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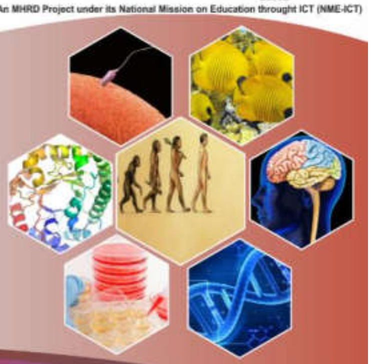

Production of Courseware

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Paper : 12 Principles of Ecology

Module : 7a Life History Strategies (Part 1)

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Description of Module	
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Contents

1. Learning Outcomes

- Students will be able to understand concept of life history strategies.
- Will be able to appreciate different life history adaptations as designs to match the environment organisms live in and resources at their disposal.
- Will understand the concept of trade-off.
- Will understand what are life history traits.
- Will understand how and why reproductive success is maximized by organisms using different strategies associated with reproduction.
- At the end will be able to appreciate there is nothing called good/ bad or perfect strategy, organisms inhabiting different environments employ different optimal balance between costs and benefits, maximising the fitness of the organism.

2. Introduction

The life history strategies lie at the heart of ecology. It is the only field which brings you close enough to the fine thread weaving the diversity and complexities of living being together. Study of life histories reveals the underlying simplicities that unite and explain the astonishing diversity of living beings existing on earth and their bizarre life cycles. A close look at these life histories reveals how beautifully they are designed to suit the lifestyle of the organisms. Life history studies also bring into the picture the various strategies or set of patterns, influencing both survival and reproduction. These strategies are nothing but adaptations which have evolved to enhance fitness by efficient use of resources. In fact, different life histories can be seen as different strategies to achieve fitness. The study of life history traits is one area that serves as key to understanding related fields also. Studying life histories traits and strategies leads to a better understanding of the action of natural selection, the central force of evolution.

3. Life History Strategies

The big, brightly coloured male blue-headed wrasse definitely deserves a second look, especially when the females are dull and smaller, relatively. The two black bands intervened by a white band distinguish his blue head from green body. It enjoys a harem of females on the small reef it lives on. It is skilled at wooing females showing off its bright colouration and elaborate courtship behaviour. It copulates with each of the females and induces them to release a batch of eggs while it's busy releasing sperms. The cloud of eggs and sperms fades as they get drifted away with the water current.

Figure 1: Male blue-headed wrasse (*Thalassoma bifasciatum*)

Source: https://www.flmnh.ufl.edu/fish/Gallery/Descript/Bluehead/Bluehead.html

Most of the eggs will not make it to larva and serve as food to a predator waiting. The survivors hatch as larvae. Only a few fortunate ones survive and successfully make it to reefs. On reaching a small reef where another single male, like its father- big and colourful, lives with its harem of females, the tiny larva continues to feed and grow. Like most of the blue-headed wrasses this one also matures as a female after one year of age. The ten centimetres long yellow coloured (initial phase) female mates with the same blue headed (terminal phase) male –double its own size. After three years it is the largest female on the reef. One fateful night the lone male on reef turns into a predator's feast. Within 24 hours the largest female present on the reef decides to take charge and acquires the blue – green colouration. Its ovaries shrink and the next day it mates as a male for the first time in its life (a phenomenon called as protogyny - starting life as female and then changing sex to male). On another reef, a different story was going on. A larva reached on the reef big enough to be defended by a single male. Holding territories doesn't make sense here, as reef if too big to be guarded single-handedly. The fortunate survivor grows, feeds and after one year its small, 10 cm long dull male. In fact it resembles a female. It wastes no energy in making futile mating efforts. It simply waits for right opportunity which comes when a large, brightly coloured blue headed male begins to mate with a female. It sneaks in and releases its sperm into spawn. Over the course of its life this small, dull male gets many such opportunities. The reproductive success (offspring surviving) of this is as much those of few large males on the reef which started off life as females (Stearns, 1992).

