REVIEW ARTICLE

# *Wolbachia*: It's Role In Pest Management

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## Abstract

*Wolbachia* is a microorganism that infects and replicates inside host cells and is mainly present in reproductive tissues of animals with joint feet and roundworms. In arthropods, it is found in insects, mites, spiders, terrestrial isopods, springtails etc. A survey that was recently conducted showed that *Wolbachia* is present in above 65% of insect species making this microorganism as one of the most intracellular bacterial genus so far discovered. *Wolbachia* controls their hosts' reproduction through unique mechanisms that incorporate cytoplasmic incompatibility (CI), parthenogenesis induction (PI), male-killing and feminization of genetic males. Recently, this bacteria has been used as a bio-control agent for controlling insect pests. Different arthropods which were laboratory-reared and field-collected, have been screened against this bacteria to see whether this bacteria can be used as a bio-control agent.


**Keywords:** Arthropod, Bacteria, Biological control, Feminization, Springtails, Survey.

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## Introduction

*Wolbachia* bacteria, inherited through cytoplasm, is present in female and male gonads of a broad variety of arthropods (Werren, 1997; Lo *et al*., 2002). Cytoplasmic incompatibility (CI), parthenogenesis induction (PI), and feminization of heritable males are the reproductive changes which occur by this bacteria in their hosts (Werren *et al*., 2008). *Wolbachia* is present everywhere (Fig. 1). Surveys that have been recently conducted showed that this bacteria is present in insect species, isopods, mites, and nematodes (Hilgenboecker *et al*., 2008; Padder *et al*., 2021).

This *Wolbachia* has many qualities; therefore, interest has been developed for this bacteria. First, it is widely distributed and affects upon hosts. Second, early stages and mitotic processes in the hosts are known to change by this intracellular bacteria. Therefore, this *Wolbachia* bacteria may be used to study the basic processes. Third, *Wolbachia* is used as a bio-control agent and as a microbial "natural enemy" (Floate *et al*., 2005).

## Evolution and Division of *Wolbachia*

### *Large-scale Phylogeny*

*Wolbachia* have a common ancestor with rickettsia which is shown by evolutions based on 16S DNA chain that codes for ribosomal RNA. The genes that specify the sequences of amino acids, two divisions (A & B) were confirmed. The B division includes the bacteria that infects wide range of invertebrates, a cytoplasmic incompatibility-inducing bacterium. Ehrlichiaequii, Ehrlichiacanis are a group of rickettsiae etc, which are closest bacteria to the *Wolbachia*.

### *Finer-scale Studies*

A finer-scale analysis utilizing a fast emerging bacterial cell-cycle gene (ftsZ) was lately counseled and revealed significant differences between *Wolbachia* genetic variants. Parthenogenesis inducing *Wolbachia* subtypes are present equally in A and B divisions, and evolutionary facts proposed that parthenogenesis inducing *Wolbachia* has emerged a number of times separately in these bacteria. Small or no hereditary reshuffling proceeds to take place among A- and B *Wolbachia*. 16S renal and finer-scale studies help in sorting *Wolbachia* strains into two groups i.e., A and B group. Hereditary reshuffling among genetic variants is main topic, specifying the normal incidence of numerous *Wolbachia* contaminations with in individuals of a few host species

### *Horizontal (Inter taxon) Transmission*

The horizontal (inter-taxon) transmission of *Wolbachia* was clearly shown by finer-scale studies phylogeny. A-division strain (designated as Adm) extensively showed horizontal transmission. Different Adm isolates that are same to ftsZ

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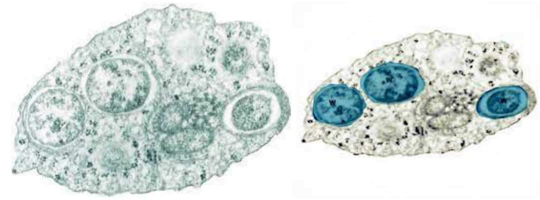

**Fig.1:** Electron micrograph of Wolbachia within an insect cell.

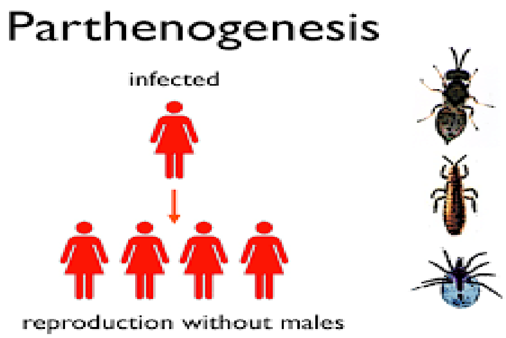


**Fig. 2:** Parthenogenesis: Whereby offspring's are produced without the embryo being fertilized by a male.

gene cycle can be set up in hosts from the insect orders, including beetles, honey bees, true flies, etc. B- *Wolbachia*, where Mormoniells vitripennis and its blowfly host each have *Wolbachia* subtypes are evolutionary connected and, lateral transfer has also been identified in these *Wolbachia*.

