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الفصل الدراسي الثاني

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Lab. 1

Introduction on biodiversity and Bioregulation

Theoretical part

General interest in biodiversity has grown rapidly in recent decades, because of its great importance for understanding the relationship between humans and the species in the environment where he lives. Life on Earth depends on balanced regime in diversity and loss of any type of species or population in any ecosystem will be reduce the biodiversity and makes defect on the planet.

The science of biodiversity originates largely from **ecology** (the study of the relationship between organisms and their environment) and **evolution** (the study of origin of diversity)

Biodiversity is often defined as the variety of all forms of the life from genes to species through to the Broad scale of ecosystem this simple definition to **Gaston,1996**) while (**Harrison *et al*,2004**) defining biodiversity as a whole number of species lives in earth now animals, plants, microorganisms) so far about 1.75 million species have been identified mostly small creators such as insects. Scientists estimate that there are actually about 13 million species have been not identified yet.

Biologists most often define biodiversity as the totality of genes, species and ecosystem of a region. An advantage of this definition is that it seems to describe most circumstances and the presents a unified view of the traditional three levels at which biological variety has been identified:

- **Genetic diversity**
- **Species diversity**
- **Ecosystem diversity**

1- **Genetic diversity**: is the different genes genotype found within the population of a single species and the pattern of variation found within different species. **For example**: Chihuahuas, Beagles, and Rottweilers are all the same species but they're not the same because there is variety in their

2- **Species diversity**: is the variety of phenotype and genotype (form, genes) among different species which inhabit an area. Its mean the number of exits species on the earth (animal, plants, microorganisms). For **example:** monkey, dragonflies, and meadow beauties are all different species.

ecosystem diversity: the variety of ecosystem or habitats that occur within a region and the relationship of species with this ecosystem. Lakes, Ponds, and Rivers are all Freshwater Ecosystems. Rocky coast, Sand Dune, Estuary, Salt Marsh, Coral Reef are all Marine Ecosystems.

Bioregulation:

The scientists analyze the component of living and nonliving materials. They found that no different between them at atomic level and all the types of atoms that found in living material also found in nonliving material, that means living organism characters found in molecular level but not found in atom level.

The molecules at a molecular level arranged to be more complex components (organelles) the atoms of living organisms bond with each other by special type of bond to form more complex molecules that also produce complex which the represent characters of Life, this structure called (cell) the cells capable of achieving different life activities like reproduction, this process to represent the life character, in cell level. Cells organize in multicellular organisms, from simplest to complex, to be tissue, organ, system, organism (individual), population, community, ecosystem, biomes, and biosphere.

Bioregulation levels, there is a differences in specific details in each level but similar in essential structure and function for example: the general structure of cell in protozoa similar to the cell in the human body in general structure but they different from each other in their function

Lab. 2

The source of biodiversity

Theoretical part

In nature difference between individuals in one species and between different species may be caused by fundamental forces of evolution: **Natural Selection, Mutations, Gene Flow, Recombination and Genetic Drift.**

1. Natural Selection

Natural Selection leads to an evolutionary change when some individuals with certain traits in a population have a higher survival and reproductive rate than others and pass on these inheritable genetic features to their offspring. Evolution acts through natural selection whereby reproductive and genetic qualities that prove advantageous to survival prevail into future generations. The cumulative effects of natural selection process have giving rise to populations that have evolved to succeed in specific environments.

Types of natural selection

Natural selection can take many forms. To make talking about this easier, we will consider the distribution of traits across a population in graphical form. In we see the normal bell curve of trait distribution. For example, if we were talking about height as a trait, we would see that without any selection pressure on this trait, the heights of individuals in a population would vary, with most individuals being of an average height and fewer being extremely short or extremely tall. However, when selection pressures act on a trait, this distribution can be altered. **(Figure1)**

I. Stabilizing selection

When selective pressures; select against the two extremes of a trait, the population experiences stabilizing selection. For example, plant height might be acted on by stabilizing selection. A plant that is too short may not be able to compete with other plants for sunlight. However, extremely tall plants may be more susceptible to wind damage. Combined, these two selection pressures select to maintain plants of medium height. The number of plants of medium height will increase while the numbers of short and tall plants will decrease. **(Figure 2)**