The story of blue-headed wrasse is intriguing beyond doubt. Nature has got plenty of such bewildering tales to tell. The question which raises head with all such tales is – why an organism has a particular kind of life- cycle? The answer is simple- nature knows the best. Through natural selection, nature has engineered all organisms to suit the environment they inhabit. A change in set of environmental conditions brings along a variation in form and function. Biologically, the only purpose to live is to reproduce and contribute to gene pool. This defines the reproductive success which is a measure of evolutionary fitness. The differences we encounter among different populations or species are actually adaptive modifications which improve their evolutionary fitness. In the case of blue-headed wrasse, on small reef where territories can be maintained, most of the young fish mature as females and very few as small, dull males. On the contrary, large reefs witness more of young fish maturing into small, dull males, never changing sex. The fish develop into the adult form which is appropriate to the reef at which they arrive. Thus, there exists an inseparable bond between the ecology and evolution. The organisms respond and adapt to the physical conditions of environment they live in. Irrespective of their design, the ultimate task of all living beings is to reproduce and leave as many successful progeny as possible. The survival and the reproductive success are two major components of fitness. Organisms strive to acquire the maximum possible fitness focussing on survival/and reproduction, through various and sometimes even bizarre ways. Nature's bag is full of such life cycles leaving one bewildered and some even demanding explanations. The answer to such intriguing puzzles is really simple. A sea of options is open to organisms as they are about to start life. Depending upon the physical conditions of environment and other selection pressures, organisms opt for a particular design of life. The decision pertaining to a design comprises many aspects of life or **“traits”**.

The rules followed and the choices made while going for a design of life are referred to as **“Life history strategy”**. Thus, life history strategy is basically the options exhausted, influencing traits associated with individual’s survival and schedule of reproduction.

4. Life History Traits

Life history of an organism includes the various phases it passes through in its life cycle. The sequence of events that occur in a general life cycle can be simplified as birth, followed by a period of growth or pre-reproductive period, a reproductive period, a post- reproductive period and death. The variations are commonly found around this simplified version of life cycle. Life history basically explains the broad features of a life cycle – how fast the organism will grow, when it will mature, how long it will survive, how many times it will reproduce, how many offspring it will have etc. Life history traits are associated directly with organism’s survival and reproduction. The life history traits affect the growth rates of populations. The average life span of the individuals, the age at which reproduction begins and ends, female fecundity (number of offspring produced by the female) etc, all these traits together not only shape up the growth rate of a population but also determine its abundance.

The principal life history traits are:

- Size at birth
- Growth pattern
- Age at maturity
- Size at maturity
- Number and size of offspring
- Age and size specific reproductive effort
- Life span

Organisms have evolved different life history strategies or ways, of combining these traits together to maximise their fitness. Basically life history strategy explains the allocation of time and resources in various activities associated with life, affecting fitness. Time and resources (or in other words energy) both are limited. Within these imposed limits an organism has to make decisions to achieve fitness. Survival and reproduction are not only the two major components of fitness but also time and energy demanding. If two processes compete directly or indirectly for the limited amount of resources and energy which an organism can procure, then an increase in resource and energy allocation to one results in a decrease in resource and energy allocated to other. Life history trade-offs are an organism's balancing of energy and resource allocations to necessary strategies of life: growth, reproduction, and survival. The success of a life history strategy depends on both the environment and the developmental constraints of an organism.

5. Trade-offs

(You can't have the best of both worlds!)

The energy an organism can harvest is finite. Also biological processes take time. The two most important components of fitness -Survival and reproduction, both use the same currency- energy and are time taking processes. The resources and time allocated to survival (growth, maintenance and defence) can't be utilised for the reproduction or vice –versa, resulting in an everlasting conflict between the two. This explains the reason-Why do not all fitness maximising traits of organism - large body size, long life spans, early maturity, high fecundity, repeated reproduction, large-sized offspring, parental care etc. ever come together. There are phylogenetic (set by evolutionary history of the lineage) and physiological or genetic constraints which limit the organisms from evolving all fitness enhancing traits, simultaneously. **Trade-off** are physiological constraints where advantage of a change in any trait is correlated with disadvantage in other. For example- organisms that allocate more resources and time to reproduction than their own growth or maintenance exhibit poor growth and subsequent survival (cost of reproduction). Similarly, an organism can allocate energy to growth for a long time, enabling it to reach a larger size and good quality offspring. The larger size is a benefit but there is a cost associated with it. The longer an organism takes to grow or mature higher the chances of predators, parasites or diseases striking it. Thus, large size comes with an inbuilt risk; the organism may die without reproducing at all. The only solution to the problem of trade-offs between the different components of fitness is the allocation of resources and time with an optimum balance between costs and benefits, maximising the fitness of the organism. Organisms inhabiting different environments employ different optimal balances. Thus, the perfectly engineered life history traits of different species or populations may be attributed to such trade-offs in fitness among different character states in different environments.

