MUTUALISM

A TYPE OF BIOLOGICAL INTERACTION

Updated May 1, 2024

MUTUALISM

INDEX

DEFINITION

MUTUALISM: definition

Il mutualismo è l’interazione biologica (simbiosi) che si instaura tra due o più specie che vivono nello stesso habitat e che porta vantaggi a tutti i partecipanti. Simbolo: (+/+)

Non è una situazione obbligatoria e quindi le specie coinvolte possono anche vivere indipendentemente l’una dall’altra.

MUTUALISM: definition

Mutualism is a biological interaction (symbiosis) that occurs between two or more species that live in the same habitat and brings benefits to all participants. It is not an obligatory situation, so the species involved can also live independently of each other. Mutualism is very widespread in nature and examples can be found in all kingdoms, microbes included. At the end of August 2016, a study was published that would highlight the important role played by mutualism in evolution. Let's now see some examples in which the relationship can be resource-service or service-service.

EXAMPLES OF RESOURCE-SERVICE INTERACTION

MUTUALISM: resource-service interaction

Pollination can be considered a classic case of mutualism in which a resource (nectar or pollen) is exchanged for a service.

The service is the dissemination of pollen.

The hummingbird hawk-moth (Macroglossum stellatarum) in flight as it sucks nectar.

MUTUALISM: resource-service interaction

I chose this butterfly as the first example for its elegance, the speed with which it moves from flower to flower (it beats its wings at a rate of 200 times per second), and the long proboscis it inserts into cup-shaped flowers to suck out their nectar.

In the following slide, another photo closes this example.

MUTUALISM: resource-service interaction

Another photo of the hummingbird hawk-moth (Macroglossum stellatarum) in flight as it sucks nectar.

MUTUALISM: resource-service interaction

Obviously, many other examples can be made among insects, drawing on other butterflies, moths, or bees, as in the photo where a bee is sucking nectar from a flower. The image clearly shows the pollen grains adhering to its body and testifying to the subsequent dissemination.

A bee sucking nectar from a flower

MUTUALISM: resource-service interaction

Another example of an exchange or barter between resource and service is provided by aphids, aka lice, that trade the sugar-rich honeydew they get from plant sap with ants which, in exchange, provide protection against predators such as ladybugs. In some cases, there are ants that nurse aphids by carrying their eggs to the nests during the winter. In short, they take serious care of them as they are decidedly precious.

MUTUALISM: resource-service interaction

An ant is extracting nectar from an aphid by caressing it with its antennae

A ladybug attacking and eating an aphid, an example of predation

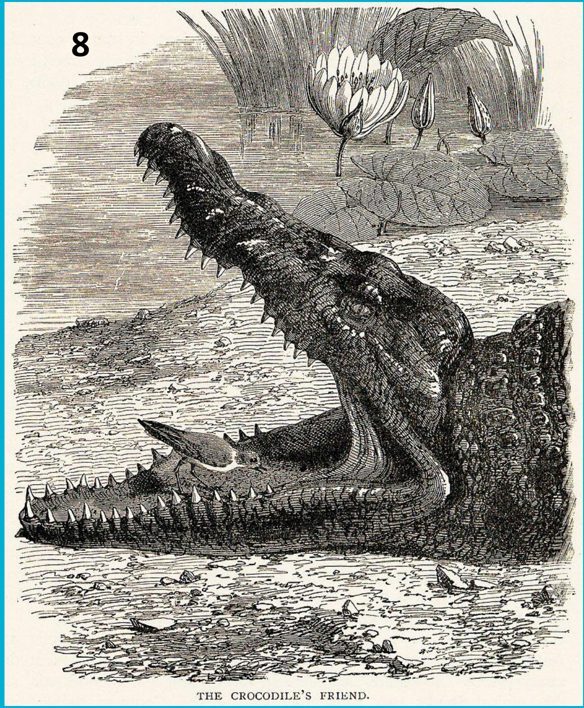
MUTUALISM: resource-service interaction

Another large group of examples in this field can be found in all cases where the resource is nourishment and the service is cleaning.