II. Directional selection

In directional selection, one extreme of the trait distribution experiences selection against it. The result is that the population's trait distribution shifts toward the other extreme. In the case of such selection, the mean of the population graph shifts. Using the familiar example of giraffe necks, there was a selection pressure against short necks, since individuals with short necks could not reach as many leaves on which to feed. As a result, the distribution of neck length shifted to favor individuals with long necks. **(Figure3)**

III. Disruptive Selection

In disruptive selection, selection pressures act against individuals in the middle of the trait distribution. The result is a bimodal, or two-peaked, curve in which the two extremes of the curve create their own smaller curves. For example, imagine a plant of extremely variable height that is pollinated by three different pollinators, one that was attracted to short plants, another that preferred plants of medium height and a third that visited only the tallest plants. If the pollinator that preferred plants of medium height disappeared from an area, medium height plants would be selected against and the population would tend toward both short and tall, but not medium height plants. Such a population, in which multiple distinct forms or morphs exist is said to be polymorphic. **(Figure 4)**

Lab.3

2. Mutation

It is a sudden change in genetic material of an organism that results from an alternation in the nucleotides sequences of DNA coding for a gene, or in the chromosomes piece, or through change occur in normal number of chromosomes, resulting in the creation of a new character or trait not found in the parental type.

Gene mutation occur in two ways: they can be inherited from parents during a person’s lifetime. Mutations that are passed from parents to child are called **hereditary mutation** or **germline mutations** (because they are present in the egg and sperm cells which are also called germ cells). This type of mutation is present through a person's life in virtually every cell in the body.

But somatic mutations occur in the DNA of individual cells at some time during a person's life, these changes can be caused by environmental factors such as ultraviolet radiation from the sun, mutagenic chemicals, heat, or can occur if a mistake is made as a DNA copies itself during cell division. Mutation in somatic cells (cells other than the sperm and egg) cannot be passed on the next generation. Generally mutations are the necessary raw materials of evolution.

3. Gene flow:

Gene flow is the transfer of genetic material between separate populations. For example in human being, culture differences as well as geographic separation maintain unique populations: it is more likely that persons will marry and have children with someone who lives nearby and speak the same language.

Migration has been significant feature of human history in both prehistoric and more recent times. No gene flow occurs if an individual migrate into a different population but does not reproduce. The migrant's gene must become part of genetic makeup of the population into which it has migrated.

If genes are carried to population where those genes previously did not exist, gene flow can be very important source of genetic variation. In the graphic below, the gene version for dark coloration moves from one population to another.

4. Recombination

Genetic recombination happens during meiosis, special types of cell division that occur during formation of the sperm and egg cell and give them correct number of chromosomes. Inside the cells that produce sperm and egg the chromosome become paired, while they are passed together, the chromosome may break, and each may swap a portion of its genetic materials for the matching portion from its mate. This form of recombination this called crossing over.

When the chromosomes glue themselves back together on separate each has picking up new material from the other. After the chromosomes separate, they are parceled out into individual sex cells. Each chromosomes move independently of all the others a phenomenon called independent assortment. Like mutation recombination an important source of new variation for natural selection to work upon the population.

5. **Genetic Drift**:

A change in allele frequency of new population as compared with origin population due to random happens or by chance. This is more likely to occur in a small population in each generation, some individuals may, just by chance, leave behind a few more descendants (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better individuals for example: the brown color arises during reproduction just by random luck. More brown genes end up in the offspring than green genes, providing diversity without any adaptations. Accidents in small populations can change the frequency of some genes. Such variations in a population occur, in the diagram at right, gray genes occur slightly more frequently in the offspring than in the parent generation. So although genetic drift is a mechanism of evolution, it doesn't work to, produce adaptations.

Lab.4

How Diversity happened

Evolution

The biological evolution is defined as any genetic change in population that is inherited over several generations. These changes may be small or large, noticeable or not so noticeable.

In order for an event to be considered an instance of evolution, changes have to occur on the genetic level of a population and be passed on from one generation to the next. This means that the **genes**, or more specifically, the **alleles** in the population change and are passed on.

These changes are noticed in the **phenotypes** (expressed physical traits that can be seen) of the population.

It has been observed that the gene structure in a particular species undergoes a small-scale evolutionary change, over time. That is the reason we find different races in human beings or different breeds in dogs. This phenomenon is called **microevolution** (figure 1).