5.1. Age at reproduction

Reproduction is a costly affair, especially for the mothers. The female invests much more than the male when it comes to reproduction. Obviously, the decision to begin reproduction is a crucial one as it is associated with allocation of energy or resources. Age at first reproduction (referred to as age at maturity) shows a great deal of variation. It varies not only among species but within populations as well. Age at maturation is absolutely critical as fitness is usually more sensitive to changes in this trait as compared to the other traits. Both early maturation and delayed maturity come with their respective costs and benefits.

The benefits of maturing earlier are twofold. First, early maturing organisms spend less time as juveniles which increases their chance of survival and reaching maturity (Bell, 1980). Second, the offspring are produced at an early age and start contributing to the population growth along with the parent (it is like compound interest, where interest adds on to the principal). Thus, early maturing organisms have higher fitness (Cole, 1954). Barring few exceptions, most insect species begin to reproduce at a very early age. At the same time the risks associated with this strategy cannot be ignored. Poor growth, increased risk of death and poor subsequent fecundity are some of the hazards associated with early reproduction. Thus, a trade –off exists between early reproductive effort and late reproductive success and or survival. There are ample evidence documented in support of such early tryst with reproduction and associated disadvantages.

5.1.1. Clutch size compromise!

Figure 2: Collared flycatcher (*Ficedula albicollis*)

Source: http://www.flickr.com/photos/42244964@N03/10255025225/in/photostream/

On the Swedish island of Gotland, the collared flycatcher (*Ficedula albicollis*) (Figure 2) population was studied by Gustafsson and Pärt (1990) for 10 long years. The researchers followed individual bird life histories. There was a variation in age at maturity among females. Some females in the population opted to invest into reproduction at an early age and began brooding at the age 1, while others waited until age 2. The females that reproduced earlier had smaller clutch sizes (number of eggs laid in a set by the female bird) throughout life, than those who were more patient.

The decision to reproduce not only affects the offspring (size and number) but also influences parent's own life span. Especially for mothers, reproduction is a costly affair. The resources available for growth and maintenance are diverted to reproductive activities, resulting in reduced longevity.

5.1.2. Mother bears the cost: Reduced longevity!

Figure 3: Rhesus macaque (*Macaca mulatta*), mother and baby

Source: http://news.bbc.co.uk/2/hi/science/nature/7934852.stm

Rhesus macaque (*Macaca mulatta*), is a long-lived, slow-reproducing primate (Figure 3). The macaques reproduce repeatedly, usually producing one young each year, which is raised by mother. The mother macaques like other primates constantly struggle to strike a balance between current reproduction and survival and future reproduction. The mothers investing in reproduction at an early age suffered in terms of longevity and had a reduced life span (Blomquist, 2009). Evidence in support of such trade-offs also comes from Sand crickets (*Gryllus firmus*) population where the choice is between flying ability and early reproduction (Zera, 2005).

5.1.3. Reproduce or Disperse?

In natural populations of sand cricket (*Gryllus firmus*), females exist as two distinct morphs: long winged and short- winged. The long-winged forms obviously have an edge when it comes to dispersal ability as they are blessed with fully developed flight muscles at the time of emergence as adults and a rich storage of triglycerides- the fuel used by flight muscles. Dispersal to more desirable patches in terms of resource is absolutely crucial for better survival chances when resources are diminishing. Thus, flying ability of long- winged females is an advantage but it comes at a cost. The ovaries of long- winged females grow at a considerably slower rate than those of short winged females. The short winged females produce less total lipid and triglycerides but more phospholipids (which is important in egg development), than long winged females. The two morphs clearly display different specializations (flight versus early reproduction) via intermediary metabolism.

