

Reproductive and Survival Strategies Utilized by Insect. A Review

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Abstract Insects are the most diverse and abundant of all groups of animals despite their small sizes and vulnerability as they employ many specialized strategies during reproduction. They have high reproductive rates and numerous behavioural and physiological adaptations that assure them a fair fight in the struggle for survival. They have different means of attracting mates prior to copulation such as serenades, dances, foreplay, nuptial gifts, aphrodisiac and visual signals. Survival strategies such as bi-parental care, maternal care, paternal care, hygienic behaviour, migration, diapause, parthenogenesis and polymorphism are exhibited by insects which give them an advantage for surviving in their environment. Humanity and other living organisms will have difficulties in surviving if all insects fail to utilize their reproductive and survival strategies and suddenly disappear.

Keywords: *insect, reproductive strategy, survival strategy and copulation*

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1. Introduction

Reproduction is the biological process by which new individual organisms are produced from their parents [1]. It is a fundamental feature of all known life. There are two forms of reproduction: Sexual and asexual reproduction. In sexual reproduction, two reproductive cells (male and female) organisms called gametes which contain half the number of chromosomes of normal cells are created by meiosis and the male gamete fertilizes the female gamete of the same species to create a fertilized zygote. This produces an offspring whose genetic make-ups are derived from those of the two parental organisms. In asexual reproduction, an organism can reproduce without the involvement of another organism creating a genetically similar or identical copy of itself. The two fundamental modes of reproduction are obtained in insect thus ensuring their rapid increase in numbers [1].

Despite insects' small sizes and apparent vulnerability, they are the most diverse and abundant of all groups of animals because they employed many special strategies during reproduction [2]. They are equipped with high reproductive rates and numerous behavioural and physiological adaptations that assure them a fair fight in the struggle for survival. With these they survive rainstorms, windstorms, and ice storms [3]. They are able to find water in the desiccating heat of mid-summer, avoid flash floods and wildfires. They locate mates and a suitable food supply; elude birds, spiders, frogs and other predators. They also defend themselves against infection by pathogenic fungi and microorganism [3].

Insects have various means of attracting mates prior to copulation such as the use of serenades, dances and foreplay, nuptial gifts, aphrodisiac and visual signals. Examples are seen in female moth who gives off a powerful pheromone that can be detected from a great distance by the male and in fireflies that use flashes of light. Parental cares such as paternal and maternal parental care also exist among the insects to ensure their survival. This could be in form of supplying physical substances or materials to their offsprings and protection of the egg.

2. Importance of Sexual and Asexual Reproduction

- To maintain a unique identity of a species and addition of new individuals in a population.
- It leads to production of genetically copies of organisms through asexual means.
- New species facilitate evolution of organisms which is necessary for survival as environmental conditions keep on changing from time to time.
- To create variations in species as no two individuals are the same, as genetic characters from both parents will help make a slightly different copy of themselves. These small variations accumulate over hundreds of years resulting in formation of new species.

3. Reproductive System of Insect

The reproductive system in male and female insects consists of a pair of germinal tubes, a pair of ducts and a

medium terminal tube which open to the exterior. The reproductive organs are collectively called genitalia and are used for mating. Most insects are oviparous. Their eggs are produced by the female in a pair of ovaries, the male produce the sperm in one testis or commonly two and are transmitted to the female during mating by means of external genitalia. The sperm is stored within the female in one or more spermathecae. At the time of fertilization, the eggs travel along oviducts to be fertilized by the sperm and are then expelled from the body through the ovipositor [2].

4. Male Reproductive System of Insect

The male reproductive system consists of a pair of testes usually located near the back of the abdomen and suspended in the body cavity by tracheae and fat body. The more primitive apterygote insects have a single testis, and in some lepidopterans two maturing testes are fused into one structure during the later stages of larval development, although the ducts leading from them remain separate. Nevertheless, most male insects have a pair of testes, inside of which are sperm tubes or follicles that are enclosed within a membranous sac. Each testis is subdivided into functional units called follicles where sperm are produced [2]. A testis is known as the germinal tube and is an elongated tube or a lobe organ. The tube is thrown into coiled enveloped by connective tissue sheath. A testis may contain hundreds of follicles. The follicles generally aligned parallel to one another. Near the distal end of each follicles, there are group of germ cells known as spermatogonia that divides by mitosis and increase in size to form spermatocytes. These spermatocytes migrate toward the basal end of the follicles, pushed along by continued cell division of the spermatogonia. Each spermatocyte undergoes meiosis and yields four haploid spermatid which develops into mature spermatozoa. Mature sperm pass out of testes through short ducts known as vasa efferentia, which are dilated in certain region for storage of mature sperms. The system also contains accessory glands which are differentiated into ectodenia and mesodenia as they originate from the vas deferens of either side. Also there is copulatory apparatus consisting of a basal portion and terminal portion which is called the aedeagus or the penis. It has chitinous hooks or spines at the terminal end. The basal portion carries a pair of long lobes called the parameres which help to hold the female during coitus.