Biologists believe that this process over a much larger time scale can lead to so much of genetic change that it may give rise to a new species. This theory is the extrapolation of microevolution over very long time scales. It is termed as **macroevolution** (figure 2)

Figure 2: the differences between microevolution and macroevolution

Patterns of evolution:

Evaluation helps us to understand the history of life. Progressive evolution is in process, species adapt and evolve to better survive in their environments and caused changes in their traits. Similar environments can cause similar adaptation in different species, and different environments can cause different adaptation in similar species these differences lead to diversity in environment. There are five main patterns of evolution:

1. **Divergent evolution**
2. **Convergent evolution**
3. **Parallel evolution**
4. **Coevolution**
5. **Adaptive evolution**

1. Divergent evolution

Divergent evolution is when two related species are evolving to become more and more dissimilar. An example of divergent evolution is the red and the kit fox. The red fox lives in farmlands and forests where its red color easily camouflages it, as compared to the kit fox that lives on the plains and in deserts where it is also easily camouflaged by its sandy coloring. Also, the kit fox has larger ears as opposed to the red fox. These characteristics show a common ancestor between the two; however, they are evolving farther and farther apart. (Figure 3)

Figur3: Describes divergent evolution toward different traits in closely related species due to different environments

2. Adaptive evolution

Natural selection can ultimately lead to the formation of a new species. Sometimes many species evolve from singles ancestral species. Similarities in skeletal and muscle structure of Hawaiian honeycreepers led scientist to conclude that the 23 species of Hawaiian honeycreepers evolved from one ancestor of Species. Such an evolutionary pattern in many related species evolved from single and ancestral species is called adaptive radiation adaptive radiation most commonly occur when species of organisms successfully invades an isolated region where a few competing species exist. If a new habitats are available, a new species will evolve.(Figure 4)

3. Convergent evolution

Convergent evolution is the opposite of divergent evolution. Instead of growing farther apart, two unrelated species evolve to be more and more similar. An example of convergent evolution is a cactus which grows in the American deserts and the euphorbia, which grows in African deserts. Both plants have fleshy stems loaded with spines which help the plants store water and ward off predators. (Figure5)

Figure 4: Adaptive or Radiation evolution

4. Parallel evolution

Parallel evolution: two or more species from similar evolutionary history continue to evolve similar characters, example: social behavior in bees, wasps, and Ants. Figure 6

5. Coevolution

Coevolution is when one species evolves in response to another species evolution. An example of coevolution is when a plant's morphology changes, thus affecting the herbivore that eats the plant, which could affect the evolution of the plant, then the animal again, so on and so forth.(Figure7)

Figure 7: Coevolution

Lab.5
Evidence for Evolution

There are basic types of evidence for evolution: Paleontological (Fossils), Biochemical, Geographic, Comparative anatomy, vestigial organ, Comparative embryology, and Biological systematics.

1. Evidence of fossils

Fossils are the preserved remains of animals, plants, and other organisms from the distant past. Examples of fossils include bones, teeth, and impressions. They are extremely important for understanding the evolutionary history of life on Earth, as they provide direct evidence of evolution and detailed information on the ancestry of organisms.

Paleontology is the study of the developing history of life on Earth, of ancient plants and animals, based on the fossil record.

Evolution of the horse Fossil represents one of the best examples of evolutionary history (Figure8), also Archaeopteryx refers to another example of fossils and it represent the link episode between birds and reptiles Figure9

Figure8: Evolution of the horse Fossil evidence, depicted by the skeletal fragments, demonstrates evolutionary milestones in this process. Notice the 57 million year evolution of the hore leg bones and teeth. Especially obvious is the transformation of the leg bones from having four distinct digits to that of today's horse.

2. Evidence of Biochemistry

Biochemistry, the study of chemicals found in cells, includes the study of molecular biology and genetics. All living things contain the same macromolecules such as **Chromosomes and Nucleic acids**, **proteins**, **enzymes**, **hormones**, **hemoglobin**, and **Cytochrome C**. The metabolism in different organisms depends on same chemical component. This similarity in biochemistry among living organisms is in itself evidence for descent from a common ancestor.

3. Evidence of Biogeography

Biogeography is study of where organisms live now and where they and their ancestors lived in the past. Two biogeographical patterns are significant. The first; closely related but different species live in slightly different habitats such as the evolution of 15 closely related species of Darwin's finches (figure10), while the second pattern; distantly related but similar species live in similar habitats around the world (figure 11).