Mutualism between the cleaner shrimp (Lysmata amboinensis) and the moray eel (Gymnothorax favagineus)

MUTUALISM: resource-service interaction

Mutualism between the impala (Aepyceros melampus) and a bird (Buphagus erythrorhynchus) that feeds on the ectoparasites present on the mammal



A drawing by Henry Scherrer (1906) which illustrates what Herodotus asserted, in 420 BC: the trochilus bird (perhaps a red-throated diver) was able to enter the mouth of the Nile crocodile to clean it.

MUTUALISM: resource-service interaction

Let’s remain in this sector, reporting another form of symbiosis for cleaning that is very interesting.

In both freshwater and marine environments, there are real cleaning stations where animals of all kinds, including rhinos, sea turtles, and fish, go to "groom" themselves. ;))

MUTUALISM: resource-service interaction

What does this grooming consist of?

- Cleaning of parasites, external and internal
- Removal of mucus, scales, and dead skin from the outer surface

The "customers" arrive and "get into position". They open their mouths or remain still to undergo the "delicate operation" like the manta in the photo in the following slide ;))

MUTUALISM: resource-service interaction

A reef manta ray at a cleaning station as it maintains a near-stationary position atop a patch of coral for several minutes to be cleaned by cleaner fish.

MUTUALISM: resource-service interaction

Cleaning stations can be associated with the coral reef or positioned under large areas of floating algae. Cleaning stations can be found in rivers or lagoons too.

A red mullet (Mulloidichthys flavolineatus), photographed in Kona (Hawaii), while it is cleaned by two wrasses

MUTUALISM: resource-service interaction

For their part, the "cleaners" have a special method of advertising their services. They have showy colors, often a blue stripe that extends over the whole body. An excellent example of convergent evolution.

Other fish (false cleaners) mimic the behavior of the cleaners to gain access to the host's tissues but with completely different and often disastrous results because they can even take away pieces of flesh. Here too we speak of convergent evolution.

MUTUALISM: resource-service interaction

Among the best-known cleaner fish, wrasses are well known. In the photo we can see two of them intent on cleaning a gill of another wrasse of very different sizes, Novaculichthys taeniurus.

MUTUALISM: resource-service interaction

In conclusion of this first series of examples, it must be added that not all the scientific world agrees on this approach, especially with regard to mutualism aimed at cleaning. Some of them in fact see it as a more complex type of interaction that can lead to parasitism. The issue has been debated for decades. Years after the writing of this presentation, the debate continues.

EXAMPLES OF RESOURCE-RESOURCE INTERACTION

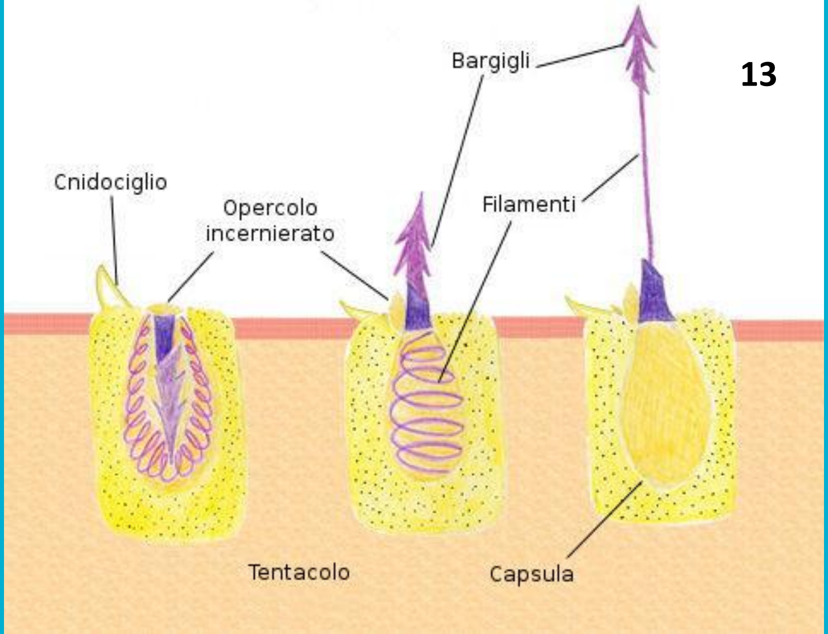
MUTUALISM: resource-resource interaction

Let's start with the best-known example: the clownfish and sea anemones.