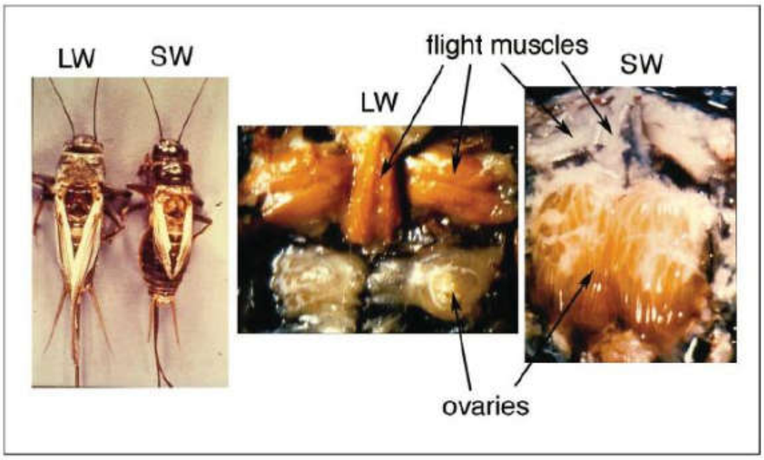

Figure 4: Long-Winged female (LW) and Short-Winged (SW) female morphs of *Gryllus firmus* of the same age (day 5 of adulthood). In the left panel, the fore wings have been removed to show variation in the hind wings. The middle and right panels illustrate dissections of morphs showing much larger, functional flight muscles, but much smaller ovaries, in the flight-capable female, and substantially-underdeveloped flight muscles but much larger ovaries in the flightless female
Source: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1007&context=bioscizera

The other alternative to this strategy is **delayed reproduction**. Here, organisms allocate energy into growth and withhold reproduction till a later age. Delayed maturity in many cases allows further growth. In many species (plants and fishes) which grow throughout life, fecundity increases with size (it is correlated with body mass). Delayed reproduction, in such cases leads to greater initial fecundity as the organisms allocate resources to growth and self-maintenance than to immediate reproduction, a kind of investment which pays off later.

5.1.4. Why do mothers matter!

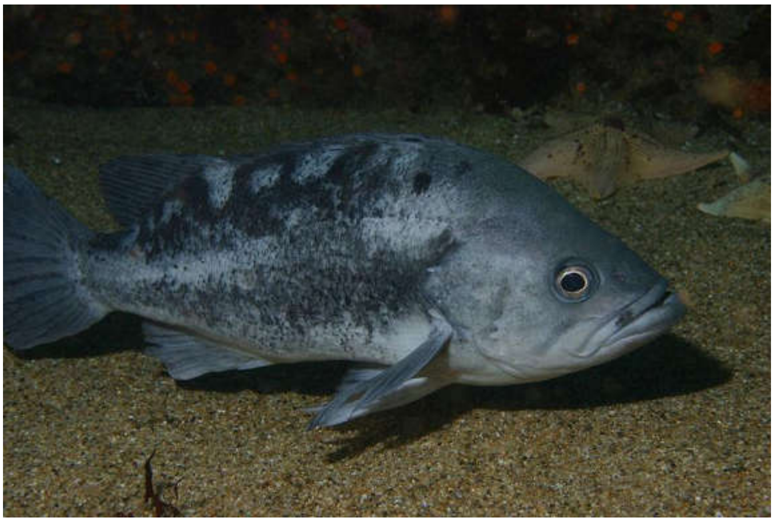

Figure 5: Black Rockfish (*Sebastes melanops*)

Source: http://www.mbnms-simon.org/other/photos/photo_info.php?photoID=455

Black rockfish (Figure 5) which lives off the pacific coast of North America Female black rockfish (*Sebastes melanops*) continues to grow throughout their lives. The larger (older) females produce a much higher number of eggs as compared to smaller (younger) females (fecundity correlated with body mass). Also, older mothers produced eggs laden with larger oil droplets for their larvae, serving as an important metabolic fuel until they can feed at their own.

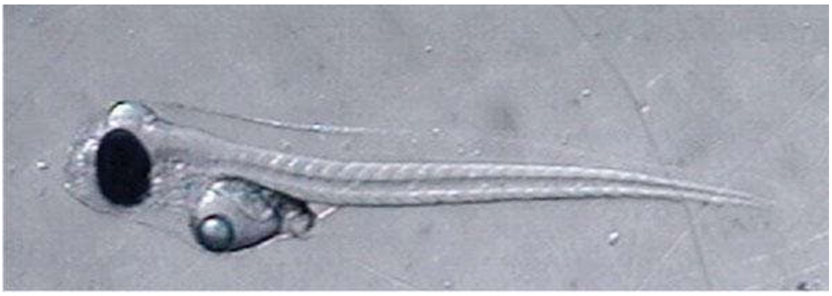

Figure 6: A larva from a 17-year-old black rockfish (*Sebastes melanops*), showing the large oil droplet used to fuel growth and stave off starvation

Source: http://www.nature.com/nature/journal/v430/n7000/fig_tab/430621a_F2.html

The larvae (Figure 6) hatching out from eggs with larger oil droplets grow faster and survive better than those hatching out from eggs with smaller oil droplets (Berkeley *et al*. 2004). The quality offspring produced increases juvenile survival rate. Thus, older rockfish mothers are reproductively more successful or have higher fitness.