4. Evidence of Comparative anatomy

Comparative anatomy is the study of the similarities and differences in the structures of different species. Similar body parts may be homologies or analogies. Both provide evidence for evolution.

Homologous structures are structures that are similar in related organisms because they were inherited from a common ancestor. These structures may or may not have the same function in the descendants. (**Figure 12, A)** shows the hands of several different mammals. They all have the same basic pattern of bones. They inherited this pattern from a common ancestor. However, their forelimbs now have different functions.

Analogous structures are structures that are similar in unrelated organisms. The structures are similar because they evolved to do the same job, not because they were inherited from a common ancestor. For example, the wings of insects, birds and bats, shown in (**Figure 12, B)**, look similar on the outside. They also have the same function. However, wings evolved independently in the two groups of animals. This is apparent when you compare the pattern of bones inside the wings.

5. Evidences of Vestigial organs

These are structures that do not have any use, but are the remains of structures that were once functional in ancestral organisms. Man has over two hundred such vestigial organs for such as: the vermiform appendix, coccyx, ear muscles, and plica semilunaris the nictitating membrane of the eye of ancestors. Also 3rd molars Horses- splint bones, whale and snake pelvis/hind legs.

The theory of evolution suggests that the forms have descended from the ancestral forms which were using these structures constantly (**Figure13**).

6. Evidences of Comparative Embryology

Comparative embryology is the study of the similarities and differences in the embryos of different species. Similarities in embryos are evidence of common ancestry. All vertebrate embryos, for example, have gill slits and tails. Most vertebrates, except for fish, lose their gill slits by adulthood. Some of them also lose their tail. In humans, the tail is reduced to the tail bone. Thus, similarities organisms share as embryos may be gone by adulthood. This is why it is valuable to compare organisms in the embryonic stage.

7. Biological systematics

Biological **systematics** is the study of the diversification of living forms, both past and present, and the relationships among living things through time. Relationships are visualized as evolutionary trees (**cladograms, phylogenetic trees, phylogenies**). Phylogenies have two components: **branch order** (showing group relationships) and **branch length** (showing amount of evolution) (**Figure 15**). Phylogenetic trees of species and higher taxa are used to study the evolution of traits (e.g., anatomical or molecular characteristics) and the distribution of organisms (biogeography). Systematics, in other words, is used to understand the evolutionary history of life on Earth

Lab.6

Measuring Biological Diversity

Relationship between the number of species and the space that are present, is one of the most important to studied in ecology, because the relations can be made the basis of measurement of biodiversity.

The measuring of the diversity represented by the following:

1- The use of indicators of biodiversity which include the total number of species and the presence of rare species.
2- The dependence of the values of relative abundance of types which prevailing the complete diagnosis and calculation of rare species.

In Addition, biological indicators can be used on discrimination between species occurred. The scientists used a number of measurements to monitor the environment such as:

- **Measurement of ecosystem function:** usually used to describe the stability of environment and the extent of their response to various pressures, and these measurements measure productivity, the role of carbon, as well as the rate of decomposition, and respiration rate.
- **The measurements of the structure of society:** the measurements are

used as indicator of the impact of different human activities on the environment such as the number of Species, relative density, and the installation of the food chain.

- **Measurement of biological reagents:** there is a measured by individuals and populations, and depends on the choice of certain types to respond quickly to the effects (Direct or Indirect) biological indicator must be sensitive to slight changes in the environment.

Some of the indicators used in studies of diversity

I. Relative abundance index (Ra)

The density defined as: (the number of individuals in the unit area) or volume of a particular certain, while **Relative abundance**: (the number of individuals returning to the type as compare with a total density. This indicator is used to determine dominant species and at least rare species in the environment.

Relative abundance index (Ra)

Ra = N / Ns*100

N=Number of individuals in one species in sample.

Ns=Total number of individuals of the different species of same sample.

Results are expressed as percentage as follows:

>70% dominant species

40-70% abundant species

100% little specie

<10% rare specie

Example :

In water invertebrate sample, there are four species with numbers of individuals as:

- First species = 5 individuals
- Second sp. = 50 individual
- Third sp. =5 individuals
- Fourth sp. =10 individuals

Calculate the relative abundance for this species.