5. Female Reproductive System of Insect

The female reproductive systems are made up of a paired ovary, accessory glands, one or more spermathecae and ducts connecting these parts. Each ovary is composed of a number of tubes called the ovariole. Each ovariole is distinguishable into an apical portion, the germarium and the vitellarium or follicle. When a female insect is actively reproducing, the ovaries swell with developing eggs and may nearly fill the abdomen. Each ovary is subdivided into functional units called ovarioles where the eggs are actually produced [2]. A typical ovary may contain dozens of ovarioles, generally aligned parallel to one another.

Near the distal end of each ovariole are a group of germ cells called oogonia that divide by mitosis and increase in size to form oocytes. During active oogenesis, new oocytes are produced on a regular schedule within each ovariole. These oocytes migrate toward the basal end of the ovariole, pushed along by continued cell division of the oogonia. Each oocyte undergoes meiosis and yields four cells; one egg and three polar bodies. The polar bodies may disintegrate or they may accompany the eggs to move down the ovariole and they grow in size by absorbing yolk. Thus, each ovariole contains a linear series of eggs in progressive stages of maturation, giving the appearance of a "chain of beads," [4] where each bead is larger than the one behind it. The wall of the egg chamber is composed of a single layer of epithelial cells which secrete the chorion that forms the egg shell. The chorion is perforated at the anterior end by the fine apertures called the micropyle to admit the stored spermatozoa, flowing out from the spermatheca.

6. Courtship Behaviours in Insects

6.1. Serenades

Insects used courtship and calling songs to find their mates. Crickets (order Orthoptera) use distinct calling and courtship songs to lure their mates. Once a female cricket *Cicada species* is nearby, "the male suitor sings his best courtship song to sweep her off her six feet" [5]. Mole crickets dig tunnels in the ground with megaphone-shaped entrances, when the males sing from inside their burrow openings the shape of the tunnel amplifies the sound. The calling song which may be heard from distances up to a mile helps the female find the males and once she is near the male suitor switches to a courtship song to convince her to mate with him [1]. Mosquitoes sing harmonic duets with each other, adjusting the frequencies of their songs simultaneously as they near the moment of copulation [4]. Male fruit flies vibrate their wings in a pulsating and rhythmic pattern. Their songs let the females know they are of the same species, and available to mate [4].

6.2. Dances and Foreplay

Series of movements, steps and touching are displayed by insects prior to mating. These make certain male flies dance their way to love, performing elaborate dances around a chosen female to attract her attention and win the right to mate with her [4]. The primitive and wingless female insects like to be cuddled and caressed to get them in the mood. Example is seen in springtails where they touch each other with their antennae [4]. In apterygotes, sperm transfer takes place externally. The male deposits his sperm on a surface and gently coax his partner to take it [4]. In dung beetles, they engage in foreplay by rolling a ball of dung that will serve as a nursery for their offspring [4].

6.3. Nuptial Gifts

This is another strategy employed by some male insects in their pursuit for a mate. Food items or inedible tokens such as fragment of leaf and a silk balloon are transferred to the females by the males during courtship or copulation [6]. In *katydid*s species the nuptial gift is package by the

male insects in an edible spermatophore which are assimilated by the female and it enhances the fitness of the offspring that will be produced [7]. The male hangingflies hunt and capture arthropod prey, then use a chemical signal to lure the female closer and then offer her the food as gift. The female examines the prey, and if she finds the meal to her liking, they mate but if the gift is insufficient, she refuses to mate with the male [4]. In Balloon flies, the males wrap the prey in pretty, silken balloons. The female flies fly into a mating swarm of the males and choose a partner who presents her with his silk package [4].

