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Mimicry in Plants

There are flowers that look like insects and weeds that masquerade as crop plants. Mimicry in plants results from natural selection: it attracts pollinators or deters predators

by Spencer C. H. Barrett

Plant adaptations can be remarkably complex. Certain species of orchids, for instance, imitate female bees; other plants look and smell like dead animals, and still others have the appearance of stones. These strange adaptations to life represent just a few of the sophisticated means by which plants enhance their chances of survival.

The idea that one species can imitate another in order to deceive an enemy and thus escape predation has fascinated biologists for more than a century. This particular survival strategy was first described in 1862 by the English naturalist Henry W. Bates, who observed that certain brightly colored species of South American butterflies were almost identical in appearance but that some were poisonous whereas others were completely harmless. He surmised that the harmless species were masquerading as harmful ones in order to avoid being eaten and called the phenomenon mimicry; it is now known as Batesian mimicry.

Mimicry in plants has not been the focus of much attention until recently, partly because in the past plants were studied largely in relation to their physical environment and partly because mimicry is simply less common in plants than it is in animals. (Most likely the reason is that plants are sedentary and have a propensity to form clusters; consequently herbivores can learn the location of individual plants and discriminate between them.) Nevertheless, observations made in 1793 by the German naturalist Christian K. Sprengel provided an early clue that plants, like animals, imitate other species. Sprengel found that certain plants, particularly orchids, do not secrete nectar themselves but instead mimic the appearance of nectar-producing species living in the same habitat.

It was not until well into this century, however, when ecology emerged as a distinct discipline, that the relation of plants to other species in the environment became the object of detailed inquiry. Since then studies have revealed that plant-animal interactions run the gamut from associations that are mutually beneficial (as in the case of pollination systems) to associations that are antagonistic (as in the case of defense against herbivory). Mimicry can play a role in all these systems, and as botanists continue to study plant-animal interactions, particularly in tropical ecosystems, it has become clear that plant mimicry is far more widespread than had been supposed.

Mimicry, in plants or in animals, is a three-part system. There is a model: the animal, plant or substrate being imitated. There is a mimic: the organism that imitates the model. And there is a signal receiver or dupe: the animal that cannot effectively distinguish between the model and the mimic. Mimetic traits may include morphological structures, color patterns, behaviors or other attributes of the mimic that promote its resemblance to a model. That model may be either an unrelated species or an inanimate object, such as the background against which an organism spends most of its time.

Mimicry is not an active strategy on the part of an individual plant; flowers do not deliberately trick or deceive animals into visiting them. Mimicry arises as the result of evolution through natural selection and the occurrence of random mutations that lead over many generations to the appearance of favorable characteristics. If such genetically based traits help to camouflage a plant, for example, the plant is likely to have a survival advantage over other plants

that are less well camouflaged. The plant will leave more descendants, thereby passing the advantage to the next generation. For natural selection to favor the evolution of mimicry, the mimic must derive a reproductive advantage from modeling itself after another organism or object; its fitness, measured as the number of offspring produced that survive into the next generation, must be increased as the result of deception.

This has rarely been documented in field studies of mimicry in animals, in part because keeping track of two or (more commonly) three interacting species can be logistically difficult. Plants, at least during the vegetative phase of their life cycle, are immobile and are therefore more easily observed and manipulated under experimental field conditions. In many cases of herbivory it is obvious that the mere survival of the plant automatically confers a fitness advantage over less fortunate individuals that are preyed upon. In pollination the number of pollinators attracted to a plant and the amount of fruit and seed produced can be considered estimates of reproductive fitness.

In most pollination systems both the plant and its pollinators benefit equally, a relationship known as mutualism. The plant offers its pollinators nutritional rewards in the form of nectar and pollen, and during feeding activities the pollinators transfer pollen from plant to plant within a species, leading to fertilization and the setting of seed. Certain plants exploit this relationship and are visited by pollinators in spite of the fact that they offer no nutritional rewards. The plants do so by mimicking any of a number of physical and chemical characteristics (including color, texture, scent and form) of nearby flowering-plant species that secrete copious quantities of nectar. The insects

are unable to distinguish between the model and the mimic and therefore pollinate both of them.

One example of such deception, whose basis is not immediately obvious to a human observer, was recently described by L. Anders Nilsson of the Institute of Systematic Botany in Uppsala. The model in this mimicry complex consists of several species of bellflowers in the genus *Campanula*; the mimic is the red helioborine orchid *Cephalanthera rubra*. Both flowers live together in dry, woody habitats throughout western Europe and the Mediterranean, where they are regularly visited by two species of solitary bees: *Chelostoma fuliginosum* and *C. campanu-*

larum. Beyond this the two flowers bear little resemblance to each other. They differ in both shape and color (the orchid is rose-colored, the bellflower a violet-blue) and belong to separate plant families. Moreover, the bellflowers produce abundant nectar for the bees that visit them, whereas the orchids produce none.