Answer :

Relative abundance for First sp. =5/5+50+5+10x100=7%

Relative abundance for Second sp. = 50/5+50+5+10x100=71%

Relative abundance for Third sp. = 5/5+50+5+10x100=7%

Relative abundance for Fourth sp. =10/5+50+5+10x100=14%

So, the first spices and the third sp. Considered as rare, while the second sp. was dominant and the fourth sp. was little

II. Constancy index (S):

This index expressed about the stability of each species in environment and the replications of its appearance in the same environment.

$$S = n / N*100$$

n= number of samples which has the species

N= total number of samples

Results are expressed as percentage as following:

50% fixed species
25-50% additive species
1-25% emergency species

Example :

In a study on some species of phytoplankton in water, and after take five replication samples) monthly, the results found as following:

- First sp. Found one time
- Second sp. found four times
- Third sp. found two times
- Fourth and fifth sp. were found one time only

Calculate the constancy index for this species:

Answer :

Constancy index for first sp. = 1/5*100 = 20%

Constancy index for second sp. = 4/5*100 = 80%

Constancy index for third sp. = 2/5*100 = 40%

Constancy index for fourth sp. = 1/5*100 = 20%

Constancy index for fifth sp. = 1/5*100 = 20%

So the first spices, fourth sp. and the fifth sp., considered an emergency species, while the second sp. was fixed species and the third species was additive species.

Species richness index (D):

Species richness: refers to the number of species and the diversity within the sample, also is this index represent the absolute number species at site.

$$D = (S - 1) / \text{Log } N$$

S = Number of species

N = total number of individuals

Example :

The calculated number of species in a sample of benthic invertebrates living in fresh water equal to 10 species, within an intensity (total number of individuals) =800 individual/m^2, Calculate the Species richness index for this sample.

Answer :

D = (S-1) /log N
D = (10-1/log 800
=9/2.9 =3.1

Lab.7
Speciation

Speciation is about how species form or originated and it is important to understand evolutionary biology.

There are two patterns of speciation as evidenced by the fossil record:

- **Anagenesis:** is the accumulation of changes associated with the transformation of one species into another, does not promote biological diversity (figure1, A).
- **Cladogenesis**: branching evolution is the budding of one or more new species from a parent species. Cladogenesis promotes biological diversity by increasing the number of species (figure1, B).

A biological concept of a species is a population or group of populations that are able to interbreed, under natural conditions to produce fertile offspring.

The selective mechanisms that favor beneficial traits, natural selection, are also responsible for speciation (the formation of an entirely new species). Evolutionary changes that occur at the species level are known as **microevolution**.

Reproductive isolation:

The reproductive isolation or hybridization barriers are a collection of mechanisms, behaviors and physiological processes that prevent the members of two different species that cross or mate from producing offspring, or which ensure that any offspring that may be produced are sterile. These barriers maintain the integrity of a species over time, reducing or directly impeding gene flow between individuals of different species, allowing the conservation of each species' characteristics. There are two types of Reproductive isolation:

I. Prezygotic: happen before zygotes are formed.

II. Post zygotic: happen after zygotes are formed

I. Prezygotic Mechanisms:

Prezygotic mechanisms prevent interspecies mating and fertilization. There are four types of isolation that prevent mating from occurring, thus maintaining species isolation.

- **Ecological isolation**
- **Temporal isolation**
- **Behavioural isolation**
- **Mechanical isolation**
- **Gametic isolation**

1. Ecological isolation:

When species occupy separate habitats or niches and do not encounter one another to reproduce due to some geographic or ecological barrier, such as ground squirrel species occupy different habitats (Figure2).

Lab.8

2. Temporal isolation

When two species are found in the same area, but are incapable of mating due to different reproductive cycles for flowering or mating. Such as Red and black sea urchins live in the same location, but release their gametes at different times of the year (figure3).

3. Behavioral isolation

Behavioral isolation when distinct mating rituals by one species may prevent members of another species from recognizing or selecting a mate. Such as male jumping spiders dance (shake their legs and wave their palps), Females of different species do not respond to the dance (Figure4, A). In many species, elaborate courtship displays identify potential mates of the correct species and synchronize gonadal maturation (Figure4, B).

4. Mechanical isolation:

Closely related species may attempt to mate but fail because they are anatomically incompatible and transfer of sperm is not possible.