6.4. Aphrodisiacs

These are drugs or foods that give an organism a strong desire to mate. Insects utilized this when all other methods failed. Male butterflies dust prospective mates with an aphrodisiac produced on the tip of the abdomen. If this works, the female will fly to a nearby plant where the male dusts her once again to be sure she's ready, and if she is, they will mate [4]. In some species of beetle (order coleoptera), the males have a variety of secretory organs and if the products of these are eaten by the female, she becomes receptive to the male [8].

6.5. Visual Signals

Some insects search for a sexual partner by giving out or looking for a visual cues or signals. In some butterfly species, the males spend most of their day time flying around or perch in a place that provides a clear view of the area looking for receptive females. If one appears, the male quickly takes flight and makes contact and escorts her to an appropriate place such as a leaf or a twig nearby for mating [4]. In Fireflies, the females send the signal to lure a male. She flashes her light in a specific code that tells passing males her species, her sex, and that she is interested in mating. A male will reply by flashing his own light and both will continue to flash their lights until they have found each other [4].

7. Survival Strategies

7.1. Bi-parental Care

This is a type of parental care where both the adult male and female insects cater for their offspring from the egg stage until pupation and in some cases to maturity. This type of care has been reported in three orders; Blattodea, Coleoptera and Hymenoptera [9]. Most species in these orders make nests underground or in wood burrows and prepare food for their offspring in the nest before oviposition is finished [9].

In order Blattodea, subsociality has been reported among many cockroach species. Feeding and protecting their young offsprings are done by the male and female insects [10]. The woodroach, *Cryptocercus punctulatus* form life-long family associations. The male and female construct and guard an extensive tunnel system or a nest, and they protect and facilitate the feeding of their offspring until they reach maturity by their hindgut fluids that serve as food to their offspring [10,11]. Colonies with a male and female pair are common in this group and both participate in an attack against an intruder [12]. Nymphs

grew more rapidly when cared for by two parents rather than one [13].

In the subfamily Panesthinae, majority of *Salganea* species have been reported to live in biparental families consisting of a male-female pair together with their offspring [9,14]. Adults of *Salganea* species defend their young nymphs and parental feeding of the young by initial instars through stomodeal trophallaxis has been reported by [15], and it is likely to be important for survivorship and normal growth in this group. In the subfamily Geoscapheinae, the adult *Macropanethia rhinoceros* provide their offspring with leaf litter and frass collected by both sexes [9,16].

Male and female burying beetles cooperate to bury and prepare small vertebrate carcasses to serve as the food source for their young. Both parents treat the carcass with preservatives from anal and oral secretions regurgitated in form of semi digested protein to the begging larvae [17]. In the burying beetle, *Nicrophorus orbicollis*, the males commonly remain in the nest until larvae are half grown and the carcass is substantially consumed while the females remain until larval development is complete and may even accompany the larvae during the wandering stage [17]. In dung beetle, *Cephalodesmius armiger*, the male and female form a permanent pair bond to rear one brood in a subterranean nest. The males forage outside for plant material while the females process the material into brood balls into which they lay a single egg. The males continue to forage and the females enlarge the brood ball as the larvae grow [17].

7.2. Maternal Care

This care is provided by the female insects alone. In embiopteran webspinner females, *Antipalurai urichi* they cover their eggs with layers of macerated bark and other substrate materials and silk to protect them from hymenopteran parasites [17]. In egg plant lace bugs, *Gargaphia solani*, they guard their eggs and gregarious nymphs until maturity. If a predator approaches their eggs, the female rushes at it, fanning her wings [17]. In membracid bug, *Umbonia crassicornis* a plant feeding insect, cuts slits in the bark with her ovipositor to facilitate nymphal feeding. She remains with the nymphs, actively maintaining feeding aggregations until the young offsprings reach adulthood [17]. In female salt-marsh beetle, *Bledius spectabilis*, maintains a burrow shaped in a way that prevents flooding during high tide. She also provides the young with algae, prevent mold, and protects the vulnerable first instars from attack by parasitic wasps [17].

In some insects, maternal care takes place during the period of development of the egg. The oviparous German cockroach, *Blattella germanica*, carries her egg sac externally until nymphs hatch. *Blattella vaga* produces maternal secretions on which her neonates feed for a short time [17]. The viviparous cockroach, *Diploptera punctata*, undergoes a 60-days "pregnancy" during which highly nutritious milk secreted from the walls of the brood sac is ingested orally by the developing offspring [17].