The actinia protects the clownfish from predators as well as providing food through the scraps of its meals.

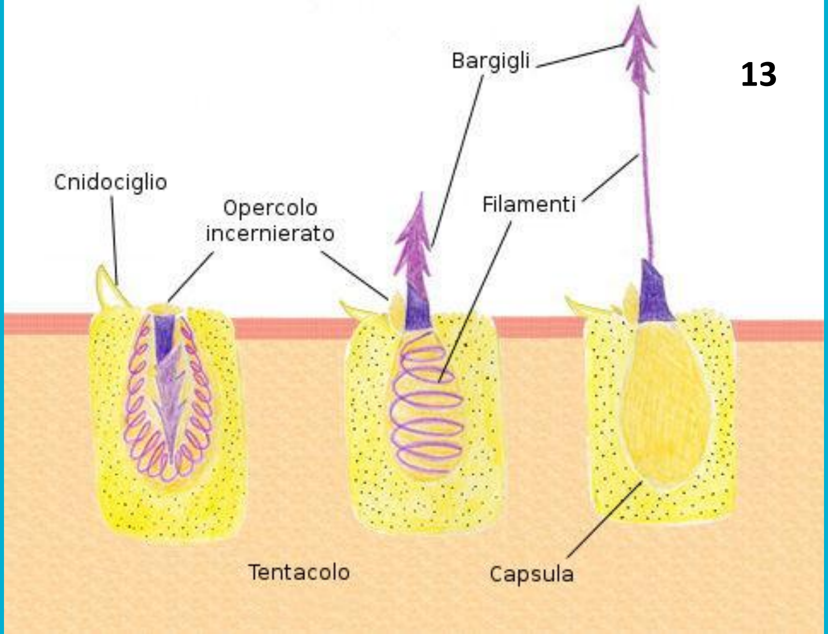
MUTUALISM: resource-resource interaction

In fact, I remember you that sea anemone has tentacles with specialized ectodermal cells called nematocysts.
Upon contact, a stinging filament is extruded as can be seen in the drawing, here on the side.



MUTUALISM: resource-resource interaction

The capsule in which the filament is spirally wound, when at rest, contains a stinging liquid. The toxins that compose it are conveyed into the victim through a hole located at the end of the filament.



MUTUALISM: resource-resource interaction

The problem now is to understand how the clownfish can be immune to this stinging substance. Essentially there are two hypotheses.

Clownfish (Amphiprion ocellaris) between the tentacles of an anemone (Heteractis magnifica)

MUTUALISM: resource-resource interaction

Hypothesis n.1

The mucus that coats the fish may be made up more of sugars than proteins and this would prevent the sea anemone from recognizing it as potential prey.

Hypothesis n.2

The coevolution of specific clownfish with as many species of actinia would explain some immunity acquired by the fish towards the stinging liquid. But….

MUTUALISM: resource-resource interaction

But ... a specific study (1) performed on Amphiprion percula highlighted that subjects whose mucus had been removed died if put into contact with the nematocysts of the usual host (Heteractis magnifica).

Amphiprion percula

MUTUALISM: resource-resource interaction

Let's continue exploring this form of mutualism which is quite complex. So far we have examined the advantage that the clownfish has. And sea anemone?

Sea anemone is protected from its predators and parasites. Furthermore, sea anemone obtains nourishment from the excrement of clownfish. In fact, the nitrogen excreted by the clownfish helps the anemone to incorporate algae into the tissues. Nitrogen also facilitates tissue growth and regeneration.

MUTUALISM: resource-resource interaction

But what are the predators of anemones? Who finds them so appetizing? Butterfly fish.