- To illustrate, mechanical barriers contribute to the reproductive isolation of flowering plants that are pollinated by insects or other animals.
- With many insects the male and female copulatory organs of closely related species do not fit together, preventing sperm transfer.

5. Gametic isolation:

Gametic isolation occurs when gametes of two species do not form a zygote because of incompatibilities preventing fusion or other mechanisms.

- In species with internal fertilization, the environment of the female reproductive tract may not be conducive to the survival of sperm from other species.
- For species with external fertilization, gamete recognition may rely on the presence of specific molecules on the egg's coat, which adhere only to specific molecules on sperm cells of the same species.
- A similar molecular recognition mechanism enables a flower to discriminate between pollen of the same species and pollen of a different species.

II. Postzygotic barriers:

Postzygotic barriers prevent the hybrid zygote from developing into a viable, fertile adult. These barriers include reduced hybrid viability, reduced hybrid fertility, and hybrid breakdown.

Lab.9

Natural Speciation

Types of Speciation

1. Allopatric speciation: physical barrier divides population.

2. Peripatric speciation: small founding population enters isolated niche.

3. Parapatric speciation: new niche found adjacent to original one.

4. Sympatric speciation: speciation occurs without physical separation.

1. **Allopatric:**

A population splits into two geographically isolated populations for example, by habitat fragmentation due to geographical change such as mountain building) such as Darwin's Galápagos Finches (Figure5). The isolated populations then undergo genotypic and/or phenotypic divergence as:

- They become subjected to dissimilar selective pressures
- They independently undergo genetic drift
- Different mutations arise in the two populations.

Ecological Niche: the role a species serves in its ecosystem including what it eats, what eats it, and how it behaves; no two species have the same ecological niche.

2. **Peripatric**:

It is a subform of allopatric speciation; new Species are formed in isolated smaller peripheral populations that are prevented from exchanging genes with the main population genetic drift proposed to play a significant role in type of speciation. **Such as** the evolution of polar bears from the brown bears is one of the best-known examples of this mode of speciation.

3. <u>Parapatric Speciation</u>

There is only partial Separation of the zone of two diverging population afforded by geography. Such as Ensatina salamanders (Figure6).

4. <u>Sympatric speciation</u>

Sympatric speciation: refers to the formation of two or more descendant species from a ancestral species all occupying the same geographic location. Often-cited examples of sympatric speciation are found in insects that become dependent on different host plants in the same area (Figure7).

Lab.10

The Biodiversity and Conservation

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity the survival of many species and habitats which are threatened due to human activity can be ensured. Other reasons for conserving biodiversity include securing valuable Natural Resources for future generations and protecting the wellbeing of ecosystem functions.

In-situ and Ex-situ conservation

Conservation can broadly be divided into two types:

<u>In-situ:</u> Conservation of habitats, species and ecosystems where they naturally occur. This is in-situ conservation and the natural processes and interaction are conserved as well as the elements of biodiversity.

<u>Ex-situ:</u> The conservation of elements of biodiversity out of the context of their natural habitats is referred to as ex-situ conservation. Zoos, botanical gardens and seed banks are all example of ex-situ conservation.

IUCN

The International Union for Conservation of Nature (IUCN); is an international organization working in the field of nature conservation and sustainable use of natural resources. It is involved in data gathering and analysis, research, field projects, advocacy, and education. IUCN's mission is to "influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable".

IUCN Red List Categories

Species are classified by the IUCN Red List into nine groups,[15] specified through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation (Table below).

Criteria → ↓Category	A Population trend % decline	B Geographic distribution Area in Km²	C&d Population size Number of mature individuals	E Extinction % Probability
EXTINCT				
EX: Extinct	Certainty that the last wild individual has died			
EW: Extinct in the Wild	Certainty that the last wild individual has died, but captive individuals persist			
THREATENED				
CR: Critically Endangered	$\geq 80^{A2/3/4}$ to $\geq 90^{A1}$	$<10^{B2}$ to $<100^{B1}$	$<50^{D1}$ to $<250^{C}$	≥ 50 in 10yr or 3ge ^{C}
EN: Endangered	$\geq 50^{A2/3/4}$ to $\geq 70^{A1}$	$<500^{B2}$ to $<5{,}000^{B1}$	$<250^{D1}$ to $<2{,}500^{C}$	≥ 20 in 20yr or 5ge ^{C}
VU: Vulnerable	$\geq 30^{A2/3/4}$ to $\geq 50^{A1}$	$<2{,}000^{B2}$ to $<20{,}000^{B1}$	$<1{,}000^{D1}$ to $<10{,}000^{C}$ or <20km ^{D2} or ≤ 5 sites ^{D2}	≥ 10 in 100 yr
NOT THREATENED				
NT: Near Threatened	Close to qualifying among threatened categories			
LC: Least Concern	Widespread and abundance taxa			
UNKNOWN STATUS				
DD: Data Deficient	Not enough information to asses extinction risk			
NE: Not Evaluated	Not assessed against criteria			
REGIONAL (in addition to global categories)				
RE: Regionally Extinct	Extinct regionally but not elsewhere			
NA: Not Applicable	Individuals are vagrant, outside their natural range or introduced for no conservation purposes			