7.3. Paternal Care

This type of care is exhibited by the male insects alone. It is probably the rarest form of parental care known in insects [4]. In giant water bug, *Abedus herberti*, the females adhere their eggs to the wing covers of a male.

The male protect the egg from predators until they are hatch [17]. In subsocial spider-hunting wasp, *Trypoxylon superbum*, the males guard the nests against parasitism and ant predation after the females have sealed the cells where they deposited their eggs [17].

Many insects taxa show indirect paternal cares to their offspring. The males invest in their offspring with nutritional offering to the female in the form of nuptial gifts of captured prey items or even their own bodies. They transfer proteins or protective substances in a spermatophore during mating [17]. The male arctiid moths, *Utetheisa ornatrix* transfers protective pyrrolizidine alkaloids to the females during mating. These alkaloids are passed to the eggs, which are then unappealing to predators [17].

7.4. Hygienic Behaviour

This is a practice carried out by insects in order to keep themselves and their environment clean. This is usually seen in the social insects like the Bees, *Apis* species. The honey bees are susceptible to a bacterial disease known as American foul brood (*Bacillus* larvae). A bee larva that gets infected by foulbrood dies, but the worker bees play a role in defence mechanism against brood disease by detecting and uncapping the cells containing brood that is dead or infected [18]. This behavioural trait allows diseases such as chalk brood, American foulbrood and Varroa to be fully or partly controlled [18].

7.5. Migration

This is the seasonal movement of insects. The day to day activities of insects often involve movements associated with feeding and mating. This behaviour gives the insects ability to escape from their natural enemies, find more favourable growing conditions, reduce competition or relieve overcrowding, locate new habitats, disperse to alternate host plants and reasserts the gene pool to minimize inbreeding [3]. Migration is usually a distinct phase in the life cycle of insects, always occurring before the onset of reproductive maturity.

The Bogong moth is a native insect of Australia that is known to migrate to cooler climates. The Madagascan sunset moth, *Chrysidia rhipheus* has migrations of up to thousands of individuals, occurring between the eastern and western ranges of their host plant, when they become depleted or unsuitable for consumption [19]. The monarch butterfly migrates from southern Canada to wintering sites in central Mexico where they spend the winter. In the late winter or early spring, the adult monarchs leave the transvolcanic mountain range in Mexico to travel north. Mating occurs and the females seek out milkweed to lay their eggs, usually first in northern Mexico and southern Texas. The caterpillars hatch and develop into adults that move north where more offspring can go as far as Central Canada until the next migratory cycle [20]. In ladybird beetles such as *Hippodamia convergens*, *Adalia bipunctata* and *Coccinella undecimpunctata* have been noted in large numbers in some places where their movements appear to be made in search for hibernation sites [21].

7.6. Diapause

This is the suspension of development that can occur at the embryonic, larval, pupal, or adult stage depending on

the species of insect. In some species, diapause is facultative and occurs only when induced by environmental conditions. In temperate climates, many species enter diapause in the fall as an overwintering adaptation. Other species have a summer diapause that helps them survive the dryness and heat. Diapause is not always cause by environmental conditions. It can also regulate development within a population to ensure optimal timing of emergence or temporal synchrony with environmental resources [3]. Female rabbit fleas, have adult diapause that is broken only when they feed on the blood of a pregnant host rabbit. By the time the baby rabbits are old enough to be weaned, the fleas's offspring will mature and will be ready to accompany the rabbits when they leave the nest [3]. With this adaptation, the fleas population are kept from exceeding the carrying capacity of its host [3].