## BRIEF HISTORY OF *WOLBACHIA*

This *Wolbachia* bacteria genus was recognized initially in the common house mosquito in 1924 by Marshall Hertig and Simeon Burt Wolbach.

The species was properly described and planned both general and precise names: *Wolbachia* pipientis (Hertig, 1936).

After 1971, *Wolbachia* received great attention when Janice Yen and A. Ralph Barr revealed that common house mosquito progeny be assassinated by protoplasmic incompatibility.

New methods by which *Wolbachia* favour propagation of contaminated females in mixed-contaminated populations were revealed which includes feminization, parthenogenesis, and male killing by which (Louis and Nigro, 1989; Saridaki and Bourtizis, 2010).

## Distribution of *Wolbachia*

This bacteria is common and present in more than 80 insect species (Werren, 1997), 17 isopods, mites and nematodes. The number of infected species number is growing fast, and limitations on the distribution of this bacterial group are unidentified. Polymerase chain reaction-based methodologies showed an organized analysis of *Wolbachia* distribution and assortment. Functional molecular tools for such surveys are 16S rDNA and finer-scale studies. The 16S rDNA and finer scale study genes include general *Wolbachia* specific primer and A-*Wolbachia* and B-*Wolbachia* particular primers. Neotropical insects which were surveyed recently exposed *Wolbachia* subtypes in more than sixteen percent of species. *Wolbachia* contamination has been explored in insects like beetles, true flies, honeybees and wasps, aphids, true bugs etc. Surveys of neo-temperate insects provide related percentage of contaminated species (Werren *et al.*, 2008). An organized analysis of new geographic areas needs to be carried out. Further systematic surveys are considered necessary.

## Methods of Sexual Differentiation in Hosts

*Wolbachia* can multiply considerably, changing the reproductive capabilities of their hosts, which includes the following:

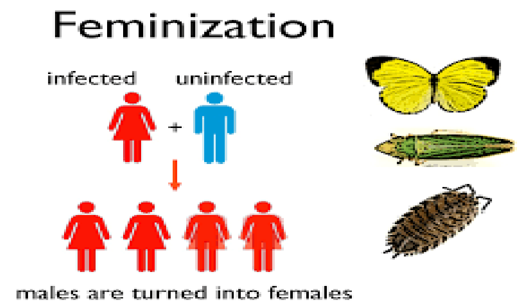


**Fig. 3:** Feminization: It is development of genetic males in to females.

- Parthenogenesis
- Feminization
- Cytoplasmic incompatibility
- Male-killing

### *Parthenogenesis*

It is the process whereby offspring's are produced without the embryo being fertilized by a male (Fig. 2). Male progeny can be produced from a few female parthenogenetic genetic variants of minute polyphagous insect of the order Hymenoptera through antibiotic treatments (Stouthamer *et al.*, 1990). Wasps of family figitidae, chalcidoids and pteromalidae are parasitic wasp genera in which parthenogenesis inducing *Wolbachia* subtypes have now been established.

The cytogenetic methods of parthenogenesis have been studied broadly in Trichogramma spp. Meiosis is natural. The chromatin becomes compact accurately in prophase of ist mitotic division and becomes unsuccessful in separating out in second stage of cell division, ensuing in repeated loss of chromosomes of the nucleus. Successive mitotic divisions appear to be common.

### *Feminization*

Cytoplasmically inherited microorganisms that induce feminization have long been known to occur in isopod crustaceans and common potato bug which is the most excellent – example (Fig. 3). A feminizing bacterium is present common potato bug which acts by abolishes an organ that secretes a substance which promotes the development of male sex characters, thus transforms the males into capable females. A common potato bug to be a *Wolbachia*, is shown by 16S rDNA sequencing recently, and this bacteria is closely related to *Wolbachia*, is indicated by finer scale studies sequencing. Feminizing *Wolbachia* bacteria population dynamics are mostly remarkable.