Rockfish also offers an example how ecological conditions can influence life history traits which in turn can affect population growth rate and abundance. Let's continue our story of the black rockfish where older mothers proved reproductively more successful attaining higher fitness. The extensive size- selective harvesting of rockfish off the Oregon coast from 1996-1999 reduced the average age of rockfish, which non-intuitively decreased the number of eggs produced by those smaller females, decreased the larval growth rate and survival.

The strategy to invest more resources into growth and self-maintenance at an early age looks so perfect at the first glance that one may ask- why do not all organisms opt for it? Here only surfaces a very crucial question - What is the probability of survival till that later age of reproduction? A longer life-span allows delayed reproduction but if chances of reaching upto that later age of reproduction are low, early reproduction is favoured.

5.1.5. Guppies not in hurry, blame the predator!

In Trinidad, guppies (*Poecilia reticulata*) were studied by David Reznick and colleagues (Reznicket al.1990; Reznick and Travis, 2002). In some streams guppies faced tremendous predation pressure from the cichlid fish *Crenicichla alta* (Figure 7), which preys heavily on large (mature) guppies. In some streams and above the waterfalls, the *Crenicichla* was absent and guppies faced lower predation. The study revealed that guppies from *Crenicichla*-dominated streams were small-sized, matured faster, reproduced earlier and produced more and small sized offspring than guppies from streams with low predation. In two streams, Reznick and colleagues moved guppies from a site where they were preyed upon by *Crenicichla*, to sites where both guppies and the predator *Crencichla* were absent. After several generations guppies were collected from both, the place of origin and introduction, and offspring were reared under common laboratory conditions. Guppies relieved of *Crencichla* predation exhibited delayed maturation and reproduction, large adult size, fewer and larger offspring.

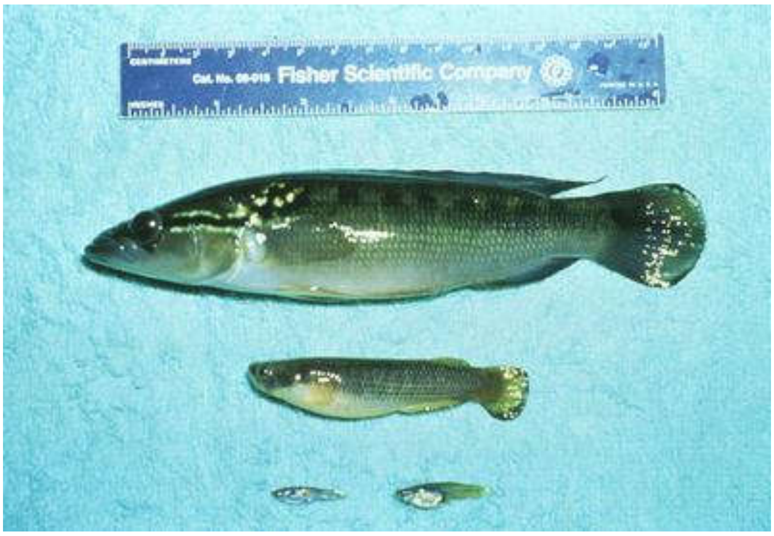

Figure 7: The fish at the top-*Crenicichla alta*. One of the key predators in high-predation localities. Middle fish *Rivulus hartii,* the only predator co-occurring with guppies in low-predation sites. The fish on the bottom left-an adult male guppy, on the bottom right- adult female guppy

Source: http://newsroom.ucr.edu/1209

Fathers also like to wait!

Figure 8: Terminal phase male blue-headed wrasse (*Thalassoma bifasciatum*)

Source: http://www.reed.edu/biology/professors/srenn/pages/teaching/web_2010/FIshEZ/index.html

The blue-headed female wrasses (*Thalassoma bifasciatum*) (Figure 8) in Panama mature earlier than males. The polygynous males prefer to wait and grow in size prior to entering reproduction. Size is important here as the reproductive success of male depends on its competitive ability with other males. On small reefs, (terminal phase) large males defending nests or maintaining mating territories are of common sight in this coral reef fish population. These dominant males are good at displaying elaborate courtship behaviour. Within the population are present another type – small, female- mimicking, males! These young males (initial phase) have very slim chances of reproductive success as compared to large older males if they have to compete directly. The young males achieve their reproductive success by sneaking into spawning of the large males. Thus, young males do not spend much time and energy in reproducing and their reproductive investment is lower on small reefs than on large reefs where it is not possible for large males to defend territories (Warner, 1984). On small reefs the reproductive success of large males is higher.