Superindexes indicate codes for criteria *A* to *D* and sub-criteria *1* to *4* — yr = years, ge = generations

Endemic vertebrates of Iraq Fish

Fish

One example is the Haditha Karst (Cave) system KBA In Iraq, which is impacted by falling groundwater levels, supporting two endemic and Critically Endangered cave fishes; the Haditha Cave fish (*Caecocypris basimi*), and the Haditha cave garra (*Typhlogarra widdowsoni*).

Amphibians

The Kurdistan Newt, or *Neurergus microspilotus*, like many salamander species, is known for its breeding behavior. It was previously thought that this newt is restricted to the Avraman Mountains of the Iraq- Iran-Turkey border. However, based on extensive fieldwork in central and northern regions of the Zagros Mountains in Kermanshah and Kurdistan Provinces, the Kurdistan Newt has been found in at least nine severely fragmented streams, with almost no movement of the species among the streams. The Kurdistan Newt is currently listed as 'Critically Endangered' on the IUCN Red list of Threatened Species.

A major threat to this species has been a series of severe droughts affecting its breeding habitat, which has led to the extirpation of some populations. Stream water is being extracted by nearby orchards and wheat fields, and some water contamination near villages is causing decline in populations.

Reptiles:

Asaccus is a genus of geckos commonly known as Southwest Asian leaf-toed geckos. The Saffine leaf-toed gecko (*Asaccus saffinae*) is endemic to northern mountains of northern Iraq and its name derived from Saffine Mountain in Erbil province where it was discovered in 2009. It is a cave dowelling gecko.

Birds

Mesopotamian Crow

Mesopotamian crow (*Corvus cornix capellanus*), also known as the Iraq Pied Crow, is a brid species crow genus. The crow is native to the region of Mesopotamia, in southern Iraq and southwest Iran between the Tigns and Euphrates rivers. The crow is sometimes considered to be a subspecies of the hooded crow (*Corvus cornix*), but is also sometimes distinguished as its own species of crow, as it is characterized by its pied coloration.

The Near-endemic Basra Reed Warbler

The Basra reed warbler (*Acrocephalus griseldis*) is a "warbler" of the genus *Acrocephalus*. It is an endemic breeder in East and southern Iraq in extensive beds of papyrus and reeds, it is easily mistaken for the great reed warbler but is a bit smaller, has writer under parts and has a narrower, longer and more pointed bill. It winters in East Africa. It is a very rare vagrant in Europe. It is found in aquatic vegetation in or around shallow, fresh or brackish water, still or flowing, mainly in dense reed beds. It is found in thickets and bush land when migrating or wintering.

Mammals

Iraq or Maxwell's Smooth-coated Otter

Smooth-coated otters occur throughout much of the Indian Subcontinent and contiguous regions of Southeast Asia, in the indomalaya ecozone. An isolated population of the species is also found in the marshes of Iraq, Smooth-coated otters are found in areas where fresh water is plentiful - wetlands and seasonal swamps, rivers, lakes, and rice paddies. Where they are the only species of otter, they may be found in almost any suitable habitat, but where they are sympatric with other species, they avoid smaller streams and canals in favor of larger bodies of water.

Although they are often found in saltwater near the coast, especially on smaller islands, they require a nearby source of fresh water. There are three recognized subspecies of *Lutrogale perspicillata*: *L. p. perspicillata* – most of India, Nepal, southwestern Yunnan, most of Southeast Asia, Sumatra, Java; *L. p. maxwelli* – southern Iraq; and *L. p. sindica* – Sind, Pakistan.