To the left: Chaetodon semilarvatus
Above: Heniochus acuminatus

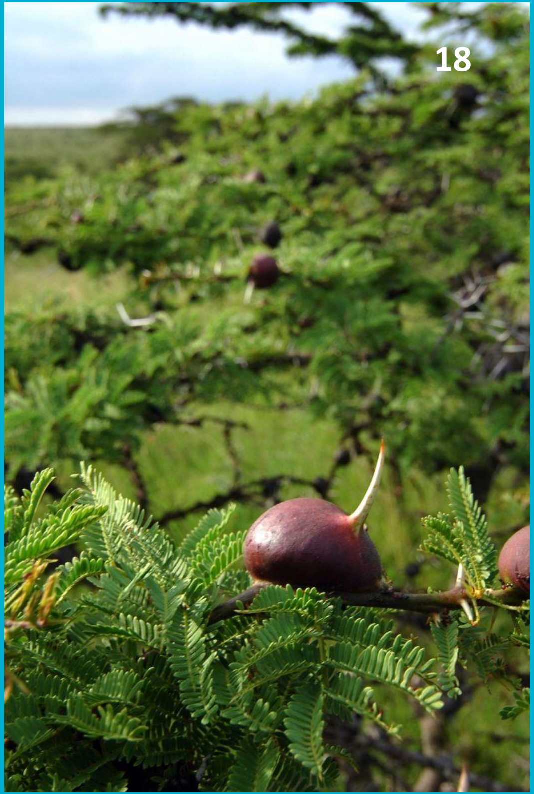
MUTUALISM: resource-resource interaction

And it doesn't end there. It would seem that the very colorful livery of the clown fish helps to attract small fish, prey of the anemone. Furthermore, its active movements around and between the tentacles would cause greater circulation of water.

In reality this form of mutualism is a little more complex than it appears and hides other interactions which I’ll invite you to reflect on in another part of this web page.

MUTUALISM: resource-resource interaction

Another extremely interesting example of mutualism of this type occurs between a typical East African acacia (Vachellia drepanolobium) and some species of ants.
The plant produces bulbous thorns (one pair at each node).



MUTUALISM: resource-resource interaction

These spines are hollow and host different species of ants which dig openings to enter and exit. So when the wind blows the plant whistles ;)) Hence the English name of Whistling Thorn.

MUTUALISM: Resource-resource interaction

The acacia offers shelter to the ants inside the thorns as well as food in the form of nectar (therefore a resource is included in addition to the service). For their part, the ants protect the plant from attacks by herbivores of all kinds, including elephants and giraffes.

MUTUALISM: resource-resource interaction

In the event of an attack on the plant, they hurry out of their refuge, emitting repellent odors. The strategy towards herbivorous insects is to chase them away or eat them.

Another service that in some cases they render to the host plant is to cut branches of nearby plants that could provide too much shade for their host.

MUTUALISM: resource-resource interaction

Another species of acacia (Acacia collinsii) in whose hollow thorns ants always find refuge but of different species.

MUTUALISM: resource-resource interaction

There are approximately 100 genera of plants (myrmecophilous plants) that live in mutualistic association with ants. Over time they have developed a whole series of structures aimed at providing food and/or shelter to these insects.

MUTUALISM: resource-resource interaction

But the plant-ant mutual association is not always good for the environment. Proof of this is the case between the Myrmecalista schumann ant and the Duroia hirsuta plant typical of the Amazon forest.

Foto scattata a Rio Caura, Venezuela.

MUTUALISM: resource-resource interaction

The ant finds accommodation in special cavities produced by the plant but is so jealous of its home that it literally destroys any plant of a different species nearby. It does this thanks to the production of formic acid. The result is an area in which there is no longer a trace of biodiversity. The natives call it "devil's garden".

CLASSICAL EXEMPLES

MUTUALISM: classical examples

I close this overview of mutualism with the examples that are generally found in all textbooks.