Within the populations of both, guppies' and blue-headed wrasses, two alternate strategies exist. The intriguing explanation for two different strategies employed can be two different routes to acquire fitness under different environmental and or social conditions. Species do not live in isolation and ecological interactions among and within species or population can also influence life history traits. In case of guppies, the predator cichlid forced the evolution of alternate strategy –early maturation and reproduction in otherwise late reproducing guppies. The intense sexual selection within blue-headed wrasse leads to alternate reproductive strategy.

Thus, the early and late maturation strategies come with their own benefits and costs and influence different components of fitness. Let us explore the other reproduction related decisions made by organisms, which involve strategic thinking.

5.2. Strategic thinking about reproduction

A codfish produces hundreds of thousands of tiny eggs whereas a Kiwi (*Apteryx*) (Figure 9) in a single egg that weighs 25 percent as much as its mother. A human baby takes almost an year to stand up and start walking while wildebeest calves, or babies of other grazing animals are up and running within few minutes after birth. The common tailor bird (*Orthotomus sutorius*) (Figure 10) parents make frequent visits to fetch food and feed the chicks while pheasant chicks (*Phasiamus colchicus*) can run and peck for food almost immediately after hatching, not bothering the parents much. All these are example of strategies employed by the animals when it comes to making decisions related to reproduction.

Figure 9: X-ray of a kiwi (*Apteryx*) showing bird's enormous egg

Source: http://sciencewritingblog.files.wordpress.com/2011/04/xray-kiwi.jpg

Figure 10: Common Tailor bird (*Orthotomus sutorius*)

Source: http://en.wikipedia.org/wiki/File:Common_Tailorbird_at_Pune.jpg

Once organism decides to reproduce the next question is regarding progeny size and number. The mother having fixed capital of calories can either make many tiny eggs or few large – sized ones. This strategy can be looked upon as - quantity versus quality, whether to lay enormous number of tiny eggs (small- egg strategy or raise a few large young (large- young strategy)? The **profligate** (small- egg strategy) or **prudential** (large young strategy) **reproduction** (Hutchinson, 1978), are two extremes but both work for the same cause –

attaining fitness. The two alternative strategies adopted by individuals of the different species work in widely different ways.

The reproductive fitness of parent is the cumulative effect of all surviving offspring produced in its life span. Higher the number of offspring produced which survive to reproduce as adults, greater the parental fitness. It would be in parent's interest therefore, to have large number of offspring. Parent can maximise its fitness by producing large number of offspring, investing a minimal possible amount into each. The return would be higher in this tactic if all survive or cost would be low in case of any accident and progeny loss. So, theoretically natural selection will push all organisms to manufacture numerous offspring. However, this is not practically possible as individuals have their own physiological constraints. Apart from physiological constraints of the individual species, environmental/ecological factors are notoriously famous to influence this trait. Length of juvenile period, competitors, predators, extent of parental care etc. all these factors also contribute substantially, to the strategic thinking about number and size of progeny to be produced.

On the other extreme, having few large young and investing more into each, promises higher reproductive fitness. The large young give a better return of survivors for every investment calorie. The fitness of progeny also depends on parent's clutch size decision. The fitness of offspring is inversely related to number of offspring produced by parent. It would be in favour for offspring if parent allocate entire reproductive effort into one single offspring. Large sized offspring have higher chances of survival. At the same time, larger offspring usually are, costlier. Clearly, there exists a **"conflict of interest between parent and offspring"** (Trivers, 1974). The conflict is obvious and logical as progeny and adults are exposed to different selective pressures. Parents often resolve this problem of conflicts by going for the largest possible number of offspring they can produce without compromising their own fitness.

5.2.1. Quantity or quality investment?

Number of offspring produced definitely adds to reproductive fitness. A mother investing very little into each egg can produce many tiny ones. Each egg is capable of developing into an adult. Thus, the measure of reproductive success (fitness) is the number of eggs produced.

Natural selection will push the organisms to produce as many eggs as produced. Everything sounds so simple and perfect but if this small egg strategy is so good then why do not all animals go for it? The answer is – fitness is not only the number produced, but the number that survives to reproduce. The chances of survival of all cod-fish eggs produced are slim. Many of those tiny eggs either satiate the predators or die by accidents and only a very tiny fraction reaches to adult stage and contributes in population growth. This explains the more or less stable population size of codfish or salmon despite such magnificent reproductive values. The calories invested in all those tiny eggs which fail to survive get wasted so at first sight it may look a bad decision but a second look endorses the strategy as the amount invested in each egg was moderately low and flooding of eggs ensured survival of at least a few.

