Environmental Microbiology
CLS 416

Lecture 2
Microbial interactions

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Outline

- Important terms (Symbiosis,ectosymbiont.Endosymbiont, ecto/endosymbiosis
- Positive interactions (mutualism, protocooperation, commensalism)
- Negative interactions(predation, parasitism, amensalism,and competition)
- Nutrient Cycling Interactions
- The importance of understanding the principle of microbial interactions (Examples from the literature)

Microbial interactions

Symbiosis

An association of two or more different species

Ectosymbisis

One organism can be located on the surface of another, as an **ectosymbiont.** In this case, the ectosymbiont usually is a smaller organism located on the surface of a larger organism.

Endosymbiosis

one organism can be located within another organism as an endosymbiont

Ecto/ endosymbiosis.

microorganisms live on both the inside and the outside of another organism

Examples (Ecto/ endosymbiosis)

1- *Thiothrix* species, a sulfur-using bacterium, which is at- ached to the surface of a mayfly larva and which itself contains a parasitic bacterium.

2- Fungi associated with plant roots (mycorrhizal fungi) often contain endosymbiotic bacteria, as well as having bacteria living on their surfaces

- Symbiotic relationships can be intermittent and cyclic or permanent
- Symbiotic interactions do not occur independently. Each time a microorganism interacts with other organisms and their environments, a series of feedback responses occurs in the larger biotic community that will impact other parts of ecosystems.