The first concerns us, the humans, and is the set of microbes that live peacefully in our intestines and in the entire digestive tract in a form of symbiotic association. The correct term is microbiota and not intestinal flora because the word flora refers to plants.

MUTUALISM: classical examples

Another well-known example is mycorrhizae, including fungi and plant roots. The photo alongside shows specimens of Amanita muscaria which tend to associate with the roots of various plants (ectomycorrhizae) visible in the photo below (the fungal mycelium is intertwined with the tips of the roots).

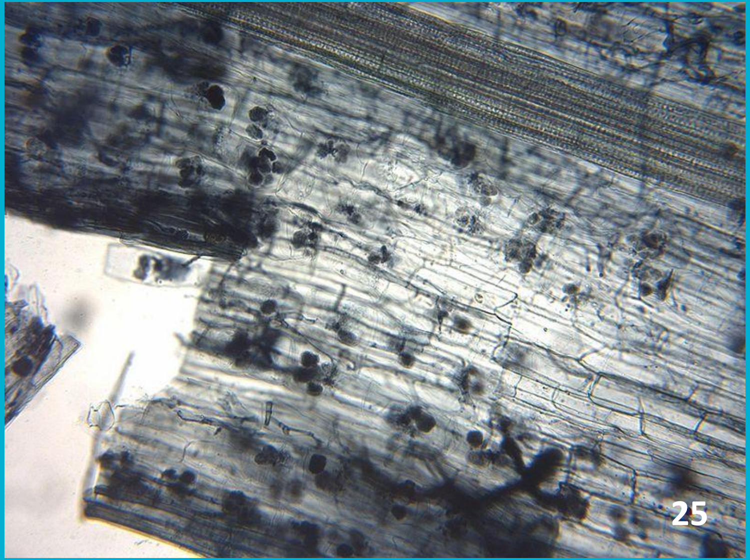
MUTUALISM: classical examples

In the previous slide, an ectomycorrhiza was clearly visible in which the fungi (usually basidiomycetes or ascomycetes) do not penetrate through the cell wall of the plant.

The case is different when the fungi penetrate inside the root cells. They were once known as endomycorrhizae. Today the classification of mycorrhizae is much more complicated also due to the new systematics of fungi.

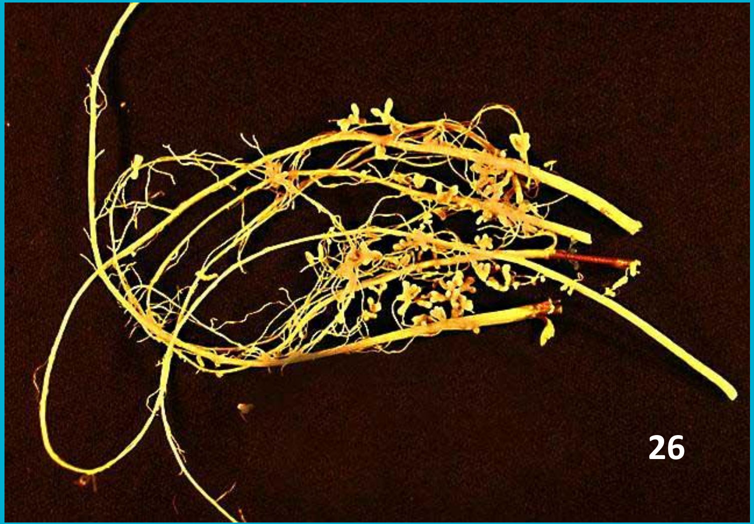
MUTUALISM: classical examples

In the photo on the side you can see the root cells of a plant into which fungal hyphae have penetrated.
In any case of mycorrhiza, the plant provides the fungus with carbohydrates and is reciprocated with the supply of phosphorus and nitrogen. It is therefore an exchange of resources.



MUTUALISM: classical examples

Nitrogen-fixing bacteria have mutualistic relationships with legumes.
By fixing nitrogen, which they could not do living independently, they provide an important source of this nutrient to legumes which reciprocate with carbon-based substances with high energy content.



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