Nilsson observed that male *Chelostoma* bees fly to the *Cephalanthera* flowers, alight and enter the flower headfirst, presumably searching for floral rewards. Not finding nectar, they back out of the flower and in doing so brush against packages of yellow pollen called pollinia. These become attached to the thorax of the bee by a sticky substance secreted by the flower's female sex organ, the

stigma. When the bee flies away, it carries the pollinia with it and deposits pollen on the stigma of the next orchid it visits. Nilsson tracked the bees and found that, by not discriminating between the two types of flowers, the bees successfully pollinate both species. He wondered why the orchids, which are distinctive to look at and lack nectar, were attractive to the bees that pollinate them.

Nilsson solved the paradox with the aid of a spectrophotometer, a device that measures the wavelengths of light reflected from an object. Although the colors of the orchid and the bellflower look very different to human observers, he found that the reflectance curves for the two flowers are virtually identical within the



DECEIVED BY physical and chemical cues, the wasp *Campsocilia ciliata* tries to mate with the orchid *Ophrys speculum*. The labellum, or lower lip, of the flower has roughly the size, shape

and fuzziness of a female wasp; male wasps apparently cannot distinguish between them. As a result the orchid is pollinated by wasps that visit one flower after another searching for a mate.

bees' visual range. The orchid appears red to the human eye because it reflects light at the red end of the spectrum (in the range of 600 to 650 nanometers), but bees see best at the ultraviolet end; like many insects, they do not distinguish among different red hues. To the bee, therefore, the orchid and the bellflower are identical; shape and scent are appar-

ently of minor importance in this deception system.

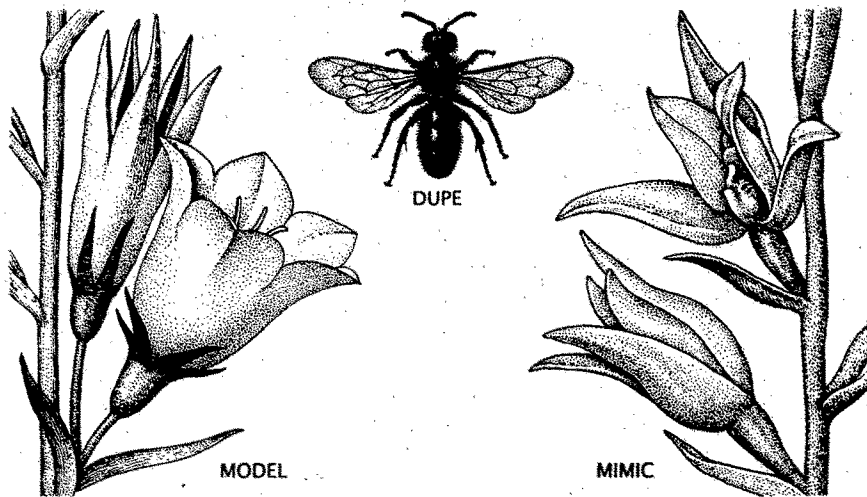
Male *Chelostoma* bees are thus deceived into visiting *Cephalanthera* flowers, a behavior that is of little benefit to the bee but very beneficial to the plant: it is pollinated without having to provide floral rewards in return. Comparison of the reproductive success of the orchid in habitats

where it coexists with bellflowers and their bee pollinators and where it does not shows that the orchids clearly increase their fitness by mimicking bellflowers. Fruit set in these areas is six times higher than it is in regions where the orchid exists without bellflowers.

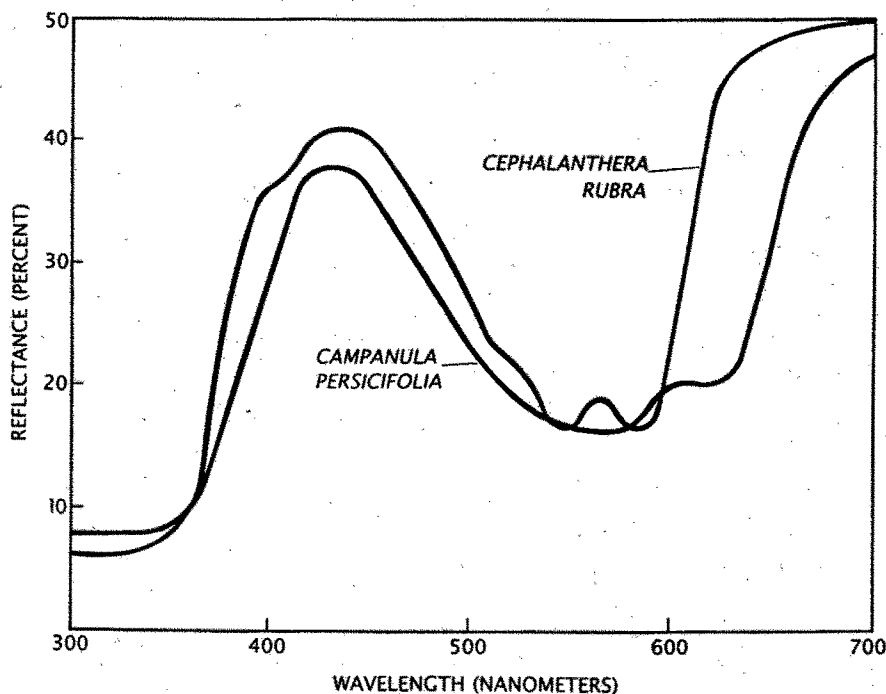
Examples of plant mimicry considerably more bizarre than this occur elsewhere in the orchid family. In one type of deception the flowers of several orchid species imitate female insects. The orchids produce no nectar but instead emit a scent remarkably like the sex pheromone of the insect species they are mimicking. In addition the labellum, or lower lip, of the orchid flower tends to have a shape and a texture like those of the insect being imitated. In orchids that attract bees, for instance, the labellum is covered with hairs.

