the presence of an anemone on the shell caused the *Calappa* to drop the hermit crab a total of 130 times or approximately 11 times per trial. On the other hand, hermit crabs without anemones were dropped only a total of 5 times or 0.42 times per trial (Table I).

The main series of experiments, however, were conducted in an effort to determine if the presence of the anemone did protect the hermit crabs from predation by *Calappa*. In over 91% of the experiments, the presence of an anemone on the shell of the hermit crab did in fact prevent its being killed by the *Calappa* (Figure 4; Table II). On the other hand, approximately 83% of the hermit crabs without anemones were either killed or partially eaten by *Calappa*.

Discussion and conclusions. Crabs of the genus *Calappa* prey on hermit crabs both in the field[5] and in the laboratory. Presumably *Calappa flammea* is a natural predator of the *Pagurus pollicaris* hermit crab since both have been collected together in the same area and *Calappa* readily preys on the hermit crab in the lab.

Results of the experiments showed that the *Calappa* can be an effective predator when given a hermit crab, in that about 83% of the hermit crabs without anemones were eaten. The only hermit crabs which emerged unscathed from these experiments were those whose cheliped happened to block the aperture in such a way that *Calappa* could not insert its dactyl tooth far enough into the aperture to initiate opening. This is in striking contrast to only one hermit crab being eaten when an anemone symbiont was present. This single occurrence was one in which the preliminary shell opening activities of the *Calappa* happened to break off that portion of the shell bearing the anemone. Thus, this case might be considered to be one of those rare exceptions which tends to 'prove' the rule.

Table I. 'Rejection' reactions and release of *Pagurus pollicaris* by 5 *Calappa flammea* during 24 trials

	Anemone present	Anemone absent
No. of trials	12	12
Total No. of 'rejection' reactions	8	0
Total No. of times hermit crab was dropped	130	5
Average No. of times hermit crab was dropped/trial	10.8	0.42

Table II. Results of predation attempts by 5 *Calappa flammea* on the hermit crab *Pagurus pollicaris* with and without the symbiotic sea anemone *Calliactis tricolor*

	No. of hermit crabs not killed	No. of hermit crabs killed or partially eaten
Anemone present	11	1[a, b]
Anemone absent	2[c]	10

[a] $P < 0.005$ that the results are independent of the presence or absence of the anemone. [b] Anemone broken off on shell fragment. [c] Two hermit crabs escaped predation by blocking the aperture of their shell with their chelae.

It is obvious that *C. flammea* is not an effective predator when preying on the *P. pollicaris* hermit crab in the presence of the symbiotic sea anemone, but the proof of how the anemone protects the hermit crab remains to be shown. However, the fact that the anemone's acontia contain numerous stinging nematocysts[6] and that the rejection reactions of the *Calappa* were often preceded by contact of the *Calappa's* mouthparts with these acontia, suggest that the acontial nematocysts play a role in this protection.

Dropping of the hermit crab by the *Calappa* and the subsequent movement away from the prey, could possibly remove the predator far enough from the vicinity of the prey to allow escape of the hermit crab in the field. The hermit crab also was able to retreat from the *Calappa* after being dropped.

These observations, although necessarily preliminary, due to the difficulty in obtaining a suitable supply of *Calappa*, strongly suggest that the association of the sea anemone *Calliactis tricolor* with the hermit crab *Pagurus pollicaris* does in fact confer selctive protection from at least one of its predaters, *Calappa flammea*[7].

Zusammenfassung. Experimenteller Nachweis, dass Einsiedlerkrebse, *Pagurus pollicaris*, mit symbiontischer Seeanemone, *Calliactis tricolor*, auf ihrer Schale vom natürlichen Feind der Krabbe, *Calappa flammea*, weitgehend gemieden werden.

R. B. McLEAN and R. N. MARISCAL[8]

Department of Biological Science,
Florida State University, Tallahassee
(Florida 32306, USA), 7 July 1972.

---

[6] R. N. MARISCAL, I. erp. mar. Biol. Ecol. *8*, 217 (1972).

[7] This work was supported in part by a Grant-in-Aid of Research from the Society of Sigma Xi to the senior author.

[8] The authors wish to thank GEORGE KIRVIN of Quality Sea Foods, Port St. Joe, Florida, for providing boat time, and ROSS McWILLIAMS for help in collecting the experimental animals.

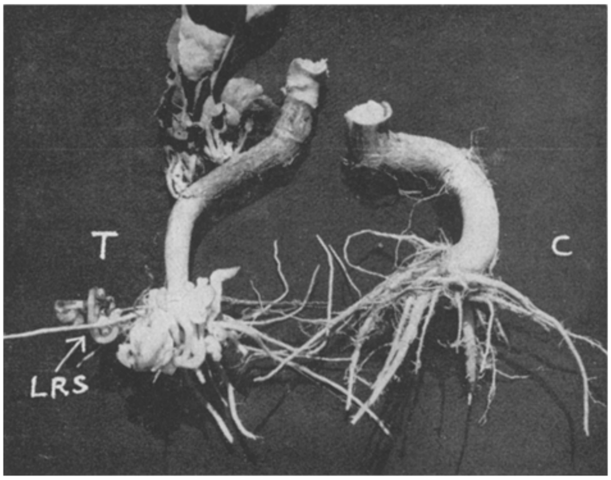
Shoot Initiation on Cauliflower Roots Caused by Morphactin

Adventitious bud formation on stem, leaf, and roots of various plants has been observed. A review of adventitious bud formation on excised leaves shows that leaves of 30 species were able to form roots which formed buds[1]. In vivo roots of *Phlox* sp. are known to be stimulated to form adventitious buds. It has been reported that cabbage could be propagated by means of root cuttings obtained from the base or crown of the plant[2]. This preliminary communication reports shoot formation on intact roots of cauliflower plants treated with morphactin.