Producing few large young is the alternate strategy to achieve reproductive fitness. The mother trades carefully by producing few young but investing more into each one of those. The chances of survival of each young are much higher than those tiny eggs produced in millions. The greater numbers of surviving offspring contribute more to population growth and at a faster rate. Thus, investing more per offspring turns out to be a smart strategy and overall higher fitness. The apportionment of energy reserves

5.2.1.1. Clutch size

The number of eggs laid by the bird in a single reproductive effort (termed as the clutch size) varies among species. The clutch size increases from equator to poles and from tropical rain – forests to tropical savannas. Clutch size also differs in case of seabirds that forage near the shore and those which forage far off. The explanation to all such observations lies in the evolutionary theory of natural selection. The nature selects the fittest where fitness is decoded as the reproductive success of the individual. One who leaves maximum number of offspring rules the game. Birds, being no exception to this rule follow this theory by heart and lay the number of eggs that will allow them to produce maximum number of offspring (maximising fitness). Thus, the number and size of the offspring produced has been adjusted via natural selection to optimise individual fitness. The optimum clutch size is that which produces the maximum fledglings (Lack, 1947). The clutch size of a species is shaped by many factors like environment, nest-predators, nest size, behaviour (number of parents caring for the young), body size, food supply etc. Clutch size may be constrained and show no variation within lineages (fixed clutch size). However, deviations from optimum clutch (referred as Lack clutch) size are no exceptions.

The clutch size variation looks pretty obvious when compared among different bird species and perhaps fails to grab our attention but it instantly ignites the curiosity when it's documented from different populations of a widely distributed bird species.

Tropical birds put fewer eggs in one basket as compared to their temperate relatives

The tropical bird's clutch size is tailored to suit the environment its living in. The stable climatic conditions in tropics result in almost uniform productivity throughout the year -- the very reason which bestows tropics with rich species diversity also limits the clutch size! (Lack 1954). The climate allows the population to stay near carrying capacity, increasing competition for food. The lower productivity of tropics (as compared to temperate areas) resulting from reduced seasonality clubbed with greater species diversity in the region makes food acquisition, a difficult task (Ashmole, 1963; Cody, 1966; Ricklefs, 1980). An increased number of predators lead to inconspicuous nest designs, enforcing a nest-size constraint. A small clutch size is also favoured as it saves energy for renesting in case the nest is robbed by the predator and the female loses all the eggs. A larger clutch size also takes longer to lay; larger brood is noisier and also needs more frequent visits to nest, attracting predator's attention and putting both offspring and parent's survival at stake. All these factors combined together, favours a greater adult survival which is perhaps further benefitted from reduced reproductive efforts through smaller clutches but more parental investment per young, ensuring higher juvenile survival (remember the currency is fitness only!). On the other hand, variable environmental conditions encourage birds to lay larger clutches to compensate for heavy losses during the harsh winter months. A drastically low population density at the end of harsh winters, when presented with an abundant food resource (as most insect populations dependent on primary producers explode in spring and summer) has the opportunity to increase in the absence of competitors. Also, longer day lengths during spring and summer allow the parents to forage longer for food, enabling them to rear a larger brood, in temperate regions. Here, the parental investment increases as more time and energy is devoted to offspring rather than allocating to own survival and maintenance – a reason for shorter life span of temperate birds than their tropical relatives!

5.2.2. Reproduce once or more than once?

Sex Desperate *Antechinus*: live fast, die young

Figure 11: ***Antechinus***

Source: http://news.nationalgeographic.com/news/2013/10/131007-marsupials-mammals-sex-mating-science-animals/