Several species in the European genus *Ophrys* have evolved so closely with their insect pollinators that they produce a fragrance similar to, if not identical with, the sexual attractant of the female insect they are mimicking. In some cases individual orchid species are named after the species of insect (fly, wasp or bee) that pollinates them. Males, particularly if they have not mated with a female, are attracted to the orchid's flowers and attempt to copulate with them. From the plant's perspective, pseudocopulation is clearly an effective strategy. When the insect lands on the flower, it makes contact with the orchid's pollinia. Unsuccessful in the mating attempt, the insect flies off in search of a more appropriate mate, transporting the pollinia to another flower of the same species.

Pseudocopulation represents one of the most beguiling and complex forms of animal-mediated pollination in flowering plants. It has evolved independently on three separate landmasses (Australia, Eurasia and South America) and is particularly prevalent in the tropics, where many orchid species reproduce by this means. Why do insects, which receive no apparent benefit, participate in the arrangement? Should natural selection not favor the survival of males that are able to conserve their energy by distinguishing a flower from a female insect? One possible explanation is that flowering time for the orchid is closely synchronized with the emergence of adult males from the pupal stage. (Male insects often emerge before the females.) Emerging males compete heavily for



MIMICRY IS A THREE-PART COMPLEX involving a model, a mimic and a dupe. Here the model is the bellflower *Campanula persicifolia* (left), which produces abundant nectar, a substance that is attractive to pollinators. The red helleborine orchid *Cephalanthera rubra* (right) produces no nectar, but it mimics the bellflower and thus deceives the dupe: the leaf-cutting bee *Chelostoma fuliginosum* (center), which visits it. The bee cannot distinguish between the colors of the two flowers and pollinates both species.



COLORS OF MODEL AND MIMIC are different to human beings, who can detect wavelengths of light at the red end of the visible spectrum (right), where the reflectance patterns of these flowers diverge. But at the ultraviolet-blue end of the spectrum (between approximately 300 and 550 nanometers), where bees see best, the reflectance curves of the two flowers are almost identical and the flower colors look the same to the bees.

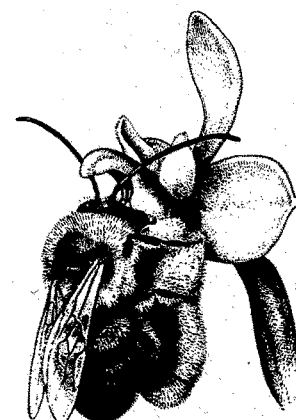
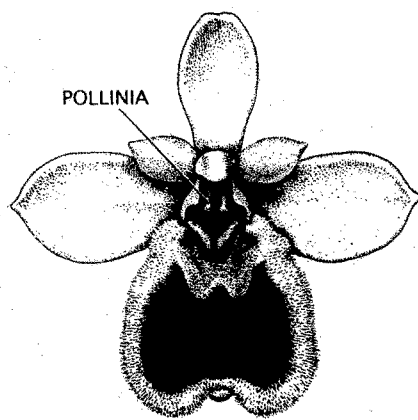
the few available adult females; under these circumstances their discriminatory powers are thought to be low. In a state of sexual frustration many males are readily deceived by the scent and appearance of the orchid flowers.

In stark contrast to the showy flowers associated with pseudocopulation is a pollination strategy in which plants assume some of the characteristics of rotting flesh. Such plants have evolved traits, including putrid odors, fleshlike colors and abundant hairs, that are repulsive to human beings but attractive to flies and other carrion-feeding insects. One of the most potent of these rotting-flesh mimics is *Amorphophallus titanum*, an eight-foot plant from Sumatra whose stench is so powerful that people are said to have fainted from sniffing it too closely.

Rotting-flesh mimics rarely offer nectar or other food rewards. Instead they deceive their pollinators by appearing to be a suitable food site for developing maggots, which normally feed on dead animal tissue. Female flies, fooled by the smell of rotting flesh, land on these flowers and in some cases even lay their eggs in them. In a manner reminiscent of the male insects that move from flower to flower seeking a mate, female flies go from one rotting-flesh mimic to another in search of egg-laying sites. As they progress from flower to flower they inadvertently collect pollen on their bodies and transport it to the flowers' stigmas, thus pollinating the species.