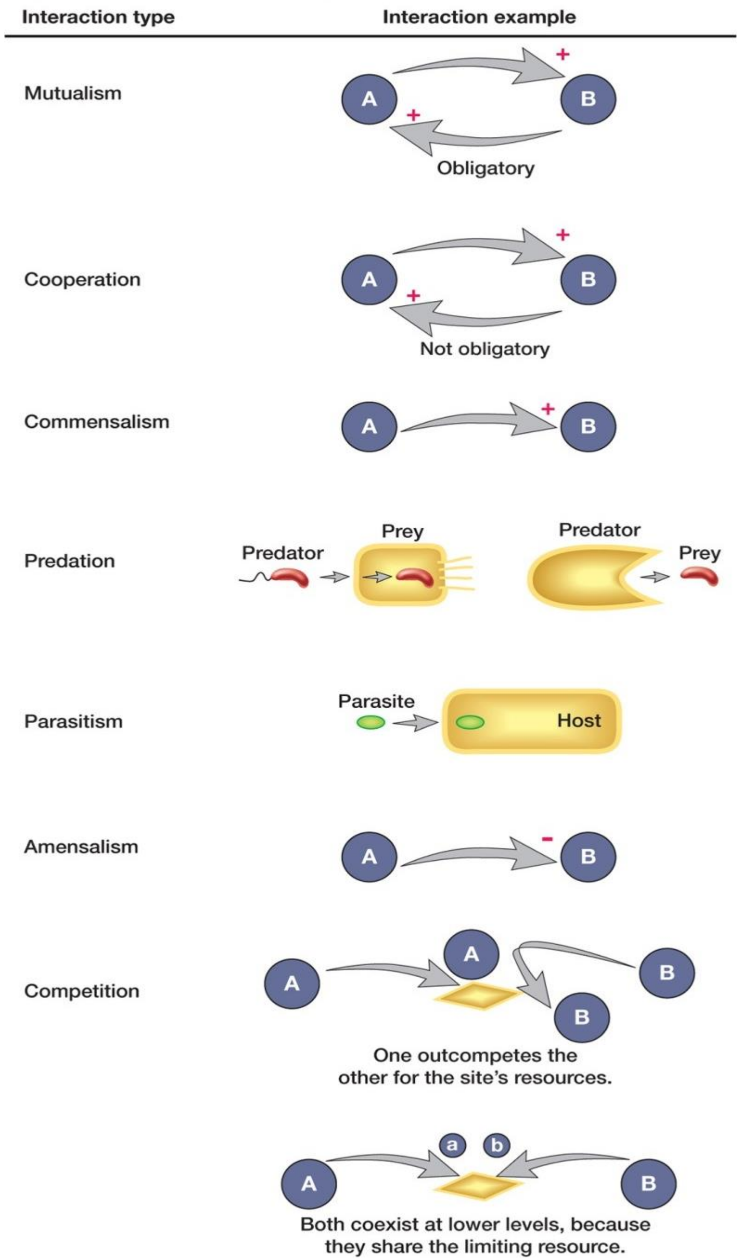
Microbial interactions

Positive interactions

- Mutualism
- Protocooperation
- Commensalism

Negative interactions

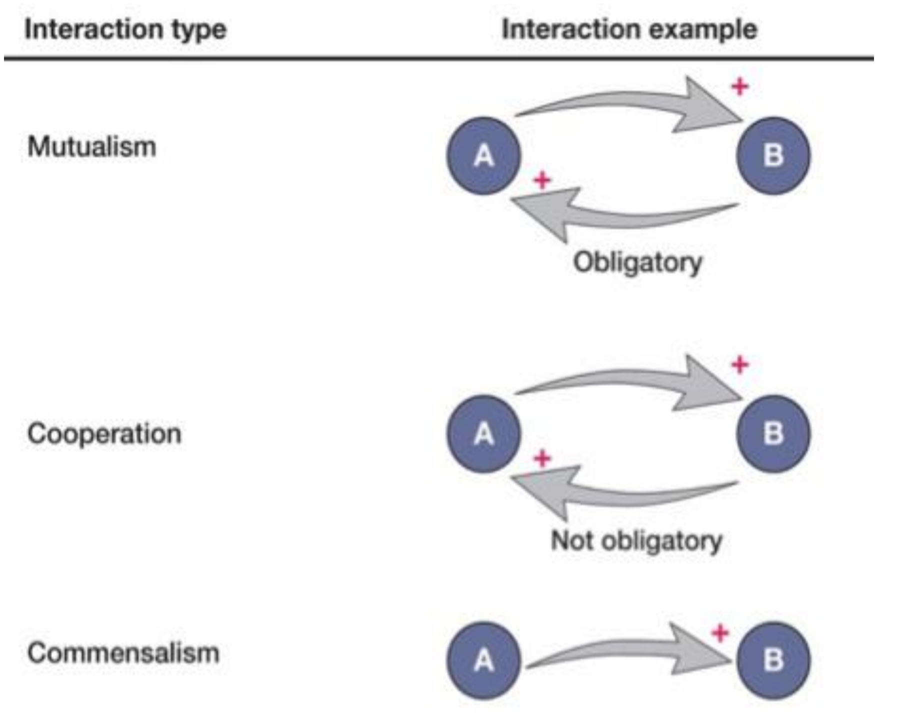
- Predation
- Parasitism
- Amensalism
- Competition



Mutualism

Mutualism [Latin *mutuus,* borrowed or reciprocal] defines the relationship in which some reciprocal benefit accrues to both partners.

- Relationship with some degree of obligation
- partners cannot live separately
- Mutualist and host are dependent on each other



Examples of Mutalism

1. The protozoan-termite relationship

- flagellated protozoa live in the gut of termites and wood roaches.
- These flagellates exist on a diet of carbohydrates, acquired as cellulose ingested by their host
- The protozoa engulf wood particles, digest the cellulose, and metabolize it to acetate and other products.
- Termites oxidize the acetate released by their flagellates.
- Because the host is almost always incapable of synthesizing cellulases (enzymes that catalyse the hydrolysis of cellulose), it is dependent on the mutualistic protozoa for its existence.

Examples of Mutalism

2. Lichens

Lichens are the association between specific ascomycetes (the fungus “**my-cobiont”**) and either green algae or cyanobacteria “**phycobiont “.**.

- The characteristic morphology of a given lichen is a property of the mutualistic association and is not exhibited by either symbiont individually.
- Because the phycobiont is a photoautotroph dependent only on light, carbon dioxide, and certain mineral nutrients,the fungus can get its organic carbon directly from the alga or cyanobacterium.
- In turn the fungus protects the phycobiont from excess light intensities, provides water and minerals to it, and creates a firm substratum within which the phycobiont can grow protected from environmental stress.

Mutualism - Syntrophism

Syntrophism [Greek *syn,* together, and *trophe,* nourishment] is an association in which the growth of one organism either depends on or is improved by growth factors, nutrients, or substrates provided by another organism growing nearby. Sometimes both organisms benefit. This type of mutualism is also known as cross- feeding or the satellite phenomenon.

