gooseberry leaves, and furthermore, that they reacted as readily to the juices of either as to the leaves themselves. For this reason only these two natural foods were used.

As we wished quantitative results as to the possible elemental substances which activated them positively in one case and negatively in another, a number of simple chemical compounds mostly of organic derivation were experimented with and the weakest solutions to which the snails would react were then determined as accurately as possible. The reactions were said to be negative if the snails turned away or withdrew themselves into their shells in very evident adverse stimulation with a number of trials with several different snails all with the same result when the substance was squirted against the head gently with a pipette. In the case of food substances giving a positive reaction it was not counted

as such unless the snails gave a large number of bites. In the case of weak solutions a positive reaction was not recorded unless the snails also ate a small piece of filter paper while immersed in the solution. It was found that a snail will not eat filter paper in pure water, but will readily eat it in a solution to which it reacts positively.

The snails were fed in two ways, first by squirting the substance (solution) against their heads by means of a pipette, and secondly by placing them directly in the solution. The pipette method gave the reaction a little more quickly but the results were the same.

In giving the food reaction to the solution, the snails usually first pushed their heads back and forth as Miss Dawson has described for *Physa* (Dawson '11), then bit when their heads touched the sides or bottom of the dish and continued biting at regular intervals ten to twenty-five times to the minute, at the same time slowly moving about searching the bottom and biting at anything solid such as mucus shreds, bits of toothpick and so forth.

The following compounds were tested in the various experiments with results as indicated:

Sodium chloride	Positive reaction to 0.172 Mol.
Potassium chloride	Positive reaction to 0.0268 Mol.
Citric acid	Positive reaction to 0.0017 Mol.
Glucose	Positive reaction to 0.055 Mol.
Dextrose	Positive reaction to 0.0055 Mol.
Saccharose	Positive reaction to 0.087 Mol.
Milk sugar	Positive reaction to 0.148 Mol.
Glycerine	Negative reaction
Saccharin	Negative reaction
Chloretone	Negative reaction
Magnesium sulphate	Negative reaction
Alcohol	Negative reaction
Cellulose	Negative reaction
Douglas corn starch	Positive reaction
Dandelion juice	Positive reaction
24-hour-old dandelion juice	Negative reaction
Gooseberry juice	Negative reaction
96-hour-old gooseberry juice	Positive reaction
Thoroughly crushed and washed dandelion stem	Positive reaction
Boiled dandelion leaves	Positive reaction
Boiled dandelion juice	Positive reaction
Crushed gooseberry leaves soaked in fresh dandelion juice for two hours	Positive reaction

Thoroughly crushed and washed gooseberry leaves were eaten a little more readily than the whole, unwashed leaf. Fresh leaves

were repeatedly left in the aquarium over night with a number of snails but only a very small portion was ever eaten. The positive reaction to gooseberry leaves soaked in crushed dandelion leaves, as well as the positive reaction to 96-hour-old gooseberry juice is unexpected. No difference in color or odor was noticeable in the gooseberry juice which differed in age, but the 24-hour dandelion juice, to which they are negative, is darker in color and slightly sour in odor. Neutralizing the gooseberry juice, which was found slightly acid, was tried, but without change in the food reaction. It is striking that snails react to a weaker solution of dextrose than of saccharose and of saccharose than of milk sugar. They give an unfailing positive reaction to Douglas corn starch, either boiled without hydrolizing or mixed up cold with water. This reaction to sugar and starch seems to be common in most lower organisms, as Miss Dawson observed it in *Physa,* although Parker failed to obtain it in *Metridia* (Parker '96) but quotes Nagel as obtaining it in *Adamsia* (Nagel '92). Baker states (Baker '02) that snails dislike coniferous and resinous trees and pungent herbs and this may explain their antipathy to chloretone and also, possibly, to the gooseberry leaves. The positive reaction to 96-hour-old gooseberry juice may be due to disappearance of the aromatic or resinous substance which is objectionable to their taste.

These results are suggestive of the possibility, which further research is needed to confirm, that the usual mode of innervation of the food reflex is through mechanical stimulation of the sensory ending of the proboscis and that taste buds in the mouth then determine its continuation. It is possible, as Copeland found in sea snails (Copeland '18), that smell stimulus sometimes initiates the food reflex of the pushing backward and forward of the head which results in a bite when a solid object is struck, giving a mechanical stimulation. In case of odorless substances such as sugar and starch, however, this would be impossible. It was found that a bite will result when the animal is in the proper physiological state, that is to say hungry, solely from a mechanical stimulation, for a snail will give an occasional biting reflex when in distilled water in a clean dish during its first trip around the dish in which no mucus or other foreign material is present. They react positively to feces, taking them into the mouth but throwing them out again without swallowing. The usual food reaction is first pushing the head backward and forward and then "biting" when something, such as any foreign material or the side of the dish, is struck. The bite of a snail consists of a rasping move-

ment of the radula. Further continuation of this biting reflex depends upon whether the substance is suitable food or not. This cycle of events occurs whenever a hungry snail is placed in new surroundings, without regard to available food, except in a negative solution, and is continued until a thorough search for food is made or indefinitely if the snail is very hungry and no food is found.

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