Some plants imitate other members of their own species, a form of deception known as Bakerian mimicry for Herbert G. Baker of the University of California at Berkeley, who first described it. For many years it has been known that members of the Caricaceae, or papaya family, are dioecious: they bear male and female flowers on separate plants. In the Caricaceae male and female flowers are strikingly different, a phenomenon known as sexual dimorphism. Male flowers in this family possess long floral tubes, whereas female flowers lack floral tubes and instead have free petals surrounding a large green ovary. Male flowers in the Caricaceae produce nectar but female flowers do not.

Baker wondered how the species was pollinated. What would attract an insect to the female flower, which produces no nectar or pollen? In studying the interactions of papaya



PSEUDOCOPULATION between two Mediterranean species, the horned bee *Eucera nigilabris* and the orchid *Ophrys tenthredinifera*, leads to pollination of the orchid. To a male bee the flower (left) looks like a female bee with her wings outspread. The bee grasps the flower's labellum and attempts to mate with it (right). While doing so he brushes against the pollinia: pollen sacs hanging from the upper lip of the flower that stick to his body. When the bee leaves, he carries the pollinia to another *Ophrys* flower.

plants with their pollinators he noted that the plants are pollinated mainly at twilight by insects such as moths in the family Sphingidae, which visit both male and female flowers equally. He concluded that to a sphingid moth flying above the plants when light levels are low the male and female flowers must look remarkably alike. Unable to distinguish between the two flower types, the moths are deceived into visiting the nectarless female flowers. Baker called the phenomenon "mistake pollination."

In most dioecious plant species male plants produce considerably more flowers than female plants. Kamaljit S. Bawa of the University of Massachusetts at Boston suggests that the skewed ratio of flowers in dioecious plants has resulted in intense natural selection for female flowers to conform to the search image developed by pollinators visiting male flowers. This type of deception is consistent with the rules of mimicry: the model (the male flower) in the family Caricaceae is much more abundant than its mimic (the female flower). For that reason pollination biologists believe mimicry in dioecious plants may be more widespread than is supposed, and it is interesting that male and female flowers in animal-pollinated plants tend to look alike, whereas those that are wind pollinated often do not.

Not all plant mimicry is one-sided as in Batesian mimicry, where one species obtains the advantage by imitating a second species. Another type of mimicry, observed commonly in animals but rarely in plants, is

known as Müllerian mimicry (after Fritz Müller, the 19th-century German zoologist who first described it). In this type of mimicry a number of unrelated species resemble one another in appearance and behavior. By forming a group of look-alikes the plants are able to take advantage of a common "advertising style," a strategy that attracts more pollinators than would be the case if each plant advertised alone.

Müllerian mimicry differs from Batesian mimicry in that there is no deception, no clear distinction between model and mimic, and all participants contribute equally; that is, all offer floral rewards of comparable value. For this reason some botanists maintain that Müllerian mimicry is not really mimicry at all but simply a function of the fact that organisms living in the same habitat evolve in similar ways, a phenomenon known as convergent evolution. (A well-known example of convergence is the evolution of succulence in desert plants. In response to the need to conserve water in arid environments, various unrelated plant species have evolved thick leaves and fleshy tissues.)

There are also floral associations that appear to combine elements of both Batesian and Müllerian mimicry systems. One example that falls into this category but is still untested is a complex of three orange-yellow butterfly-pollinated plants: *Lantana camara* in the verbena family, *Asclepias curassavica* in the milkweed family and *Epidendrum radicans* in the orchid family. The three plants are commonly found together in road-

side communities in the American tropics, where they are visited by the same individual butterflies.