Protocooperation

- A positive (not obligate) symbiosis which involves syntrophic (one organism lives off the byproducts of another) relationships
- Benefits both organisms in relationship
- Differs from mutualism because cooperative relationship is not obligatory

Examples of protocooperation

1) **A Marine Worm-Bacterial Protocooperative relationship**
the worms secrete mucous from tiny glands on their backs to feed the bacteria, and in return they are protected by some degree of insulation.

Figure:Alvinella pompejana

2) **quorum sensing (autoinduction)**

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Quorum sensing (autoinduction)

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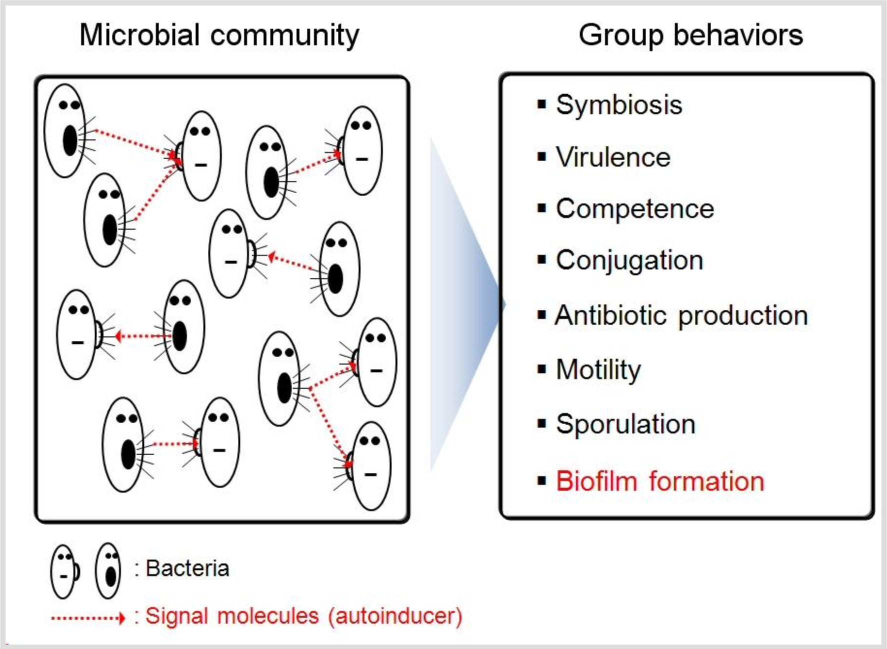
- A phenomenon whereby the accumulation of signalling molecules enable a single cell to sense the number of bacteria (cell density)
- The microorganisms produce specific autoinducer compounds, and as the population increases and the concentration of these compounds reaches critical levels, specific genes are expressed.



Quorum sensing (autoinduction)

- Many bacteria rely on QS to control the expression of genes responsible for disease

- Very important for pathogenic bacteria during infection of a host

(e.g. human,other animals or plants) to coordinate their virulence in order to escape the immune response of the host in order to establish a successful infection

- The most common signals in gram-negative bacteria are acyl *h*omoserine *l*actones (HSLs).
- Gram-positive bacteria often using an oligopeptide signal.

Commensalism

Commensalism [Latin *com,* together, and *mensa,* table] is a relationship in which one symbiont, the **commensal,** benefits while the other (sometimes called the host) is neither harmed nor helped (neutral

- Commensal - organism that benefits
- When the commensal is separated from its host experimentally, it can survive without being provided some factor or factors of host origin.
- Commensalistic relationships between microorganisms include situations in which the waste product of one microorganism is the substrate for another species.
- Commensalistic associations also occur when one microbial group modifies the environment to make it more suited for another organism.