Antechinus (Figure 11), also famous as marsupial mouse is a small-sized mouse like marsupial found in Australia. The carnivorous mammal survives mainly on insects though fruits and small vertebrates (e.g. frogs and lizard) can also be a part of the diet. The dull coloured animal exhibits a very interesting phenomenon in its life. As the winter approaches the male *Antechinus* stops producing sperms irreversibly and for the next two weeks is engaged into intense mating season as all the females come into estrous at the same time in a population. During this short mating period males copulate frenetically with as many females as possible and each of these session may run from 5 to14 hours. The most striking feature of this bizarre phenomenon is all the males in the population, die at the end of the breeding season little before they complete the first year of their lives. The timing of this suicidal mass mating event is consistent in any given population. The males die because of physiological stress, resulting from aggression and competition for females and the exertion from multiple mating sessions. The unusually high levels of stress related corticosteroids in the blood lead to internal bleeding and the collapse of immune system. This once in a life time affair literally costs the male its life. What could be the reason for this suicidal mating behaviour and why do not other mammals do the same? The phenomenon which is exhibited here is called semelparity, where the animal dies after single reproductive event and is common among many animal groups like insects and salmons but rare among mammals. In case of *Antechinus*, the males do not fight out the battle for females with claws or teeth rather sperm competition is the driving force behind this fatal mating effort. The copulation doesn't ensure the reproductive success of a male as the fertilisation is not immediate. The female may store the sperms for upto a period of two weeks in the oviducts, a strategy, whereby the sperms fight out the battle internally and only the most viable sperms fertilise the eggs resulting in the good quality offspring. This explains the desperation of male to impregnate as many females as possible as the ultimate goal is to father as many offsprings as possible (reproductive fitness of male). The answer to the second part of the puzzle lies in the fact that marsupial females produce only one litter during this annual food peak as the young ones are born at an early stage of development as compared to the placental mammals) and rely on the mother's milk for a considerably long period of time, rendering the female unavailable for mating. The placental mammals can fit in several litters annually, and therefore male is not forced to exhaust all the energy reserves in one go. Also, *Antechinus* rely heavily on insects, a food supply that fluctuates in different seasons reaching its peak in summers when most insect populations explode. Therefore the young ones are timed when there is abundant food supply and female has better chances of raising the young ones. The breeding season of the *Antechinus* is thus highly shortened and closely synchronized with the food supply and the males are forced to make the best possible use of this tight window of time. The life history of *Antechinus* is thus so intricately designed where everything falls perfectly in place.

Iteoparity is the alternative reproductive strategy (in contrast with semelparity) where organism live on to reproduce repeatedly and life histories of most of the plants and animals reflect this trait.

5.3. Parental care

Atlantic puffins make responsible fathers

Figure 12: Atlantic puffin (*Fratercula arctica*)

Source: http://animals.nationalgeographic.com/animals/birds/atlantic-puffin/

Atlantic puffins or more commonly known as "sea parrots" are sea birds found in Atlantic ocean. These puffins are one of those few fortunate bird species where males get an equally attractive partner, a trend not common among birds. These sexually monomorphic and socially monogamous (make bond- pairs but extra-pair matings are not uncommon) sea-parrots spend most of their lives at sea and return to land only during spring and summer to form breeding colonies. As puffins are colony breeders and several adjacent nesting burrows are of common sight, male spend more time maintaining and defending the burrow but do not shy away from landing help to female once egg is laid (Creelman and Storey, 1991). The female lays a single egg and male does not shy away from bearing the responsibility of not just incubating and guarding it but on hatching even feeding the chick. So, Atlantic puffins make responsible fathers who share the responsibility of raising the chick (direct parental care), an investment actually, ensuring high juvenile fitness, in addition to defending territory (indirect parental care).

6. Summary

Organisms inhabiting different environments are designed differently. These designs are actually adaptive modifications to environment the organisms live in. Irrespective of the design, the ultimate purpose of all organisms living is to reproduce and contribute into gene pool. Natural selection has tailored all organisms to perform this single ultimate task.

The astonishing diversity of life forms we come across is simply a reflection of how organisms achieve that ultimate goal. The different strategies adopted by different species or different populations are the consequences of different selection pressures.

Different life history strategies are adopted by species and or populations depending on the environment they inhabit. The environment includes not only factors like temperature, humidity or salinity but also predators and competitors. The prominent life history traits influenced are age at first reproduction (maturity), size, number and size of progeny, how many times to reproduce and how long to live. All these traits are either directly or indirectly related to organism's survival or reproduction. As the resources and time at organism's disposal are limited allocation needs to be made among various life activities. The energy and time allocated to one activity or trait is not available for the other, which results in trade-offs. A conflict is expected between survival traits (size or growth, age at first reproduction, life span) and reproduction related traits (clutch/litter size, size of offspring, number of reproductive efforts made etc). The trade-offs impose a limit on organisms and thus prevent all traits evolving to maximum fitness. The organisms ultimately settle down for the optimum fitness possible in the face of various constraints set by this trade-offs.

It is fascinating indeed to see that the most complex questions have really simple solutions. The life histories of animals which many times leave us confused are nature's engineering to achieve whatever is best remaining well within the limits set by nature itself.