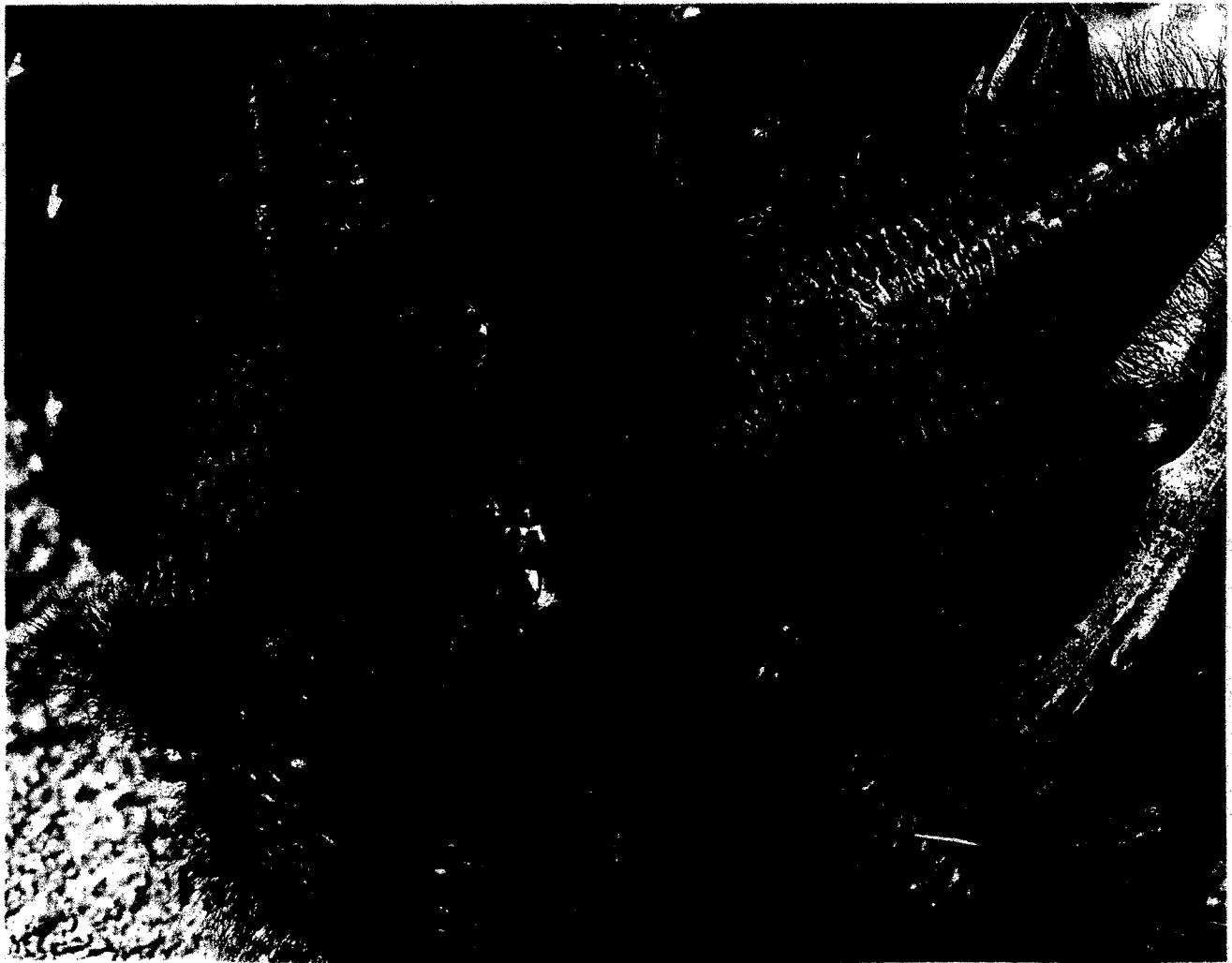
Lantana and *Asclepias*, which produce abundant nectar, are thought to be Müllerian mimics of each other. *Epidendrum*, which produces no nectar, is considered a Batesian mimic of the other two. The three species meet the outward criteria of a mimicry complex: they inhabit the same area and have flowers that are similar in size and color. Nevertheless, recent work has failed to demonstrate that each species is pollinated more (and therefore produces more offspring) when it occurs in association with the other two species than when it occurs in isolation.

Plants do not always mimic other organisms and need not always deceive for the purpose of pollina-

tion. In some species mimicry has evolved in response to predation by animals. Certain plant species resemble the shape, size, color and even the texture of an inanimate background to such an extent that they are camouflaged against potential herbivores. For example, several hundred species in the southern African ice-plant family, the Mesembryanthemaceae, have evolved a striking resemblance to stones and pebbles. Stone mimicry in the family is most developed in the genus *Lithops*: the entire plant, not just part of it, resembles a stone. *Lithops* plants are virtually impossible to spot against low-growing vegetation, particularly during the dry season, when they shrivel and often become lightly covered with sand.

Delbert Wiens of the University of Utah suggests that animals such as

ground-foraging birds, small mammals or ungulates that once roamed the plains of Africa in large numbers may have provided the selective force that has led to the radiation of these mimetic forms. Grazing on low-growing vegetation, the animals might have devoured anything remotely plantlike in appearance, particularly during the dry season, when many plants wilt and die. This hypothesis is supported by the fact that *Lithops* flowers (which are readily visible) are short-lived and appear only during the wet season, when there is abundant herbage for grazing animals. The difficulty of identifying the selection pressures responsible for stone mimicry is a reminder that life is continuously evolving. When the intricate relation between model, mimic and dupe is disrupted, for instance by human disturbance,



CARRIONLIKE PLANT *Stapelia nobilis* from southern Africa has the color and stench of rotting flesh. To an insect the flower's red petals, which are covered with fine hairs, look and feel like fur. The female blowfly seen here, apparently unable to tell the