### *Cytoplasmic Incompatibility*

In cytoplasmic incompatibility where embryonic death occurs when infected males mate with either uninfected females or infected females carrying different type of *Wolbachia* (Fig. 4). Reproductive incompatibility between semen and ovum is a *Wolbachia*-induced cytoplasmic incompatibility in which zygotic death in diploid species occurs naturally and in haplo-diploid species, male production occurs. Cytoplasmic incompatibility takes two forms, one- way and two-way. One-way incompatibility classically occurs when the semen from

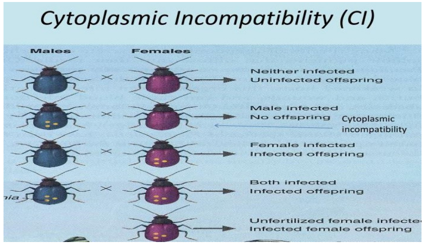


**Fig. 4:** Cytoplasmic incompatibility: In which embryonic death occurs when infected males mate with either uninfected females or infected females carrying different type of *Wolbachia*.

a *Wolbachia*-infected male fertilizes an uninfected ovum. An equal cross (un-contaminated male and contaminated female) is well matched. Two-way incompatibility typically occurs when female harbor different subtypes of *Wolbachia* that is equally mismatched.

In the insects like common house mosquitoes, fruit flies, and Mormoniella vitripennis, cytological methods of cytoplasmic incompatibility have been considered. In Mormoniella vitripennis, in its first mitosis, paternal chromosomes form a disperse chromatin weight, and fails to undergo separation, and naturally are misplaced in afterward genetic and cytogenetic analyses have revealed divisions. Development of haploid (male) progeny occurs by paternal genome loss.

### *Male-killing*

*Wolbachia* is transmitted mainly through mothers that kill males during initial stage of developing embryo (Fig. 5). Hence, contaminated females may hatch into mixed progeny of male and female eggs, but only the females live and turn out into adults. In insect orders which include beetles, true flies, butterflies and moths cases of male-killing by *Wolbachia* have been reported.

### Fitness Advantages by *Wolbachia* Contamination

Some species of mosquito and common fruit flies develop viral resistance when contaminated by *Wolbachia*. When mosquitoes gets infected by this bacteria, they become more opposing to RNA viruses like Drosophila c virus, noro-virus etc. Also, if Culex pipiens contains more *Wolbachia*, these mosquitoes become more resistant to chemicals that kill insects. In Cimex lectularius, the *Wolbachia* strain cCle helps the host synthesize B vitamins.

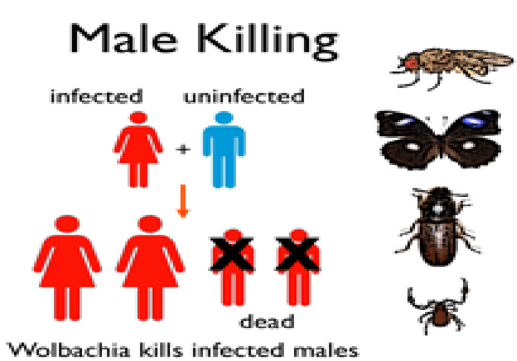


**Fig. 5:** Male Killing: In male killing males selectively die during embryonic and larval development.

### Significance of *Wolbachia* Contamination to the Host

#### *Effects on Host Reproduction*

This bacteria effects on their hosts by four methods, as explained above.

#### *Effects on Host Physiology*

*Wolbachia* influences the breeding and existence of the host's progeny; and can also affect the host directly. These effects may be useful or harmful and mystified by hereditary and eco-friendly elements. Contaminations may be important for host continued existence (Foster *et al.* 2004; Wani *et al.*, 2018a) or boost egg-laying capacity (Girin & Bouletreau 1995; Wani *et al.*, 2018b) and survival (Dobson *et al.*, 2003; Bano *et al.*, 2021).

## Conclusion

Investigation on wolbachia bacteria is expected to go through a rapid growth in upcoming years. There is extensive curiosity in this bacteria. A lot of the investigation on *Wolbachia* is quiet in the discovery stage. The questions to be analyzed are; how extensively *Wolbachia* spread (e.g., are these bacteria present in animals) and by which way does *Wolbachia* transfer among species? What is the growing trend of this bacterial contamination within and among species? Does this bacteria helps in biological evolution and can *Wolbachia* be efficiently utilized in biological control?

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