Examples of Commensalism

- **Intestinal microorganisms**

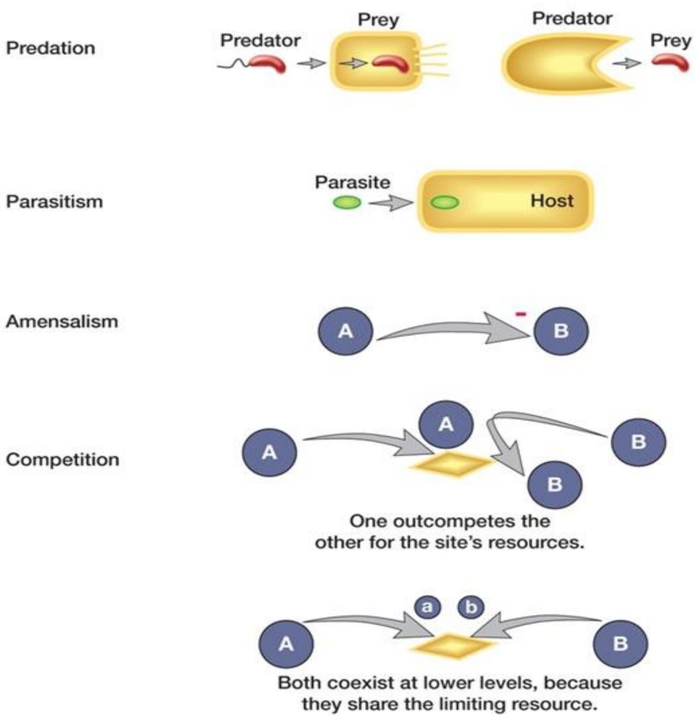
in the human colon, when oxygen is used up by the facultatively anaerobic *E. coli,* obligate anaerobes such as *Bacteroides* are able to grow in the colon.

- **Microbial succession during spoilage of milk**
  - fermenting bacteria promote growth of acid tolerant species

- **Formation of biofilms**
  - initial colonizer helps other microorganisms attach

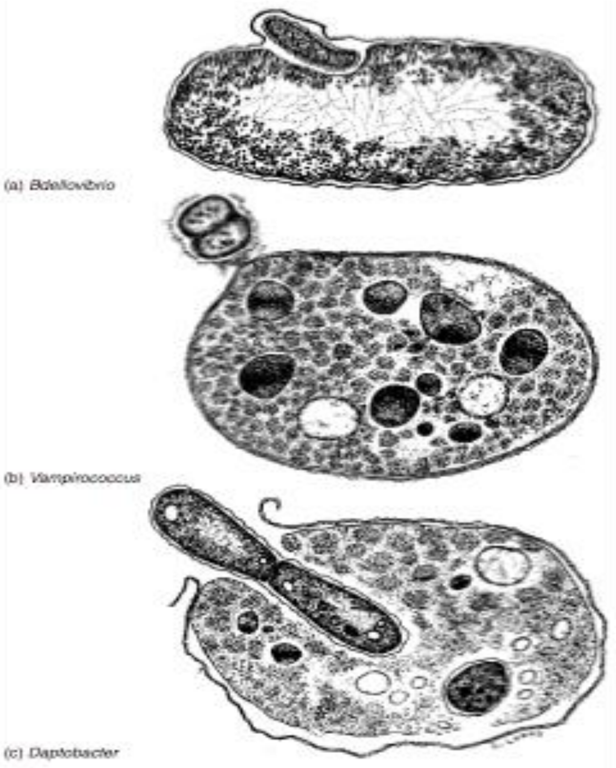
- **Skin or surface microbes on plants or animals**
  - host plant or animal releases volatile, soluble, and particulate organic compounds used by commensals

Negative interactions



Predation

- When one organism, the predator, engulfs and digests another organism, the prey
- The prey can be larger or smaller than the predator, and this normally results in the death of the prey.