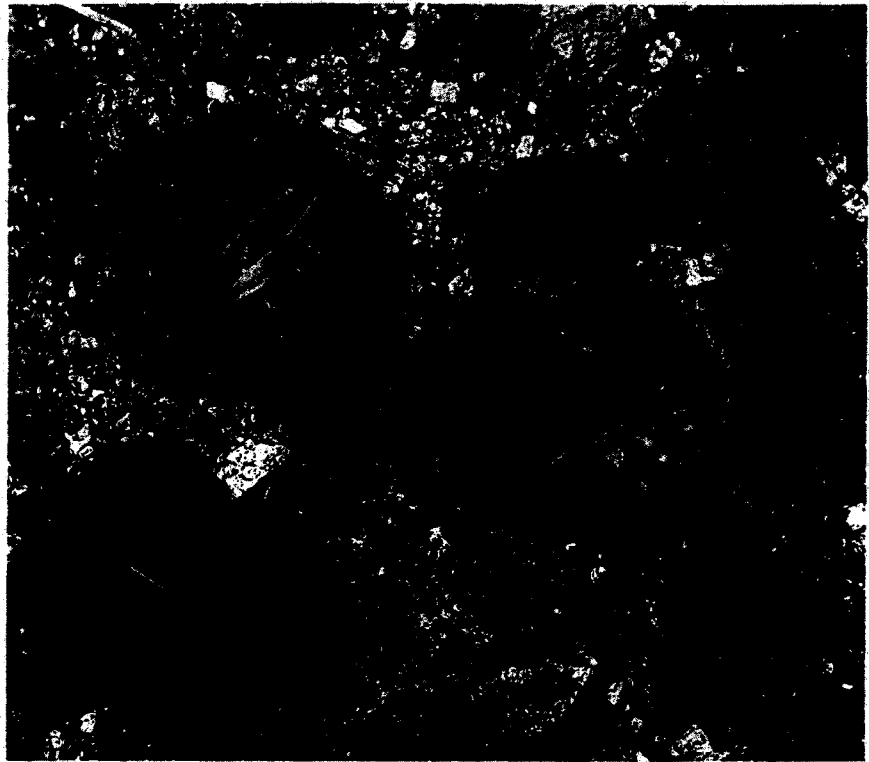
difference between the plant and an animal carcass, has just laid a mass of white eggs at the bottom of the flower. The maggots that hatch from these eggs need animal protein for development and will die soon after birth for lack of a suitable food supply.

only parts of the original mimicry complex may remain intact. In these cases the striking resemblance between models and their mimics is an intriguing glimpse of past evolutionary processes that are no longer in operation today.

Not all mimicry among plants is a reflection of evolutionary events in the distant past. One of the most destructive predators of plants is the species *Homo sapiens*, and several studies of cultivated crops indicate that farming practices have had a powerful influence on the genetics and evolution of certain species of weeds. Coincident with cultivation came the need to control weeds that invade agricultural land and reduce crop yields by competing with crops for nutrients and light.

Since plants were first domesticated by human beings, farmers have removed troublesome weeds from their crops by hand, and in spite of the widespread use of herbicides, hand weeding is still practiced, particularly in less developed countries. In the process of removing weeds, whether by hand or by hoe, agricultural workers are faced with the problem of distinguishing between the crop and the weed. In the majority of cases it is easy for the agricultural worker to distinguish between them. When the crop and the weed species are similar in appearance, however, the weed may be overlooked through mistaken identity with the crop. This is most likely to occur when the individual weeds are scattered throughout the crop at relatively low density, but it may also occur at high weed densities when the toil of hand weeding lowers workers' discriminatory powers, leading to more mistakes. In either case, weeds that more closely resemble the crop have a better chance of survival.

My own interest in this absorbing subject came about while I was studying the problem of wild-rice infestations in cultivated rice fields in Swaziland. During the 1950's two species of wild rice, *Oryza rufipogon* and *Oryza punctata*, had invaded the rice fields, where they multiplied and spread rapidly. Because the wild species are similar in appearance to cultivated rice, the full extent of their invasion was not recognized until the weed populations were too large to be effectively controlled. My observations of hand weeding by agricultural workers in the fields indicated that distinguishing between the different types of rice plants was very



STONE MIMICRY is best developed in the genus *Lithops* from southern Africa. From a distance these three plants are difficult to distinguish from the pebbles that surround them; during the dry season they shrivel and are almost invisible even at close range.

difficult and often the weed rices were left standing.

Weeding in rice paddies, as in most cultivated fields, is usually undertaken during the early stages of crop growth, when competition between the rice crop and invading weeds is greatest. Therefore most weed mimics imitate the seedling stage in the plant's life cycle and are indistinguishable from the crop until the flowering stage, by which time most of the damage has been done.

In Swaziland I observed that under certain conditions cultivated rice and the wild rice *O. rufipogon* hybridize and produce viable offspring. This makes the job of distinguishing between crop and weed particularly troublesome. The complexities of hybridization between cultivated and weed rices have been extensively studied by scientists at the National Institute of Genetics in Japan. They found that certain cultivated traits—such as flowering at the same time as cultivated rice, synchronous germination and reduced shattering ability (the propensity of the rice seeds to fall prematurely from the head of the rice plant)—were expressed in crop-weed hybrids. Unfortunately the hybrids retain the traits that make wild rice inedible: their grains are small

and have extremely hard husks that are difficult to mill. Even more troublesome is the fact that domesticated traits expressed in the hybrids allow them to persist and proliferate, making the weedy rices a still greater agricultural problem.