Seven-week-old cauliflower (*Brassica oleracea* Linn. var. *botrytis* c.v. Snowball) plants (having 11–13 leaves) raised 45 cm apart in the field were dabbed on the lamina with absorbent cotton soaked with aqueous morphactin (Chlorfluorenol IT 3456) solution, the shoot apex was thoroughly wetted with it. The concentrations used were 100, 250, 500, and 1000 ppm (0.02% Tween 80 served as surfactant). For controls, one set was treated with surfactant only, whilst the other set remained untreated; 10 plants were used for each treatment.

Ten weeks after treatment, some of the morphactin treated plants showed shoots arising from the underground part of the plant. Three plants from each group were removed from the soil and the adhering soil washed off. It was observed that the morphactin treated plants at all concentrations bore numerous shoots on the underground part of the stem, tap root and lateral roots (Figure). There were no shoots/buds on the roots of control plants. 3 plants of each group were studied a week later and another 3 in the following week. The remaining one plant of each group was retained in the field for further observations.

These shoots first grew downward then upward making a U shaped base, and some of these bore roots. The shoots that had become exposed to sun were green, whilst those still underground had numerous crumpled leaves with thickened petiole and midrib and yellow lamina. As many as 35 underground shoots were observed on one of the plants treated with 1000 ppm morphactin solution and the lowest number for this group was 20 shoots. In one case as many as 16 shoots were seen arising from different loci on a lateral root. Plants treated with 500 ppm had 18–28 shoots, whilst those treated with 250 ppm had 13–20 and those with 100 ppm had 8–15 shoots. Shoots were rare on the lateral roots at lower concentrations.



Basal portion of cauliflower plants after 10 weeks of treatment. (C) control, (T) aerial portions treated with 1000 ppm morphactin solution, showing numerous shoots on tap root and one of the lateral roots. LRS, lateral root shoots.

Cytokinins are known to stimulate shoot bud initiation on explants in vitro, this holds good even for the triploid tissue viz. the mature endosperm in tissue culture[3]. In potato plants, treatment with cytokinin resulted in upward and erect growth of stoloniferous shoots. The presence of cytokinins in leaves of *Bryophyllum* and *Begonia* strengthens the view that cytokinin and auxins mediate environmental influence on regeneration capacity in these plants[4]. Morphactins can 'simulate' the effect of cytokinins[5], by increasing the number of regeneration loci on leaf discs of *Begonia*. Recent work[6] has shown that Morphactins are capable of inducing cytokinin-dependent tobacco callus tissue to become cytokinin-autonomous, i.e. to continue growth without cytokinin. This shows that fluorenes can induce a directed and heritable cellular change in tobacco tissue in culture in which a specific biosynthetic system, i.e. endogenous cytokinin system, is regularly and persistently activated.

The present findings can be explained on the assumption that morphactin absorbed via the aerial parts of the plant was transported to roots, and there it either simulated cytokinin's activity or it activated the cytokinin's biosynthesis, and manifested the consequences in the root zone. Such shoots would indeed be of use in propagation of important types of cauliflower. Work is in progress to elucidate the mechanism of action of morphactin on cauliflower.

Résumé. Des plantes de choux-fleurs traitées avec une solution de morphactine ont produit des bourgeons sur leurs racines.

M. Ilyas[7]

1250, Ballimaran, Delhi–6 (India), 22 March 1972.

---

[1] C. Broertjes, B. Haccius and S. Weidlich, Euphytica *17*, 321 (1968).

[2] C. L. Isbell, Proc. Am. Soc. hort. Sci. *46*, 341 (1945).

[3] S. S. Bhojwani and B. M. Johri, Z. Pflanzenphysiol. *63*, 269 (1970).

[4] O. M. Heide and F. Skoog, Physiologia Plant. *20*, 771 (1967).

[5] G. Schneider, A. Rev. Plant Physiol. *21*, 499 (1970).

[6] T. W. Bednar and E. M. Linsmaier-Bednar, Proc. natn. Acad. Sci., USA *68*, 1178 (1971).

[7] Acknowledgements. Thanks are due to M/S. E. Merck AG, Darmstadt, for liberal supply of morphactin, Dr. V. P. Singh, Secretary, Univ. Garden Comm., and Prof. H. Y. Mohan Ram, Dept. Botany, Delhi University, for their keen interest and facilities.

Photoreactivable Sectors and the Systematics of the Genus *Pichia*[1]

On the bases of biochemical, ecological and life-cycle considerations, Wickerham[2] has arranged the 25 species of yeasts belonging to the genus *Hansenula* according to a phylogenetic scheme consisting of 5 major and one subsidiary lines of descent. Spencer et al.[3,4] noted that variations in the structure of cell wall mannans of species of *Hansenula* correlate well with the relationships proposed by Wickerham. We recently reported[5] that the magnitudes of the photoreactivable (PR) sectors (i.e. fraction of the ultraviolet, inactivational cross-section of a cell subject to repair by exposure to visible light) of these species also are consonant with Wickerham's phylogenetic scheme; only very primitive species fail to photoreactivate, advanced species have PR sectors ranging from 0.3 to 0.7 and all species belonging to line 5 of the scheme have a distinctive PR sector of 0.1.

The genera *Hansenula* and *Pichia* are differentiated, categorically, only by the inability of species of *Pichia* to utilize nitrate. As yet, intrageneric evolutionary relationships among species of *Pichia* are moot. Wickerham and Burton[6] have adduced strong arguments to the effect that the genus *Pichia* arose from one or more primitive species of *Hansenula*. Spencer and Gorin[3] have shown that the cell wall mannans of many *Pichias* are struc-