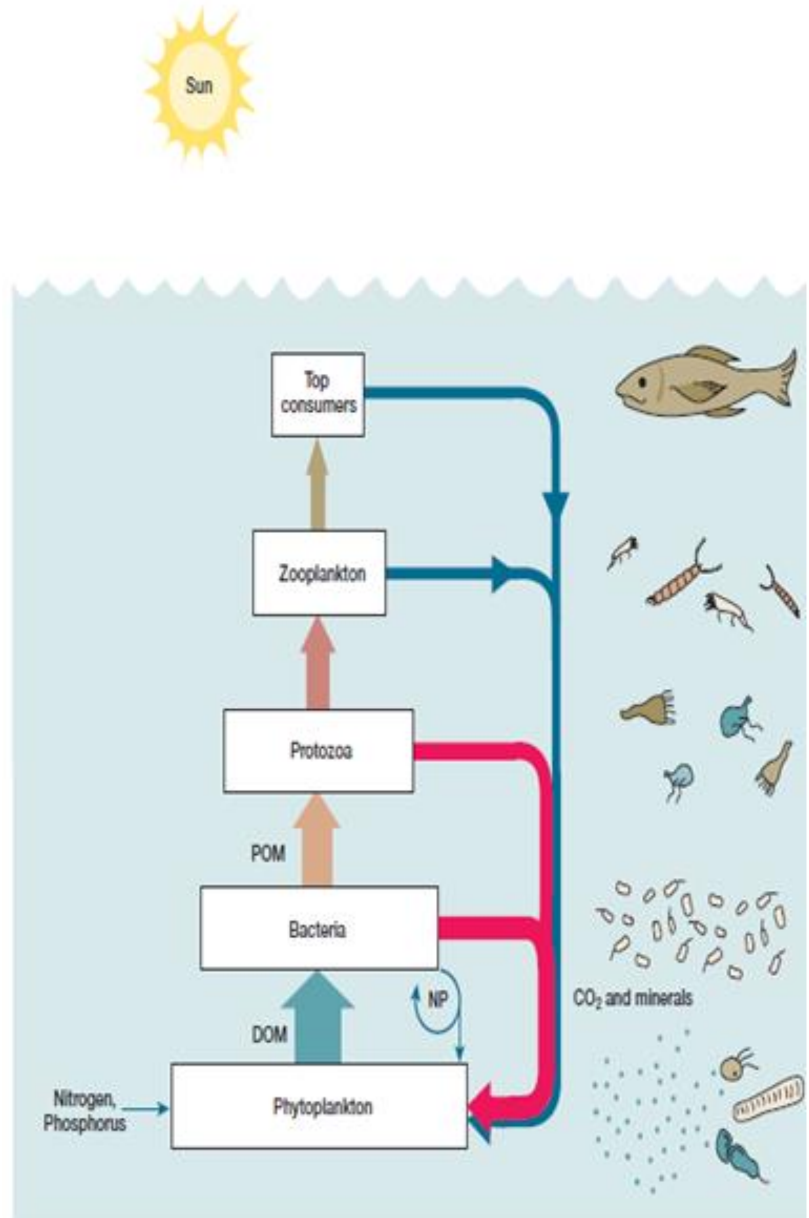
Examples

a) *Bdellovibrio,* a periplasmic predator that penetrates the cell wall and grows outside the plasma membrane,

b) *Vampirococcus* with its unique epibiotic mode of attacking a prey bacterium

c) *Daptobacter* showing its cytoplasmic location as it attacks a susceptible bacterium.

Predation



It has beneficial effects:

- Digestion, e.g The microbial loop
- Protection and increased fitness
- Survival and increased pathogensity e.g, The intracellular survival of Legionella ingested by ciliates

The microbial loop

Parasitism

- The population that benefits, the parasite, drives its nutritional requirements from host, which is harmed
- It can involve physical maintenance in or on the host.
- Characterized by relatively long period of contact

Parasitism or Predation!!

- In microbial world the distinction between parasitism and predation is not sharp

- Depending on the equilibrium between the two organisms, this may shift and what might have been a stable parasitic relationship may then become a pathogenic one which can be defined as predation

Amensalism

Amensalism A relationship in which the product of one organism has negative effect on other organism

Example

- The production of antibiotics that can inhibit or kill a susceptible microorganism
- Bacteriocins (Proteinaceous toxins produced by bacteria with antimicrobial toxicity. Most bacteriocins target other strains of the same species as the producing organism, but some are more broad-spectrum)

Competition

- **Competition** arises when different microorganisms within a population or community try to acquire the same resource, whether this is a physical location or a particular limiting nutrient

- This principle of competition was studied by E. F. Gause, who in 1934 described this as the **competitive exclusion principle**.(When competition between species results in the elimination of one species from a given habitat or region

Nutrient Cycling Interactions

- Microorganisms interact with each other in the cycling of nutrients, including carbon, sulfur, nitrogen, phosphorus, iron, and manganese.
- This nutrient cycling, called **biogeochemical cycling**
- Nutrients are transformed and cycled, often by oxidation-reduction reactions