In an attempt to eradicate hybrid weeds from rice fields, plant geneticists in India developed purple-leaved strains of cultivated rice. They theorized that this would be a simple and effective means by which workers weeding rice fields by hand could differentiate the weed species from the edible species. Unfortunately the natural process of hybridization between the crop and the weed, in association with hand weeding, soon led to the appearance of purple-leaved weedy rices and color was rendered ineffective as a means of distinguishing between the different species.

Another serious pest of cultivated rice is barnyard grass. Barnyard grasses (*Echinochloa*) are among the world's most widespread and noxious weeds, infesting a wide variety of crops including corn, cotton and fruit trees as well as rice. They can usually be recognized by their reddish leaf bases, drooping leaves and

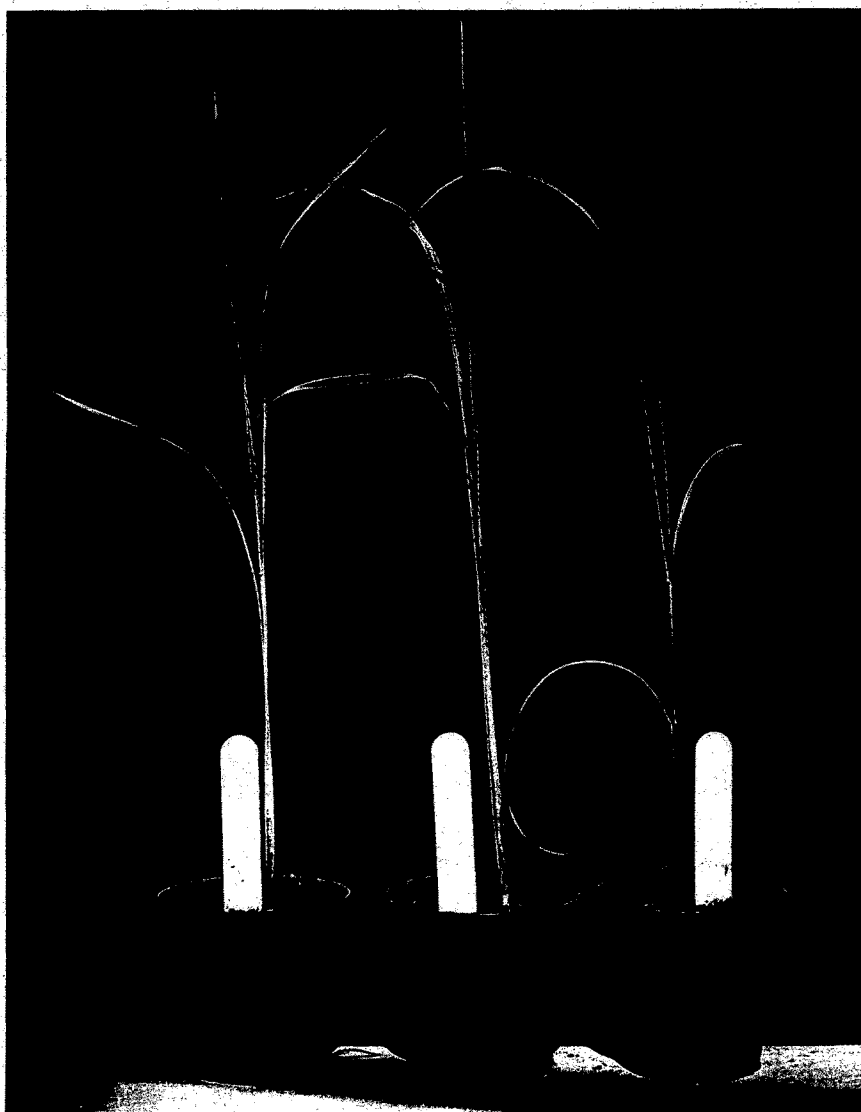
early flowering time. Various mutations resulting in the loss of these characteristics, however, have arisen among species of barnyard grass that infest Asian rice fields, making them so similar to cultivated rice that they are almost indistinguishable from it, particularly during the vegetative growth period. It is possible to differentiate between them, but only by examining cultivated rice plants closely for the presence of a ligule, a short appendage at the base of its leaves. This requires more time than is generally available to hand weeders, and so the weed species are often overlooked.

Today two of these rice mimics, *Echinochloa oryzoides* and *E. phyllo-*

pogon (once called *E. oryzicola*), are obligate rice-field weeds that have spread from Asia to many of the major rice-growing regions of the world, including California. It appears that they entered the U.S. as contaminants of rice seed not long after the beginning of rice culture in the state, because they appeared as weeds in early rice trials at the Biggs Rice Research Station in California's Central Valley. Today they are one of the most serious weeds of rice in California. Although hand weeding is no longer practiced in that state, the close resemblance of barnyard grass to rice may have indirectly furthered its spread through California. Rice seed from fields thought to be weed-

free but infested with barnyard grass was certified for distribution around the state in the early 1900's.