7.7. Parthenogenesis

This is a type of asexual reproduction in which the females are able to produce viable offspring without a contribution of a sperm from a male [3]. In this process the offspring develops from unfertilized eggs. This occurs in nearly all the insect orders, but is particularly well seen in the Bees, Wasps, Aphids, and in Stick insects [22]. Obligate parthenogenesis is seen in some insects where the species cannot reproduce sexually. Facultative parthenogenesis is also observed in some species of insects where they alternate between sexual and asexual reproduction [22]. They use this means to exploit available resources in the environment. Arrhenotokous parthenogenesis is seen in bees, and wasps where the males develop from unfertilized eggs and the females develop from fertilized eggs [22]. [3], reported that arrhenotoky occurs in all members of the order Hymenoptera (ants, bees, and wasps) and in a few species of thrips and scale insects. In these insects, all the females are diploid and all the males are haploid. Mated females have voluntary control over the release of stored sperm so they can opt to lay either a fertilized egg (female) or an unfertilized egg (male). This adaptation allows the female to regulate the sex of her offspring and is an important factor in evolution of colony structure for the social ants, bees, and wasps.

In thelytoky parthenogenesis, the females are produced from unfertilized eggs as seen in aphids [23]. In few social hymenopterans, like the Cape bee, *Apis mellifera capensis*, *Mycocepurus smithii* and clonal raider ant, *Cerapachys biroi*, the queens or workers are capable of producing diploid female offspring through thelytoky [24], and the daughters produced may or may not be complete clones of their mother depending on the type of parthenogenesis that take place [25]. The offspring can develop into either queens or workers. In ants, bees and wasps haploid males are produced from unfertilized eggs through arrhenotokous parthenogenesis. According to [3], thelytoky is found in many aphids, scale insects, some cockroaches, stick insects and a few weevils. In these insects, the females produce diploid eggs that develop directly into female offspring having exactly the same genetic make-up as their mother. As the daughters subsequently have the ability to clone themselves through parthenogenesis, this form of reproduction has the

potential to produce a large number of offspring in a short period of time.

7.8. Polymorphism

In social insects, this is associated with division of labour in the nest. Among the ants, large individuals with big mandibles usually serve as soldiers or foragers, while smaller individuals concentrate on care of the young or other housekeeping tasks. In honey bees, the workers have wax glands, stings, and pollen baskets that are not present in queens or drones. This type of specialization among insect is an adaptation that gives social insects the ability to utilize their resources more efficiently and survive in their environment [3].

Polymorphism in non social species can be regarded as habitat diversity. In England's peppered moth, *Biston betularia*, the light-coloured morph of this moth is hard to find in the daytime when it rests against a background of lichens growing on the bark of trees. A dark coloured morph is easy to see against the lichen, but hard to spot against the dark background of bare bark. Depending on the background, the less visible morph is the one most likely to survive bird predation [3]. In Africa, the desert locust, *Schistocerca gregaria* has two morphs that differ both in physical appearance and behaviour. Under low population densities, these grasshoppers develop into adults that are largely green in colour and have relatively short wings and show little or no tendency to migrate. Under crowded conditions, these grasshoppers develop into brownish adults with longer wings. These individuals end up to form huge swarms containing millions of individuals that migrate over hundreds of miles [3]. In parthenogenetic aphids, their morphs are made up of several generations of wingless (apterous) individuals followed by a generation of winged (alate) migrants. It is reported that this alternation of generations provides a mechanism for dispersal from one habitat to another as environmental conditions and host plant quality change throughout the year. According to [3], the rosy apple aphid, *Anuraphis rosea* reproduces asexually in the early spring producing several wingless generation on apple trees which is its primary host. As the apple foliage matures and become less desirable, an alate generation develops parthenogenetically and flies to narrow-leaved plantain which is the secondary host. Several wingless generations develop asexually on plantain until in the late summer or early fall before another alate generation develops and flies back to the primary host. This generation gives birth to a sexual generation that will mate and lay overwintering eggs on the apple trees.

8. Conclusion

Insects are the most diverse and abundant of all the groups of arthropods. The number of insect species so far recorded is over a million with many more yet to be described. Their wide distribution is made possible by their reproduction and survival strategies. They are equipped with high reproductive rates and numerous behavioural and physiological adaptations that assure them a fair fight in the struggle for survival. They use various means to attract mates prior to copulation and parental cares also exist among them to ensure their

survival. Humanity and other living organisms will have difficulty in surviving if all insects fail to utilize their reproductive and survival strategies and suddenly disappear. Most of them produce useful materials like honey and bee wax from bees, silk from silk worms and shellac from a wax secreted by the lac insects. Moreover, cross fertilization of many flowers and fruits are made possible by insects and they also serve as an important source of food. As an important food source, they are either consumed directly as in entomophagy or indirectly by feeding on other organisms that fed on them along the food chain.

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