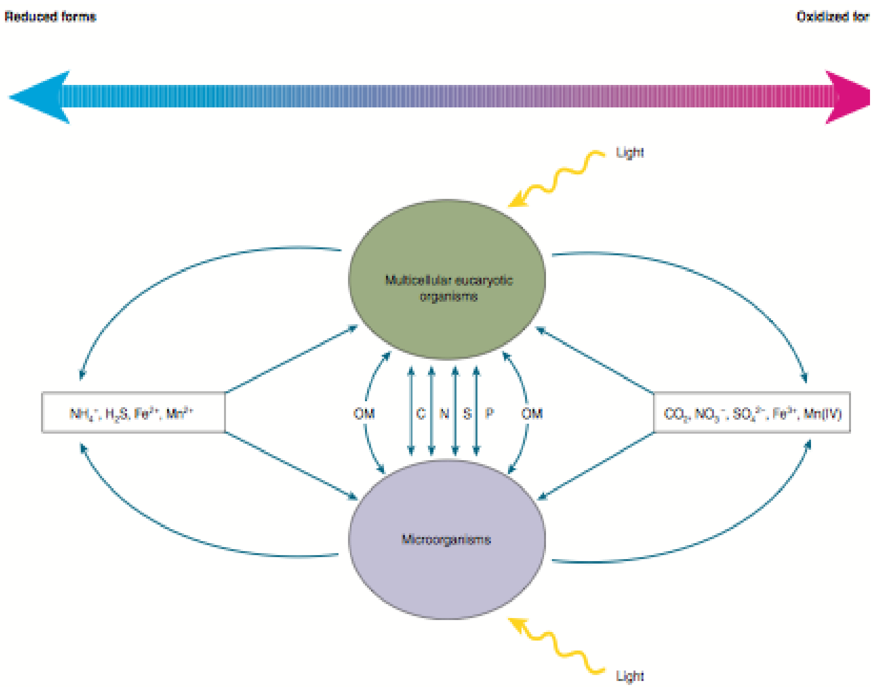


Figure: Macrobiogeochemistry

The importance of understanding the microbial interactions (Research focus)

- Analyzing the impact of the human host microbiota composition and activity
- Understanding the underlying governing principles that shape a microbial community is key for microbial ecology engineering synthetic microbiomes for various biotechnological applications.

Examples

- the bioconversion of unprocessed cellulolytic feedstocks into biofuel isobutanol using fungal–bacterial communities
- biosensing and bioremediation against environmental toxins such as arsenic and pathogens such as Pseudomonas aeruginosa and Vibrio cholerae have been demonstrated using engineered quorum-sensing Escherichia coli
- utilizing microorganisms to reduce the concentration and toxicity of various chemical pollutants, such as petroleum hydrocarbons pesticides and metals Biodegradation and its application in bioremediation of organic pollutants have benefited from the biochemical and molecular studies of microbial processes

Example from the literature

Symbiosis of *Aeromonas veronii* Biovar sobria and *Hirudo medicinalis, the Medicinal Leech: a Novel Model for Digestive Tract Associations (example of symbiosis, endosymbiosis and permanent t)*

ABSTRACT

Hirudo medicinalis, the medicinal leech, is applied postoperatively in modern medicine. Infections by Aeromonas occur in up to 20% of patients unless a preemptive antibiotic treatment is administered. The associated

infections demonstrate the need for a better understanding of the digestive tract flora of H. medicinalis. Early studies reported the presence of a single bacterial species in the digestive tract and suggested that these bacteria were endosymbionts contributing to the digestion of blood. In this study, we cultivated bacteria from the digestive tract and characterized them biochemically. The biochemical test results identified the isolates as Aeromonas veronii biovar sobria. This species identification was supported by sequence comparison of a variable region of the genes coding for 16S rRNA. In a colonization assay, a rifampin-resistant derivative of a symbiotic isolate was fed in a blood meal to H. medicinalis. The strain colonized the digestive tract rapidly and reached a concentration similar to that of the native bacterial flora. For the first 12 h, the in vivo doubling time was 1.2 h at 23°C. After 12 h, at a density of 5 3 107 CFU/ml, the increase in viable counts ceased, suggesting a dramatic reduction in the bacterial growth rate. Two human fecal isolates, identified as Aeromonas hydrophila and A. veronii biovar sobria, were also able to colonize the digestive tract. These data demonstrate that the main culturable bacterium in the crop of H. medicinalis is A. veronii biovar sobria and that the medicinal leech can be used as a model for digestive tract association of Aeromonas species.

Reading assignment

Stress and Ecosystems. in term of the factors that lead to the creation of extreme environments

Thank You

References

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