From California the mimic *E. oryzoides* is thought to have been exported as a rice-seed contaminant to Australia, where it was first collected at the rice research institution at Leeton in New South Wales in 1938. Today it is found scattered throughout the rice-growing areas of that state and has the potential of becoming a serious agricultural problem. Anthony Brown of the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia and I have examined the genetic variation of several enzymes present in populations of *E. oryzoides* from California and Australia. Our data indicate that populations in Australia represent a highly limited extract of the genetic information present in California populations of the same species. We concluded, therefore, that the variety of *E. oryzoides* found in Australia could have come only from ancestral stock in California.



THREE-WEEK-OLD SEEDLINGS of cultivated rice (left) are compared with two barnyard grasses: a mimic, *Echinochloa phyllopogon* (middle), and a nonmimic, *E. crus-galli* (right). Although the barnyard grasses are closely related, *E. phyllopogon* resembles rice more than it does *E. crus-galli*. Distinguishing between *E. phyllopogon* and rice is tricky: rice has a ligule (a small appendage at the base of its leaves) that *E. phyllopogon* lacks. *E. crus-galli*, on the other hand, is easily recognized by its reddish purple stem.

Mimicry is not limited to the vegetative stage of a cultivated crop; it can also be expressed at several other stages in a plant's life cycle. For example, in the intensive small-scale farming that characterizes the growing of cultivated rice in many parts of the world, particularly Asia, the transplantation of seedlings by hand from nursery beds to rice paddies provides an additional opportunity for human selection to occur.

Mimicry may also develop at the seed stage. Seed mimicry was first described by Russian botanists in the early 1900's based on observations of a variant of the weed *Camelina sativa* (var. *linicola*) found in flax fields in the Soviet Union. *Camelina sativa* plants have thin, unbranched stems, narrow, pale leaves and look like flax plants. The resemblance, however, is not the result of selection by hand weeding, which is not practiced in flax fields, but simply adjustment to life among the densely packed and shaded stands of flax. Mimicry in *C. sativa* involves the seeds of the weed, which resemble those of flax in several important respects.

Camelina seeds ripen at the same time as those of the flax plant, and because the fruits in which they occur are nondehiscent (they remain attached to the plant), they are harvested along with the crop. Normally seeds other than those of flax are removed during the processes of threshing and winnowing, but *Came-*



HAND WEEDING OF RICE is still practiced in many less developed countries by workers who spend long hours pulling weeds from rice paddies. Rice-mimicking weeds, overlooked under the combined pressures of time and fatigue, have become serious

agricultural problems in some areas. The women in this photograph, made in 1969, are hand weeding rice fields in Swaziland. By the mid-1970's, rice cultivation in Swaziland ceased entirely because of the weed problem posed by the wild rice species.

lina seeds have evolved winnowing properties similar to those of flax. The seeds of the two species look different but the weed and flax seeds are blown the same distance by the winnowing machine. As a result the seeds are mixed together and sown the following season, ensuring that the mimicry complex continues. In various parts of the Soviet Union the seeds of different flax varieties have different characteristics. Remarkably, the *Camelina*-seed mimics in each region have evolved in parallel with their models and so persist as weeds.

With the introduction of more sophisticated winnowing machines as well as improved varieties of crops, it is likely that the intimate relationship between crops and their weeds will break down—at least temporarily. For example, the introduction of early-maturing dwarf varieties of cultivated rice in California fields makes it easier to recognize contamination by *E. phyllopogon*. The development of rice varieties, which bear seed before the seeds of its mimic are mature, are likely to lead to loss of the weed mimic altogether.

Interaction between species is always unpredictable and a change in one species frequently elicits a change in the other. Although it is possible the new selection pressures acting on *E. phyllopogon* will lead to the evolution of mimics that match their flowering time with that of rice, my own studies suggest this is unlikely: populations of *E. phyllopogon* in California contain relatively little genetic variation for such traits as development time, and this limits their capacity for evolutionary change.

Mimicry in agricultural systems is not always detrimental to human beings. Some weed mimics have, by virtue of their similarity to crop species, become crops of major importance themselves. N. I. Vavilov of the Academy of Sciences of the U.S.S.R. was the first to observe in the late 1920's that in early cereal crops such as wheat, weeds resembling rye and oats were harvested and accidentally exposed to selection by man for domesticated traits including large seeds, rigid panicles and nonshattering habit. With time the weeds gradually evolved into useful crops in their own right and today are entirely de-

pendent on man for their survival. Vavilov used the term "secondary crop" to designate those domesticated plant species that were originally derived from mimetic weeds, and the entire process, which has no real counterpart among mimetic phenomena in more natural ecosystems, is referred to as Vavilovian mimicry. That evolution such as this can occur so quickly provides compelling evidence for the evolution of adaptation by natural selection.

Mimicry in plants involves many types of ecological interactions and covers a broad gamut from pollination strategies based on deception, to the avoidance of predation by camouflage to the survival of weeds based on selection by human beings for plants that mimic crop species. In each case mimicry results from the interplay between random genetic mutations and the selective pressures of the environment in which an organism lives. Thus the occurrence of mimicry in plants is a vivid demonstration of the power of natural selection as a guiding force in evolutionary change.